SHORT TERM SCIENTIFIC MISSION (STSM) – SCIENTIFIC REPORT

The STSM applicant submits this report for approval to the STSM coordinator

Action number: CA15127
STSM title: A study of Uncertainty polytopes for modelling failures in FSO communication networks resilient to weather conditions
STSM start and end date: 02/12/2018 to 08/12/2018
Grantee name: Dritan Nace

PURPOSE OF THE STSM/

(max. 500 words)

The purpose of the STSM was to extend the work done on FSO (free space optics) network optimization models proposed in the M. Pióro et al. paper "Optimizing flow thinning protection in multi-commodity networks with variable link capacity" (Operations Research, vol. 64, no. 2, pp. 273-289, 2016) and more recently a communication in RNDM'2017 and another accepted for publication in Optical Switching and Networking. The extension aims at studying the so called *uncertainty polytope* and propose other ways in characterizing it to efficiently describe the varying weather conditions. As FSO networks are vulnerable to weather conditions, their transmission quality can be easily degraded if special measures are not taken. Hence, it is important to be able to represent the uncertainty related to weather conditions in a more compact way allowing a more tight representation of available weather data through link degradation vectors while simplifying the calculation of the robust link dimensioning solutions for this problem.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

(max. 500 words)

Dimensioning of FSO networks is not an easy task because of non-compactness of the related linear (or mixed-integer) programming formulations. Roughly speaking, in such formulations there are a large number of failure/degradation states (S – the set of failure states representing the weather record data) that should be handled which makes the calculations difficult and sometimes ineffective. Another point is that S does not represent the precise failure set that may occur in the future but it gives only good estimations of such failures, so it is interesting to find a way to deal with robustness at a minimum cost while making the problem tractable. A way to deal with this issue is proposed in some precedent works where we have used a special kind of virtual failure sets, called K-sets parameterized by an integer value K, where K is less than or equal to the number of all links in the network. For a given K, the K-set contains all states corresponding to all combinations of K, or less, simultaneously affected links. We have extended this work and consider a modified type of K- set where instead of links we consider nodes. The main motivation for this change comes from the nature of failures which are due to weather conditions affecting some geographical area and where each link failure is mainly caused by bad weather conditions affecting

its transmitter or receiver area.

We also started working on another approach to generate these K-sets. The idea behind is to build some subsets of links in accordance with their affinity in terms of sharing the same failure sets in a more sophisticated way. We call these subsets failure patterns, i.e., a failure pattern is composed of one or few links that occurs frequently together in failure situations. Our aim is to find a representative reduced number of such patterns, say p, in the way that all k combinations of these patterns cover a large number of failure states in S.

The numerical results that show the (good) efficiency of the approach were obtained by means of the CPLEX solver.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

(max. 500 words)

The major result of the STSM consists in studying the uncertainty polytope state characterization to the existing mixed-integer programming resilient optimization (dimensioning) model of FSO networks and extending it with a more tight mathematical representation. This proposal has been tested on a moderate size network taken from SNDLIB and for several type of weather conditions. The numerical results confirms the advantage of the new uncertainty set comparing to the previous one.

The results achieved during the STSM will form the basis for a section in Chapter 3.11, on optimization of FSO mesh networks resilient to weather conditions, in the RECODIS final book "Guide to Disaster-resilient Communication Networks".

FUTURE COLLABORATIONS (if applicable)

(max. 500 words)

The collaboration of Prof. Dritan Nace (the STSM applicant) with University of Technology of Warsaw will continue, with eventually another visit next year.