



P₄ on Raspberry PI for Networking Education

A P₄ Education Workgroup Project

Noa Zilberman
Radostin Stoyanov

Sándor Laki
Dávid Kis
Péter Vörös

Robert Soulé



Teaching Computer Networks

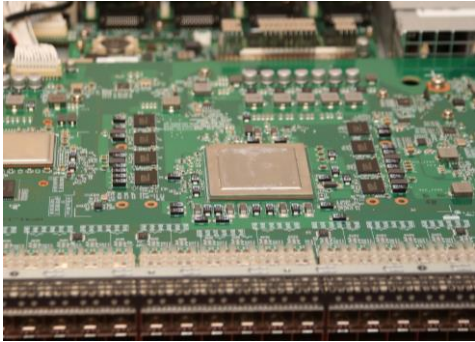
- “Learning by doing”
 - Improves students’ understanding
 - Increases students’ engagement
- Programming exercises & software solutions
 - Can’t cover all material
 - Don’t provide real-world experience
 - Not exciting!
- P4 is ideal for teaching computer networks
 - Quick to learn, easy to use



```
if (networking_course==boring)
{
    result=try(replace_professor);
    if (result==FAIL){
        learn_ai;
    }
}
```



Teaching Computer Networks Using P4



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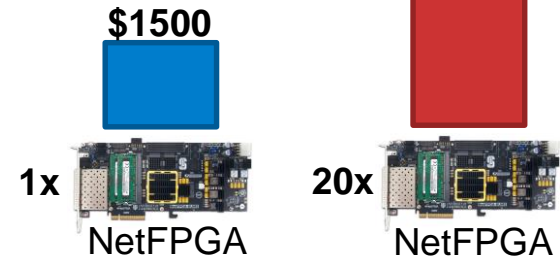


Teaching Networking Using P4+Hardware - Today

- **P4 programmable switch-ASIC**
 - Too expensive for many (>1000's of \$)
 - Closed / partially closed source
- **SmartNICs**
 - Cost \$1000-\$2000
 - Closed source
 - Requires micro-architecture knowledge
- **NetFPGA**
 - Cost ~\$1500
 - Open-source
 - Requires FPGA design knowledge

Equipping a class is expensive

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What Is The Ideal Platform For Teaching?

- **Low cost**
 - Less than \$100
- **Easy to learn**
 - And easy to use
- **Availability**
 - Worldwide, in-stock
 - Long term support
- **Open-source**
- **Training resources available**
- **Wireless + Wired connectivity**
 - Students can use their laptops
 - ...or existing lab machines
- **Network performance**
 - "Home" level

P4P



RaspberryPI 4 Model B 4GB
Quad-core ARM64 processor
On-board WiFi, 1GbE RJ-45
\$60-\$80, availability

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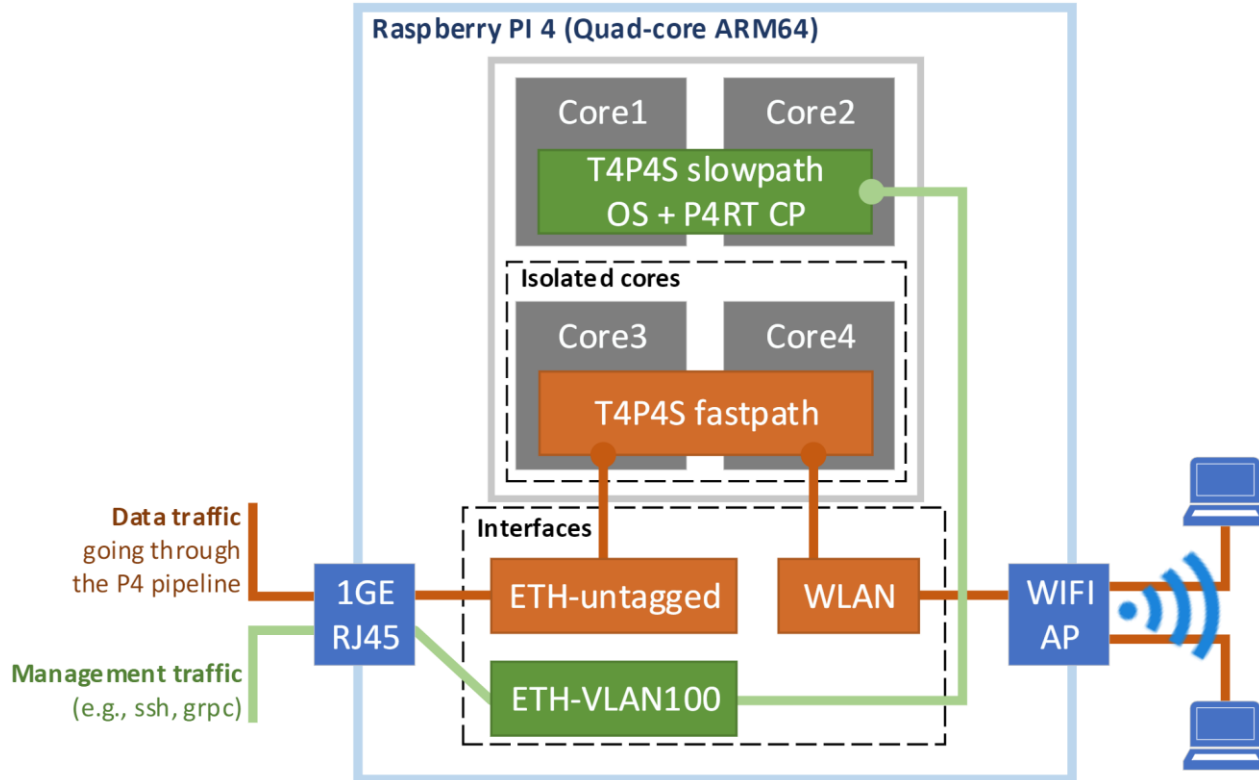
T4P4S P4 Compiler
Open source, supports multiple
backends incl. DPDK &
v1model

P4PI Is More Than a Hardware Platform



- **Training Materials**
 - Tutorials, exercises etc.
- **P4PI Repository**
 - P4PI source code, wiki, tools, reference programs.
- **Community engagement**

P4PI Reference Architecture



P4Pi-Led Labs



1 P4Pi, 1 Student



1 P4Pi, Multiple Students



Multiple P4Pi, Multiple Students

Networking 101

Send, Capture & Observe

Forwarding

Capture the flag

Networking 201

P4Calc

Firewall

IPv4 Router

Advanced Networking

Kernel bypass, HW/SW Co-design, Reproducibility, Research Projects



P4Pi and NetFPGA have different goals

	NetFPGA	P4Pi
Networking course	Advanced	101+
Hardware type	FPGA	CPU
Use case	Data centre	Home, IoT
Performance	Goal	Non-goal
Cost	Medium	Low

Summary

- P4PI platform is currently **under development**
 - To be released this month
 - <https://github.com/p4lang/p4pi>
- Developed for **networking education**
 - Cheap, available and open
 - Hands-on experience
- Making P4 available **for hobbyists**
 - Everyone need a P4 access point at home
 - ... and other crazy ideas



Hackathon at SIGCOMM 2021

Join us!

- August 23rd
- P4 and P4PI tutorials
- **Educators track** - Practicing and developing teaching materials
- **Contributors track** - Porting projects to P4PI, improving tools etc.
- **Hackers track** - Exploring new use cases and cool ideas using P4PI
- Will provide Raspberry PI platforms to registered participants (limited)



Thank You

www.github.com/p4lang/p4pi

P4PI Performance Over WiFi (Preliminary)

- **Setup**

- Laptop + RPi located in different rooms (~5m distance)
- Using iperf3 - upstream & downstream, TCP and UDP
- PortForwarding P4 program using T4P4S and tun/tap pmd

