SHORT TERM SCIENTIFIC MISSION (STSM)
SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

Action number: CA15127 RECODIS
STSM title: Improving network availability in transport networks
STSM start and end date: 04/12/2017 to 15/12/2017
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PURPOSE OF THE STSM:

Today's communication networks are considered to be a topmost critical infrastructure. The critical telecommunication services already have to be resilient against (natural and man-made) disasters and not only against single link failures.

Satisfying new strict QoS requirements is becoming a necessity to support the critical communication services on which governments and people relay more and more.

In order to improve the availability of the transport network the SPINE concept was introduced in [1]. The basic idea of SPINE is to upgrade a set of links and nodes to improve their availability to support specific protection and routing methods to ensure higher end-to-end availability. In [2] the SPINE concept was utilized to support differentiated resilience classes in multilayer networks. In [2] the class 1 traffic (i.e. high priority traffic) is protected by a backup protection path (i.e. the 1+1 dedicated protection approach is deployed), while class 2 traffic is unprotected.

The goal of the STSM is to investigate the scenario where the high priority traffic is protected by another, more general dedicated protection method i.e. GDP (General Dedicated Protection) [3.4]. Note that the GDP provides optimal resilient capacity allocation against multiple link failures.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

During the STSM, I visited Dr. Teresa Martinez Gomes at INESC Coimbra - Instituto de Engenharia de Sistemas e Computadores de Coimbra located at the Department of Electrical and Computer Engineering of the University of Coimbra.

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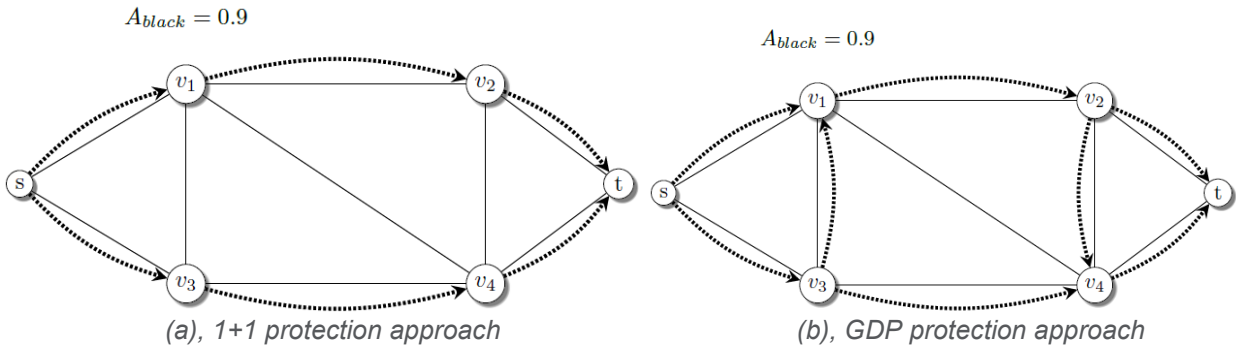
The main work was conducted with Dr. Teresa Gomes and Dr. Rita Girão Silva.

In the first days of the STSM we discussed further the theoretical aspect of the SPINE and GDP (in later papers mentioned as IGDP or GDP-R) and the theoretical aspects of the integration of the two concepts (GDP and Spine). We agreed that the GDP can improve the overall availability of the critical connections, since the GDP is able to protect an arbitrary failure list (SRLG – Shared Risk Link Group – list) if it is protectable (i.e. if the network remains connected after the failure event). Furthermore, the GDP not only protects the connection against the failures listed in the SRLG list, but is also able to improve the overall availability due to its specific structure.

This can be demonstrated through an example (Figures 1 and 2). On Figure 1(a) we see a connection request s-t, which is protected with 1+1 providing protection against all singe failures. On Figure 1(b) we see the same request protected by GDP. The GDP solution is not only able to protect against all single link failures, but also several double link failures which could not be protected by 1+1: (s,v1) and (v3,v4) or (v3,v4) and (v2,t), or (s,v1) and (v4,t).



(a), 1+1 protection approach (b), GDP protection approach

Figure1. Connection request

In this example the overall availability of the connection protected by 1+1 is 0.927 and by GDP it is 0.952

In Figure 2 we see how a random generated SPINE affects the overall availability. In this scenario the upgraded links have a higher availability of 0.99 (all other links' availability remains 0.9).

In this scenario the availability of 1+1 is: 0.961 and by GDP it is 0.978.

This means that the downtime in a year decreases by 1+1 from 26.645 to 14.235 and the downtime by GDP decreases from 17.52 to 8.03 days.

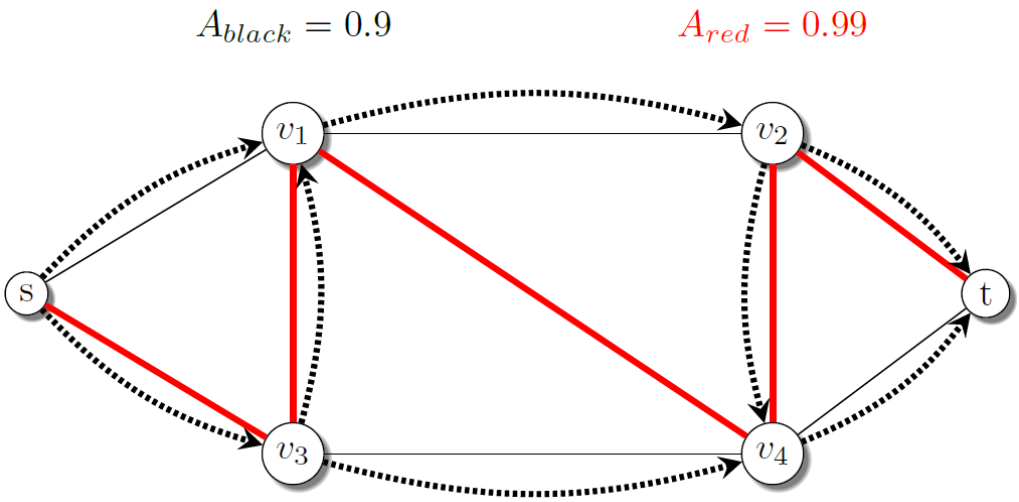


Figure2. SPINE + GDP

(Of course this result depends on the SPINE parameters and on the GDP solution itself.)

Our goal is to provide more differentiated resilience classes and ensure higher overall availability for the critical services. This can be done by integration of the GDP and SPINE.

In order to find the best way to integrate these two methods we had daily meetings. The main results of the meetings are summarized in the next section.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

During my stay we discussed several aspects of the integration. Without being comprehensive the main aspects were:

- How to upgrade the links along the SPINE?
- How to integrate the SPINE into the SRLG model?
    - The links on the SPINE should fail with lower probability, and hence are less often included in the SRLGs. Note that the links of the SPINE should be always protected against the single link failure scenario.
    - To be able to model large scale disaster and introduce a probabilistic model for correlated link failures [5] we are going to collaborate with Vass Balázs and János Tapolcai.

- How to modify the SPINE and GDP problem formulation in order to achieve the best performance?
    - After the network availability is improvedi.e. the SPINE is calculated and the links are updated (i.e. the availability of the network elements is enhanced) the GDP routing can be modified in such a manner that the GDP prefers to use the links on the SPINE.
    - The SPINE itself could be generated without the disjoint backup path constraint, as GDP will ensure protection against single and multiple link failures.
    - Several SPINE problems should be considered:
        - Maximization of the sum of availabilities of the WPs of all the flows, which is equivalent to the maximization of the average value of the availability for the WPs of all the flows.
        - Maximization of the minimal availability of the WPs of all the flows.
- Which different service classes should be considered?

Besides the theoretical discussion, the practical implementation was investigated too i.e. how to integrate the different tools. In order to make this possible we discussed the technical aspect (tasks to be done, input or output file formats etc.).

We created a roadmap for the work that has to be carried out.

FUTURE COLLABORATIONS (if applicable)

The collaboration will result in a submitted conference paper after the proper integration of the two concepts is finished. This work can be a contribution to the chapter entitled “Enhancing availability for critical services (WG1)" of the planned RECODIS Book.

In order to support further collaboration, BME will offer a thesis topic related to the integration of the GDP and SPINE concepts.

[1] Alashaikh, Abdulaziz, Teresa Gomes, and David Tipper. "The spine concept for improving network availability." *Computer Networks* 82 (2015): 4-19.

[2] Alashaikh, Abdulaziz, David Tipper, and Teresa Gomes. "Supporting differentiated resilience classes in multilayer networks." *Design of Reliable Communication Networks (DRCN), 2016 12th International Conference on the*. IEEE, 2016.

[3] Babarczi, P., Pašić, A., Tapolcai, J., Németh, F., & Ladóczki, B. (2015). Instantaneous recovery of unicast connections in transport networks: Routing versus coding. *Computer Networks*, *82*, 68-80..

[4] P. Babarczi, J. Tapolcai, and P. Ho, “Availability-constrained Dedicated Segment Protection in circuit switched mesh networks,” in Proc. Workshop on Reliable Networks Design and Modeling (RNDM), Saint Petersburg, Russia, 2009, pp. 1-6.

[5] J. Tapolcai, B. Vass, Z. Heszberger, J. Biró, D. Hay, F. A. Kuipers, and L. Rónyai, “A Tractable Stochastic Model of Correlated Link Failures Caused by Disasters,” in Proc. IEEE INFOCOM, Honolulu, USA, 2018.