Challenges and Opportunities of Measurement for Future Software Defined Infrastructure

Yan Luo
Dept. of ECE, University of Massachusetts Lowell
yan_luo@uml.edu , http://acanets.uml.edu/

Measurement is instrumental in quantifying the performance of cyberinfrastructure, understanding resource usage, provisioning and troubleshooting. Measurement, however, has faced several challenges: (1) scaling challenge: It is non-trivial to provide detailed per-flow measurement data at a line rate of 100+Gbps, and collecting the metrics on every core in a data center is an enormous task; (2) the diversity and dynamics of measurement tasks: The measurement target could change rapidly, so do the interested metrics; and (3) knowledge discovery from measurement data: the massive measurement data are under-exploited assets that could help learn interesting patterns, predict trends and lead to actions. In the past decade, measurement is merely a second class citizen until an infrastructure issue arises. We believe that there are a number of directions in innovating infrastructure measurement which would yield significant leap forward:

(1) *Software defined measurement (SDM)*. Programming a measurement task has become increasing important and interesting, because the data flows traverse a Software Defined Infrastructure (SDI) consisting of different network domains and heterogeneous computing elements. In addition, measurement objectives typically vary from time to time in scope, granularity, conditions, and actions. For example, using fixed measurement metrics for every single application flow is not necessary or feasible as one may need to "zoom in" or "zoom out" on a particular flow. The measurement may have to start or stop when a given condition is met. There is a strong need to support such flexibility, and a software-defined approach is very promising. We envision that (1) a SDM control plane that supports measurement task creation, scheduling, results collection through APIs and (2) a SDM data plane that is programmable in defining and instantiating a measurement task with its measurement target, metrics, algorithms, and conditions of start/stop it. Language and framework supports for measurement are interesting to investigate.
(2) *Mining measurement data*. Big data has changed how science discovery works. Measurement data increase in size as well as their value of providing useful information about the SDI. The analysis of network flow data obtained from measurement instruments is challenged with the data volume and a variety of flow features. This calls for new systems to process the streaming data, new algorithms to derive knowledge from data, and new control schemes to take advantages of the learned infrastructure usage patterns.
(3) *Adaptive infrastructure optimization*. The knowledge from measurement data would enhance the predictability of infrastructure performance, and the software defined measurement framework would allow the control plane of a SDI to proactively gather up-to-date metrics, and adapt the system parameters in response to application and system conditions. This is to elevate the measurement to a first class citizen so that its benefits can be maximized for supporting scalable, quantifiable, and adaptive SDIs.

Brief Bio

Dr. Yan Luo is an Associate Professor of the Department of Electrical and Computer Engineering at the University of Massachusetts Lowell. While his research interest spans broadly computer architecture and network systems, Prof. Luo's current research focuses on heterogeneous architecture and systems, software defined networks and deep learning. He has served on the program committee of numerous international conferences and as a guest editor and referee of premier journals. Prof. Luo directs the Laboratory of Advanced Computing and Networking Systems, which has been supported by National Science Foundation, Intel, Raytheon/BBN, Xilinx and Altera. He is currently leading a NSF-funded multi-institutional team working on software-defined privacy-preserving network measurement instrument for international research network connections.