SC23 Network Research Exhibition: Demonstration Preliminary Abstract

[High Performance Network Entropy Platform Prototype for The Research Platforms with International P4 Experimental Networks]

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Abstract

Recent successes of implemented "research platforms" have been demonstrated as key enablers of large-scale data intensive science. These platforms are based on architecture consisting of various orchestration techniques (e.g., Kubernetes), low management overhead, and tenant-oriented applications. This approach develops services focused on meeting requirements of research science communities, especially data intensive science. For major research platforms usage scenarios, high performance WAN networking is a high priority concern. Recently, P4 has become a major enabler for these types of services. Consequently, research testbeds such as the International P4 Experimental Networks testbed, have become important resources for exploring potential contributions of techniques for programmable data planes to high performance networking for science. To support different monitoring and anomalies detection approaches, we will prototype & demonstrate Network Entropy Platform for the Global Research Platforms(GRP) with International P4 Experimental Networks(iP4EN).

Goals

This SC23 NRE demonstration will illustrate the challenges to enabling Kubernetes integration with P4 Experimental Network Services over the Global Research Platform (GRP) over high-speed network. This demonstration will also showcase solutions to those challenges:
(1) P4 software only Experimental Network Services in a container/Kubernetes environment with a cluster in the Global Research Platform over high-performance WANs.
(2) P4 hardware only Experimental Network Services in a Container/Kubernetes environment with a dedicated cluster in the Global Research Platform across high performance WANs.
(3) P4 integrated hardware and software as Experimental Network Services in a Container/Kubernetes for the Global Research Platform across high performance WANs.
(4) Prototype Kubernetes L2 and L3 network integration with P4 Experimental Network Services for the Global Research Platform across high performance WANs.

Resources

(1) Selected US and international iP4EN sites will participate in these demonstrations. The current International P4 Experimental Networks and testbeds configuration is shown at the end of this document.

(2) The StarLight International/National Communications Exchange Facility.

(3) Required resources from SCinet WAN are 1.2 Tbps E2E WAN services from the StarLight International/National Communications Exchange Facility in Chicago to the SC23 venue, between StarLight and the JBDT Facility in McLean, between the JBDT Facility and the SC23 venue and among all sites.

(4) With support from the SC23 SCinet team, vlans will be implemented from StarLight over 100G/200G/400G paths to showcase floor and public L3 routes from the StarLight booth to PRP/TNRP/GRP sites and other partner booths at SC23.

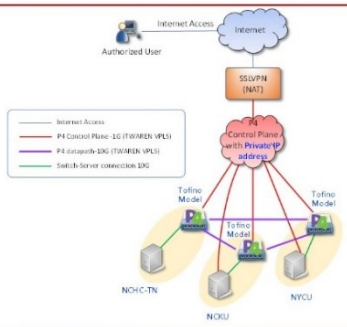
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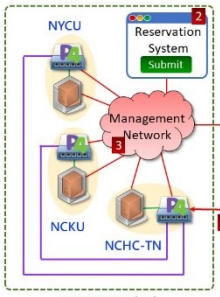
P4 Testbed Automation with Real Traffic Analysis for Tenants

- To boost research and experiment activities of programmable switch technology in Taiwan, TWAREN deploys a P4 network testbed based on hardware Tofino P4 switches.
- Users can access the testbed by passing through SSLVPN authentication system. After booking required resources via the reservation system, the testbed will perform the automation by allocating a brand-new experimental environment for the user on schedule.
- In addition, real traffic of CDN service operated by our team can be mirrored to the P4 switch for users to investigate and analysis.



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P4 Testbed Automation with Real Traffic Analysis for Tenants





1. Tenants can access the P4 testbed after passing the SSLVPN authentication system.
2. Tenants can book required resources via the reservation system.
3. Automation: a brand-new experimental environment will be deployed automatically on schedule.
4. The real CDN traffic can be mirrored to the P4 switch for further analysis.

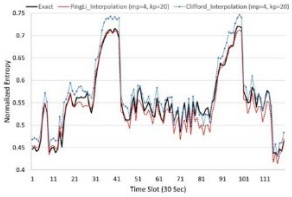
Real-Time Anomaly Detection with Entropy

The empirical entropy of the network flow attributes is an essential measure for identifying anomalous network traffic. However, computing the exact entropy values for high-speed networks in real time is computationally expensive. Accordingly, the present study replaces the complex computations of existing stable random projection methods for entropy estimation with a simple table lookup procedure. Notably, the size of the lookup table is reduced through a piece-wise linear interpolation heuristic in order to facilitate the implementation of the proposed scheme in resource-constrained pipeline environments.

The proposed architecture enables entropy estimation to be performed using both the Log-Mean Estimator (LME) method and the New Estimator of Compressed Counting (NECC) algorithm reported in the literature. The feasibility of the proposed approach is verified empirically using both real-world network traffic traces and synthetic data streams. Moreover, the practical applicability is demonstrated via stream-based implementation in the programmable data planes of the NetFPGA-Plus framework and a Tofino P4 switch, respectively. The results indicate that the proposed tabulation-based entropy estimation scheme allows minimum-sized Ethernet frames to be processed with a wire speed of up to several hundred gigabits per second.

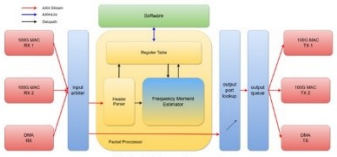
"Tabular Interpolation Approach Based on Stable Random Projection for Estimating Empirical Entropy of High-Speed Network Traffic" IEEE Access, 27 September 2022, Y. Lai, et al.

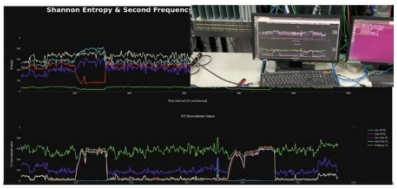
"Sketch-based Entropy Estimation: a Tabular Interpolation Approach Using P4" , Y. Lai, et al EuroP4 2022 workshop, CoNEXT 2022

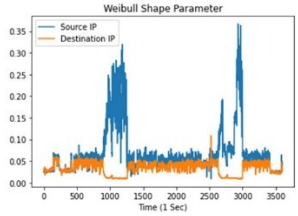


Real-Time Anomaly Detection with Frequency Moment Estimation

Frequency moments serve as crucial metrics in the analysis of network traffic and in identifying irregular patterns. However, executing real-time, online computations remains a challenging task. We presents an implementation of the Frequency Moment estimation utilizing the 100Gbps Xilinx Alveo U200 acceleration card of the NetFPGA-PLUS platform. We further showcase its applications in scan anomaly detection and parameter estimation for the Weibull model of flow length distribution.







International P4 Experimental Networks (iP4EN)

