

SHORT TERM SCIENTIFIC MISSION (STSM) SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

Action number: CA15127

STSM application number: 42954

STSM title: Software-Defined Unmanned Aerial Vehicle Networks in Post-Disaster Scenarios

STSM start and end date: 05/01/2019 to 18/01/2019

Grantee name: Dr. Zhongliang Zhao (MC substitute), University of Bern, Switzerland

Host name: Dr. Christian Esposito, University of Naples "Federico II", Italy

Working Group: WG4

PURPOSE OF THE STSM:

Unmanned Aerial Vehicles (UAVs) empower people to reach endangered areas under emergency or post-disaster situations. By collaborating with each other, multiple UAVs forming a UAV network (UAVNet) could work together to perform specific tasks in a more efficient and intelligent way than having a single UAV. In this STSM, we analyze an use case of post-disaster scenario to evaluate the optimal UAV relay node placement, UAV trajectory optimization, and UAV network routing protocols for life video surveillance services in post-disaster scenarios. We explore the Software-Defined UAV Networking (SD-UAVNet) architecture, which facilitates the management of UAV networks through a centralized SDN UAV controller. By combining the grantee' expertise on UAVNet system implementation and grant host's expertise on game theory-based performance modelling and optimization, we are able to extend the SD-UAVNet framework into a more comprehensive framework for UAV network experiment, performance modelling and evaluation in post-disaster scenarios. The results of this STSM, which includes the simulation results of the UAV network routing protocols with optimized UAV placement and movement, will be included in the RECODIS bookchapter 3.9 entitled "Routing in Post-Disaster Scenarios".

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

During the STSM, the grantee present the core ideas and the existing components of the Software-Defined UAV Networking framework, which includes the concept of using a centralized UAV controller to manage the global UAV network node context information, and make network control (UAV movement, data forwarding, etc) by using the collected information. However, the current framework does not include any optimization module to control UAVs' placements and movements. This means the overall movements of all the

UAV nodes are not optimized, which leads to non-optimized UAV placements and energy consumption. The grantee and host analyzed the problem together, and built a simple model to solve the problem of maximizing the UAV network nodes' coverage area and keeping the UAV network nodes' connectivity at the same time. As maximizing the network coverage and keeping the network node connected are the two contradictory problems, a game theory approach is a perfect solution to find the optimal solution to place the UAV nodes in proper positions such that both the network coverage is maximized while the UAV nodes are still connected. Starting from this model, we will consider more requirements (such as UAV's remaining energy) to further improve the model to make it more realistic to the UAV network deployment in post-disaster scenarios. The proposed optimal UAV movement modeling function is added to the UAV controller node architecture, shown as the "UAV Placement Manager" module in Fig 1.

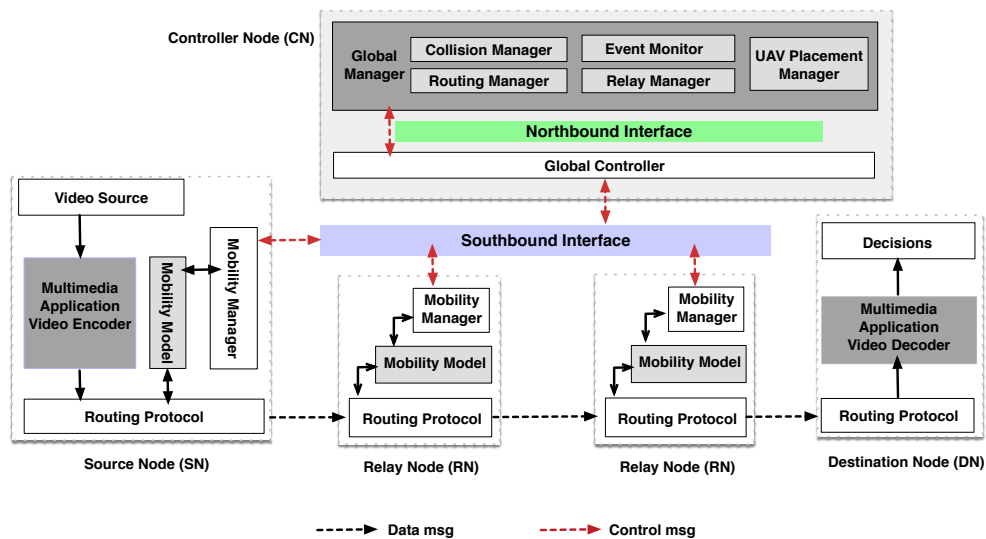


Fig. SD-UAVNet Architecture with UAV placement manager included in the UAV controller

DESCRIPTION OF THE MAIN RESULTS OBTAINED

The main output of this STSM is to extend the scope of the network resilience analysis in the relevant RECODIS book chapter from fix wired networks to mobile wireless networks. This includes adding the simulation results of the SD-UAVNet routing protocol for video surveillance application into the RECODIS book chapter 3.9 entitled "Routing in Post-Disaster Scenarios", which currently covers only discussions about resilience recovery mechanisms in wired and fix networks. With the experiment results obtained from this STSM, we will extend the network resilience to mobile and ad-hoc networks in post-disaster scenarios. In addition, with the expertise of the grant host, we are able to extend the SD-UAVNet framework with the capability of modelling the placement of UAV nodes and their trajectories to meet the requirements of coverage and connectivity in the same time. This enables us to design UAV network routing protocols by considering minimized UAV movements thanks to the network context information available at the centralized UAV controller, which can save energy for UAV nodes. Starting from the achieved basic modelling of UAV movements, we will extend the modelling to consider more constraints in the UAV network deployments, such as node movement collision avoidance, etc.

FUTURE COLLABORATIONS (if applicable)

Based on the achieved results that are directly derived from this STSM and the common research interests, the home institute of the STSM grantee and the host institute have agreed to further enhance the collaborations to combine the expertises of two institutes. This enhanced collaborations will enable us to submit joint publications, visit each other more often, and prepare research proposals together.

To benefit from the scientific results of this STSM, we have two publication plans in the coming three months. The first one is about extending the SD-UAVNet framework with the proposed network performance optimization models and submit it to a journal with special issue on mobile ad-hoc network performance modeling and evaluation. The second joint publication plan is about improving a joint conference paper submission that was rejected recently, revise it and send it to a journal. The RECODIS book chapter 3.9 will be another direct outcome as a future collaboration.

In addition to the planned joint scientific publications as direct collaborations, we also find that the two groups have many research topics in common. For instance, both groups are working on Internet of Things, and we decided to exchange our expertises and project results to enhance the work on these topics.

As for joint project proposal, we have identified two very interesting EU H2020 proposals, and started to contacting potential partners to team up the consortiums.