EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

SHORT TERM

SCIENTIFIC MISSION (STSM) – SCIENTIFIC REPORT

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

Action number: CA15127
STSM title: Optimization model for designing wireless mesh networks resilient to weather conditions
STSM start and end date: 04/04/2018 to 17/04/2018
Grantee name: Emma Fitzgerald

PURPOSE OF THE STSM/

(max.500 words)

The aim of the STSM was to extend the optimisation model for Flow Thinning, a protection strategy for free-space optical networks, to radio-based wireless mesh networks, in order to protect them against adverse weather conditions. Since radio links, unlike free-space optical links, interfere with each other, this necessitates significant changes to the optimisation model. In particular, the overall performance of the network, in terms of its ability to meet traffic demands, becomes dependent on link scheduling, as well as the nodes' transmission power and modulation and coding schemes (MCS) used.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

(max.500 words)

During the STSM, new optimisation models were developed for radio-based mesh networks. Two different models were developed. In both models, weather conditions are expressed as failure states, characterised by different path loss exponents on different links depending on how they are affected by the prevailing weather conditions. The objective is to maximise the service level, that is, the proportion of the demand flows met by the network in each failure state. In the first model, a weighted sum of the service levels of each state is taken over the distribution of all possible states. This model is aimed at network planning and includes a constraint on the overall power used by the network across all states. The second model is intended for online optimisation in which the network responds to failure states as they occur. Here, we do not include a power limit, since the state distribution is not known in advance, and instead decompose the problem such that it can be solved for each state separately.

For both models, we employ column generation to generate compatible sets (c-sets) – sets of links able to successfully transmit simultaneously. For each c-set, we optimise for node transmission power and MCS for each node. This allows the network to adjust to adverse conditions by lowering transmission rates, allowing for continued transmission in some cases where the original MCS is not achievable. Adjusting transmission power and MCS can also reduce interference on nearby links.

The optimisation models developed were implemented in AMPL and solved using the CPLEX solver. A test network was used based on the data obtained from the work on Flow Thinning at Warsaw University of Technology. This data describes a realistic network topology with demands derived from real-world demographic data, and failure states derived from historical weather data. Our models were solved on this network for varying demand levels, and the performance was investigated.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

(max. 500 words)

The main result of the STSM was the two optimisation models developed. These provide a general method to protect against multiple partial link failures in radio networks, with optimised node transmission power, MCSs, and link scheduling. Our experimental results show that a reasonable service level can be obtained for the traffic demands even in challenging failure states, and that the optimisation problems can be solved in a short enough time to be practical for implementation, both for the networking planning case and the online optimisation case.

A manuscript is currently in preparation to be published as an invited paper at the 10th International Workshop on Resilient Networks Design and Modelling (RNDM), to be held in August 2018. This paper will also form the basis for a section in Chapter 3.11, on optimisation of wireless 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 Dr. Emma Fitzgerald (the STSM applicant) with Prof. Michał Pióro and Dr. Artur Tomaszewski at Warsaw University of Technology will continue, with further visits planned for later this year.