Optical Networking for Cloud Computing

Thomas M. Bohnert, Sergi Figuerola, Nicola Ciulli, Dimitra Simeonidou, Pascale Vicat-Blanc
SAP Research, i2CAT, Nextworks, University of Essex, INRIA
thomas.michael.bohnert@sap.com

Abstract: The vision of the GEYSERS project is to qualify optical infrastructure providers and network operators with a new architecture and by thus enabling them to enhance their traditional business operations towards true end-to-end Cloud Computing product offerings. Optical network infrastructure providers will compose logical infrastructures and rent them out to network operators; network operators will run cost-efficient, dynamic and mission-specific networks by means of integrated control and management techniques. On top of this GEYSERS develops Coud Computing extensions that allow high-end IT resources at users' premises to be fully integrated with the network services procedures, both at the infrastructure-planning and connection-provisioning phases. Following this vision, GEYSERS will specify and implement a novel optical-network architecture able to support 'Optical Network + Any-IT' resource provisioning seamlessly and efficiently and by thus conceive a true end-to-end Cloud Computing Infrastructure-as-a-Service framework that ranges beyond contemporary data-center confined Cloud Computing frameworks.

1. Introduction

Over the last 40 years, the Internet has grown into a huge interconnection of networks that provide connectivity to IT resources and people, hence becoming a central and critical tool for various facets of the society: industry, business, science, learning, health, leisure, etc. The extent of the Internet's growth and usage raises a number of critical issues associated with its design principles that need to be addressed before the Internet reaches its limits. It has to support applications that are ever more dynamic in nature and demanding in bandwidth and other requirements including quality of service, resilience, security, etc. Thus, the scale of information processing is increasing, from the current petabytes to the projected exabytes in networked storage at the end of the decade. Many emerging applications, sketching the Future 3D Internet, have huge and increasing capacity requirements in terms of bandwidth. Moreover, applications such as UHD IPTV, 3D games, virtual worlds, photorealistic telepresence in media, but also the ones coming from the Cloud Tsunami (Software as a Service), cause in-depth transformations in networks and IT infrastructures. These more sophisticated applications have new combined digital capacity requirements (storage and bandwidth, computing and bandwidth, etc.).

Another important issue is that the popularity of content and applications on the Internet is highly variable. The Future Internet needs to provide mechanisms that facilitate elasticity of resources with the aim to face the sporadic, unpredictable demands and support the exploding and dynamic behavior of services and applications. As a huge energy consumer, the Internet must be energy-conscious. Reducing the actual energy consumption and being able to efficiently use only what is strictly needed to process and transport data is important on many accounts, among which the ecological and financial aspects are the most prominent.

In this context, the development and support of applications that are critical for society and business (health, population protection, disaster planning, and finance) or for real-time communication require a highly reliable, secure and robust Internet, that is able to guarantee the quality of service requirements of these applications.

Finally, the Future Internet needs to form sustainable business model. In order to drive innovation, competition, and research, all actors of the value chain should be able to receive a fair share of the revenues. We believe that combining optical network technology with Cloud technology is key in addressing these issues.

2 The European project GEYSERS (Generalized architEcture for dYnamic infraStructure sERviceS)

It is now well known that the current Internet, with its best-effort approach, cannot deliver the emerging high-performance and high-capacity network-based services satisfactorily. Optical technology network seems to be the only solution to face these huge bandwidth requirements with high reliability, performance and low energy consumption. On another side, dynamic virtual infrastructure services delivery (Cloud approach) is the answer to the enterprises' needs in cost and resource usage optimization to remain competitive and profitable even when the demand is sporadic and unpredictable.

Indeed, resource sharing and Cloud computing provide the required elasticity, but the application of the same approach to network resources is still missing. The more sophisticated applications have strict and dynamic IT

resource requirements (e.g., automatic scaling up and down of computing and data repositories), which increases the needs in combined capacities for Internet service delivery as well as Cloud services (IaaS, PaaS, SaaS, etc.). The current decoupling between applications and network layers leads to inefficient resource utilization and over-provisioning, where the network connectivity is not tailored to the cloud dynamics. All of this creates a high need for an integrated approach namely the extension of the Infrastructure-as-a-Service paradigm to the optical network and IT infrastructure, both together. Realizing the convergence of the IT world with the optical network world will help bring revenues to all the actors involved in the value chain. “Premium” advanced network and IT managed services will ensure a future architecture for the Future Internet.

The European project GEYSERS (Generalized architEcture for dYnamic infraStructure sERviceS) aims at addressing these problems and explores this Holistic Vision for a Sustainable Future Internet. Its action is two-fold: designing a new architecture, with a new reference model, and then deploying it in a large scale pan-European testbed as a proof of concept. The project focuses on the following key points: **Virtualization of optical networks**, in order to address the huge capacity requirements in terms of bandwidth and limit energy consumption; **IaaS approach**, to open possibilities for new sustainable business models with new roles besides the current models of legacy telcos**; Enhancement of legacy control planes** to provide combined and dynamic service provisioning comprising optical networks and IT resources, to address the need for combined digital capacity and deal with the high reliability and SLAs delivery; **Development of novel interfaces to map applications’ SLA** (Cloud Computing) down to the infrastructure and provide on-demand virtual infrastructure services.

The new architecture defined by GEYSERS is orthogonal to the current Internet Protocol architecture and all transport protocols or mechanisms. GEYSERS layered architecture includes three separate functional planes and their associated requirements originate from different domains: physical infrastructure, virtual infrastructure, optical network and IT provisioning and control plane as well as application and services. The most prominent challenges addressed by the GEYSERS architecture are: I.) Network and IT resources virtualization, abstraction; II.) Virtual optical infrastructure and IT resource composition; III.) Seamless and integrated optical network and IT dynamic provisioning services; III.) Global optimization of virtual network and IT-resources for energy consumption and Green-IT considerations.

The support of the aforementioned (and those that are not mentioned in this abstract) architectural requirements generates new business models which are based on the dynamicity of resource ownership and the convergence of IT and network infrastructure provisioning. GEYSERS identifies four pillars for contextualizing the GEYSERS use cases. This is the **RORA model** - Resources (net + IT), Ownership (models), Roles and Actors - that directly impact its business models. This model is essentially make of, **Resources** (A seamless integration of IT- and network resources allows the provisioning of unified services to consumers, requiring a flexible, adaptive and dynamic association for heterogeneous resources); **Ownership** (The paradigm of ownership specifies the actions that a specific entity is able to perform over a set of physical resources, including secure credential management); **Roles** (A role in GEYSERS corresponds to the behavior of an entity participating in the end-to-end workflow of GEYSERS provisioning. GEYSERS enhances the current business models with specific roles that reflect the importance of virtualizing network and IT infrastructure); **Actor** (An entity taking part in a use case that may or may not interact with other entities that take one or several roles)

To prove the architecture's feasibility and efficiency in addressing the listed issues, these concepts are being implemented in prototypes which will be evaluated in a pan-European optical network interconnecting sets of IT resources as well as mini data centers. This testbed running the GEYSERS “control and management stack” will thus sketch this envisioned sustainable future Internet infrastructure, combining optical network technology with the Cloud paradigm.

2. Acknowledgement

GEYSERS is funded under the European Union's Seventh Framework Programme (FP7), project number 248657.