GENERALISED ARCHITECTURE FOR DYNAMIC INFRASTRUCTURE SERVICES

Large Scale Integrated Project
Co-funded by the European Commission within the Seventh Framework Programme
Grant Agreement no. 248657
Strategic objective: The Network of the Future (ICT-2009.1.1)

Start date of project: January 1st, 2010 (39 months duration)

Deliverable D7.5
Final Report

Version 1.0

Due date: **31 May 2013**
Submission date: **11 May 2013**
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Dissemination Level		
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Table of Contents

0 Project Beneficiaries

Partner no.	Participant organisation name	Participant short name	Country
1	INTEROUTE S.P.A. IRT Italy	IRT	Italy
2	MARTEL GMBH	MARTEL	Switzerland
3	ADVA AG OPTICAL NETWORKING	ADVA	Germany
4	SAP AG	SA	Germany
5	ALCATEL-LUCENT ITALIA S.P.A.	ALU I	Italy
6	TELEFONICA INVESTIGACION Y DESARROLLO SA	TID	Spain
7	TELEKOMUNIKACJA POLSKA S.A.	TP	Poland
8	INSTYTUT CHEMII BIOORGANICZNEJ PAN	PSNC	Poland
9	NEXTWORKS	NXW	Italy
10	INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE	INRIA	France
11	FUNDACIO PRIVADA i2CAT, INTERNET I INNOVACIO DIGITAL A CATALUNYA	i2CAT	Spain
12	UNIVERSITEIT VAN AMSTERDAM	UvA	The Netherlands
13**	UNIVERSITY OF ESSEX	UEssex	United Kingdom
14	RESEARCH AND EDUCATION LABORATORY IN INFORMATION TECHNOLOGIES	AIT	Greece
15	TECHNISCHE UNIVERSITAET BRAUNSCHWEIG	TUBS	Germany
16	INTERDISCIPLINARY INSTITUTE FOR BROADBAND TECHNOLOGY	IBBT	Belgium
17	INDIAN INSTITUTE OF TECHNOLOGY BOMBAY	IIT	India
18 *	Lyatiss	Lyatiss	France
19 *	ADVA Optical Networking Sp. z o.o	ADVA	Poland
20**	University of Bristol	UNIVBRIS	United Kingdom

* Added in Contract Amendment 1:

- Lyatiss from 1st July, 2010

- ADVA Optical Networking Sp. z o.o from 1st January, 2010

** Added in Contract Amendment 2:

- University of Bristol was added as a new partner as of 1st September 2012 taking over the project duties of University of Essex

1 Executive Summary

In line with its objectives, GEYSERS provided optical Infrastructure Providers and Network Operators with the tools to enhance and complement their traditional set of business models. The technological enablers for this were the latest advances in physical resource partitioning, logical infrastructure composition and network control plane architectures, which allow Network Operators (Service Providers) to operate highly specific, cost-efficient, dynamic, and application demand driven networks. The GEYSERS project further enhanced the position of Infrastructure Providers by providing a mechanism for the seamless integration and provisioning of network and IT resources. Such future photonic networks that can support an IT-services oriented Future Internet architecture will enable and foster the emergence of novel domains of distributed applications, which ultimately bring in a whole new and powerful market opportunity for Infrastructure Providers and Network Operators.

Today, best practices in optical network and IT infrastructure management are characterized by global services and delivery over generic infrastructures, driven by the ubiquitous presence of the Internet. As the scale of information processing is increasing, from Petabyes of Internet data to the projected Exabytes in networked storage at the end of this decade, Future Networks are required to provide new answers to support the Future of Internet and its new emerging applications[i,ii]. This is becoming even more important considering the current development and technical enhancement of photonic networks, dynamic control planes, multi core processing, cloud computing, data repositories, and energy efficiency, which are driving profound transformations of optical networks and users capabilities. These technological advances are driving the emergence of ever more demanding applications such as UHD IPTV, 3D games, virtual worlds, and photorealistic telepresence in media. These are high-performance and high-capacity network based applications with strict IT (e.g. computing and data repositories) resource requirements, which the current Best Effort Internet intrinsically cannot deliver.

As a result, today's telecom operators are facing an increasing need for providing users with dynamic high-capacity and high-performance optical network connectivity services tightly bundled with IT resources. To realize this kind of networked-IT infrastructure service, envisioned to facilitate Future Internet, a next generation network architecture must be deployed, before the current Internet reaches its limits. This new generation network architecture must seamlessly integrate optical network technologies and IT resources, and provide customized infrastructure provisioning services to facilitate the seamless integration of optical network segments and technologies. Such an infrastructure service should be supported by a revolutionized service provisioning framework [iii].

GEYSERS defined and implemented a novel photonic network architecture, capable of provisioning 'Optical Network + Any-IT[1]' resources to Network Operators for end-to-end service delivery. GEYSERS had a revolutionary vision coupled with an evolutionary approach that followed a network-centric and bottom-up strategy. This vision was based on partitioning the photonic network infrastructure to create specific logical infrastructures, composed by optical network and IT resources. This composition enables to overcome the limitations of networks and domain segmentation. Each logical infrastructure is controlled by an enhanced Network Control Plane capable of provisioning Optical Network Services bundled with IT resources on an on-demand basis. Furthermore, the logical composition of photonic networks

[1] In the context of the GEYSER project, IT services are referred to provisioning of IT resources and IT resources are referred to physical infrastructure of IT such as computing and data repositories.

enables the GMPLS/PCE control plane to dynamically scale infrastructure resources based on the needs of the Network Operator.

2 A summary description of project context and objectives

The main objective of GEYSERS was to define, develop and validate an end-to-end network architecture, based on extending standard ones, which is able to create a new planning, provisioning and (ultimately) business framework for network Infrastructure Provider and Network Operators (Service Providers).

In this framework, the network Infrastructure Provider will be able to compose and offer part of its infrastructures (possibly combined with IT infrastructures) as logical infrastructure to Network Operators. Network operators will operate the leased logical infrastructures with Control Plane (ASON/GMPLS and PCE) technologies and will offer coupled, optimized and dynamic Network+IT provisioning services (i.e. interconnections between end-user and IT resources).

This overall goal was achieved through the following technical objectives. The technical objectives (#1 and #2) are further broken down into their basic requirements, features and capabilities. This level of specification is intended to provide a clear and detailed view of the technical scope of GEYSERS` technical objectives

1. **Define and design a new Logical Infrastructure Composition Layer (LICL)** as a new powerful tool for Infrastructure Providers, capable of:
   - 1.1. Implementing a distributed optical network and IT resource information model. This model will provide a semantic framework for composition of the logical infrastructures and exchange of resources information between infrastructure operators.
   - 1.2. Partitioning the physical infrastructure by abstracting its optical network and IT resources, and offering them according to the Infrastructure as a Service (IaaS) paradigm.
   - 1.3. Dynamic and on-demand creation of multiple isolated logical infrastructures sharing the same physical substrate. This on-demand functionality will be based on the interface and SLA definitions at the control plane level.
   - 1.4. Composing resources from different Infrastructure Providers, in order to build a logical infrastructure, spanning multi-domain/provider resources, and overcome the network segmentation.
   - 1.5. Managing (planning and scheduling) both static and dynamic resource sharing between the Network Operator and physical Infrastructure Provider, or between Infrastructure Providers.
   - 1.6. Establishing a synchronization mechanism that will keep consistency between the physical layer resources and logical layer resources
   - 1.7. Providing energy-aware resource composition and partitioning capability.

2. **Define and design an enhanced Network Control Plane (NCP) architecture and protocol extensions**, as the major provisioning tool for Network Operators, with the following features and capabilities:

   2.1. Be a backward-compatible superset of the ASON/GMPLS and PCE architectures, thus leading to a GEYSERS "GMPLS+" and "PCE+"[2]. The approach followed in specifying the new NCP architecture and protocol extensions will be driven by a major requirement: interoperate with (or across) network segments (e.g. routing areas or administrative domains) controlled standard ASON/GMPLS and PCE Control Plane instances. **The GEYSERS NCP will "add" enhanced capabilities, still preserving the legacy and standard ones from ASON/GMPLS and PCE.**

   2.2. Support advanced provisioning (i.e. dynamic and/or scheduled) of end-to-end optical network (i.e. connections), for advanced Bandwidth on Demand (BoD) services at the user-network interface (thus extending the ASON/OIF UNI reference point). This will be developed based on the consortium core developers' experience on development of IT-aware GMPLS control plane in the PHOSPHORUS[3] EU FP6 Integrated Project.

   2.3. Offer new connection services paradigms, based on the seamless control of both optical network and IT resources, i.e. at:

   - the Routing Plane: coupled advertizement of network + IT resources and combined computation of network + IT resources in PCE modules
   - the Signalling Plane: seamless signalling and configuration of network + IT resources; this will involve a deeper interfacing between the Network Control Plane and the end-user application domain

   2.4. *(As a consequence of the two above features)* Offer an evolved User-to-Network Interface (UNI) with low-level granularity (e.g. single application or application session), supporting Service Level Agreement (SLA) negotiation for enforcement mechanisms and advanced synchronization mechanisms (e.g. transparent routing and monitoring).

   2.5. Be able to "re-think" and change the underlying controlled infrastructure. Since this infrastructure is a logical one, and offered dynamically by the LICL, the Network Operator (Service Providers) will be able to lease/drop pieces of infrastructure, as needed by its technical operations or business requirements. GMPLS+/PCE+ will be the tool to implement these dynamics.

   2.6. Closely interoperate with the Network Management plane in the connection service provisioning chain, beyond today's schemes (e.g. SPC Calls/LSPs commanded by the NMS). The objective is to allow dynamic connection provisioning (e.g. triggered by the end-users through the OIF UNI), exploiting the capabilities of ASON/GMPLS for service routing and signalling, but still relying on the NMS as the major decision point for transport services deployment.

   2.7. Promote energy-awareness, for an energy-efficient routing and provisioning of transport network connection services. GMPLS+/PCE+ will take into account energy consumption parameters of network nodes and both TE and Data links (i.e. an extended Traffic Engineering description of GMPLS resources).

3. **Provide a cost-effective, proof-of-concept implementation** of the LICL and NCP architectures, by developing a set of prototypes of the main architectural modules, selecting the most significant features. **GEYSERS will be able to produce a real implementation and validation of the proposed architectures within its timeframe, since a number of existing software/hardware platforms are available to its consortium, along with the ability and expertize to work on them** (thanks to the fact that the core developers of them belong to the consortium). Examples are: the ASON/GMPLS full stack developed in the framework of the PHOSPHORUS FP6 IP (NXW, PSNC,

[2] From now on shortly referred to as "GMPLS+/PCE+", as an alias for the GEYSERS NCP.
[3] http://www.ist-phosphorus.eu/

UEssex), the ADVA Optical GMPLS stack, the GMPLS UNI-C developed by TID in the framework of the MUPBED FP6 IP.

4. **Deploy a distributed and multi-site validation testbed**, based on the experimental network facilities from the PHOSPHORUS EU FP6 Integrated Project and CARRIOCAS[4] French National project, in order to integrate, experiment and validate the GEYSERS concept and prototype developments.

5. Liaise and cooperate with major standardization bodies (ITU, IETF, OGF) and consortia to ensure that GEYSERS solutions comply with emerging standards, and provide input based on GEYSERS developments. This should assist a technology innovation and exploitation cycle within GEYSERS and beyond.

6. Ultimately, **strengthen the market position of the European industry and telecom sector** in the development of the Network of the Future and its associated services, by providing a novel architecture capable to extend Network Operator (Service Providers) and Infrastructure Provider services under a new business model and market approach.

2.1 GEYSERS Architectural layering reference model

This section introduces the GEYSERS high level architecture, based on the indications and requirements coming from the various telecom operators, network equipment vendors, and application vendors in the consortium. The GEYSERS novel layering structure is shown in Figure 1. It comprises (top-down view):

1- Application requirements Layer (Service Middleware Layer)

2- IT aware Network Control Plane Layer (NCP+)

3- Logical Infrastructure Composition Layer (LICL)

4- Physical optical network + IT resource infrastructure layer

[4] http://www.carriocas.org

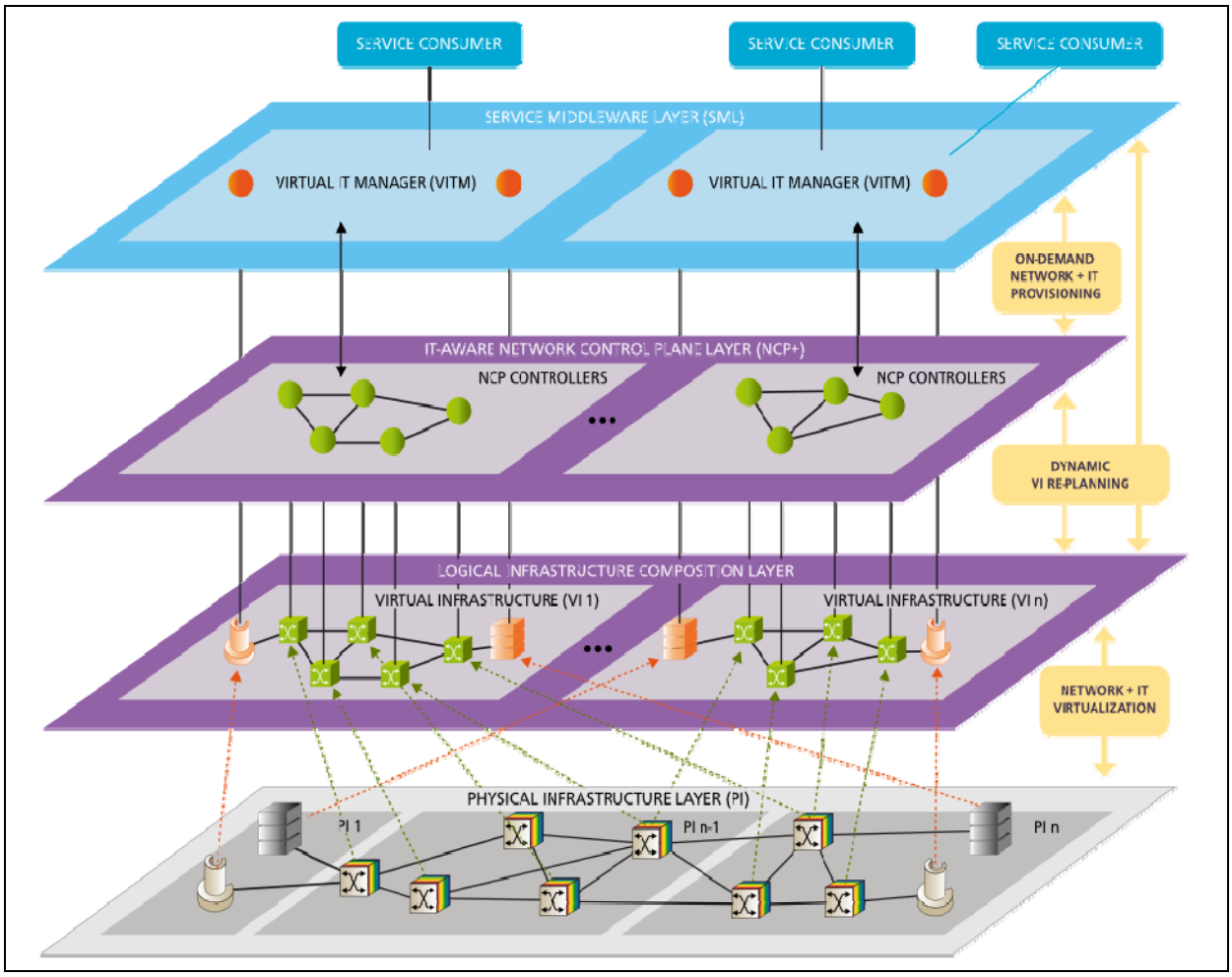

Figure 1: GEYSERS architectural layering

The novelty in the GEYSERS architecture lies in the following two layers: the Logical Infrastructure Composition Layer (LICL) and the Network Control Plane (NCP+) layer. Under this architecture, several independent logical infrastructures can co-exist; isolated, yet sharing the same physical layer.

Logical Infrastructure Composition Layer: This layer allows/supports the partitioning of the physical infrastructure, including both Optical Network and IT resources. It utilizes a semantic resource description and information modelling mechanisms for hiding the technological details of the physical layer from Network Operators. Logical resources are represented seamlessly using a standard set of attributes which allows the Control Plane to overcome the network and technology segmentation. Partitioning provides a 1:N logical representation of a physical resource from one or multiple domains. The logical infrastructure layer allows for dynamic and consistent monitoring of the physical layer and binding/associating the right security and access control policies. Furthermore, this layer constitutes the application of specific logical infrastructures by interconnecting the logical resources based on applications' requirements.

Network Control Plane: This layer is an extension of ASON/GMPLS and PCE, both in terms of architectural elements and protocol objects/procedures. The NCP layer is responsible for mapping applications requirements and control/management of the logical infrastructure composed by the LICL, seen and controlled just as a physical infrastructure. Each logical infrastructure can include both network and IT resources, and is controlled by a single instance of an NCP. The NCP is in charge of dynamic provisioning, monitoring and recovery functions. The main targeted features of the NCP layer are listed in the related objective in the previous section; these technical objectives will drive the specification of the NCP architecture and its prototype development.

As part of its architecture, GEYSERS defined the workflow that provides full interoperability and interaction between Infrastructure Providers and Network Operators (with its application service requirements) for planning, provisioning and accessing network and IT resources.

The GEYSERS architecture is also backward compatible and it is able to interact with its standard neighbouring domains at two levels:

1- Transit level: where the GEYSERS Network Control Plane can interact with control and management of neighbouring domains to request or provide resources (e.g. transient bandwidth).

2- Hybrid infrastructure level, where the GEYSERS Logical Infrastructure Composition Layer can interact with its neighbouring infrastructure domains to compose a logical infrastructure with the help of neighbouring infrastructures in offering their resources as a service.

2.2 GEYSERS testbed layout

The GEYSERS Pan-European testbed was based on the resulting infrastructure of the PHOSPHORUS FP6 IP project and the CARRIOCAS French National project. It was composed of existing local testbeds of UEssex (later moved to UNIVBRIS), i2CAT, UVA, INRIA, IBBT/iMinds and PSNC, interconnected through associated National Research and Education networks (PSNC, JANET, SURFnet, RedIRIS) and GÉANT3.

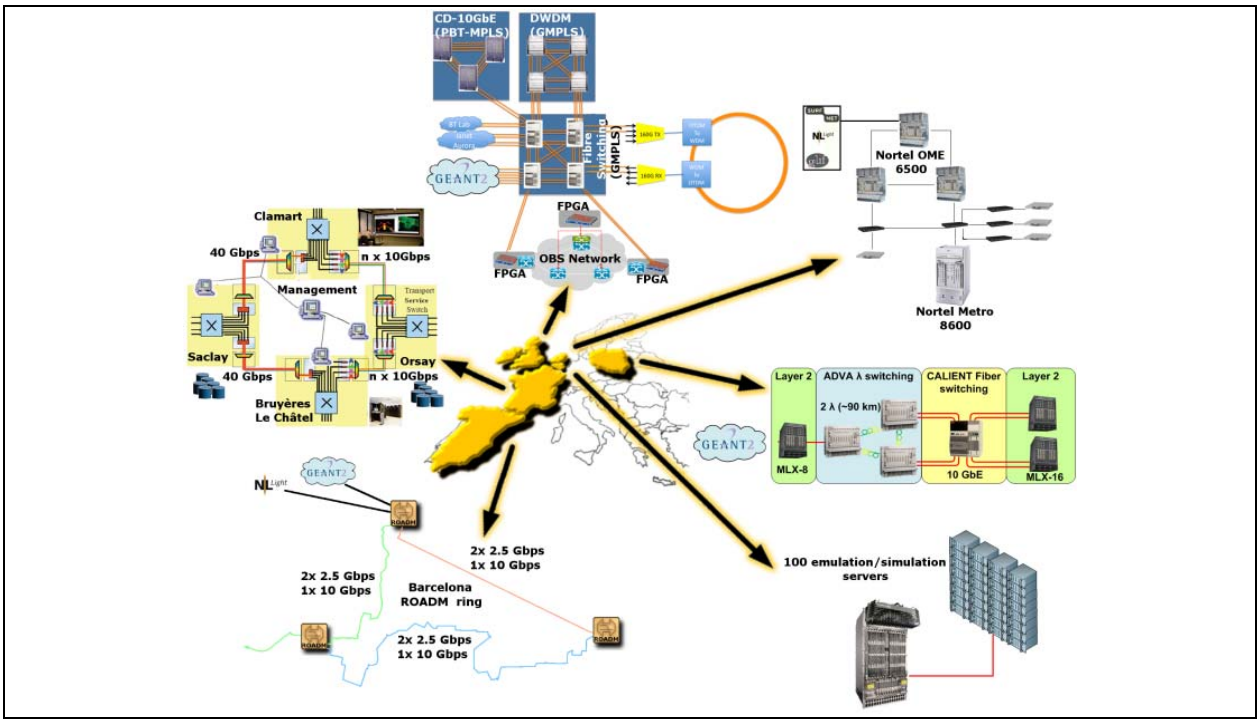

Figure 2: GEYSERS Pan-European testbed and its interconnection

These testbeds offered 1Gbps and 10Gbps layer 1 (optical) and layer 2 (Ethernet) switching, access to high performance IT facilities including computing clusters and data/contents repositories, as well as network- based IT applications including data replication and networked storage. The facilities in these testbeds were used for deployment, test and demonstration of the GEYSERS outcomes in a real, distributed network environment. Figure 2 shows the in-kind testbed and existing facilities contributed by partners.

3 A description of the main S&T results/ foregrounds

3.1 The expected final results and their potential impact and use

1. GEYSERS was expected to *accelerate the uptake of the next generation of network and service infrastructures.*

GEYSERS has achieved this by **introducing a new architecture that will re-qualify the interworking of legacy planes** by means of a logical infrastructure representation layer for network and IT resources. This enables a new business model where Infrastructure Providers' resources are partitioned into a logical composition of IT and network resources into the Logical Infrastructure Composition Layer (LICL). These are then offered on demand to Network Operators as a service in a fully integrated management system.

The LICL allows multiple Network Operators to operate different Logical Infrastructure instances on the same physical infrastructure substrate and, subsequently, enables different network services to support specific applications requirements

The GEYSERS approach differs from the classical approach to resource partitioning in network infrastructures through Network Management Systems (NMS), which configure static and inflexible binding rules between network resources (e.g. ports, fibres, equipment) and rigid usage profiles (i.e. UCLP, ARGIA).

GEYSERS also takes a different approach from the ITU-T based Next Generation Network architecture. Through the logical partitioning of functions into a Service Stratum and a Transport Stratum, NGN is capable of abstracting the connectivity services by creating abstract views of the network resources.

Going beyond the aforementioned approaches, the GEYSERS architecture provides users with advanced and flexible on-demand services while preserving the network provider's resource ownership. GEYSERS paves the way towards seamless and generic infrastructure services, enabling a new paradigm for shared ownership and operation.

Other research initiatives can be framed in the same context as GEYSERS for what concerns the resource abstraction or virtualization: namely the FEDERICA and 4WARD projects (both in FP7). GEYSERS leverages on FEDERICA's concept of "Network Factory" to provide "slices" of network resources and computing elements, but extends it in contents (i.e. not just network circuits and PCs but also equipment, ports, fibres and generic IT resources) and scope (i.e. not just research infrastructures, but also commercial networks and real business stakeholders). With respect to 4WARD, GEYSERS also extends the abstraction scope beyond the IP layer, which was the focus of that project.

2. GEYSERS was expected to *strengthen the positioning of European industry in the field of Future Internet technologies and reinforce European leadership in mobile and wireless broadband systems optical networks cognitive network management technologies.*

GEYSERS has achieved this through **innovations that are breakthroughs in the design and implementation of Future Networks**. They have attracted a global interest and have generated considerable feedback across interdisciplinary stakeholders. GEYSERS' evolved Network Control Plane enables European Network Operators to provide end-to-end

services by seamlessly controlling optical network and IT resources, with dynamic wavelength allocation functionalities and capabilities to (re)plan infrastructure resources on demand.

3. GEYSERS was expected to *increase the economic efficiency of access/transport infrastructures.*

GEYSERS has achieved this through an **optimized cost-efficient use of infrastructures**. These are considered to be key differentiating factors in the business.

The GEYSERS concept allows a new business model to be applied to the telecom market: current carrier roles can be split into infrastructure owners/providers and Network Operators with no infrastructure. Therefore, current carriers can also make a profit, in addition to network provisioning service, by offering unused parts of their infrastructure to other Service Providers, and increase their revenues. See the table below:

	Present	**After GEYSERS**	
Concept	**Current Carriers**	**Infrastructure Providers**	**Network Operators**
Financial Impact	Return of investment is hard to achieve for infrastructure when selling services only	Users pay for both infrastructure + service	Capability to seamlessly provide end-to-end delivery network and IT services
User Satisfaction	Users locked in service contracts and have no control over the network	Users empowered to perform required changes on the network at will as if they owned all of it	On demand set-up of tailored specific infrastructures mapping the application requirements
Operation Expenses	NOC must perform all the changes with little time left to plan ahead or monitor	Users do the simple changes, NOC does the network planning	Dynamic Control Plane allows them to offer better services with lower OPEX

4. GEYSERS was expected to have an impact on *converged infrastructures in support of Future Networks.*

GEYSERS focused on ultra-high capacity optical networks based on dynamic wavelength allocation with end-to-end service delivery capability. The Logical Infrastructure Composition has **overcome network and domain segmentation limitations.** The Network Control Plane has been shown to support flexible management in a multi-infrastructure operator environment with end-to-end carrier grade performance.

5. GEYSERS was expected to bring *wider market opportunities from new classes of applications taking advantage of convergence.*

GEYSERS has provided the dedicated support of **highly-IT reliant distributed mission-critical enterprise applications,** by defining a Future Network architecture that enables Infrastructure Providers, Network Operators and application providers to contribute in a business model where **complex services with complex attributes** can be pooled.

6. GEYSERS was expected to have an impact on *global standards, interoperability and European IPRs reflecting federated and coherent roadmaps.*

GEYSERS has contributed to the following **global standards bodies:** OGF ISOD, NIST, TMF, OGF, IETF.

As a result of the activity developed in GEYSERS, TID has requested two patents:

- *System and Method for live content distribution optimization over a CDN*: the objective is to apply concepts of Cross-Stratum Optimization to merge network- and IT-related information (in this case, video servers load, for

example) and optimize the distribution of the live video contents over a CDN. This is needed, mainly, due to the unicast nature of these transmissions.

- *System and Method for Cloud computing services IT-related information management*: defines a method to i) gather information about free IT resources in the network and ii) offer such information to other entities. It includes also the definition of the system to implement such method.

3.2 Deliverable List

All deliverables with a dissemination level of "PU" are available from the project Website (www.fp7-geysers.eu).

Del. no.	Deliverable name	Lead participant	Nature	Dissemi-nation level
D1.1	Identification, Description and Evaluation of the Use Case Portfolio and potential Business Models	SAP	R	PU
D1.2	Identification, Analysis and Technical Specification of Requirements	SAP/ ALU-I	R	PU
D1.2 Update	Identification, Analysis and Technical Specification of Functional and Non-Functional Requirements	ALU-I	R	PU
D1.3	Technical Specification of Service and System Parameterization for Operation and Validation	SAP	R	PU
D1.4	Initial Set and Technical Specification of System Requirements	SAP/ ALU-I	R	PU
D1.5	Collected Use Cases	SAP/IRT	R	PU
D2.1	Initial GEYSERS Architecture & Interfaces Specification	UEssex/ TID	R	PU
D2.2	GEYSERS overall architecture & interfaces specification and service provisioning workflow	UEssex/ TID	R	PU
D2.2 Update	GEYSERS overall architecture & interfaces specification and service provisioning workflow	UEssex/ TID	R	PU
D2.3	GEYSERS architecture technology benchmarking	AIT	R	PU
D2.4	Initial report on GEYSERS architectural validation and verification	IBBT	R	PU
D2.5	Final report on GEYSERS architectural validation and verification	IBBT	R	PU
D2.6	Refined GEYSERS architecture, interface specification and service provisioning workflow	UEssex/ TID	R	PU
D2.7	Final GEYSERS Architecture and service provisioning workflow	TID/ UEssex	R	PU
D3.1	Functional Description of the Logical Infrastructure Composition Layer (LICL)	i2CAT	R	PU

D3.2	Preliminary LICL Software Release	UvA	R/P	PU
D3.3	LICL Sub-systems Release	PSNC	R/P	PU
D3.4	Final LICL Prototype	i2CAT	P	PU
D3.4v2	Final LICL Prototype Update	i2CAT	R/P	PU
D4.1	GMPLS+/PCE+ Control Plane architecture	NXW	R	PU
D4.2	NIPS user-network interface and procedures	SAP	R	PU
D4.3	GMPLS+/PCE+ NCP software architecture and high-level design	NXW	R	PU
D4.4	GMPLS+/PCE+ NCP prototypes software releases	NXW	P	CO
D4.5	GMPLS+/PCE+ NCP prototypes	PSNC	P	CO
D4.6	Consolidated GMPLS+/PCE+ NCP prototypes	NXW	P	CO
D4.7	Final NCP+ integrated prototypes	NXW	P	CO
D5.1	Testbed implementation	TID	R	PU
D5.1.1	Testbed implementation update	PSNC	R	PU
D5.2	Report on integration and validation	PSNC	R	PU
D5.2 *	Report on integration and validation	PSNC	R	PU
D6.1	Web site	INRIA	O	PU
D6.2	Exploitation Plan	NXW	R	RE
D6.3	Report on related research activities	Lyatiss	R	PU
D6.4	Report on standards: standards needed to support GEYSERS architecture + standards provided by GEYSERS	LYaTiss	R	PU
D6.5	Final impact analysis report	Lyatiss	R	PU
D6.5 Part II *	Final dissemination and impact analysis report	Lyatiss	R	PU
D7.1	Project Presentation	Martel	O	PU
D7.2	1st Periodic Report	Martel	R	CO
D7.3	2nd Periodic Report	Martel	R	CO
D7.4	3rd Periodic Report	Martel	R	CO
D7.5	Final Report	Martel	R	PU

* This deliverable is an update of the previous release, to report on work done in the extension period

3.3 Plan for the use and dissemination of foreground

Taking into account the well-balanced consortium (Infrastructure Providers, Network Operators, vendors, application owners/developers, universities, research centres and research-performing SME), the exploitation of results in GEYSERS will address diversified business and research sectors.

A structured plan for dissemination was implemented during the GEYSERS project in order to support an effective sharing of the results within the partners of the consortium, as well as across external research communities. The members of the consortium, actively participated in the most relevant research forums and used many different communication channels to disseminate activities and results to the technical/scientific community through international journals, conferences, workshops and to standardization bodies,

In order to coordinate all those activities, a specific Work Package (WP6 - Exploitation/Dissemination and Standardization) was established. The objective of WP6 was to cover all the necessary actions to transform the scientific and technical achievements of the project into effective impact.

A number of actions were initially identified; these were:

- Install and operate a WWW/wiki server for public information dissemination
- Produce PR material and activities, such as leaflets, contributions to conferences, papers, press releases, etc.
- Monitor/analyse potential industries for the application of GEYSERS results, to identify market opportunities
- Proactively ensure concertation and collaboration with companion European and related national projects

For software exploitation, some parts of the developed software prototypes will be either distributed under FOSS licences, or under proprietary license terms and conditions.

Throughout the project lifetime the consortium has focused on informing and convincing the industrial and research community on the business opportunities that exist in the area of Optical Networking combined with IT Infrastructure Service Support for Internet of Service market. The project has pursued its proposed vision and while carrying out the associated technical work it has disseminated technical knowledge and findings, experience and software to a broader public audience. In addition, the GEYSERS consortium has very actively participated in standardization activities. In particular workshops, special sessions and industrial panels at conferences and standardization bodies were organized, with the objective to create and inform a community of network and IaaS players and stakeholders about the GEYSERS vision, directions and results, and at the same time obtain more information on any related efforts and initiatives. This has seeded collaborations with external enterprises and researchers throughout the project, as discussed earlier, but has also provided the means to motivate individual and collective exploitation of the project's results.

Some evidence supporting the direction taken by the project is provided below:

- Network issues have been clearly raised and stated in Cloud space (Amazon, the leader of IaaS Cloud has launched the VPC service early in 2011, Network vendor announced and joined the Openstack Quantum initiative in 2011, VMWare made strong announcements around the network at VMworld 2011).
- Software-defined Networks movement has started with the ONF initiative (All Network vendors have now joined as well as emerging SDN startups, Open Network Summit gathered 200 attendants in October 2011 and 900 in April 2012).
- Major Telcoms are entering the Cloud space with networking services (AT&T, NTT, Deutsche Telecom, BT, Orange, Verizon, etc.).

Therefore, the international community (academic but also industrial) is now aware that network flexibility and bandwidth provisioning are real issues in the Cloud IaaS context and that there is a great opportunity for the networking community to participate in the network infrastructure on-demand offer.

A questionnaire was developed with the aim to gain feedback - mostly externally to the consortium - regarding the motivation and relevance of the GEYSERS architecture.

A study was also made of the literature, which supports the outcomes of GEYSERS and the potential impact on industrial technology and best practices. For example, some of the benefits of infrastructure as a Service identified by Bhardjwaj et al. [Bhardwaj2010] include:

- Cloud technology is paid incrementally, saving organizations money.
- Organizations can store more data than on private computer systems.
- No longer do IT personnel need to worry about keeping [infrastructure management] software up to date.
- Cloud computing offers much more flexibility than past computing methods.
- Employees can access information wherever they are, rather than having to remain at their desks.
- No longer having to worry about constant server updates and other computing issues, government organizations will be free to concentrate on innovation.
- Decoupling and separation of the business service from the infrastructure needed to run it (virtualization).
- Flexibility to choose multiple vendors that provide reliable and scalable business services, development environments, and infrastructure that can be leveraged out of the box and billed on a metered basis—with no long term contracts.
- Elastic nature of the infrastructure to rapidly allocate and de-allocate massively scalable resources to business services on an on demand basis.
- Cost allocation flexibility for customers wanting to move CapEx into OpEx.
- Reduced costs due to operational efficiencies, and more rapid deployment of new business services.

These points are fundamental to GEYSERS' architectural objectives but the need for convergence builds on this. In a recent IEEE Computer Magazine article - "Converged Infrastructure: Addressing the Efficiency Challenge" [Garber2012], Lee Garber presented some further arguments for convergence, which support and coincide with the objectives of GEYSERS. The important comments are summarized below:

- Because computing, storage and networking reside in separate silos in the typical datacenter architecture, companies are required to buy the infrastructure elements separately and spend considerable time and money integrating, optimizing and testing them. Scaling and flexibly using these systems can be difficult and costly. GEYSERS reduces these silos with its consolidated information model and management workflows that cross the different kinds of resources.
- Several companies are already selling converged infrastructure, suggesting that the industry is already aware of this market need. Converged-infrastructure systems can contain components all from the same vendor or from different companies. GEYSERS enables the inclusion of different vendors with the use of resource adapters.
- Customers with converged infrastructure can buy a system and start using it often within hours, given the reduced effort associated with switching context between silos during configuration. GEYSERS offers different layers of APIs for managing virtual infrastructure at different layers, but these different layers interact via defined workflows. Instead of separate management tools for computing, storage and networking, convergence reduces management complexity and the amount of support staff necessary.
- One challenge with current converged platforms is that they use a limited number of products and technologies selected by the vendors involved, such that they do not offer flexibility of choice and may not appeal to companies with specific product technology preferences - users are locked in. GEYSERS provides a generic information model and provisioning workflows that can be deployed on top of any vendors, given the adapters and interfaces are implemented.

The partners' exploitation plans are briefly presented below.

Partner	Exploitation Statements
IRT	INTEROUTE is interested in GEYSERS topic and outcomes, since they own and operate one of the biggest fibre NGN network in Europe, fully interconnected with main worldwide marketplaces including Europe, the Far East and the Middle East. GEYSERS concepts allow Interoute to deploy its own dynamic core based on the GEYSERS architecture and to provide dynamic services to end- users acting as a Service Provider. At the same time, Interoute will be able to deploy its NMS portfolio introducing outsourced solution for dynamic network, acting this time as an Infrastructure Provider. Financial and Broadcast markets are two likely examples of end-users in such a dynamic network.
TID	Telefónica is a leading telecom operator with a growth strategy, and which is currently searching for new incomes from added-value services within the Future Internet. In this sense, the project leverages on existing strategic activities. On one side, the use of GEYSERS technologies within a single network provider permits a new degree of service multiplexing within a single Network Operator, thus leading to CAPEX savings. In addition, the use of logical infrastructure-sharing can be exploited to support infrastructure- sharing strategies. Currently, Network Operators are steadily exploring the infrastructure's capital investment sharing (e.g. in emerging or non-strategic markets). The combined use of LILC and GMPLS can be used in this scenario, to assure a proper isolation of the different networks, while minimizing the total cost of ownership Finally, based on the results of GEYSERS, Telefónica units will benefit from the proposed developments as potential solutions for future business models. As an example, Cloud Computing is seen as a growing market, in which Telefónica can search for income sharing approaches with IT providers. In this sense, the expected result of the project is the validation of scenarios, in which an operator's transport network is used to offer added-value IT services. Telefonica applied for 2 patents from their work in GEYSERS: • *System and Method for live content distribution optimization over a CDN*: the objective is to apply concepts of Cross-Stratum Optimization to merge network- and IT-related information (in this case, video servers load, for example) and optimize the distribution of the live video contents over a CDN. This is needed, mainly, due to the unicast nature of these transmissions. • *System and Method for Cloud computing services IT-related information management*: defines a method to i) gather information about free IT resources in the network and ii) offer such information to other entities. It includes also the definition of the system to implement such method.
ADVA	GEYSERS` EU-wide multi-vendor testbed provides a unique opportunity to validate and enhance interoperability features of ADVA's equipment. This will enable ADVA to increase equipment sales and ADVA market share. Equipment using GEYSERS enhanced control plane will be able to get deployed in any industrial environment supporting standards-based network reference points with ease. This significantly enhances project exploitation possibilities.
SAP	SAP industry solutions support the unique business processes of more than 25 industry segments, including high-tech, retail, public sector and financial services. These Service Providers seek new solutions for making their operations leaner and more agile. Part of SAP's vision of supporting these goals is the development of application-level support for the Internet of Services (IoS). The IoS defines a strategy for enabling better interconnection and consumption of services rendered by a multiplicity of providers on top of the Future Internet. GEYSERS promotes the network becoming part of the Infrastructure as a Service (IaaS) initiative. The value of providing infrastructure as a service is that the infrastructure resources can be tailored to meet the needs of the customer and business applications, while the modifications to the infrastructure can be achieved without physical access (typically an expensive operation). Further automation can enable this process to become dynamic where additional resources can be provisioned to facilitate changes on-demand, as specified in a Service

	Level Agreement (SLA). Networking is a significant element of the IaaS initiatives. Provisioning of the network for specific customer and business application demands is particularly challenging in the inter-domain model.
ALU-I	Alcatel-Lucent Italy is hosting the headquarters of Alcatel`s Optics Business Unit. GEYSERS consisted of an excellent combination of competences to assess new network architectures, features, infrastructure sharing, network virtualization models and business modelling to be developed in optical products in order to cope with new telecom business paradigms that affect transport infrastructure with a special focus on large research networks. Alcatel-Lucent Italy mainly explored the project result implications on policy and dynamic management of the resources, bandwidth on demand and zero touch photonics on the overall optic product line (WDM and TSS), also taking into account the emerging models of operator domain split (e.g. Network Providers vs. Service Providers). Specific attention was paid to the IT focus & market in its objectives.
TP	TP is a leading telecom operator in Poland with the largest infrastructure among all other telecom operators. Its contribution to GEYSERS allowed it to take an active role in forming a vision of the future internet. TP R&D is a research and development branch of the TP, and therefore this department was the representative of TP for the project. TP is interested in defining new business opportunities driven by the outcomes of the GEYSERS project. As TP has the largest infrastructure network in Poland it needs to consider its role as both an Infrastructure Provider and a Service Provider. This allowed the creation of new business models, the optimization of the usage of the available network resources, and the offering of a wider range of services to its customers.
PSNC	PSNC, as an operator of Polish National Research and Education Network, sees one of the outcomes of GEYSERS as being the gaining of expertise in the operation of its own optical network (PIONIER), which is still being developed. PSNC is convinced that research and development in the area of Control Planes, Bandwidth on Demand, and integrated management of IT resources will strengthen its position in this field. The requirements of the next generation will allow PSNC to adjust PIONIER's infrastructure so that it can offer new advanced services supporting high demanding applications and IT infrastructure in a dynamic and flexible way. PSNC will use the technology roadmaps generated by the GEYSERS project to make PIONIER a part of future global research infrastructure able to handle requirements from users with highly demanding needs. Also, an experience of dynamic multi-domain resource management will enable PIONIER NREN to share its resources using Logical Infrastructure concepts in respect to local administrative and security policies. A management of Network+IT resources will exert a direct influence on current and future services provided internally within PIONIER's infrastructure. This will also enable the multi-domain collaboration of services, allowing improved accessibility and quality.
NXW	Nextworks undertook the research and development planned in the GEYSERS project in order to advance the competitiveness of its consulting and solution-provider activities in the TLC sector. The current status of the consulting market where Nextworks operates is mainly dominated by large staff-leasing companies providing relatively unskilled personnel to customers in the TLC manufacturer sector. On the other hand, Nextworks offers specialized consultancy services, where the unique selling feature is the know-how of its personnel. This generates a compelling need to specialize its knowledge and its theoretical and practical expertise more and more, in order to differentiate itself from the competition. Nextworks will use its involvement in the project activities and the results of the GEYSERS project to improve its technological expertise in the field of GMPLS Control Plane and PCE. The enhanced know-how developed in the project will primarily allow Nextworks researchers and engineers to be more effective in their consulting, implementation and prototyping activities. Moreover, the fact that the

	GEYSERS consortium includes representatives of the major business roles in the current and future TLC market opens another solid opportunity for the SME to establish a long-term cooperation with these players (beyond the project) on the leading edge R&D activities and evolutions. Nextworks has outlined some preliminary exploitation routes in order to apply the results of its work in GEYSERS to its market-related activities.
INRIA/ Lyatiss	One early exploitation in the project was that INRIA RESO launched the start-up Lyatiss that was able to directly exploit the results of the project. The technical cooperation with the major industrial actors and collaborators involved in GEYSERS help to mature the software technology. A high visibility of the GEYSERS architecture and results is giving a strong advantage to Lyatiss for entering the emerging international market of software solutions for bandwidth and virtual infrastructure on demand. The important exploitation and dissemination activities of INRIA in the GEYSERS project will attract opportunities to reach market prospects. The first step for exploitation (i.e. to convince Infrastructure Owners that the GEYSERS architecture is able to support an interesting business model based on value sharing is being achieved. INRIA/Lyatiss now aims at studying the incremental deployment of this model with early customers (infrastructure owners). In France, INRIA/Lyatiss will introduce GEYSERS results to several projects it is involved with (CARRIOCAS[5], GRID5000[6]) and to its strategic and close industrial partners like Orange.
UEssex/ UNIVBRIS	UEssex is interested in the results from GEYSERS both for internal and external exploitation purposes. Particularly, as a university mainly focusing on knowledge transfer, UEssex is already making use of the results for student education at all-levels and to provide training to its industrial partners. UEssex will also help industrial partners to promote the importance of devising new solutions to provide better services for the EU research community.
IBBT/ iMinds	The role of IBBT/iMinds, as an independent research institute, is to transfer the knowledge it created in the GEYSERS project to industrial partners (in particular in Flanders) for further commercialization the results. IBBT will use the results obtained within the project for further enhancement of its knowledge and competence in the fields of optical networks, and the broader context of network management and control, including distributed software. The enhanced knowledge and competence obtained through the participation in the GEYSERS project, will be exploited and used for participating in new projects and setting up partnerships in other projects, both in the academic and (national and European) industry world. The scientific results will also impact on education, because the research was performed at the Department of Information Technology (INTEC) of Ghent University, where INTEC is responsible for Bachelor and Master courses on distributed software and telecommunication networks.
UvA	UvA will use GEYSERS results and experiences gained for student education and will contribute to standardization activity in area of advanced networking and distributed applications. UvA is involved in a number of national Dutch and international projects, both in networking, Gird and Cloud Computing. UvA will make GEYSERS results visible to several national and international projects such as GigaPort, VL-e, CineGrid that address correspondingly advance networking infrastructure and distributed applications issues. UvA will promote novel GEYSERS solutions to industrial partners to create network services matching better requirements of the future networking and distributed applications.

[5] http://www.carriocas.org
[6] http://www.grid5000.fr

i2CAT	i2CAT will exploit and present the project outcomes among its board members, composed of Infrastructure Providers, Network Operators, applications developers and users, in order to promote the innovations and generation the new business in Catalonia. The scope and industrial partner's interests around GEYSERS will definitely help i2CAT on maturing and improving the cumulative expertise gained on the Infrastructure as a service through participation in projects like UCLP (Canada) and FEDERICA FP7, PHOSPHORUS FP6 or MANTYCHORE. The partitioning of infrastructure resources is one of the main research areas of the i2CAT foundation. Therefore, i2CAT now expects GEYSERS to open the sector to new business models and steer the standardization bodies towards defining new mechanisms that facilitates the industrial acquisition of GEYSERS outcomes. i2CAT is seriously considering pushing for the creation of a start-up, focused on offering services to infrastructure providers from the exploitation and dissemination benefits driven from GEYSERS.
AIT	Through participation in this consortium AIT has gained considerable exposure to various aspects of the associated research topics, and will assist in the advancement of the relevant state of the art. AIT actively assisted in the presentation and dissemination of the results that were produced as the outcome of the work performed within GEYSERS through publications in major international journals, conferences, specialized workshops and other relevant events. AIT will assist in further raising awareness with regards to the GEYSERS focus, work and output to a wider non–technical audience through lectures to young students and public domain seminars/webinars. In addition, it should be noted that AIT will be feeding the knowledge and expertise acquired through the project to its educational activities including both postgraduate MSc level programmes as well as professional training courses.

3.4 Standardization

As standards for interoperability are essential for allowing innovations to complement existing products and services and integrate existing systems, allowing open markets and competition, GEYSERS has also contributed to the following global standards bodies: IETF, TMF, DMTF, OGF, NIST and the VXDL Forum.

This was another mechanism to allow the project consortium to ensure effective exploitation of the project reference model, output and results and facilitate large scale deployment of new services in optical infrastructures that GEYSERS is proposing; thereby, further increasing the overall project impact.

Organization	Working Groups	Relevance for GEYSERS	GEYSERS representation
IETF - Internet Engineering Task Force	PCE WORKING GROUP	High	NXW&TID
	Clouds Bar BoF	High	NXW&TID
	VNRG - Virtual Networks Research Group	High	NXW&TID
	CCAMP WORKING GROUP	Low	NXW&TID
	MPLS WORKING Group	Low	NXW&TID
TMF – TeleManagement Forum	TM Forum Interface Program	Medium	UvA, Alcatel-Lucent
DMTF – Distributed Management Task Force	Cloud Management Working Group	High	UvA
OGF – Open Grid Forum	NSI-WG - Network Service Interface Working Group	Medium	UvA, i2CAT

	NML-WG - Network Markup Language Working Group	Medium	UvA, i2CAT
	ISOD-RG - Infrastructure Services On-Demand Provisioning Research Group	High	UvA, PSNC, i2CAT
NIST – National Institute of Standards and Technologies	NIST Cloud Computing Standards Roadmap Working Group	High	UvA
International Communities	**Relevance for GEYSERS**	**GEYSERS representation**	
VXDL Forum	High	Lyatiss-INRIA	

3.4.1 IETF

GEYSERS standardization activities in IETF are following two main directions: Cross-Stratum Optimization and Cloud Reference Framework. The former is dedicated to the standardization of a framework for Cross Stratum Optimization (CSO) regulating the interactions between the application/service layer and the network layer in order to optimize the utilization of both network and IT resources. The latter is focused on the definition of a Cloud Reference Framework, with special attention on the definition of an inter-cloud control and management plane. The next sub-sections will provide details about the standardization strategy followed for the two areas, showing the main results and the next plans.

3.4.1.1 *Cross-stratum optimization*

GEYSERS has investigated the Cross-Stratum Optimization issue from multiple perspectives, proposing solutions both in terms of high-level cross-layer architecture design in Work Package 2 and in Work Package 4, specifying a network to service interface between the SML and the NCP+ for the joint provisioning of network and IT services (the NIPS UNI [GEYSERS-D42]), as well as internal NCP+ procedures and PCEP protocol extensions in support of assisted unicast, restricted and full anycast connectivity services [GEYSERS-D4.1].

The overall strategy behind the GEYSERS standardization in this area is based on three main steps: (1) creating awareness around the CSO challenges through the participation in related discussions and workshops; (2) presenting the GEYSERS vision in terms of requirements and functional architecture through initial IETF informational drafts, possibly involving also external partners to reach more consensus in the community; (3) submitting and maintaining a comprehensive IETF informational draft within a key WG (e.g. the PCE WG) about the overall framework and procedures defined in GEYSERS. This draft could potentially act as baseline for future standardization actions focused on part of the extensions defined in Work Package 4 for the PCEP protocol.

Following this strategy, NXW and TID have been active since the second year of the project in promoting the GEYSERS solutions. In particular, they have initially presented the GEYSERS vision in terms of requirements and high-level cross-layer architecture in unofficial meetings on CSO topics co-located with IETF meetings (e.g. [TID-CSO] presentation at IETF 80 meeting) and have actively participated in the Cloud Computing and CSO workshop presenting the NIPS UNI [NIPS-UNI-CSO]. As a second step, a functional architecture for CSO-enabled service provisioning has been proposed in an IETF draft [CSO-ARCH] submitted in October 2011 and presented at the CSO workshop during the IETF 82 meeting. This architecture reflects the GEYSERS framework in terms of SML and NCP+ functionalities and cross-layer interactions,

specifying the functionalities expected at the NIPS UNI level. In the same context, TID and NXW have also submitted a further draft [CSO-REQ] focused on the requirements for CSO-enabled path computation, presenting the PCE and PCEP requirements in support of path computation for assisted unicast and anycast, as well as advance reservations. Finally, all these activities have moved from the CSO group (the related WG has never been officially established) to the PCE Working Group (WG), where they have converged on a single draft about CSO-enabled Path Computation [PCE-CSO], submitted jointly with Huawei Technologies and periodically updated.

The table below provides a summary of the standardization activities in the CSO area.

Title	Event	Type of contribution	Date of publication	GEYSERS author(s)
A carrier view on Cross Stratum	IETF 80	Presentation	March 2011	Javier Jimenez (Telefonica I+D)
CSO for optical networks: the GEYSERS approach	Cloud Computing and Cross-Stratum Optimization Workshop	Presentation	June 2011	Nicola Ciulli, Giada Landi (Nextworks) Javier Jimenez, Alejandro Tovar (Telefonica I+D)
Architecture for Service Provisioning with Cross Stratum Optimization v00	IETF 82	IETF Internet Draft	October 2011	Luis M. Contreras, Alejandro Tovar (Telefonica I+D) Giada Landi, Nicola Ciulli (Nextworks)
Path Computation Requirements for Cross Stratum Optimization v00	IETF 82	IETF Internet Draft	October 2011	Alejandro Tovar, Luis M. Contreras (Telefonica I+D) Giada Landi, Nicola Ciulli (Nextworks)
Cross Stratum Optimization enabled Path Computation v01	IETF 83	IETF Internet Draft	March 2012	Nicola Ciulli (Nextworks) L. Contreras, O. Gonzalez de Dios (Telefonica I+D)
Cross Stratum Optimization enabled Path Computation v02	IETF 85	IETF Internet Draft	September 2012	Nicola Ciulli (Nextworks) L. Contreras, O. Gonzalez de Dios (Telefonica I+D)

3.4.1.2 *Cloud reference framework (UvA)*

Besides Cross-Stratum Optimization, another contribution from GEYSERS within IETF is focused on network and protocol related issues in cloud operation and inter-cloud interoperability. Although the service orientation and utility/infrastructure focus of clouds is generally outside the scope of the IETF, a number of initiatives in IETF have made attempts to address network and general infrastructure related issues. These have been addressed in a number of Working Groups in particular, address allocation for distributed data centers, Content Distribution Network (CDN) inter-connection Birds of Feather (BoF), and incidents reporting and attack protection in clouds BoF.
The Cloud Bar BoF that initially took place at IETF78 (August 2010) has resulted in the submission of several Internet Drafts providing information to the Internet community on the current Cloud Computing standardization and practices, in particular a general cloud and inter-cloud reference framework where the GEYSERS project provided contribution related to defining the Inter-Cloud Architecture Framework and NCP+ based Inter-Cloud Control and Management Plane.

The IETF standardization activity by the GEYSERS project was also promoted at the TNC2011 conference by organizing the NREN and Cloud Standardization BoF. The project was represented by: Yuri Demchenko (UvA) – the Chair of the

meeting, and Bartosz Belter (PSNC) – a speaker. Bartosz Belter presented the architectural approach taken in GEYSERS and explained how it fits into the NREN community. Although the NREN Cloud BoF was considered as purely technical, a discussion on business impacts of clouds on NRENs and related communities was raised several times. The GEYSERS presentation stimulated a discussion on the role of NRENs in the cloud-related research activities.

The NREN Cloud BoF will try to look at future developments and future technologies to solve the problem of better supporting collaborative groups of people and wider user communities at all layers of networking and applications infrastructure. This BoF will provide a venue to discuss a wide spectrum of research and technology problems in provisioning infrastructure services on-demand, existing frameworks to support on-demand infrastructure services provisioning, and new emerging business models for infrastructure virtualization, such as Cloud Infrastructure as a Service (IaaS). The BoF will host presentations from EU projects and activities such as GEANT3, GEYSERS, NOVI, OGF ISOD Research Group and facilitate information and experience dissemination and exchange with the TERENA community.

The GEYSERS project contribution has been provided to the currently active “Cloud Reference Framework. Internet-Draft, version 0.4, December 27, 2012” [CRF] document (as well as to the previous version 0.3 of June 28, 2012) that proposes a framework for developing new standards to support cloud services through the network, transport, messaging services and consistent definition of the Inter-Cloud Control and Management Plane for provisioned infrastructure services on demand. The document defines the Cloud Reference Service Model and Inter-Cloud Architecture Framework. The proposed Cloud Services Reference Model defines a number of horizontal layers:

- User/Customer side Functions and Resources Layer (DCL)
- Access and Service Delivery Layer (ADL)
- Application/Service Layer (ASL)
- Resource Control Layer (RCL)
- Resource Abstract and Virtualization Layer (RAVL)
- Physical Resource Layer (PRL)

and one vertical plane:

- Cloud Management Plane

The draft also provides the definition of the Inter-Cloud Architecture Framework (ICAF), which must address the following requirements:

- ICAF should support communication between cloud applications and services belonging to different service layers (vertical integration), between cloud domains and heterogeneous platforms (horizontal integration).
- ICAF should provide a possibility that applications could control infrastructure and related supporting services at different service layers to achieve run-time optimization and required Quality of Service (QoS) (typically related to inter-cloud control and management functions).
- ICAF should support cloud services/infrastructures provisioning on-demand and their lifecycle management, including composition, deployment, operation, and monitoring, involving resources and services from multiple providers (this is typically related to service management and operations support functions).
- Provide a framework for heterogeneous inter-cloud federation.
- Facilitate interoperable and measurable intra-provider infrastructures.
- Explicit/Guaranteed intra- and inter-cloud network infrastructure provisioning (as NaaS service model).
- Support existing Cloud Provider operational and business models and provide a basis for new forms of infrastructure services provisioning and operation.

More specific Inter-cloud functional requirements are articulated as follows:

- Provide a mechanism for resource search and discovery, to determine which serving cloud might have certain resources available (including a match making mechanism).
- Provide a mechanism to authenticate participating entities belonging to different cloud domains.
- Provide a mechanism for requesting, controlling, and releasing resources between two clouds.
- Provide a secure transport channel between the interconnecting entities.
- Provide end-to-end isolation to support multi-tenancy.
- Provide a mechanism for monitoring, assuring, and troubleshooting across the interconnection.
- Provide a mechanism for defining the monitoring metrics such as Delay-Jitter-Loss. This may be useful for monitoring a flow such as TCP/UDP between IP prefix and a destination address across the interconnection.

The proposed Inter-Cloud Architecture Framework includes the following components with the related interfaces:

(1) Intercloud Control and Management Plane (ICCMP) for intercloud applications/infrastructure control and management, including inter-applications signalling, synchronization and session management, configuration, monitoring, run time infrastructure optimization including VM migration, resources scaling, and jobs/objects routing;
(2) Intercloud Federation Framework (ICFF) to allow independent clouds and related infrastructure components federation of independently managed cloud based infrastructure components belonging to different cloud providers and/or administrative domains; this should support federation at the level of services, business applications, semantics, and namespaces, assuming necessary gateway or federation services;
(3) Intercloud Operation Framework (ICOF) which includes functionalities to support multi-provider infrastructure operation including business workflow, SLA management, and accounting. ICOF defines the basic roles, actors and their relationships in terms of resources operation, management and ownership. ICOF requires support from and interacts with both ICCMP and ICFF.

The current draft provides a good definition of the network related functionalities in typical cloud infrastructures and moves in the direction of considering the cloud based infrastructure services as an integrally management component. These aspects will be reflected in the next draft which is scheduled to submit to IETF in June 2013.

In this respect, the GEYSERS architecture and its components are considered as an implementation of the Intercloud Control and Management Plane (ICCMP) in particular LICL and NCP+ components. Proposed in GEYSERS, the SDF, RORA model and SLA management framework provided input to the definition of the Intercloud Operations Framework (ICOF).

3.4.2 TMF

The project involvement into TMF activity was conducted via Alcatel Lucent membership and UvA associated membership. TMF activities on Service Delivery Framework (SDF), SLA Management, Software Enabled Service Management Solutions and Cloud Initiative have being followed (see deliverable 6.2) with contributions provided to the discussion at TMF on the SDF implementation and Use Cases. As an outcome of this activity, the GEYSERS enhanced SDF model has been proposed that incorporated additional SDF stages specific for complex multilayer combined Network+IT resources provisioning such as Planning and Re-Planning (see deliverables D2.3 and D2.2, D2.5, D2.7).

3.4.3 OGF

The project involvement in OGF activities are mainly focused on NML and NSI working groups and ISOD Research Group.

3.4.3.1 *NML-WG*

Developments in the Network Mark-up Language Working Group and the GEYSERS Information Modelling Framework have had a significant influence on each other. The purpose of the NML-WG is to combine efforts of multiple projects to describe network topologies, so that the outcome is a standardized network description ontology and schema, facilitating interoperability between different projects. For GEYSERS, one of the basic requirements for the design of the LICL component is the ability to describe multi-domain and multi-technology computing infrastructures. The final result of the synergies between the NML-WG and GEYSERS is that the GEYSERS Information Modelling Framework is fully compliant with the first draft version of the NML schema that has been recently released.

The background of the NML-WG is in the area of hybrid networks. Hybrid networks offer end users a mix of traditional connections and new optical services in the form of dedicated lightpaths. These must be requested in advance and are currently configured on demand by the operators. The user must be aware of the topology and of the techniques involved in the provisioning because lightpaths are circuit switched. Once connected, they offer a high-speed, low-level connection to the requested destination. The working group will provide an extensible schema to describe computer networks. This schema should provide an abstraction layer for networks, specifically hybrid networks. Such a schema can be used to create inter-domain network graphs at various abstraction levels, to provide an information model for service discovery, and to facilitate lightpath provisioning.

The synergies between GEYSERS and the NML-WG have led to the development of the Infrastructure and Network Description Language (INDL). INDL uses NML as a basis for modelling the network part of computing infrastructures. INDL itself serves as the basis of the GEYSERS Information Modelling Framework.

3.4.3.2 *NSI-WG*

One of the key innovations of GEYSERS is the aggregation and abstraction of resources from multiple administrative domains. The Network Service Interface (NSI) Working Group (WG) is aimed at providing recommendations for a generic network service interface that can be called by a network external entity such as end users, middleware, and other network service providers. The recommendation will define the information exchange, the required messages and protocols, operational environment, and other relevant aspects.

The NSI-WG is focused on high performance networks that offer advanced network services to end users with differing requirements. The user/application/middleware may request network services from one or more network service providers through a network service interface. The network service setup then requires configuration, monitoring and orchestration of network resources under particular agreements and policies. Provisioning mechanisms support allocating, configuring, and maintaining network internal resources.

The scope of the NSI-WG includes, in particular, the interface between Grid middleware and the network infrastructure as well as the interface between network domains in order to provide interoperability in a heterogeneous multi-domain environment. The WG will consider user authentication/authorization, service negotiation agreements, and information exchange to describe advanced network services.

Synergies between GEYSERS and the NSI-WG have led to a similar hierarchical and service oriented approach in the LICL design for overcoming multi-domain problems. This approach enables the GEYSERS architecture to aggregate and abstract resources located in multiple administrative domains.

3.4.3.3 *ISOD-RG*

The On-demand Infrastructure Services Provisioning (ISOD) Research Group (RG) led by the UvA and has been heavily influenced by many aspects of the GEYSERS architecture. The ISOD RG will explore frameworks that support on-demand infrastructure services provisioning, and new emerging operational and business models for infrastructure

virtualization, such as the GEYSERS architecture. The proposed effort will investigate architecture and components that reflect the requirements and capabilities of both infrastructure and applications providers. The recommendations will define a general approach to building dynamically provisioned, composable and corresponding service delivery framework and workflow. The ISOD RG will also explore frameworks for providing consistent security services for dynamically provisioned, combined network and IT resources and applications. Again, the GEYSERS architecture is one of the key example architecture from which the ISOD RG intends to learn.

The main purpose of the ISOD RG is to develop an informational architecture framework that outlines the necessary components for on-demand infrastructure services provisioning (in particular, generic IaaS Cloud provisioning model) that can support new emerging business and operational models for virtualized infrastructure providers. The expected results should create a basis for developing heterogeneous services inter-operation and creation of new interoperable and composable services.

It is intended that ISOD RG will provide Use Cases and recommendations for development of upper layer service frameworks for a number of currently running related initiatives at OGF, such as NSI WG, NML WG, OCCI WG, CDMI at SNIA, and will review standardization work done by the ITU-T and TeleManagement Forum (TMF) for possible adoption by OGF user community.

3.4.4 NIST

The project involvement into NIST activity was conducted via UvA's participation in the NIST Cloud Computing Collaboration Activity and involvement into international standardization coordination activities such as European CloudScape Initiative that held meetings in February 2010, 2011 and 2012.

Contribution has been provided to discussion and standardization process on the Reference Cloud Computing Architecture (CCRA) and Cloud Computing Security Infrastructure.

As outcome of this activity, the GEYSERS adopted and implemented Network+ IT provisioning architecture consistent with the industry adopted CCRA and related cloud services provisioning and service models.

3.4.5 VXDL Forum

Virtual Infrastructures are complex dynamic objects that have a lifetime (composition, reservation, activation, migration, evolution, pause, store, and reactivate operations). For example, users need to define the virtual infrastructure topology and capacity according to the requirements of the applications they plan to run over it. To facilitate the specification and the manipulation of these objects, VXDL proposes a simple open language. VXDL is the programming language for Clouds IaaS and NaaS and the abstract low level interface for SaaS and PaaS.

The Virtual Infrastructure Description Language (VXDL) is a language that allows the description of a Virtual Infrastructure (VI) or a "compute-and-communicate" resources graph. A VI is a time-limited organized aggregation of heterogeneous computing and communication resources. This means IT resources for data processing or storage, but also the underlying interconnection topology including configurable communication equipment and timeline representation. The VI concept and its associated VXDL description language brings two original aspects to the Infrastructure as a Service paradigm (IaaS), both related to the networking aspects: (i) the joined specification of network elements and computing elements and (ii) the link- organization concept, which permits a simple and abstract description of complex structures. The VXDL language mainly aims at enabling the description of resources and networks that are virtual (dematerialized), but also to some extent, adaptable to physical ones.

The concept of virtual infrastructures combining computing, storage and networking resources in an abstract network of virtual resources, is one of the core concepts of GEYSERS. For example, this is the key concept of LICL and VXDL is expressing the external view of such concept.

Within the research and implementation process on allocation of VIs in GEYSERS, VXDL has been extended in order to support the specification of virtual networks with constraints related to optical network technology. For example, VIs can be described with parameters such as the fiber type, number of wavelengths, optical impairment and optical add/drop capabilities. Moreover, VXDL is being extended with energy management parameters, such as power constraints. The goal was to establish the baseline of VXDL generator for PaaS and SaaS services providers as well as VXDL parser implementations for IaaS service providers.

Lyatiss has launched and animated the VXDL forum as an industry consortium for Virtual infrastructure design and specification. This activity faced the lack of maturity of the eco-system with respect to the integration of the network as the same level as the IT resources. Though gaining traction, the definition of a north-bound interface for SDN is in its infancy and hasn't yet reached a mature state that would allow building a virtual infrastructure (network+IT) specification language for the industry. Opportunity to carry on this work with existing efforts has been conducted with OpenStack Quantum or during panels at 2012 AdvancedTCA Summit with Cisco, BigSwitch and Dell. Lyatiss' work has thus been focused on evangelization of the need for a virtual infrastructure language specification through the participation of panels, and presentation of VXDL.

Section A (public)

This section includes three templates.

3.5 List of all scientific (peer-reviewed) publications relating to the foreground of the project

TEMPLATE A1: LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS (CHRONOLOGICAL ORDER)										
No.	**Title**	**Main author**	**Title of the periodical or the series**	**Number, date or frequency**	**Publisher**	**Place of publication**	**Year of publication**	**Relevant pages**	**Permanent identifiers (if available)**	**Is/Will open access provided to this publication?**
1	Contributions to the book-chapter "Bringing Optical Networks to the Cloud: an Architecture for a Sustainable Future Internet"	SAP, NXW, INRIA, i2CAT, UvA, UEssex, AIT, TUBS, LYaTiss, PSNC	Architecture in the Future Internet Assembly Book 2011				2010			
2	Preparation, main edition and submission of an article GEYSERS: A Novel Network Architecture for "Optical + IT" Service Provisioning	UEssex, AIT, PSNC	IEEE Communications Magazine				2010			
3	Optimized Parallel Transmission in OTN/WDM Networks to Support High-Speed Ethernet with Multiple Lane Distribution	TUBS	IEEE/OSA Journal of Optical Communications and Networking				2012			

	(MLD)		(JOCN)							
4	Anycast routing for survivable optical grids: scalable solution methods and the impact of relocation	IBBT	In IEEE/OSA J. Opt. Commun. Netw				2011			
5	Architectural Requirements for Cloud Computing Systems: An Enterprise Cloud Approach	TUBS	Journal of Grid Computing (Springer)				2010			
6	Isolation and Resource Efficiency of Virtual Optical Networks	IBBT	Int. Conf. Computing, Networking and Communications (ICNC 2012)				2012			
7	Logical Infrastructure Composition Layer, the GEYSERS Holistic Approach for Infrastructure Virtualization	i2CAT, UvA, iMinds/IBBT, Lyatiss	Proc. TERENA Networking Conference (TNC 2012)				2012			
8	Optical networks for grid and cloud computing applications	IBBT	Proc. IEEE, Vol. 100, No. 5, May 2012				2012	pp. 1149-1167		
9	Resilient network dimensioning for optical grid/clouds using relocation (Invited Paper)	IBBT	2012 Proc. Workshop on New Trends in Optical Networks Survivability, at IEEE Int. Conf. on Commun. (ICC 2012)				2012			
10	A Network Control Plane	Nextworks,	FuNeMS 2012,				2012			

	architecture for on-demand co-provisioning of optical network and IT services	iMinds/IBBT, AIT	Berlin							
11	Virtual Infrastructure Planning: The GEYSERS Approach	Nextworks, iMinds/IBBT, AIT, Lyatiss, UEssex	FuNeMS 2012, Berlin				2012			
12	Optimized PLI-aware Virtual Optical Network Composition	Nextworks, iMinds/IBBT, AIT, UEssex	ICTON 2012, UK				2012			
13	Optimized Parallel Transmission in OTN/WDM Networks to Support High-Speed Ethernet with Multiple Lane Distribution	X. Chen, A. Jukan, TUBS	IEEE/OSA Journal of Optical Communications and Networking (JOCN,	Vol.4, No.3,			2012			
14	Joint Dimensioning of Server and Network Infrastructure for Resilient Optical Grids/Clouds	iMinds/IBBT	IEEE Trans. Netw.				2012, rev. 2013			
15	Virtual Optical Network Composition over Mixed-Line-Rate and Multiple-Modulation-Format WDM Networks	UEssex	ECOC 2012, Amsterdam				2012			
16	Virtualization over Converged Wireless, Optical and IT elements in Support of Resilient Cloud and Mobile Cloud Services	AIT, UEssex	ECEC 2012				2012			

17	Towards Cloud-Ready Transport Networks	L. M. Contreras, V. López, Ó. G., de Dios, A. Tovar, F. Muñoz, A. Azañón	IEEE Communications Magazine	Vol. 50, Issue. 9			2012			
18	Converged Optical Network and Data Center Infrastructure Planning	AIT	September 2012, Journal of Optical Communications and Networking (JOCN	Vol. 4, No. 9			2012			
19	Energy-Efficient Resource Provisioning Algorithms for Optical Clouds	IMinds/IBBT, AIT	September 2012, IEEE/OSA J. Optical Commun. Netw. (published in print, March 2013)				2012/2013			
20	In Proc OPC 2012 Stochastic Virtual Infrastructure Planning in Elastic Cloud Deploying Optical Networking	AIT	In proc. of OFC 2012, Pres. number: OW1A.3				2012			
21	On the viability of a CSO Architecture for on-demand virtualised Cloud Planning and Provisioning Proceedings:	TID, iMinds/IBBT, Lyatiss, i2CAT	CloudNet 2012				2012			
22	Energy-Efficient Resource-Provisioning Algorithms for	iMinds, AIT	Journal of Optical	Vol. 5, Issue 3, pp. 226-239			2013			

	Optical Clouds		Communications and Networking (JOCN)							
23	Impairment-aware Optical Network Virtualization in Single-Line-Rate and Mixed-Line-Rate WDM Networks	UEssex	Journal of Optical Communications and Networking	Vol. 5 Issue 4, pp.283-293			2013			
24	Stochastic Optimization for Deployment of Correlated Cloud-Based Services over Optical Networks	AIT	IEEE Journal on Selected Areas in Communication Special Issue on Networking Challenges in Cloud Computing Systems and Applications				2013			
25	Energy Efficient VI Planning over Converged Optical Networks and IT Resources. In Green Communications	AIT, UEssex	Book Chapter		Green Communications, CRC Press		2013			
26	The impact of renewable energy sources in the CO2 emissions of converged optical network and cloud infrastructures	AIT, UEssex	Book Chapter		Green Communications, CRC Press		2013			
27	Security Infrastructure for Dynamically Provisioned Cloud Infrastructure Services	UvA	Book Chapter Privacy and Security for Cloud Computing		Springer London		2013	167-210		

3.6 List of all dissemination activities

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
No.	**Type of activities**	**Main leader**	**Title**	**Date/Period**	**Place**	**Type of audience**	**Size of audience**	**Countries addressed**
1	Poster Presentation	i2CAT: S. Figuerola	FI 2010, GEYSERS http://www.etsi.org/WebSite/NewsandEvents/FNT/2010_FutureNetworkTechnologies_Agenda_Day2.aspx	March 9th, 2010	Sophia Antipolis, France	Researchers, Industry	200	World
2	Workshop	NXW, i2CAT, INRIA, IRT	Presented at the ETSI Future Network Technologies Workshop	March 10th - 11th, 2010	Sophia Antipolis, France	Researchers, Industry	200	World
3	Workshop	NXW (presenter), i2CAT (session chair), UvA (organized the ISOD BoF)	Presented the GEYSERS NCP at the "On-demand Infrastructure Services Provisioning Workshop" at OGF28	March 15th - 19th, 2010	Munich, Germany	Researchers, Industry	50-60	World
4	Workshop	i2CAT: S. Figuerola	Presented the GEYSERS Reference Model at IRTF 77 (NVRG working group)	March 23rd, 2010	Anaheim, USA	Researchers, Industry	100	World
5	Conference	UvA (Y. Demchenko, Cees de Laat), RedIRIS (D.R. Lopez), i2CAT (J.A. García-Espín)	TERENA Networking Conference Paper/Poster presentation: "Security services lifecycle management in dynamically provisioned composable services"	May 31st - June 3rd, 2010	Vilnius, Lithuania	Researchers, Industry	50	World
6	Workshop	i2CAT: J.A. Garcia-Espin	Presented "An Optical Network and IT Infrastructure Virtualization Framework from GEYSERS Project" at the RT-Multilayer Workshop	June 14th - 16th, 2010	Catalonia, Spain	Researchers, Industry	40-50	World

			organized by the Advanced Network Architectures Lab group of the UPC					
7	Conference	i2CAT, NXW	Presented a paper at the Future Network & Mobile Summit 2010, entitled: "GEYSERS Architecture (Generalised architEcture for dYnamic infraStructure sERviceS)"	June 16th - 18th, 2010	Florence, Italy	Researchers, Industry	50-60	World
8	Conference	i2CAT S. Figuerola	Presented a paper at the Future Network & Mobile Summit 2010, entitled: "Impact of GEYSERS architecture on Green IT"	June 16th - 18th, 2010	Florence, Italy	Researchers, Industry	50-60	World
9	Conference	IIT: Ashwin Gumaste	Presented at the 12th International Conference on Transparent Optical Networks (ICTON 2010)	June 27th, 2010,	Munich, Germany	Researchers, Academics, Industry	100	World
10	Conference	i2CAT: S. Figuerola	9th International Conference on Optical Internet (COIN 2010)	July, 2010	Jeju, Korea	Researchers, Academics, Industry	100	World
11	Conference	AIT: K. Katrinis, A. Tzanakaki	"Analytical approximation of the energy-efficiency of protection mechanisms in WDM optical network planning", presented at ICCCN 2010	August 2nd - 5th, 2010, ETH	Zurich, Switzerland	Researchers, Academics, Industry	50-60	World
12	Presentation	i2CAT: S. Figuerola (via video-conference)	Presentation of GEYSERS at the Future Internet session of the 30th meeting of APAN	August 11th, 2010	Hanoi, Vietnam	Researchers, Academics, Industry	50	World
13	Conference	i2CAT: S. Figuerola	GEYSERS presented at the ECOC 2010	September 19th - 23rd	Torino, Italy	Researchers, Academics, Industry	100s	World
14	Conference	AIT: K. Georgakilas, K. Katrinis, A. Tzanakaki, J. M. Gutierrez, O.B. Madsen	"Comparison of Energy Consumption of Path Protection Schemes in WDM Optical Networks", presented at ECOC 2010	September 19th - 23rd, 2010	Torino, Italy	Researchers, Academics, Industry	100s	World
15	Presentation	IRT, SAP, ALU-I, NXW, INRIA, i2CAT, Martel, PSNC	Booth at ICT2010 and presentation of GEYSERS	September 28th - 29th, 2010	Brussels, Belgium	Researchers, Academics, Industry	1000s	World
16	Presentation	NXW, i2CAT	Presentation of the GEYSERS NCP+ at the CaON cluster meeting	October 6th - 8th,	Stockholm,	Researchers, Academics,	100	World

				2010	Sweden	Industry		
17	Presentation	PSNC, i2CAT, NXW, Martel	Future Internet Assembly (FIA)	November 15th - 17th, 2010	Ghent, Belgium	Researchers, Industry	200	World
18	Conference	UvA	Presented GEYSERS and GEANT3 at CloudCom 2010	November 30th - December 3rd, 2010	Indianapolis, USA	Researchers, Academics, Industry	100	World
19	Conference	PSNC: B. Belter	Presentation of GEYSERS at the Future Internet session of the I3 Conference	December 1st - 3rd, 2010	Wroclaw, Poland	Researchers, Academics, Industry	200	World
20	Conference	IBBT: C. Develder	Presentation of the paper: "Column generation for dimensioning resilient optical grid networks with relocation" with GEYSERS acknowledgement, at IEEE Globecom 2010	December 6th – 11th, 2010	Miami, USA	Researchers, Academics, Industry	1000+	World
21	Conference	IIT (organization and session chairing) Presentations made by ADVA, TID and LYaTiss	IEEE ANTS Symposium (Mumbai): Cloud Computing and Operators Vision for Future	December 16th - 18th, 2010	Mumbai, India	Researchers, Academics, Industry, Service Providers	300	World
22	Workshop	UvA	Cloud Security Workshop and presented ongoing work on GEYSERS Security Framework	January 10th - 11th, 2011	Stavanger, Norway	Researchers, Academics, Industry	50	World
23	Conference	i2CAT	ONDM 2011 - Participated in a round table discussion in one of the Workshop seminars	February 8th - 10th, 2011	Bologna, Italy	Researchers, Academics, Industry	200	World
24	Conference	NXW	ONDM 2011 - Presented GEYSERS NCP+ at the ONDM 2011 workshop on "Control Plane Evolution in Metro and Core networks	February 9th, 2011	Bologna, Italy	Researchers, Academics, Industry	100	World
25	Presentation	i2CAT: NXW:	7th Concertation Meeting, FI Cluster meeting Panel and CaON cluster meeting	February 10th - 11th, 2011	Brussels, Belgium	Researchers, Academics, Industry	60	Europe
26	Presentation	i2CAT:	Participated in the EuroLab-Expert Group meeting within the NEX!WORKS ETP group	March 2nd, 2011	Munich, Germany	Experts Meeting	50	Europe

27	Workshop	UvA	Attended CloudscapeIII workshop and disseminated information on GEYSERS	Belgium, March 15th - 16th, 2011	Brussels, Belgium	Researchers, Academics, Industry	50	World
28	Conference	ADVA PL	Presentation of GEYSERS at PLNOG 2011	March 16th - 17th, 2011	Krakow, Poland	Researchers, Academics, Industry	50	World
29	Conference	UvA	Paper presented at ISGC2011 Conference: " Defining Generic Architecture for Cloud IaaS Provisioning model", ISGC2011/OGF31, (http://event.twgrid.org/isgc2011/index.html	March 21st - 24th, 2011	Taipei, Taiwan	Researchers, Academics, Industry	50	World
30	Presentation	NXW	Contributed to the GEYSERS presentation material presented at the Cross-Stratum Optimization meeting at IEFT80	March 27th - April 1st, 2011	Prague, Czech Republic	Researchers, Academics, Industry	100	World
31	Presentation	UvA	Standardization activity	Gaithersburg, MD	Gaithersburg	Researchers, Academics, Industry	>1000 (via mailing lists)	World
32	Presentation	INRIA, Lyatiss	Presentation: "Locating virtual Infrastructures: users and InP perspectives"	May 2011,	Dublin, Ireland	Researchers, Academics	100	World
33	Presentation	UvA	Presentation: "Defining Generic Architecture for Cloud Infrastructure as a Service Provisioning model"	May 7th - 9th, 2011	Nordwijk, Netherlands	Researchers, Academics, Industry	>200	World
34	Presentation	UvA	Presentation: "Access Control Infrastructure for On-Demand Provisioned Virtualized Infrastructure Services"	May 23rd - 27th, 2011,	Philadelphia, USA	Researchers, Academics, Industry	>200	World
35	Presentation	UvA, i2CAT	Presentation: , "On-Demand Provisioning of Cloud and Grid based Infrastructure Services for Collaborative Projects and Groups"	May 23rd - 27th, 2011	Philadelphia, USA	Researchers, Academics, Industry	>200	World
36	Presentation	UvA, PSNC	Presentation: "BoF: Provisioning infrastructure services on-demand: beyond Grids and Clouds"	May 16th - 19th, 2011	Prague, Czech Republic	NREN, researchers, academic, industry	>500	EU, NREN, World
37	Presentation	AIT, IBBT, UEssex, NXW, SAP, i2CAT, Lyatiss, UvA, PSNC,	Presentation: "Power Considerations for ICT Sustainability: the GEYSERS Approach"	May 2011	Budapest, Hungary	Researchers, Academics, Industry	100	World

		TP						
38	Presentation	Lyatiss	Network virtualization: performance, sharing and applications	Ph.D dissertation at ENS, Lyon, May 2011	Lyon, France	Researchers, Ph.D students	50	France
39	Presentation	Lyatiss	Dynamically provisioned virtual infrastructures, specifications, allocation and execution	Ph.D dissertation ate ENS, Lyon, May 2011	Lyon, France	Researchers, Ph.D students	50	France
40	Presentation	AIT, IBBT, UEssex, NXW, SAP, i2CAT	ICTON 2011: Invited paper: “Energy Efficiency Considerations in Integrated IT and Optical Network Resilient Infrastructures”	June 2011	Stockholm, Sweden	Researchers, Academics, Industry	100	World
41	Presentation	Lyatiss	RESCOM Summer School: Invited Speaker	June 5th - 10th, 2011	La Palmyre, France	Researchers, Academics, Industry, Ph.D students	100	France
42	Workshop	TID	EC Event: Presented the GEYSERS NIPS in the workshop: "Cloud Services and Networks"	June 14th, 2011.	Brussels, Belgium	Researchers, Academics, Industry, Ph.D students	100	France
43	Presentation	AIT	ICTON 2011: Invited paper: "The Impact of Optical Wavelength Conversion on the Energy Efficiency of Resilient WDM Optical Networks”	June 2011	Stockholm, Sweden	Researchers, Academics, Industry	60	World
44	Conference	IBBT	Article in ICC 2011 Proceedings: Title: "Survivable optical grid dimensioning: anycast routing with server and network failure protection", Proc. IEEE International Conference on Communications	June 5th - 9th, 2011	Kyoto, Japan	Researchers, Academics, Industry	100	World
45	Conference	IBBT	16th IEEE: Article in the Proceedings of the 16th IEEE International Workshop on Computer Aided Modeling, Analysis and Design of Communication Links and Networks (CAMAD 2011), pp. 87-91 Title: “Design and Implementation of a Simulation Environment for Network Virtualization"	June 10th - 11th, 2011	Kyoto, Japan	Researchers, Academics, Industry	100	World
46	Conference	Lyatiss	Structure 2011, Participant	June 22nd - 23rd, 2011	San Francisco, USA	Researchers, Academics, Industry	100	World
47	Presentation	UvA	ISOD-RG meeting at OGF32, Standardization meeting and workshop	July 15th - 19th,	Salt Lake	Researchers, Academics,	1000	World

				2011	City, USA	Industry		
48	Conference	IBBT, AIT	IEEE: Article in the Proceedings of the IEEE International Conference. On Computer Communications and Networks (ICCCN 2011). Title: “Calculating the minimum bounds of energy consumption for cloud networks"	July 31st - August 4th, 2011	Maui, Hawaii	Researchers, Academics, Industry	1000	World
49	Presentation	Z. Zhao, A. Taal, P. Grosso, Cees de Laat, UvA	IEEE International Conference on Network and Storage: Paper Presentation: "Resource discovery in large scale network infrastructure”	August 28th - 30th, 2011	Dalian, Lianong China	Researchers, Academics, Industry	100	World
50	Presentation	UvA, i2CAT, Lyatiss	OGF33 ISOD-RG Workshop and meeting: Presentations, contributions	September 19th - 21st, 2011	Lyon, France	Researchers, Academics, Industry	30-80	World
51	Conference	AIT	ECOC’2011 Conference paper, poster: “Energy Aware Planning of Multiple Virtual Infrastructures over Converged Optical Network and IT Physical Resources”	September 2011	Switzerland	Researchers, Academics, Industry	>1000	World
52	Conference	AIT: A. Tzanakaki, M.P. Anastasopoulos, K. Georgakilas	ECOC’ 2011: Conference paper, poster: “Evolutionary Optimization for Energy Efficient Service Provisioning in IT and Optical Network Infrastructures”	September 2011	Switzerland	Researchers, Academics, Industry	>1000	World
53	Conference	A. Tzanakaki, Juan Pedro Fernandez-Palacios	ECOC’ 2011: Organization and chairing of the GEYSERS-MAINS workshop on "Convergence of Optical Networks and Clouds”	September 2011	Switzerland	Researchers, Academics, Industry	>1000	World
54	Conference	S.Peng, R. Najabati, S. Azodolmolky, E. Escalona, D.Simeonidou, UEssex	ECOC’ 2011: Paper presentation: "An Impairment-aware Virtual Optical Network Composition Mechanisms for Future Internet"	September 2011	Switzerland	Researchers, Academics, Industry	>1000	World
55	Presentation	IRT	IDC Cloud Symposium: Speaker at a round table	September 21st, 2011	Milan, Italy	Researchers, Academics. Industry	>1000	World
56	Presentation	UvA	OGF33: ISOD-rg Meeting Presentation: "Dynamic Access Control Infrastructure for On-demand Provisioned Cloud Services	September 2011	Lyon, France	Researchers, Academics. Industry	>100	World
57	Workshop	AIT	Green Corss Cluster EU workshop:	October 2011	Brussels,	Researchers,	>100	World

			"Energy Efficiency Considerations in Converged Optical Network and IT Infrastructures"		Belgium	Academics. Industry		
58	Presentation	NXW	STRONGEST project: Presented "GEYSERS: Network Control Plane evolution and Infrastructure Virtualization for energy efficiency" held at Green Telecommunications Workshop	October 18th, 2011.	Pisa, Italy	Researchers, Academics. Industry	>100	World
59	Conference	M. P. Anastasopoulos, A.Tzanakaki, K. Georgakilas	IEEE CloudCom: Paper Presentation "Virtual Infrastructure Planning in Elastic Cloud Deploying Optical Networking"	November 2011	Athens, Greece	Researchers, Academics. Industry	>100	World
60	Conference	UvA	SC2011: Exhibition and demo	November 12th - 18th, 2011	Seattle, Canada	Researchers, Academics. Industry	>1000	World
61	Workshop	Y. Demhenko	NetCloud 2011: This workshop was co-organized by GEANT3, GEYSERS and NOVI projects and is highly relevant to NREN's activity	November 29th - December 1st, 2011	Athens, Greece	Researchers, Academics. Industry	>100	World
62	Publication	M. P. Anastasopoulos, A. Tzanakaki, K. Georgakilas	OSA Optics Express: Publication: "Evolutionary Optimization for Energy Efficient Service Provisioning in IT and Optical Network Infrastructures"	December 2011		Researchers, Academics. Industry	>1000	World
63	Publication	M. P. Anastasopoulos, A. Tzanakaki, K. Georgakilas, D. Simeonidou, "	OSA Optics Express: Publication: "Energy Aware Planning of Multiple Virtual Infrastructures over Converged Optical Network and IT Physical Resources"	December 2011		Researchers, Academics. Industry	>1000	World
64	Presentation	IBBT	ICNC: Paper Presentation: *Isolation and Resource Efficiency of Virtual Optical Networks*	January 30th - February 2nd, 2012	Maui Hawaii, USA	Researchers, Academics, Industry	100s	World
65	Conference	i2CAT, NXW, UEssex	Conference Attendance only: Future Networks 9th FP7 Concertation Meeting, Brussels	February 13th-14th, 2012	Brussels	Researchers, Academics, Industry	100s	World
66	Workshop	IBBT	Optical Networks: Invited Talk: *An Integrated Network and IT Control Plane for Cloud Computing*	March 9th, 2012	UC Davis, USA	Academia	100s	USA
67	Conference	AIT	OFC 2012: Paper Presentation:	March 2012	Los	Researchers,	100s	World

			Stochastic Virtual Infrastructure Planning in Elastic Cloud Deploying Optical Network		Angeles, USA	Academics, Industry		
68	Presentation	i2CAT, UvA, IBBT, Lyatiss	Paper Presentation : Logical Infrastructure Composition Layer, the GEYSERS Holistic Approach for Infrastructure Virtualisation	March 9th, 2012	Iceland	Researchers, Academics, Industry	100s	World
69	Conference	UEssex	OFC 2012: Paper Presentation: *Virtual Optical Network Composition over Single-Line-Rate and Mixed-Line-Rate WDM Optical Networks*	March 2012	Los Angeles, USA	Researchers, Academics, Industry	100s	World
70	Conference	AIT	ONDM 2012: Paper presentation: "Adaptive Virtual Infrastructure planning over Interconnected IT and Optical Network Resources using Evolutionary Game Theory"	April 17th - 20th, 2012	Colchester, UK	Researchers, Academics, Industry	>50	World
71	Standardization	Nicola Ciulli	IETF 83: Standardization Activity	March 25th - 30th 2012	Paris, France	Researchers, Academics, Industry	>100	World
72	Presentation	X. Chen, A. Jukan, A. Gumaste	Paper Presentation: ONDM On the Usage of FDLs in Optical Parallel Transmission to Support High Speed Ethernet	April 17th - 20th, 2012	Colchester, UK	Researchers, Academics, Industry	>50	World
73	Presentation	S.. Peng, R. Nejabati, E. Escalona, D. Simeonidou, A. Tzanakaki, M. Anastasopoulos	Paper Presentation: ONDM Performance Modelling and Analysis of Dynamic Virtual Optical Network Composition	April 17th - 20th, 2012	Colchester, UK	Researchers, Academics, Industry	>50	World
74	Presentation	i2CAT: S. Figuerola, Martel: M. Potts, UEssex/UBristol: D. Simeonidou	Paper Presentation: Future Internet Assembly (FIA)	May 10th - 11th, 2012	Aalborg, Denmark	Researchers, Academics, Industry	>50	World
75	Presentation	i2CATT, UvA, iMinds/IBBT, Lyatiss	Paper Presentation: TERENA Networking Conference (TNC 2012), Logical Infrastructure Composition Layer, the GEYSERS Holistic Approach for Infrastructure Virtualisation	May 21st - 24th, 2012	Reykjavik, Iceland	Researchers, Academics, Industry	>50	World
76	Presentation	M. Ghijsen, J. van der Ham, P. Grosso, & C. de Laat, UvA	Paper Presentation: International Conference on Optical Internet (COIN2012) Towards an Infrastructure Description Language for Modeling	May 29th - 31st , 2012	Yokoham, Japan	Researchers, Academics, Industry	>50	World

			Computing Infrastructures					
77	Workshop	IBBT	IEEE Int. Conference ICC 2012: Resilient network dimensioning for optical grid/clouds using relocation (Invited Paper and presented at Workshop)	June 11th, 2012	Ottawa, Canada	Researchers, Academics, Industry	30	World
78	Workshop	AIT, UEssex	ETSI workshop: Presented the poster: "Energy Efficiency and CO2 Emissions Considerations in Integrated IT and Optical Network Infrastructures"	June 21st - 22nd, 2012	Genoa, Italy	Researchers, Academics, Industry	30	World
79	Standarization	i2CAT, UVA, UEssex	OGF35: Standardization Activity	June 17th - 19th, 2012	Delft, Netherlands	Researchers, Academics, Industry	100	World
80	Presentation	i2CAT, UESSEX, iMinds/IBBT	Paper Presentation: 17th European Conference on Network and Optical Communications (NOC 2012) Converged IT and Optical Network Virtualisation: the Last (Clean-)Step towards the Future Internet Infrastructure Management In Proc. Eur. Conf. on Netw. and Optical Commun	June 20th - 22nd, 2012	Spain	Researchers, Academics, Industry	100	World
81	Presentation	X. Chen, M. Chamania, A. Jukan, TUBS	Paper Presentation: 17th European Conference on Network and Optical Communications (NOC 2012) On the Effectiveness of Optical Parallel Transmission in IP Offloading	June 20th - 22nd, 2012	Spain	Researchers, Academics, Industry	100	Europe
82	Conference	IBBT	14th Int. Conference ICTON 2012: Selecting the best locations for data centres in resilient optical grid/cloud dimensioning (Invited Paper, but not with GEYSERS acknowledgment)	July 2nd - 5th, 2012	Coventry, UK	Researchers, Academics, Industry	200-300	World
83	Conference	IBBT	14th Int. Conference ICTON 2012: Invited Paper, but not with GEYSERS acknowledgment *Selecting the best locations for data centers in resilient optical grid/cloud dimensioning*	July 2nd - 5th, 2012	Coventry, UK	Researchers, Academics, Industry	200-300	World
84	Presentation	G. Landi, N. Ciulli, J. Buysse, K. Georgakilas, M. Anastasopoulos, A. Tzanakaki, C.	Paper Presentation: Future Network & Mobile Summit (FuNeMS) 2012 Service Level Management Convergence for Future Network Enterprise Platforms	July 4th - 6th, 2012	Berlin, Germany	Researchers, Academics, Industry	200-300	World

		Develder, E. Escalona, D. Parniewicz",						
85	Presentation	Nextworks, iMinds/IBBT, AIT, UEssex, PSNC	Paper Presentation: Future Network & Mobile Summit (FuNeMS) 2012 A Network Control Plane architecture for on-demand co-provisioning of optical network and IT services	July 4th - 6th, 2012	Berlin, Germany	Researchers, Academics, Industry	200-300	World
86	Presentation	A. Tzanakaki, M. P. Anastasopoulos, K. Georgakilas, J. A. Garcia-Espin, J. Ferrer Riera, S. Figuerola, M. Ghijsen, Y. Demchenko, C. T. A. M. De Laat, P. Vicat-Blanc, S. Soudan, F. Anhalt, S. Peng, E. Escalona, R. Nejabati, D. Simeonidou	Paper Presentation: Future Network & Mobile Summit (FuNeMS) 2012 Virtual Infrastructure Planning: The GEYSERS Approach	July 4th - 6th, 2012	Berlin, Germany	Researchers, Academics, Industry	200-300	World
87	Workshop	A. Tzanakaki, M. P. Anastasopoulos	Workshop on Cloud Networking – Technical and Business Challenges Future Network & Mobile Summit (FuNeMS) 2012 Planning Optimized Virtual Infrastructures over Converged Optical Network and IT Physical Infrastructures	July 4th - 6th, 2012	Berlin, Germany	Researchers, Academics, Industry	100	World
88	Presentation	A.-F. Antonescu, P. Robinson, L. M. Contreras-Murillo, J. Aznar, S. Soudan, F. Anhalt	Paper Presentation: 10th IEEE International Symposium on Parallel and Distributed Processing with Applications (ISPA 2012 Towards Cross Stratum SLA Management with the GEYSERS Architecture	July 10th - 13th, 2012	Madrid, Spain	Researchers, Academics, Industry	100	World
89	Workshop	TID, NXW	International Workshop on Cross-Stratum Optimization for Cloud Computing and Distributed Networked Applications	July 13th, 2012	Madrid, Spain	Researchers, Academics, Industry	100	World
90	Presentation	Demchenko, Y.,	Paper Presentation: 3rd International Conference on Cloud	July 22nd –-27th,	Nice,	Researchers,	100	World

		C.Ngo, M.Makkes, R.Strijkers, C. de Laat	Computing, GRIDs, and Virtualization (Cloud Computing 2012) Defining Inter-Cloud Architecture for Interoperability and Integration. ISBN: 978-1-61208-216-5	2012	France	Academics, Industry		
91	Presentation	C.Ngo, P. Membrey, Y.Demchenko, C. de Laat	Paper Presentation: 7th ARES conference (ARES 2012) Policy and Context Management in Dynamically Provisioned Access Control Service for Virtualised Cloud Infrastructures	August 20th - 24th, 2012,	Prague, Czech Republic	Researchers, Academics, Industry	100	World
92	Conference	IBBT	Photonics in Switching 2012: Invited Talk *Designing resilient optical grids/clouds*	September 11th - 14th, 2012	Ajaccio, France	Researchers, Academics, Industry	>200	World
93	Conference	AIT	ECOC 2012: Poster Presentation *Virtualization over Converged Wireless, Optical and IT elements in Support of Resilient Cloud and Mobile Cloud Services*	September 16th - 20th, 2012	Amsterdam, Netherlands	Researchers, Academics, Industry	>1000	World
94	Conference	S. Peng, R. Nejabati, E. Escalona, D. Simeonidou	ECOC 2012: *Virtual Optical Network Composition over Mixed-Line-Rate and Multiple-Modulation-Format WDM Networks*	September 16th - 20th, 2012	Amsterdam, Netherlands	Researchers, Academics, Industry	>1000	World
95	Presentation	Giorgio Parladori	Conference Paper: NETWORKS 2012. Energy Efficiency in Optical Networks	October 15th - 18th, 2012	Rome, Italy	Researchers, Academics, Industry	50	World
96	Presentation	P. Donadio	Conference Paper: NETWORKS 2012. Network Virtualization and Cloud Computing	October 15th - 18th, 2012	Rome, Italy	Researchers, Academics, Industry	50	World
97	Presentation	Shuping Peng, Reza Nejabati, D. Simeonidou, UNIVBRIS	Presentation: *Impairment-aware Optical Network Virtualization*, Photonics Hyperhighway workshop	October, 2012	Southampton, UK.	Researchers, Academics, Industry	>100	World
98	Presentation	Participant: C. Develder	Invited talk: Jacques Cartier : Colloquium on "Towards ecological and energy efficient Information and Communication Technology"	November 19th - 20th, 2012	France	Researchers, Academics, Industry	>50	France
99	Presentation	Y.Demchenko	Poster and Paper Presentation at 7th International Conference on Cooperation and Promotion of Information Resources in Science and Technology (COINFO2012)	November 24th - 26th, 2012	Nanjing, China	Researchers, Academics, Industry	>50	World
100	Conference	J. Buysse	IEEE Int. Conference: Poster Presentation: On the viability of a CSO	November 28th -	Paris,	Researchers,	>50	World

			Architecture for on-demand virtualized Cloud Planning and Provisioning	30th, 2012	France	Academics, Industry		
101	Presentation	C. Ngo, Y.Demchenko, C. de Laat, UvA	Paper: 4th IEEE International Conference on Cloud Computing Technology and Science (IEEE CloudCom 2012) Toward a Dynamic Trust Establishment Approach for Multi-provider Intercloud Environment	December 3rd - 6th, 2012	Taiwan, Tapei	Researchers, Academics, Industry	>50	World
102	Conference	A.-F. Antonescu, P. Robinson, T. Braun	Paper: Dynamic Topology Orchestration for Distributed Cloud-Based Applications	December 3rd - 6th, 2012	UK	Researchers, Academics, Industry	>50	World
103	Presentation	A. Shankar, D. Bhamare, A. Gumaste and M. Krishnamoorthy	Paper Presentation: Optimizing Transport Technology Choices for Virtual Machines (VMs) in Data-Center and Cloud Environments	February, 2013	Kanpur, India	Researchers, Academics, Industry	>50	World
104	Standardization	TID, Nextworks	IETF Internet Draft: Cross Stratum Optimization enabled Path Computation v03	February, 2013		Researchers, Academics, Industry	100s	World
105	Presentation	A. Tzanakaki, M. P. Anastasopoulos, K. Georgakilas	Paper: Dynamic and Adaptive Optical Networks	March 9th - 13th, 2013	San Francisco, USA	Researchers, Academics, Industry	>50	World
106	Conference	UEssex, AIT	Invited Talk: Optical Fiber Communication Conference (OFC/NFOEC 2013	March 18th - 13th, 2013	Los Angeles, California	Researchers, Academics, Industry	>50	World
107	Presentation	Y. Demchenko, C. Ngo, C. de Laat, J.A. Garcia-Espin, S. Figuerola, J. Rodriguez, L.M. Contreras, G. Landi, N. Ciulli	Paper: The 27th IEEE International Conference on Advanced Information Networking and Applications (AINA-2013) Intercloud Architecture Framework for Heterogeneous Cloud based Infrastructure Services Provisioning On-Demand	March 25th - 28th 2013,	Barcelona, Spain	Researchers, Academics, Industry	>50	World

3.7 List of all future dissemination activities

TEMPLATE A3: LIST OF FUTURE DISSEMINATION ACTIVITIES								
No.	**Type of activities**	**Main leader**	**Title**	**Date/Period**	**Place**	**Type of audience**	**Size of audience**	**Countries addressed**
1	Presentation	(TUBS)X. Chen, A. Jukan, (IIT) A. Gumaste	Paper to be published in the proceedings Mini Conference IEEE INFOCOM 2013 Multipath De-fragmentation: Achieving Better Spectral Efficiency in Elastic Optical Path Networks	April 14th - 19th, 2013	Torino, Italy	Researchers, Industry	50	World
2	Conference	A.-F. Antonescu, P. Robinson, T. Braun	Conference Paper: Dynamic SLA Management with Forecasting using Multi-Objective Optimizations	May 27th - 31st, 2013	Ghent, Belgium	Researchers, Industry	200	World
3	Conference	(TUBS) X. Chen, Y. Zhong, A. Jukan	IEEE ICC'2013 Conference Paper: Dynamic SLA Management with Forecasting using Multi-Objective Optimizations	June 9th - 13th, 2013	Budapest, Hungary	Researchers, Industry	50-60	World
4	Conference	(TUBS) X. Chen, Y. Zhong, A. Jukan	NOC/OC&I 2013 Paper to be included in the proceedings Multipath Routing in Path Computation Element (PCE): Protocol Extensions and Implementation	July 10th - 12th, 2013,	Graz, Austria,	Researchers, Industry	100	World

Section B (Confidential or public: confidential information to be marked clearly)

Part B1

3.8 List of applications for patents

TEMPLATE B1: LIST OF APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS, ETC.					
Type of IP Rights:	Confidential Click on YES/NO	Foreseen embargo date	Application reference(s)	Subject or title of application	Applicant (s) (as on the application)
Patent	Yes	19/10/2012	P201231621	Método y sistema para manejar información de IT relacionada con servicios informáticos en la nube.	Telefónica S.A.
Patent	Yes	13/12/2012	EP12382501	System, Method and live streaming optimizer server for live content distribution optimization over a content delivery network	Telefónica S.A.

4 Report on societal implications

Replies to the following questions will assist the Commission to obtain statistics and indicators on societal and socio-economic issues addressed by projects. The questions are arranged in a number of key themes. As well as producing certain statistics, the replies will also help identify those projects that have shown a real engagement with wider societal issues, and thereby identify interesting approaches to these issues and best practices. The replies for individual projects will not be made public.

A General Information *(completed automatically when **Grant Agreement number** is entered.*	
Grant Agreement Number:	248657
Title of Project:	GEYSERS
Name and Title of Coordinator:	Matteo Biancani, IRT

B Ethics	
1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	***No***
2. Please indicate whether your project involved any of the following issues (tick box) :	
RESEARCH ON HUMANS	
• Did the project involve children?	
• Did the project involve patients?	
• Did the project involve persons not able to give consent?	
• Did the project involve adult healthy volunteers?	
• Did the project involve Human genetic material?	
• Did the project involve Human biological samples?	

• Did the project involve Human data collection?	
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	
• Did the project involve Human Foetal Tissue / Cells?	
• Did the project involve Human Embryonic Stem Cells (hESCs)?	
• Did the project on human Embryonic Stem Cells involve cells in culture?	
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	
PRIVACY	
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	
• Did the project involve tracking the location or observation of people?	
RESEARCH ON ANIMALS	
• Did the project involve research on animals?	
• Were those animals transgenic small laboratory animals?	
• Were those animals transgenic farm animals?	
• Were those animals cloned farm animals?	
• Were those animals non-human primates?	
RESEARCH INVOLVING DEVELOPING COUNTRIES	
• Did the project involve the use of local resources (genetic, animal, plant etc)?	
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	
DUAL USE	
• Research having direct military use	
• Research having the potential for terrorist abuse	

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator		1
Work package leaders	3	6
Experienced researchers (i.e. PhD holders)	6	10
PhD Students	3	10
Other	5	11

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	**15**
Of which, indicate the number of men:	11

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project?

○	Yes
X	No

6. Which of the following actions did you carry out and how effective were they?

	Not at all effective				Very effective
❑ Design and implement an equal opportunity policy	○	○	○	○	○
❑ Set targets to achieve a gender balance in the workforce	○	○	○	○	○
❑ Organise conferences and workshops on gender	○	○	○	○	○
❑ Actions to improve work-life balance	○	○	○	○	○

○ Other:

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

○ Yes- please specify

X No

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

○ Yes- please specify

X No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

X Yes- please specify Website: www.fp7-geysers.eu, Videos newsletters

○ No

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

○ Main discipline[7]:

○ Associated discipline[7]: ○ Associated discipline[7]:

[7] Insert number from list below (Frascati Manual).

G Engaging with Civil society and policy makers

11a Did your project engage with societal actors beyond the research community? *(if 'No', go to Question 14)*	○ X	Yes No

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

- ○ No
- ○ Yes- in determining what research should be performed
- ○ Yes - in implementing the research
- ○ Yes, in communicating /disseminating / using the results of the project

11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	○ ○	Yes No

12. Did you engage with government / public bodies or policy makers (including international organisations)

- X No
- ○ Yes- in framing the research agenda
- ○ Yes - in implementing the research agenda
- ○ Yes, in communicating /disseminating / using the results of the project

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

- X Yes – as a **primary** objective (please indicate areas below- multiple answers possible)
- ○ Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
- ○ No

13b If Yes, in which fields?

Agriculture		Energy		Human rights	
Audio-visual and Media		Enlargement		Information Society	X
Budget		Enterprise		Institutional affairs	
Competition		Environment		Internal Market	
Consumers		External Relations		Justice, freedom and security	
Culture		External Trade		Public Health	
Customs		Fisheries and Maritime Affairs		Regional Policy	
Development Economic and Monetary Affairs		Food Safety		Research and Innovation	X
		Foreign and Security Policy		Space	
Education, Training, Youth		Fraud		Taxation	
Employment and Social Affairs		Humanitarian aid		Transport	

13c If Yes, at which level?

- ○ Local / regional levels
- ○ National level
- X European level
- ○ International level

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?		**3**
To how many of these is open access[8] provided?		
How many of these are published in open access journals?		
How many of these are published in open repositories?		
To how many of these is open access not provided?		**3**
Please check all applicable reasons for not providing open access:		
x publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available ❑ no suitable open access journal available ❑ no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access ❑ other[9]: ……		
15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*		**2**
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	**None**
	Registered design	**None**
	Other	**None**
17. How many spin-off companies were created / are planned as a direct result of the project?		**1 - Lyatiss**
Indicate the approximate number of additional jobs in these companies:		**2**

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

❑	Increase in employment, or	❑	In small & medium-sized enterprises
❑	Safeguard employment, or	x	In large companies
❑	Decrease in employment,	❑	None of the above / not relevant to the project
❑	Difficult to estimate / not possible to quantify		

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:* *24*
Difficult to estimate / not possible to quantify	❑

[8] Open Access is defined as free of charge access for anyone via Internet.
[9] For instance: classification for security project.

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

○ Yes X No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

○ Yes X No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

X	Press Release	X	Coverage in specialist press
X	Media briefing	❑	Coverage in general (non-specialist) press
❑	TV coverage / report	X	Coverage in national press
❑	Radio coverage / report	X	Coverage in international press
X	Brochures /posters / flyers	X	Website for the general public / internet
X	DVD /Film /Multimedia	X	Event targeting general public (festival, conference, exhibition, science café)

23 In which languages are the information products for the general public produced?

❑	Language of the coordinator		
x	Other language(s) (English)		

5 References

[i] M. Handley, " Why the Internet only just works", BT Technology Journal, Vol. 24, Nr 3, July 2006

[ii] B. Swanson, G. Gilder, "Estimating the Exaflood", http://www.discovery.org/a/4428, accessed 29th October 2008.

[iii] E. Desurvire, "Capacity demand and technology challenges for lightwave systems in the next two decades," JLT, Dec. 2006.