STSM report:
Modelling, evaluation and analysis of control plane availability in Software Defined Networking (SDN)

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Purpose of the STSM

The goal of this STSM was to continue working jointly on modelling, evaluation and analysis of control plane availability in Software Defined Networking (SDN).

In SDN all control plane logic is concentrated in the software entity called SDN controller, as illustrated in Fig. 1. The task of the controller is to react to the events coming from the data plane (e.g. routing of new flows, re-routing in the case of link or node failures) and attend the requests coming from the network applications (e.g. steer the traffic according to the specified QoS policy or install a bandwidth on demand). Hence, a failure of the controller will have a huge impact on the network performance and agility. During my previous visit to Prof. P. Heegaard and Prof. B. Helvik from the host institution in November 2016, we had developed a comprehensive model able to capture dynamic behaviour of SDN controllers. This model was used to analyze steady state availability, as well as the frequency and duration of the outages, or the controller clusters[1].

The main objective of this STSM was to extend our previous work on characterization of failure dynamics of SDN controllers to provide a model capturing the performance of the entire control plane. During my visit, I had the opportunity to meet Prof. K. Trivedi from Duke University, who is expert on

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[1] The work has been submitted to International Workshop on Resilient Networks Design and Modeling (RNDM), 2017

software reliability. This visit overlapping gave us the possibility to have fruitful discussions on our model and ways to extend it as summarized in the next section.

Main results of the work carried out during STSM

During the STSM different approaches to analyse, model and evaluate the availability of SDN control plane have been discussed:

Analysis: We have performed an extensive survey on performance reports from the major open source controllers OpenDaylight and ONOS, in order to identify the bottlenecks in control plane availability. From these performance reports many useful metrics can be derived, such as nature and frequency of different failure modes [L+96].

- Different frameworks and software packages for trend analysis and statistical inference, such as SREPT [RGT00], were discussed to get the most relevant information.
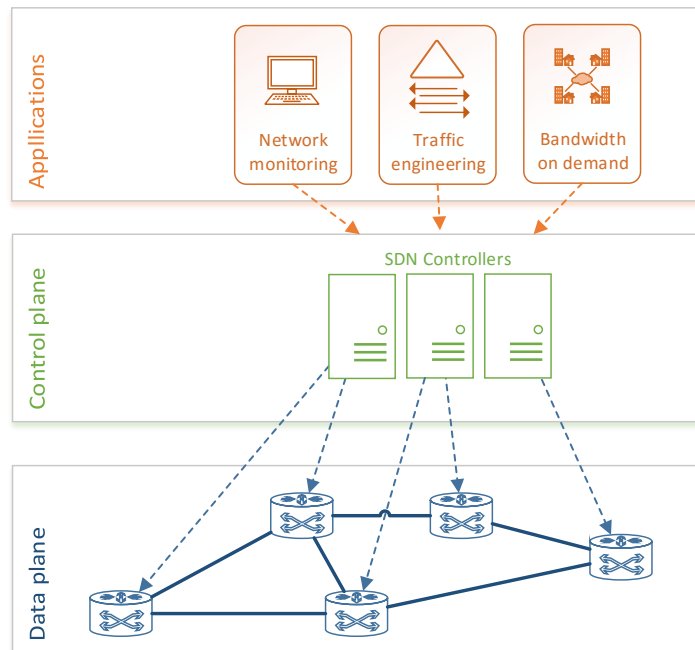- We plan to complement these data sheets with the measurements at our SDN testbed at TUM.

Figure 1: Software Defined Networking architecture.

Modeling: The modeling of the control plane was done in the formalism of Non-Homogeneous Continuous Time Markov Chains(NH-CTMC) and Stochastic Reward Nets (SRN). For simpler small size problems closed form solution can be derived [Tri08], while for large problem instances, the tools such as SPNP [HTT00] and SHARPE [HSZT00] can be used to obtain the solution, either based on numerical approximation or discrete event simulation. An interaction between controller and network application will be modelled following the approach presented in [WT05].

Evaluation: Once the models are finalized, we plan to perform a case study based the actual SDN controllers. The models will be used to compare different control plane designs, as well as to evaluate relevant dependability metrics, such as user perceived service availability and reliability. The most critical components will be identified, and sensitivity study on the most relevant parameters will be performed. Efficiency of different protection schemes will be compared and alternative approaches to improve the control plane availability will be proposed.

Future collaborations

The visit triggered an interesting discussion in the areas of software reliability measurement and modelling. We plan to do a follow up over email and conference calls, and possible during one of the future STSMs.

The following conferences have been identified as suitable for publishing the results of our collaboration:

- International Workshop on Software Aging and Rejuvenation (WoSAR)

- International Symposium on Software Reliability Engineering (ISSRE)

- International Conference on Dependable Systems and Networks (DSN)

- Intl. Conference on Design of Reliable Communication Networks (DRCN)

References

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