VOLUME 1
NUMBER 3

NOVEMBER 2010

The STRONGEST NEWSLETTER

Periodic newsletter based on views and achievements from the FP7 STRONGEST project

Hot topics

What's going on in STRONGEST?

From ECOC 2010

What's going on in STRONGEST?

STRONGEST completes its first nine months of activity. Its main objective is ***to design and demonstrate an evolutionary ultra-high capacity multilayer transport network, compatible with Gbit/s access rates, based on optimized integration of Optical and Packet nodes, and equipped with a multi-domain, multi-technology control plane.*** STRONGEST keeps studying: the utilization of the Path Computation Element for end-to-end path restoration in WSON networks; the development of multi-layer (MPLS-TP over WSON) dynamic routing algorithms for a unified Control Plane approach; the definition of burst based traffic aggregation and forwarding mechanisms for Ethernet L2 switching; the modelling of CAPEX and energy consumption in optical multilayer networks; and, finally, the behaviour of service set-up and tear-down. Concerning Control Plane, a case study focused on the technical comparison of different multi-domain routing approaches has been carried out and the performances of different architectures exploiting PCE-based solutions in multi-domain single/multi-carrier networks have been evaluated and compared. As regards end-to-end services and traffic admittance solutions, the novel concept of "Wholesale QoS domains" to enable a simple end-to-end QoS has been presented and a PCE architecture enabling effective TE metric abstraction schemes in multicarrier networks has been proposed. The architecture, exploiting both PCE and hierarchical OIF E-NNI routing, is particularly suitable for network scenarios where end-to-end services require strict delay constraints. All these studies have been essential for the preparation of several papers presented at ECOC 2010, as reported in the central pages of this issue of the newsletter, thus assuring an effective dissemination of STRONGEST outcomes.

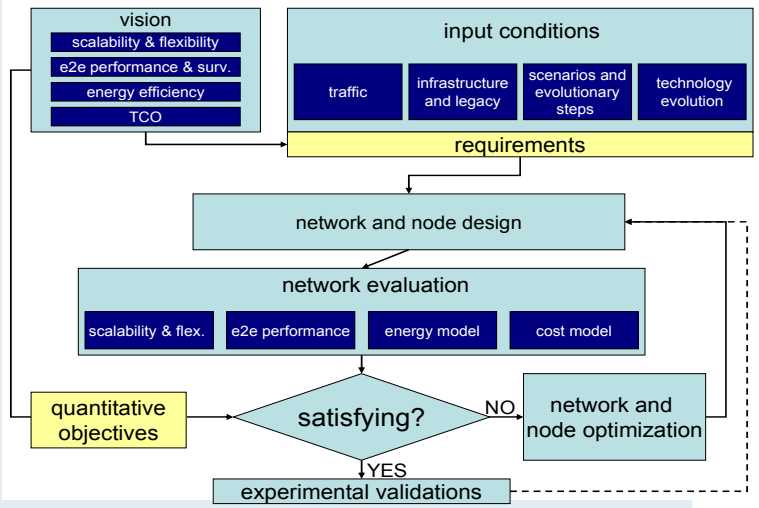
STRONGEST keeps studying the utilization of the Path Computation Element for end-to-end path restoration in WSON networks and the modelling of CAPEX and energy consumption in optical multilayer networks

Contents

STRONGEST working methodology

There are at least two reasons to run a research activity: the first one, more general, is to discover new things and to improve the knowledge we have about nature; the second one is more focussed to find solutions to existing or potential problems. STRONGEST research is mainly driven by the second stimulus. The problems that STRONGEST aims to address are the scalability of transport networks, their excessive energy consumption and high cost.

STRONGEST methodology to achieve its main objective, i.e. the design of an architecture assuring better scalability, reduced power consumption and lower cost, is depicted in the figure. In the early stage STRONGEST defines its own overall ***vision***, outlining the key items to work on. These items are then translated into numerical requirements by a detailed analysis process. In a parallel phase, the ***input conditions*** for the architectural studies are identified and summarized (traffic matrices, as produced by a proper traffic model; a survey of existing infrastructures and legacy networks, as supplied by STRONGEST carriers; the basic architectural steps, worked out according to the original Project vision, from the closer one to the most advanced; and, finally, a clear view of relevant technology evolution, as obtained by a continuous monitoring process). Infrastructure, basic architectures and traffic demands are the main ingredients that are required to provide a detailed ***network design***. Some tools and/or ***evaluation*** methods are then set up to assess the network with respect to scalability, flexibility, performance, energy consumption and cost. The outputs of this evaluation are subsequently compared with the previously defined ***quantitative objectives***.



STRONGEST activities flow-chart

After this assessment, further ***network and node optimization*** may be required, to bring quality parameters within the STRONGEST objective limits. At last the ***experimental validation*** of innovative network concepts and elements is envisaged, to verify the feasibility of the complete STRONGEST target architecture.

If you wish to get in touch with us, please contact: contact-strongest@ac.upc.edu.

From ECOC 2010

What's new for the STRONGEST scenario?

The European Conference and Exhibition on Optical Communication, one of the world-class scientific events in its field, held its 36th edition (ECOC 2010) in Torino, on September 19-23, 2010. More than one thousand professionals of the international technical community met in Torino to exchange and discuss the latest results and achievements produced by worldwide research.

Dealing with innovations in optical communication technologies, the ECOC scope is quite relevant to the STRONGEST objectives; indeed, the Project was deeply involved in this event through some of its partners, that co-chaired the conference and some sessions, and presented several technical papers. For those who did not attend, this brief report outlines the main outcomes of the conference relevant to STRONGEST objectives.

Network scalability and flexibility

The severe requirements set by the traffic growth and the opportunities offered by optical transmission in the future years to overcome the so called "capacity crunch" have been deeply debated in plenary talks, workshops, symposia and presentations. It is a common view that traffic will continue to scale at a rate larger than 50% per year, requiring the availability of multi-terabit/s capacity per optical fibre, while the beneficial effects (on bandwidth efficiency) of wavelength-division multiplexing are approaching their limits. This will lead, in the near future, to a transport bandwidth shortage.

From a transmission point of view, the introduction of 100 Gbit/s systems in the backbone seems nearly viable, and even competitive with 40 Gbit/s. Thanks to ITU-T and IEEE efforts, 100 Gbit/s standards are now available, for circuit and packet interfaces, respectively. Transmission technology is moving towards coherent detection (to overcome stringent constraints from CD, PMD and SNR) and spectrally efficient modulation formats, like QPSK and 16-QAM, to take full advantage of the finite fibre bandwidth.

Higher bit-rates, e.g. 400 Gbit/s or more, seem still far from practical exploitation. Yet, looking for ultimate transmission performance, several promising results of challenging "hero" experiments have been presented at the conference. For ultra long-haul: 112x112 Gbit/s transmission over 9360 km with 28 GHz spacing and coherent detection, resulting in a record spectral efficiency for trans-pacific distance. For ultra-high bit-rate: transmission of 448 Gbit/s over 1200 km, with all-ETDM generation of 224 Gbit/s per-polarization, and coherent detection. For ultra-high spectral efficiency: 512 QAM 54 Gbit/s coherent optical transmission over 159 km with an optical bandwidth of 4.1 GHz, demonstrating spectral efficiency of 12,4 bit/s/Hz thanks to multi-level modulation with very high multiplicity. For optical OFDM: transmission of a 16-QAM, 213.7Gb/s (189.7Gb/s without overhead) direct-detection optical OFDM super-channel over 720-km SSMF.

Besides, it has been emphasized by many authors that, further to increasing bit-rate and spectral efficiency, a complementary way to increase available capacity in optical networks relies on flexible fibre utilization, i.e. on dynamic allocation of bandwidth, data-rates and light paths, even with the possibility of dynamic configuration of channel spacing.

Finally, as regards optical fibre transmission properties, there is still some space for improving physical characteristics, but probably the most exciting perspective is offered, at present, by multi-core optical fibres, that promise to multiply by an order of magnitude the capacity of a single fibre, using a highly compact space division multiplexing approach.

End-to-end performance and survivability

The evolution towards innovative transport networks, assuring ultra-high capacity and being QoS aware, has been considered in several ways. Among others, the STRONGEST architectural vision for future metro and core networks has been presented, together with the migration steps and technical challenges towards the final architecture envisaged by the Project.

Also, an interesting benchmark of networking paradigms in core networks has been shown, comparing different advanced networking solutions against QoS parameters. In particular optical circuit switching (OCS), optical fast circuit switching (OFCS), optical burst switching (OBS), and clustered architectures for nodes in optical networks (CANON) have been considered and compared.

Finally, interesting experimental demonstrations of network control planes based on the path computation elements (PCE) approach have been presented.

Energy efficiency

The energy efficiency topic has been dealt with by some invited and regular papers. In general, it has been observed that, although IP backbone networks are not the most energy consuming segments, yet they will present, in the next years, the highest energy consumption growth rates (together with data centers), because of the steep traffic volume growth and the presence of power-hungry IP routers. Hence, optical bypass of routers is recognized as one of the key approaches towards more energy efficient backbones. Innovative concepts and solutions have been presented and described. Among others, for instance, a network topology design algorithm has been proposed and demonstrated to calculate energy optimal topologies, based on a concept that aims to reduce the power consumption of the network by aggregating traffic on specific links and powering off those conveying no traffic.

Cost reduction

One half day symposium has been devoted to techno-economic aspects and scenarios for the deployment of 100 Gbit/s coherent systems. Several operators have presented their experience in trialling, planning and installing high bit rate systems (40 Gbit/s, and then 100 Gbit/s, possibly coherent), that are considered quite appealing, from a technical point of view. Yet, depending on specific conditions (expected traffic growth, link lengths, coexistence with lower bit-rate earlier systems, transmission characteristics of existing fibers, availability or shortage of wavelengths) different opinions have been expressed on economics and deployment pressure for 100 Gb/s (coherent) transmission systems.

Technically, modulation formats and spectral efficiency are key issues to conveniently exploit the bandwidth of deployed fibres. As regards economics, not only the cost of transponders and muxponders has to be considered, but rather the WDM system as a whole, looking for a better usage of wavelengths, fibre, space and power.

As regards specifically the coherent option for 100 Gbit/s, it has clear advantages (with respect to the non-coherent one) in terms of longer hauls, and better PMD and CD tolerance, that result in possible savings in regenerators and dispersion compensators; yet, the system by itself is more complex, and likely more power consuming. So, the overall balance has to be carefully considered.

At present some operators feel comfortable with 40 Gbit/s in the long haul, with no pressure to deploy 100 Gbit/s in a short time, rather waiting for volumes development; others are inclined to skip the intermediate 40 Gbit/s step, looking directly for viable 100 Gbit/s (coherent?) solutions. For metro/regional applications 100 Gbit/s economics are much more critical, as cheaper solutions and components are still lacking.

From ECOC 2010

STRONGEST contributions to ECOC 2010

Evolutionary approach towards Ultra-High Capacity and QoS aware transport networks

J. Fernández-Palacios

One of the main concerns in the industry of the telecommunications is the development of a new network architecture to be deployed in the next years since current architectures would need high investments to scale in order to be able to support the Internet traffic growth. This paper describes the FP7 STRONGEST architectural vision for future metro and core networks as well as the migration steps and technical challenges towards the STRONGEST's final architecture.

Energy-Efficient Design of Wavelength-Routing Networks

A. Bianco, E. Bonetto, D. Cuda, G. Gavilanes Castillo, M. Mellia, F. Neri

We discuss the power-aware Logical Topology Design problem in wavelength routing networks, and analyze the economical impacts of power-efficiency. Results show that energy-optimized logical topologies can bring significant economical savings.

Lab-Trial of Multi-Domain Lightpath Provisioning with PCE Path Computation combining BRPC and Path-Key Topology Confidentiality in GMPLS Translucent WSON networks

R. Casellas, R. Martinez, R. Muñoz, T. Tsuritani, L. Liu, M. Tsurusawa

We present a lab-trial of lightpath provisioning for multi-area, OSNR-aware and GMPLS enabled WSON combining BRPC for path optimality with Path Keys for topology confidentiality. We quantitatively show its feasibility and performance such as the setup delay.

QoS Performance Benchmarking of Networking Paradigms in Core Networks

A. Stavdas, T. Orphanoudakis, A. Drakos

We benchmark OCS, OFCS, OBS and CANON against QoS parameters. The results demonstrate that sub-walength switching alone cannot guarantee efficiency. We show that CANON can simultaneously provide for both, statistical multiplexing gains and QoS guarantees outperforming the other paradigms.

Designated PCE Election Procedure for Traffic Engineering Database Creation in GMPLS Multi-Layer Networks

F. Cugini, N. Andriolli, G. Bottari, P. Iovanna, L. Valcarenghi, P. Castoldi

A Designated PCE (DP) election procedure for PCE Traffic Engineering Database creation and maintenance is proposed. A DP-based scheme is applied to improve the network stability and scalability while guaranteeing effective multi-layer Traffic Engineering performance.

Routing in Meshed and Clustered Optical Networks

C. (T.) Politi, V. Anagnostopoulos, A. Stavdas

The benefit of node clustering in optical networks regarding routing with PLI awareness is investigated under the CANON network architecture where regenerators are conveniently placed and routing is confined among a small subset of nodes.

Experimental Evaluation of Dynamic PCE-based Path Restoration with Centralized and Distributed Wavelength Assignment in GMPLS-enabled Transparent WSON networks

R. Munoz, R. Casellas, R. Martìnez

We experimentally assess the feasibility of PCE-based path computation for dynamic restoration, and evaluate the impact on the blocking probability, restorability and restoration delay of centralized (i.e., PCE-based) and distributed (i.e., destination-based) wavelength assignment strategies.

Optical Networks: How Much Power Do They Consume and How Can We Optimize This?

W. Vereecken, W. Van Heddeghem, B. Puype, D. Colle, M. Pickavet, Piet Demeester

Both bandwidth demand and energy consumption of ICT and communication networks is increasing and optical networks are regarded to provide high bandwidth solutions while enabling more energy efficiency. In this article we give an overview of energy consumption in access and core networks with a focus on optical technologies. Also, possible strategies to enable power reductions are discussed.

The EC view on Optical Networking

Andrew Houghton, Deputy Head of the Future Networks Unit (DG Information Society and Media, European Commission) closed the Symposium on Optical Networking with the presentation: "Optical Networking: Supporting the Digital Agenda and Future Broadband Services in Europe". In his talk Mr. Houghton described the importance of communication network infrastructure to support the achievement of European Union policy goals, economic growth and employment, highlighting that, in view of a future Internet running on a high-speed broadband optical fibre infrastructure, research is required to match the requirements of users, applications and services to the capabilities of the infrastructure.

Mr. Houghton also briefly outlined the FP7 Work Programme 2011-12 for Objective 1.1. "Future Networks", that will be focused on Call 8, whose planned date of publication is 26 July 2011 and expected deadline is 17 January 2012.

The Green Touch meeting

On September 21, in the same location as ECOC 2010, a meeting of "The Green Touch" initiative was held. The Green Touch is an open consortium, promoted by Alcatel-Lucent Bell Labs, aimed at identifying, in a 5 years time-frame, new network architectures and technologies that should improve the energy efficiency of telecommunication networks by a factor 1000. The consortium brings together telecom operators, manufacturers and academic bodies. Several STRONGEST partners (Alcatel-Lucent, Deutsche Telekom, CNIT, Telecom Italia, Telefonica Investigacion y Desarrollo) have been invited to the meeting, giving presentations relevant to "green" telecommunication networks and participating in a final panel session on the subject: "In what way can optics be used to create the largest increase in network energy efficiency?"

Collaborations

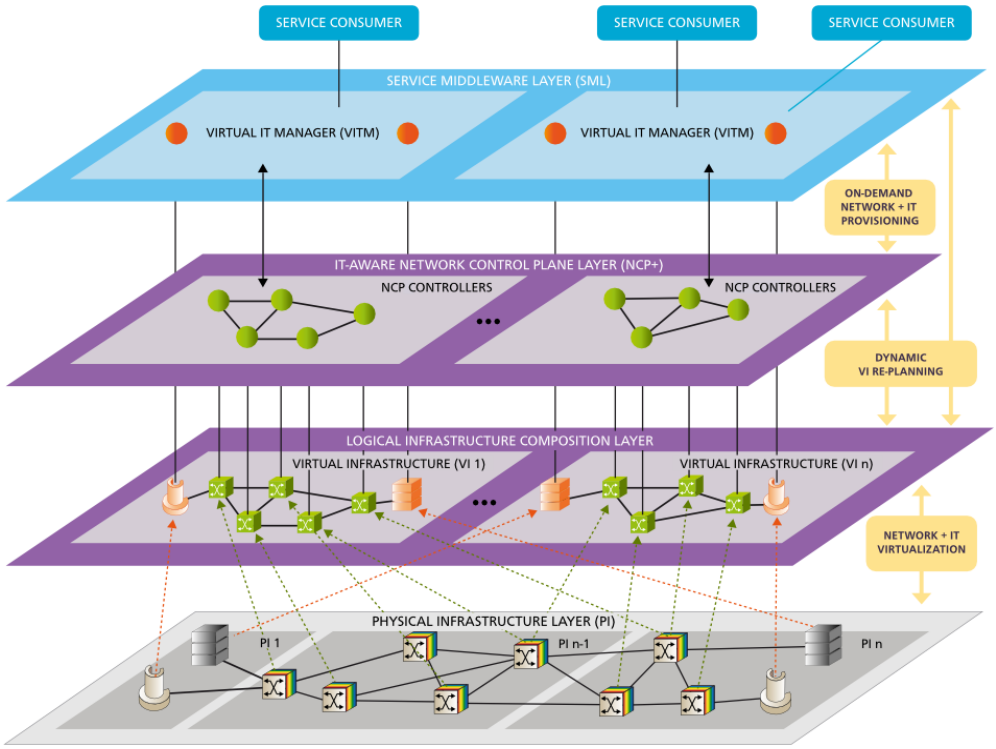
The GEYSERS Project

GEYSERS's vision is to qualify optical infrastructure providers and network operators with a new architecture, to enhance their traditional business operations. Infrastructure Providers will compose virtual infrastructures and rent them out to Virtual Infrastructure Operators, which will run cost-efficient, dynamic and mission-specific infrastructures by means of integrated control and virtualization management techniques.

The main objective of GEYSERS is 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 infrastructure providers and operators.*** To do so, GEYSERS will define and implement a novel architecture, capable of provisioning Optical Network and IT resources for end-to-end service delivery. GEYSERS proposes a revolutionary vision under an evolutionary approach that follows a network-centric and bottom-up strategy.

This vision is based on partitioning the photonic network infrastructure to create specific ***virtual infrastructures***, composed by optical network and IT resources at the edges. Each virtual infrastructure will be controlled by an ***enhanced Network Control Plane capable for the provisioning of Optical Network dynamic services coupled with IT resources***. Furthermore, the virtual composition of photonic networks will enable the enhanced GMPLS/PCE control plane to dynamically scale infrastructure resources (optical + IT) based on the needs of the Virtual Infrastructure Operator.

According to this vision of the future of telecoms,



GEYSERS "virtualized" architecture

GEYSERS specifies and implements a novel architecture able to support "Optical Network + Any-IT" resource provisioning seamlessly and efficiently. Energy-consumption metrics for the end-to-end service routing are part of this efficiency.

STRONGEST and GEYSERS: many points for potential collaborations:

- STRONGEST and GEYSERS work on control plane solutions based on GMPLS and PCE architectures
- Both projects focus on delivering energy efficient network solutions
- GEYSERS considers optical infrastructure in its Network + IT virtualization service architecture
  - GEYSERS can benefit from the knowledge developed within the STRONGEST about optical transport network technologies and technology evolution.
  - STRONGEST can take advantage of the optical layer virtualization capabilities developed within GEYSERS.
- The projects can investigate potential interoperability scenarios involving the STRONGEST core optical networks testbeds and the GEYSERS optical + IT virtualization and control tools.

Further information about the GEYSERS project are available at:

http://www.geysers.eu/

The main objective of GEYSERS is to define, develop and validate an end-to-end network architecture, based on extending standard ones, which is able to create, thanks to virtualization, a new planning, provisioning and (ultimately) business framework for infrastructure providers and operators. STRONGEST can take advantage of the optical layer virtualization capabilities developed within GEYSERS.

Outline

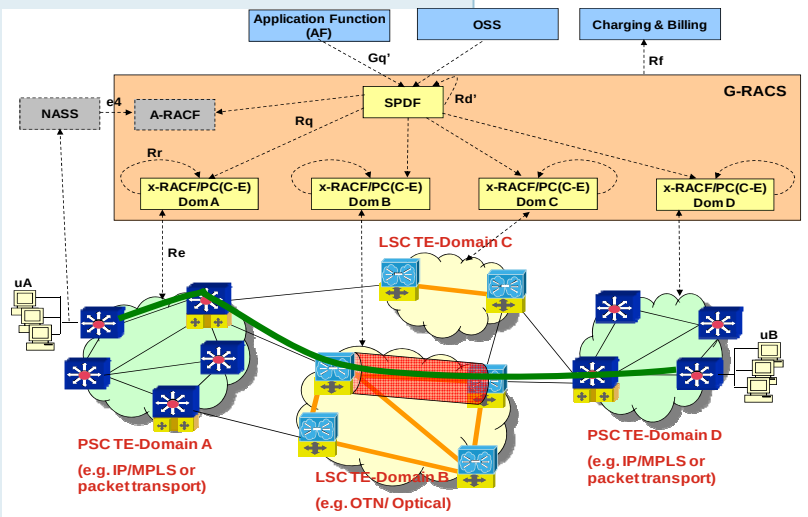
STRONGEST control plane architecture

In order to support innovative STRONGEST architectures, guaranteeing more scalability and lower cost per bit, two fundamental technical issues related to the control plane architecture are addressed by the Project, i.e.:

- Automated end-to-end service provisioning and QoS assurance by Resource and Admission Control Subsystem (RACS) and Path Computation Element (PCE) interworking.
- Scalable GMPLS-based control plane solutions in MPLS-TP/WSON networks composed by thousands of nodes.

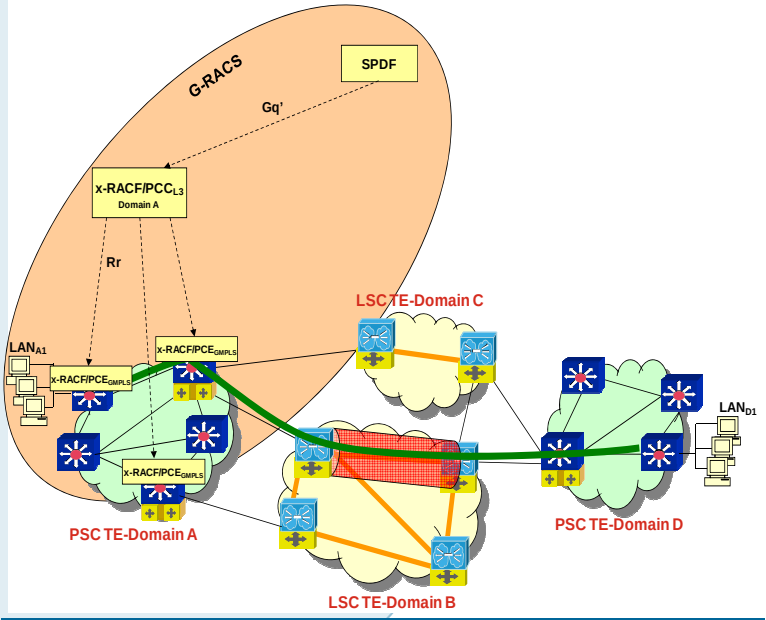
This architecture, based on the TISPAN RACS model, consists of a hierarchical PCE interacting with a GMPLS distributed control plane, both embedded in a wider control framework provided by either the ETSI TISPAN RACS or the 3GPP Policy and Charging Control (PCC). This solution extends the traditional PCE-based architecture, providing: an abstract interface towards applications, services and charging/OSS systems; admission and policy control services defined by both the operator and the subscribers; and an easier support of inter-domain and inter-carrier interworking and interoperability.

The functional elements constituting such architecture are the Service Policy Decision Function (SPDF) module and the integration of both the TISPAN x-RACF (Resource and Admission Control Function) and the PCE entities. The SPDF integrates different functions such as: providing the network topology and technology abstraction to the applications; interacting with the charging and OSS systems; interdomain/carrier communication; implementing a policy decision function; and coordinating multiple x-RACF/PCE modules for multi-domain and multi-layer path computation and resource admission control purposes. Beside managing the inter-domain path computation and resource admission control functions, the x-RACF/ PCE module is responsible for interfacing with the GMPLS-enabled control plane which automatically sets-up the connections. The x-RACF can be either fully centralized, fully distributed (in the network nodes), or partially distributed (with many x-RACF instances, organized in a tree structure, controlling the same network resource). ***The partially distributed x-RACF/PCEs option appears to be the most promising approach*** since it offers a layered view with a clear separation between the transport functions (distributed in the low-tier modules) and the service functions (implemented in the top-tier module). In the network architecture envisaged by the Project, the MPLS-TP and WSON technologies are the basis of a cost-efficient core network, compliant with the traffic volume future growth. In this scenario, however, the control plane scalability is the main constraint, due to the significant increase of both MPLS-TP and WSON nodes number. ***An effective solution relies on adequately segmenting the network topology in a multi-domain/multilayer infrastructure.*** Thus, several control plane issues (routing information; inter-domain path computation and signaling mechanisms; switching capabilities) need to be studied. In order not to jeopardize the control plane scalability and the domain confidentiality when routing must be carried out in multi-domain networks, an interesting approach considered by STRONGEST relies ***on the hierarchical routing, following both the OIF-ENNI Routing and the Hierarchical PCE (HPCE) approaches.*** These schemes use topology summarization and aim at simplifying the representation of the topology of each domain through reducing the number of nodes and links. However, the information required to perform end-to-end path computation with all the constraints and TE parameters is preserved. ***Dedicated routing controllers and/or PCEs are the preferred solutions to perform multi-domain path computation.*** Several PCE-based solutions are taken into account, sorted by complexity and communication between collaborating PCEs: the per-domain is the simplest solution wherein no communication exists between peering PCEs leading to attain suboptimal path computations; the Backward Recursive Path Computation (BRPC) technique involves more PCE collaboration and allows the computation of more optimized paths.



Functional elements constituting the G-RACS architecture

This architecture, based on the TISPAN RACS model, consists of a hierarchical PCE interacting with a GMPLS distributed control plane, both embedded in a wider control framework provided by either the ETSI TISPAN RACS or the 3GPP Policy and Charging Control



Partially distributed x-RACF deployment

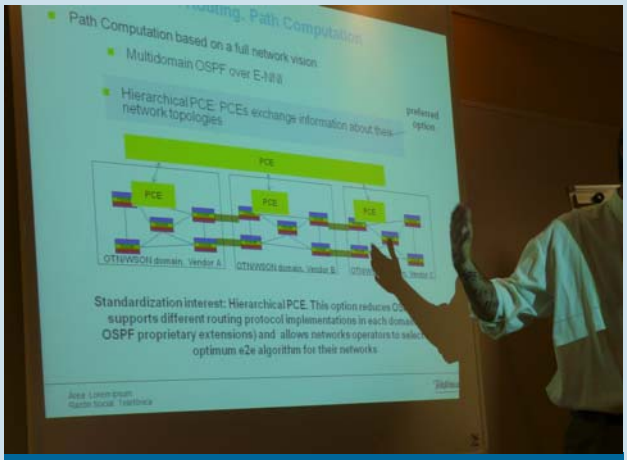
If you wish to get in touch with us, please contact: contact-strongest@ac.upc.edu.

Collaborations

CaON Cluster meetings

The Converged and Optical Networks (CaON) cluster met for an internal workshop in Stockholm (6th – 8th October), motivated by the need to create an informal environment to foster a fruitful exchange of views and ideas among Projects, and for its Concertation Meeting in Brussels (18th – 20th October). In both occasions STRONGEST fed the discussion with contributions about the evolution of metropolitan and backbone transport network architectures. The most important items discussed during the two meetings, with a different detail level, due to their different nature, were:

- ***Multi-domain and inter-carrier interworking***. STRONGEST, GEYSERS and MAINS proposed different architectures to cope with these specific interworking issues, especially at control plane level. STRONGEST, in particular, proposed its control architecture, based on the TISPAN RACS model, consisting of a hierarchical PCE interacting with a GMPLS distributed control plane. The cluster agreed that inter-carrier interworking is the key challenge for the evolution of networks control.
- ***Resource virtualisation and isolation.*** GEYSERS proposed to extend the virtualization concept to the infrastructure, while STRONGEST described the possible adoption of virtualization to achieve a complete decoupling between service level (client) and transport level (server).
- ***Power efficiency by multi-layer optimisation.*** The cluster recognized that, although IP backbone networks are not the most energy consuming segments, yet they will present, in the next years, the highest energy consumption growth rates (together with data centres). Hence the importance of paying significant attention to the development of power efficient transport networks.
- ***IT resources (e.g. data-centers; caching of cloud services) directly in core network.*** The discussion about this item focused on the diatribe between the centralization or distribution of data centers, in particular for achieving energy efficiency objectives. The answer to this issue is still open.



CaON workshop– discussion about hierarchical PCE

Events, participations and contributions

In the last three months STRONGEST had no plenary meetings. The Project actively partecipated in ECOC 2010 (Turin, Italy, Sep. 19 - 23), since several papers have been provided and presented under the STRONGEST umbrella.

STRONGEST also participated in the Converged and Optical Networks (CaON) cluster workshop held in Stockholm, October 6th - 8th, 2010, organized by the Cluster coordinator (M. Popov).

The workshop represented an informal discussion in preparation for the CaON official cluster meeting, held in Brussels (20th October). STRONGEST also had the opportunity to present its objectives and preliminary results to the *Photonics* (area *Communication Networks*) Concertation meeting 2010.

During the *Socio-Economics of the Network of the Future* workshop (Brussels, 18th October) STRONGEST actively participated with an invited statement in the discussion about *The price of quality in telecommunication network*, giving an overview of the end-to-end QoS assurance in transport networks.

STRONGEST submitted to the IEEE Communications Magazine a paper titled *STRONGEST Project: A Step-wise Roadmap for Future Converged, Packet-based Multilayer Architecture.*

In the near future

- Turin, 16th-18th November, 2010: STRONGEST third plenary meeting.
- STRONGEST will participate, at ONDM 2011, in a joint workshop with ICT MAINS, GEYSRES and ETICS with the presentation *Multilayer control plane architecture in MPLS-TP over WSON networks.*

Scalable, Tunable and Resilient Optical Networks Guaranteeing Extremely-high Speed Transport

STRONGEST

website: www.ict-strongest.eu

Partners: *Telecom Italia (IT), Alcatel-Lucent Deutschland (D), British Telecom (UK), CTTC (ES), CNIT (IT), Deutsche Telekom (D), Ericsson (IT), IBBT (BEL), Nokia Siemens Networks Germany (D), Telefonica (ES), Universitaet Stuttgart (D), Universitat Politècnica de Catalunya (ES), University of Essex (UK), University of Peloponnese (GR), VECOMM (IT), PrimeTel PLC (CY), Nokia Siemens Networks Israel (IS)*

Project Coordinator

Andrea DI GIGLIO

Telecom Italia S.p.A.

Email:andrea.digiglio@telecomitalia.it

Duration: *01/2010 – 12/2012*

INFSO-ICT *247674*

The research leading to these results has received funding from the European Community's Seventh Framework Programme FP7/2007-2013 under grant agreement n° 247674.