Executable Formal Semantics of P4 and Applications

Abstract

Programmable packet processors and P4 as a programming language for such devices have gained significant interest because the flexibility that they provide enables rapid development of a diverse set of applications that work at line rate. However, this flexibility, combined with the complexity of devices and networks, increases the chance of introducing subtle bugs that are hard to discover manually. Worse, this is a domain where bugs can have catastrophic effects. Hence there is a need for automatic tools for analysis of P4 programs and networks.

We argue that analysis tools must be based on a formal semantics of the P4 language rather than on its informal specification. Moreover, to increase confidence in the correctness of the formal semantics, it should be: (1) executable, in order to be rigorously tested against potentially hundreds or even thousands of programs; (2) compact and human readable, in order to be easily inspected and ultimately trusted by everyone. To this end, we provide an executable formal semantics of the P4 language in the K framework. Based on this semantics, an interpreter and various analysis tools including a symbolic model checker and a deductive program verifier are provided by the framework for free.

This talk overviews the K semantics of P4 and some of its potential applications both for the P4 application developers in the context of verification of properties about P4 programs and networks as well as for the P4 language designers and compiler developers. We will also discuss the main challenges encountered during our (post-mortem) semantics engineering effort, and conclude by recommending that there are benefits in designing and rapid prototyping future versions of P4 using this framework.

Bio

Ali Kheradmand is a third year Ph.D. student in Computer Science at the University of Illinois at Urbana-Champaign working with professor Grigore Rosu. His research interests generally include applications of software engineering, programming languages, and formal methods in ensuring the reliability of concurrent and networked systems. In collaboration with Fujitsu Laboratories of America, he is working on Deltanet, one of the fastest real-time network verification tools to date. Ali has received his BSc in Computer Engineering from Sharif University of Technology in 2014.