Model-Based Generation of Service Provider Network Topologies

Creation of network topologies with service provider network characteristics using the MOST-Model.

Graduate

Pascal Christen

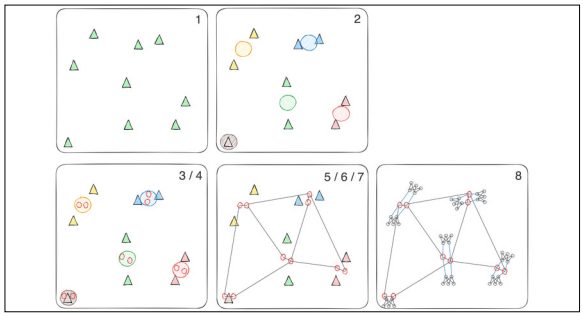
Lukas Ribi

Objective: Researchers and network engineers working for service providers need to validate network technologies to see how they scale on networks of varying sizes. Currently, these test networks are often created based on random graphs. Due to their randomness, they often lack characteristics found in real service provider networks. The goal was to develop an approach to generate network topologies with specific characteristics of these service provider networks. Furthermore, the existing Graph Analyzer system created during the previous term project had to be expanded to include edge weights in graph property calculations. In addition, a new graph property indicating robustness needed to be implemented.

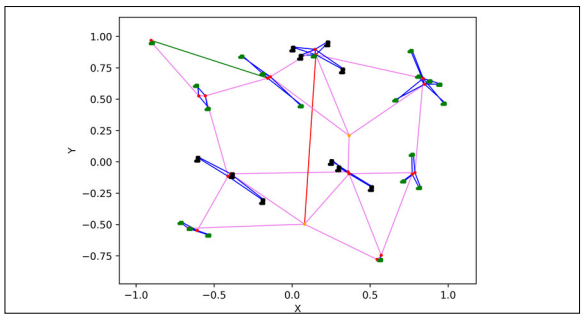
Approach: The MOST-Model (Mesh-Oriented Service Provider Topology) has been developed to facilitate the generation of network topologies that structurally resemble service provider networks. The model consists of eight steps and is parameterised to provide flexibility in the generation process. The model is inspired by existing methodologies and uses approaches that lead to characteristics matching service provider networks. A Gabriel graph is used to create the topology with additional optimisations to ensure redundancy. In other published papers, it has been documented that this type of graph reflects backbone networks well. The newly created Graph Generator application uses the MOST-Model to generate topologies. An API provides the ability to interact with it. The Frontend of the Graph Analyzer system has been extended to integrate the Graph Generator. It allows the seamless generation and visualisation of topologies using adjustable model parameters. The generated result can subsequently be imported into the Graph Analyzer system.
Graph property calculations have been extended by incorporating edge weights from imported topology data. An approach using a targeted attack on high-degree nodes was chosen to calculate the robustness of a graph.

Conclusion: During the bachelor's thesis, the MOST-Model was developed to generate network topologies with service provider network characteristics. Due to the underlying use of the Gabriel graph, the number of edges is minimised while still providing redundancy through alternative paths. This property reflects service provider network requirements from a cost and availability perspective. Known issues of the Gabriel graph, such as stub links, are mitigated through applied optimisations. The model has been integrated into the Graph Analyzer system as a separate application. This separation allows the straightforward integration of the MOST-Model via the Graph Generator application into other systems and contexts. In addition, the results can be imported into other applications by providing the generated topologies in the commonly used GEXF and GraphML file formats. The resulting Graph Analyzer system provides an easy way to examine how networks are structured and can generate new topologies through the Graph Generator application. The source code is publicly available and published under the permissive MIT license.

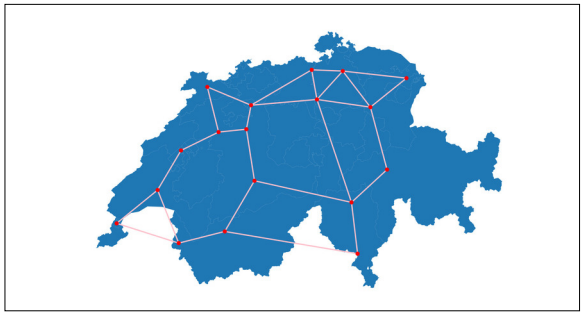
Simplified MOST-Model process visualisation
Own presentment



Generated network topology
Own presentment



Application of the model on random Swiss city locations
Own presentment [Map Source: © swisstopo]



Advisor
Prof. Laurent Metzger

Co-Examiner
Marcel Witmer, Cisco Systems (Switzerland) GmbH, Wallisellen, ZH

Subject Area
Networks, Security & Cloud Infrastructure, Software

Project Partner
Cisco Systems, Machelen, Belgium