



Getting started with P4Pi

First steps, backends, UI, etc.

Supported backends/compiler



- **T4P4S**
 - DPDK-based software target
 - Supports v1model and psa
 - Better performance
 - No full language support
- **BMv2 (simple_switch_grpc)**
 - Reference implementation
 - Supports v1model and psa
 - Low performance
 - Full language support

T4P4S for P4Pi

- Open source compiler
 - **Core compiler**
 - GitHub fork: <https://github.com/P4EDGE/t4p4s>
 - **P4Runtime component**
 - GitHub: [https://github.com/P4ELTE/P4Runtime GRPCPP](https://github.com/P4ELTE/P4Runtime_GRPCPP)
 - **P4-16** language support
 - V1model and experimental PSA support
 - Support of multiple targets
 - by the **Hardware Independent Core** and **Network Hardware Abstraction Libraries**
 - NetHALs for Intel (DPDK), **Freescale (ODP SDK)**,...



T4P4S - Status and Constraints

- **egress_port** can be written in both ingress and egress controls
 - Run-to-completion execution model
 - egress_spec is not used
 - For broadcasting egress_port needs to be set to 100
- Missing core features in T4P4S – **any contribution is welcome**
 - Lookahead in parsing block is not supported
 - Meters are not implemented
 - Ternary match-kind is not supported
- Supported features in P4Runtime component – **any contribution is welcome**
 - Inserting table entries
 - Reading counters
 - Generating digest message

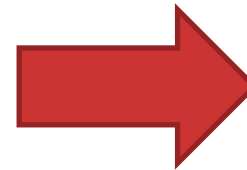
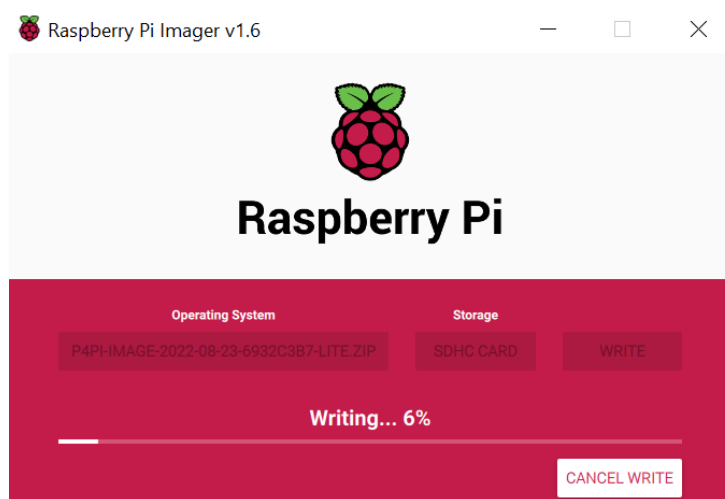
BMv2 for P4Pi

- Open source reference implementation
 - <https://github.com/p4lang/behavioral-model>
- Full P4-16 language support
 - v1model and PSA
- Lower performance
- P4Runtime support
- Switch api for configuring non-programmable elements (e.g., queues and multicast groups)
 - simple_switch_CLI
 - A good guide on this: <https://github.com/nsg-ethz/p4-learning/wiki/BMv2-Simple-Switch>



First steps

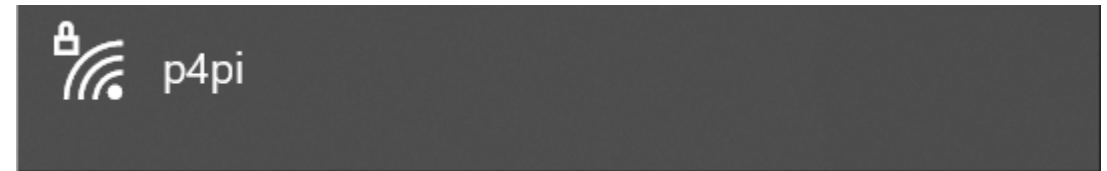
- Download the latest release:
<https://github.com/p4lang/p4pi/releases/tag/sigcomm2022>
- Download Raspberry Pi Imager: <https://www.raspberrypi.com/software/>
- **Erase the SD Card**
- **Then write the custom P4Pi image to the card**
- Step by step guide: <https://github.com/p4lang/p4pi/wiki/Installing-P4Pi>



First steps



- After powering up the P4Pi node, booting may take a few minutes
- Connect to access point „p4pi”
 - Keyphrase: raspberry
- You can open an SSH terminal or use the web interface
 - MGMT IP: 192.168.4.1
 - Username: pi
 - Password: raspberry



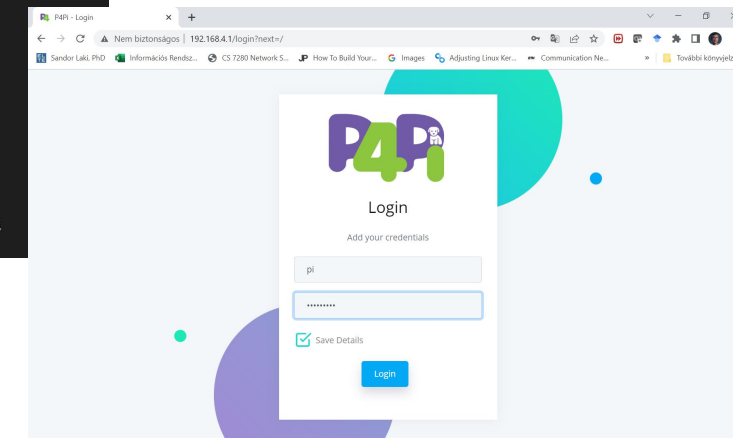
```
• DISPLAY : ✓ (automatically set on remote server)
> For more info, ctrl+click on help or visit our website

Linux p4pi 5.15.33-v8+ #1 SMP PREEMPT Sat Jul 9 11:27:09 UTC 2022 aarch64

/usr/bin/xauth: file /home/pi/.Xauthority does not exist

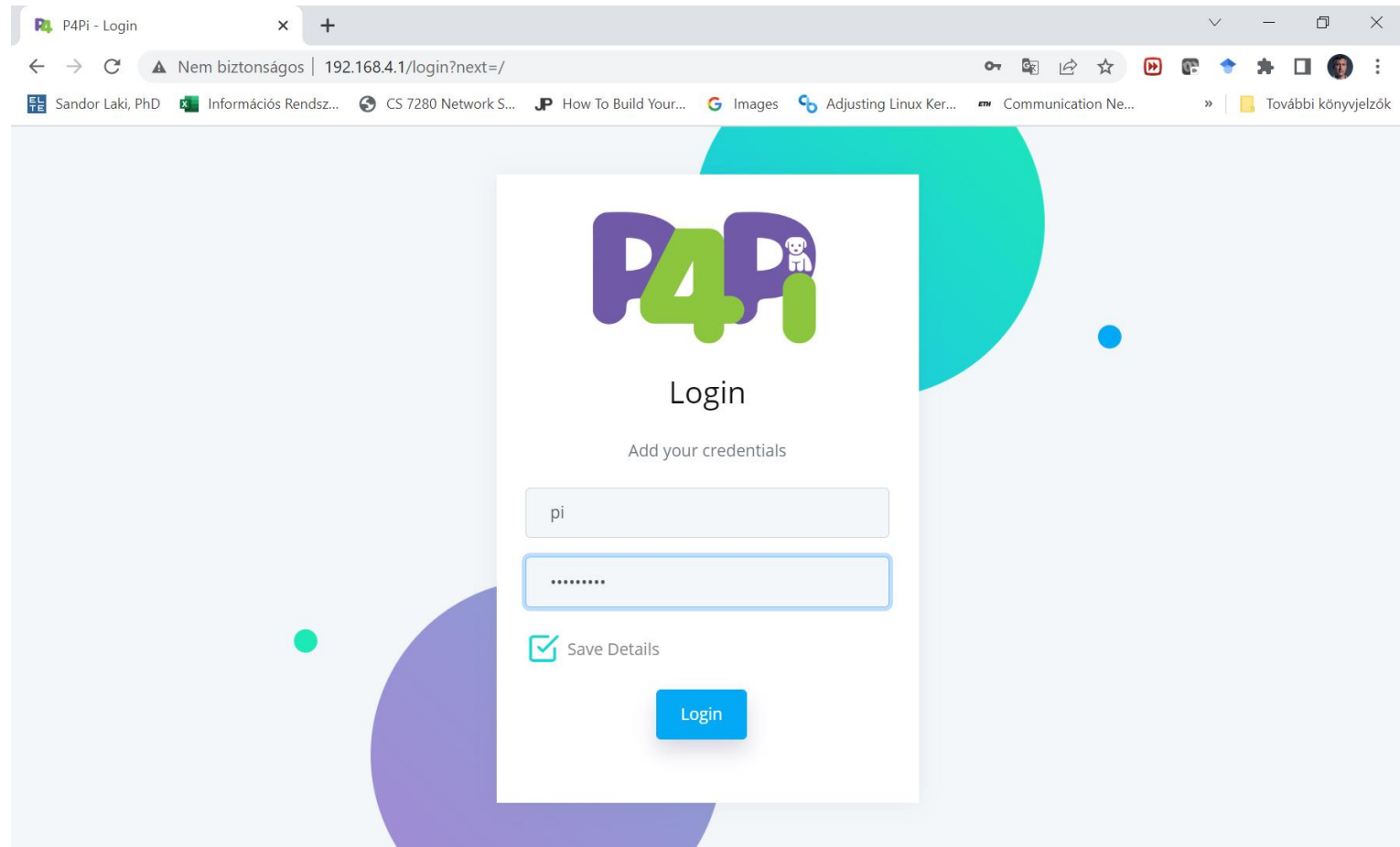
SSH is enabled and the default password for the 'pi' user has not been changed.
This is a security risk - please login as the 'pi' user and type 'passwd' to set a new password.

pi@p4pi:~$
```



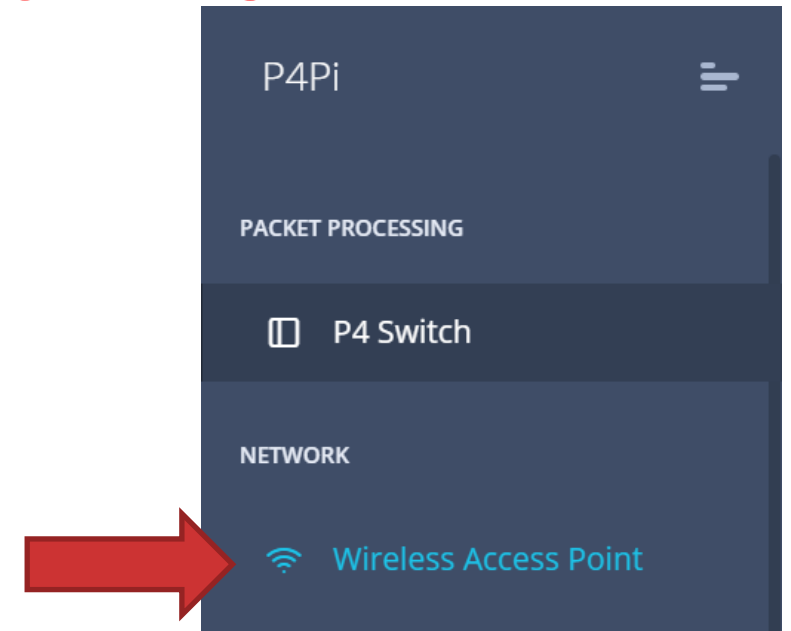
First steps

- Login via the web interface
 - <http://192.168.4.1>
 - Username: pi
 - Password: raspberry



IMPORTANT: before starting the HACKATHON

- **Change the SSID of the access point**
 - Connect to the web interface and login
 - <http://192.168.4.1>
 - Choose from the menu (on the left) *Wireless Access Point*
- **Change the SSID to something unique (e.g., your name)**
- **Change the password**
- Press the *Save* button (at the bottom)



Service Set Identifier (SSID)

p4pi-42

Save

WARNING: Pressing this button will restart the main system services. You will likely be disconnected from the WiFi access point. After restarting finished, you will be able to connect the device again.

Running examples on P4Pi *(via the web interface)*

The screenshot displays the P4Pi web interface in a browser window. The browser's address bar shows the URL `192.168.4.1`. The page title is "P4Pi - P4 Compiler". The interface is titled "P4 Switch" and contains the following sections:

- P4 Program**
- Compiler / Target**: A dropdown menu set to "T4P4S".
- P4 Program**: A dropdown menu set to "L2 Switch".
- Terminal Output**: A scrollable area showing the following log messages:

```
[51/59] Compiling C object l2switch.p/srcgen_multi_parser.stage_0.c.o
[52/59] Compiling C object l2switch.p/srcgen_multi_controlplane.stage_1.c.o
[53/59] Compiling C object l2switch.p/srcgen_multi_dataplane.stage_1.c.o
[54/59] Compiling C object l2switch.p/srcgen_multi_controlplane.stage_2.c.o
[55/59] Compiling C object l2switch.p/srcgen_multi_actions.stage_2.c.o
[56/59] Compiling C object l2switch.p/srcgen_multi_dataplane.stage_2.c.o
[57/59] Compiling C object l2switch.p/srcgen_multi_actions.stage_3.c.o
[58/59] Compiling C object l2switch.p/srcgen_multi_dataplane.stage_3.c.o
[59/59] Linking target l2switch
[[1:32mRUN SWITCH[[0m] [[1:33m./build/last/build/l2switch[[0m
EAL: Detected 4 lcore(s)
EAL: Detected 1 NUMA nodes
EAL: Detected shared linkage of DPDK
EAL: Multi-process socket /var/run/dpdk/rte/mp_socket
EAL: Selected IOVA mode 'PA'
EAL: No available hugepages reported in hugepages-32768kB
EAL: No available hugepages reported in hugepages-64kB
EAL: No available hugepages reported in hugepages-1048576kB
EAL: Probing VFIO support...
EAL: No legacy callbacks, legacy socket not created
```
- Buttons**: "Run" and "Kill" buttons.

The browser's taskbar on the right shows the Windows Start button, search, task view, and several application icons including Chrome, a file explorer, and a presentation software. The system tray at the bottom right displays the time "14:57", the date "csütörtök 2022. 08. 25.", and a notification icon with the number "5".

Terminal tab on the web interface

The image shows a web browser window with a terminal interface. The browser's address bar displays "Nem biztonságos | 192.168.4.1/terminal". The terminal window shows a connection status of "connected" and a "Disconnect" button. The prompt is "root@p4pi:/srv/p4edge#".

The left sidebar of the web interface is organized into sections:

- P4Pi**
- PACKET PROCESSING**
- NETWORK**
 - Wireless Access Point
 - Statistics
 - Entries
- SYSTEM**
 - Terminal** (highlighted)
 - Authentication
 - Logout - [pi]

At the bottom of the sidebar, it says "POWERED BY P4EDGE.NET".

The right side of the image shows a Windows taskbar with various application icons and a system tray at the bottom right displaying the time "14:58" and date "csütörtök 2022. 08. 25." along with a notification icon showing "5".

L2 Switching example with bmv2

The screenshot displays the P4Pi web interface in a browser window. The browser's address bar shows the URL `192.168.4.1`. The page title is "P4Pi - P4 Compiler". The interface is divided into several sections:

- PACKET PROCESSING:** Includes a "P4 Switch" option.
- NETWORK:** Includes "Wireless Access Point", "Statistics", and "Entries".
- SYSTEM:** Includes "Terminal", "Authentication", and "Logout - [pi]".

The main content area is titled "P4 Switch" and contains the following configuration options:

- P4 Program:** A dropdown menu currently set to "BMv2".
- Compiler / Target:** A dropdown menu currently set to "BMv2".
- P4 Program:** A dropdown menu currently set to "L2 Switch".

Below the configuration options is a terminal window showing the following output:

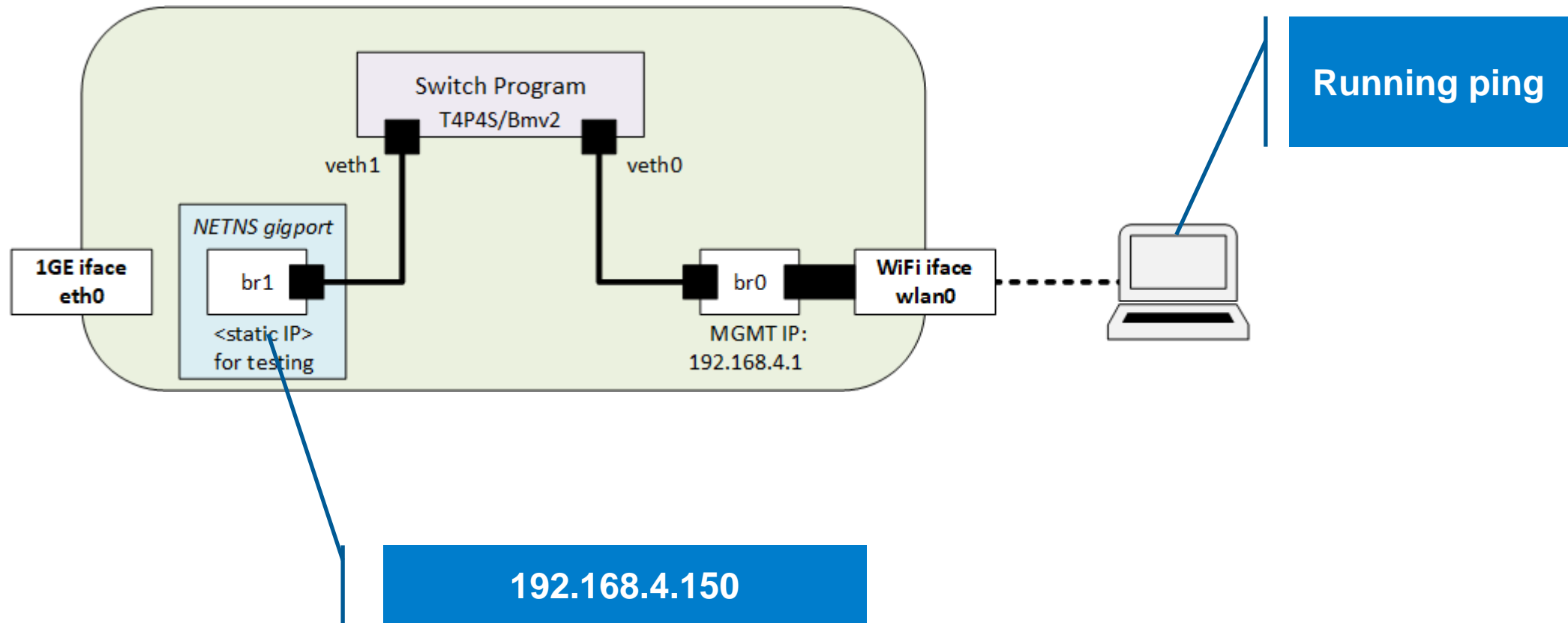
```
Compiling P4 code
Launching BMv2 switch
Calling target program-options parser
Adding interface veth0 as port 0
Adding interface veth1 as port 1
```

At the bottom of the terminal window are two buttons: "Run" and "Kill".

The Windows taskbar on the right side of the screen shows the time as 15:00 on 2022.08.25 (csütörtök).

Initial network setting

- Testing the switch



Ping does not work

Parancssor - ping 192.168.4.150

Microsoft Windows [Version 10.0.19044.1889]
(c) Microsoft Corporation. Minden jog fenntartva.

C:\Users\Laki Sándor>ping 192.168.4.150

Pinging 192.168.4.150 with 32 bytes of data:
Reply from 192.168.4.6: Destination host unreachable.
Reply from 192.168.4.6: Destination host unreachable.

The image shows a portion of the Windows taskbar on the right side of the screen. It includes the Start button (Windows logo), a search icon, a task view icon, and a system tray area. The system tray contains a network icon, a volume icon, a globe icon, a battery icon, and a clock showing 15:00 on August 25, 2022. There is also a notification icon with the number 5.

Setting up a multicast group for broadcasting

The screenshot shows a web browser window with a terminal interface. The browser's address bar displays "Nem biztonságos | 192.168.4.1/terminal". The terminal output is as follows:

```
Status: connected Disconnect
root@p4pi:/srv/p4edge# simple_switch_CLI
Obtaining JSON from switch...
Done
Control utility for runtime P4 table manipulation
RuntimeCmd: mc_mgrp_create 1
Creating multicast group 1
RuntimeCmd: mc_node_create 0 0 1
Creating node with rid 0 , port map 11 and lag map
node was created with handle 0
RuntimeCmd: mc_node_associate 1 0
Associating node 0 to multicast group 1
RuntimeCmd:
```

The terminal interface includes a sidebar on the left with the following sections:

- P4Pi**
- PACKET PROCESSING**
- P4 Switch**
- NETWORK**
 - Wireless Access Point
 - Statistics
 - Entries
- SYSTEM**
 - Terminal (selected)
 - Authentication
 - Logout - [pi]

At the bottom of the sidebar, it says "POWERED BY P4EDGE.NET". The browser's taskbar on the right shows various application icons, including the Windows Start button, search, task view, and several open applications like a terminal, a file manager, and a presentation software. The system tray at the bottom right shows the time "15:06", the date "csütörtök 2022. 08. 25.", and a notification icon with the number "5".

Destination can be reached 😊

Parancssor

Microsoft Windows [Version 10.0.19044.1889]
(c) Microsoft Corporation. Minden jog fenntartva.

C:\Users\Laki Sándor>ping 192.168.4.150

Pinging 192.168.4.150 with 32 bytes of data:

Reply from 192.168.4.6: Destination host unreachable.

Reply from 192.168.4.6: Destination host unreachable.

Reply from 192.168.4.6: Destination host unreachable.

Reply from 192.168.4.6: Destination host unreachable.

Ping statistics for 192.168.4.150:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

C:\Users\Laki Sándor>ping 192.168.4.150

Pinging 192.168.4.150 with 32 bytes of data:

Reply from 192.168.4.6: Destination host unreachable.

Reply from 192.168.4.6: Destination host unreachable.

Reply from 192.168.4.6: Destination host unreachable.

Reply from 192.168.4.6: Destination host unreachable.

Ping statistics for 192.168.4.150:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

C:\Users\Laki Sándor>ping 192.168.4.150

Pinging 192.168.4.150 with 32 bytes of data:

Reply from 192.168.4.150: bytes=32 time=6ms TTL=64

Reply from 192.168.4.150: bytes=32 time=3ms TTL=64

Reply from 192.168.4.150: bytes=32 time=5ms TTL=64

Reply from 192.168.4.150: bytes=32 time=5ms TTL=64

Ping statistics for 192.168.4.150:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 3ms, Maximum = 6ms, Average = 4ms

C:\Users\Laki Sándor>

The image shows a Windows taskbar on the right side of the screen. It includes the Start button (Windows logo), a search icon, a task view icon, and a system tray. The system tray contains a volume icon, a network icon, and a clock showing the time 15:06 and the date 2022. 08. 25. There is also a notification icon with a number 5.



Running your small P₄ project
on P₄Pi

// small == a single P₄ file

Projects consisting of a single P4 file can be uploaded via the web interface

The screenshot displays the P4Pi - P4 Compiler web interface in a browser window. The browser's address bar shows the URL `192.168.4.1`. The interface includes a sidebar on the left with navigation icons. The main content area is titled "P4 Program" and contains the following elements:

- Compiler / Target:** A dropdown menu currently set to "BMv2".
- P4 Program:** A dropdown menu currently set to "Upload".
- Upload source:** A text input field containing "Fájl kiválasztása" and "Nincs fájl kiválasztva", with an "Upload" button below it.
- Output Log:** A scrollable area showing the compilation process. The log contains the following text:

```
[51/59] Compiling C object l2switch.p/srcgen_multi_parser.stage_0.c.o
[52/59] Compiling C object l2switch.p/srcgen_multi_controlplane.stage_1.c.o
[53/59] Compiling C object l2switch.p/srcgen_multi_dataplane.stage_1.c.o
[54/59] Compiling C object l2switch.p/srcgen_multi_controlplane.stage_2.c.o
[55/59] Compiling C object l2switch.p/srcgen_multi_actions.stage_2.c.o
[56/59] Compiling C object l2switch.p/srcgen_multi_dataplane.stage_2.c.o
[57/59] Compiling C object l2switch.p/srcgen_multi_actions.stage_3.c.o
[58/59] Compiling C object l2switch.p/srcgen_multi_dataplane.stage_3.c.o
[59/59] Linking target l2switch
[[1;32mRUN SWITCH[[0m] [[1;33m./build/last/build/l2switch[[0m
EAL: Detected 4 lcore(s)
EAL: Detected 1 NUMA nodes
EAL: Detected shared linkage of DPDK
EAL: Multi-process socket /var/run/dpdk/rte/mp_socket
EAL: Selected IOVA mode 'PA'
EAL: No available hugepages reported in hugepages-32768kB
EAL: No available hugepages reported in hugepages-64kB
EAL: No available hugepages reported in hugepages-1048576kB
EAL: Probing VFIO support...
EAL: No legacy callbacks, legacy socket not created
```
- Control Buttons:** "Run" and "Kill" buttons located at the bottom of the output log area.

The browser's taskbar on the right shows the Windows Start menu, search, and several application icons. The system tray at the bottom right indicates the time is 14:57 on 2022.08.25.



Running your bigger P₄ project
on P₄Pi

// bigger == P₄ project with multiple P₄ files

Running a bigger project on P4Pi (assuming BMv2 backend)

Open an SSH terminal
to P4Pi

Create
the project folder

BMv2 example:
`mkdir /root/bmv2/examples/myproject`

Running a bigger project on P4Pi (assuming BMv2 backend)

Open an SSH terminal
to P4Pi

Create
the project folder

Copy your P4 files to
this folder

Using scp or other tools



Running a bigger project on P4Pi (assuming BMv2 backend)

Open an SSH terminal
to P4Pi

Create
the project folder

Copy your P4 files to
this folder

Rename the main P4
file to
<projectname>.p4

BMv2 example assuming that the main file is
called *myprotocol.p4*

```
cd /root/bmv2/examples/myproject  
mv myprotocol.p4 myproject.p4
```

Running a bigger project on P4Pi (assuming BMv2 backend)

Rename the main P4
file to
<projectname>.p4

Setup the backend

Backends are implemented as services. We
have to stop and disable the T4P4S service
and enable the Bmv2 service

```
systemctl stop t4p4s.service  
systemctl disable t4p4s.service  
systemctl enable bmv2.service
```


Running a bigger project on P4Pi (assuming BMv2 backend)

Rename the main P4
file to
<projectname>.p4

Setup the backend

Run your P4 project

Setting up the switch configuration, defining the
project name to be executed, and restarting the
backend service

```
echo myproject > /root/t4p4s-service  
systemctl restart bmv2.service
```

Running a bigger project on P4Pi (assuming BMv2 backend)

Rename the main P4
file to
<projectname>.p4

Setup the backend

Run your P4 project

Configure the switch

Modifying switch configuration (e.g., queues,
mcast, etc.)

simple_switch_CLI

Running a bigger project on P4Pi (assuming BMv2 backend)

Configure the switch

P4 runtime shell

P4 Runtime GRPC server is sitting on port 50051, so you can connect your CP to the switch. We also have a helper script to run P4RTShell and connect it to your running P4 data plane:

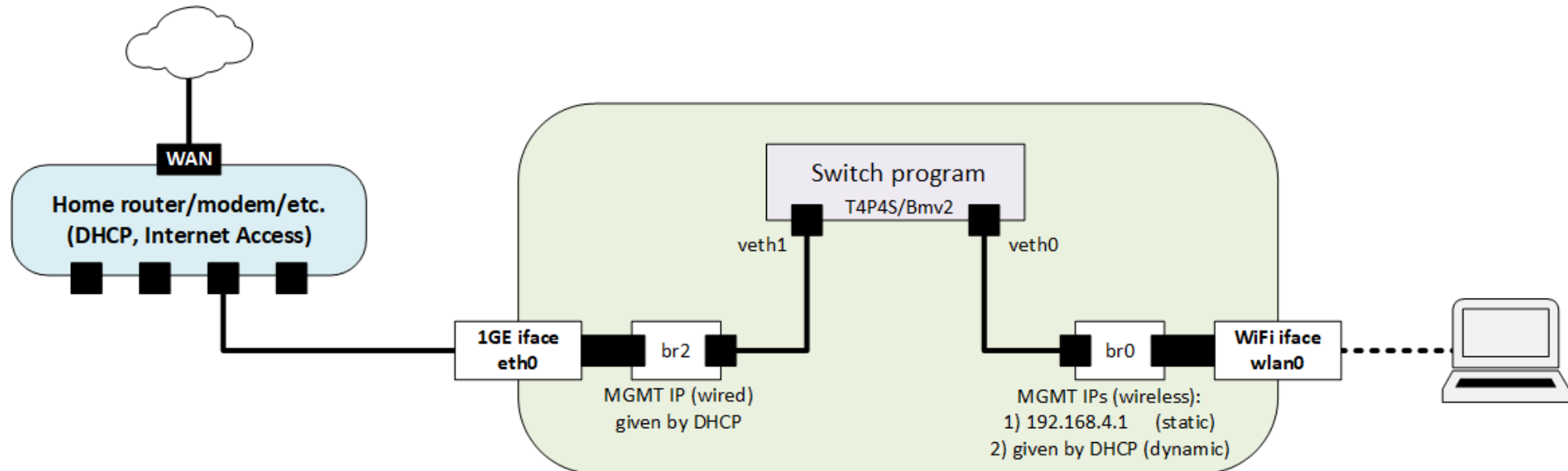
```
bmv2-p4rtshell myproject
```

Starting a new project with T4P4S backend

- **The process is similar, more info:**
 - <https://github.com/p4lang/p4pi/wiki/Creating-a-new-T4P4S-project-on-P4Pi>

„Hot-spot” network settings

- Placing the P4 data plane between wlan0 and eth0
 - All packets between the two interfaces go through your P4 pipeline



- The settings can be activated with the following script:
 - `sudo /root/t4p4s/setup_eth_wlan_bridge.sh`



For more details visit

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