Purpose of the STSM

The purpose of the STSM was to extend considerations of the M. Pióro et al. paper "Maximization of multicast periodic traffic throughput in multi-hop wireless networks with broadcast transmissions" (*Ad Hoc Networks*, vol. 77, 2018, pp. 119-142) in order to include resilience to adverse weather conditions in optimization modelling of wireless mesh networks (WMN) with broadcast radio transmissions realizing multicast packet traffic (such networks will be referred to as WMN/radio). For that we adapted an optimization approach applicable to FSO (free space optics) wireless meshed networks (referred to as WMN/FSO) involving a protection strategy called *Flow Thinning* (FT) 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, 2016, pp. 273-289). The main issue in the adaptation in question was to include interference into the previously developed (also during my previous RECODIS short time scientific missions) WMN/FSO model.

Description of work carried out during the STSM

During the STSM, a recent version of the FT optimization model for resilient WMN/FSO dimensioning (including uncertainty polytopes and affine flow thinning) was adapted to multicast WMN/radio based on the TDMA MAC protocol. The adapted model takes into account the interference observed at the receivers caused by the signals simultaneously broadcasted from the transmitting nodes. This required optimization of the so called compatible sets, used in the time-slots of the transmission frame.

Another important change introduced is the traffic model applied in WMN/radio. Now it is assumed that the multicast traffic streams are elastic and that in the nominal network state (corresponding to perfect weather) their volumes are maximized according the max-min fairness principle. In other states (when some links loose part of their nominal capacity) affine flow thinning of the nominal flows on the individual source-destination paths of the multicast trees is applied, admitting a decrease in nominal traffic volumes. Note that this is a major change also with respect to the original WMN/FSO model, where multicast is not considered and minimization of the total cost of links is the main optimization objective.

Finally, an important aspect of the work was verification of appropriateness of weather state modelling (that had been used for WMN/FSO) to WMN/radio. This modelling is based on the modulation and coding scheme (MCS) adjustments in reaction to changing weather condition. It turns out that the weather states distinguished for WMN/FSO in the previous models are relevant to WMN/radio as well. This means that the uncertainty polytopes used for WMN/FSO remain valid for WMN/radio.

Description of the main results obtained

The main result of the described STSM is formulation of a two-phase mixed-integer programming (MIP) optimization model for WMN/radio resilient to adverse weather conditions.

In the first phase, the model maximizes the traffic carried by the network's multicast streams through an iterative application of the column generation algorithm involving a master problem (a linear programming problem) and a pricing problem (a MIP problem), where the generated objects are compatible sets, and signal interference is taken into account in the mathematical description of a compatible set. In the model the multicast routing trees are predefined.

In the second phase, affine flow thinning coefficients are optimized for the assumed uncertainty polytope, assuring the resilience of the optimized WMN/radio to link capacity degradation caused by changing weather conditions.

Further collaborations

The collaboration of Prof. Michal Pioro (the STSM applicant) with MobiMESH will continue, with further visits planned using other than RECODIS financing means.