Optimized SDN Controller Placement and Synchronization Strategy in Edge Networks

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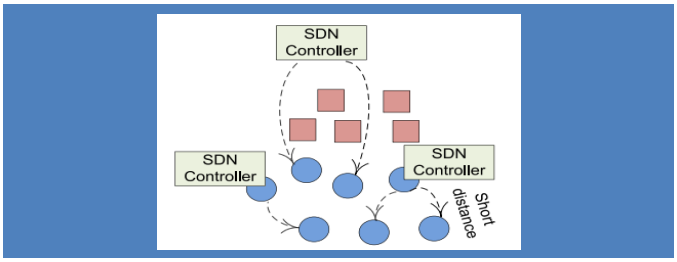
Objectives

In order to apply SDN centralized control in edge networks, the bottleneck in wireless channels makes it necessary to set up multiple controllers in different nodes, with the control traffic overhead minimized. We focus on following objectives:

- An optimal strategy to determine the amount of controllers and the locations to place them.
- An adaptive learning algorithm to determine the rate of inter-controller synchronizations based on the feedback from SDN applications.
- Implementations and evaluations of algorithms above using state-of-the-art SDN controllers and real edge devices.



Technical Challenges

- The algorithm must take different types of costs into consideration, including traffic overhead and delay, inter-controller communications and controller-node communications.
- The algorithm should find the balance between minimizing the costs and guaranteeing the performance of SDN applications. Meanwhile, it should handle the variety of different applications.
- The algorithm should finish in reasonable time in order to dynamically adapt to the network changes.

Approaches

- We model different costs during the process of SDN control based on measured results, then proposed both an optimal solution and a scalable approximate algorithm of controller placement with good performance in practical.
- We propose a new mechanism that learns from actual network performance metrics and adaptively adjusts the synchronization rates, which has provable performance guarantees and fast convergence speed.
- We deploy state-of-the-art SDN controllers (ONOS and Ryu) and multiple applications (routing, load balancing) to show the benefits of our methods.

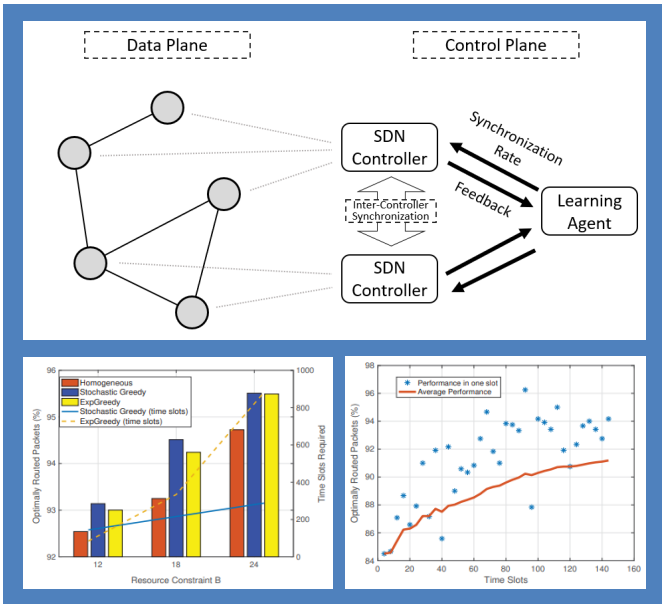
Military & Coalition Relevance

- The proposed methods of setting up a distributed SDN control plane provide solutions to military scenarios, e.g., tactical networks that are highly dynamic because of unstable links and nodes movement.

Results

We have following demonstrations:

- We set up an edge network topology in the Mininet emulator, and deploy an SDN controller cluster consisting of multiple Ryu controller instances according to our controller placement algorithm. Controllers synchronize with each other periodically in order to keep the consistency.
- We emulate random link failures in the data plane, and have an application in the control plane to repair routing. The routing success rate will be monitored and sent to a learning agent. Based on this feedback, the learning agent adjust the synchronization rate between each pair of controllers.
- We record the application performance and the control message overhead in real time, which will indicate that our algorithm converges fast to a balance among multiple metrics.



Summary & Future Work

- We studied the problem of finding the optimal placement and synchronization rates among controllers in a distributed eventually-consistent SDN system. We will continue to explore the issues related to the multi-controller scenario in our future works.

Publication(s) & Impact

- Poularakis, K., Qin, Q., Ma, L., Kompella, S., Leung, K. K., & Tassiulas, L. (2019). Learning the Optimal Synchronization Rates in Distributed SDN Control Architectures. In IEEE INFOCOM 2019-IEEE Conference on Computer Communications……
- Qin, Q., Poularakis, K., Iosifidis, G., Kompella, S., & Tassiulas, L. (2018). SDN controller placement with delay-overhead balancing in wireless edge networks. IEEE Transactions on Network and Service Management, 15(4), 1446-1459.