

## 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: Resilient communication services protecting end-user applications from disaster-based failures

**STSM title:** Alert-based resilience of wireless communications under weather – induced disruptions

**STSM start and end date:** 01/10/2019 to 08/10/2019

**Grantee:** dr. Rasa Bruzgiene, Kaunas University of Technology, Lithuania

**Host:** Prof. Nadezda Kunicina, Riga Technical University, Latvia

**Working Group:** WG2 - Weather-based disruptions

### PURPOSE OF THE STSM:

Different weather conditions as heavy rain or snow, intensive fog, variation in temperature, *etc.* are known as the most important factors attenuating signals' strength in wireless communications. Moreover, it is one of the key reasons that results in appearance of disruptions over wireless communications or even loss of communication in general. Due to this, the motivation for this STSM has arisen from the continuous work with scientists from RTU, KTU, TU-GRAZ and UNIZA, with whom together techniques for an improvement of the resilience of wireless communications in a face of weather-induced disruptions have been developed. Therefore, the main aim of this STSM was twofold – to focus on the alert technique, which should help identify the beginning of the weather-induced disruptions of the transmission and prevent service suspension by activating proper resilient mechanisms over the network - and – to work jointly with STSM host on the preparation of proposed solution (technique) for a training school of COST RECODIS.

The work of this STSM was done under COST RECODIS WG2 “Weather-based disruptions” topics as it provides results for developed solutions of end-to-end transmission continuity over wireless links in the presence of weather-based disruptions.

### DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

During the whole stay in Latvia and work in Institute of Industrial Electronics and Electrical Engineering of Riga Technical University, it was done:

- *Regular meetings* with the host discussing the resilience aspects of wireless communications in a presence of bad weather conditions and role of the alert systems as well it adaptation efficiency in improving (increasing) robustness of wireless network/system against weather-induced disruptions;
- *Revision* of Quality-driven alert-based technique focusing to it novelty, structural elements and application in a presence of fog over FSO links;
- *Analytical verification and evaluation* of the effectiveness of Quality of Service (QoS) and Quality of Experience (QoE) application for the improvement of resilience in FSO due to fog-induced disruptions;
- *Discussions* on technical details of the practical part of the course and on abilities to transform proposed scientific methods and details of proposed alert-based technique for societal needs;

- *Work on preparation of the content for training course and discussions with STSM host on the presentation style of the course.*

The main points, that were most important to STSM grantee from work carried out during the STSM, are presented in the next section below.

## DESCRIPTION OF THE MAIN RESULTS OBTAINED

The main focus of grantee's work during this STSM was on the alert technique, which should help identify the beginning of the weather-induced disruptions on the data transmission over wireless link and prevent service suspension by activating proper resilient mechanisms over the network.

*Problem description.* The idea for alert-based technique arisen from the problematic issues of data transmission over FSO network in a presence of intensive fog. It is related with Mie scattering attenuation, which affects FSO communication links because the influence of a high concentration of water particles with radii is observed and it is comparable with the selected communication wavelength. Absorption and scattering due to particulate matter may significantly attenuate the transmitted optical signal, while the wave-front quality of a signal-carrying laser beam transmitting through the atmosphere can be severely degraded, causing intensity fading, increasing bit error rates and/or random signal losses at the receiver. On the same note, weather conditions (especially for fog) are variable and it is not so easy to identify or even predict the imminent risk of it to wireless communication systems. Moreover, the duration and intensity of precipitation are also dynamic. In this case, to address this problem the preparation of a wireless network should be done by updating existing wireless communication system with an alert, based on the correlation of continuous evaluation of the objective QoE parameters from the provider's point of view with measured QoS metrics in real-time. Such pre-disruption stage is important whereas wireless communication system's readiness can help to avoid disruptions or it caused long-term consequences during the transmission of services.

*Short details of the technique.* The alert-based technique presents idea how to use quality as 'an enabler' in developing the mechanisms of network preparedness for incoming disruptions and ensuring end-to-end transmission continuity over wireless links in the presence of weather-induced disruptions. The objective QoE assessment from a provider's point of view in a presence of bad weather conditions serves as a part of the quality-driven alert procedure. The continuous evaluation of the objective QoE gives a result in identification of the borderline zone, in which the QoS parameters of a service (BER, SNR, etc.) started to degrade, but the service is perceived as available. This borderline zone is an indicator, that the operator should react in order to provide and maintain an acceptable level of service in the face of disruptions on FSO link, caused by fog. The evaluation of this alert technique have shown, that the correlation between QoS, QoD and QoE gives a possibility to identify the beginning of the service degradation, which is important in order to start a recovery process in service provision (QoR).

*Preparation of alert-based technique for societal needs* (RECODIS training school). During this STSM the grantee was working on the structure of the training course as well as content to each part of it. Generally, the course will be formed from two parts:

– *practical exercise* - trainees will be practically involved in the evaluation of the performed service and identification of the beginning of the disruption on the transmission; the results of this exercise will be examined and discussed through use case on FSO system (detailed how it can be used in updating the network or system in order to prevent of a service suspension in a case of weather-induced disruptions).

– *theoretical knowledge* – the content of the training course for RECODIS training school was prepared according to the outline as follows:

- Weather-induced disruptions to wireless communications – problems, issues, concepts
- Resilience of wireless network and its relation to a user experience – definitions, problem description, dependence on quality parameters and importance
- Interrelation between the quality metrics of different OSI layers and its relation with network resilience
- Conceptual model for continuous evaluation of objective QoE parameters;
- Quality-focused alert technique – structural elements by different states in communication performance; composition of QoE objective evaluation
- Use case of the alert-based technique over FSO system - basic problem, which was addressed; identification of the acceptable service level by objective borderline zone; efficiency of the adaptation of such technique to wireless communication system.

**FUTURE COLLABORATIONS (if applicable)**

Based on the results, that were achieved during the period of this STSM, the host Prof. Nadezda Kunicina and the STSM grantee dr. Rasa Bruzgiene agreed to collaborate in joint research, papers and conferences not only on the topics that will arise within COST RECODIS WG2 activities (as this COST action is approaching the end), but on others, which will combine the expertise and knowledge of both sides as well. *Long term collaboration* – to extend joint activities and prepare research proposals for international projects as well scientific publications.

These plans in host and grantee joint collaborations will enable to submit joint publications, participate in international conferences, visit each other more often, and get useful results for further joint work.