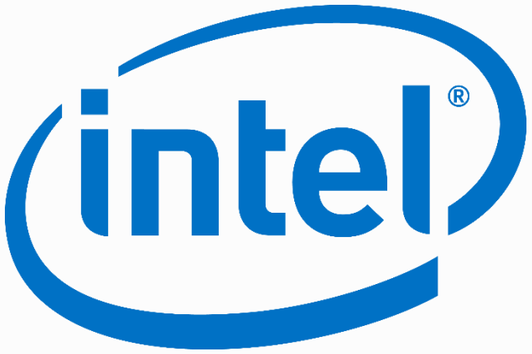
presented by



Improving UEFI Network Stack Performance

Spring 2019 UEFI Plugfest

April 8-12, 2019

Presented by Maciej Rabeda (Intel) and Vincent Zimmer (Intel)

Agenda

- Motivation
- Starting point
- Design limitations
- What can be done?
- Tackling the problem
- Results

Motivation

Motivation

- Legacy BIOS is still there
  - Cost vs benefits of transitioning to UEFI from Legacy
- UEFI network performance complaints
- Linuxboot

```
SeaBIOS (version rel-1.9.1-0-gb3ef39f-prebuilt.qemu-project.org)

Initializing Intel(R) Boot Agent XE (X550) v2.4.31
PXE 2.1 Build 092 (WfM 2.0)

Intel(R) Boot Agent XE (X550) v2.4.31
Copyright (C) 1997-2018, Intel Corporation

CLIENT MAC ADDR: D0 0D E0 00 00 02  GUID: 00000000 0000 0000 0000 000000000000
DHCP._
```

Real world feedback to address this issue

Starting point

- How good/bad is it really?
- PXE boot to WDS
  - Legacy vs. UEFI
  - Adapter: Intel(R) X550-T2
  - Client directly connected to WDS
- Measure boot.wim transfer time with Wireshark

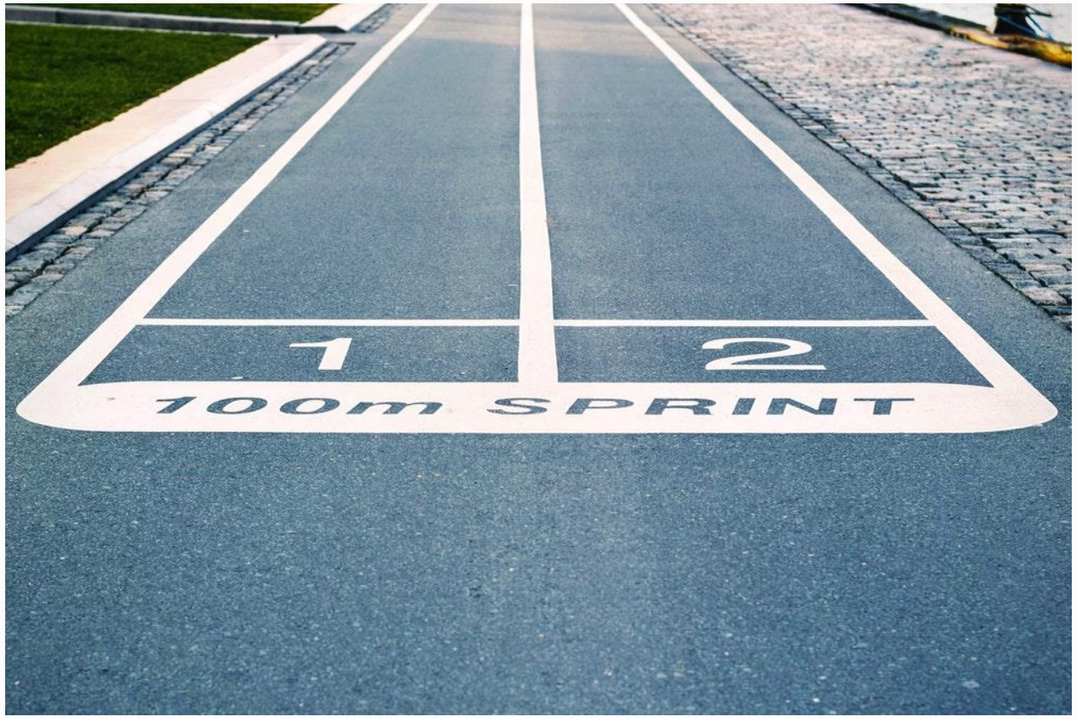
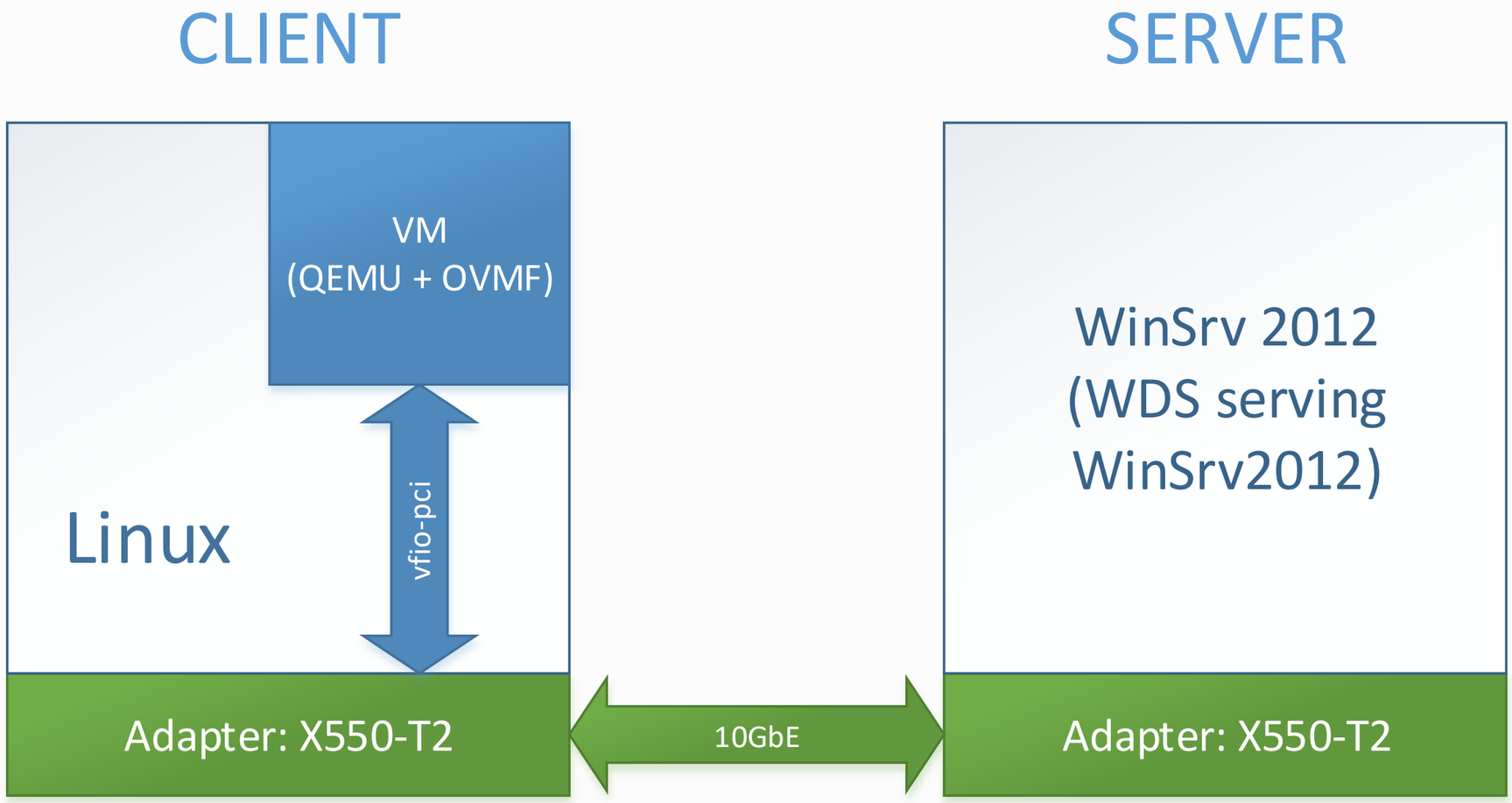


Photo by Tim Gouw on Unsplash

Test setup


CLIENT
SERVER
VM
(QEMU + OVMF)
Linux
vfio-pci
WinSrv 2012
(WDS serving
WinSrv2012)
Adapter: X550-T2
10GbE
Adapter: X550-T2

Starting point - numbers

Technology	Platform	Environment	Avg. time[s]	Avg. speed[Mbps]
Intel(R) Legacy PXE 10G	Bare metal	UEFI CSM	2.1	~790
	QEMU	SeaBIOS	5.5	~300
UEFI PXE	Bare metal	UEFI	9	~185
	QEMU	UEFI (OVMF 2018 DEBUG)	8.4	~200
	QEMU	UEFI (OVMF 2018 RELEASE)	3	~550

Optimized UEFI is still behind

Identifying the sky

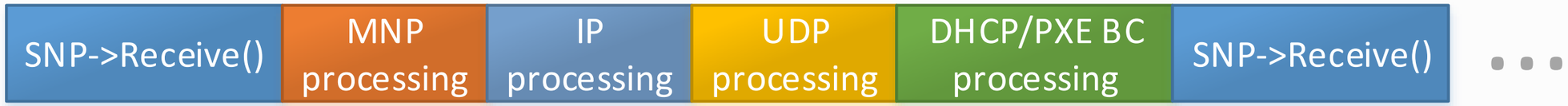
- Test: UEFI networking limits
  - Server: Tx packet flood to client, full MTU, fixed number of packets (10 million)
  - Snp->Receive() loop: 10 Gbps
  - Mnp->Receive() loop
    - ARP & IP unloaded 4.5 Gbps
    - IP unloaded 4 Gbps
  - PXE BC DL 0.55 Gbps

Observations

- OEMs building stack drivers in DEBUG mode (instead of RELEASE)
- Extra receivers on MNP layer reduce Rx throughput
  - Packet processing through whole stack before receiving another packet
  - Event and DPC cost
- Improvement potential with current stack driver:
  - 4 Gbps on MNP but only 0.55 Gbps on PXE BC

What can be done?

- Culprit
  - It’s probably our stack (same WDS serving legacy and UEFI install images)
- Optimization opportunity?
  - Is it stack complexity alone?
  - Still does not address whole packet processing before receiving next one



The problem areas identified

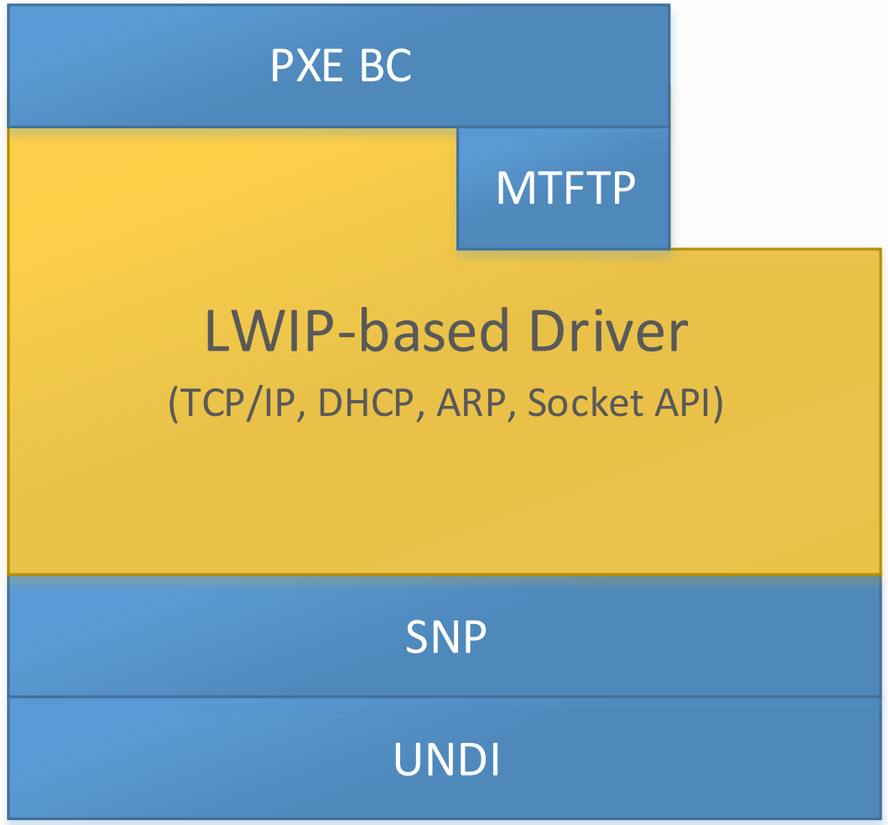
But I want to play...

Play time

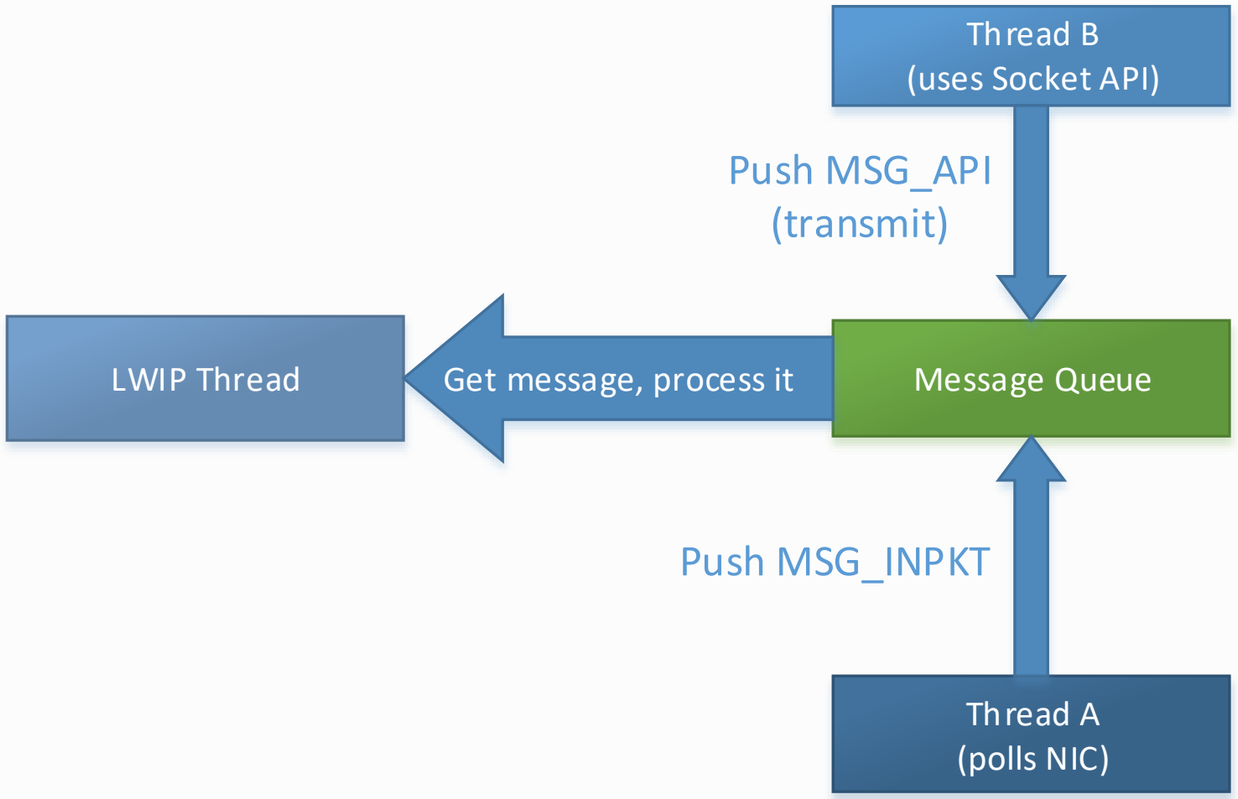
- Idea: multiprocessing in UEFI networking
- Feasability:
  - Got EFI_MP_SERVICES_PROTOCOL
- Benefits:
  - Network offload (partial or full) from Boot strap processor (BSP) to Application Processors (Aps)
  - Performance scalability
- Concerns:
  - Thread safety (core, stack, protocols...)
  - Current network stack complexity
  - UEFI spec conformance

Design assumptions

- Provide an alternate TCP/IP stack to an existing one
- Offload whole networking from BSP to APs up to OS-like socket layer
- Use an existing open-source, thread-safe TCP/IP implementation
- Use SNP for interfacing to network adapters
- Expose DHCP API (needed by PXE BC)

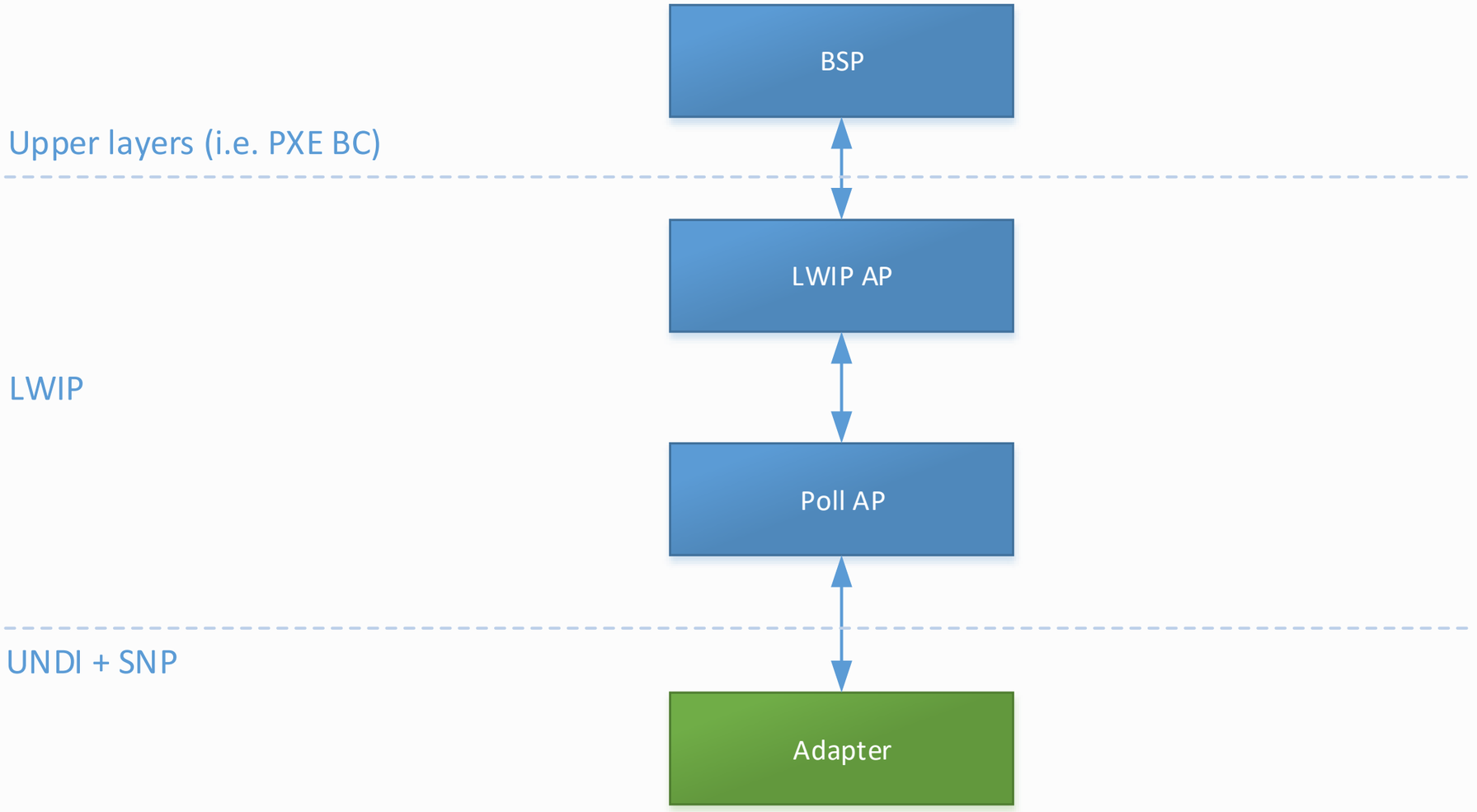


TCP/IP stack

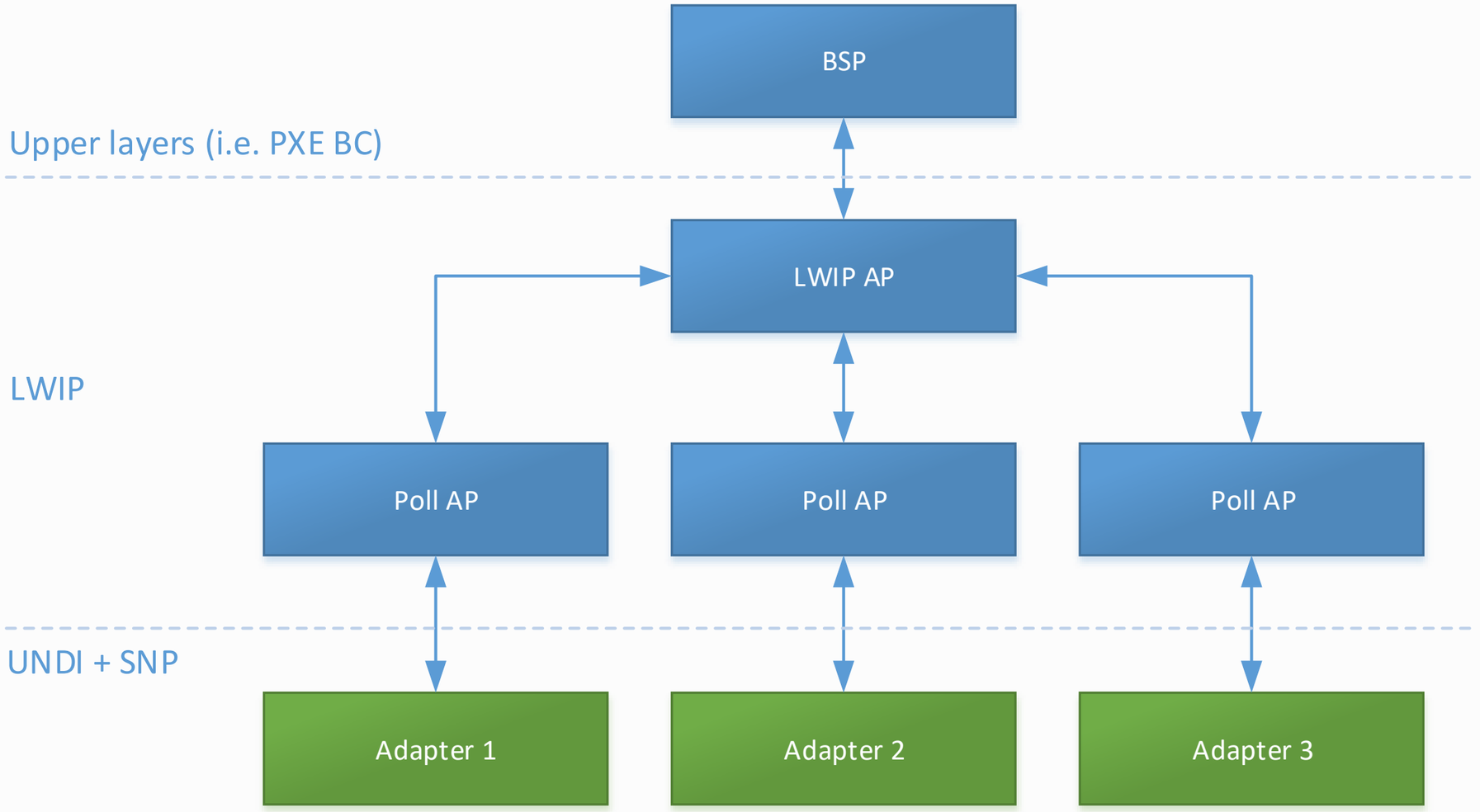


- Implementation used: lwIP
  - Uses single thread for all packet processing
  - Thread-safe at API levels thanks to message mechanisms
  - Exposes OS-like socket layer
  - Almost autonomous - needs minimal changes to make it work with UEFI

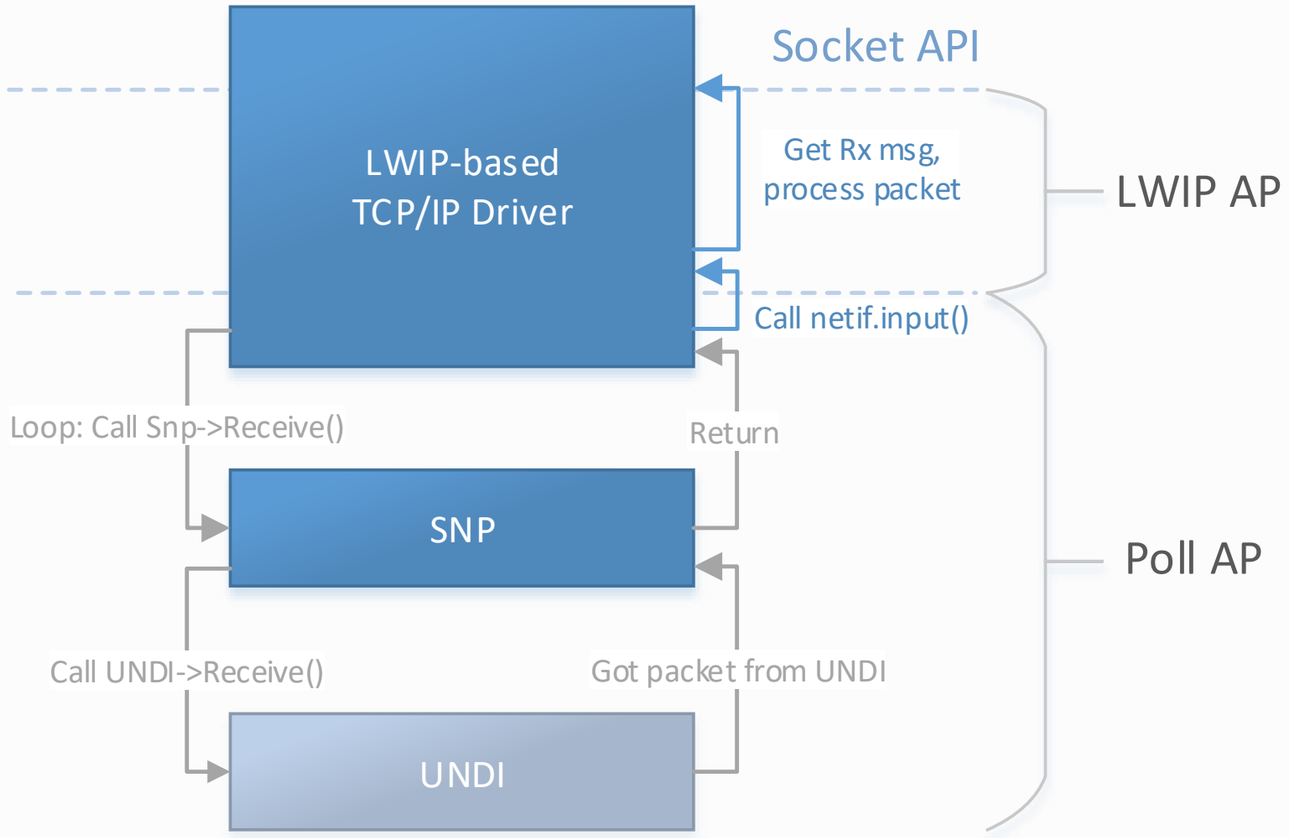
Multiprocessing



Multiprocessing

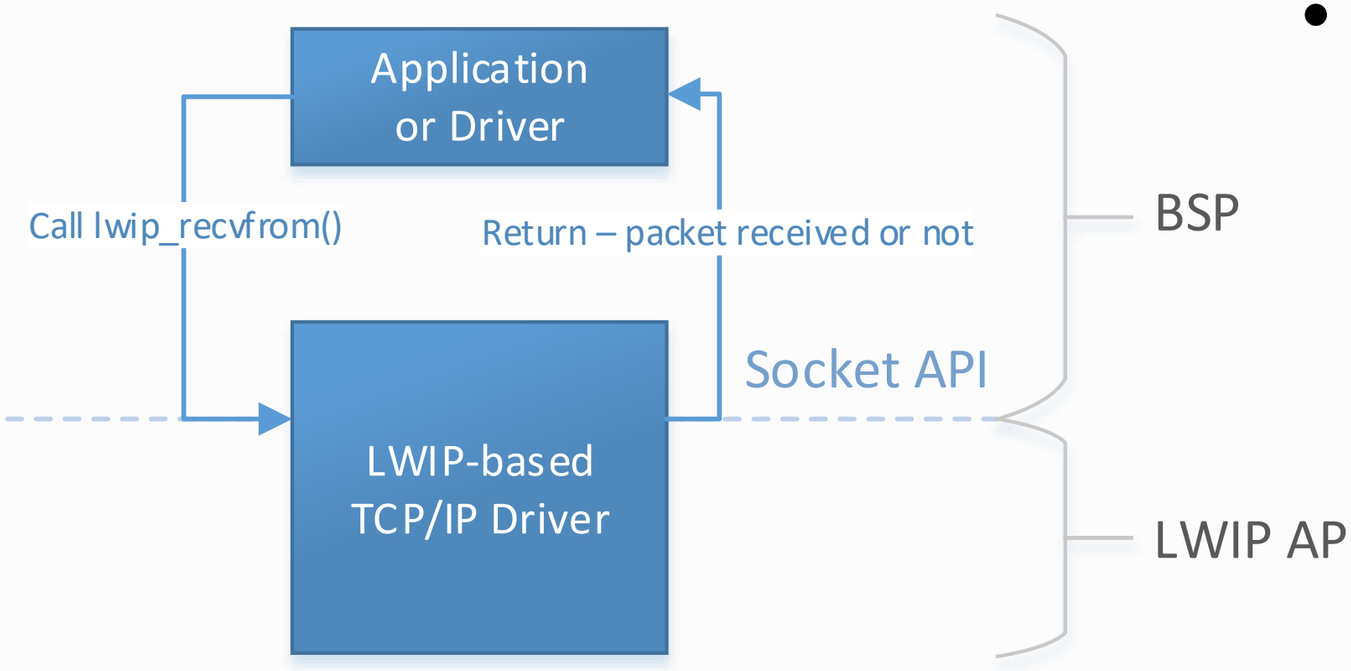


Receive path – APs



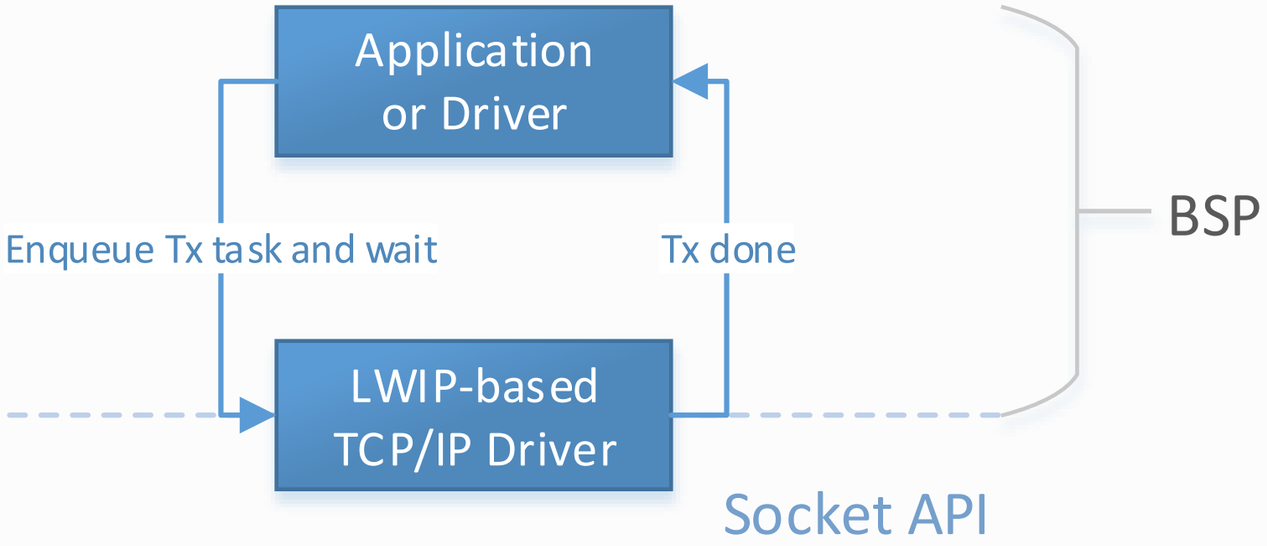
- Poll APs:
  - Interface SNP in busy-poll
  - Once packet is received, send msg to LWIP AP to process
- LWIP AP:
  - Process the packet
  - Assign to proper sockets

Receive path – BSP



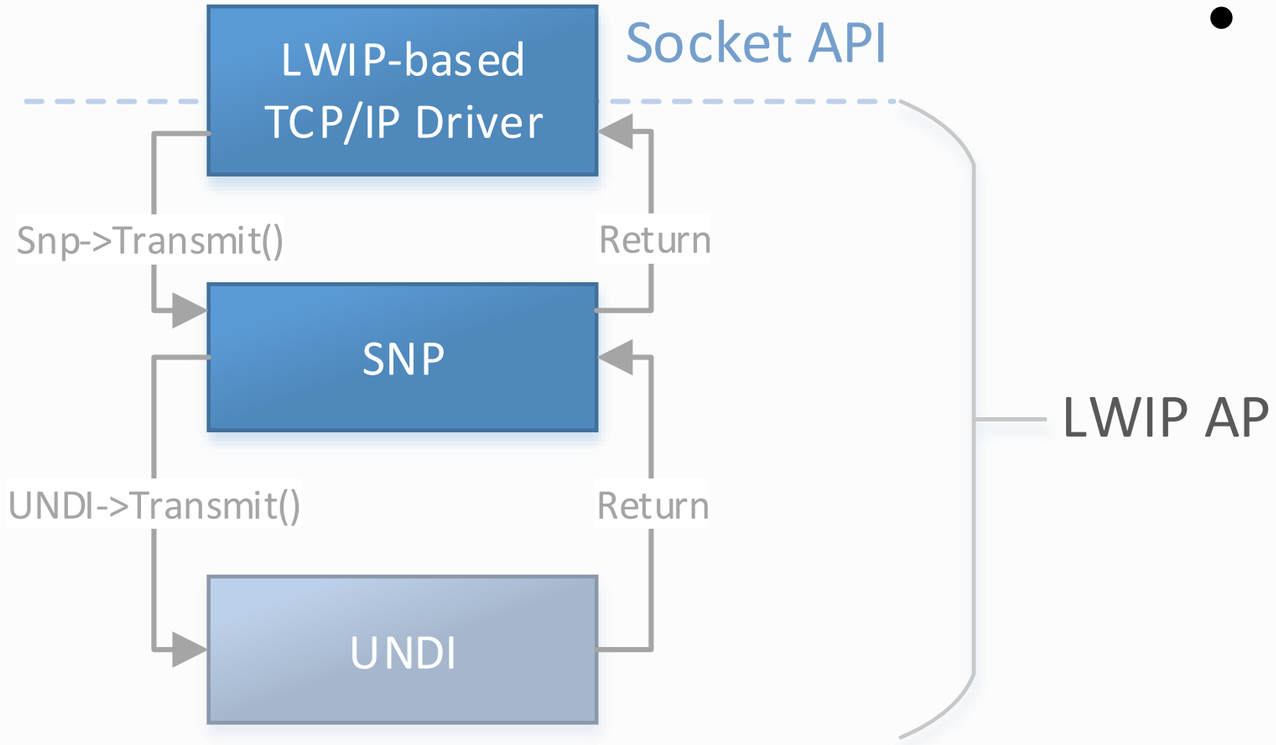
- BSP
  - Loop lwip_recvfrom() to get packets from socket

Transmit path – BSP



- BSP
  - Send message to LWIP AP to send a packet
  - Wait for LWIP AP to finish the transmit

Transmit path – AP



- LWIP AP
  - Triggered with a message
  - Call SNP->Transmit() directly
  - Signal the waiting application Tx has finished

Summary of changes

- New
  - MdeModulePkg/Universal/
    - Network/MpTcpIpDxe
    - ThreadingDxe
  - MdeModulePkg/Library/
    - DxeThreadingLib
    - DxeThreadingStructLib
- Modified
  - MdeModulePkg/Universal/
    - Network/Snp4Dxe
    - Network/Mtftp4Dxe
    - Network/PxeBc4Dxe
  - OvmfPkg/Library/
    - PlatformDebugLibIoPort

Final tests

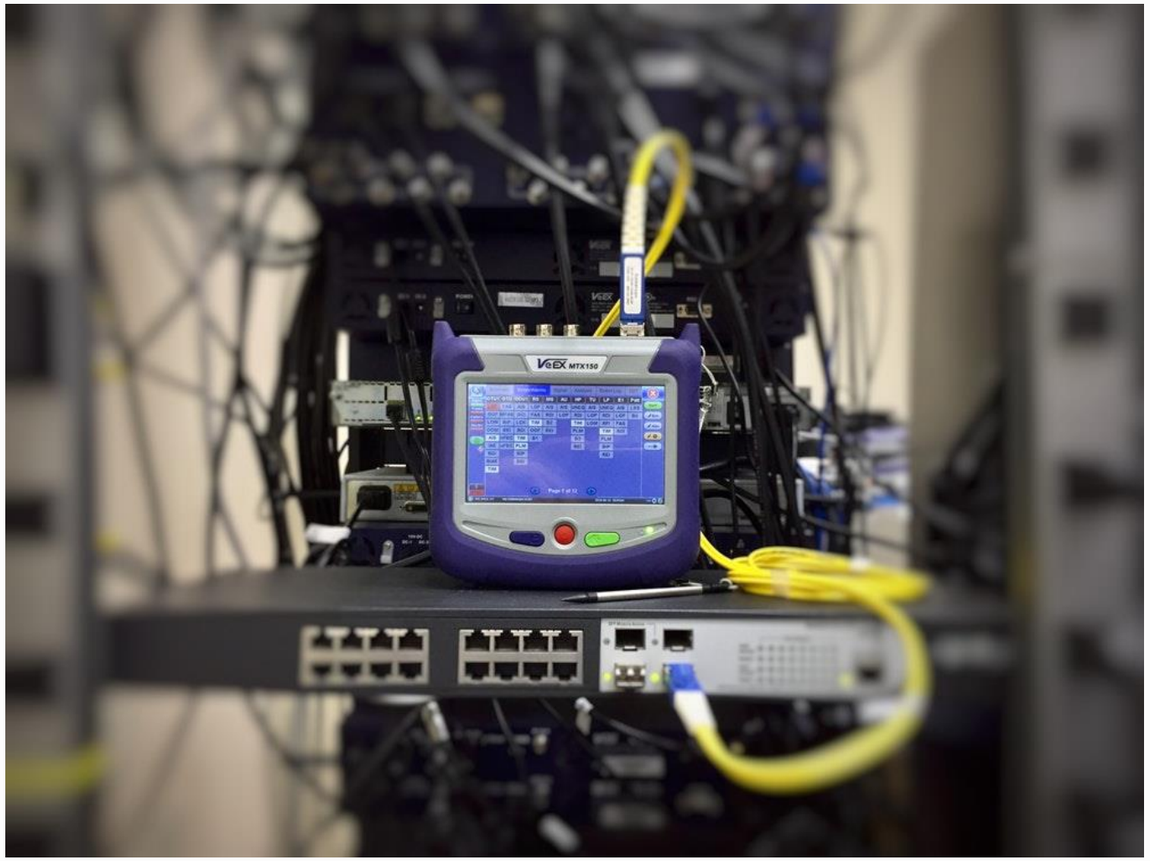


Photo by Ildefonso Polo on Unsplash

- After all the changes, I could successfully boot to WDS
- How good it is?
  - Same PXE install image DL time test

Results

Technology	Platform	Environment	Avg. time[s]	Avg. speed[Mbps]
Intel(R) Legacy PXE 10G	Bare metal	UEFI CSM	2.1	~790
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	QEMU	UEFI (OVMF 2018 DEBUG)	8.4	~200
	QEMU	UEFI (OVMF 2018 RELEASE)	3	~550
	QEMU	UEFI (OVMF 2018 modified)	1.5	~1100

Modern system software techniques can yield 2X UEFI, 1.5X legacy

Summary

- Proven doable
  - Faster than legacy and current solution
- Alternative rather than substitute
- Perf could be better (~1.1Gbps, ~90kpps)
  - Linux OS does 350kpps on a single core
  - Receive Side Scaling, interrupts, etc.
- **Code can be found at:**

https://github.com/tianocore/edk2-staging/tree/MpNetworkStack

Thanks for attending the 2019 Spring UEFI Plugfest

For more information on UEFI Forum and UEFI Specifications, visit http://www.uefi.org

presented by