

SHORT TERM SCIENTIFIC MISSION (STSM) SCIENTIFIC REPORT

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

Action number: CA15127

STSM title: Preparations for RECODIS Training School Course Entitled A Framework for Disaster Resilience

STSM start and end date: 1/12/2019 to 7/12/2019

Grantee name: Balázs Vass

PURPOSE OF THE STSM:

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The purpose of the STSM was two-fold, namely 1) to discuss the possibilities of improving the FRADIR concept, and submit a related paper in 2020, and, in addition, 2) improving the overall quality of my presentation based on FRADIR-II at the RECODIS Training School with the help of Teresa Gomes, one of the co-authors of the study.

Note that, besides enhancing the value of the Training School, by submitting a paper on reliable network design, the contribution of this tentative STSM fits nicely into the scientific objectives of the Action.

As planned, to ensure the best result, the aim was to prepare and discuss a version on my training school presentation (and related materials) before my visit, then, during my stay, I to dedicate my time to enhance it as much as possible with the help and insights of Teresa. Naturally, new FRADIR framework-bettering ideas were expected to emerge during this process which would be discussed in an upcoming paper on this topic. Then, we aim to start to write a new paper after the RECODIS Training School.

Paper FRADIR-II: An Improved Framework for Disaster Resilience improves the performance of its previous counterpart. In the novel framework, two different failure models are jointly considered: independent random failures and regional failures that may be used to model the effect of disasters. First, an infrastructure against random failures is designed, termed as the spine, which guarantees a certain availability to the working paths. Second, to prepare this infrastructure against disasters, there is introduced a probabilistic regional failure model, where a modified Euclidean distance of an edge to the epicentre of a disaster is used. The proposed function jointly takes into account the physical length of the edges and their availability, so that a higher/lower availability is reflected in a higher/lower distance from the epicentre. This novel availability-aware disaster failure model generates a failure list which is deemed to be more realistic than previous approaches. Next, a heuristic for link upgrade attempting at the reduction of the likelihood of regional failures disconnecting the network is proposed. Finally, a generalized

dedicated protection algorithm is used to route the connection requests, protecting the obtained failure list. The experimental results show that FRADIR-II can provide disaster resilience even in critical infrastructures.

As Teresa is one of the co-authors of the paper and expert in the spine concept, the visit at her significantly improve the overall quality of my future presentation on FRADIR-II at the RECODIS Training School.

The purposes of this STSM were:

- (i) discussing the possibilities of improving the FRADIR concept, and submitting a related paper in 2020,
- (ii) enhancing the quality of the RECODIS Training School course entitled A Framework for Disaster Resilience.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

In the limits of this STSM, we had two purposes: 1) enhancing my COST RECODIS Training School presentation, and 2) coming up with new ideas for merging the network protection approaches used in the FRADIR concept. As some quick response deadlines with the RECODIS book shifted, a third line emerged in my work in Coimbra: 3) finalizing the chapter I am responsible for.

I had a very cosy private room at the university, where I could work without any disturbance. Usually, I carried out my work at the university between 9 AM till 6 PM.

We had several meetings with Teresa and her colleague and co-author of the FRADIR-II paper Rita Girão-Silva on renewing the FRADIR concept. We agreed on several points where the current framework could be enhanced, these were the followings: i) we need a heuristic which can calculate the Spine for larger networks too, ii) turn the greedy network upgrade heuristic (to get a disaster-proof network) into a proper ILP-based optimisation problem (this way merging more deeply the failure modelling and network planning component), iii) when simulating, real-world inputs should be used (e.g. earthquake or fire histories) to demonstrate the benefit of the framework. We agreed that Teresa and Rita will work on the enhanced heuristic while I will work on the ILP for the network upgrade.

Speaking of the platform where our new results should be published, we decided to aim for the IEEE Access and take the opportunity to have our paper submission as a candidate for RECODIS WG1 paper sponsored by the COST Action. Of course, a one-week STSM is not enough to carry out the work, thus we aim to submit our results until June 2020.

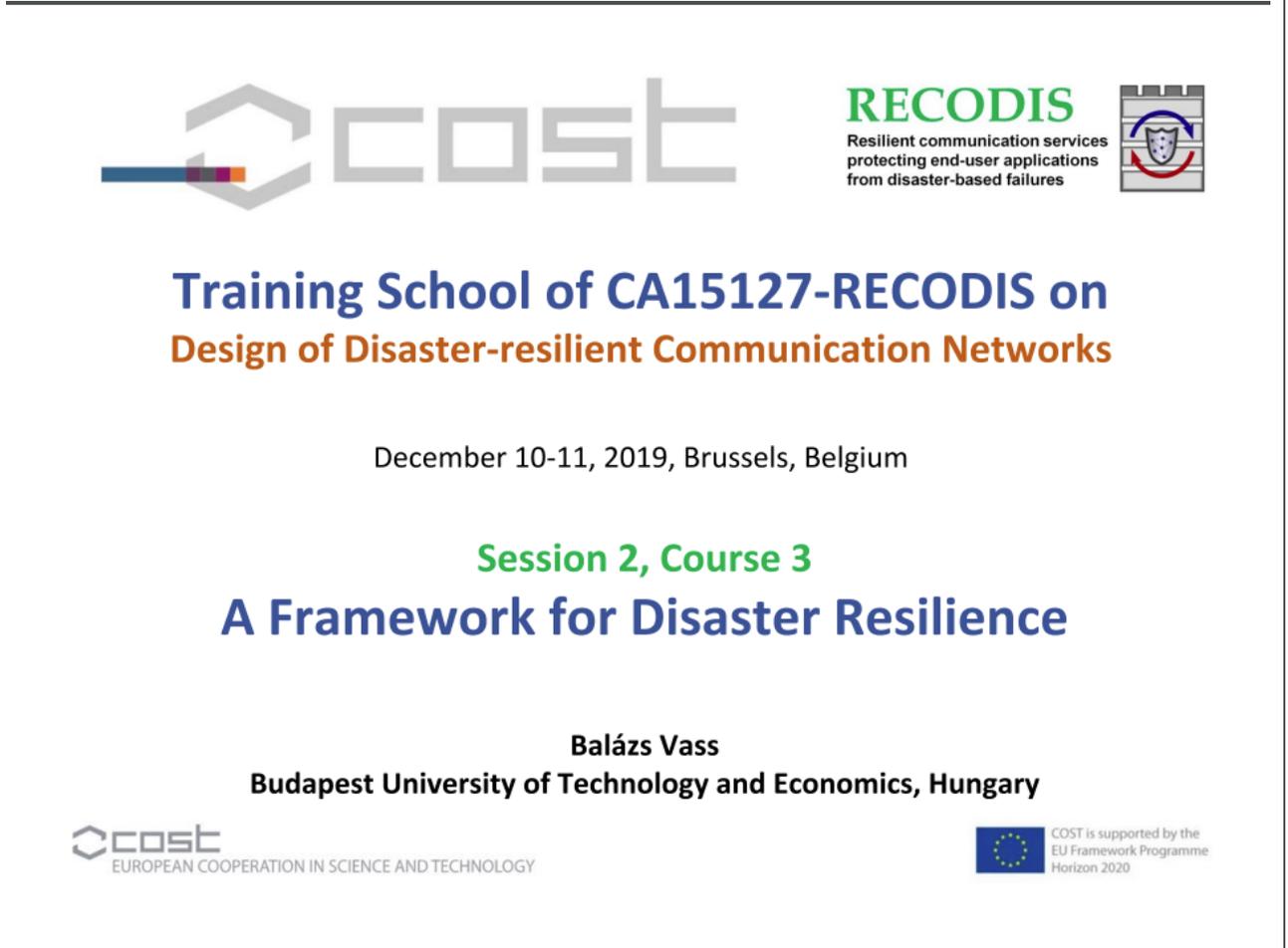
My time spent on polishing the presentations for the Training School was partially taken by the imminent issues which arose with the RECODIS book chapter I am responsible for. In the end, I believe, both the presentations became adequate and the Latex project of the book chapter became easily mergeable with the other book-related files.

Besides working with Teresa and Rita, I had very inspiring conversations with Dorabella Santos, a mathematician post-doc researcher of INESC Coimbra working in ResNeD, a research project led by Teresa Gomes. Also, usually, we had lunch together, where sometimes Lúcia Martins was also present, this way I could meet with almost every people from the Coimbra university who are interested in network resiliency.

Coimbra is a friendly city with a very old university and a nice milieu. I feel fortunate that I had the possibility to work there.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

There are two main results of this STSM. The first is the FRADIR presentation at the Training School. Its slides are also reachable at the RECODIS website at http://cost-recodis.eu/index.php/?option=com_content&view=article&id=63. The following screenshot is the opening slide of the presentation:



The other main result is an ILP for the network upgrade procedure in the FRADIR-II paper which can replace the current (probably sub-optimal) greedy upgrade method. A draft of the optimization problem is sketched here:

Notation	Description
A	Average availability of the links
$a(e)$	availability of edge $e \in E$
$a'(e)$	upgraded availability of edge $e \in E$
$U, u(e), u'(e)$	$1 - A, 1 - a(e), 1 - a'(e)$
P	set of grid points
R	set of disaster radiuses
$\Pr(r, p)$	probability of a disaster with radius r at point p
$I_{S,p,r,\vec{d}}$	Indicator function: 1 if all links of S fail in case of the original availabilities, else 0.
$I'_{S,p,r,\vec{d}}$	Same as $I_{S,p,r,\vec{d}}$, but with the upgraded availabilities
$c(e)$	$-\ln \frac{u'(e)}{u(e)} \cdot l(e)$

$$\sum_{\substack{r \in R \\ p \in P}} \Pr(r, p) \cdot I'_{S,p,r,\vec{d}} < T, \quad \forall S \in m_e \quad (1)$$

$$I'_{S,p,r,\vec{d}} = \begin{cases} 1 & \text{if } \max_{e \in S} (d(e, p) \cdot U) \leq r \cdot u'(e) \\ 0 & \text{else} \end{cases} \quad (2)$$

$$u(e) \leq u'(e) \quad (3)$$

$$\min \sum_{e \in E} c(e) \quad (4)$$

Fig. 1: Formulation for minimum cost cut elimination

Note that its final version may look very different.

FUTURE COLLABORATIONS (if applicable)

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As a consequence of my visit, the Coimbra and Budapest team of RECODIS people are planning to submit a joint journal paper in mid-2020, ideally in IEEE Access. With this aim, we are carrying out our joint research also in continuation.