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POWERING INNOVATION

Application Specific Fast-Path for QorIQ and QorIQ Qonverge

FTF-ENT-F0012

Hemant Agrawal
Software Architect

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Agenda

- **Application Specific Fast-Path (ASF) concepts and architecture**
  - Features
  - Use-cases
- **ASF internals**
  - IPv4 Forwarding
  - NAT Processing
  - IPSEC Processing
  - IP Termination
- **Performance**
  - Benchmarks on DPAA and non-DPAA
  - Leveraging hardware acceleration
- **Conclusion**

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Faster Packet Processing

- All flows are created equal …
- … But some flows can be put on a fast-track
- Store flows requiring simple, deterministic processing in a cache
- Recognize cached flows and process such packets in a separate highly optimized context

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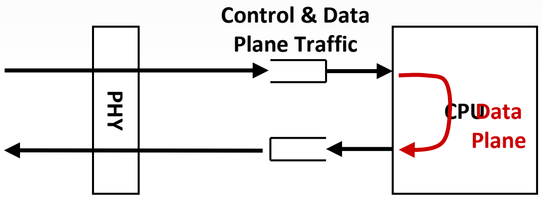
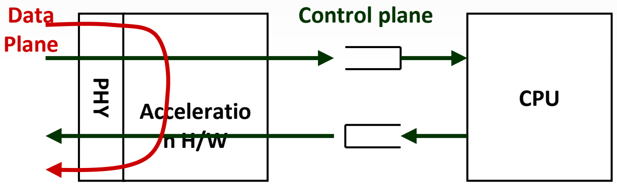
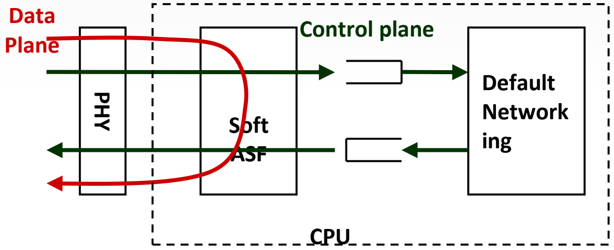
What is Fast-Path?



a. Forwarding by CPU



b. Hardware based Data Path Acceleration



c. Software based Data Path Acceleration

- Most network packet processing can be broken down into two paths
  - Fast path, also known as the data path, requires quick and efficient switching/routing of packets
  - Slow path, also known as the control path, requires more processing and has more inherent latency than the data path
- Application Specific Fast-Path
  - Optimized software implementation for Data Path
  - Customized for QorIQ platforms
  - Achieve higher throughput for specific applications
  - Leverages functionality provided by H/W

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Why Application Specific Fast-Path?

- **What is Fast-Path?**
  - Offloads data-path processing from a conventional network stack to a highly optimized context
  - Tightly coupled with hardware accelerators/low-level drivers
- **Why do we need it?**
  - 2x-8x speedup over conventional network stack
  - Better leverage of our HW acceleration capabilities
  - Make extra headroom in CPU for other tasks
- **Why do it in software?**
  - No need for specialized HW engines – save die-size/power
  - Open source C code in Linux – easy to compile, integrate, debug and customize
  - Bundled with SDK – out-of-the-box experience
- **What is our differentiation?**
  - Seamless integration with Linux® & VortiQa*
  - More features – IPSec, Zero-copy termination

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Fast-Path for Different Applications

Application	Fast-Path	Slow-Path
Layer 2 bridging	FDB lookup, VLAN add/delete, Learning	Aging, STP
IPv4 forwarding	Dest-cache lookup, L2 modify	LPM route-table lookup, ARP
NAPT	5-tuple lookup, IP/Port/L2 modify	Connection setup/destroy, policy, ALG
Firewall	Access control list, pin-holes	Stateful packet inspection, ALG
IPSec	5-tuple lookup, encap/decap + crypto	SA setup, security policy
QoS	Enforcement – sched, police, congestion, shaper	Policy, provisioning

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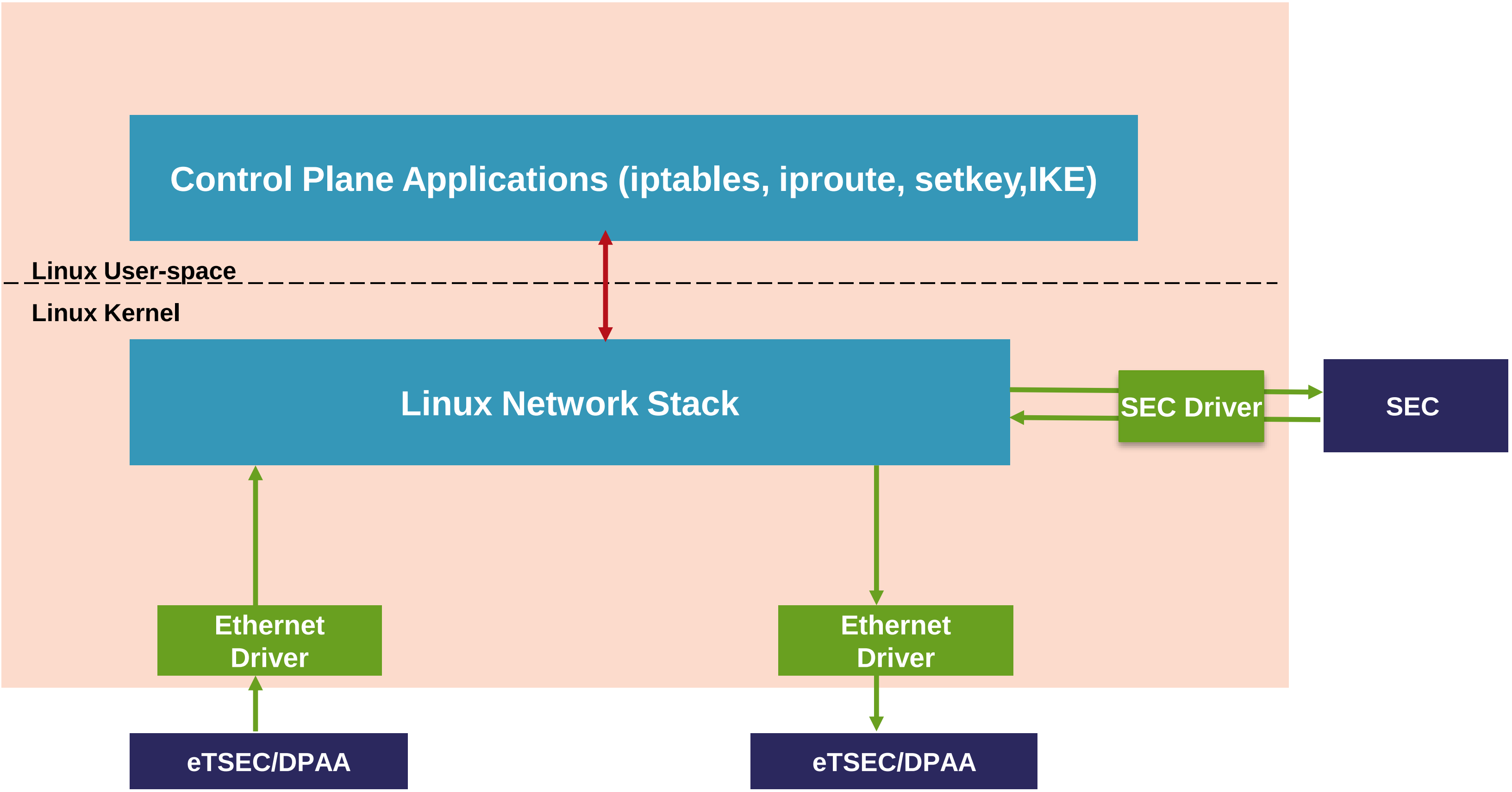
Linux Network Processing

- ↔ Data Packet flow
- ↔ Control Packet flow
- ↔ Configuration flow



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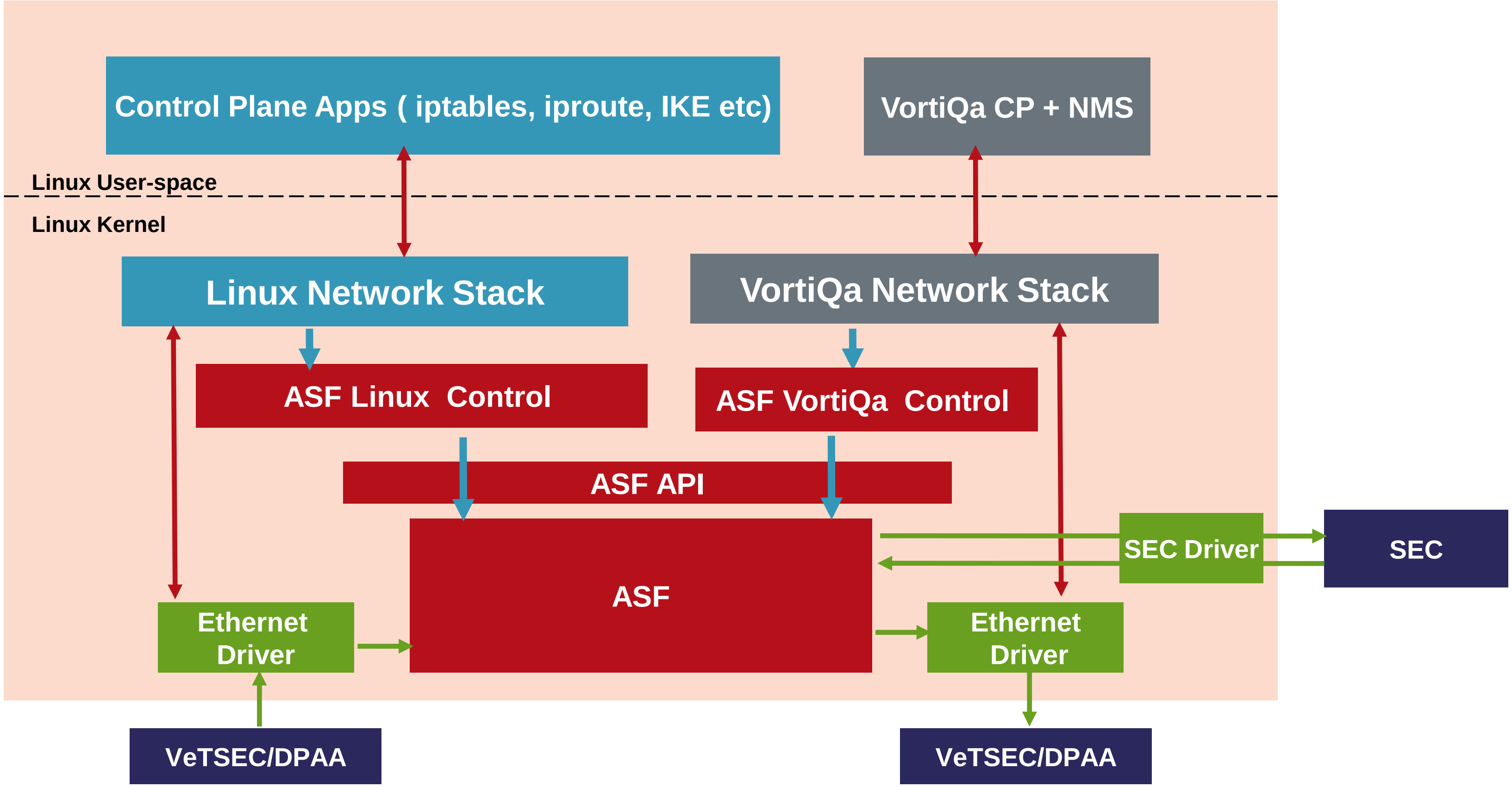
Linux Network Processing with ASF

↔ Data Packet flow

↔ Control Packet flow

↔ Configuration flow



Control Plane Apps (iptables, iproute, IKE etc)

VortiQa CP + NMS

Linux User-space

Linux Kernel

Linux Network Stack

VortiQa Network Stack

ASF Linux Control

ASF VortiQa Control

ASF API

ASF

SEC Driver

SEC

Ethernet Driver

Ethernet Driver

VeTSEC/DPAA

VeTSEC/DPAA

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Target Application Segments

- **Low-End gateways**
  - E.g. Multi-Service gateway, SOHO/SMB, WLAN AP
  - Applications – Routing, L2 switching, NAPT/Firewall, QoS
- **Security appliances**
  - Enterprise UTM, VPN gateway
  - Applications – IPSec, NAPT/Firewall
- **Wireless backhaul**
  - Femto, Pico, Macro cells
  - Applications – IPSec, Zero-copy termination, QoS
- **Edge/Access**
  - DSLAM, SGN
  - Applications – IPSec, NAPT/Firewall, QoS, IPv6, VSG

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ASF Feature List (SDK 1.2 & WUSDK)

- **Core Features**
  - IPv4 Forwarding
  - NAPT/Firewall
  - IPSec (ESP/AH-Tunnel, NAT-T)
  - Fragmentation & re-assembly
  - Zero Copy local termination to user-space
  - Per-flow statistics and aging
  - IPv6 Forward, NAPT/Firewall (Off-train)
  - QoS – policing, shaping, scheduling (HW).

- **Platform Integration**
  - Platforms
    - P102x, P101x, P202x
    - P4080, P1023, P3041, P2040, P5020
    - PSC9131/32
  - IP
    - VeTSEC, eTSEC
    - SEC 3.x, SEC 4.x
    - DPAA – FM/BM/QM

- **Network Stack Integration**
  - Linux (2.6.33, .34, .35 & 3.0)
    - Conn-track + IP-Tables (NAT/Firewall)
    - IPv4 Forwarding + IP Toolkit
    - Native IPSec Stack + Racoon/Strong-Swan
    - PMAL Socket (IP-Termination)
    - Real Time Kernel Patch
    - IPv6 (Off-train)
    - TC integration for QoS
  - VortiQa
    - VortiQa NAPT/Firewall
    - VortiQa IPSec
    - VortiQa IPv6 (Off-train)

- **Interface Support**
  - Ethernet
  - VLAN
  - PPPoE

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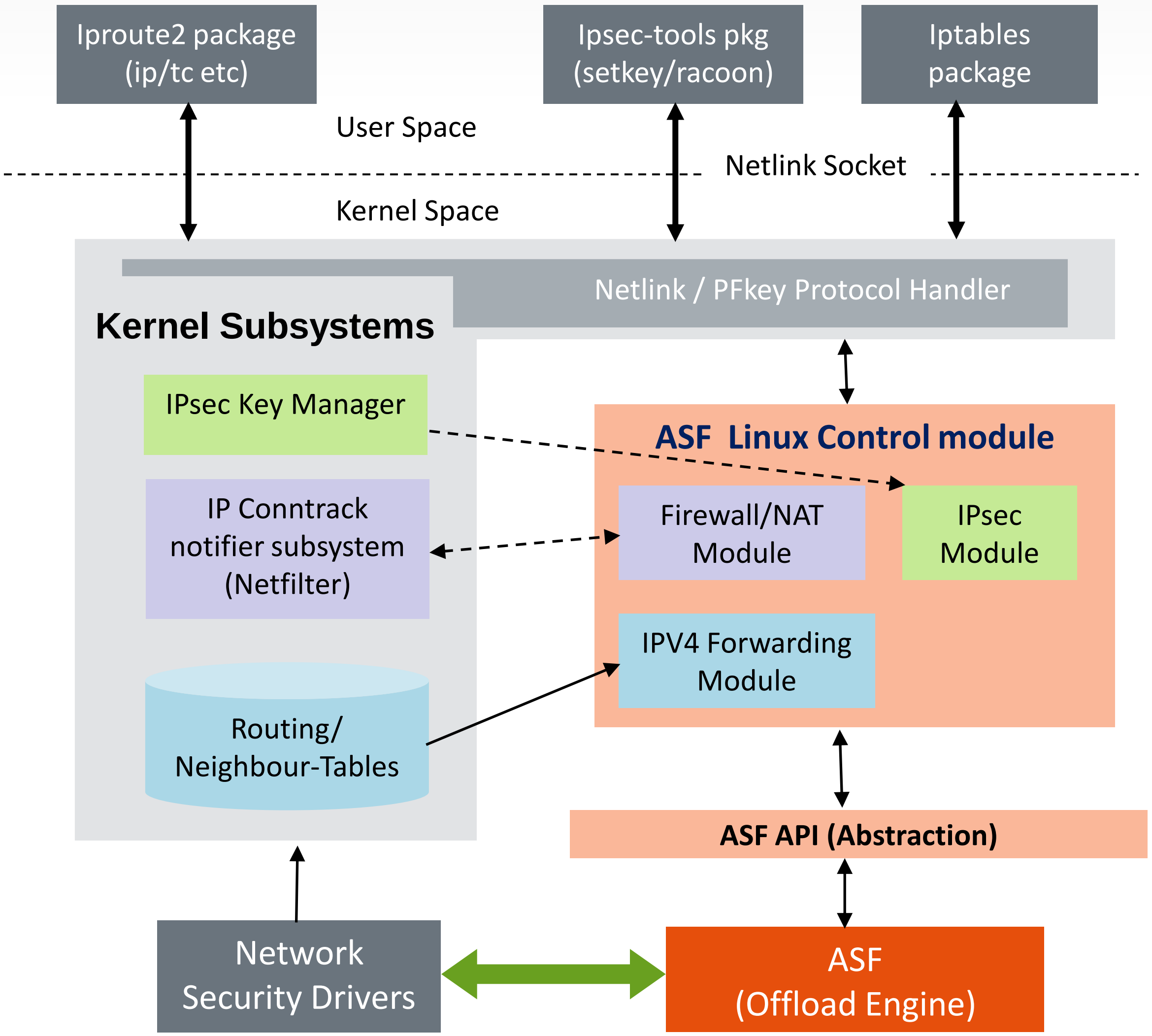
ASF Control Linux Integration



- Seamless Integration with Linux Network stack
- Standard Linux tools for configuration
- Uses existing notification mechanisms
- Control module adds logic for offload
- ASF-API abstracts actual fast-path implementation

⟷ Data Path

→ Control Path

- - - - - - -▶ Async Events

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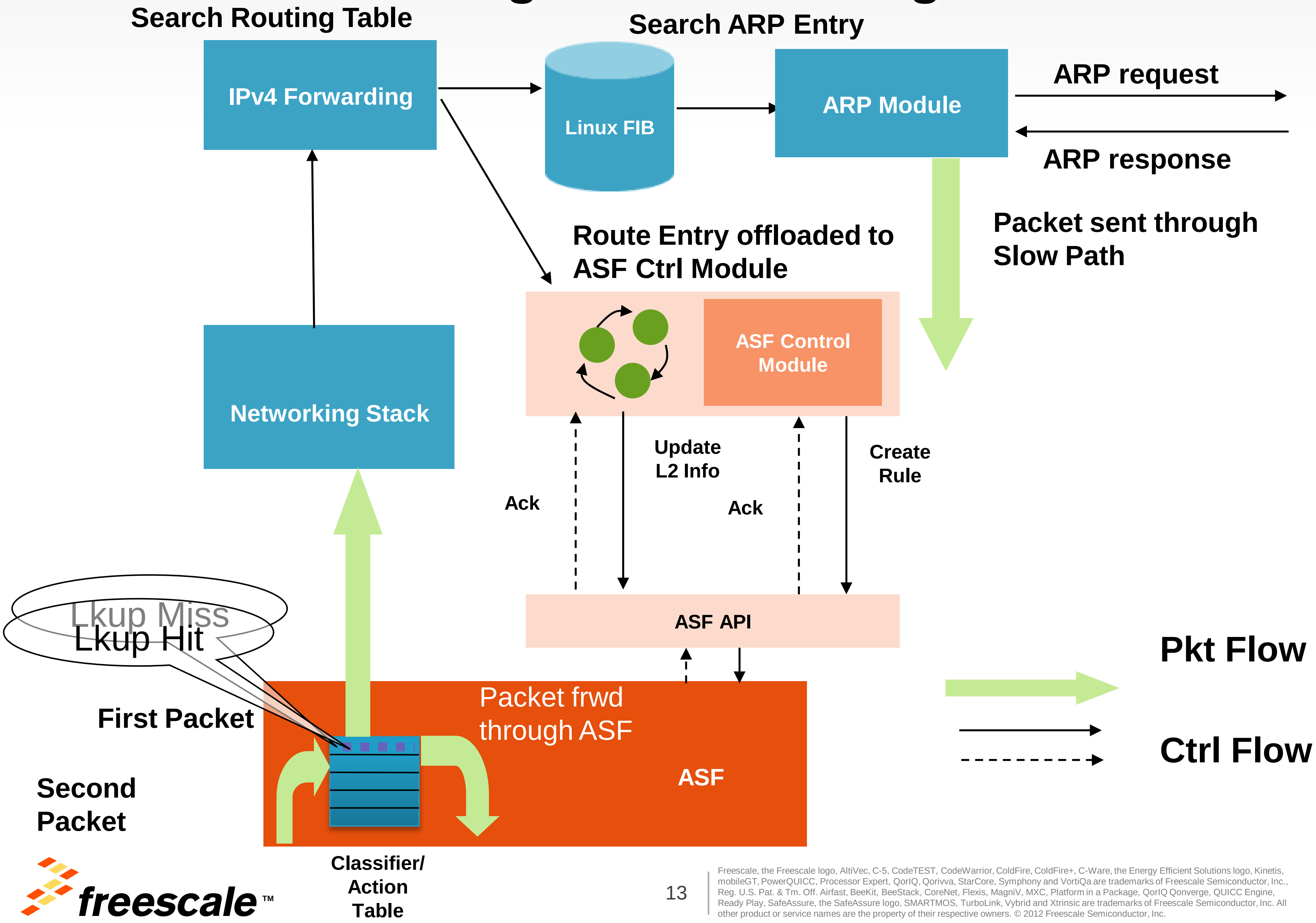
ASF IPv4 Forwarding Flow Offloading



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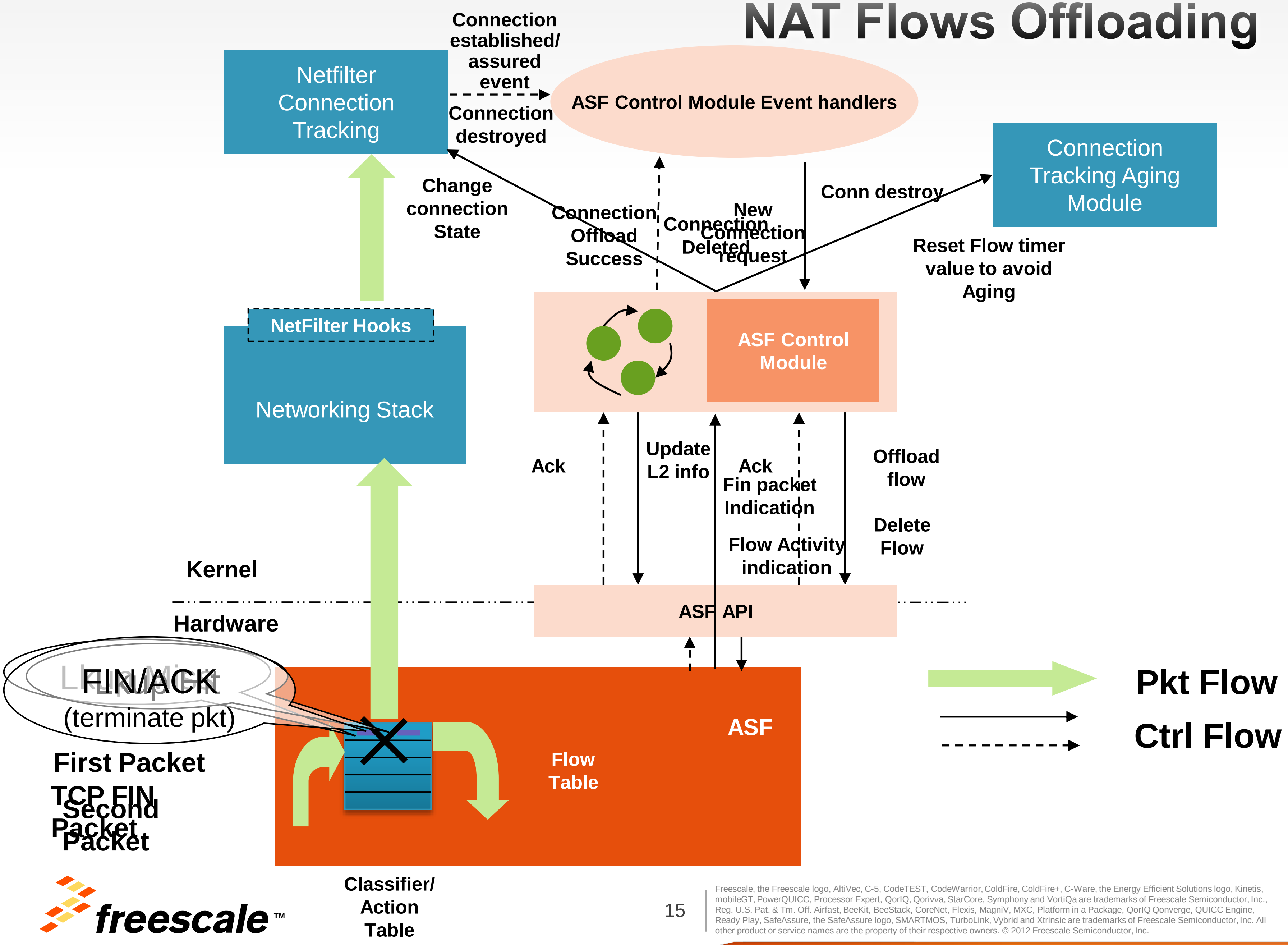
NAT Flows Offloading



Netfilter Connection Tracking

Connection established/ assured event

ASF Control Module Event handlers

Connection destroyed

Connection Tracking Aging Module

Change connection State

Connection Offload Success

Connection Deleted

New Connection request

Conn destroy

Reset Flow timer value to avoid Aging

NetFilter Hooks

Networking Stack

ASF Control Module

Ack

Update L2 info

Ack

Fin packet Indication

Flow Activity indication

Offload flow

Delete Flow

Kernel

Hardware

ASF API

LkupMiss

FIN/ACK

(terminate pkt)

First Packet

TCP FIN Packet

Second Packet

Flow Table

ASF

Classifier/ Action Table

Pkt Flow

Ctrl Flow

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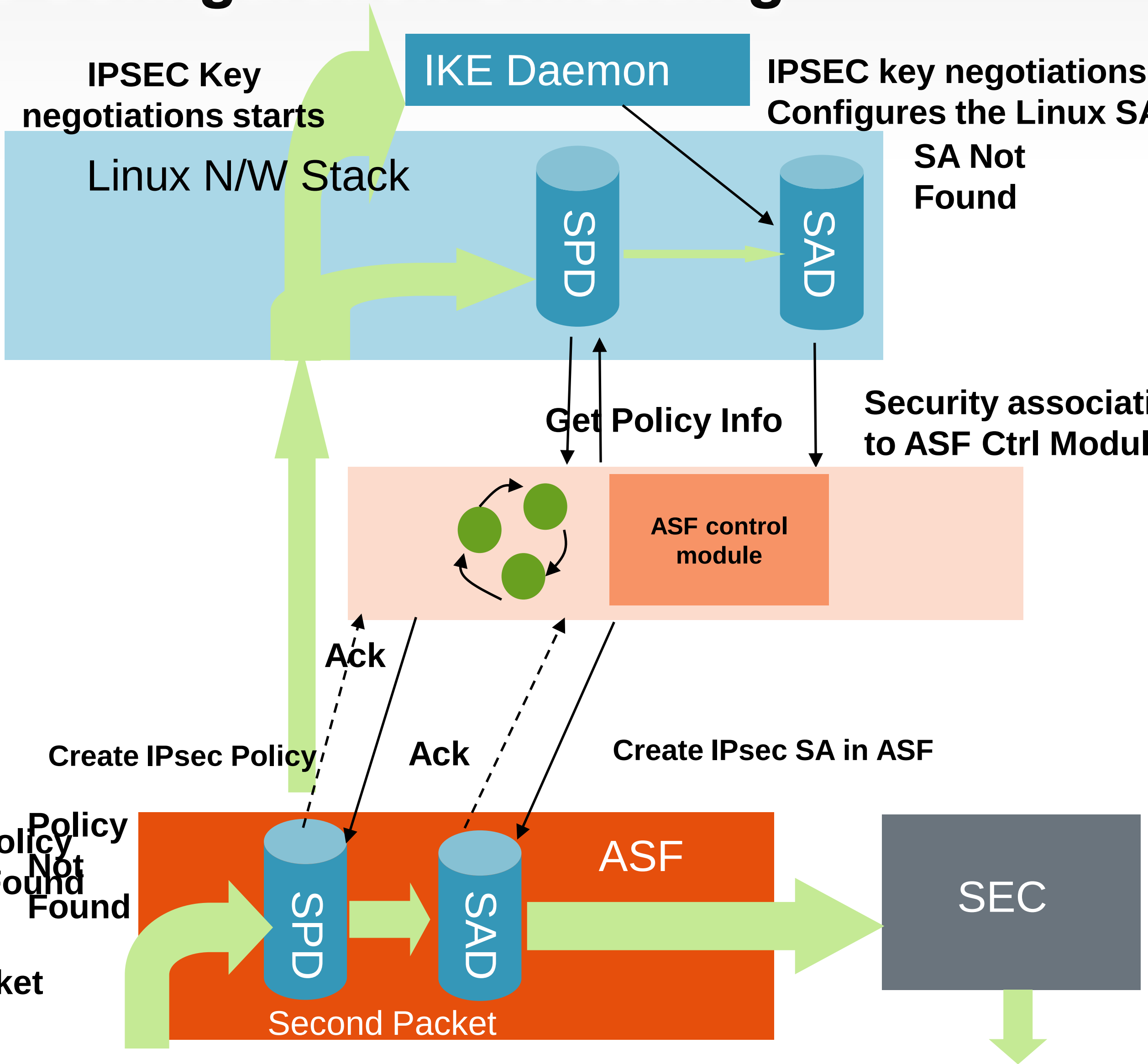
IPSec Configuration Offloading



IPSEC Key negotiations starts

IKE Daemon

IPSEC key negotiations completes
Configures the Linux SAD

Linux N/W Stack

SPD

SAD

SA Not Found

Get Policy Info

Security association offloaded to ASF Ctrl Module

ASF control module

Ack

Create IPsec Policy

Ack

Create IPsec SA in ASF

Second Packet Forwarded through ASF

Policy Not Found

Policy Not Found

ASF

SPD

SAD

SEC

First Packet

Second Packet

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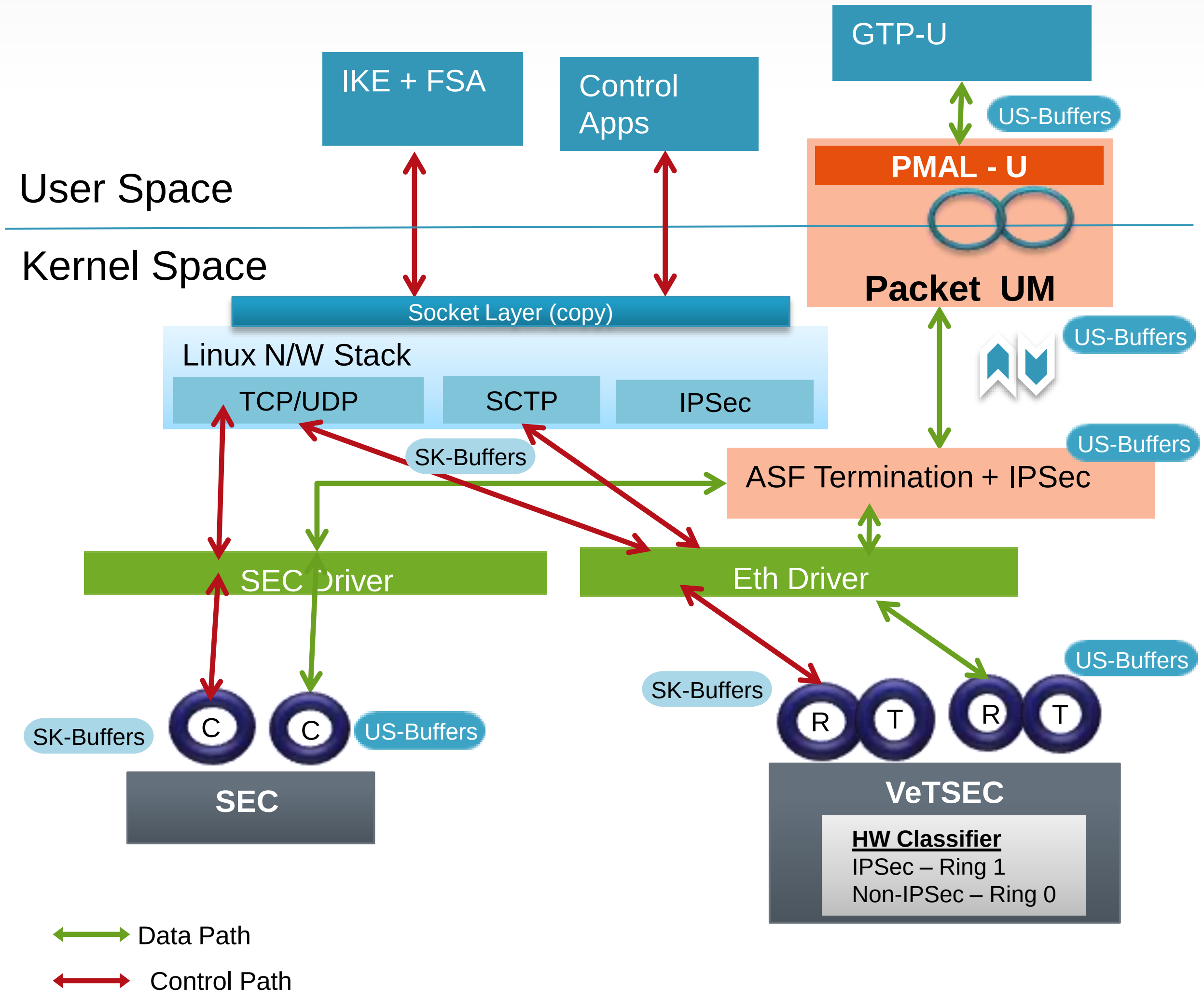
ASF Local UDP Termination – with IPSEC



- Zero-copy packet termination to user-space.
- Standard sockets with Packet-UM options.
- Multiple applications & flows using 5-tuple.
- All features of ASF Firewall, IPSec, QoS.
- Uses multiple BD-rings & classification in hardware.

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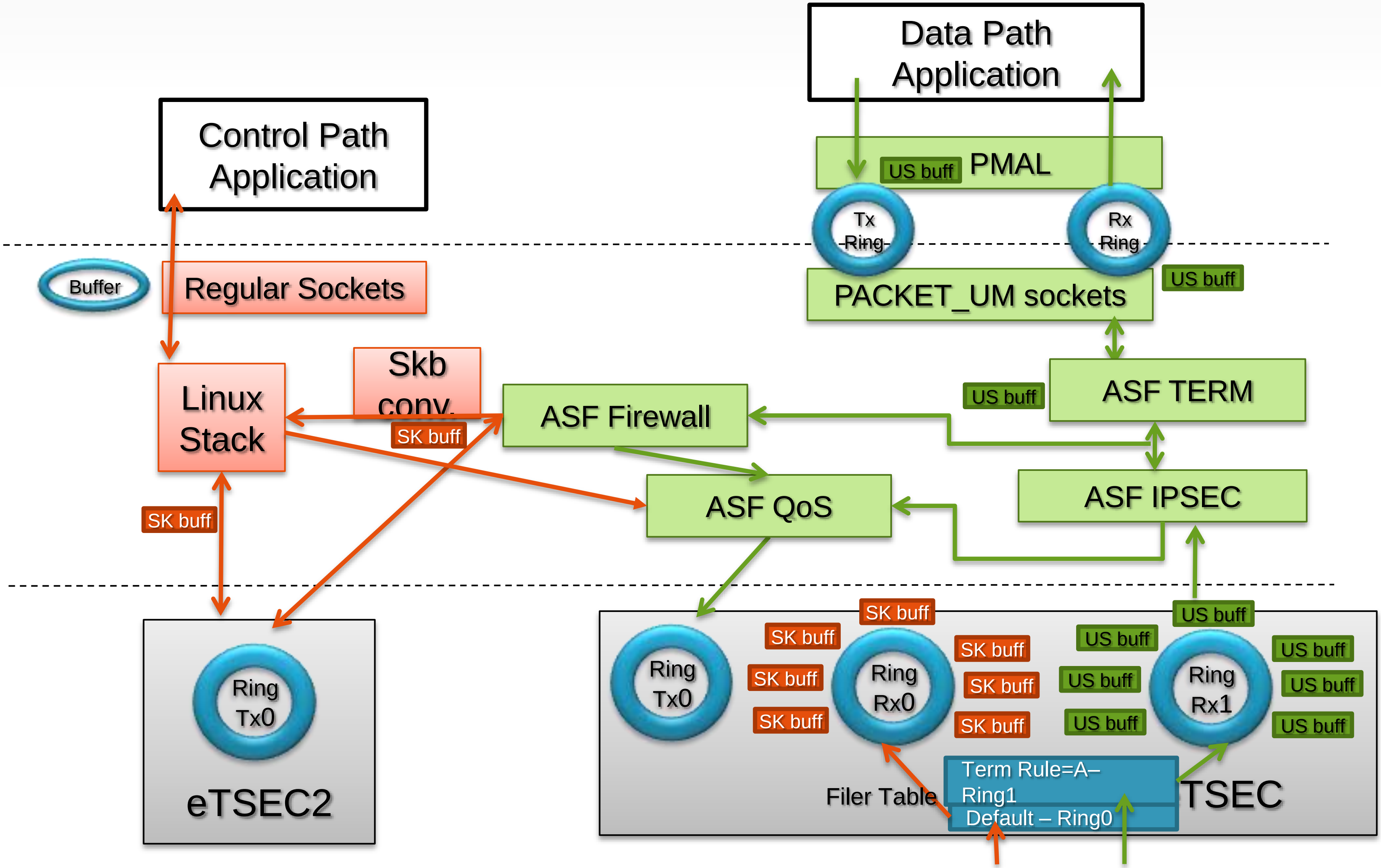
ASF QoS support



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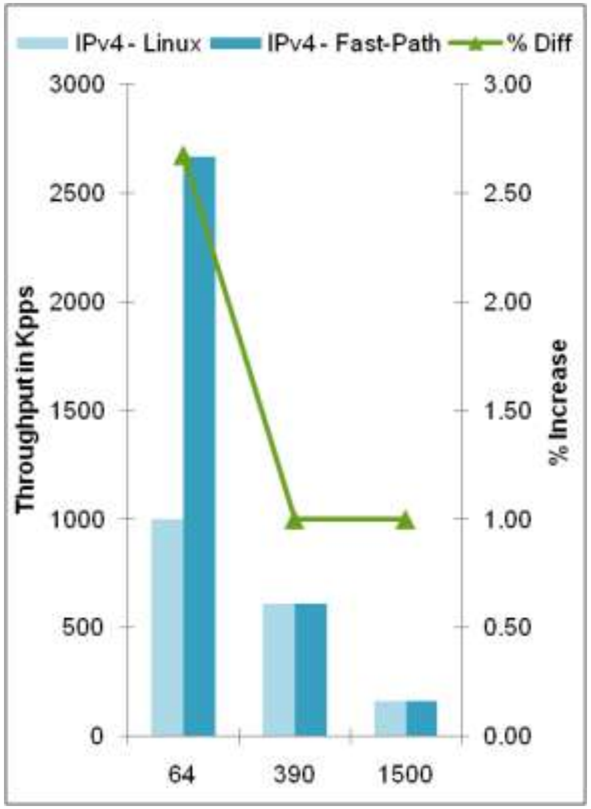
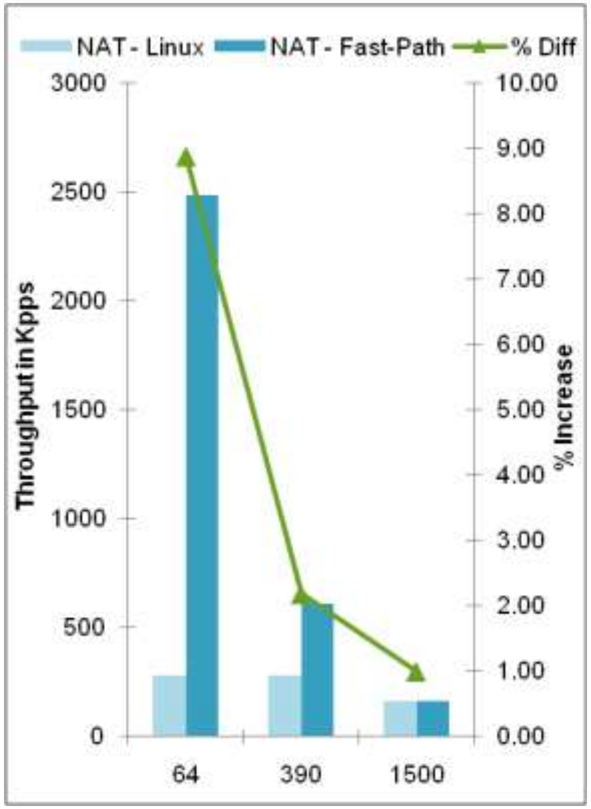
ASF Performance Advantage

- Results on P2020 RDB - 1200/600/400 : 2-core SMP Linux



IPv4



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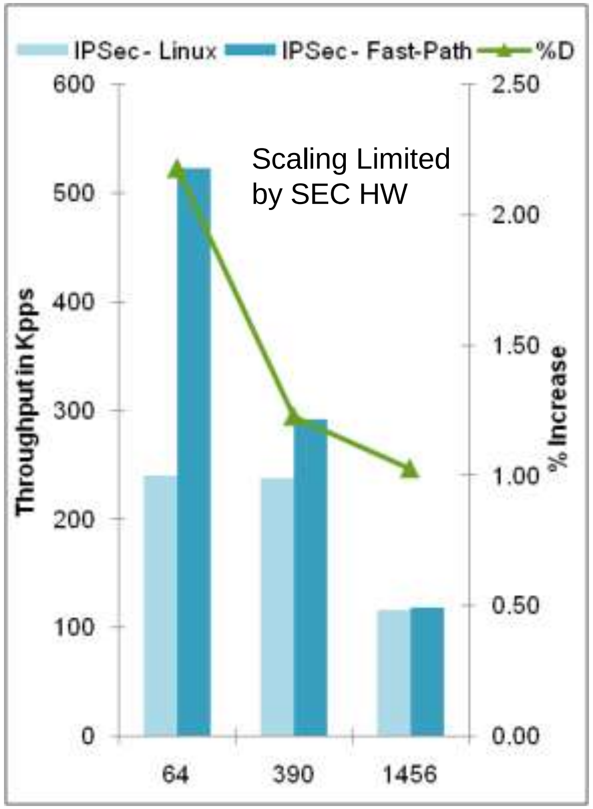

Scaling Limited by SEC HW

IPSec

Significant (2x to 8x) performance improvement over native Linux

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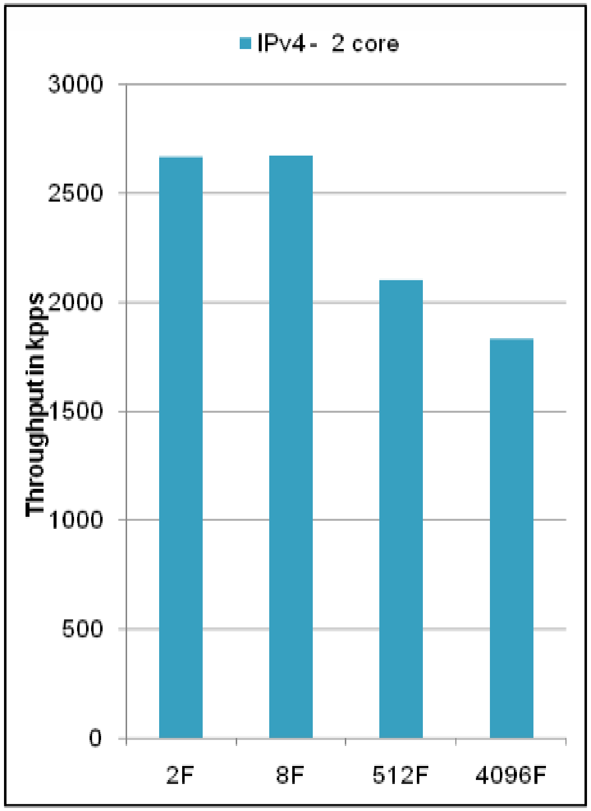
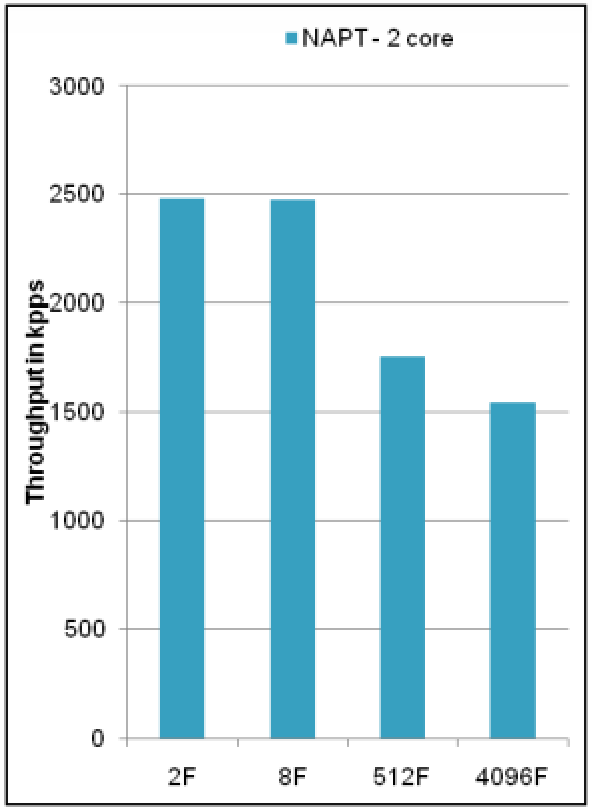
ASF Flow Scaling

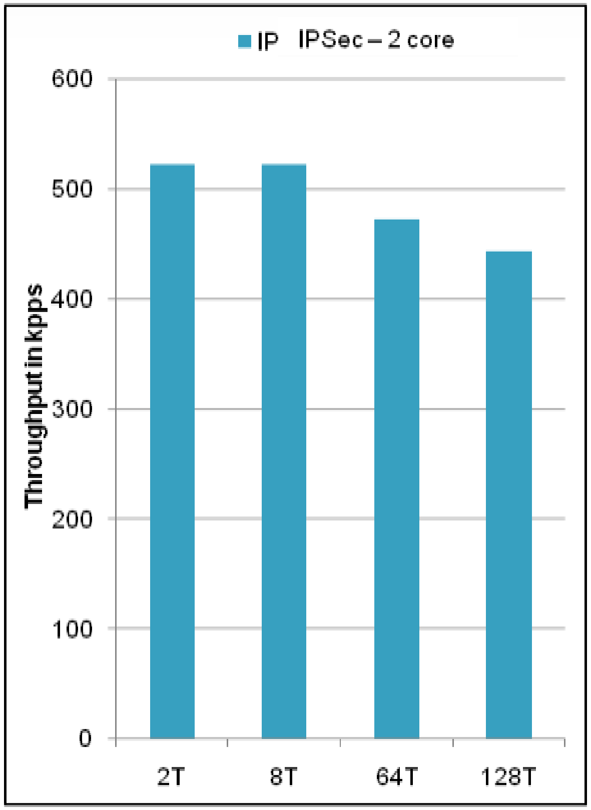
- Results on P2020 RDB - 1200/600/400 : 2-core SMP Linux – 64 byte traffic



IPv4



NAPT



IPSec

Low performance degradation for handling multiple flows

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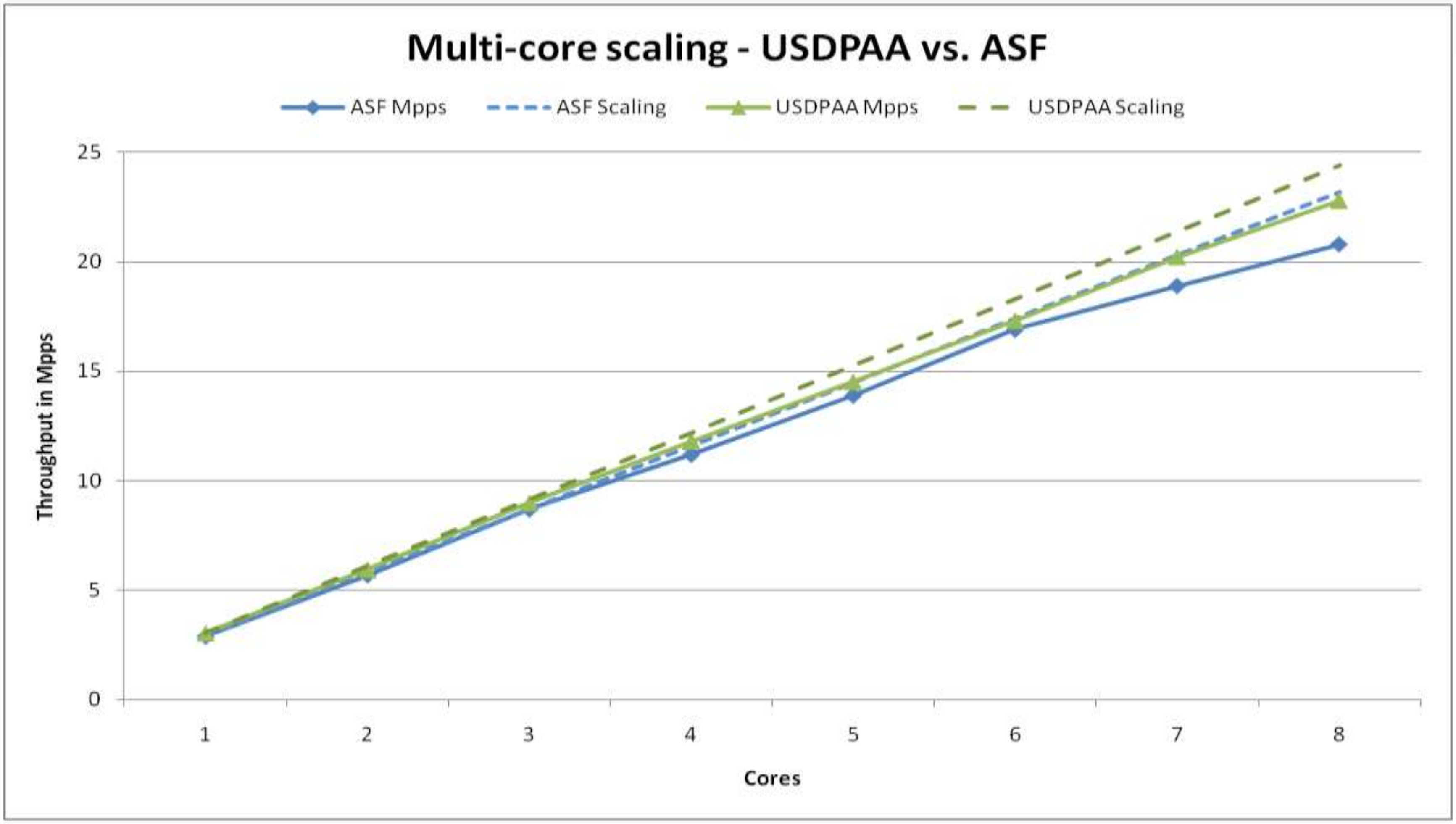
ASF Multicore Scaling



Almost linear scaling across multiple cores

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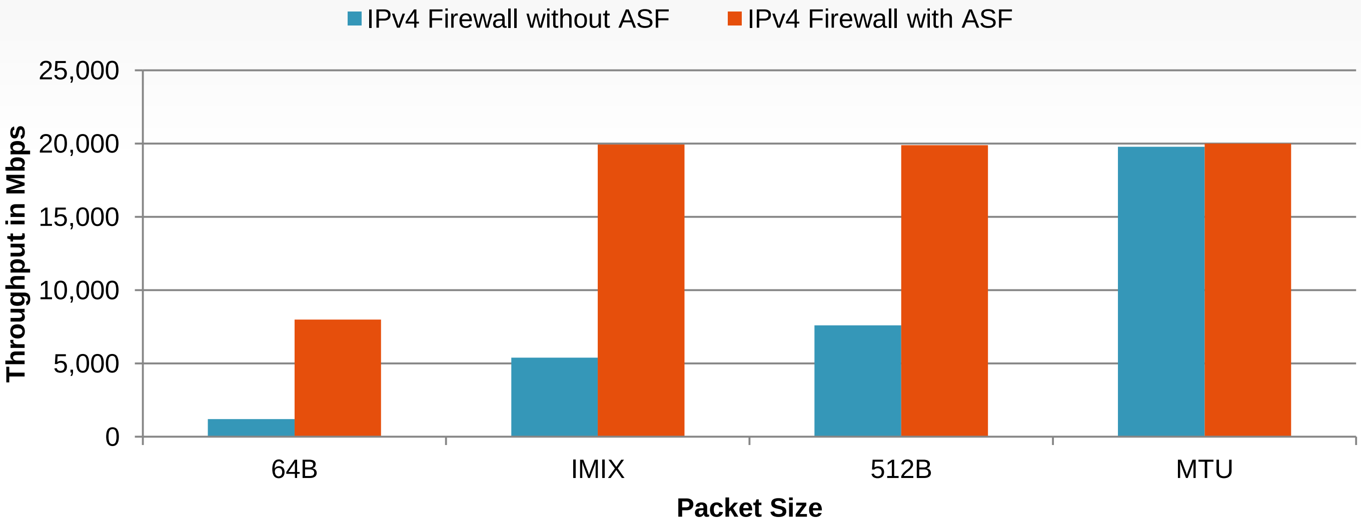
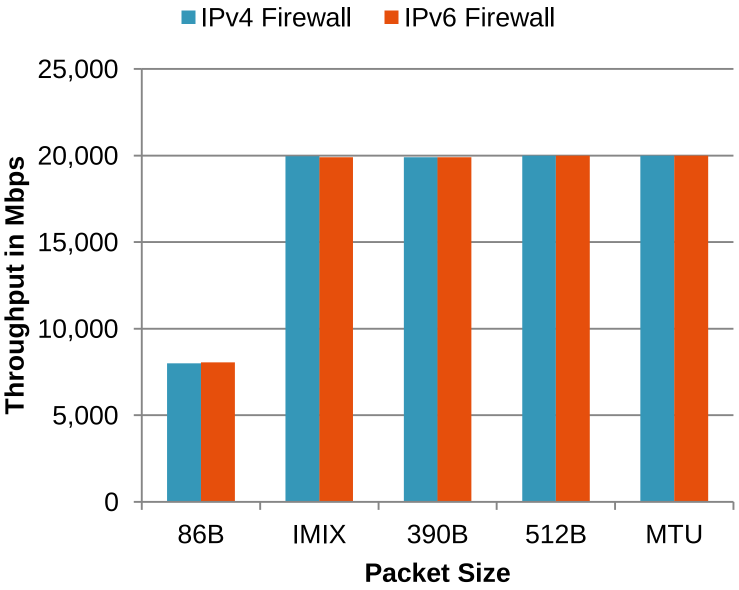
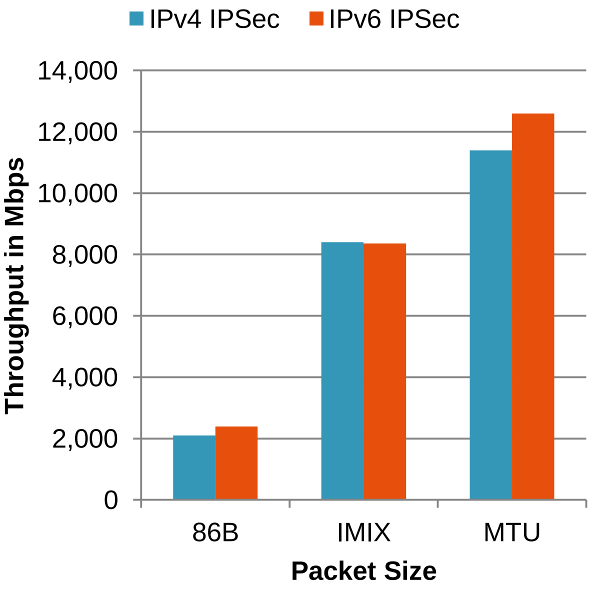
ASF with VortiQa



ASF boosts VortiQa performance by up to 7x





High Performance IPv4 & IPv6

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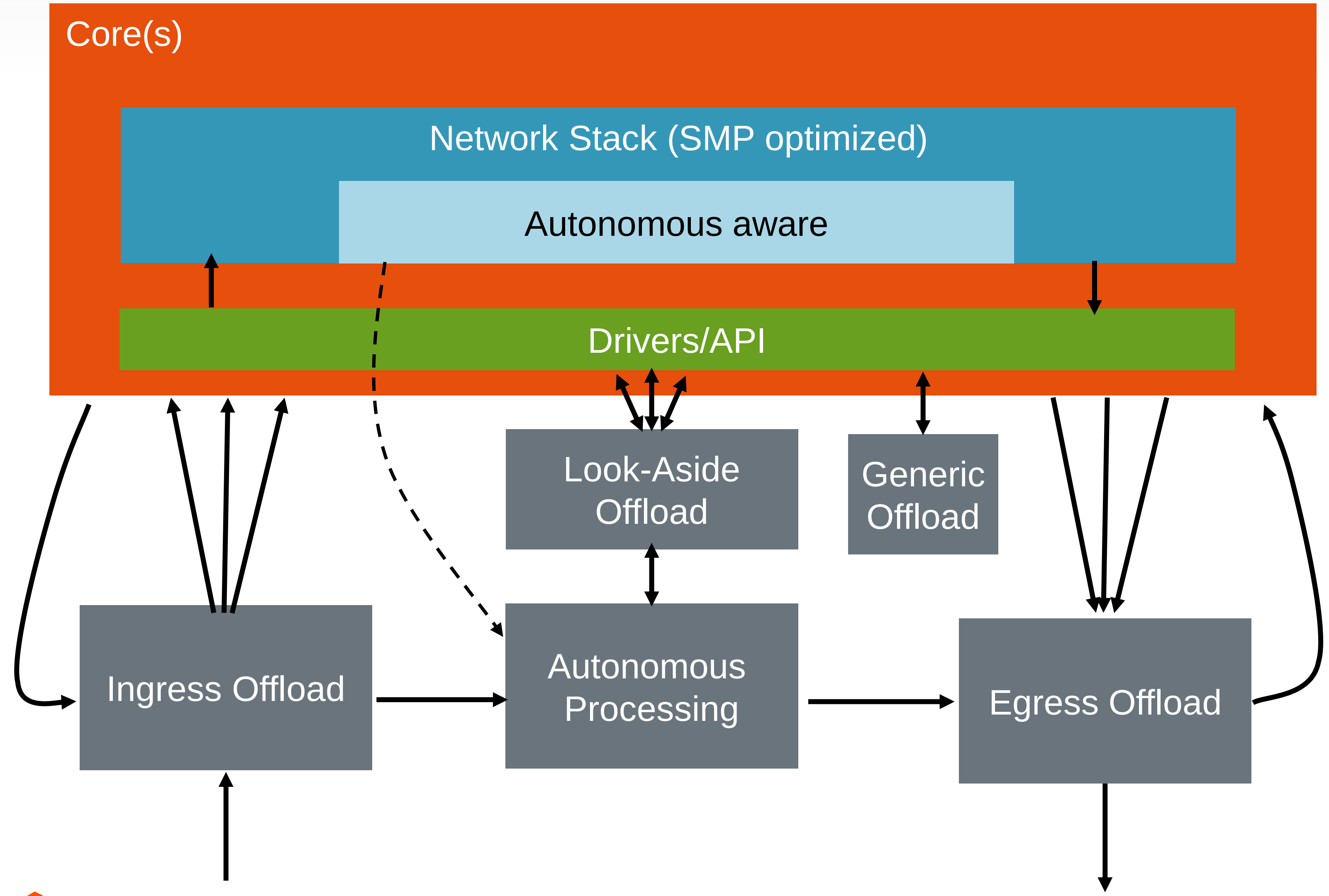
Data Path Hardware Acceleration



Core(s)

Network Stack (SMP optimized)

Autonomous aware

Drivers/API

Look-Aside Offload

Generic Offload

Ingress Offload

Autonomous Processing

Egress Offload

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Leveraging Hardware Acceleration in ASF

Offload	Feature	Advantage
Ingress	Hash calculation	Packet distribution to multiple cores, flow-pinning, table lookup
	Coarse classification	Offload stateless ACL processing
	Packet parsing	Avoid software overhead
Generic	Hardware buffer management	No buffer alloc/free operations in software
	Hardware queue management	Simpler packet Rx/Tx, efficient stashing (to L1/L2), leaves room in cache for other data
Egress	Hardware QoS	Avoid software overhead, mitigate DoS attacks, prioritize CPU cycles
Core	Backside L2 cache	Faster access for multiple flow tables
Look-Aside	Protocol-aware cryptography	Offload protocol encapsulation/decapsulation, sequence tracking etc.

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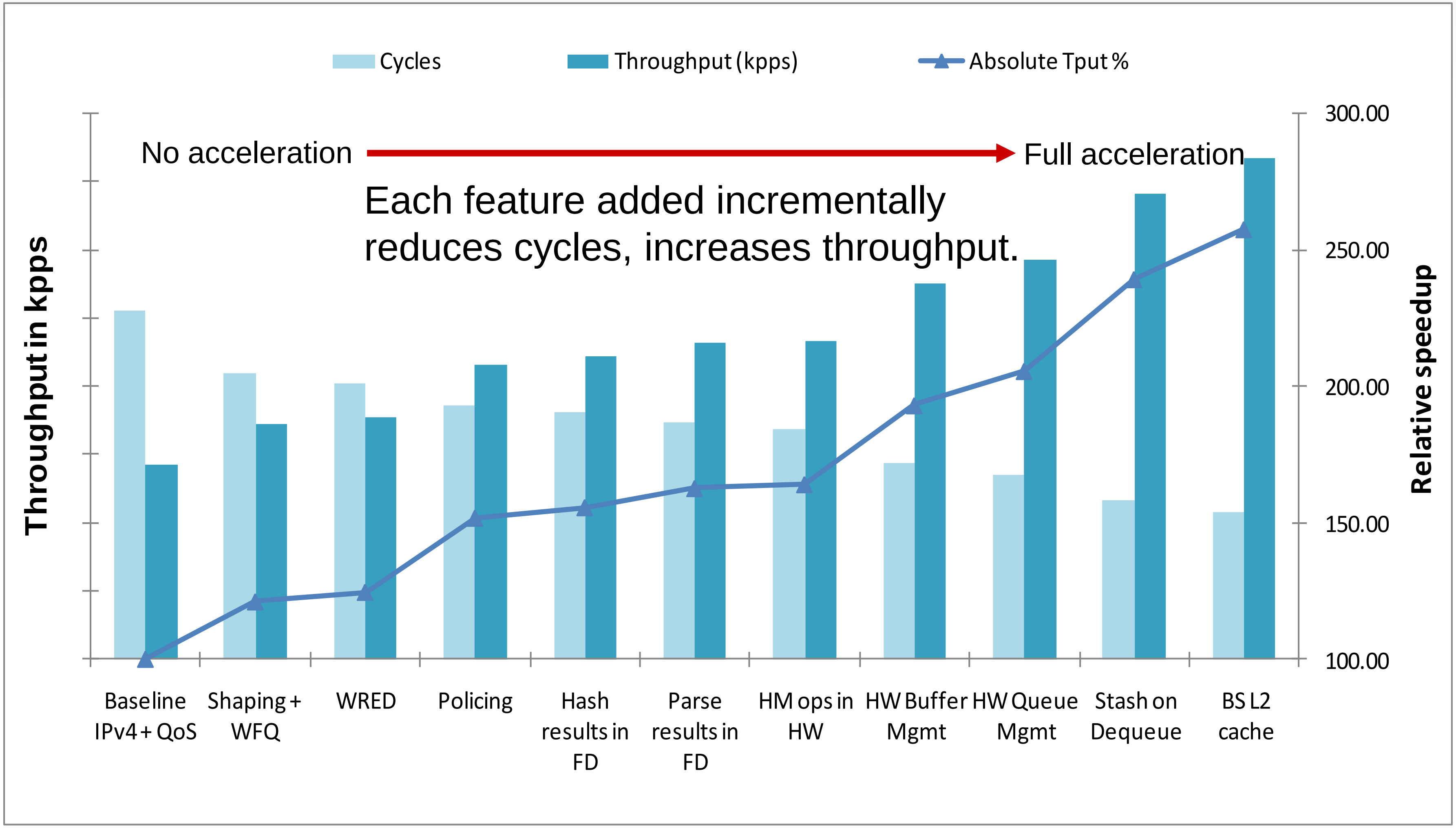
Hardware Acceleration Advantage



No acceleration → Full acceleration

Each feature added incrementally reduces cycles, increases throughput.

Hardware Acceleration provides up to 2x- 3x improvement

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Summary and Q&A

- **ASF – Application Specific Fast-Path**
  - Optimized packet processing path
  - Consistent interface across platforms
  - Easy integration with network stacks
  - Single solution across QorIQ & Qonverge platforms

- **Performance Advantage**
  - Flexibility to leverage hardware acceleration
  - Optimized for Multicore scaling

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