SHORT TERM SCIENTIFIC MISSION (STSM) – SCIENTIFIC REPORT

The STSM applicant submits this report for approval to the STSM coordinator

Action number: CA15127
STSM title: Investigating the Temporal Aspects of Geographically Correlated Network Failures (Working Group 1: Large-scale natural disasters)
STSM start and end date: 08/04/2018 to 14/04/2018
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PURPOSE OF THE STSM/

There seems to be a split between two general approaches in disaster-impact computations. The more popular approach is to consider a broad array of possible disaster regions, and compute either the effect of a worst case disaster region or a random disaster scenario. In this approach the temporal aspect of the disaster itself and recovery after a disaster is ignored, one simply computes the impact based on the damage a disaster inflicts on the network.

In contrast, the other approach is to take a fixed disaster scenario, and model the performance and recovery of the network over time. This gives more insight on the total impact of the disaster on the network, but the result is limited to specific scenarios.

The purpose of the STSM was to gain insight in how to combine these two approaches, and in the potential advantages of the combination of the approaches.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

The STSM was implemented at the Norwegian University of Science and Technology (NTNU) in Trondheim, Norway and was hosted by Prof. P. E. Heegaard.

The first part of the STSM involved presenting my own (multiple disaster scenario) approach to Prof. Heegaard and other researchers at the NTNU. This was followed by discussions of how to combine the multiple scenario approach with a single scenario performance and recovery modelling approach. In addition to discussions about the use cases of such a combination and their advantages over current approaches.

The conclusion of these discussions was that it is indeed possible to combine these approaches, and that such a combined approach could be very effective in evaluating recovery strategies as preparation for potential disasters.

By considering a broad array of possible disaster scenarios, instead of a single disaster, the general performance of different strategies can be evaluated. As recovery is inherently a process over time, this requires a model and method to go from a disaster scenario + network topology + strategy to the state of the network over time. In addition, this "state over time" needs to be transformed to a single value reflecting the effectiveness of the recovery strategy.

A specific use case, which we considered in more detail, is the evaluation of quick local disaster recovery:

After a disaster strikes a communication network some of its components will fail, thus disconnecting areas from the network. It is imperative that these areas are connected again as soon as possible, both for emergency operations, but also to enable people in the area to get up-to-date information about their situation as soon as possible.

As repair of the network can take in the order of days to months, quick temporary measures need to be taken to restore some network functionality in the affected areas as quickly as possible. Due to time and resource constraints, it is impossible to recover all, or even close to all, functionality during this quick emergency recovery, thus choices have to be made on which areas need to be given priority first.

Computing the optimal choice of recovery actions after a disaster might be computationally expensive, especially with the limited amount of resources due to the destruction and chaos caused by the disaster. In addition, the choice of which actions to take has to be made as quick as possible after a disaster, at which point the complete state of the network might not be known. For these reasons, it might be preferable to be able to make some quick decisions based on a simple rule of thumb instead.

To evaluate which simple strategies, or rule of thumbs, to use, one can evaluate different strategies to a broad class of disaster scenarios, comparing them to the optimal choice of actions as well. The chosen strategy can then be prepared and quickly implemented after a disaster actually strikes the network.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

Our main results are the proposed combined approaches described above. In addition, we have fleshed out the specific `evaluation of quick local recovery actions' use case.

We have considered a disaster and recovery situation, where only nodes are damaged, and some of the nodes can be temporarily replaced by emergency equipment. These assumptions are based on the observations made, and the proposal of Moveable Deployable Resource Units (MDRU), in (Sakano, Toshikazu, et al. "Disaster-resilient networking: a new vision based on movable and deployable resource units." IEEE Network 27.4 (2013): 40-46.).

Based on these assumptions, we have created a model for the state of the network over time after a disaster and during recovery, as well as a method to evaluate this state over time. Based on this model, we have created an algorithm to evaluate different recovery strategies with respect to a large set of representative disaster scenarios.

One of the main ideas behind the algorithm is to only evaluate a local area around the disaster region, as to not take into account the global situation of the network, but only the area that is cut of from the network by the disaster. This area requires network recovery the most, e.g. for emergency coordination purposes. In addition, the global traffic can typically be rerouted around the disaster region, but this is not an option to restore required network functionality in the disconnected areas. Thus, the focus needs to be set on the local affected area.

This also has a positive effect on computation efficiency, as it reduces the number of network components that need to be considered when evaluating a specific scenario. As a direct result, more details can be incorporated in the network topology. While in typical approaches, where the impact of disasters to the network as a whole is considered, these details might not be as important, and can perhaps safely be ignored, they are of the utmost importance when assessing the effect of the disaster and the recovery strategy on the most affected, local, areas.

FUTURE COLLABORATIONS (if applicable)

We plan to further collaborate on this topic, with to goal to submit a paper to a conference or journal.