Time synchronisation in programmable device¶

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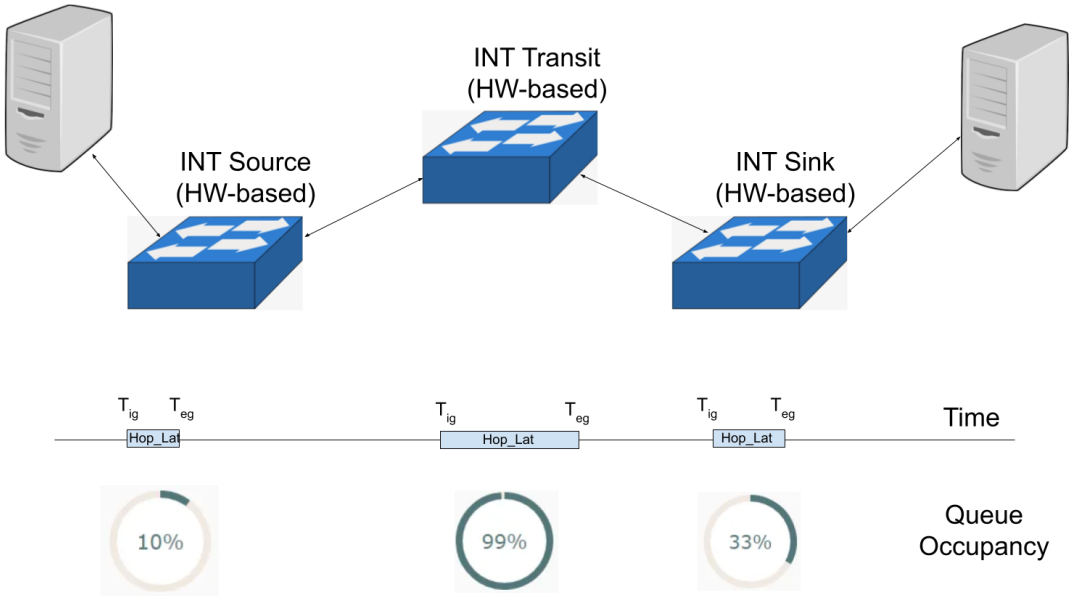
Motivation

- In-band Network Telemetry (INT)



Hop Latency = T_{egress} - $T_{ingress}$

Goals

- As part of GN4-3-WP6 research, we are validating various P4 platforms in terms of their ability to implement INT
- One of the key capabilities of INT is to record timestamps of the packet's passage through the switch
- Requirements dependant on the specific use-case:
  - One-way Delay (Clock Synchronization)
  - Microburst measurements (Timestamp Stability)
- Goal:
  - To analyze the capabilities of current P4-programmable platforms in terms of timestamp (TS) recording and clock synchronization (CS)

Platforms tested

- Software-based
  - BMv2
  - DPDK: T4P4S, p4c-dpdk
  - BPF: p4c-ebpf, p4-xdp, p4c-ubpf
- SmartNIC-based
  - NetFPGA
  - Netcope P4
  - Netronome
- Hardware switch
  - Intel Tofino

T4P4S

P4→NetFPGA

NETCOPE TECHNOLOGIES

Intel® Tofino™

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Major Findings

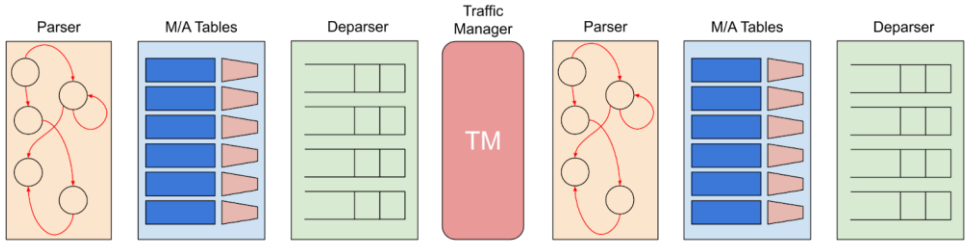
- **Timestamp support**
  - Some platforms do not support timestamps at all
    - T4P4S, p4c-dpdk, p4c-ebpf
- **Timestamp format, range and meaning**

Platform	Resolution [bits]	Meaning	Epoch
BMv2	48	Number of microseconds	Switch start
Tofino v1	48	Number of nanoseconds	Adjustable
Netcope P4	64	Number of nanoseconds	Adjustable
NetFPGA	64	Number of units derived from the clock signal source (8ns or 6.4ns)	Since the FPGA boot time

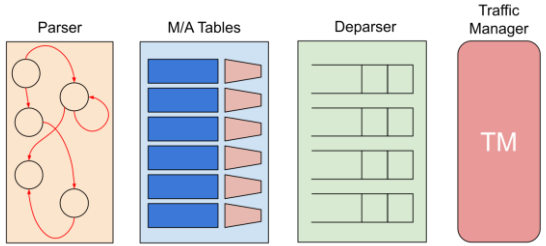
Major Findings

- **Impact of P4 architecture used**
  - TS recorded during transition between PHY and MAC (Tofino, Netcope, Netronome)
  - TS recorded when entering the ingress and egress pipeline (Tofino)
  - TS obtained by calling extern (NetFPGA, Netronome)
  - Some of the architectures have ingress pipeline only (NetFPGA, Netcope)

PSA Architecture

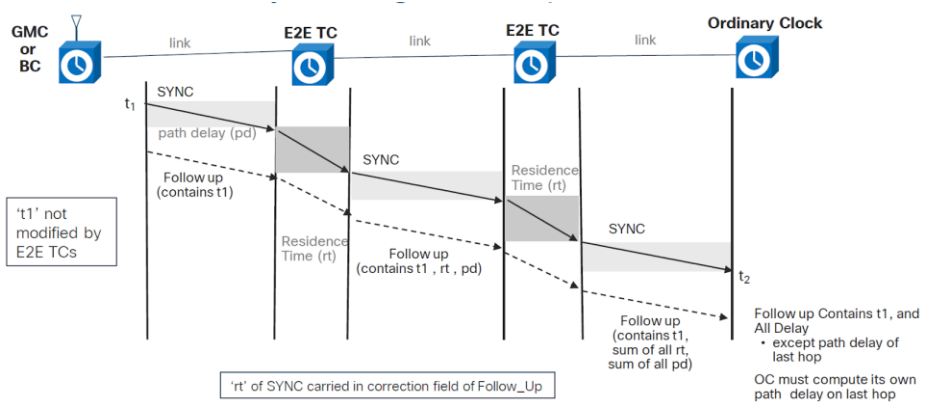


SimpleSumeSwitch Architecture



Major Findings

- **Clock Synchronization**
  - No synchronization
    - NetFPGA
  - Network Time Protocol (NTP) – accuracy in orders of milliseconds, software-based approach
    - Netcope P4
  - Precise Time Protocol (PTP) – sub-microsecond accuracy, hardware support required
    - NIC (ptp4lin, phc2sys)
    - Tofino



PTP switch:
- Calculates residence time
- Updates correctionField in PTP packet

- P4-based switches can help in significant expansion of PTP in the near future

Conclusions

- Existing platforms vary considerably
  - Support for TS, format, range, location where the TS is recorded
- Software-based platforms
  - TS and CS not implemented or used from the system time
  - Measurement accuracy affected by software layer overhead
  - DPDK-based platforms are the most promising (T4P4S)
- Hardware-based platforms
  - TS and CS implemented (NTP, PTP, PPS)
  - Tofino represents the best production quality platform
- More detailed information is part of the White Paper, which will be coming soon

Thank you

Any questions?

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