POLITECNICO DI TORINO

POLITECNICO DI TORINO
Master degree course in Communications and Computer Networks Engineering

Master Degree Thesis

# Design of State Replication for Stateful Software Defined Networking

**Supervisors**
prof. Paolo Giaccone
prof. Andrea Bianco

**Candidate**
German Sviridov

Academic Year 2016-2017

The field of software defined networking (SDN) has been rapidly evolving in the recent years. Multiple per-packet processing functions are being defined in order to introduce a tighter control over the network. However, these new functionalities can create considerable overhead and significant delays for control information exchanged with the controller. These factors lead to a reduced reactivity to network events and an overall performance degradation.

In order to overcome these limitations a big effort is being devoted towards the definition of a novel approach based on stateful functionalities. The use of stateful approaches allows to offload some of the controller functions directly to the switches by defining persistent states that can hold state information related to per-packet processing rules. The proposed solutions however make use of a centralized state placement, eventually forcing the majority of traffic to pass through a single device which can create single points of failure and reduced performance.

The purpose of this research is to design and implement a scalable stateful solution that would lead to an increased performance and reliability. The idea behind the proposed approach is to distribute the state information across multiple forwarding devices while guaranteeing high consistency among the states. The proposed solution is able to provide lower overhead and thus better performance in respect to the solutions present in literature and is able to prevent state information loss in case of isolated failures.

The implementation and evaluation has been performed in an emulated network environment with virtual switches programmed in P4, an emerging data-plane programming language.

In a scenario of a DDoS attack towards an autonomous system by neighboring autonomous systems the solution based on distributed states led to a substantial improvement in terms of reactiveness and introduced overhead in respect to solutions based on classical SDN. The obtained results are also compared to the results produced by a collaborating research group whose effort was devoted to a yet non-standardized extension of an existing technology (OPP).

In this work is presented an analytical model targeting the optimal distribution of replicated states for programmable stateful dataplanes. The model provides richer possibilities in terms of network programming functionalities which allow to achieve better network resources' utilization when embedding network programs in the dataplane.

Although the analytical model itself provides a leading contribution to the field, the major contribution of this work resides in the feasibility analysis of implementing a replication scheme entirely in the dataplane and the consequent design and implementation of a functional prototype.

The feasibility analysis requires a robust understanding of the state of the art replication mechanisms and their suitability in the case of stateful dataplanes. For

this reason this work contains a critique towards replication schemes currently implemented in production environments alongside with the proposed state of art alternatives. A major portion of the work is dedicated towards the design of a suitable replication mechanism by considering limited capabilities of the commercially available forwarding devices.

Finally the evaluation of a functional prototype is performed. The results of the evaluation show the net superiority of the proposed model in terms of resource utilization while still providing bounded approximation errors of the global state.