

Helix Nebula – The Science Cloud

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Executive Summary

This document provides a summary of the work achieved during the second year of the Helix Nebula pilot-phase project in the area of interoperability between commercial cloud providers and publicly funded infrastructures.

The work package delivered:

- Three interoperability workshops aimed to identify, discuss and agree recommendations concerning interoperability aspects and implementation actions;
- An extra interoperability workshop co-located with the EGI community forum scheduled in May 2014;
- 17 high level recommendations and 30 implementation actions on which progress has been monitored and documented;
- An established collaboration with the FedSM project and exploitation of the FitSM standard through a dedicated training and implementation workshop;
- An established collaboration with the EGI Federated Cloud for the integration of the affiliated publicly-funded cloud service providers through the development of a connector for SlipStream and demonstration of flagship deployment;
- An established collaboration with DANTE for interconnecting commercial cloud providers to publicly funded infrastructures and research and education institutions via GEANT and the NRENs.

Thanks to the valuable input from several Helix Nebula stakeholders, this document provides a final roadmap for members of the Helix Nebula initiative, as well as suggestions for suppliers and e-Infrastructures involved with service provisions in the Helix Nebula marketplace, to guide future activities in the area of interoperability.

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1 Introduction

Following the publication of the “Strategic Plan for a Scientific Cloud Computing infrastructure for Europe” in August 2011 [1], the Helix Nebula initiative supported by the Helix Nebula EU funded project gathered leading commercial cloud providers together with research organizations and publicly funded e-Infrastructures to work on heavy IT requirements of the largest scientific organizations in Europe, so as to create a federated, accessible, sustainable, competitive and secure cloud infrastructure, for the scientific community but the Industry and society at large.

At the end of the first year, the Helix Nebula project met the following key targets:

- 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 to include publicly funded infrastructures, in conjunction with EGI.eu
- Identified additional use cases and second year flagship deployments
- Developed sustainable business models for cloud services, based on current supply-side and demand-side procurement practices, which withstand comparison to in-house approaches
- Expanded the consortium from 20 to 41 members and extended the public-private governance model to address the need for a comprehensive ecosystem of services

These achievements demonstrated the validity of the updated strategy at the core of the Helix Nebula initiative [2] and boosted motivation and commitment across the consortium towards far-reaching goals.

The work on interoperability contributed substantially to achieving these results by facilitating continuous dialogue and the exchange of information & practices between publicly funded e-Infrastructures and commercial cloud providers, with the users’ continuous input.

As also described in the Interoperability Requirements Report (Deliverable D6.1) [3], Helix Nebula adopted the European Interoperability Framework 2.0 [4] as a reference tool for the analysis and so to organise the existing and emerging issues across different interoperability levels. It should be noted that this scheme does not explicitly identify the level ‘Services’; this is partially covered by the semantic layer (see Figure 1).

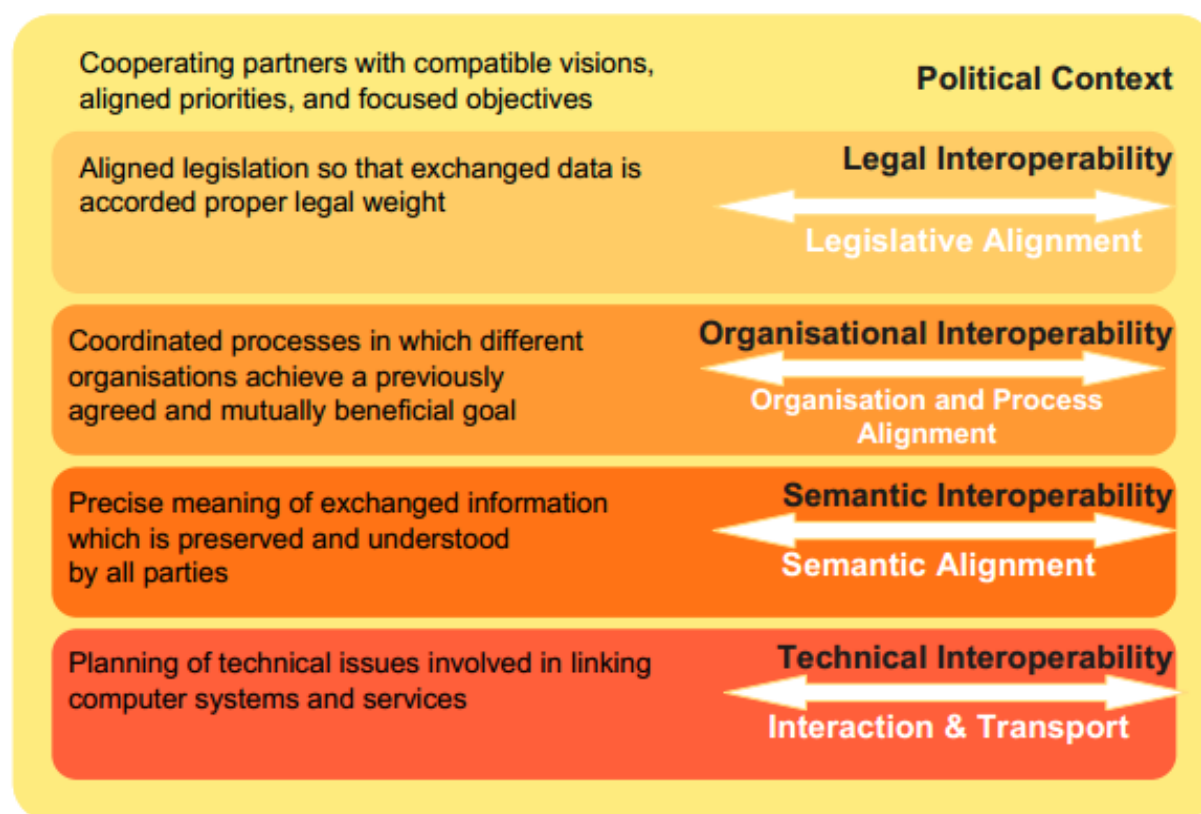


Figure 1 Interoperability Levels according to the European Interoperability Framework (EIF) 2.0

The technical interoperability offered high-level operational challenges to suppliers, given the demanding clients’ requirements. Critical aspects have been also identified in the organizational and legal levels, and in the political context related to vision, governance and constraints of publicly funded infrastructures compared to commercial providers. In spite of difficulties encountered in this area, many issues were addressed thanks to the openness, commitment and willingness of EGI.eu and GÉANT to cooperate with commercial partners.

Finally, the increasing cloud-bursting need among user communities became evident, since many organisations have in-house capacity they need to scale out within specific timeframes. The need for a marketplace thus became evident; so that customers and users can see what combination of best price with the right SLA is available for their specific needs.

2 Implementation of interoperability recommendations and actions

During the first year of the Helix Nebula project, an intense activity was devoted to gathering requirements, identifying areas of intervention concerning interoperability aspects and listing recommendations to guide future work. Such interoperability recommendations were listed in D6.1 [3], and then articulated in a number of agreed specific actions to be implemented according to different levels of priority. Action owners and relevant contributors were identified to follow up progress and to monitor possible blocking issues for a more rapid resolution.

Face-to-face meetings and three interoperability workshops were organised during 2013 to lay out the organizational, technical, legal and commercial issues at stake and to understand the priorities, actions and assess progress. It is important to remark that the execution of the identified actions was almost entirely unfunded. Therefore the planned work is not expected to be completed within the lifespan of this EC funded project.

This document also aims to identify the relevant actions that could be undertaken in the future, beyond the lifetime of the current EC project.

2.1 Political Context

In September 2012, the European Commission documented and published a strategy “Unleashing the Potential of Cloud Computing in Europe” [5]. The document outlines actions to obtain a net gain of 2.5 million new jobs in Europe, and an annual boost of €160 billion to the European Union GDP (around 1%) by 2020. During 2013, this strategy was pursued through the establishment of some parallel initiatives and related working groups working on key actions:

- Cutting through the jungle of technical standards so that cloud users get interoperability, data portability and reversibility;
- Support EU-wide certification schemes for trustworthy cloud providers;
- Development of model 'safe and fair' contract terms for cloud computing contracts including Service Level Agreements;
- Establish a European Cloud Partnership with Member States and industry to harness the purchase power of the public sector (20% of all IT spending) in order to shape the European cloud market, enhance the chances for European cloud providers to grow & on competitive scale, and to deliver cheaper and improved e-Government models

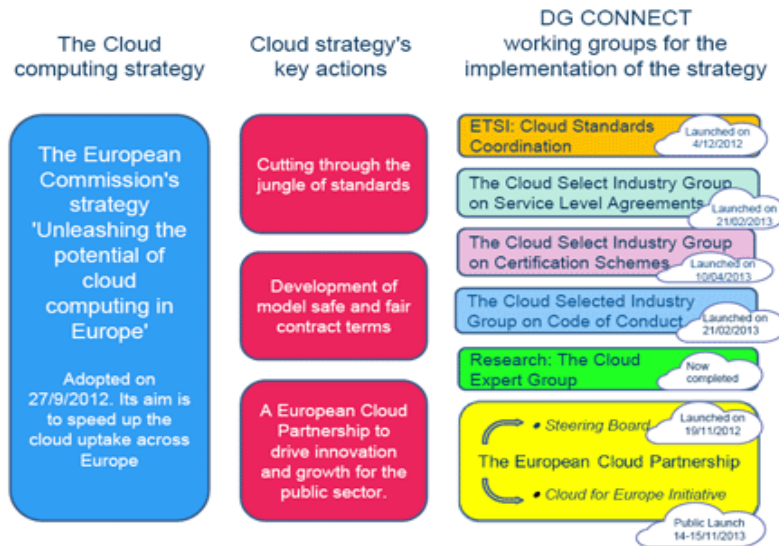


Figure 2: European Cloud Computing Strategy – Key actions and implementation

Some Helix Nebula partners, including Atos, CSA, CloudSigma, SAP and T-Systems, as well as EGI, have been involved in the working groups for the implementation of the strategy set up by the Directorate General for Communications Networks, Content & Technology (DG CONNECT) [17]. Participation in these activities supported the alignment of the Helix Nebula project with cloud policy development in Europe.

Among partners, differences in respective company vision, culture and strategy persist. However, this has not had a significant impact on the joint decision to make the transition to production, within an open marketplace.

Instead, this proves how critical it is to find common grounds and of a level playing field with publicly funded e-Infrastructures. The project focused on a suitable model for the integration of publicly funded e-Infrastructures and commercial suppliers in the Helix Nebula cloud platform: as is reflected in the following recommendation reported in D6.1.

Recommendation 1: Ensure a level playing field for the various players in the service delivery field and eradicate any potential fear of unfair internal competition among the publicly funded and commercial actors.

In the second year of the project, different options were discussed for appropriate policies/business models ensuring a level playing field for all players when accessing resources through the Helix Nebula broker. EGI.eu, SAP and T-Systems respectively leaders of WP6, WP7 and WP8, plus DANTE, took part in this action.

Following the 3rd Helix Nebula General Assembly in September 2013, the partners opted for the business model ‘Generic Cloud Computing for European Science’ described in D7.2 [18], which assigned the following roles: IaaS Broker and service integrators, IaaS providers, and consultancy and support providers. More details on the status of collaboration and integration with different e-Infrastructures are described in Section 3 of this document. The same document also analysed the level playing field aspect and proposed possible solutions (see Section 4.5.3 of D7.2). The current vision is that EGI can offer its resources to the Helix Nebula marketplace: 1) charge-free at point of delivery to existing user communities that receive a grant (resource owners); 2) as a paid service to any other research community with a pricing model covering the full cost of service provision. The specific commercial agreements with the marketplace operator (CGI) need to be defined and will be the focus of the 4th Helix Nebula Interoperability Workshop to be co-located with the EGI Community Forum in May 2014 [19].

Recommendation 2: Both publicly funded and commercial cloud providers should agree on a core set of open standards endorsed by the user communities and liaise with ETSI to ensure that their view on standards selection and road-mapping is considered.

In December 2013, ETSI released the “Final Report of the Cloud Standards Coordination working group” [6]. The Helix Nebula partners participated in meetings of the group and welcomed the guidelines of the report referring to the roles played by the different parties for the use cases identified in phases of acquisition, operation and termination of cloud services. The content of the ETSI report is being taken into account in the definition of the policies and processes within the Helix Nebula Marketplace in its first deployment phase. Helix Nebula adopted an adapter-based approach to technical interoperability, through which programmatic calls are translated from a single user interface to each provider’s interface. These translations are performed by a broker (the Blue Box).

Recommendation 3: Establish contacts between commercial cloud providers and publicly funded infrastructures to ensure that security requirements are agreed and aligned with ENISA recommendations

The ENISA report on ‘Certification in the EU Cloud Strategy’ [7] builds on the results of the Certification group and proposes two solutions to move forward. The first is a list of certification schemes to allow users to identify what best fits their needs. This list was announced in late February 2014 [27] and published in a dedicated section of the ENISA website [28]. The second solution proposed is for ENISA to develop a meta-framework to compare schemes and thus better deal with requirements from government administrations for example.

Exchange of views and practices on Security Policies within the Helix Nebula consortium and with the EGI Federated Cloud were addressed in a preparatory call. Starting in summer 2013, contact has been established between leaders of security activities within the EGI Federated Cloud and the Helix Nebula consortium. Exchange of information has been facilitated through EGI.eu staff involved in Helix Nebula and the EGI Security Policy Group was asked to review the identified security requirements. Most of the security requirements developed by Helix Nebula refer to the broker, therefore not directly impacting the providers. No specific activities in developing and aligning security policies across service providers were planned during the lifetime of the project. This is a key area of development for the future.

In December 2013, ENISA published a report on “Incident Reporting for Cloud Computing” [8]. This report analyses how cloud providers, customers in critical sectors, and government authorities can set up cloud security incident reporting schemes. ENISA’s report looks at how incident reporting about cloud security incidents could be implemented in an effective and efficient way as a first step - but not as a guide - towards studying how to implement incident reporting in cloud-deployed services.

Public and commercial providers involved in Helix Nebula are keen to take into account ENISA’s suggestions; however their implementation will need to take into account the complexity of service management in a federated and hybrid cloud environment.

2.2 Legal Interoperability

The Helix Nebula consortium has always shown awareness of the high complexity of the legal scenario for provision of cloud services in a hybrid scenario. Hence, legal departments within the partner organizations have been regularly consulted on different legal aspects during the entire duration of the project and of the overall initiative.

Applicable competition law has been a major concern for all players within Helix Nebula, especially as many of them are major IT players in Europe. Accordingly, Helix Nebula has adopted Antitrust Guidelines for itself, its members and all attendees, customers and other participants, as a guideline for participation in the Helix Nebula activities, which are subject to strict compliance with “Helix Nebula’s Antitrust Guidelines” [9].

In the paper “Ensuring Competition in the Clouds: The Role of Competition Law?” [10] it is stressed that “inappropriate, pre-emptive interference in the functioning of the market for cloud services runs the risk of undermining current growth, but equally, the non-applicability of competition law until dominance is attained could prejudice the goals of competition law in the cloud computing sector where, as in the ICT sector as a whole,

network effects are likely to be strong. A competition authority might start having legal grounds to intervene, when competition has already been distorted and subsequent network effects make effective competition difficult to restore. The definition of the market will therefore be critical, and other methods such as public procurement may become more significant. The plans to require data portability for data protection law purposes should also assist in this context, although they only apply to ‘personal data’ as defined”.

With reference to the monitoring of legal matters and subsequent interoperability related aspects, contact has also been established by Helix Nebula with the Queen Mary Cloud Legal project [20], currently working on advanced comparative analysis of legislation applicable to cloud computing within the 28 EU countries and at the international level. The Queen Mary Cloud Legal project is providing a useful comprehensive view specifically targeting players operating in cloud computing services. However, legal aspects of interoperability in a federated environment and overall cloud governance challenges are considered by legal experts and scholars to be frontier and pioneering topics [11].

So far, self-regulatory models have been the main way to facilitate interoperability and data portability in cloud computing.

Recommendation 4: Publicly funded and commercial cloud providers should agree on a set of important elements that customers should consider when agreeing on cloud contracts, both for terms and conditions and for SLAs.

Atos is actively participating in the European Cloud Partnership activities seeking to establish and document a European Trusted Cloud, as well as participating in ongoing Cloud Select Industry Group (SIG) meetings, including the SLA group, currently analysing submissions and relevant contributions from group members. Atos is keeping the Helix Nebula suppliers updated on progress on this aspect. Furthermore, commercial suppliers are also investigating possible SLA schemes applicable within the heterogeneous offering under development for the Helix Nebula Marketplace. A Master Services Agreement has been drafted and is being finalised among the partners of the Helix Nebula Marketplace, thus providing a consistent framework for customers to procure services within a federated marketplace.

Recommendation 5: Ensure that both publicly funded and commercial cloud providers comply with the EC data protection regulation, once it gets approved

The European Commission proposed a new data protection reform in January 2012 to overhaul the current and largely outdated 1995 EU Data Protection Directive (95/46/EC).

Following the revelations on mass surveillance programs involving some of the large Internet players, the second half of 2013 and beginning of 2014 has been marked by intense discussion in the European Parliament around this legislative package.

The European Parliament voted in favour of an amended version in October 2013 and the text was scrutinised by the Council of the European Union. However, many crucial issues, such as the form of the new legislation (regulation or directive) and key principles including the much debated “one-stop-shop” and territorial competence required solving. The European Parliament finally adopted the EU Data Protection Package in March 2014, including the position of the Council, and demonstrating the overall endorsement of the Commission's data protection reform. Helix Nebula welcomes the approval of the Data Protection Package and the partners are committed to respect the new legal provisions in the delivery of cloud services.

A Cloud Select Industry working group including members of the Helix Nebula consortium was established by the European Commission at the end of 2012 to work on a Code of Conduct, [21]. The code of conduct prepared by the group was referred to in Art.29 - Working Party - for feedback on the privacy aspects and is expected later in 2014.

Recommendation 6: Publicly funded and commercial cloud providers should develop a common understanding of the impact of extra-EU legislation on the provision of their services to consumers inside and outside of their local legal jurisdiction.

The Helix Nebula's publicly funded and commercial suppliers have been following up debates and updated on studies in this area. Of particular relevance is the analysis carried out by the Dutch data protection authority on cloud computing services from American providers following a request of opinion submitted by SURF market [11]. Another specific study under the title “Cloud Computing in Higher Education and Research Institutions and the USA Patriot Act” [12] was carried out by the Institute for Information Law - University of Amsterdam, and was published in November 2012. However, the same institute is undertaking further study and analysis following recent revelations on US Governmental Access to Cloud data from abroad [14]. In the process of defining a coherent legislative framework for cloud computing, the EU also has to pay particular attention to provisions, including data transfer and treatment in future international trade agreements.

Recommendation 7: Publicly funded and commercial cloud providers should agree on a common policy that protects users' IPR on the provided software, information and data.

EGI has a policy stating that resource providers do not retain any intellectual property rights on the software, information and data provided to the services by its users. Commercial suppliers are considering this approach for the initial launch of the production platform through the Master Services Agreement.

2.3 Organizational Interoperability

In a federated environment including publicly funded as well as commercial resources, organizational interoperability is a delicate and challenging aspect with a heavy impact on the business models and the quality of the services provisioned.

Recommendation 8: Publicly funded and commercial cloud providers should agree on a minimal set of requirements for IT service management and a related maturity assessment framework that should be adopted by all members of Helix Nebula to evaluate the alignment of their service management practice.

Having common grounds in IT service management practices across a federation of independent providers is essential. Some commercial providers already comply or are certified ISO/EIC 20000 providers and manage their services according to ITIL best practices [16]. Nevertheless, these common grounds are missing. Implementing the full ISO standard or ITIL is neither viable, nor meaningful as many processes connected to IT service provision are confined to the boundary of a single service provider.

FitSM [23] has been identified as a suitable framework to implement IT service management in Helix Nebula. FitSM is a standard for lightweight service management in federated IT infrastructures based on ISO/EIC 20000 standard and defined by the EC-funded FedSM project [24]. The FitSM approach is meant to be pragmatic and to identify IT processes & their requirements and to define which framework can be used by resource centres participating in a federated service provision such as EGI.

The full compatibility of FitSM with these exiting standards, combined with an easy implementation tailored to the federated environment was the main reason the Helix Nebula suppliers adopted FitSM. A dedicated workshop was organized in January 2014 in Darmstadt, Germany to train and certify designated staff of the Helix Nebula consortium in “Foundation in Service Management for federated IT infrastructures according to FitSM-1:2013”. The workshop also served to discuss the implementation of specific policies and processes in the Helix Nebula production environment. One of the outcomes of the workshop was the identification of an initial set of 14 support processes that are being worked out by CGI for implementation into the Helix Nebula Marketplace. This activity was supported by the EC-funded FedSM project [24].

Recommendation 9: Publicly funded and commercial cloud providers should agree on the common set of services needed to participate in the federation.

Following the FitSM workshop in January, the commercial providers started discussions to achieve an agreement on a common set of service management structures for the launch of the production platform of the Helix Nebula Marketplace. CGI drafted a policy document based on the FitSM standards to address this aspect. Policies for all 14 service processes have been defined, with workflows to implement those with the highest priority.

Recommendation 10: Commercial cloud providers should be able to connect to GÉANT, on the basis of an agreed business model, to ensure that users can have the same level of connectivity available in publicly funded e-Infrastructures to transfer data.

GÉANT is the pan-European research and education network that interconnects Europe's National Research and Education Networks (NRENs) and is managed by DANTE, which joined the Helix Nebula consortium in October 2012.

This partnership opened up the opportunity to test resources on the GÉANT network during the pilot phase flagship deployments. This also raises two key questions: How will the future business model of GÉANT function?; and how will the commercial resource providers be incorporated into that business model?. Commercial cloud providers should be able to connect to GÉANT on the basis of an agreed business model, so as to ensure that users can transfer data through the same level of connectivity across publicly funded e-Infrastructures.

SAP developed Business Model Canvases which in cooperation with DANTE, which explain how commercial suppliers can maintain the connection to GÉANT beyond the pilot phase (see Figure 3 and 4). The most important key concept is that only customers in the public sector (B2A) such as research organizations can access the GÉANT network. Thus, corporate (B2B) or private consumers (B2C) cannot use the network. Moreover, customers will not be charged for network activities, but exclusively for services provided outside of the network by commercial resource providers. Yet, the use is exclusively for customers in B2A. This implies that the HN suppliers will have to maintain (at least) two networking links: one with GÉANT and another one with a commercial carrier, and manage access to both networks. Some of the advantages identified from having a single party managing access to the GÉANT network are thus diluted, because all HN Suppliers will have to manage their interface with GÉANT, as well as their own network facilities and services.

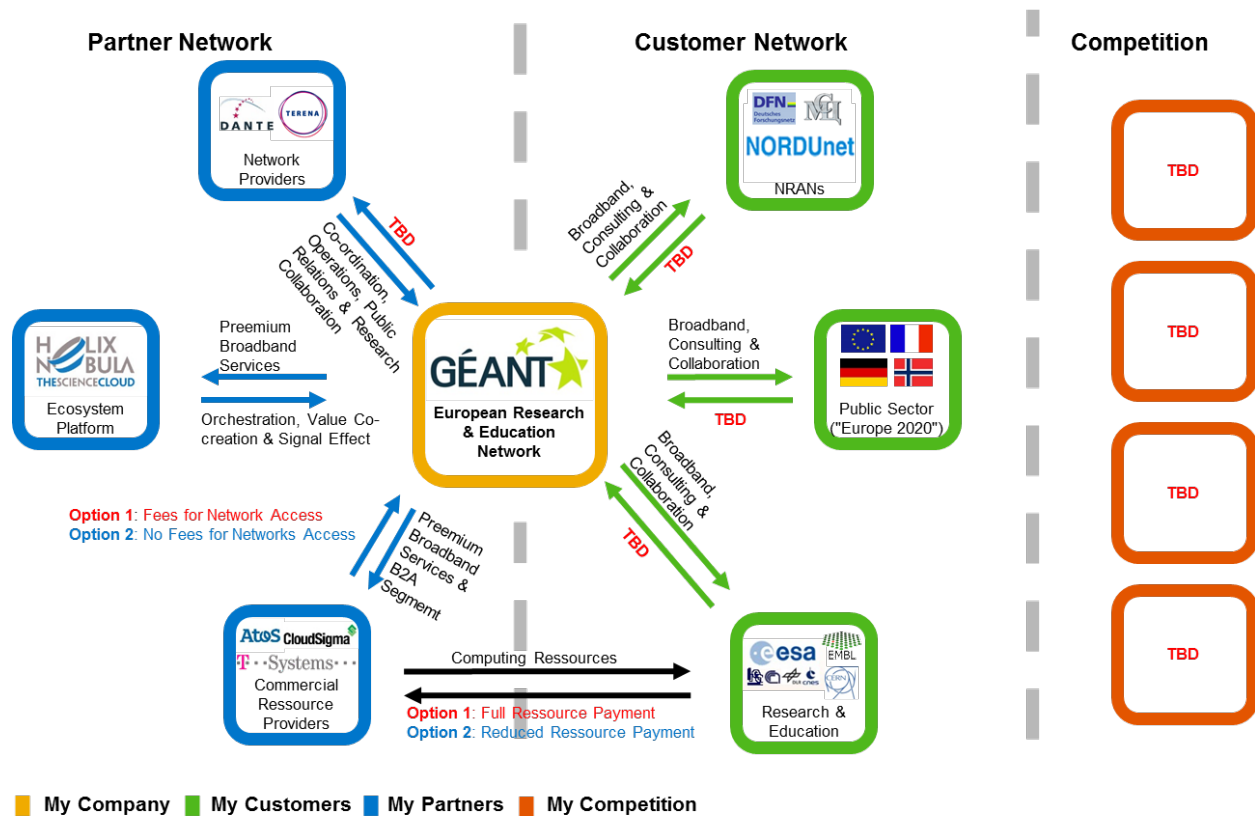


Figure 3 The GÉANT Business Model in Helix Nebula (Network View)

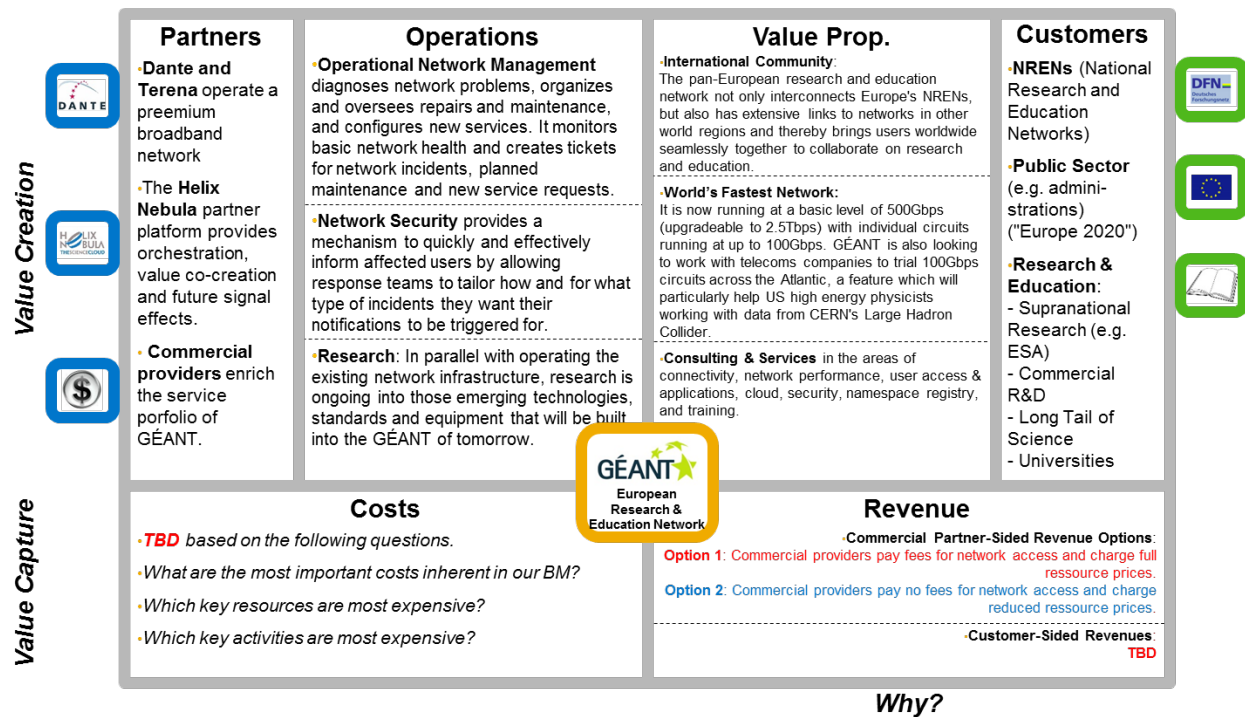


Figure 4 The GÉANT Business Model in Helix Nebula (Enterprise View)

The use of the Helix Nebula services by the science community the, entails the establishment of a hybrid scenario where resources from publicly funded e-Infrastructures such as GÉANT and those of commercial providers are combined. This vital aspect was also discussed at the EIROforum meeting with the European Commission in October 2013. The European Commission agreed that having GÉANT work with commercial cloud suppliers is part of their vision and strategy, which includes both GÉANT and EGI.

2.4 Semantic and Technical Interoperability

Recommendation 11: Both publicly funded and commercial cloud providers should agree on a compatible scheme to describe elements of a service catalogue to ease service selection across different providers.

The Helix Nebula ServArch team defined a common set of elements for the service catalogue that are being implemented in HNX [25].

Recommendation 12: The issues concerning accounting, billing, payment and settlement should be analysed to determine the possibilities and restrictions for both publicly funded and commercial cloud providers to agree on compatible accounting and billing parameters across settlements between providers and single integrated billing towards the customer.

In virtual and face-to-face meetings throughout last year, the aspects of accounting, billing, payment and settlement were discussed by all suppliers involved. Centralization of accounting and invoicing, - although more straightforward for users - was considered as non-achievable in the immediate future, given the level of complexity and heterogeneity among the suppliers.

In the foreseen scenario for the initial service deployment, each customer establishes a bi-lateral agreement with each provider, and entrusts the authentication credential with the broker. Yet, the origin and the location of the services delivered has to be clarified, and the transaction justified so that tax authorities can clearly see how services are being invoiced, and thus stave off assumptions of skimming.

Concerning interoperability for such aspects, EGI has to carefully consider issues linked to liability, service levels, legal issues and financial management in order to play a part in this marketplace. Resource providers affiliated to EGI and aiming to participate into the Helix Nebula Marketplace will likely define a bi-lateral commercial agreement with the marketplace operator. From the perspective of GÉANT, the relationship is bilateral and achieved via the organisation connecting to the network.

Financial aspects are thus directly connected to the organisation, which can control monetary transactions and the resource consumption in a one-to-one relationship. Moreover, if the organisation can gather several providers into a single marketplace, interaction between the customers and the user communities will be considerably simplified and will allow them to obtain the cloud services they want.

Recommendation 13: Users should be provided with a Single Sign-On (SSO) mechanism that enables them to authenticate on and have full control of the cloud services available in the federation. Re-use of existing sources of authentication should be considered

Scientific user communities are now familiar with mechanisms offering added value functionality, like SSO/authentication in federated environments such as those provided by EGI and GÉANT. The Helix Nebula Marketplace plans to offer Federated Identity management and SSO access in the third release foreseen later in 2014. Discussion is also on-going between EGI.eu, DANTE and the NRENs to harmonize AAI functionalities for publicly funded e-Infrastructures. Outcomes on this activity will hence span beyond the end of the Helix Nebula EC funded project.

Recommendation 14: Users should be able to port virtual machine images across different providers without complex translators.

Analysis of the results of the flagship deployments is ongoing. Based on this evaluation, a plan to bridge pending gaps and to improve the management of virtual machine images will be produced. However the results of this activity will only be known after the end date of the Helix Nebula EU funded project.

Recommendation 15: Users should be able to manage their virtual machines using a uniform interface across the different cloud providers (both publicly funded and commercial). Interfaces should be based on open standards and should not limit the available service functionality. Additional de-facto standard interfaces may be exposed to lower entry barriers and simplify the transition to open standards.

Work on the development of uniform interfaces is ongoing and a timeline for release in the Helix Nebula marketplace is under preparation. The current Blue Box provides a uniform interface to each cloud provider. The Amazon EC2 interface is also supported as a de-facto standard, via a dedicated bridge.

Recommendation 16: Users should be able to create, retrieve, update and delete data elements using a uniform interface across the different cloud providers (both publicly

funded and commercial). Interfaces should be based on open standards and should not limit the available service functionality. Additional de-facto standard interfaces may be exposed to lower entry barriers and simplify the transition to open standards.

This functionality is being investigated for development and implementation in a mature version of the Helix Nebula Marketplace.

Recommendation 17: EGI, commercial providers and DANTE should investigate how Software Defined Networking (SDN) can benefit a federated cloud computing infrastructure

DANTE has closely collaborated with the Helix Nebula commercial providers and with EGI on SDN aspects. Dialogue between GEANT and the Helix Nebula suppliers on how SDN can support clouds started during the HN GA in Heidelberg in September 2013 and a demo is being prepared for the TNC2014 conference on 19 - 22 May 2014 in Dublin, Ireland.

3 Business case for the hybrid cloud model and integration scenarios of e-Infrastructures

Detailed information on current business models and integration scenarios in Helix Nebula is illustrated in “Information as a Service – Towards Value Co-Creation in a European Cloud Computing Platform Ecosystem” Deliverable 7.4 [26].

3.1 Integration with EGI

Within D6.1, integration scenarios between EGI and Helix Nebula were defined. As an initial step, the “Integration with an External Broker” was selected. The implementation needed the development of an OCCI connector software component for the SlipStream-based Blue Box. Such a software component has been funded by the EGI-InSPIRE project and is currently in final stage of testing. Using an initial version developed internally by EGI.eu, it was possible to demonstrate the deployment of the ESA flagship application into the EGI Federated Cloud (Sep 2013). The full-featured OCCI connector will be able to support the deployment of all flagships on top of a hybrid scenario where both providers from the EGI Federated Cloud and commercial suppliers are involved. The test is expected to be completed in May 2014 with CERN evaluating the hybrid deployment model.

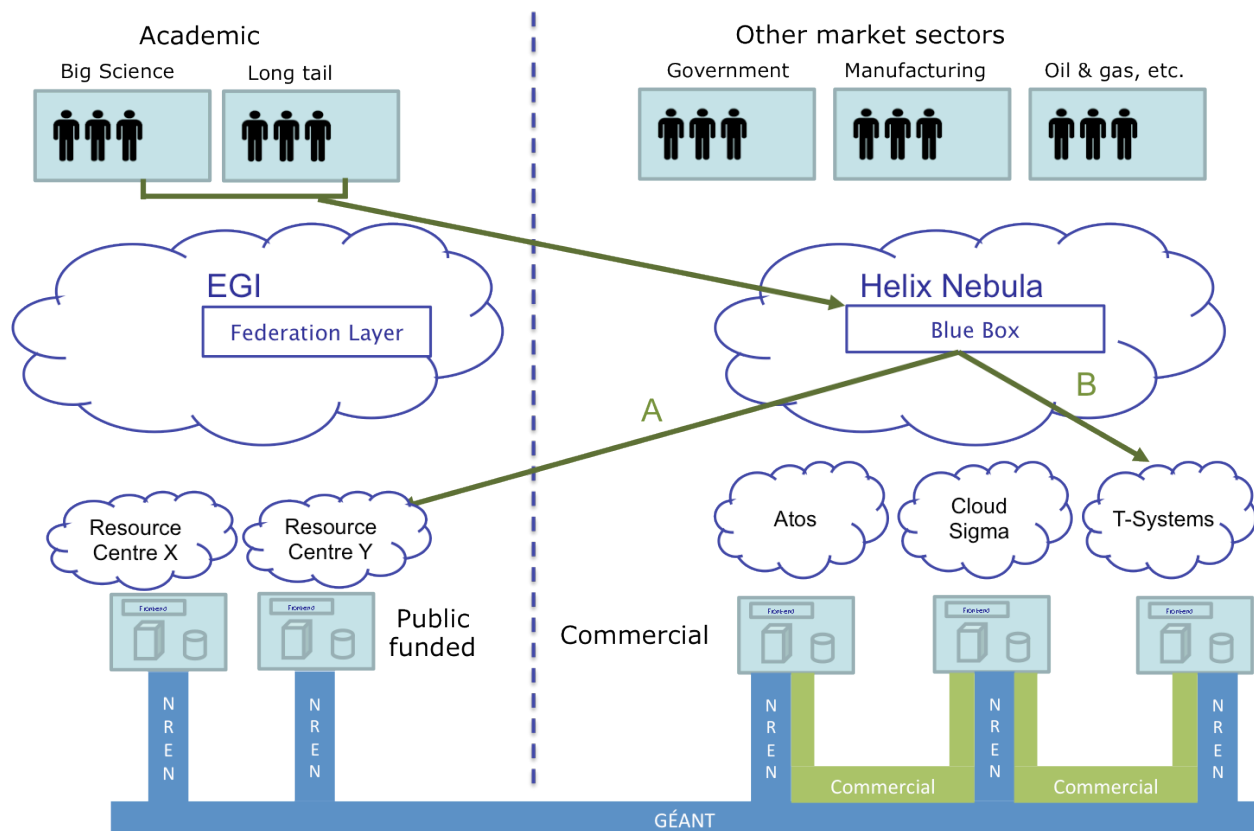


Figure 5 Integration Scenario #2: Integration of an External Broker

The technical integration of the EGI Federated Cloud is expected to be completed and demonstrated by the end of the project. From the organizational viewpoint, two main business models have been identified:

1. Private integration of owned resources for free access: the EGI providers would be enabled and visible from the marketplace only to those user communities who have received a grant for the use of EGI resources free of charge and whom have made an explicit request to HNX to reach commercial providers; EGI.eu in collaboration with the EGI providers need to define an agreement with the Helix Nebula Marketplace operator on the business model for access to EGI resources (e.g., free for the volume of activities on the EGI sites if the revenue from the commercial providers exceed a certain threshold; fixed fee)
2. Public integration of resources for paid access: the EGI providers that aim to offer paid services through HNX will sign the commercial agreement with the marketplace operator and are allowed to list their resources on the service catalogue for all potential customers.

Discussion is ongoing as to whether resource providers within the EGI Federated Cloud are requested to sign the Helix Nebula Marketplace (HNX) Memorandum of Understanding. These aspects will be addressed at the 4th Helix Nebula Interoperability workshop [19].

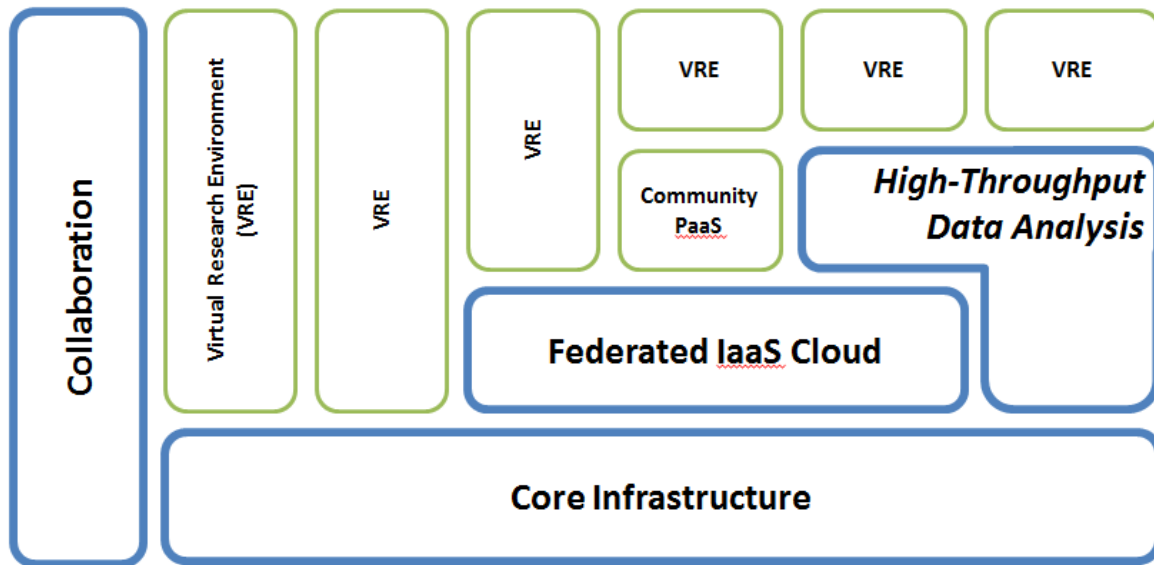


Figure 6 Software platform architecture of the EGI Federated Cloud

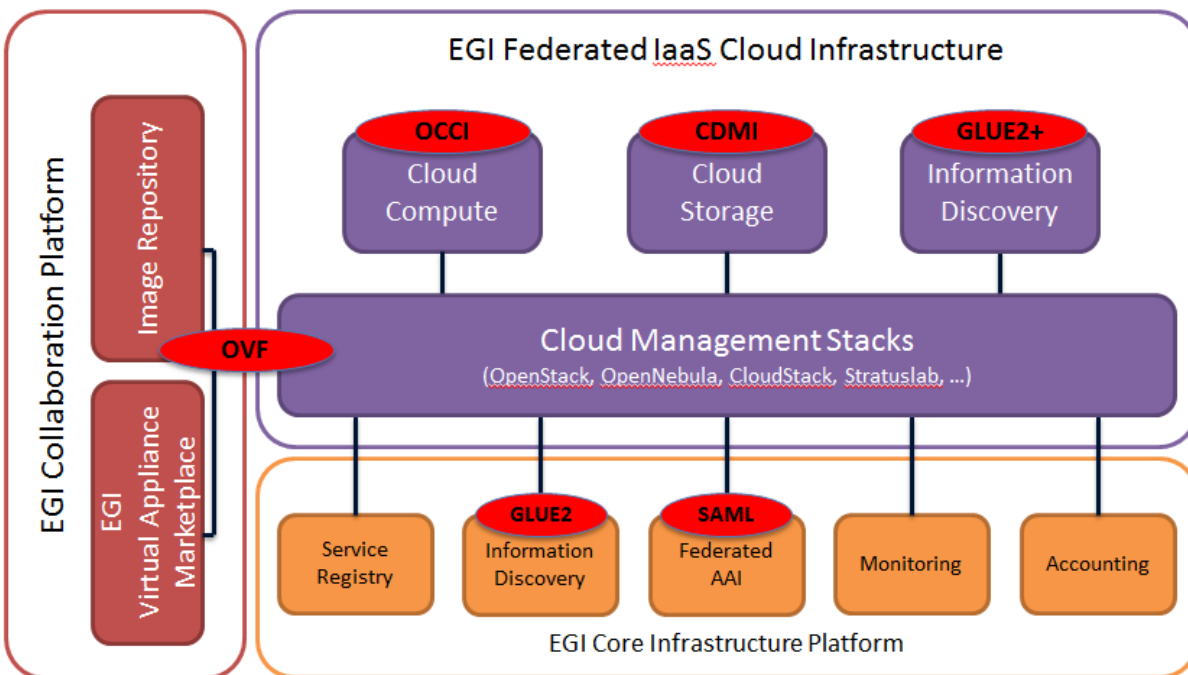


Figure 7 EGI Federated Cloud Infrastructure Platform

The open standards currently supported by the EGI Federated cloud are:

- ✓ **OCCI:** Open Cloud Computing Interface
 - RESTful API to manage virtual machine in the Cloud
 - From OGF
- ✓ **CDMI:** Cloud Data Management Interface

- RESTFul API to create, retrieve, update and delete data elements from the Cloud
- From SNIA
- ✓ **OVF:** Open Virtualization Format
 - Standard format for packaging and distributing virtual machines
 - From DMTF
- ✓ **SAML:** Security Assertion Mark-up Language
 - Standard for conveying identity tokens and attributes
 - From OASIS
- ✓ **GLUE2:**
 - Standard to describe and publish information on structured distributed infrastructures
 - From OGF
- ✓ **UR:** Usage Records, v2
 - Standard to express, collect and aggregate usage accounting records
 - From OGF

3.2 Integration with GÉANT

The potential Integration of the GÉANT/NREN business model is under deep scrutiny by DANTE and the NRENs, in alignment with discussions with SAP and described above with reference to Recommendation 10. In a first phase, GÉANT will be available for pilot users in the Helix Nebula marketplace, while commercial high-speed internet will provide connectivity for production users.

In a second phase, following the pending resolution of some policy aspects by DANTE and the NRENs, in mid-2014, it is foreseen to implement advanced Internet options such as inter-cloud routing and to have GÉANT available in production use. Progress toward advanced access networking options (e.g. security automation) is planned for late 2014 in the third development phase of the Helix Nebula marketplace.

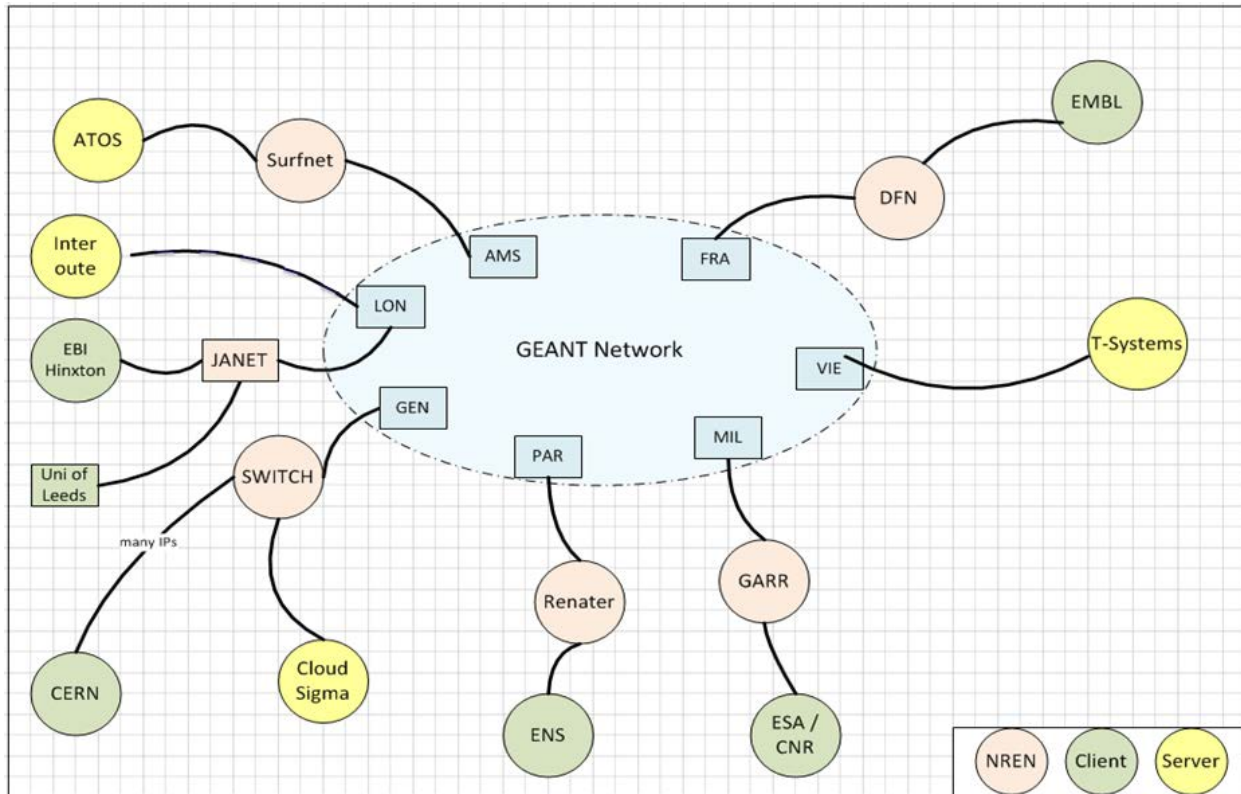


Figure 8 Active interconnections of commercial providers to GÉANT/NRENs (including examples of the demand side)

3.3 Collaboration with EUDAT

Representatives from the EUDAT project were invited to join the interoperability discussion, nevertheless they considered that it was too early to present requirements to the Helix Nebula consortium. It should also be highlighted that the first phase of Helix Nebula focused on infrastructure as a service layer, thus mainly virtual machine and object storage management. A closer engagement will be established after the launch of HNX 1.0, when the focus will move towards the upper layers; to supporting the "Information as a Service" business model.

3.4 Collaboration with PRACE

In March 2014, Helix Nebula and PRACE held a face-to-face meeting to investigate areas of collaboration. The management team of the Helix Nebula initiative and PRACE representatives exchanged views on governance and plans for Helix Nebula and on the functioning of peer review based systems for access to the PRACE supercomputer on the 6 Tier-0 HPC sites in Europe and to the wider national Tier-1 system.

As the Helix Nebula resources comprise the Atos Spain HPC site, with possible other HPC facilities joining the initiative in the future, training activities for the use of HPC machines

were identified as an area for joint initiatives. Current PRACE trainings are open to anyone in Europe and are not conditional to proposals acceptance in a PRACE peer review.

Data management was also addressed as a topic of interest for PRACE users. PRACE offers data storage, especially for analysis in Tier-1 machines, for a limited duration. After the end of the project, users will have to retrieve, manage and decide if to they want to publish their data.

Applicants that fail to obtain a resource allocation with PRACE or PRACE users that need data management services could benefit from the Helix Nebula offering integrated with PRACE.

Identity management and data staging may be the subject of common activities, in the context of an e-Infrastructures commons marketplace including major e-Infrastructures and commercial providers.

Finally, both PRACE and Helix Nebula are working on promoting access to HPC and cloud services to innovative SMEs in science and applied research. In this domain, PRACE recommended that Helix Nebula engages with the EU project Fortissimo, aiming at enabling European manufacturing industries to benefit from the efficiency and competitive advantages of simulation on HPC-based cloud infrastructure.

4 Requirements Implementation Status

The following table contains the status and brief progress report for each of the implementation actions related to the various recommendations.

Table 1 Recommendations Implementation Plan

#	Description	Action	P	S	Owner	Progress
1	Ensure a level playing field for the various players in the service delivery field and eradicate any potential fear of unfair internal competition among the publicly funded and commercial actors	1.1 Agree on appropriate policies/business models that ensure level playing field when accessing resources through the BlueBox	H	P	HN WP6	<p>EGI affiliated resource centres can offer their resources through the Helix Nebula marketplace: 1) free of charge to user communities that received a grant (resource owners) and aim to expand the resource usage to commercial providers; EGI resource providers do not appear in the marketplace and are enabled on case by case to eligible users; 2) pay as you go for EGI resource providers that can support this business model.</p> <p>Open actions:</p> <ul style="list-style-type: none"> - agree with CGI on the policy and possible pricing scheme for using HNX to access free resources - define the commercial agreement for EGI resource centres
2	Both publicly funded and commercial cloud providers should agree on a core set of open standards endorsed by the user communities and liaise with ETSI to ensure that their view on standards selection and road-mapping is considered	2.1 Agree on a minimum set of agreed formats to simplify interoperability	H	P	HN TechArch	<p>Helix Nebula adopted an adapter-based approach to technical interoperability where programmatic calls are translated from common user-facing interface to the providers.</p> <p>Common formats that have been defined or adopted are:</p> <ul style="list-style-type: none"> - connector architecture including OCCI - most connectors use common libcloud based capabilities

		2.2 Liaise with ETSI and promote the agreed formats	M	N	HN TechArch	The “Final Report of the Cloud Standards Coordination working group” identified a number of aspects related to interoperability. The Helix Nebula partners are following up on how to align on agreed formats.
3	Establish contacts between commercial cloud providers and publicly funded infrastructures to ensure that security requirements are agreed and aligned with ENISA recommendations	Exchange and agree security requirements	M	P	HN WP5	The Helix Nebula security requirements have been shared with EGI security experts. Review is awaited by the end of April 2014
4	Publicly funded and commercial cloud providers should agree on a set of important elements that customers should consider when agreeing on cloud contracts, both for terms and conditions and SLAs	4.1 Identify the important elements that customers should consider when evaluating cloud contracts and SLAs. Define KPIs to compare them	H	P	HN ServArch	A Master Services Agreement has been drafted among the HNX partners; this provides a common legal framework about the provision of cloud services and is to be used as the starting point for contracts between the customers and both the HNX marketplace and the IaaS providers, with possible addenda for specific customers or supplier variations.
5	Ensure that both publicly funded and commercial cloud providers comply with the EC data protection regulation, once it is approved	5.1 Engage and liaise with organisations performing a similar study	M	P	HN ServArch	Atos and others have participated in the Cloud Select Industry Group on the Code of Conduct organised by the EC, within the European Cloud Partnership. Outputs are expected and will be considered for adoption when available.
		5.2 Obtain a statement of adoption of the code of practice by each provider	H	N	HN ServArch	To address legal concerns that may arise in the context of competition law, the partners agreed and documented in March 2013 a code of conduct: the Helix Nebula Antitrust Guidelines. These are being referred to at every supply and management meeting. The code of conduct prepared by the Cloud Select Industry Group was sent to Art.29 Working Party for feedback that is expected later in 2014. It will be considered for adoption within the Helix Nebula marketplace (HNX).

6	Publicly funded and commercial cloud providers should develop a common understanding on the impact of extra-EU legislation on the provision of their services to consumers outside of their local legal jurisdiction	6.1 Engage with organisations performing similar study and liaise with them	L	N	HN ServArch	There has been much discussion on the relevance and impact of various American legislations (e.g. Patriot Act, FISA); which are considered not to apply due to the European basis of providers, but subject to consideration may the issue arise with reference to the establishment of data centres outside Europe or changes in partnerships. Further clarification is expected from legal services
7	Publicly funded and commercial cloud providers should agree on a common policy to protect users' IPR on the provided software, information and data	7.1 Update the code of practice with an IPR related statement	H	P	HN ServArch	EGI has an existing policy stating that resource providers do not retain any intellectual property rights on the software, information and data provided to the services by its users. The statement for the Helix Nebula Marketplace will be part of the Master Services Agreement (MSA).
8	Publicly funded and commercial cloud providers should agree on a minimal set of requirements for IT service management and a related maturity assessment framework that should be adopted by all members of Helix Nebula to evaluate the alignment of their service management practice	8.1 Agree on requirements and assessment framework	H	C	HN ServArch	Helix Nebula adopted the FitSM standard as a set of requirements; supporting its implementation and to assess material for service management in federated infrastructures. The same standard is also adopted by EGI. It has been incorporated at the basis of the federated inter-supplier service management within the new HNX environment.
9	Publicly funded and commercial cloud providers should agree on the common set of services needed to participate in the federation	9.1 Identify a set of core services to be offered by each cloud provider to participate in the federation	H	P	HN ServArch	Helix Nebula and its associated marketplace (HNX) have started with generic IaaS, which standardization is enhanced by the adoption of the SlipStream Blue Box as a uniform front end. CGI has defined a policy document based on the FitSM standard to address this aspect
		9.2 Define the technical specification	M	P	HN TechArch	A reference architecture was drafted but needs to be updated and completed
		9.3 Define SLA template	H	P	HN ServArch	Elements of the SLA are defined in the MSA

10	Commercial cloud providers should be able to connect to GÉANT, on the basis of an agreed business model, to ensure that users can have the same connectivity level available in publicly funded e-Infrastructures to transfer data	10.1 Discuss and identify a suitable business model to connect the Helix Nebula resource providers to GÉANT after the pilot phase	M	C	HN WP7	By using its Business Model Canvases, SAP provided a concept in cooperation with DANTE that explains how commercial suppliers can finally be connected to GÉANT after the pilot phase.
11	Both publicly funded and commercial cloud providers should agree on a compatible scheme to describe elements of a service catalogue that eases service selection across different providers	11.1 Define the service catalogue elements that should listed as compatible with the various resource centres	M	C	HN ServArch	A service catalogue scheme has been defined by TechArch and agreed among the HNX providers; and is being implemented in the marketplace
12	The issues concerning accounting, billing, payment and settlement should be analysed to determine the possibilities and restrictions for both publicly funded and commercial cloud providers to agree on compatible accounting and billing parameters, cross settlements between providers and single integrated billing towards the customer	12.1 Determine the optimum accounting and billing model to be applied depending on the business model	H	P	HN WP7	The service catalogue has been defined with an option for expressing prices for services. Each provider sets its services independently to avoid cartel issues.
13	Users should be provided with a Single Sign-On (SSO) mechanism that enables authentication and full control of the cloud services available in the federation. Re-use of existing sources of authentication should be considered	13.1 Compare the Single Sign-On (SSO) solutions in use by the suppliers and evaluate support from Blue Boxes	M	P	HN TechArch	The Helix Nebula Marketplace plans to offer a Federated Identity and SSO access in the third release foreseen for late summer 2014. Discussion is also on-going between EGI.eu, DANTE and NRENs to harmonize AAI functionalities for publicly funded e-Infrastructures. Outcomes on this activity will hence span beyond the end of the Helix Nebula EC funded project.

		13.2 Ask for a statement from Blue Box implementers about the possibility to integrate the missing SSOs	M	N	HN TechArch	This activity is planned within an evolution timeline for the HNX marketplace
		13.3 Offers seamless SSO functionality from the Blue Box	M	N	HN TechArch	This activity is planned within an evolution timeline for the HNX marketplace
14	Users should be able to port virtual machine images across different providers without complex translators	14.1 Analyse the results of the flagship deployment and document the gaps	H	P	HN TechArch	The current roadmap defined by TA and maintained by CGI is the result of a partial gap analysis
		14.2 Implement solutions to bridge the gaps	M	N	HN TechArch	This activity is foreseen to be completed after the end of the Helix Nebula- EU project
15	Users should be able to manage their virtual machines using a uniform interface across the different cloud providers (both publicly funded and commercial). Interfaces should be based on open standards and should not limit the available service functionality. Additional de-facto standard interfaces simplify the transition to open standards and may be exposed to lower entry barriers	15.1 Evaluate the functionalities exposed by the Blue Box implementations and identify unsupported features with regards to the resource providers interfaces	H	P	HN TechArch	The current blue box provides uniform interfacing to each cloud provider. EC2 is now available as a de-facto standard, via a dedicated bridge
		15.2 Extend the Blue Box interface to fill the gaps while using an open standard interface	H	N	HN TechArch	This activity is planned within an evolution timeline for the HNX marketplace

16	Users should be able to create, retrieve, update and delete data elements using a uniform interface across the different cloud providers (both publicly funded and commercial). Interfaces should be based on open standards and should not limit the available service functionality. Additional de-facto standard interfaces may be exposed to lower entry barriers and simplify the transition to open standards	16.1 Evaluate the functionalities exposed by the Blue Box implementations and identify unsupported features with regards to the resource providers interfaces	H	P	HN TechArch	(same as above) The current Blue Box provides uniform interfacing to each cloud provider. The EC2 bridge is now available as a de-facto standard, via a dedicated bridge
		16.2 Extend the Blue Box interface to fill the gaps while using an open standard interface	M	N	HN TechArch	This activity is planned within the evolution timeline for the HNX marketplace.
17	EGI, commercial providers and DANTE should investigate how SDN can benefit a federated cloud computing infrastructure	17.1 Create a dedicated task force with a clear mandate and duration	H	P	DANTE	This activity is partly achieved: Dialogue between GEANT and the HN consortium on how SDN can support clouds during the HN GA in Heidelberg in Sept. 2013. Follow up discussions to define a test/show case for TNC2014
		17.2 Execute the work plan	M	P	DANTE	This action is partially completed: a demo at TNC 2014 is on track.

P (Priority) = H (High); M (Medium); L (Low)

S (State) = P (Partially completed); C (Completed); N (No started)

5 Interoperability roadmap for Helix Nebula: Future Steps

As highlighted in section 2 of this document, advancement on interoperability actions show different levels of progress while HNX is moving towards production. The EGI Federated Cloud is also making the transition to production phase. GÉANT is developing use cases for the delivery of Cloud services to campus-based users within its Open Cloud eXchange (OCX). In order to progress towards operational interoperability, it is crucial to ensure channels and models to exchange information and collaborate on common issues remain active beyond the end of the current Helix Nebula EC project. The following steps are suggested in order to continue the work on interoperability:

- Monitor evolution of political context and assess opportunities to ensure a level playing field between commercial and publicly funded providers; these opportunities may come from the emerging pay-for-use schemes for e-Infrastructures services available to scientific communities, pre-commercial procurement (PCP) and Public Procurement for Innovation (PPI)
- Continue engaging the Helix Nebula initiative with organizations in charge of leading work on EU security, certification, standardization, data protection and management for the implementation of effective interoperable solutions
- Advancing the Helix Nebula platform through the adoption of a user-friendly common interface allowing the automated discovery of services in a transparent way & allowing comparison of contractual terms and conditions, SLAs, pricing, KPIs, QoS
- Continue close collaboration with publicly funded e-Infrastructures such as GEANT, EGI, EUDAT and PRACE to support excellent science in Europe and the achievement of an integrated European Research Area
- Planning a long-term vision for the Helix Nebula initiative taking into account opportunities to increase the level of interoperability offered by Horizon 2020
- Establish agreed and interoperable service management policies, process and procedures for cloud offering in a hybrid federated environment as well as the correct mechanism to assess their effectiveness and implement corrective measures, building on fruitful collaboration with FedSM for the adoption of the FitSM standard.

To create the conditions for a fruitful continuation of work around interoperability, it is suggested to:

- Ensure the exchange of information and set up of virtual task forces among representatives of commercial suppliers and publicly funded e-Infrastructures in areas such as security, support, incident management. Such activities should be foreseen in the individual roadmaps of HNX, EGI and GÉANT
- Identify the main e-Infrastructure events, involving a large and wide range of user communities during the next years, to discuss further alignment and the integration of respective development plans according to users' need
- Investigate deriving economies and synergies by sharing horizontal legal, economic, and policy expertise, common training and communication activities, if/when of common interests to members of the Helix Nebula consortium.

6 Conclusions

The Helix Nebula project supported the implementation of the objectives set in the “Strategic Plan for a Scientific Cloud Computing infrastructure for Europe” and the model of a Public Private Partnership. The Helix Nebula partners faced the challenge of developing an open cloud marketplace for Europe, which can fulfil the requirements of world leading research institutions in Europe, and integrate the high level expertise available across European e-Infrastructures.

In this context, work package 6 established a discussion framework around interoperability among commercial cloud providers and e-Infrastructures. Work package 6 thus delivered:

- Three interoperability workshops aimed to identify, discuss and agree recommendations and implementation actions;
- An extra interoperability workshop co-located with the EGI community forum scheduled for May 2014 to further develop the business integration of EGI within HNX;
- 17 high level recommendations and 30 implementation actions which progress has been monitored and documented;
- A collaboration with the FedSM project and exploitation of the FitSM standard through a dedicated training and implementation workshop;
- A collaboration with the EGI Federated Cloud for the integration of the affiliated publicly-funded cloud service providers through the development of a connector for SlipStream and a demonstration of flagship deployments;
- A plan for the deployment of the Helix Nebula flagships in the hybrid cloud scenario to be completed by the end of the project;
- A collaboration with DANTE for interconnecting commercial cloud providers to publicly funded infrastructures; research & education institutions via the publicly funded research and education network.

In this delicate phase of transition between the end of the EU support-action pilot phase , and the launch of a production environment, it is crucial contain knowledge, preserve the collaboration channels established and to ensure the sustainability of activities focused on interoperability; in light of emerging developments of more integrated services across different e-Infrastructures.

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