

Scientific Report: Short Term Scientific Mission COST Action CA15127

Fernando Kuipers

1 STSM Details

STSM Title: SDN-based network resilience

STSM Applicant: Dr. Fernando Kuipers, Technische Universiteit Delft, Delft, the Netherlands

Host: Prof. Wolfgang Kellerer & Dr. Carmen Mas Machuca, Technical University of Munich, Munich, Germany

Period: June 18-29, 2018

Working group: WG3

2 Purpose of the STSM

The purpose of this STSM (as part of WG3) was two-fold:

- To work together with Dr. Mas Machuca on editing and contributing to the RECODIS book.
- To explore opportunities for collaboration with the group of Prof. Kellerer. For example, w.r.t. the topics SDN controller resiliency and SDN-based multicast resiliency.

3 Description of the work carried out during the STSM

During the STSM visit, Fernando has given a presentation on June 20th, 2018, entitled “Towards a Tactile Internet.” The Tactile Internet relates to transporting “touch” over the Internet and once realized would constitute a paradigm shift in how we use the Internet. Key requirements that need to be met in order to realise the Tactile Internet are: (1) high network reliability and (2) low network latency. In the talk, various topics (all relevant to RECODIS) were presented, namely:

- Network resilience. The concepts of geographically correlated network failures and spatiotemporal network resilience were discussed.
- IoT security. LoRaWAN security vulnerabilities were revealed and findings from the development and deployment of an IoT honeypot were presented.
- Quality-of-Service (QoS). The notion of efficiency and resilience by design was put forth.

- Software-Defined Networking & P4. By leveraging the advances brought by softwarized networks, new techniques for fast fail-over and congestion detection were given.

In addition to the presentation, on June 27th also a class on “Network Resilience” was given to MSc students at the Technical University of Munich. The remainder of the time was spent on discussing topics for collaboration.

4 Description of the main research results obtained

The first result was editing the RECODIS book chapter “Definition of Metrics of Network Topologies to Measure Resilience of Carrier Networks” and providing some additional text for it, namely:

As part of the betweenness centrality text: The betweenness centrality metric can be extended to reflect the importance of a network region in which several nodes may reside, as is done in [F. Iqbal and F.A. Kuipers, “On Centrality-Related Disaster Vulnerability of Network Regions,” Proc. of RNDM 2017]. In that case, the betweenness centrality of a network region is reflected by the number of shortest paths (between all nodes) that pass through the region, via any links that cross the region. Also here it holds that the failure of a network region with higher betweenness centrality has a bigger impact on the network than the failure of a network region with lower betweenness centrality.

As part of the Functional metrics section: The Average Two-Terminal Reliability (ATTR) is defined as the number of connected node pairs divided by the total amount of node pairs. In [J. Oostenbrink and F.A. Kuipers, “Computing the Impact of Disasters on Networks,” Proc. of CINS 2017], the vulnerability of a network to geographically correlated disasters, such as earthquakes, is computed based on a finite set of disaster areas and occurrence probabilities. Instead of considering a single value, like the worst-case value or the expected value, the entire probability distribution is returned, from which “single values” can be derived. As a case study, Japanese networks (from which the geographic information is known) and Earthquake scenarios have been taken as input and the cumulative distribution function of ATTR is returned, assuming only 1 disaster happens at a time. The distribution reflects the probability of ending up with a certain ATTR value after a disaster strikes. Given this model, local recovery strategies are evaluated in [J. Oostenbrink, F.A. Kuipers, P. Heegaard, and B. Helvik, “Evaluating Local Disaster Recovery Strategies,” Proc. of CINS 2018].

The second result comprises the valuable discussions with Prof. Wolfgang Kellerer, Dr. Carmen Mas Machuca, and their PhD students:

- We have discussed how to switch VNFs from one switch to another (the current state of the VNFs also needs to be transported, and potentially also their flows need to be rerouted to go through the new switches) with the least amount of downtime. Based on our prior work [B. Turkovic, F.A. Kuipers, N. van Adrichem, and K. Langendoen, “Fast network congestion detection and avoidance using P4,” Proc. of NEAT 2018], our idea is to use P4. Two options can be considered: (1) implement all needed VNFs in the dataplane on all switches, or (2) load new P4 code to the switches and study the migration of an entire SFC.

- We have discussed the SDN controller robustness problem. While previously this was considered from the “Controller Placement Problem” point of view, a different complementary perspective is to consider the SDN controller fail-over times. That is, how long does it take for a slave controller to take over control from a failed master controller and can this time be improved, for instance through a proxy layer.
- We have discussed how the work on QoS and spatiotemporal network resilience that was highlighted during the presentation could be used in the context of industrial wireless sensor networks where performance and resilience guarantees are important.
- We have discussed how to schedule VNFs for aircraft communicating with a network on the ground, such that a balance can be struck between a smooth service and not too many VNF migrations. Time is an important aspect here (what time granularity & how far into the future to plan for). Possibly the notion of “Context-aware route planning” could be applicable.

The discussions on these topics are still ongoing. In addition, there was also a discussion with the group of Prof. Steinbach, that is working on various aspects of the Tactile Internet.

5 Future collaboration with the Host institution

During the STSM, it became obvious that Fernando Kuipers and the group of Prof. Kellerer share many research interests, and therefore we plan on collaborating well beyond the scope of this STSM. Our collaboration will focus on following up on the work that was initiated in this STSM and which has been described in the previous section. Possibly, someone from Technical University of Munich will also visit Delft University of Technology, to further intensify our collaboration.