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: Efficiency of Quality-driven Techniques for Improvement of Resilience in Wireless Communications Against Weather-based Disruptions
STSM start and end date: 23/04/2019 to 27/04/2019
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:

The motivation for this STSM has arisen from the continuous work with scientists from RTU, KTU, TU-GRAZ and UNIZA in developing novel ideas how to use various quality parameters of a wireless network or service over it in order to provide and maintain an acceptable level of service in the face of various disruptions. Therefore, the main aim of this STSM was to evaluate the created techniques based on the application of Quality parameters from different OSI layers (network, transport, application) for an improvement of the resilience of wireless communications in a face of weather-induced disruptions. Moreover, the analytical verification of the correctness of the developed approaches was done and analyzed also during this STSM. Besides this, my STSM was supposed to bring a new scientific knowledge in the context of improvement of resilience in data transmission over WSN-based autonomous beekeeping system due to bad weather conditions. It was also important to my motivation for this STSM, that the host is working with this system and investigating it capabilities as well.
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 her achievements in investigations of WSN-based autonomous beekeeping system, it resilience in bad weather conditions, mainly focusing on extreme temperature of the weather. Also, it was discussed the required improvements in the second generation of this system, that it would be possible to activate a proposed solution for data rerouting in a case of weather-based disruptions on transmission process.
- *Visit* to beekeeping company “Meduspils” and meeting with the beekeeper as well an owner of the company Jānis Vainovskis in order to gain knowledge in beekeeping system and needs/ expectations of a

beekeeper in improvements of the existing WSN-based beekeeping system for an more effective monitoring of life and work of bees inside beehives.

- *Revision* of proposed Quality-driven techniques focusing to it novelty, structural elements and application in a case of different weather conditions.
- *Analytical verification and evaluation* of the effectiveness of Quality of Service (QoS), Quality of Experience (QoE) and Quality of Delivery (QoD) application for the improvement of resilience in FSO, WSN and modular wireless positioning system due to bad weather-induced disruptions.
- *Correction* of the chapter's 2.6 title (new working title is: *Environmental Conditions Mitigation by Application of Quality-driven Techniques to Improve Wireless Communications Resilience*), content and text in section 4 (*Quality-driven Techniques to Improve Resilience*) for the planned RECODIS book.

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 investigations during this STSM was on the evaluation of the created techniques based on the application of Quality parameters from different OSI layers (network, transport, application) for an improvement of the resilience of wireless communications in a face of weather-induced disruptions. When it comes to the evaluation of the proposed solutions, it is worth noting here, that three Quality-driven techniques were proposed for an improvement of the resilience of different wireless communication systems (Free Space Optics (FSO), Wireless Sensor Network (WSN) and Modular Wireless Positioning System) in a bad weather condition. In particular, the detailed outcomes of this STSM are described in the chapter 2.6 of COST RECODIS book, which can be found at book contribution section in a website of this action.

First of all, the conceptual model for an alert creation on the communication process over the FSO systems in a presence of fog, as it is one of the most serious degradation factors for this system, was developed together with scientists from TU Graz and UNIZA. In this case, the objective QoE assessment technique in the face of bad weather conditions serves as a part of the proposed quality-driven alert procedure (see Fig. 1).

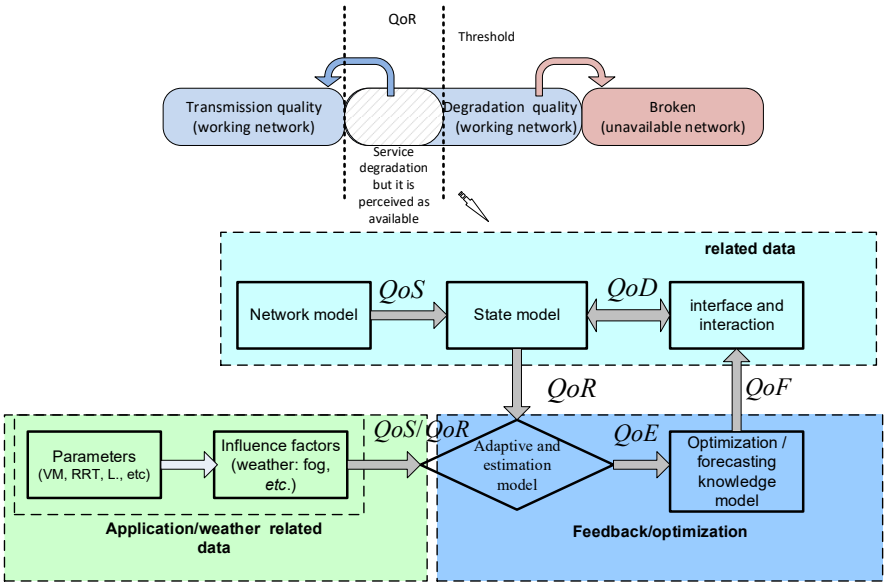

Fig. 1. Composition of objective QoE evaluation according to the states in service performance

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 results of 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).

Secondly, the Quality-based data rerouting and a topology adaptation technique in Wireless Sensor Network were proposed in cooperation with scientists from RTU. It is worth noting here, that the reliability of communication in WSN-based system is a key driver in order to guarantee the stability of such systems. It was proven, that the bad conditions of the weather (as high level of humidity, fog or snow) has no particular impact to the transmission of data over wireless link on the WSN-based beekeeping system. However, there is a significant affect of the extreme temperature to a lifetime of sensor nodes outdoors. The battery drain process takes place at a very fast rate in those sensor nodes, that are directly affected by a low temperature, i.e. -20º C or -30º C. Such temperature can normally be expected in Riga during a winter season, so it affects the beekeeping system, which is located in Riga's botanical garden, as well. In this case, the idea of the proposed Quality-driven technique refers to the possibility to use a variation in an energy of a sensor's battery (one of QoS parameters) for a data rerouting as well re-topology of the system in order to assure a better resilience of data transmission in WSN in a face of extreme temperature. Moreover, the existing sensor nodes are placed inside and outside of beehives, so the sensors inside would serve as main nodes for data routing, as they would be charged 25-50% more, in contrast to sensors outside (Fig. 2).

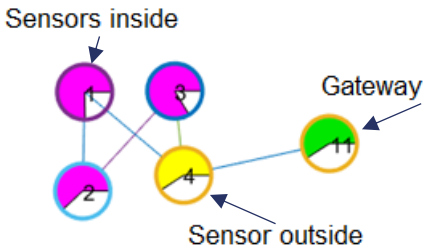

Fig. 2 Difference of the power conpsumption for sensors inside/outside the beehive

The actual topology of WSN-based beekeeping system would depend on the number of those sensor nodes, which can actively continue in data transmission process according to their needs on power consumption. The results of the evaluation of this technique have shown, that Quality-focused data rerouting garantees the better resilience of data transmission in a presence of extreme low temperature, thus assuring the energy-efficiency design of in-field WSN system.

Thirdly, the adaptation of a wireless localization system in focus to QoS parameters (accuracy and availability) was proposed in coopeation with scientists from UNIZA. It was proven, that the changes in environment, caused by movement of obstacles, can have negative impact on RSS readings and thus can reduce Quality of Service. In this case, the possibility to use other sensors available in widely used devices can provide additional solution in detection of large localization errors of fingerprinting algorithm and thus improving QoS by increasing availability of the system. The adaptation technique of the wireless localization system is more described in the subsection 4.3 of the chapter. The results of it evaluation have shown, that implementation of the proposed solution in the modular wireless positioning system will make it possible to perform a reliable service in a presence of changing envinronmental conditions.

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, but on others, which will combine the expertise and knowledge of both sides as well.
Medium term collaboration – 1) to investigate the solutions for creation of a smart beehive in cooperation with beekeeping company in Latvia; 2) to investigate the Quality of Protection aspects in WSN-based in-field systems and it role in the resilience of such systems.
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.