Helix Nebula – The Science Cloud

Helix Nebula – The Science Cloud: A catalyst for change in Europe

Abstract: Helix Nebula – the Science Cloud - is the catalyst for major changes in the way the European research community uses IT services, including a self-financing Public-Private Partnership (PPP) for cloud services. It addresses a key strategic interest for the European economy; to ensure accessible, sustainable, competitive and secure infrastructure, not only for the scientific community but throughout industry and society.

This exciting initiative, currently partially funded by the EC FP7 INFRASTRUCTURES Programme, can bring true benefits to Europe, its public sector and the IT services industry by transforming today's fragmented IT infrastructure into a platform enabling large-scale and trusted cloud services with more diversity than can be obtained from the current market.

This document analyses and explains acceleration themes that will have direct impact on our ability to build a flourishing open cloud services market in Europe, and proposes a coherent and consistent set of concrete actions towards that goal.

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Executive Summary

As we approach the end of the second full year of the Helix Nebula initiative, and of the first full year of its associated EC FP7 Project, we are on course to deliver the goal of enabling a federated cloud service across Europe. So far, the initiative has:

- Deployed and validated three high-profile flagships in high energy physics, life sciences and earth science, on commercial cloud services hosted by multiple suppliers
- Made use of network connectivity to the commercial data centres utilising GÉANT, DANTE and several NRENs
- Defined a federated cloud architecture, in conjunction with EGI.eu
- Identified further use cases and flagships for deployment in the second half of 2013
- Developed sustainable business models for cloud services, based on current supply-side and demand-side procurement practices, that withstand comparison to in-house approaches
- Expanded the consortium from 20 to 34 members and extended the public-private governance model to address the need for a comprehensive ecosystem of services

The initiative has enjoyed high visibility at a number of trade, academic and EC events. The next stage is to take Europe from *"cloud-active"* to *"cloud-productive"*, a transition identified at the Digital Agenda Assembly in June 2012.

To kick-start the up-take of cloud computing in Europe's research community, Helix Nebula has started by addressing the needs of big science as represented by the inter-governmental research organisations such as CERN, EMBL and ESA. Having proved that these flagship use-cases can be supported by Helix Nebula, work is now in hand to implement and exercise the simplified interfaces required, and lay the ground for wider adoption and use.

The preparation now in hand includes activities at a number of layers – policy, business, services and technology – and now is the time to expand the engagement to include national participants.

In this document, we propose and explain a number of acceleration themes to make this happen:

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- Federating multiple commercial cloud service suppliers into an open, standards-based platform
- Using data-intensive science to bolster the data-driven economy
- Building the hybrid cloud, putting together public and private cloud services
- Adhering to open standards that encourage uptake of a federated cloud
- Providing network access to cloud services
- Introduce a financial incentive model to encourage a rapid uptake of cloud services.

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Introduction and background

Helix Nebula - the Science Cloud - is introducing major changes in the way the European research community uses IT services. It has established a growing Public-Private Partnership of more than 30 commercial cloud providers (suppliers) and publicly funded research organisations (users). Three high-profile flagships, sponsored by CERN (high energy physics), EMBL (life sciences) and ESA (earth science), have been deployed and extensively tested across a series of cloud service suppliers. Links have been established with DANTE (Project Coordinator for GÉANT) and a number of NRENs so that commercial data centres across Europe are accessible to the user organisations via the GÉANT network.

The commitments behind these initial flagships have created a critical mass that attracts suppliers to the initiative, to work together and make investments. Flagship applications from more research disciplines, that will stretch the functionality and impact of Helix Nebula, have been identified for deployment during the second half of 2013.

Deployments and tests have revealed a series of gaps in the current set of offerings on the cloud market and confirm our strategy[1] to create an open standards-based multi-vendor federated cloud services market. This will allow the diversity of Europe's suppliers to compete with current big players on the global public cloud computing market as the best means of promoting Europe's ability to take a leadership role.

Based on the experience gathered from the proof of concept deployments, Helix Nebula's technical and service architecture groups have defined a federated cloud architecture to enable an open platform for science innovation that can expand to also provide new attractive large-scale cloud services for public administrations and businesses. EGI.eu is contributing to the development of this architecture with its own federated cloud architecture that complements that emerging from Helix Nebula, so that the EGI's publicly funded e-infrastructure could be interfaced with the commercial resources within Helix Nebula.

[1] http://cdsweb.cern.ch/record/1374172/files/CERN-OPEN-2011-036.pdf

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The next steps

Helix Nebula intends to expand its activity beyond the initial pilot phase to become an open market place for science, where data, scientists, funding bodies, SMEs and downstream industry collaborate. We aim to take Europe from *cloud-active* to *cloud-productive* by helping to build a competitive, efficient and sustainable strategic foothold in the vital supply of "*digital energy*", as important a driver of growth for modern economies as oil, gas or electricity. Helix Nebula has achieved a high level of visibility at trade, academic and EC events across Europe and enjoys continuous coverage in the media supported by an active presence on the web and major social networks.

An in-depth analysis of the procurement methods of the users and suppliers has been performed and a number of candidate business models highlighted that could ensure the sustainability of the initiative.

The transparency of pricing of services will contribute to a more effective market and allow the users to complete a factual comparison of the cost of cloud services compared to the use of in-house resources.

The public-private governance model has been expanded by refining the roles of the suppliers to an array of activities that will contribute to expanding the initiative into an ecosystem of services including consultancy, training etc.

Accelerators

This rapid growth has stimulated the business interests of many suppliers but the viability of the future of Helix Nebula and its ability to realise its vision depends on being able to attract a significant number of paying users to the platform. There is a reticence amongst the users and suppliers to make the commitments necessary to pass the hurdle from Helix Nebula's pilot phase to full-scale production services that is undermining that viability.

The cloud services suppliers see the potential benefit of such services but some of them fear the lack of opportunity to differentiate themselves and show added-value by operating beyond commodity services. Hence they do not want to fund the development of these services unless they are assured of a clear return on investment in terms of business generated.

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The cloud services consumers also want the federated services because they will help make a more efficient market, reduce prices and provide independence from individual suppliers. But the consumers are equally reluctant to pay for the development and maintenance of the services, and prefer to focus their money on paying for the consumption of such services in a pay-per-use model that has made cloud computing attractive. There is also a reluctance to make a long-term commitment to purchasing services because the market is evolving so quickly.

We propose a consistent package of measures to address these issues and accelerate the expansion of the Helix Nebula initiative and the context in which it operates, so it can become the viable and sustainable cloud computing service marketplace for the public sector.

These measures are discussed below, under the following themes:

- Federating multiple commercial cloud service suppliers into an open platform
- Using data-intensive science to bolster the data-driven economy
- Building the hybrid cloud by putting together public and private cloud services
- Adhering to open standards that encourage uptake of a federated cloud
- Providing network access to cloud services
- Introducing a financial incentive model to include more stakeholders and increase demand for cloud services

ISTAG, the Information Society Technologies Advisory Group, refers to Software Technologies as "the Missing KET" (Key Enabling Technology) in its report "Toward a Strategic Agenda for Software Technologies in Europe". This report summarises the importance of cloud computing, as follows:

> *"Given the expected economic impact of Cloud Computing, a concern is the creation/improvement of European industrial capabilities in the Cloud market at global scale. While cloud provision is dominated by major US firms, Europe is characterised by smaller suppliers which generally provide software services to public and business clients."* [2]

It goes on to make recommendations that are entirely consistent with those in this document:

[2] http://cordis.europa.eu/fp7/ict/docs/istag-soft-tech-wgreport2012.pdf

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"To strengthen the European Cloud system, Europe should devise and implement a range of policies which need to take this difference into account. Short term research should focus more on facilitating interoperability to address the heterogeneity of offerings, markets and solutions, rather than looking for answers to issues already satisfactorily solved. In addition, the uptake of cloud services should be encouraged to support innovative SMEs and facilitate the creation of large scale European providers" [3]

Federating multiple commercial cloud service suppliers into an open platform

Energy plays an important role in the national security of any given country as a fuel to power the economic engine. Foreign energy supplies are vulnerable to unnatural disruptions from conflict, exporters' interests, and non-state actors targeting the supply and transportation of energy resources. Political and economic instability can also prevent the proper functioning of the energy industry in a supplier country. New threats to energy security have emerged in the form of the increased world competition for energy resources due to the increased pace of industrialization in developing countries. The possibility of price rises resulting from the peaking of energy production also attracts the attention of governments. Long term measures to increase energy security center on reducing dependence on any one source of imported energy, increasing the number of suppliers, exploiting native resources, and reducing overall demand through energy conservation measures.

ICT services, such as cloud computing, are a form of energy that will power the global economy in the 21st century. ICT services will have an impact on society similar to fossil fuels in the past and so establishing a federated model that can draw on multiple suppliers distributed across many regions is of strategic importance to Europe.

Europe's opportunity lies in federating the diversity of its cloud services suppliers into an open cloud market that can compete with global leaders. A key point is the development of federated services across multiple suppliers. There are basic IaaS processing services available, but these will need further development if they are to offer the range of services, scale, quality, security and policy assurances needed for the future.

[3] European Commission - Advances in Clouds. Report from the CLOUD Computing Expert Working Group, 2012, http://cordis.europa.eu/fp7/ict/ssai/docs/future-cc-2may-finalreport-experts.pdf

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The continued development of European eInfrastructure provides a major opportunity. The scientific research sector, with its extreme computing needs, can be used to kick-start a market for federated cloud services in Europe by providing exciting and ambitious use cases that can test such developments and build scale. For example, the initial set of three flagship applications deployed by Helix Nebula have stretched what is possible with cloud services today and could be greatly enhanced if advanced real-time and continuous data analysis services were available. Leveraging Europe's leading position and investments in science to develop a coherent market in cloud services will further strengthen its position in the supply of such services to the public and private sectors.

The IDC report entitled "*Quantitative Estimates of the Demand for Cloud Computing in Europe and the Likely Barriers to Up-take*"[4] makes a number for recommendations of which we see the following as being particularly relevant to establish a European federated cloud infrastructure on a large scale:

> *"The European Commission should create the pre-conditions so that the principle of data access and portability between cloud vendors is widely accepted and the risk of lock-in of users in proprietary systems is prevented."*
>
> *"The European Commission should promote common standards and interoperability of public cloud systems, to maximise economies of scale across the EU and create the preconditions for portability between cloud vendors"*

Emerging open standards for APIs and protocols interfacing cloud services exist, such as Open Cloud Computing Interface[5] (OCCI). Such open standard interfaces are still immature and have not gained the support of commercial cloud services suppliers but are being assessed elsewhere for federated use cases such as in EGI's Federated Cloud Infrastructure[6]. We imagine a market of cloud services providers and a customer base that will have freedom of choice and not be locked into individual suppliers. This will encourage innovation on behalf of the service suppliers and give the users the ability to use state-of-the-art services for their research.

[4] IDC SMART 2011/0045 report, 13th July 2012
http://ec.europa.eu/information_society/activities/cloudcomputing/docs/quantitative_estimates.pdf
[5] http://occi-wg.org/
[6] http://www.egi.eu/infrastructure/cloud/

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However, the call for interoperability should not only be interpreted in a technical sense. A cloud broker/matchmaking role has been identified as a key enabler of an efficient market by the recently completed e-FISCAL project[7], which compared the cost of publicly funded e-infrastructures with commercial cloud computing services. It *"makes it easier for organizations to consume and maintain cloud services, particularly when they span multiple providers"* (see Gartner's report on Cloud Computing[8])

The issues associated with creating cloud broker/matchmaking services are primarily those of policy. There are potential issues associated with the transparency and the ownership of cloud broker/matchmaking services. If they are operated by a cloud services supplier, then that supplier is put in a dominant position in the market. There will be a temptation for the supplier to favour their own cloud services above those of their competitors.

This could lead to a scenario that is similar to that found with commercial internet search engines, which return results that favour their own products and services. This situation is considered to be a breach of antitrust laws by Joaquín Almunia, the EC vice-President responsible for competition, as explained in a recent article in the Financial Times[9]. A high-level panel discussion convened by DG Connect (Brussels, 17 September 2012) led to a report, *"The role of Taxation, IPR and State Aid in EU ICT competitiveness",* which said:

> *"While discussing the challenges faced by ICT companies in Europe, the panellists often pointed to globally uncompetitive EU state aid rules, a convoluted and expensive IP system and an unfinished internal market. Many panellists agreed other regions and countries were much better prepared, and willing to strategically invest in sectors that they see as key to their economic future.[...] When drafting policy, emphasis should not only be put on the protocols or technology, but also other factors that are needed to implement the single market, and harmonize rules consistently to ensure compatibility across all industry sectors[10]".*

[7] http://www.efiscal.eu
[8] http://www.gartner.com/technology/research/cloud-computing/cloud-services-brokerage.jsp
[9] http://www.ft.com/intl/cms/s/0/2b5bead6-5b3c-11e2-8d06-00144feab49a.html#axzz2ILwSnVGl
[10] http://ec.europa.eu/digital-agenda/sites/digital-agenda/files/1. Framework Conditions report Final.doc.pdf

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To ensure an open and free cloud services market can exist, the broker/matchmaking services should be an integrated functionality of the federated services that can be easily configured and managed by each user and/or operated by a trusted party in a manner that would avoid any conflict of interest.

These services must go beyond pure brokerage of IT infrastructure services, to permit the creation of public-private teams of skilled personnel across the suppliers and users, enabling the sharing of knowledge to develop a co-design[11] approach to cloud services and applications. The introduction of cloud broker/matchmaking services will reduce the variety of interfaces the user needs to master in order to procure and to use services from multiple suppliers. At the same time it reduces the barrier to entry into the market for new suppliers.

While federation of services is a vital characteristic, legal and regulatory frameworks that encourage the creation of the cloud services marketplace are necessary as well, as a means of ensuring that such a federated framework will be applied. A contractual framework should be developed, that takes effect for both users and suppliers who sign-up for the usage of the cloud broker/matchmaking service, with terms and conditions consistent with EC legislation and data protection policies, and as a means of implementing a confidence-building and trustworthy framework for commerce. As a practical guideline, the terms and conditions of such a contract should address all the points raised by the QMUL Cloud Legal Project in their recent paper "*Negotiating Cloud Contracts: Looking at Clouds from Both Sides Now*"[12].

Using data-intensive science to bolster the data-driven economy

A global milestone was reached in 2007, when the world produced more data than could fit in all of the world's storage; by 2011, in what one might compare to an ever-expanding snowball, we were producing over twice as much data as could be stored. The scale is almost unimaginable:

[11] http://echallenges.org/e2010/outbox/eChallenges_e2007_ref_195_doc_3562.pdf

[12] W. Kuan Hon, Christopher Millard & Ian Walden, 16 STAN. TECH. L. REV. 81 (2012), http://stlr.stanford.edu/pdf/cloudcontracts.pdf

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> *"In one day, a high-throughput DNA-sequencing machine can read about 26 billion characters of the human genetic code. The total data flow is more than 20 new US Libraries of Congress each and every year. That is from one specialised instrument, in one scientific sub-discipline. Enlarge that picture across all of science, across the world, and you start to see the dimension of the opportunity and challenge presented.[13]"*

The world's big science undertakings are increasing the emphasis on handling observational, experimental and computer-generated data in virtually all domains, from physics to the humanities and social sciences. Extracting meaningful, high quality analytical results from large distributed data sets requires new tools and techniques. The deployment of eScience applications in the context of Helix Nebula has confirmed the current gap and urgency of being able to make available and share scientific data if their full value is to be exploited.

The high-level expert group report, Riding the Wave, quoted above, highlighted the need for "*a scientific e-infrastructure that supports seamless access, use, re-use, and trust of data*." This need coupled with the move towards an open data strategy[14] for information that public bodies produce means the cloud computing infrastructure must be able to support data-intensive activities.

Helix Nebula, as a competitive cloud infrastructure, will support easy and cost effective access to state-of-the-art computing resources. But in order to maximise progress in science and ensure the sustainability of the services, free and open access to data-sets needs to be made available to as many potential users and contributors as possible.

The US Office of Science and Technology Policy (OSTP) has released the "*Memorandum for the heads of executive departments and agencies*" addressing "**Increasing Access to the Results of Federally Funded Scientific Research"**[15] with the following Policy Principle introduction:

[13] Riding the wave: How Europe can gain from the rising tide of scientific data, Final report of the High Level Expert Group on Scientific Data, October 2010, http://cordis.europa.eu/fp7/ict/e-infrastructure/docs/hlg-sdi-report.pdf

[14] Amending Directive 2003/98/EC on re-use of public sector information, 2011/0430 (COD), http://ec.europa.eu/information_society/policy/psi/docs/pdfs/directive_proposal/2012/en.pdf

[15] Memorandum for the heads of executive departments and agencies, http://www.whitehouse.gov/sites/default/files/microsites/ostp/ostp_public_access_memo_2013.pdf, issued 22 February 2013.

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"The Administration is committed to ensuring that, to the greatest extent and with the fewest constraints possible and consistent with law and the objectives set out below, the direct results of federally funded scientific research are made available to and useful for the public, industry, and the scientific community. Such results include peer-reviewed publications and digital data."

The EC's "Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL Amending Directive 2003/98/EC on re-use of public sector information"[16] is a good vehicle to maximise exploitation of public funded data assets although it might require additional focus on Cloud Computing capacities. The current version does not highlight sufficiently the aspect of open access to data coupled with the existence of a federated cloud computing environment in Europe. Similarly issues related to intellectual property and national security (e.g. impacting work of national authorities like geological surveys, dual-use of data, pricing, etc.) outlined in the document merit further elaboration. In order to link the directive to concrete actions, a scheme for funding its elaboration and implementation should be foreseen.

Building the hybrid cloud, putting together public and private cloud services

The work of Helix Nebula on an architecture model[17] has shown that it is technically feasible to allow publicly funded infrastructures to interoperate with commercial cloud services. Such hybrid systems are in the interest of the users of publicly funded infrastructures and funding agencies because they will provide "*freedom of choice*" over the source of resources to be consumed and the manner in which they can be obtained, facilitating the goal of *"making every researcher digital"*.

[16] http://ec.europa.eu/information_society/policy/psi/docs/pdfs/directive_proposal/2012/en.pdf
COM(2011) 877 final

[17] http://cdsweb.cern.ch/record/1478364/files/HelixNebula-NOTE-2012-001.pdf

This integration will allow the public infrastructure users to strike a balance between publicly funded resources and commercial cloud services while taking into account aspects of policy and cost. Private sector service providers can supply additional capacity and different resources/services not available in the public funded infrastructures. Research and innovation activities that have the potential for commercial exploitation can work with the private sector to unlock that potential without compromising the position for less commercially attractive research activities. In this manner, Helix Nebula is implementing what the e-Infrastructrue Reflection Group (eIRG) refers to as the *e-Infrastructure Commons* in its 2012 Roadmap paper[18].

Public organisations, just as commercial cloud service suppliers, should be able to register as suppliers, such as research organisations offering data sets commercially. This has the potential to bring the public and private sectors together in a hybrid cloud, the attraction being that it means that the public sector has something to offer the private sector other than a simple demand for cloud services. The current situation is inhibiting establishment of hybrid cloud infrastructures. It also inhibits the establishment of big-data services since there are a number of sensitivities to be addressed before we can envisage a model where all datasets are hosted on commercial cloud services.

Business models need to be developed that ensure the dataset owners, which are publicly funded research centres, do not lose control of their datasets and the associated intellectual property. They also need guarantees about the long-term availability of the cloud services and the data. Furthermore, it is of upmost importance that data catalogue services, such as those being developed by the EUDAT project[19], are available to all research communities' datasets hosted by both public and private cloud services.

[18] http://www.e-irg.eu/images/stories/publ/e-irg_roadmap_2012-final.pdf

[19] http://www.eudat.eu/

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There have been many community specific research data infrastructures established in recent years, such as The Catalog of Life indexing the world's known species[20], iMARINE[21] and GENESI-DEC[22], which have produced valuable data curation tools and expertise, along with data sharing policies. Being able to interface these data e-infrastructures into a hybrid cloud model will allow a larger user base to exploit the data, bigger opportunities to contribute scientific data to multi-disciplinary research, and provide sustainability models for their continued existence.

Adhering to open standards that encourage adoption of a federated cloud

The proof of concept deployments of the Helix Nebula flagships identified a number of key elements that need to be put in place for a federated cloud to be widely adopted, including:

- A standard set of APIs for suppliers and consumers; this needs to include relevant APIs of current global players offering ease of migration
- A federated identity management system offering a single sign-on facility to access cloud services across multiple-suppliers
- A means of automation of cloud management processes to provide on-demand services, resource pooling and rapid elasticity across cloud providers.

The role of standards in the evolution of the cloud is highlighted in SWD(2012) 271 (Unleashing the Potential of Cloud Computing in Europe[23]), which says:

> *"A jungle of standards generates confusion by, on one hand, a proliferation of standards and on the other hand a lack of certainty as to which standards provide adequate levels of interoperability of data formats to permit portability; the extent to which safeguards are in place for the protection of personal data; or the problem of the data breaches and the protection against cyberattacks."*

[20] http://www.catalogueoflife.org/
[21] http://www.i-marine.eu/Pages/Home.aspx
[22] http://www.genesi-dec.eu/
[23] http://ec.europa.eu/information_society/activities/cloudcomputing/docs/com/com_cloud.pdf

> *"This strategy does not foresee the building of a "European Super-Cloud", i.e. a dedicated hardware infrastructure to provide generic cloud computing services to public sector users across Europe. However, one of the aims is to have publicly available cloud offerings ("public cloud") that meet European standards not only in regulatory terms but in terms of being competitive, open and secure."*

The adoption of an open, standards-based approach to create a common platform has proven to be successful, especially when supported by public procurement policies that promote interoperability, with striking examples such as the rising dominance of open source software and the Linux operating system. Many developing countries are now taking this approach in order to achieve a rapid development and uptake of computing platforms:

> *"Technology is necessary for development as it makes people have access to computer resources. It is not the software that does the development or that gives the access to knowledge rather it is a tool that makes the access to knowledge and resources much easier. By buying software, one gets linked to and becomes dependant on its developers. As the software evolves, one has to buy upgrades, patches or new versions. And there may be a situation one would have to buy different software, which is often not compatible with the previous one.*
>
> *"To reach sustainability, whether in an open source and closed source the project must make one of its initial objectives of implementing sustainability plan at a very early stage of the project's life. For developing countries like ours open standards offer clear advantages as compared to proprietary solutions. Government may play an important role in software development by bringing in the standards based on open source platforms."*[24]

Companies such as Amazon provide a number of proprietary interfaces for their public cloud services[25] that have become de-facto standards and which form the basis of an enormous amount of currently-existing cloud software and management tools. Hence, offering compatibility with those dominant service providers will make it easier to attract a large user-base.

[24] Punam Gupta1 and Sapna Kapoor1, Open source platform and sustainability, http://www.csi-sigegov.org/emerging_pdf/14_125-132.pdf

[25] http://aws.amazon.com/

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Both the users and suppliers recognise the advantages a federated identity management system can offer to manage access to a large-scale cloud platform and to facilitate the authentication and authorization to services provided by multiple-suppliers.

The need for demonstrable security combined with ease of access is one of the key reasons for taking such a structured approach to the federation required, in both technology and service aspects. Given the relative immaturity of cloud technologies and rapid innovation in the sector, adopting extensible standards that allow exposure of innovation by suppliers will also prevent entrenchment by legacy service providers through rigid standards and thereby encourage competition and innovation. The model must also encourage innovation both from currently-participating suppliers and other organisations (e.g. SMEs) that can improve and expand the set of services. In the absence of widely accepted open standards, the best that can be achieved today is to simultaneously support de-facto standards and progressively increase the adoption of open standards.

Providing network access to cloud services

An agreement has been made with GÉANT, involving DANTE and the relevant NRENs, so that the commercial data centres hosting Helix Nebula cloud services could be integrated into the GÉANT network. The proof of concept deployments demonstrated this integration which greatly simplifies the creation of a hybrid cloud. The agreement is limited to the duration of the two year pilot phase and valid only for non-commercial network traffic.

Network access to the cloud services and the transfer of large datasets can represent a significant cost for the users. Demand-side users are reluctant to make commitments for the use of the cloud services beyond the end of the pilot phase without assurances that they can continue to make use of the GÉANT network to access the cloud services.

This situation was addressed in the work of the GÉANT Expert Group Report "Knowledge without Borders - GÉANT 2020 as the European Communications Commons" in particular, the recommendation to extend beyond the traditional uses in research and education into wider public services.

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> *"Leveraging the scale and capacity for innovation, the networks can be key drivers of public sector change, enabling service delivery and partnerships. By aggregating smart users, the European networks can help drive innovation in public sector service provision, assist in reducing the costs of public services and improving the user satisfaction."*[26]

As Helix Nebula moves into production, it is important that the agreement reached with GÉANT is extended and expanded to more NRENs to allow as many commercial cloud services suppliers as possible to participate. The suppliers and users should be able to connect to the broker/matchmaking services via the GÉANT network and commercial networks.

To ensure research centres can effectively leverage the potential of the federated cloud in the future it will be necessary to establish adequate and more advanced network connectivity. This will be of particular interest for those research centres which plan to shift significant parts of their current internal IT capacities to the federated cloud or for the sites which would start feeding future big-data cloud services.

Moving large scale scientific data sets into the cloud will require multi-site hosting arrangements between commercial cloud providers that make connectivity a key success factor for driving this scientific eco-system. Hence, the development of more advanced software-defined networking functions could help support large-scale federated cloud computing.

Reducing the cost of commercial cloud services

Initial investigations on the potential impact of cloud services in the research community suggest that the commercial public cloud services are likely to be most cost effective for the *"long tail of science"* conducted by researchers that do not have access to significant in-house computing resources and skills. Efforts must be made to simplify access to commercial cloud services for such groups that may have straightforward requirements and frequently do not have sufficient in-house IT expertise to manage and operate their own computing resources.

[26] http://cordis.europa.eu/fp7/ict/e-infrastructure/docs/geg-report.pdf

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Conversely, it will require further reduction in costs for large research users with important in-house computing capacity to find commercial cloud services as financially attractive as is the case for small scale users. As one industry representative put it "*why would I hire a car on a daily basis if I know in advance I will use it every day for 3 years – it will be cheaper to buy my own*".

There is evidence that commercial cloud services suppliers are willing to adapt their business models in order to attract large research users using approaches such as pricing based on aggregated demand at the institution or research group level and features such as buy-back of unused capacity. Unfortunately, it is often not possible for the research organisations to provide the necessary financial input to build a business case on which the commercial providers can base a decision. Exploration of innovative business models should be encouraged because the large research users can help Europe's cloud suppliers produce next generation cloud services which would put Europe in a leadership position. It may be necessary to provide incentives that bring together the commercial cloud services and publicly-funded e-infrastructures into a common, open platform to allow such issues to be addressed.

It is recognised that not all publicly funded research centres are in a position to make accurate estimations of the total cost of ownership of in-house IT services since some contributing costs are borne by different departments. But in order for the demand-side users to be encouraged to purchase cloud computing services, the services offered must be economically advantageous compared to other means of procuring IT services.

These alternatives include purchasing and operating IT equipment internally which requires capital investment and IT expertise but remains economically attractive for IT-intensive applications with a sustained and predictable usage. Also, purchasing services from the established global cloud service providers might be more attractive.

This is particularly true for the "*long tail*" of researchers who do not have the in-house IT resources and experience. Those market leading providers offer extremely competitive pricing schemes which need to be met by Helix Nebula suppliers. Prices change rapidly and the market leaders are currently engaged in a price-war in order to eliminate the competition[27].

[27] http://readwrite.com/2012/11/28/who-will-win-the-google-amazon-microsoft-cloud-computing-price-war

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Financial incentive model to encourage a rapid uptake of cloud services

We propose a scheme of financial incentives to encourage the use of cloud computing in the context of the Helix Nebula initiative. The principle of incentives was recently proposed by the European Economic and Social Committee (EESC) in response to the European Commission's recent Communication on "Unleashing the potential of cloud computing in Europe"[28]:

> *To promote the use of cloud, the EESC has backed the Commission's suggestion to do away with the plethora of technical standards and create EU-wide certification schemes for cloud service providers. It has also come out in favour of drafting model conditions for CC contracts in service level agreements and developing cloud-based public sectors.*
>
> *The EESC argues that special incentives are needed to bring this about. Under current market conditions, expanding the use of the cloud in Europe will inevitably strengthen non-European operators", said Mr Pigal, who is also concerned over the "dominance of non-European operators" in cloud computing.*

Providing financial incentives to encourage the use of cloud services will greatly increase their rate of development by suppliers and adoption by users. We envisage a model whereby financial incentives can be targeted at the demand-side (users) and supply-side (cloud services suppliers). For users, the incentives would enable them to support their migration to the cloud and to procure cloud services at a lower-price. For suppliers, the incentives would reduce the cost of providing a service e.g. through supporting the integration of their services with the Helix Nebula federated cloud API.

The level of the financial incentives to users should be calculated so that it becomes financially advantageous for them to migrate from legacy IT services to a common cloud services platform as part of a longer-term vision. The incentives can be either general (i.e. for all users and supplies) or focussed on specific user groups, suppliers or service types. The incentives can also be adjusted over time so that, for example, the incentives are initially significant then gradually reduced over time as a function of the total volume of cloud service usage and maturity of the market.

[28] http://www.neurope.eu/article/eu-cloud-computing-strategy-criticised?utm_source=twitterfeed&utm_medium=twitter

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The financial incentives programme could be implemented using a number of instruments, depending on the funding agency and target group. For example, Pre-Commercial Procurement[29] (PCP) has already been highlighted by DG-CONNECT as a means of encouraging the development of advanced services for data access, storage, discovery, integration, curation and analytics support to more efficient and innovative research. Similarly, Public Procurement of Innovative Solutions[30] (PPI) can encourage the procurement of the resulting advanced services by the public sector research organisations.

We see a number of advantages of introducing such a financial incentive scheme:

- Users become aware of the "real" cost of the IT services. Currently, the funding model for the construction and operation of public e-infrastructures means that the user is oblivious to the cost of the resources they consume. Making the users aware of the cost will encourage them to compare alternatives and find the most cost effective solution to their needs. Consequently Helix Nebula will contribute to the reduction of the total cost of e-Infrastructures for all stakeholders.
- Suppliers will be encouraged to enter the cloud services market and compete in an open market.
- Users will be encouraged to contribute datasets and software (including tools, apps and algorithms) to the platform.
- The incentive package is a simple and practical means of implementing a "cloud first" policy for Europe.
- The federated cloud model with multiple-suppliers and multiple-users is particularly suited to the application of financial incentives as it will encourage a growing market.

The broker/matchmaking services will provide a direct and practical means to implement financial incentive programmes. The broker/matchmaking service will be able to report on key performance metrics to the financial incentive programme sponsors and offer historical data as well as forecasts for any combination of users, services and suppliers.

[29] http://cordis.europa.eu/fp7/ict/pcp/overview_en.html
[30] http://cordis.europa.eu/fp7/ict/pcp/links_en.html

This will allow the sponsors to have rapid and factual feedback on the impact of their incentives via a suite of tools and make adjustments as necessary. The European Einfrastructures Observatory project[31] provides an example of what key performance indicator tools could offer in this domain.

A financial incentive scheme will act as a catalyst for attracting more sponsors of similar incentives to the cloud platform. We envisage other funding agencies, at the European and national level, to expand the scope of the financial incentive programme according to their policies and priorities. For example, stakeholders could sponsor an incentive programme for the users of Research Infrastructures (RIs) present on the ESFRI roadmap[32] that are well advanced in construction.

In addition, the European association of national Research Facilities laboratories (ERF[33]) represents international-level multidisciplinary Research Infrastructures, funded by national sources but offering open and free access, and serving every year over 20,000 academic and industrial users from Europe and all over the world. A report[34] for the ERF workshop on the socio-economic relevance of research infrastructures held in June 2012 stated:

> *"Even though the RIs are working in different disciplines, they have one thing in common: all require e-infrastructure and related ICT services. The worst case scenario in Europe is that all RIs develop their own, incompatible ICT environment. Substantial focus is required to build multidisciplinary collaboration to provide these services, as also to bring researchers and e-infrastructure providers working closer together."*

Such an incentive programme would increase the impact of the research infrastructures and encourage multi-disciplinary research as researchers active in life sciences, physical sciences, environmental sciences and social sciences and humanities collaborate on a common platform.

[31] http://www.enventory.eu/
[32] http://ec.europa.eu/research/infrastructures/pdf/esfri-strategy_report_and_roadmap.pdf
[33] http://www.europeanresearchfacilities.eu
[34] http://erf.desy.de/sites2009/site_erf/content/e99281/e112179/infoboxContent116075/Booklet.pdf

The rapid expansion of the use of IT throughout science, industry and society is increasing the impact the IT industry is having on the environment. Regional stakeholders could sponsor an incentive programme for cloud services hosted in energy-efficient data centres with a low Power Usage Effectiveness (PUE) metric and those that make use of renewable energy sources. The value of such an incentive programme would be to contribute directly to reducing the impact of the growing IT industry's energy and carbon footprint on the environment. Exposing the efficiency gains through higher utilisation of cloud infrastructure would also serve to highlight the environmental benefits of cloud based infrastructure delivery over in-house infrastructure often running at lower utilisation levels.

National research councils could sponsor an incentive programme for their grantees. Encouraging grantees to make use of a common platform will accelerate their research and allow them to concentrate their effort on the science rather than IT provisioning and management. In addition, using a common cloud platform to host the data and results of will encourage them to contribute new services and ensure that the artifacts of their research remain available once their grant funding is consumed.

The recent **Conclusions on 'A reinforced European research area partnership for excellence and growth'**[35] issued by the Competitiveness Council "*EMPHASISES that transnational research and innovation should be enabled by fostering and exploiting synergies between national programmes with international programmes, where appropriate by strategically aligning national funds and other funds at EU level, rather than cross-border funding per se*." and "*CONSIDERS that excellent research depends notably upon world-class facilities and research infrastructures, including regional partner facilities, e-infrastructures that enable computer and data-intensive collaborative research, and remote access to resources and equipment, and that research infrastructures attract talent and stimulate science, research, education, innovation and business opportunities*."

[35] Conclusions on 'A reinforced European research area partnership for excellence and growth', 11 December 2012, http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/intm/134168.pdf

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Beyond the initial flagships that have helped to kick-start the Helix Nebula initiative, interest has been shown by national research organisations and funding agencies into contributing to the overall initiative at a national level. A dialog is underway with a first set of member states to understand how Helix Nebula can link with national activities. At the national level, funding bodies could choose to sponsor incentive programmes for their national users and/or suppliers. This possibility will enable integration and aggregation of European level and national policies which could be targeted to specific subgroups of users and suppliers to further stimulate the uptake of cloud computing in specific sectors. For example, national funding agencies could make use of structural funds[36] to increase ICT development in their regions by supporting the construction of new energy efficient data centres to host commercial cloud services.

The incentive model can be extended beyond Europe to facilitate international collaboration through joint sponsorship of incentive programmes by a number of countries or regions.

The incentive model can use public funding to leverage additional sponsorship from private companies and foundations. This can include technology companies serving the IT sector. For example, a microprocessor manufacturer could sponsor an incentive programme for suppliers that offer cloud services running on IT equipment that uses their products. A pharmaceutical company could sponsor an incentive programme to encourage research on a specific gene. A philanthropist could sponsor an incentive programme for research in their scientific field of choice.

In parallel to EC funding addressing EU science policies, also national funding bodies are investing in research activities, addressing beside EU policy- also national or regional policy requirements. Funding requests are therefore issued to several addressees, which naturally makes the exploitation of synergy across funding activities very difficult.

[36] http://ec.europa.eu/regional_policy/index_en.cfm

Helix Nebula, being the "Science Cloud" could contribute to make research activities and outcome more visible in a Pan-European context. Since Helix Nebula, being initialized by research labs owning unique instrumentations and data, scientists will use this platform as their first choice working environment where they find beside the data, tools, also their peers, similar to NSF[37] cyber infrastructure.

Funding bodies will be able to identify on-line where funding outcome of national or EC grants have successfully been concluded and where synergy across funding bodies and cross-domain can be exploited.

Summary

Helix Nebula was conceived as a way of bringing coherence to a highly fragmented IT services industry through the vision of a federated 'science cloud' integrated with publicly-funded scientific e-Infrastructures. Since the publication of the Helix Nebula strategy document in August 2011, much has been achieved to transform the fragmented ICT infrastructure in Europe into a platform enabling large-scale and trusted cloud services - for businesses as well as public bodies - with more diversity than can be obtained from today's market.

Two fundamental steps remain if the vision of Helix Nebula is to become reality. One is to bring together a critical mass of supply-side interests and the other is to do the same for the demand-side. The accelerators described in this document represent a consistent set of concrete actions that will have direct impact on the creation of a flourishing open cloud services market in Europe by facilitating supply and stimulating demand. There is currently a window of opportunity for Europe to use public and private finance to fulfil the Helix Nebula vision of a transformative, innovative and collaborative cloud-based infrastructure for Europe and beyond.

[37] http://www.nsf.gov/pubs/2007/nsf0728/nsf0728.pdf

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Helix Nebula Documents

This section lists a series of relevant documents that have been published by the Helix Nebula initiative. The full set of all documents published by the initiative are available here: https://cdsweb.cern.ch/collection/Helix%20Nebula

Strategy and requirements

- **Strategic Plan for a Scientific Cloud Computing infrastructure for Europe**

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.

http://cds.cern.ch/record/1374172

- **Requirements Definition Template**

This document provides a template for the assessment of potential flagship use cases to be considered for the Strategic Plan for a Scientific Cloud Computing infrastructure for Europe. The purpose of this template is to ensure sufficient information is gathered about proposed future flagships as part of the planning and selection process.

http://cdsweb.cern.ch/record/1484437

- **Consolidated User and Service Requirements Report**

This document aims to consolidate the lessons learned from the three Proof of Concept (PoC) Infrastructure as a Service (IaaS) environments, with the scope of offering compute power to ESA, CERN and EMBL in a utilitarian way making compute power a commodity such as water, electricity and power.

http://cds.cern.ch/record/1501967

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Business Models

- **Analysis of the existing supply and demand side – Big Science - business processes for the procurement of IT infrastructure services**

The description and analysis of business processes in this deliverable define the framework and restrictions for the definition of potential business models. Accounting and costing processes of both sides and the process of budget provision on the demand side has been examined to find potential restrictions on future contract terms. In the last section of the deliverable the cost and pricing model examination derived of completed surveys, shows potentials from cloud computing for the demand side. It describes the outcomes of applying different pricing models to the different needs of the demand side scenarios. http://cds.cern.ch/record/1529847

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Summary of general assembly meetings

- **Summary of the First General Assembly**

This document provides a summary of the General Assembly of the Helix Nebula - the Science Cloud initiative that was held at CERN in Geneva on 5–6 July 2012. The objectives of the general assembly were to review the initial results of the Proof of Concept (PoC) stage of flagship application deployments and to plan the next step of the two-year pilot stage, taking into account the experience from the PoC.

http://cdsweb.cern.ch/record/1475236

- **Summary of the Second General Assembly**

This document provides a summary of the general assembly of the Helix Nebula - the Science Cloud initiative that was held at ESRIN in Frascati, Italy on 17-18 January 2013. The objective of this general assembly was to prepare the transition from a proof of concept to a viable service.

http://cds.cern.ch/record/1514609

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Architecture documents

- **The Helix Nebula Architecture**

This document captures the current knowledge of the Helix Nebula Technology and Architecture Group regarding the need for a federated framework to simplify discovery, access, usage and management of a federated cloud system. Alongside this objective, we aim at providing an integration framework, where current and future suppliers (i.e. Cloud service providers) can easily interface their system in order to attract and receive cloud workload.

http://cds.cern.ch/record/1478364

- **Service Architecture**

This document outlines the current knowledge of the Helix Nebula supply side regarding the need for a structured Service Architecture. It introduces why such architecture is needed.

http://cds.cern.ch/record/1525897

- **Helix Nebula Blue Box Approach**

This document captures the current knowledge of the Helix Nebula supply-side regarding the need for a federated framework to simplify discovery, access, usage and management of a federated cloud system. Alongside this objective, the suppliers aim to provide an integration framework, where current and future suppliers (i.e. cloud service providers) can easily interface their system in order to attract and receive cloud workload.

http://cds.cern.ch/record/1523702

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Communication plans and material

- **Communication Plan**

The purpose of this document is to detail the aims and focus of the communication and dissemination strategy of the Helix Nebula initiative. This deliverable serves as the core communication and dissemination guide and reference for the Helix Nebula consortium.

http://cdsweb.cern.ch/record/1476358

- **Communication Material: Public Event "Results and Engagement", 16 January 2013, Frascati, Italy**

This folder compiles the communication material used to advertise the public event *Results and Engagement,* organized to present the results achieved during the proof of concept stage and enhance the discussion on the candidate flagship use cases.

http://cds.cern.ch/record/1504344

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