



# P<sub>4</sub>-programmable smartNIC controlled by ONOS

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# CodiLime at a glance

**10+**

Years in business

**3**

Offices

**200+**

Software, DevOps &  
Network engineers

**6**

Our clients' time  
zones



## Software product engineering

Building and enhancing  
networking products



## Network engineering

Deploying, testing and monitoring  
your network solutions

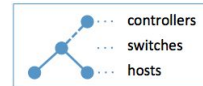
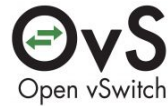
# What is the solution built around...



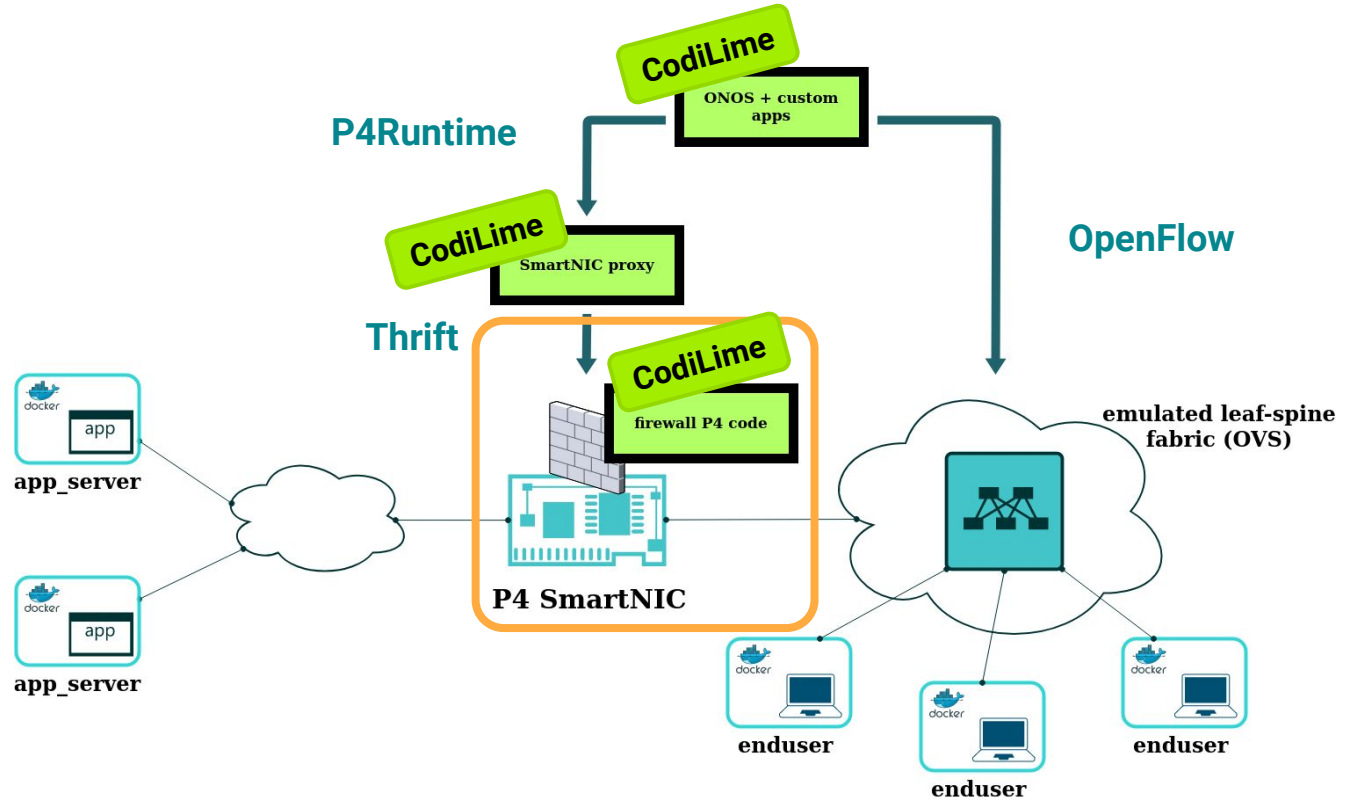
Netronome Agilio CX 2 x 10GbE



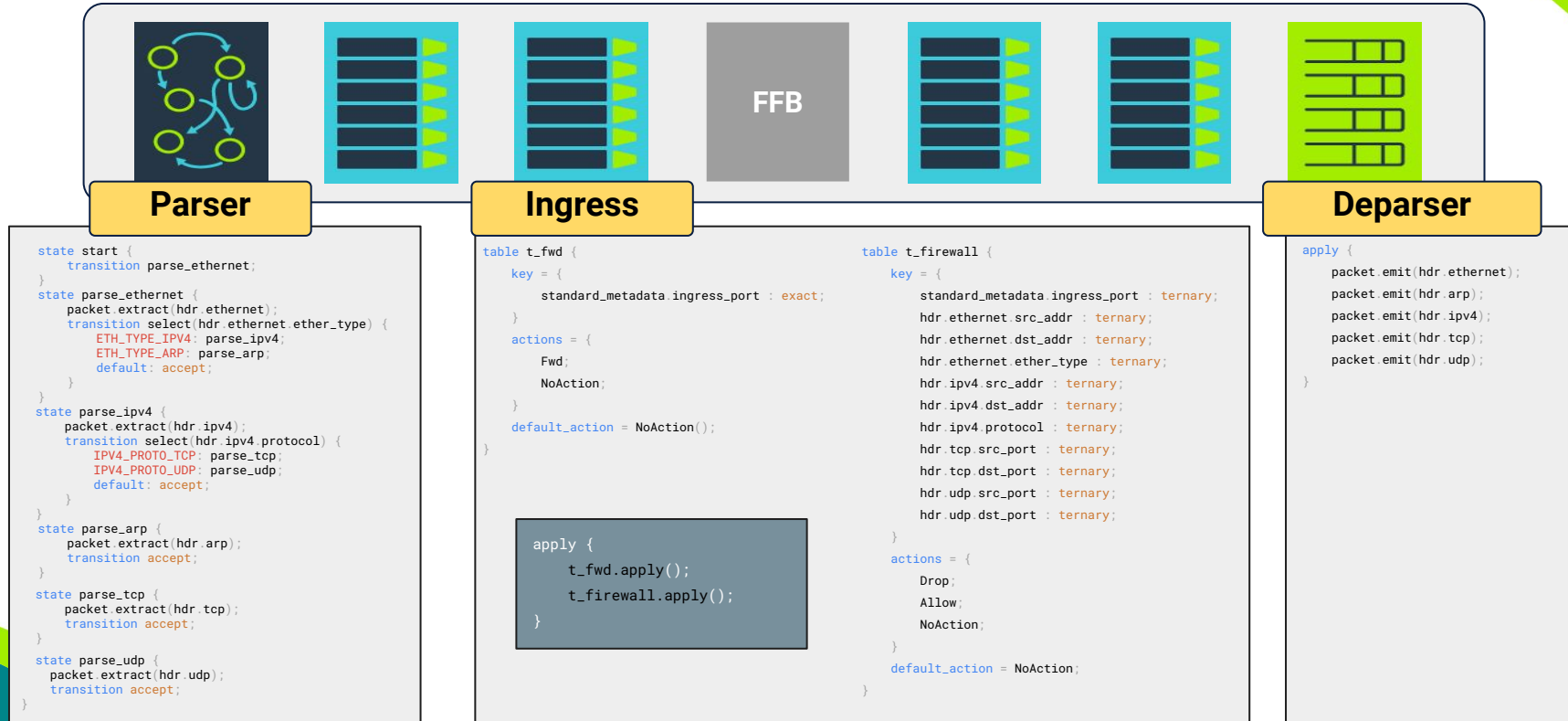
Linux



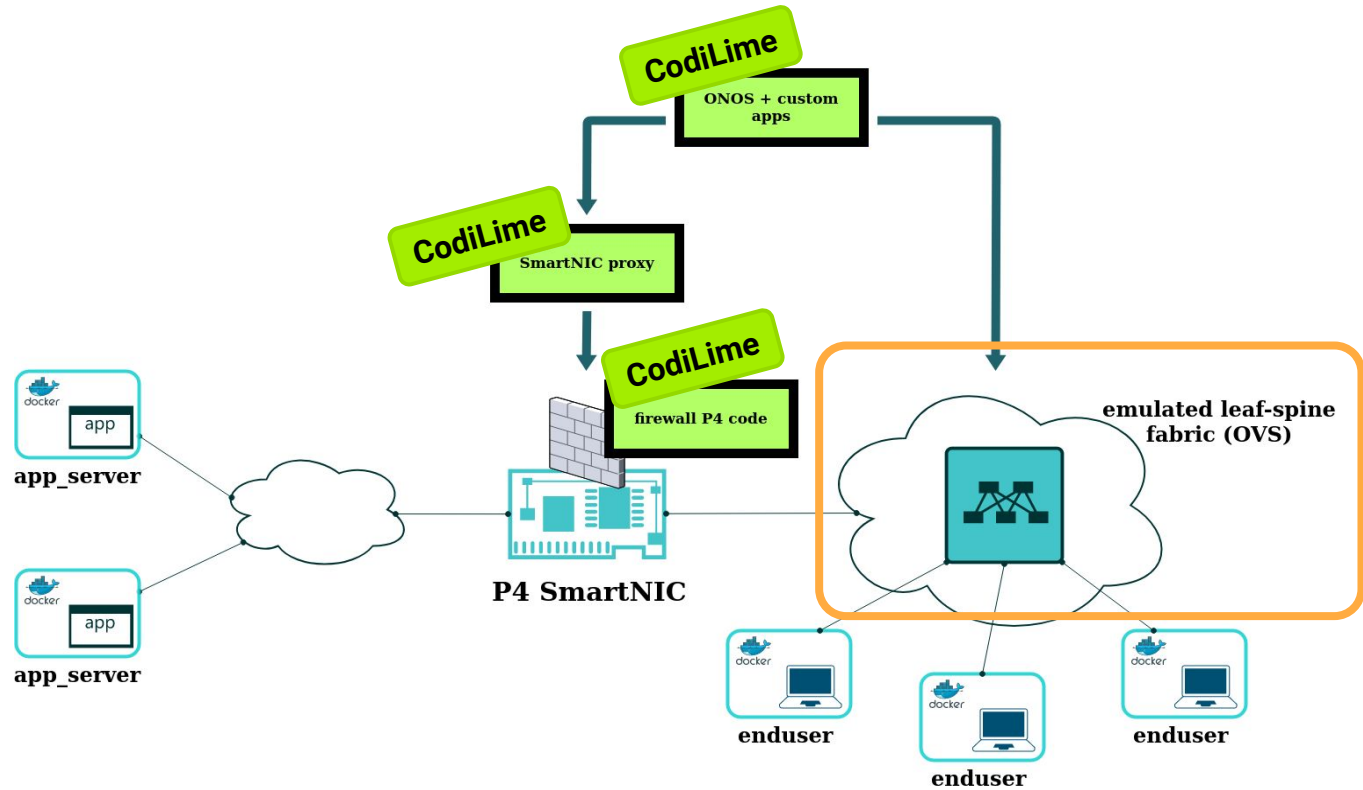
# PoC architecture overview



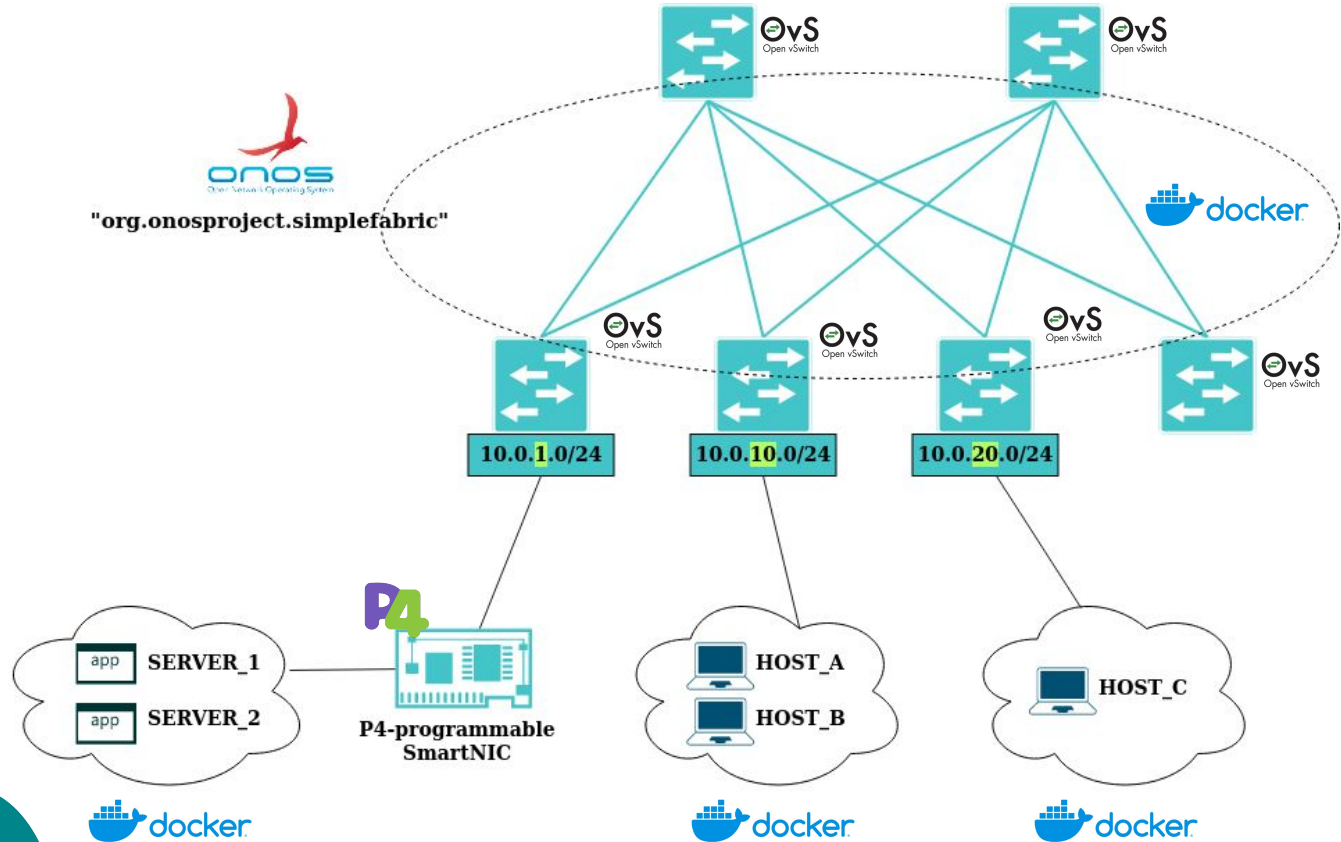
# Firewall function P4 code (V1 Model)



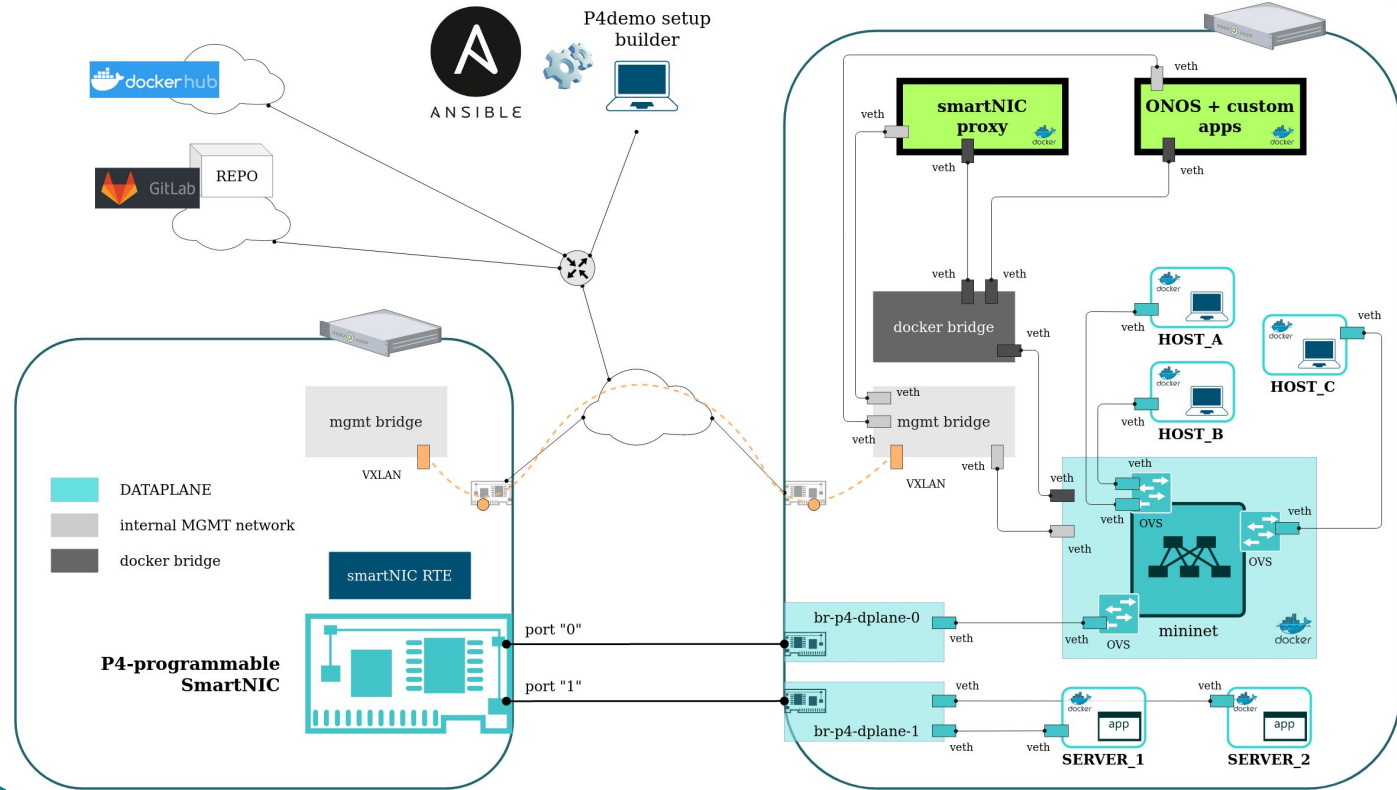
# PoC architecture overview



# PoC - leaf-spine fabric + hosts

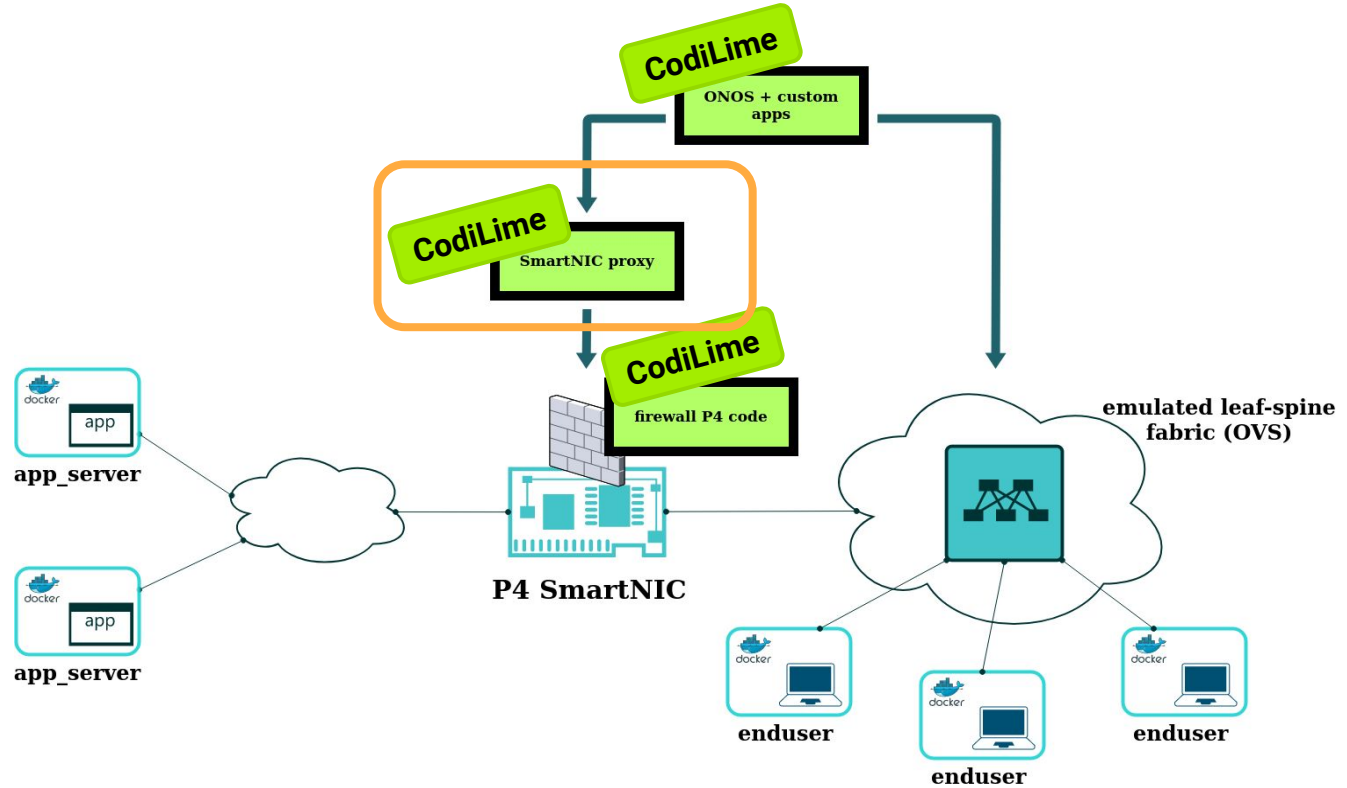


# PoC - physical arch. overview





# PoC architecture overview



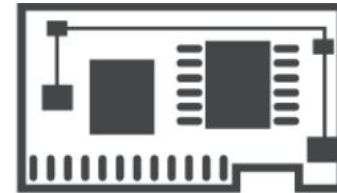
# ONOS <-> SmartNIC communication

Protocols supported:

- P4Runtime Support

Protocols supported:

- P4Runtime Support
- Thrift based BMv2 like protocol



**SmartNIC**

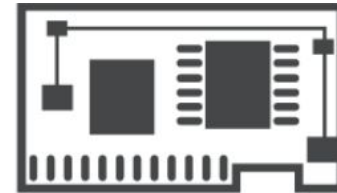
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- **P4Runtime Support**

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**SmartNIC**

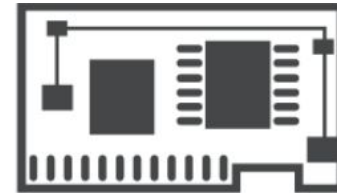
# SmartNIC proxy SW development

Protocols supported:

- P4Runtime Support 1.x

Protocols supported:

- P4Runtime Support pre-1.0.0 (version from mid 2018)



**SmartNIC**

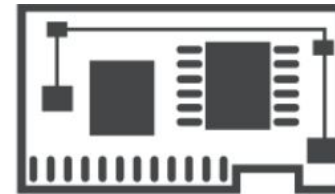
# SmartNIC proxy SW development

## Protocols supported:

- P4Runtime downgraded to pre-1.0.0

## Protocols supported:

- P4Runtime Support pre-1.0.0 (version from mid 2018)



SmartNIC

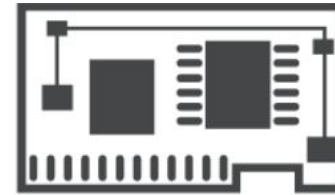
# SmartNIC proxy SW development

## Protocols supported:

- P4Runtime downgraded to pre-1.0.0

## Protocols supported:

- P4Runtime Support pre-1.0.0 (version from mid 2018)
- P4Runtime implementation in preview version
  - Ternary matching didn't work
  - Packet-Out didn't work



SmartNIC

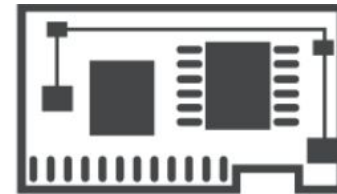
# ONOS + SmartNIC Connectivity

Protocols supported:

- P4Runtime Support
- No Thrift based protocol support ?

Protocols supported:

- P4Runtime Support
- Thrift based BMv2 like protocol ?



**SmartNIC**

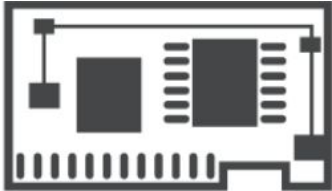
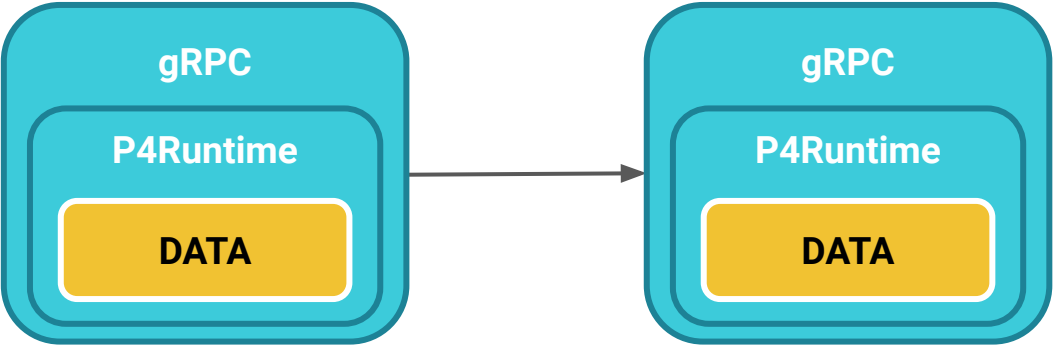
# SmartNIC proxy SW development



SmartNIC

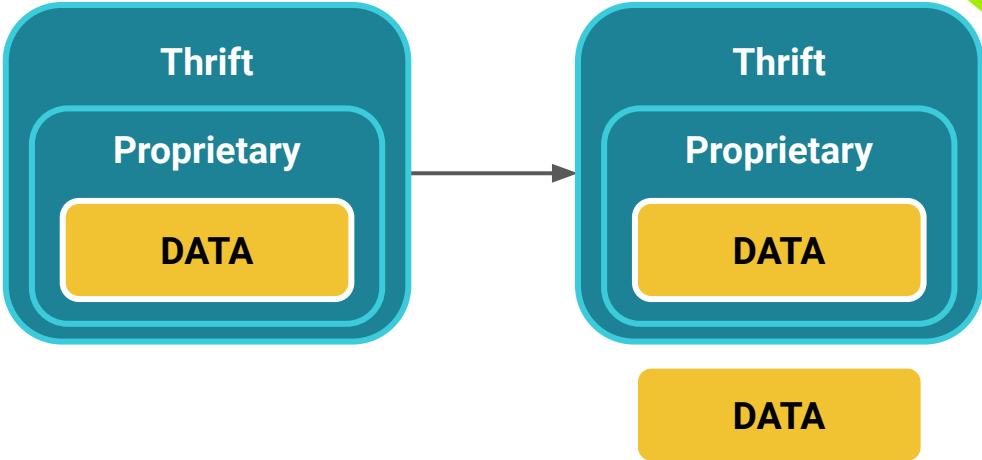


# SmartNIC proxy SW development



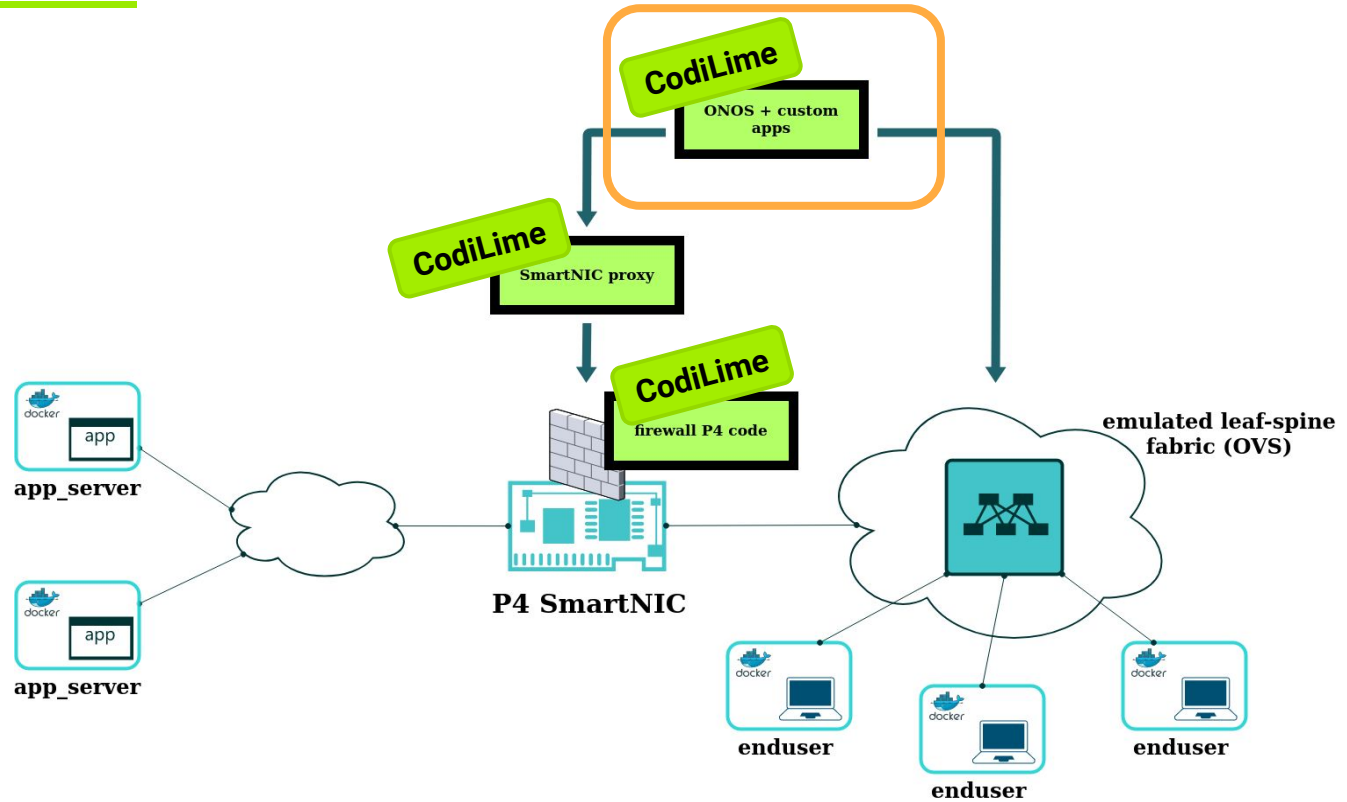
SmartNIC

# SmartNIC proxy SW development

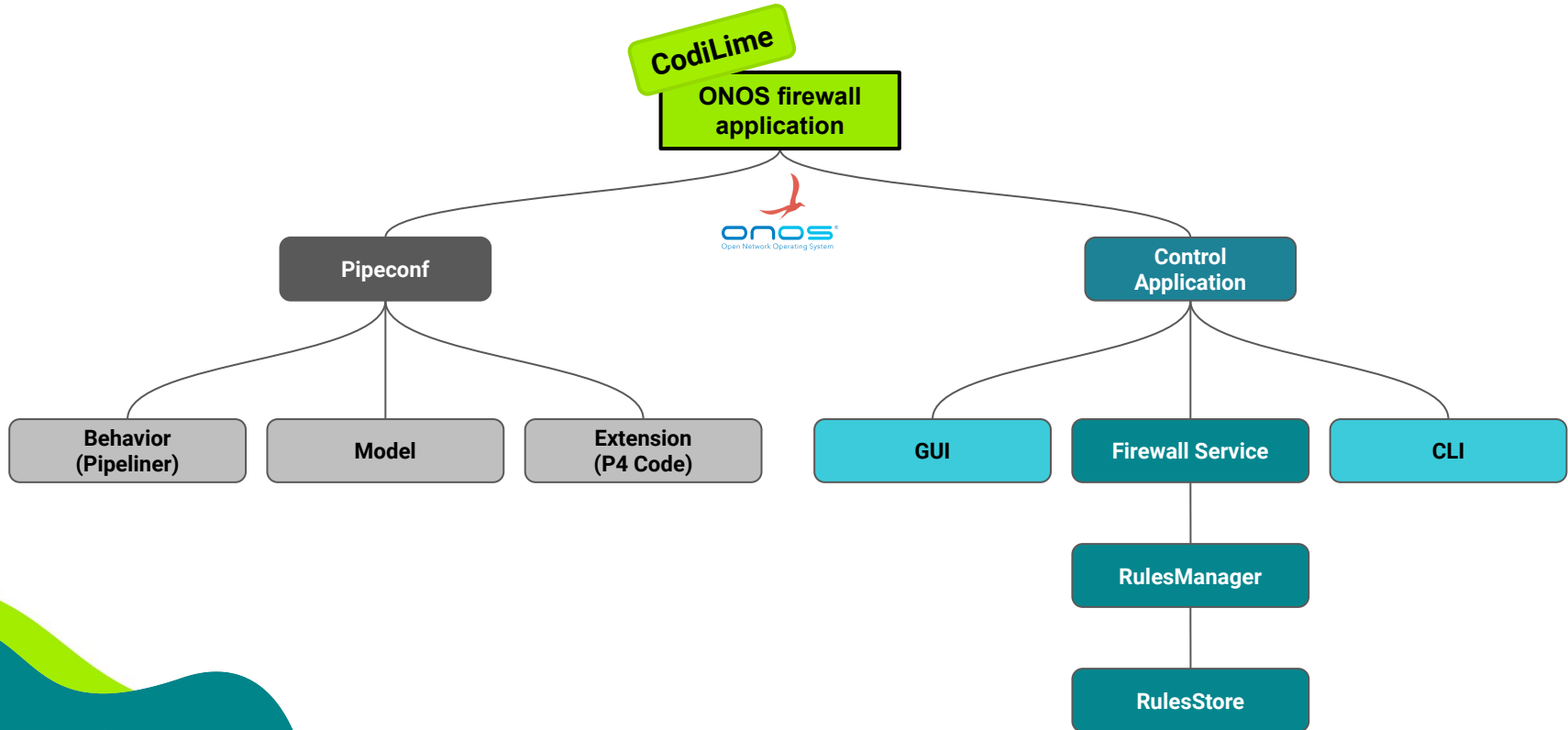


SmartNIC

# PoC architecture overview



# ONOS Firewall Application - Overview



# ONOS customization & app development

The screenshot displays the ONOS (Open Network Operating System) web interface. The main header shows the ONOS logo and the text "Open Network Operating System". The page title is "Firewall Enabled Devices (1 Total)". Below the title, there is a search bar and a dropdown menu labeled "All Fields".

The main content area shows a list of devices under the heading "DEVICE ID". One device, "device:smartnic-proxy", is selected and its details are shown in a modal window titled "device:smartnic-proxy".

The modal window displays a table of rules for the selected device. The table has the following columns: ID, Action, Status, Source MAC Address, Destination MAC Address, Source IPv4 Address, Destination IPv4 Address, IP Protocol, Source Port, Destination Port, Ingress Interface, and EtherType.

ID	Action	Status	Source MAC Address	Destination MAC Address	Source IPv4 Address	Destination IPv4 Address	IP Protocol	Source Port	Destination Port	Ingress Interface	EtherType
1	■	✓			10.0.10.0/24	10.0.1.11/32	0x6		9051		
4	■	✓			10.0.10.102/32	10.0.1.11/32	0x6		9056-9060		
7	■	✓			10.0.20.103/32	10.0.1.22/32	0x11		7031		
8	■	✓			10.0.20.103/32	10.0.1.22/32	0x11	30123			
9	■	✓			10.0.10.101/32	10.0.1.0/24	0x1				
10	▶	✓			10.0.10.101/32	10.0.1.0/24	0x1				
11	■	✓	00:10:00:01:00:11								0x806

# ONOS customization & app development

```
karaf@root > firewall-list 17:01:10
Device: device:smartnic-proxy
1: DENY for ipv4_src_addr=10.0.10.0/24, ipv4_dst_addr=10.0.1.11/32, ipv4_proto=0x6, tp_dst_port='9051'
4: DENY for ipv4_src_addr=10.0.10.102/32, ipv4_dst_addr=10.0.1.11/32, ipv4_proto=0x6, tp_dst_port='9056-9060'
7: DENY for ipv4_src_addr=10.0.20.103/32, ipv4_dst_addr=10.0.1.22/32, ipv4_proto=0x11, tp_dst_port='7031'
8: DENY for ipv4_src_addr=10.0.20.103/32, ipv4_dst_addr=10.0.1.22/32, ipv4_proto=0x11, tp_src_port='30123'
9: DENY for ipv4_src_addr=10.0.10.101/32, ipv4_dst_addr=10.0.1.0/24, ipv4_proto=0x1
10: ALLOW for ipv4_src_addr=10.0.10.101/32, ipv4_dst_addr=10.0.1.0/24, ipv4_proto=0x1
11: DENY for src_mac=00:10:00:01:00:11, eth_type=0x806
karaf@root > firewall-add --tp_dst_port=1-5 device:smartnic-proxy deny 17:01:26
FirewallEntry{deviceId=device:smartnic-proxy, ruleId=12, corrFlowId=[6b000031d6a471, 6b0000a309c0d4, 6b00001443375f, 6b0000fbd71786, 6b0000853cc058, 6b0000b8eef70, 6b0000cfc6a15e, 6b0000d19e6a6a, 6b00003e93cad1, 6b00002e4834f3], super=FirewallRule{metadataIngressPort=null, ethernetSrcAddr=Null, ethernetDestAddr=Null, ethernetType=Null, ipv4SrcAddr=Null, ipv4DstAddr=Null, ipv4Proto=Null, tpSrcPort=null, tpDstPort=org.onosproject.p4app.common.firewall.FirewallRule$ListRangeValue@72a6d7a7, action=DENY}}
karaf@root > firewall-list 17:01:36
Device: device:smartnic-proxy
1: DENY for ipv4_src_addr=10.0.10.0/24, ipv4_dst_addr=10.0.1.11/32, ipv4_proto=0x6, tp_dst_port='9051'
4: DENY for ipv4_src_addr=10.0.10.102/32, ipv4_dst_addr=10.0.1.11/32, ipv4_proto=0x6, tp_dst_port='9056-9060'
7: DENY for ipv4_src_addr=10.0.20.103/32, ipv4_dst_addr=10.0.1.22/32, ipv4_proto=0x11, tp_dst_port='7031'
8: DENY for ipv4_src_addr=10.0.20.103/32, ipv4_dst_addr=10.0.1.22/32, ipv4_proto=0x11, tp_src_port='30123'
9: DENY for ipv4_src_addr=10.0.10.101/32, ipv4_dst_addr=10.0.1.0/24, ipv4_proto=0x1
10: ALLOW for ipv4_src_addr=10.0.10.101/32, ipv4_dst_addr=10.0.1.0/24, ipv4_proto=0x1
11: DENY for src_mac=00:10:00:01:00:11, eth_type=0x806
12: DENY for tp_dst_port='1-5'
karaf@root > firewall-remove device:smartnic-proxy 12 17:01:42
karaf@root > firewall-list 17:02:06
Device: device:smartnic-proxy
1: DENY for ipv4_src_addr=10.0.10.0/24, ipv4_dst_addr=10.0.1.11/32, ipv4_proto=0x6, tp_dst_port='9051'
4: DENY for ipv4_src_addr=10.0.10.102/32, ipv4_dst_addr=10.0.1.11/32, ipv4_proto=0x6, tp_dst_port='9056-9060'
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8: DENY for ipv4_src_addr=10.0.20.103/32, ipv4_dst_addr=10.0.1.22/32, ipv4_proto=0x11, tp_src_port='30123'
9: DENY for ipv4_src_addr=10.0.10.101/32, ipv4_dst_addr=10.0.1.0/24, ipv4_proto=0x1
10: ALLOW for ipv4_src_addr=10.0.10.101/32, ipv4_dst_addr=10.0.1.0/24, ipv4_proto=0x1
11: DENY for src_mac=00:10:00:01:00:11, eth_type=0x806
karaf@root > 17:02:23
```



# Demo

---

# DEMO



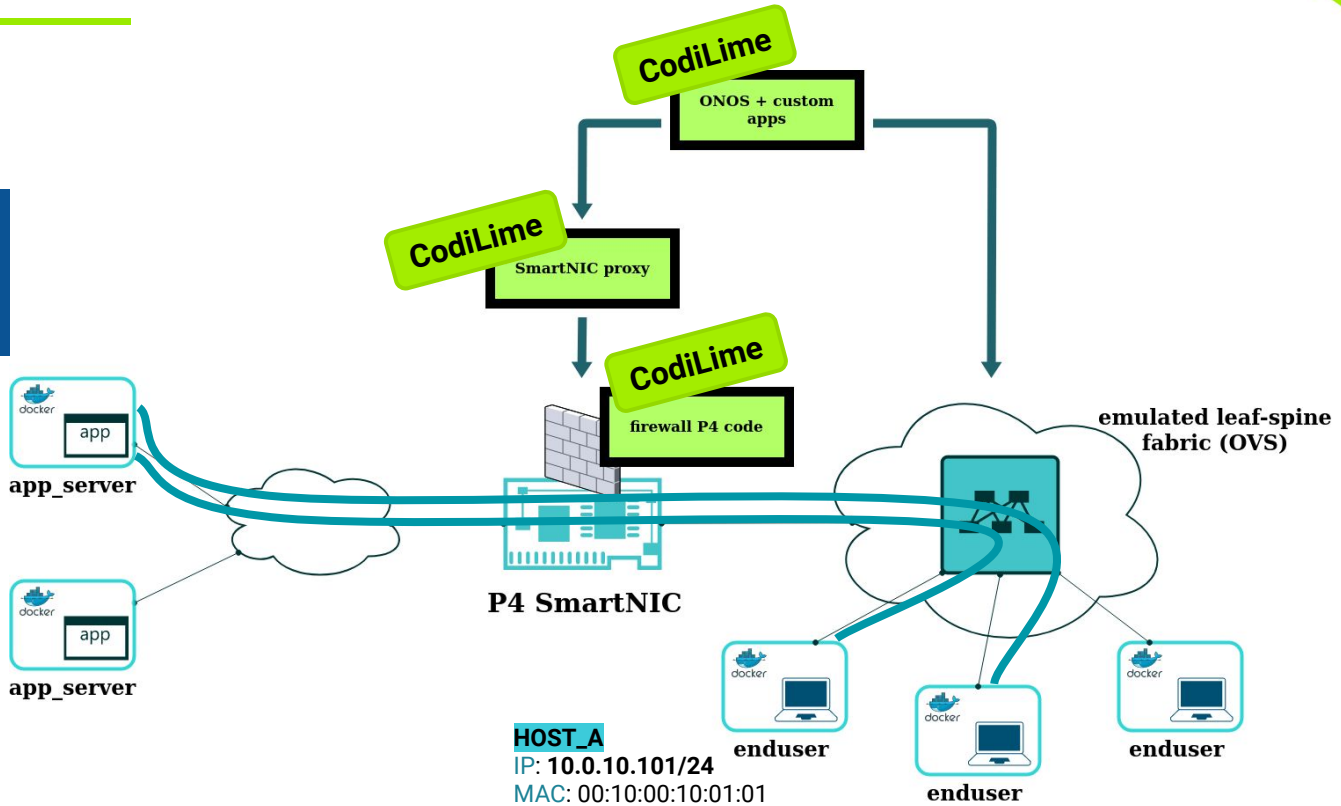
# Demo - Scenario #1 (TCP)

NGINX server  
listening on TCP ports:  
9051-9060

**SERVER\_1**

IP: 10.0.1.11/24

MAC: 00:10:00:01:00:11



**HOST\_A**

IP: 10.0.10.101/24

MAC: 00:10:00:10:01:01

**HOST\_B**

IP: 10.0.10.102/24

MAC: 00:10:00:10:01:02

# Demo - Scenario #1 (TCP)

NGINX server  
listening on TCP ports:  
9051-9060

**SERVER\_1**  
IP: 10.0.1.11/24  
MAC: 00:10:00:01:00:11



TCP, dst\_port: 9051



TCP, dst\_port: 9051

P4 SmartNIC

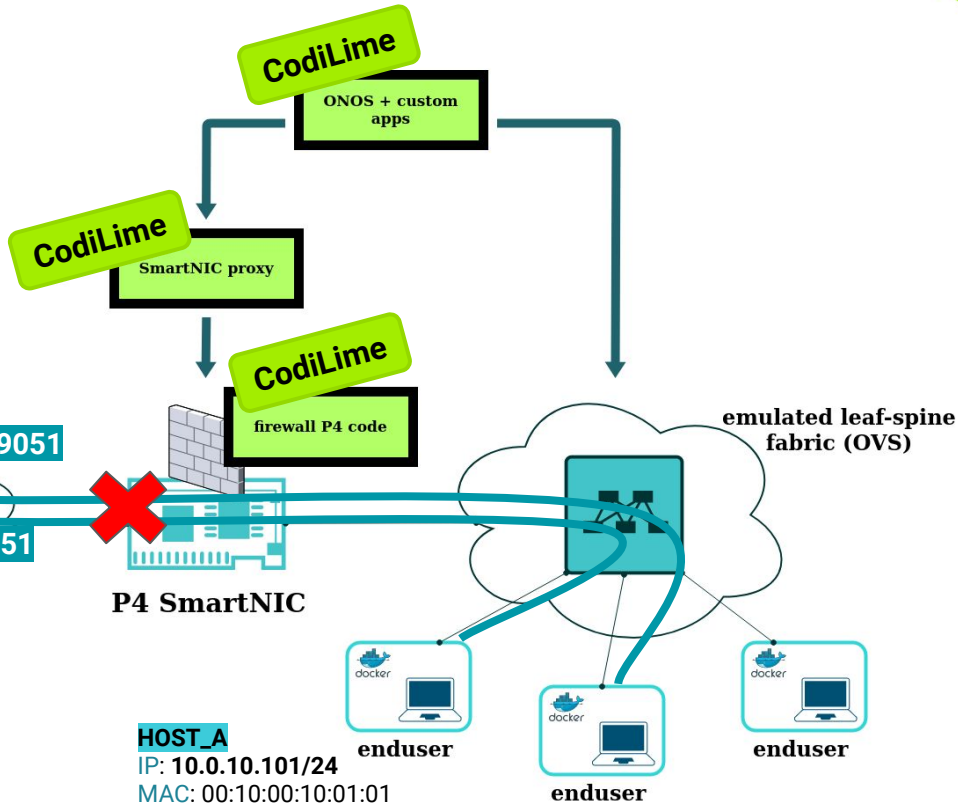
**HOST\_A**

IP: 10.0.10.101/24  
MAC: 00:10:00:10:01:01



**HOST\_B**

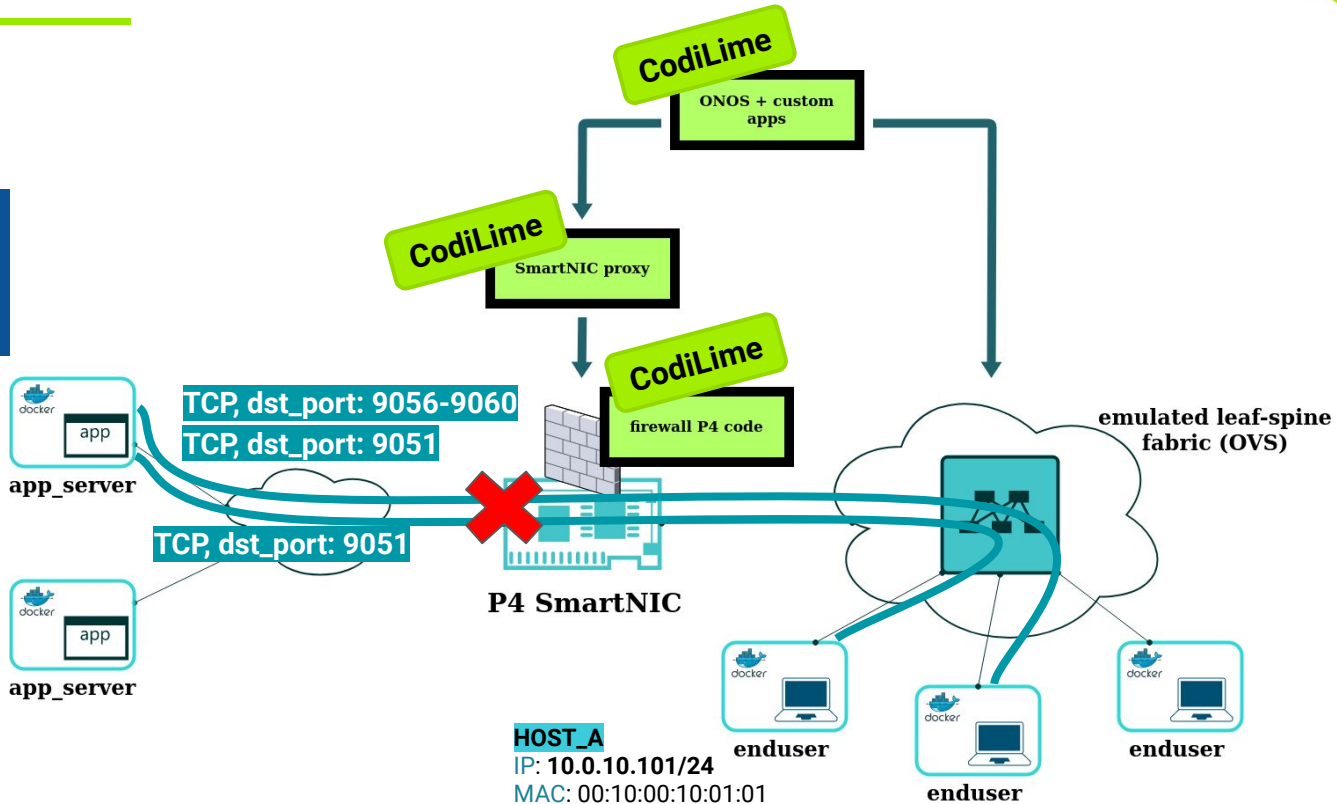
IP: 10.0.10.102/24  
MAC: 00:10:00:10:01:02



# Demo - Scenario #1 (TCP)

NGINX server  
listening on TCP ports:  
9051-9060

**SERVER\_1**  
IP: 10.0.1.11/24  
MAC: 00:10:00:01:00:11



**HOST\_A**  
IP: 10.0.10.101/24  
MAC: 00:10:00:10:01:01

**HOST\_B**  
IP: 10.0.10.102/24  
MAC: 00:10:00:10:01:02

```

pawel@pawel-ThinkPad-T490: ~
/app #
/app #
/app # netstat -tunlp
Active Internet connections (only servers)
Proto Recv-Q Send-Q Local Address           Foreign Address         State       PID/Program name
tcp        0      0 0.0.0.0:9051          0.0.0.0:*               LISTEN      8/nginx
tcp        0      0 0.0.0.0:9052          0.0.0.0:*               LISTEN      8/nginx
tcp        0      0 0.0.0.0:9053          0.0.0.0:*               LISTEN      8/nginx
tcp        0      0 0.0.0.0:9054          0.0.0.0:*               LISTEN      8/nginx
tcp        0      0 0.0.0.0:9055          0.0.0.0:*               LISTEN      8/nginx
tcp        0      0 0.0.0.0:9056          0.0.0.0:*               LISTEN      8/nginx
tcp        0      0 0.0.0.0:9057          0.0.0.0:*               LISTEN      8/nginx
tcp        0      0 0.0.0.0:9058          0.0.0.0:*               LISTEN      8/nginx
tcp        0      0 0.0.0.0:9059          0.0.0.0:*               LISTEN      8/nginx
tcp        0      0 0.0.0.0:9060          0.0.0.0:*               LISTEN      8/nginx
/app #
/app #
/app # curl localhost:9056
-----
      THIS IS
-----
      *** Codlllme P4 demo ***
-----
      ENJOY !!!
-----
/app #
/app #
/app #

```

```

ptions [nop,nop,TS val 1300109804 ecr 27303827], length 0
0x0000: 0000 0000 0001 0010 0001 0011 0800 4500 .....E.
0x0010: 0034 96c9 4000 4006 7a89 0a00 010b 0a00 .4..@.@.z.....
0x0020: 1467 235b df1e 8c7d ef93 6f50 be33 8011 .g#[...].oP.3..
0x0030: 01fd 2998 0000 0101 080a 4d7e 19ec 01a0 ..).....M-...
0x0040: 9f93 ..

10:37:16.677652 00:00:00:00:20 > 00:10:00:01:00:11, ethertype IPv4 (0x0800), length 66: (tos 0x0, ttl 64, id 513
1, offset 0, flags [DF], proto TCP (6), length 52)
10.0.20.103.57118 > 10.0.1.11.9051: Flags [.], cksum 0x96a8 (correct), seq 80, ack 472, win 501, options [nop,n
op,TS val 27303827 ecr 1300109804], length 0
0x0000: 0010 0001 0011 0000 0000 0020 0800 4500 .....E.
0x0010: 0034 140b 4000 4006 fd47 0a00 1467 0a00 .4..@.@..G...g.
0x0020: 010b df1e 235b 6f50 be33 8c7d ef94 8010 ...#[op.3.]....
0x0030: 01f5 96a8 0000 0101 080a 01a0 9f93 4d7e ..).....M-...
0x0040: 19ec ..

10:37:21.845086 00:10:00:01:00:11 > 00:00:00:00:00:01, ethertype ARP (0x0806), length 42: Ethernet (len 6), IPv4 (l
en 4), Request who-has 10.0.1.1 tell 10.0.1.11, length 28
0x0000: 0000 0000 0001 0010 0001 0011 0806 0001 .....
0x0010: 0800 0604 0001 0010 0001 0011 0a00 010b .....
0x0020: 0000 0000 0000 0a00 0101 0000 0000 0000 .....
0x0030: 0000 0000 0000 0000 0000 0000 .....

10:37:21.846582 00:00:00:00:00:01 > 00:10:00:01:00:11, ethertype ARP (0x0806), length 60: Ethernet (len 6), IPv4 (l
en 4), Reply 10.0.1.1 is-at 00:00:00:00:00:01, length 46
0x0000: 0010 0001 0011 0000 0000 0001 0806 0001 .....
0x0010: 0800 0604 0002 0000 0000 0001 0a00 0101 .....
0x0020: 0010 0001 0011 0a00 010b 0000 0000 0000 .....
0x0030: 0000 0000 0000 0000 0000 0000 .....

```

```

-----
      THIS IS
-----
      *** Codlllme P4 demo ***
-----
      ENJOY !!!
-----
p4demo@rd-trex1:~$
p4demo@rd-trex1:~$
p4demo@rd-trex1:~$ hostB curl 10.0.1.11:9051
^Cp4demo@rd-trex1:~$
p4demo@rd-trex1:~$ hostA curl 10.0.1.11:9051
^Cp4demo@rd-trex1:~$
p4demo@rd-trex1:~$
p4demo@rd-trex1:~$ hostC curl 10.0.1.11:9051
-----
      THIS IS
-----
      *** Codlllme P4 demo ***
-----
      ENJOY !!!
-----
p4demo@rd-trex1:~$
p4demo@rd-trex1:~$
p4demo@rd-trex1:~$
p4demo@rd-trex1:~$
p4demo@rd-trex1:~$ hostA curl 10.0.1.11:9051

```

```

nop,TS val 1300109804 ecr 27303827], length 0
0x0000: 0000 0000 0001 0010 0001 0011 0800 4500 .....E.
0x0010: 0034 96c9 4000 4006 7a89 0a00 010b 0a00 .4..@.@.z.....
0x0020: 1467 235b df1e 8c7d ef93 6f50 be33 8011 .g#[...].oP.3..
0x0030: 01fd 96a0 0000 0101 080a 4d7e 19ec 01a0 ..).....M-...
0x0040: 9f93 ..

10:37:16.677628 00:00:00:00:20 > 00:10:00:01:00:11, ethertype IPv4 (0x0800), length 66: (tos 0x0, ttl 64, id 513
1, offset 0, flags [DF], proto TCP (6), length 52)
10.0.20.103.57118 > 10.0.1.11.9051: Flags [.], cksum 0x2998 (incorrect -> 0x96a8), seq 80, ack 472, win 501, op
tions [nop,nop,TS val 27303827 ecr 1300109804], length 0
0x0000: 0010 0001 0011 0000 0000 0020 0800 4500 .....E.
0x0010: 0034 140b 4000 4006 fd47 0a00 1467 0a00 .4..@.@..G...g.
0x0020: 010b df1e 235b 6f50 be33 8c7d ef94 8010 ...#[op.3.]....
0x0030: 01f5 2998 0000 0101 080a 01a0 9f93 4d7e ..).....M-...
0x0040: 19ec ..

10:37:21.845161 00:10:00:01:00:11 > 00:00:00:00:00:01, ethertype ARP (0x0806), length 60: Ethernet (len 6), IPv4 (l
en 4), Request who-has 10.0.1.1 tell 10.0.1.11, length 46
0x0000: 0000 0000 0001 0010 0001 0011 0806 0001 .....
0x0010: 0800 0604 0001 0010 0001 0011 0a00 010b .....
0x0020: 0000 0000 0000 0a00 0101 0000 0000 0000 .....
0x0030: 0000 0000 0000 0000 0000 0000 .....

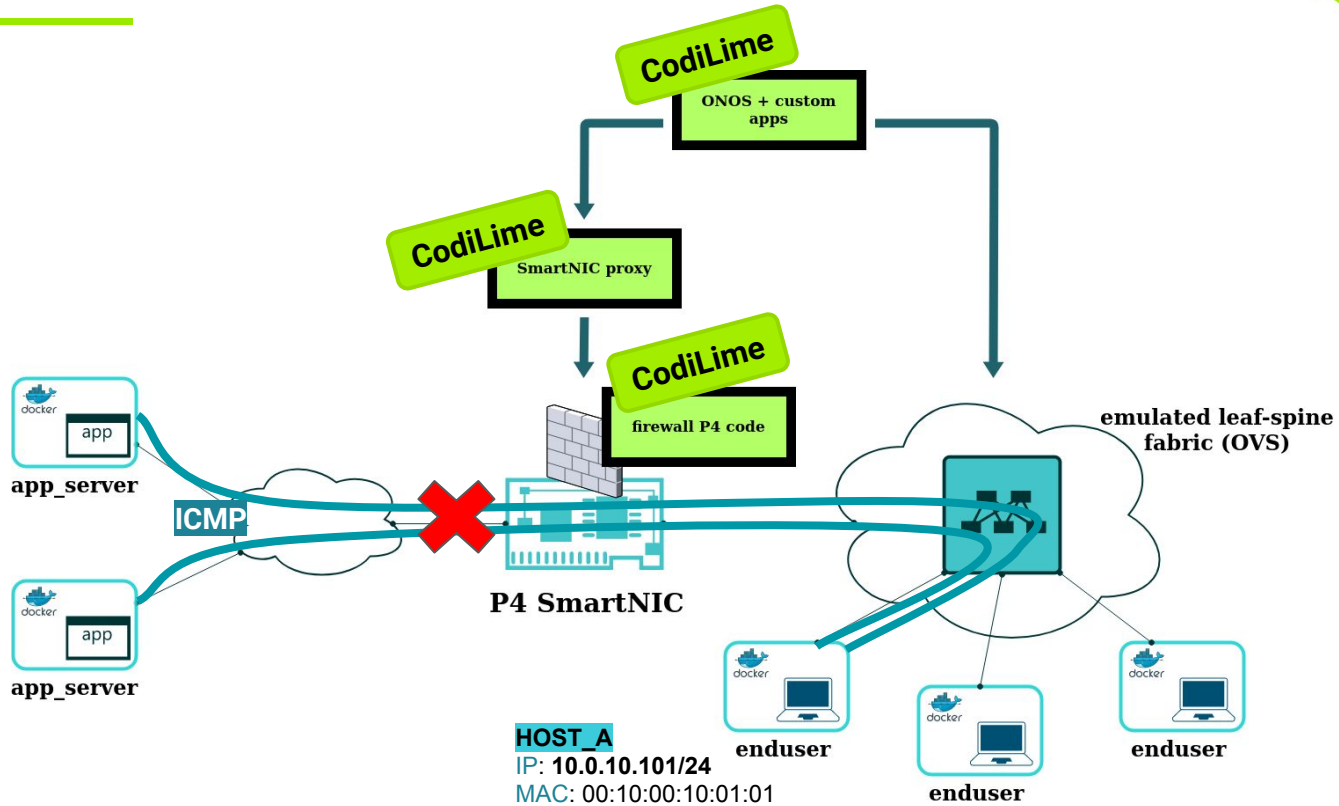
10:37:21.846511 00:00:00:00:00:01 > 00:10:00:01:00:11, ethertype ARP (0x0806), length 42: Ethernet (len 6), IPv4 (l
en 4), Reply 10.0.1.1 is-at 00:00:00:00:00:01, length 28
0x0000: 0010 0001 0011 0000 0000 0001 0806 0001 .....
0x0010: 0800 0604 0002 0000 0000 0001 0a00 0101 .....
0x0020: 0010 0001 0011 0a00 010b 0000 0000 0000 .....
0x0030: 0000 0000 0000 0000 0000 0000 .....

```

# Demo - Scenario #2 (ICMP)

**SERVER\_1**  
IP: 10.0.1.11/24  
MAC: 00:10:00:01:00:11

**SERVER\_2**  
IP: 10.0.1.22/24  
MAC: 00:10:00:01:00:22



```
p4demo@rd-trex1:~$
p4demo@rd-trex1:~$
p4demo@rd-trex1:~$
p4demo@rd-trex1:~$
```

```
--- 10.0.1.11 ping statistics ---
4 packets transmitted, 0 packets received, 100% packet loss
p4demo@rd-trex1:~$
p4demo@rd-trex1:~$
p4demo@rd-trex1:~$ hostB ping 10.0.1.11
PING 10.0.1.11 (10.0.1.11): 56 data bytes
64 bytes from 10.0.1.11: seq=0 ttl=64 time=1.213 ms
64 bytes from 10.0.1.11: seq=1 ttl=64 time=0.254 ms
^C
--- 10.0.1.11 ping statistics ---
2 packets transmitted, 2 packets received, 0% packet loss
round-trip min/avg/max = 0.254/0.733/1.213 ms
p4demo@rd-trex1:~$
p4demo@rd-trex1:~$ hostC ping 10.0.1.11
PING 10.0.1.11 (10.0.1.11): 56 data bytes
64 bytes from 10.0.1.11: seq=0 ttl=64 time=1.513 ms
64 bytes from 10.0.1.11: seq=1 ttl=64 time=0.332 ms
^C
--- 10.0.1.11 ping statistics ---
2 packets transmitted, 2 packets received, 0% packet loss
round-trip min/avg/max = 0.332/0.922/1.513 ms
p4demo@rd-trex1:~$
p4demo@rd-trex1:~$
p4demo@rd-trex1:~$ hostA ping 10.0.1.11
PING 10.0.1.11 (10.0.1.11): 56 data bytes
64 bytes from 10.0.1.11: seq=0 ttl=64 time=1.334 ms
64 bytes from 10.0.1.11: seq=1 ttl=64 time=0.285 ms
```

```
0x0010: 0054 3d85 0000 4001 1db5 0a00 010b 0a00 .T...@.....
0x0020: 0a65 0000 d200 6f02 0000 8d3d 31bf 0000 .e...o....=1...
0x0030: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0040: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0050: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0060: 0000 ..
11:55:16.229233 00:00:00:00:00:10 > 00:10:00:01:00:11, ethertype IPv4 (0x0800), length 98: (tos 0x0, ttl 64, id 864
9, offset 0, flags [DF], proto ICMP (1), length 84)
10.0.10.101 > 10.0.1.11: ICMP echo request, id 28418, seq 1, length 64
0x0000: 0010 0001 0011 0000 0000 0010 0800 4500 .....E.
0x0010: 0054 21c9 4000 4001 f970 0a00 0a65 0a00 .Tl@.p...e...
0x0020: 010b 0800 1abd 6f02 0001 2d80 40bf 0000 .....o...@...
0x0030: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0040: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0050: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0060: 0000 ..
11:55:16.229288 00:10:00:01:00:11 > 00:00:00:00:00:01, ethertype IPv4 (0x0800), length 98: (tos 0x0, ttl 64, id 158
35, offset 0, flags [none], proto ICMP (1), length 84)
10.0.1.11 > 10.0.10.101: ICMP echo reply, id 28418, seq 1, length 64
0x0000: 0000 0000 0001 0010 0001 0011 0800 4500 .....E.
0x0010: 0054 3ddb 0000 4001 1d5f 0a00 010b 0a00 .T...@.....
0x0020: 0a65 0000 22bd 6f02 0001 2d80 40bf 0000 .e...o...@...
0x0030: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0040: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0050: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0060: 0000 ..
```

```
0x0010: 0054 3d85 0000 4001 1db5 0a00 010b 0a00 .T...@.....
0x0020: 0a65 0000 d200 6f02 0000 8d3d 31bf 0000 .e...o....=1...
0x0030: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0040: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0050: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0060: 0000 ..
11:55:16.229191 00:00:00:00:00:10 > 00:10:00:01:00:11, ethertype IPv4 (0x0800), length 98: (tos 0x0, ttl 64, id 864
9, offset 0, flags [DF], proto ICMP (1), length 84)
10.0.10.101 > 10.0.1.11: ICMP echo request, id 28418, seq 1, length 64
0x0000: 0010 0001 0011 0000 0000 0010 0800 4500 .....E.
0x0010: 0054 21c9 4000 4001 f970 0a00 0a65 0a00 .Tl@.p...e...
0x0020: 010b 0800 1abd 6f02 0001 2d80 40bf 0000 .....o...@...
0x0030: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0040: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0050: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0060: 0000 ..
11:55:16.229351 00:10:00:01:00:11 > 00:00:00:00:00:01, ethertype IPv4 (0x0800), length 98: (tos 0x0, ttl 64, id 158
35, offset 0, flags [none], proto ICMP (1), length 84)
10.0.1.11 > 10.0.10.101: ICMP echo reply, id 28418, seq 1, length 64
0x0000: 0000 0000 0001 0010 0001 0011 0800 4500 .....E.
0x0010: 0054 3ddb 0000 4001 1d5f 0a00 010b 0a00 .T...@.....
0x0020: 0a65 0000 22bd 6f02 0001 2d80 40bf 0000 .e...o...@...
0x0030: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0040: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0050: 0000 0000 0000 0000 0000 0000 0000 0000 .....
0x0060: 0000 ..
```

# More technical details...



<https://www.youtube.com/watch?v=lwjoggSE0ml>



# Thank You

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