



P4 on Raspberry Pi for Research and Education

A P4 Education Workgroup Project

The networking community has long sought better ways to teach networking in the classroom. The emergence of programmable network devices and the P4 language have provided an exciting opportunity for pedagogy: students can gain hands-on experience with network protocols and algorithms by programming the data plane.

While P4 has clearly become critical to the networking community, there are a limited number of options for P4 research and education. At one end of the spectrum, software solutions, such as the behavioral model (BMv2) switch combined with Mininet, lack the realism that engages students and often do not pass the bar for academic publications. At the other end of the spectrum, programmable ASIC-based switches are cost prohibitive. Other solutions, such as NetFPGA (<https://netfpga.org/>), are still cost prohibitive for large classes and require additional tools, servers and FPGA design knowledge.

P4Pi is a new low-cost, open-source hardware platform intended for teaching and research purposes. P4Pi enables designing and deploying P4-based network devices using the Raspberry Pi platform. By setting a target price tag of less than an academic book (under \$100), P4Pi aims to enable academic institutes to provide hands-on experience in networking education.

There are multiple ways to compile P4 code to run on P4Pi. Beginners can use BMv2 and port code written within the P4 tutorials environment to run on the hardware. More advanced students can use the T4P4S compiler or p4c-dpdk to compile P4 code to DPDK.

Examples for teaching exercises using P4Pi include simple layer 2 forwarding, traffic filtering, stateful firewall, and in-network calculator.

A semester long hands-on course project can be *Building an Internet Router* using P4Pi, based on the classic NetFPGA-based project. The project combines aspects of data-plane design, control plane design and protocol implementation (PW-OSPF). The project allows for multiple stages of evaluations, including interoperability tests involving multiple students' groups.

P4Pi Repository: <https://github.com/p4lang/p4pi>

Additional resources: <https://github.com/p4lang/p4pi/wiki/Available-Resources>

Upcoming tutorial at NetSoft 2022: <https://netsoft2022.ieee-netsoft.org/program/tutorials/>