Bridging the Architectural Gap between NOS Design Principles in Software-Defined Networks

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ABSTRACT

We design Barista, as a new framework that seeks to enable flexible and customizable instantiations of network operating systems (NOSs) supporting diverse design choices, using two key features that harmonize architectural differences across design choices: component synthesis and dynamic event control. With these capabilities, Barista operators can easily enable functionalities and dynamically adjust the control flows among the functionalities to deploy.

1 INTRODUCTION

In software-defined networks (SDNs), a network operating system (NOS) is a vital element since it determines the functionalities of SDN. However, it appears that today's NOSs are still not enough to satisfy the requirements of network operators. For example, operators need a scalable NOS to manage a large number of cloud entities around the networks. At the same time, they also need a secure NOS that protects the assets of their networks and the NOS itself against attacks [1]. While they do indeed want to achieve the functionalities of both NOSs, it is quite challenging to integrate those functionalities due to their *architectural difference*. ONOS [2] aims at high parallelism and distribution to handle large-scale networks while SE-Floodlight [3] focuses on centralization to inspect all control flows inside a NOS. In turn, their design principles are conflict to each other.

To address the architectural difference, we design a novel NOS framework, called Barista, that supports flexible composition of the functionalities found in today's NOSs in a hybrid manner. For this, we focus on two key aspects of its design: *component synthesis* and *dynamic event control*. These capabilities allow operators to easily enable functionalities and dynamically handle events for them, satisfying their operating requirements.

2 OUR APPROACH

Unlike the specialization of today's NOSs, the goal of Barista is to enable operator-defined composability of NOS functionalities for various operating requirements.

Component Synthesis: The modular design of the Barista framework enables operator-defined composability of NOS functionalities, and provides those functionalities (e.g., clustering, role-based authorization, and flow rule conflict resolution) as component extensions. Then, modularized components communicate with each other based on event-driven interaction instead of direct function calls. To fully modularize and isolate them, Barista supports portable component extensions that can be executed inside or outside the framework without any modification as well.

Dynamic Event Control: Barista allows operators to customize the control flows across NOS components. The key problem of the architectural difference comes from the different style of message processing mechanisms in NOSs. The Barista event handling framework first extends the SDN event handling model by incorporating two additional event classes: inter-component and meta events. The inter-component event class is to replace direct function calls between components with a pair of request-response events for full per-component isolation. The meta event class is a novel event class that can dynamically modify the set of active components based on current operating conditions. Second, it allows operators to define dynamic event chaining among components (the combination of sequential and parallel chaining).Third, it enables NOS authors to express event distribution policies for controlling event visibility per NOS component. With those features, NOS functionalities can be deployed according to their required processing styles selectively.

3 CONCLUSION

Contemporary NOS solutions tend to be focused on specific dimensions, and the integration of the functionalities across NOSs is challenging due to incompatible design principles, making it difficult for operators to satisfy their demands. Barista takes an important step toward addressing this problem by providing a NOS component synthesis framework that simplifies integration of composable NOS modules with a dynamic event handling mechanism.

REFERENCES

[1] Seungsoo Lee, Changhoon Yoon, Chanhee Lee, Seungwon Shin, Vinod Yegneswaran, and Phillip Porras. 2017. DELTA: A Security Assessment Framework for Software-Defined Networks. In *Proceedings of the Annual Network and Distributed System Security Symposium (NDSS)*.

[2] "OnLab.us". Accessed: 2017/08/01. "Open Network Operating System". http://onosproject.org. (Accessed: 2017/08/01).

[3] Phillip Porras, Steven Cheung, Martin Fong, Keith Skinner, and Vinod Yegneswaran. 2015. Securing the Software-Defined Network Control Layer. In *Proceedings of the Network and Distributed System Security Symposium (NDSS)*.

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