

Half-Day Tutorial Proposal

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1 Title

Programming data-planes in P4, a high-level language for packet processors.

2 Outline

- Introduction (0.5h)
 - P4 motivation: this first subsection overviews on a time-line basis the research that led to the emergence of a high-level language to Program Protocol-independent Packet Processors, a.k.a. P4.
 - The community and the consortium: this subsection illustrates the P4 consortium main aims. The explanation covers information about the consortium membership, the community events, the language development activities and the related work-groups. Further, directives on how to contribute the P4 community are provided.
- Language Walkthrough (1h): this section presents the P4 programming model by introducing the main elements of the language. Definition of protocol headers, match-action tables and control flow is explained by giving an overview of the language syntax and constructs.
- P4 Software tools (0.5h): this section introduces a set of open source tools that can be used to experiment with the language. The toolset includes the P4 front-end compiler, a software back-end, i.e., the P4 software-switch, and the CLI used to program the software-switch.
- Hands-on session (2h)
 - Reviewing a P4 example step-by-step: this subsection reviews one of the example programs provided within the P4 public repository (e.g., the simple router). The code of the example is illustrated in detail to get the audience to familiarize with the programming model. Finally, a short demo in Mininet is run to show a software-switch executing the network behavior implemented by the example program.

- Assignments in class: this subsection provides the audience with one simple network protocol to be implemented in P4. The assignment requires a simple protocol logic to be written in P4 and then run in the Mininet simulation environment. Further and advanced assignments are provided to whom gets easily into the language to experience more challenging implementation tasks.
- Discussion on possible P4 projects: the audience is invited to come up with own ideas to be implemented in P4. The speakers support the attendees with the design and the implementation of their own projects.

3 Speakers and the topics they will cover

Shortly after the P4 inception, Dr. Radu State joined the P4 consortium on behalf of the University of Luxembourg. Salvatore Signorello is a PhD supervised by R. State, who has been following the development of the P4 community since the consortium creation. Salvatore will first introduce the motivation that led to the P4 language creation, then he will overview the consortium main aim and its ongoing activities.

Jérôme François and Salvatore Signorello will provide an overview of the language and the development environment. Then, they will guide the audience through the hands-on session, helping them with the assignments and providing them with advice for the development of their own future projects in P4.

4 Speakers Short Biographies

Radu State is a senior researcher with the Interdisciplinary Center on Security and Trust (SnT) in Luxembourg heading the SEDAN group that addresses research activities in the areas of security, service management and monitoring. He was a former professor at the University of Lorraine and a senior researcher at INRIA Nancy (France). Having authored more than 100 papers, his research interests cover network and system security and management. He holds a Ph.D and a HDR from University of Lorraine and a M.Sc from the Johns Hopkins University.

Jérôme François is a permanent researcher at INRIA in the Madynes Team. Previously, he was a research associate at the SnT of University of Luxembourg. He studied at ESIAL, a French leading school in computer science. He received his Ph.D. on robustness and identification of communicating applications from the University Henri Poincaré in Nancy (France) in December 2009. He published several papers in major conferences on topics related to security and network management (IFIP Networking, IEEE/IFIP NOMS, IEEE/IFIP IM, RAID, IEEE ICC, CNSM) for which he also served as TPC member. His research interests are in network management with a special focus on security mechanisms for new network paradigms like SDN, NFV and ICN.

Salvatore Signorello is a member the SEDAN group at SnT in Luxembourg doing a joint PhD with the University of Nancy. Salvatore holds a master's cum laude from the

University of Catania (Italy) with a thesis about the integration of WSNs in the mainstream Internet through IPv6 and 6LoWPAN. He has also worked as CNIT member on the network infrastructure of the Convergence EU-FP7 project (a publish-subscribe system on an Information-Centric Network) for two years. Salvatore's research interests are in Information-Centric Networking and, more generally, in programmable data-planes. Salvatore attended the P4 tutorial held at SIGCOMM'15 as well as the 1st P4 Boot Camp hosted by Barefoot Networks in November 2015.

5 Importance and timeliness

The Software-Defined Networking (SDN) has changed the way network operators design and deploy network solutions. Fairly speaking, the OpenFlow (OF) protocol played a major role in the realization of the SDN vision and, today, this term is always misused to refer to that broader vision. In 2009 the first OF specification comprised few header fields and a single match-action table. Today, we have reached more than 40 header fields, multiple processing pipelines and many more specification extensions are continuously proposed and discussed. However, today's OF still shows some limitations and follows a dangerous evolution trend. The processing of a new protocol still requires an OF extension to be proposed, accepted, integrated and then implemented by network vendors. Instead of repeatedly extending the specification to deal with new protocol standards, which never cease to appear, future network devices could be designed to support programmable packet parsing and processing. This hypothesis has been further strengthened by several recent advances in literature showing that such capabilities are not out-of-reach [1, 2].

Once these next-generation fully-programmable network devices will be produced, there will be the need to program them to implement desired behaviors. As already happened for previous general-purpose processors, the flexibility of those facilities could be mastered through the use of high-level programming languages. One common open high-level language, instead of a plethora of proprietary microcode languages, could ease prototyping, testing and disseminating new ideas. Moreover, network programs will be written once and then ported many times regardless of the hardware setting, though assuming that there will be compilers for different platforms. P4 was originally proposed [3] as candidate language for the future programmable network devices. P4's goals are protocol independence, target independence and reconfigurability in the field. Since the inception, the P4 language has generated a notable momentum across both the industry and academia, gathering together the biggest network operators and some enthusiastic academics in a no-profit consortium [4]. The potential of the language to describe common networking tasks has already been showcased by some preliminary works [5, 6]. Today, an hectic ecosystem of open source software tools is maintained and developed by the P4 community at [4].

5.1 Intended audience, prerequisites and expected outcome

The tutorial targets a broad audience of Ph.D. students, researchers and professionals that do research in communications. There are no specific prerequisites except a basic knowledge of computer networking. The attendees will be provided with a virtual image containing all

the necessary software to experiment with the language during the hands-on session. Hence, participants are expected to bring their own laptops. The main goal of the tutorial is to introduce the audience to the language, providing them with the knowledge necessary to develop and prototype their own ideas in P4. Further, the tutorial aims at encouraging the audience to join the P4 community and contribute to the language development.

6 Previous lecture and tutorial experience of the tutorial speaker(s)

Radu State has been teaching graduate-course on network security and management both at the University of Luxembourg and at the University Nancy, since he joined INRIA in 2002. Moreover, throughout his academic career, Radu instructed several tutorials focused on security in computer networks. To mention a few: "Malware, Reverse Engineering and Automated Malware Analysis for Android" at IM'13, "Assessing and Hacking Network Security" at IARA'07.

Jérôme François regularly teaches at the University of Nancy. Since 2006, he has been teaching MS students in computer networks-related courses and supervising PhDs in computer science on topics for network monitoring and security. Further, he held several tutorials on network management at different AIMS and NOMS editions.

References

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