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Abstract:

This deliverables reports the joint activities planned within the WP22.

Keyword list: MPLS, GMPLS, BGP, Control Plane

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1. Executive Summary :

This deliverables reports the joint activities planned within the WP22. The different activities address some key research aspects in the evolution of IP-MPLS multi-service networks towards next generation all-optical networks.

Specifically, the first activity will deal with the Path Computation Element (PCE) architecture, which has the potential to provide effective Traffic Engineering (TE) solutions in single-domain, multi-domain and multi-layer networks.

The second activity will regard the extension of BGP in support of multi-domain Label Switched Path establishment with QoS and /or resilience/protection provisioning.

The absence of electrical regenerators in transparent WDM networks significantly contributes to reduce the overall network cost. In transparent WDM networks, a proper resource allocation requires to take into account the presence of physical impairments in Routing and Wavelength Assignment (RWA) and lightpath provisioning. The aim of the third research activity is to perform theoretical and experimental analysis on the signaling-based approach to encompass physical impairment parameters within the GMPLS protocol suite.

The fourth activity will investigate inter-domain protection mechanisms for a MPLS over GMPLS network scenario.

The major current challenges for the evolution of the Virtual Private LAN Service (VPLS) from a MPLS-based implementation to an eventual all optical GMPLS will be investigated in the fifth activity.

One of main challenges of wavelength routed networks is how to manage differentiated survivability mechanisms under network failure leading to achieve efficient network performance (e.g., resource usage, recovery time, availability). The sixth activity will focus on protection and restoration recovery schemes in Wavelength-Routed Networks (WRN) subject to the Wavelength Continuity Constraint (WCC).

The seventh activity will be devoted to resilience Issues in the GMPLS-enabled Control Plane. This because the control plane plays a key role in the proper operation of GMPLS-based optical networks, and thus its survivability emerges as a crucial issue. Particularly, the control plane not only gives support for routing and signalling messages, but also for the management information regarding already established transport plane connections.

The topics about QoS, control plane, resilience and survivability for PBT and T-MPLS networks will be investigated in the eighth research activity.

2. Planned Activities

In this Section, a detailed description of the joint activities defined within the framework of the WP22 is reported.

2.1 Joint Activity on the scalability of Path Computation Elements

The Path Computation Element (PCE) architecture has the potential to provide effective Traffic Engineering (TE) solutions in single-domain, multi-domain and multi-layer networks. However, several aspects of the current PCE Architecture have so far received limited attention, especially regarding scalability aspects and several implementation issues are still open.

The aim of this joint research activity is to perform theoretical and experimental studies on the current PCE Architecture specifications, such as PCEP protocol extensions and TE efficiency. Moreover, several PCE implementation issues will be investigated, with particular focus on scalability and interoperability problems.

In particular, the joint activity will encompass tasks such as:

- To conceptually propose heuristics and algorithms for path computation and wavelength assignment. This could encompass RWA for more than one (independent) metric, or the combination of a objective metric plus a "bounding"-like metric e.g. optimize TE metric with the second metric (e.g. hop count or whatever) remaining below a given threshold.
- To validate the proposed algorithm(s) in simulation environments, obtaining key performance indicators.
- To validate the proposed algorithm(s) in real networks deploying a PCE as per current IETF drafts and RFCs.
- To evaluate partner's prototypes and implementations in terms of scalability and performance.
- To propose adapted extensions addressing identified issues or drawbacks.

In this joint activity CTTC (Ramon Casellas, ramon.casellas@cttc.es), IKR (Sebastian Gunreben, sebastian.gunreben@ikr.uni-stuttgart.de) and AGH (Jacek Rzasa, rzasa@agh.edu.pl) will be involved, providing both common and complementary expertise and equipment.

The activity work will also consist on the integration of both simulation and real network experimental results. Specifically, combined tasks of proposing a theoretical algorithm, validating it in a simulator, and comparing the results with the implementation on a real PCE-enabled network, will be carried out.

The first year of the joint activity will focus on single-domain, single-layer optical network with a PC, to be extended to multi-layer networks on the second stage.

Joint publications on international major conferences and journals, such as ECOC conference, will be produced. There are no planned mobility actions for at least the first year.

2.2 BGP extensions for inter-domain TE in transport networks

There are two main aspects which will be the focus of this research activity – inter-domain QoS provisioning in an inter-carrier scenario and inter-provider policy exchange mechanisms for support of multi-domain transit LSP establishment.

The multi-domain LSP provisioning issue attracts a lot of attention in the past few years and poses numerous challenges to the existing protocols. Extending BGP seems like a natural next-step towards providing inter-domain QoS due to its ubiquitous usage in the Internet today and the unavoidable migration towards IP-based control plane under the GMPLS umbrella. Some of the issues to be solved are the QoS-related information dissemination via the BGP protocol and the possible scalability problems which might arise from simply extending the protocol with the needed information fields. An intelligent scheme for incorporating the QoS related information must be created in such a way that neither the scalability of the protocol nor its complexity will be compromised. Furthermore, TE-related features such as disjoint path computation must be included as well. All modifications and extensions of the protocol must be done in such a way that the strongest features of the protocol remain. Such one feature is the extended policy support offered by BGP and highly appreciated and used from service providers today.

The second aspect of this research activity will be to identify the different political aspects of TE-oriented interconnection between network operators. The interplay between policy-complying and QoS-supporting path selection is crucial. We will focus on designing such algorithm(s) which support both aspects. By using this approach the routing can be optimized to take into consideration both policy and QoS-related features which will result in decisions which jointly satisfy both the providers' requirements for lower OPEX and greater control of their connections, and the customers' requirements for qualitative services.

Furthermore, the applicability of the extended BGP protocol in existing and emerging multi-domain path computation architectures will be investigated.

In this joint activity COM-DTU (Anna Vasileva Manolova, avm@com.dtu.dk), AGH (Krzysztof Wajda, wajda@kt.agh.edu.pl), UC3M (Ricardo Romeral Ortega, rromeram@it.uc3m.es), and BME (Tibor Cinkler, cinkler@tmit.bme.hu) will be involved.

Both theoretical and experimental work will be conducted. The theoretically defined algorithms and extensions will be experimentally evaluated on either a real test-bed or in a software-developed environment such as OPNET or ns-2. Publications in major conference and journals are expected.

All partners will take part in at least one mobility action.

2.3 Enhancing GMPLS signaling protocol for encompassing Quality of Transmission (QoT)

The absence of electrical regenerators in transparent WDM networks significantly contributes to reduce the overall network cost. In transparent WDM networks, a proper resource allocation requires to take into account the presence of physical impairments in Routing and Wavelength Assignment (RWA) and lightpath provisioning. However, current GMPLS protocol suite does not encompass the evaluation of physical impairment parameters.

The aim of this joint research activity is to perform theoretical and experimental analysis on the signaling-based approach to encompass physical impairment parameters within the GMPLS protocol suite.

The two institutions involved in this Joint Activity provide complementary expertise:

- SSSUP (Filippo Cugini, filippo.cugini@cnit.it, Piero Castoldi castoldi@sssup.it) has ongoing theoretical and experimental activities on GMPLS control plane.
- FT (Esther Le Rouzic, esther.lerouzic@orange-ftgroup.com) has expertise and ongoing studies on network planning and impairment parameters that affect the lightpath Quality of Transmission (QoT).

Joint publications on international optical networking journals are expected.

2.4 MPLS-ASON/GMPLS Interconnection

In this activity, we consider a scenario with MPLS islands belonging to the same MPLS domain connected through one ASON/GMPLS domain (the opposite situation is also possible due to maturity of MPLS concept used ofen in backbone). We assume that MPLS and ASON/GMPLS network are managed by different operators; therefore, we are in a multi-domain scenario. The exchange of topology information between client and server networks has to be restricted, due to administrative and security reasons. Hence, the overlay model, designed for a business model in which one optical core operator lease its network facilities to Internet service providers (ISPs), should be applied.

Both network technologies, MPLS and ASON/GMPLS, provide intra-domain recovery mechanisms able to recover LSPs from failures over resources strictly in that domain. For example, in MPLS fast reroute mechanisms can be used to recover MPLS LSPs from failures in that network; whereas a wider variety of mechanisms have been proposed to be used in ASON GMPLS networks.

However, when a border node has failed, it is not clear how the different layers have to become coordinated and which domain has to provide the recovery mechanism. This case can be extended to a more general description in which when the server layer cannot provide the needed recovery after the detection of an intra-domain failure, it communicates this event to the client layer to provide recover in the client layer.

Therefore, the objectives of this activity are to define and test extensions in order to extend protection mechanisms already defined for the intra-domain scenario, to the multilayer and multi-domain scenario which has been presented. Moreover, specific analysis has to be done in the multi-domain diverse routing.

The main objectives of this joint activity are:

- Study how different domains can interchange data (tokens) about protection LSPs without sharing information. We will propose a standardized tokens and interchange mechanisms for these tokens
- Study the requirements to allow to a LSR signal a multi-domain LSP with availability restrictions (not just the type of protection LSP, not 1:1 or 1+1 protection solicitation). Propose needed extension to RSVP-TE to allow this inter-domain solicitations
- Extend RSVP-TE to allow automatic search for optical protection over a set of LSPs.

UPC (Salvatore Spadaro, spadaro@tsc.upc.edu), UC3M (Ricardo Romeral, rromeral@it.uc3m.es), AGH (Krzysztof Monist, Krzysztof Wajda, wajda@kt.agh.edu.pl) and FUB (Francesco Matera, mat@fub.it) will participate to this joint activity.

Both theoretical and experimental work will be done and publications in major conference (ECOC, ICTON) and journal (Journal on Optical Networking) are expected.

At least two mobility actions will be done, mainly to do experimental test-bed integration work.

2.5 Scalability issues in G/MPLS-based VPLS network design

A major current challenge for the evolution of the VPLS (Virtual Private LAN Service) from a MPLS-based implementation to an eventual all optical GMPLS one is solving the scalability problem that derives from the connection-oriented nature of this technology. One of the open questions is how to provide the LAN’s broadcast emulation in an efficient way given the fact that in principle there must be a different delivery tree per VPLS, which implicitly means that there must be LAN-specific forwarding information inside the core of the VPLS Service Provider network. This is a major design target of VPLS provisioning over connection-oriented networks: all VPN-specific information must remain in the edge nodes. Otherwise the state in core routers explodes. If this is a concern in MPLS, the problem is more complex in the optical case. The amount of lightpath switching entries is much more limited than in the electronic domain and so is the number of available optical multipoint units. Therefore, traffic engineering and grooming methods are necessary to take full advantage of optical technology in a cost-effective way.

Finally, if several optical service provider networks are involved, VPLS interconnection across multiple domains may require optical processing of stacked labels which is another open research issue. This JA will address all these issues and will study the alternatives, and will propose practical solutions to these questions.

UC3M (David Larrabeiti, dlarra@it.uc3m.es) and FUB (Francesco Matera, mat@fub.it) will participate to this joint activity.

Both theoretical and simulation studies will be carried out as well as practical assessment in testbed.

2.6 GMPLS-based RWA algorithms for optical protection/restoration

One of main challenges of wavelength routed Networks is how to manage differentiated survivability mechanisms under network failure leading to achieve efficient network performance (e.g., resource usage, recovery time, availability). In this Joint Activity, we specifically focus on protection and restoration recovery schemes in Wavelength-Routed Networks (WRN) subject to the Wavelength Continuity Constraint (WCC).

In GMPLS networks, upon reception of a connection request, the source node executes a constraint shortest path first (CSPF) algorithm to find two feasible end-to-end link-disjoint working and backup paths, considering as input the topology and network resource state collected in the traffic engineering database (TED). Indeed, GMPLS routing protocols (e.g., Open Shortest Path First - Traffic Engineering, OSPF-TE [IETF RFC 4203]) flood any change occurring in that network state, which permits nodes to maintain a detailed view of current network topology and resource availability. Standard GMPLS routing protocols flood TE link attributes at bandwidth granularity (unreserved bandwidth and maximum supported bandwidth) in bytes/sec. Apart from that, in order to ensure link-disjointness between working and backup paths, the shared risk link group (SRLG) concept is disseminated as a TE link attribute.

The lack of per-wavelength channel granularity dissemination restricts the CSPF computation when facing up the wavelength assignment (especially under the WCC restriction) which is addressed by the signalling protocol (i.e., Resource Reservation Protocol - Traffic Engineering, RSVP-TE [IETF RFC 3473]). In particular, through the Label Set object which aims at collecting available wavelengths contiguous from source to destination nodes along the computed path. Next, the selected channel from the received Label Set (e.g., through a random heuristic) is notified to the rest of nodes through the Generalized Label object carried into the RSVP-TE Resv message traveling back to the source node along the same route.

In this context, neither standard GMPLS OSPF-TE nor RSVP-TE protocols convey the required routing and signaling information to deal with efficient distributed RWA algorithms and reservation protocols. This joint activity aims at:

- Proposing RWA algorithms and reservation protocols along with the required extensions to the current GMPLS RSVP-TE and OSPF-TE protocols addressing identified drawbacks.
- Validating the proposed GMPLS-based RWA mechanisms in simulation and real experimental environments.

CTTC (Raul Muñoz, raul.munoz@cttc.es), SSSUP (Isabella Cerutti, isabella.cerutti@sssup.it), UPCT (Pablo Pavon, pablo.pavon@upct.es) FUB (Francesco Matera, mat@fub.it), RACTI (Kyriakos Vlachos, kvlachos@ceid.upatras.gr), AIT (Anna Tzanakaki, atza@ait.edu.gr), KTH (Lena Wosinska, wosinska@kth.se) and COM-DTU (Sarah Ruepp, sr@com.dtu.dk) will participate to this joint activity.

Both simulation and real network experimental results will be provided and publications in international conferences (ICC 2009, ICTON 2009) and journals (Journal on Optical Networking) are expected.

No planned mobility action for the first year. However almost all partners have shown their interest in the mobility actions, fact that may lead to mobility exchange for the second year.

2.7 Resilience Issues in the GMPLS-enabled Control Plane

Because the control plane plays a key role in the proper operation of GMPLS-based optical networks, its survivability emerges as a crucial issue. Particularly, the control plane not only gives support for routing and signalling messages, but also for the management information regarding already established transport plane connections. Until now, great efforts have been made to enhance the resilience of the transport plane. Nonetheless, no mechanisms to deal with control plane failures have been proposed. In fact, the control plane has been typically transmitted in-fibre, which joins transport and control plane fault recovery mechanisms. In turn, GMPLS promotes the control plane to be transmitted out-of-fibre, which provides enhanced flexibility derived from the physical separation from the transport plane. However, in such a situation, new failure detection and recovery capabilities should be provided to the control plane, as control plane failures cannot be addressed by transport plane native mechanisms.

This activity is devoted to design and validate suitable failure detection and recovery mechanisms for the GMPLS-enabled control plane, achieving the resilience required for next-generation optical transport networks performance. In this context, the role of Link Management Protection (LMP) in the GMPLS control plane is extensively evaluated, giving answers to key issues not addressed by current standardization. In addition, the activity concentrates on the comparison amongst different control plane topologies from the reliability viewpoint. In fact, in GMPLS, control and transport plane configuations do not need to follow identical topologies. Therefore, it becomes important to qualify control plane topologies in terms of the grade of resilence they can offer.

UPC (Salvatore Spadaro, spadaro@tsc.upc.edu), AGH (Krzysztof Wajda (wajda@kt.agh.edu.pl), and BME (Tibor Cinckler, cinkler@tmit.bme.hu) will taje part of this activity.

Publications in international conferences (ONDM 2009, ICTON 2009) and journals (Photonic Network Communications) are expected.

2.8 Carrier Ethernet Transport

Ethernet as a transport technology has, up to now, lacked the features such as network layer architecture, customer separation and manageability that carriers require for wide-scale deployment. However, with the advent of PBB-TE and T-MPLS, it is now possible to use Ethernet as a transport technology, making the use of Ethernet as a convergence layer for Next Generation Networks a distinct possibility. Triple Play services, in particular IPTV, are expected to be main drivers for this development, however, a number of challenges must be addressed and a number of enhancements are still required for PBT-TE and T-MPLS to make them ready for large scale triple play deployments. Main areas for further research are:

1) QoS and control plane: For PBT and T-MPLS, a dynamic control plane is a key area for future development. Today, the technologies deliver managed end-to-end connections similar to SHD/SONET but new demanding applications in terms of quality and bandwidth would require control plane actions to guarantee proper behaviour of the application. To develop dynamic a carrier Ethernet control plane, compatibility with the ETSI TISPAN RACS and ITU RACF specifications will provide a roadmap for Next generation Networks (NGN) compliance.

2) OAM functions for layer 2 flow monitoring: both point 2 point and point 2 multipoint. With the IPTV service, the viewers will directly watch the quality of the network, thus it is very important that the network delivers carrier grade quality. Today, the networks do not deliver the required OAM functionalities and IPTV operators are forced to deploy very expensive solutions to monitor the TV signals. Typically, monitoring the quality is done by decoding all the TV signals on various locations in the network. OAM for multicast (E-tree) is an area of further study.

3) Resilience and survivability: In PBB-TE, working and protection paths are precalculated, and the forwarding tables in nodes on these paths are provisioned/configured with the required forwarding entries. . T-MPLS defines its protection capability using ITU-T's Recommendations G.8131/Y.1382 (T-MPLS linear protection switching with 1+1, 1:1 and 1:N options) and G.8132/Y.1383 (T-MPLS ring protection switching). Protection of E-tree and sensitive I-frames are areas for further research. PBB-TE protection using multiple spanning trees.

These are the proposed objectives:

- Investigation of control plane architectures for Carrier Ethernet (NGN, GMPLS…)
- Evaluation of QoS mapping techniques (class based, flow based, hierarchical scheduling and shaping)
- New OAM functions supporting IPTV flow quality assessment. (Both point 2 point and point 2 multipoint)
- Carrier Ethernet and EPON’s combined.
- Protection and restoration for PBB-TE and T-MPLS. Comparison of proposed schemes (linear/ring). Focus on new schemes for point 2 multipoint protections and focus on protection of sensitive (I) frames.

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