OpenFlow and beyond on the Cisco Catalyst 9000

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Agenda

- Catalyst 9K OpenFlow
- OpenFlow pipeline abstraction
- TFM and flexible pipelines
- Beyond OpenFlow: hybrid behavior
  - LLDP and PoE
  - MacSec and MKA

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Catalyst 9K OpenFlow

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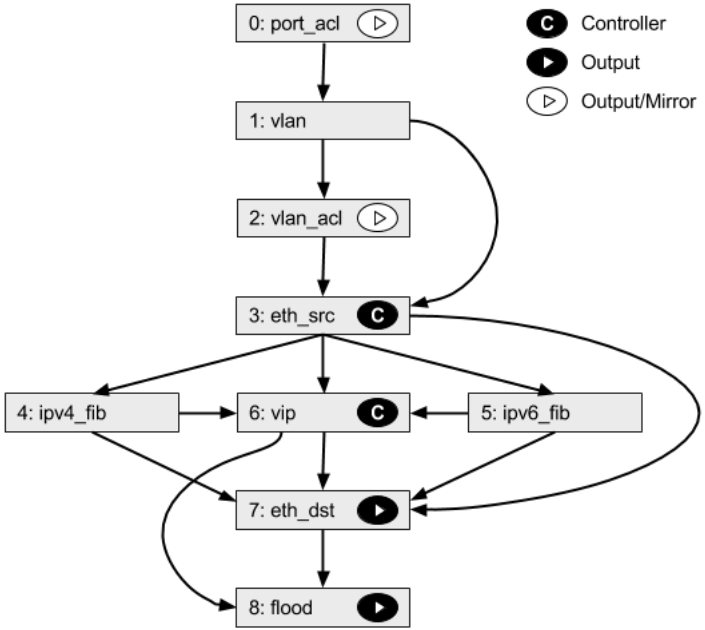
Cisco Catalyst 9000 enables Faucet OpenFlow

Built for Programmability



Programmability

OpenConfig, GNMI, GNOI

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Catalyst 9K OpenFlow in the wild

- General availability since IOS-XE 16.9.1 (August 2018)
  - Major release 3 times a year
- 4000+ fixed and modular switches deployed in enterprise at 40+ locations worldwide
  - Faucet and proprietary controllers
- Hybrid features like LLDP for PoE utilized in production
- Active feature development in coordination with customers

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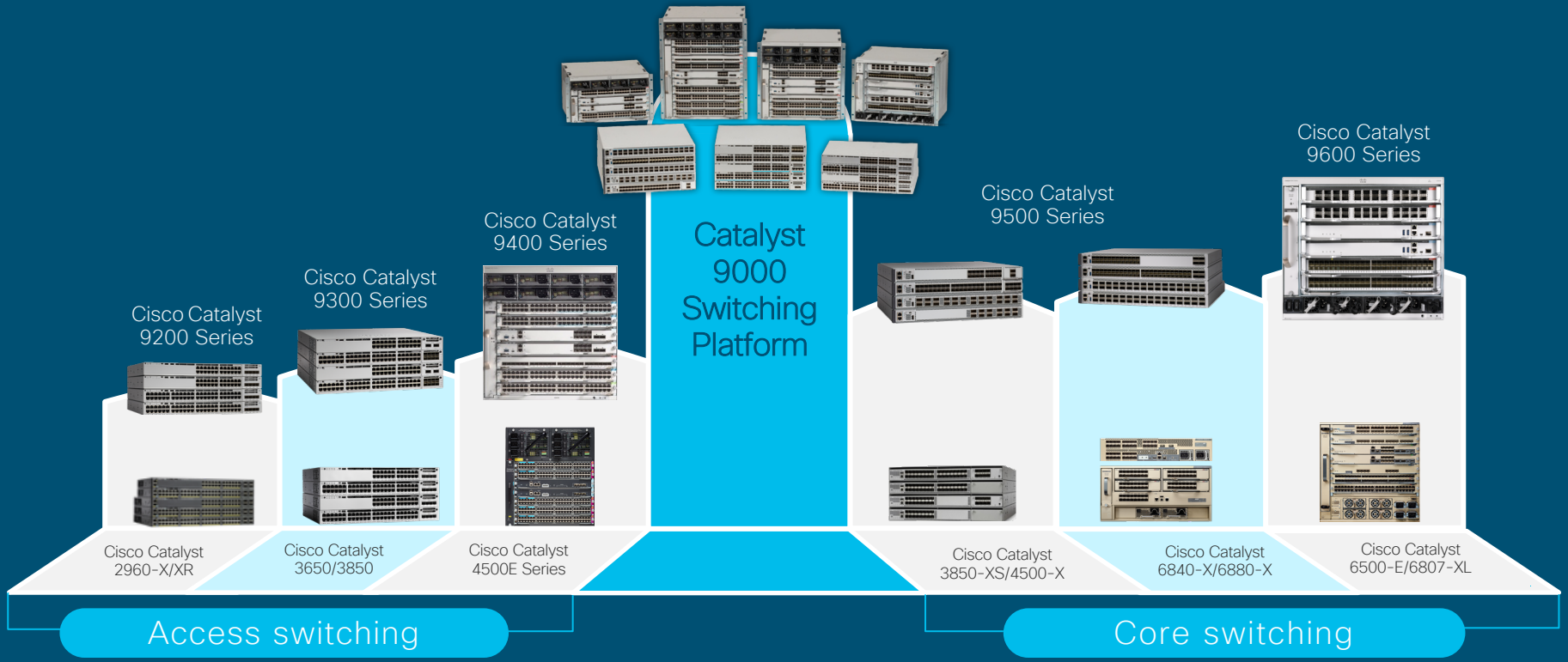
Cisco Switching Portfolio



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Catalyst 9K OpenFlow Summary

- Powered by UADP
  - Programmable pipeline
  - Flexible match and actions
- Faucet and TFM compatible
- Software enhancements for features and scale

Platform	Type	Number of Tables	Number of Priority Levels	Number of Flows
9300	Fixed access, copper	16	128	9K
9400	Modular access, copper	16	128	27K
9500	Fixed agg/core, optical	16	128	27K
9500H	Fixed agg/core, optical, high performance	16	128	27K

UADP 3.0

~20B transistors

16-nm technology

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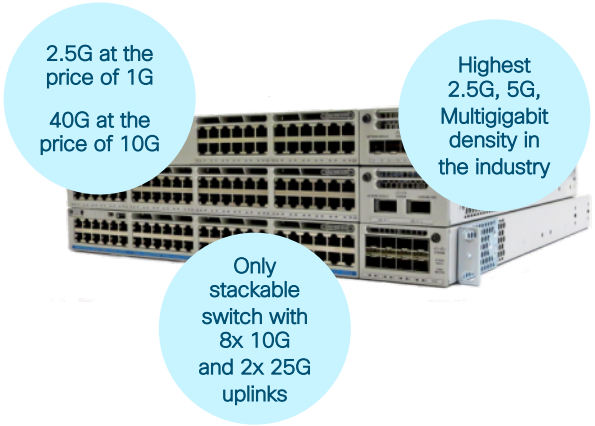
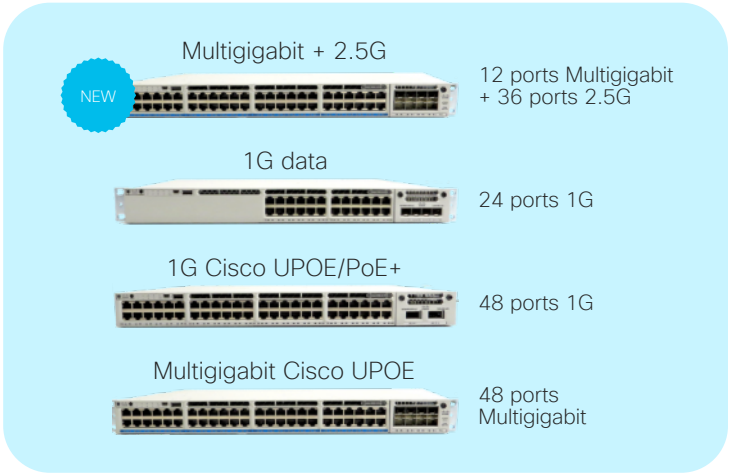
Cisco Catalyst 9300 Series

New generation of fixed access





Cisco Catalyst 9000 leadership
UADP 2.0
Cisco IOS® XE Software
SD-Access
x86 CPU and containers
Encrypted Traffic Analytics (ETA)*
AES-256/MACsec-256
Trustworthy systems
Cisco StackWise® Virtual
IEEE1588 and AVB
NBAR2
Perpetual/Fast PoE
Model-driven programmability
Patching/GIR
Streaming telemetry

Modular fans | Modular uplinks | Higher-efficiency AC and DC power supplies

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* Roadmap

Cisco Catalyst 9400 Series

New generation of modular access

4-Slot* 7-Slot 10-Slot

Supervisor
- Sup-1: 80G per slot access optimized
- Sup-1XL*: 120G per slot core optimized

Access line cards
- 24x Multigigabit + 24x Cisco UPOE®
- 48x Cisco UPOE
- 48x PoE+, 48x data

Core line cards
- 24x 10G SFP+
- 48x 1G SFP
- 24x 1G SFP

Power supply
- 3200W AC
- 3200W DC*
- 2100W AC

Cisco® Catalyst® 9000 leadership
UADP 2.0
Open Cisco IOS® XE
SD-Access
x86 CPU and containers
Encrypted Traffic Analytics*
256-bit MACsec*
Trustworthy systems
Cisco StackWise® Virtual*
IEEE1588 and AVB*
NBAR2
Model-driven programmability
Patching and GIR
Streaming telemetry

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* Roadmap

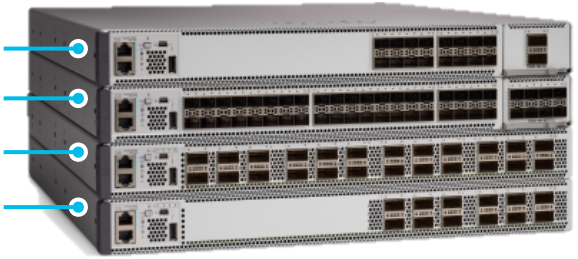
Cisco Catalyst 9500 Series

New generation of purpose-built fixed core/aggregation

UADP 2.0

- 40G at the price of 10G
- Industry's first 40G enterprise switch
- Optimized 10G switch for midsize backbone

Cisco Catalyst 9500-16X
Cisco Catalyst 9500-40X
Cisco Catalyst 9500-24Q
Cisco Catalyst 9500-12Q



UADP 3.0

- 1TB SSD storage
- Industry's first 100G enterprise switch
- 8x buffering vs. the competition

Cisco Catalyst 9500-24Y4C
Cisco Catalyst 9500-48Y4C
Cisco Catalyst 9500-32QC
Cisco Catalyst 9500-32C

Modular fans

Modular uplinks

Modular power supplies

Storage for application hosting

Extending Cisco® Catalyst® 4000 and 6000 Series leadership in fixed core
13x throughput (3.2 Tbps)
6x performance (1 Bpps)
No oversubscription
8x 40G density
Pluggable SSD storage
USB 3.0
4x memory and flash
2x CPU cores
Customizable templates
Cisco StackWise® Virtual

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OpenFlow Table Feature Message and flexible pipelines

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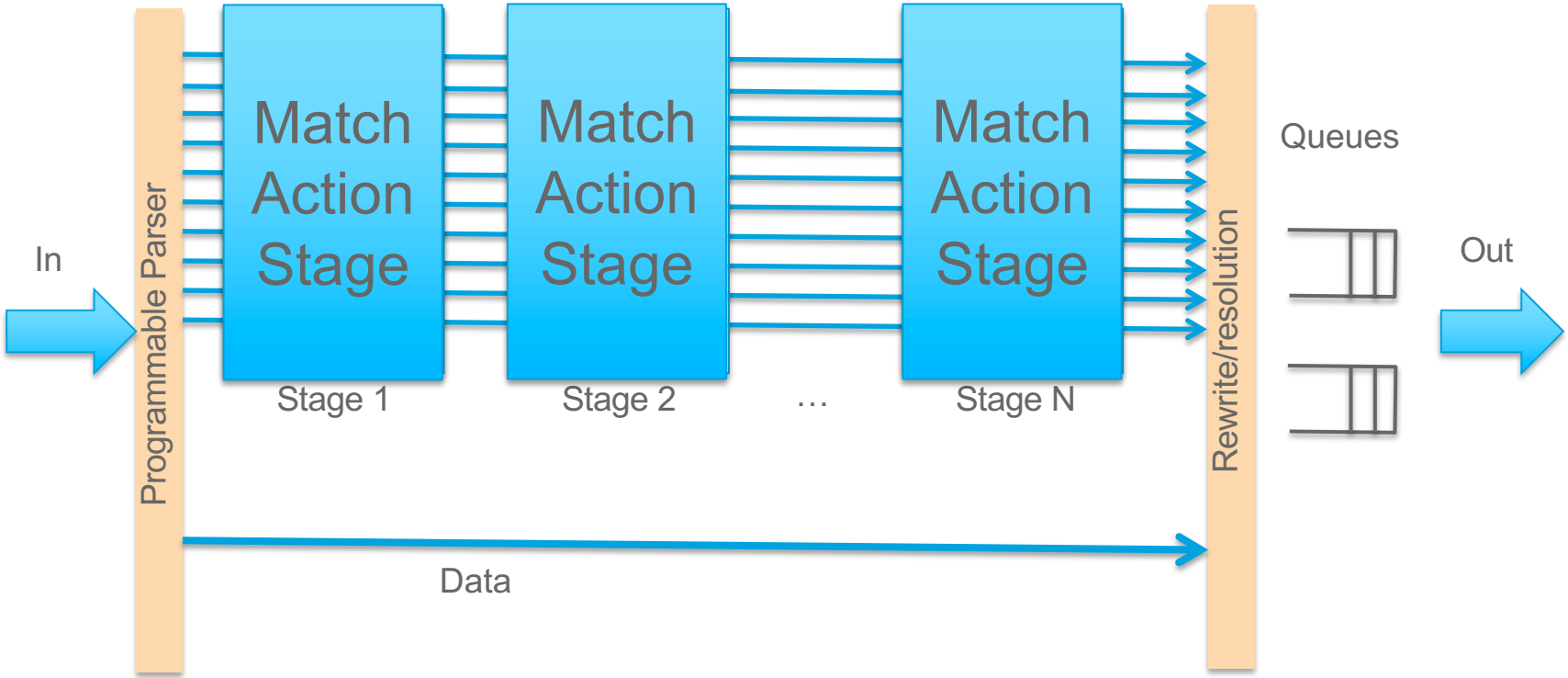
Match-Action Table Pipeline



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What’s in your pipeline?

- Fixed vs Flexible
- Number of pipeline stages
- Operations associated with pipeline stages

With a sufficient number of recirculations, a fixed pipeline could emulate a flexible pipeline

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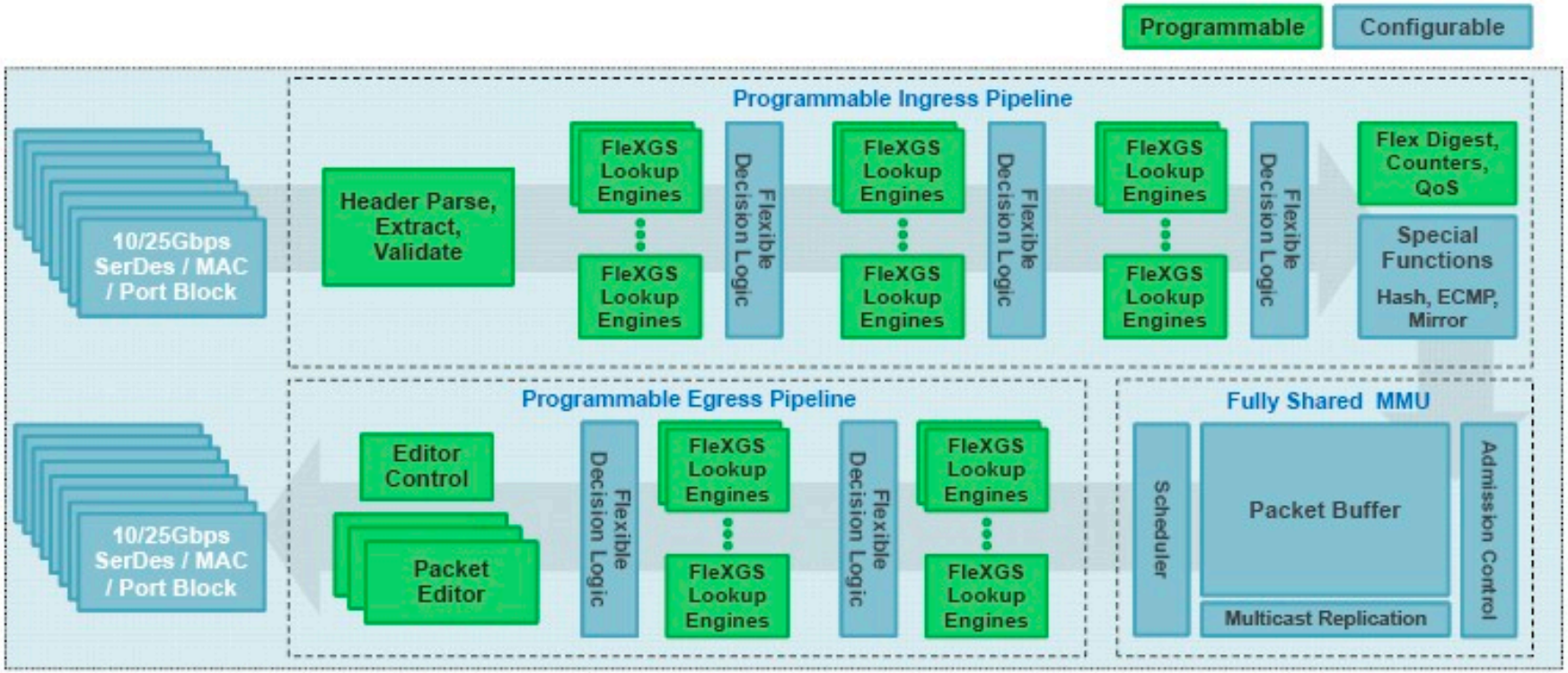
Broadcom Trident 3 pipeline



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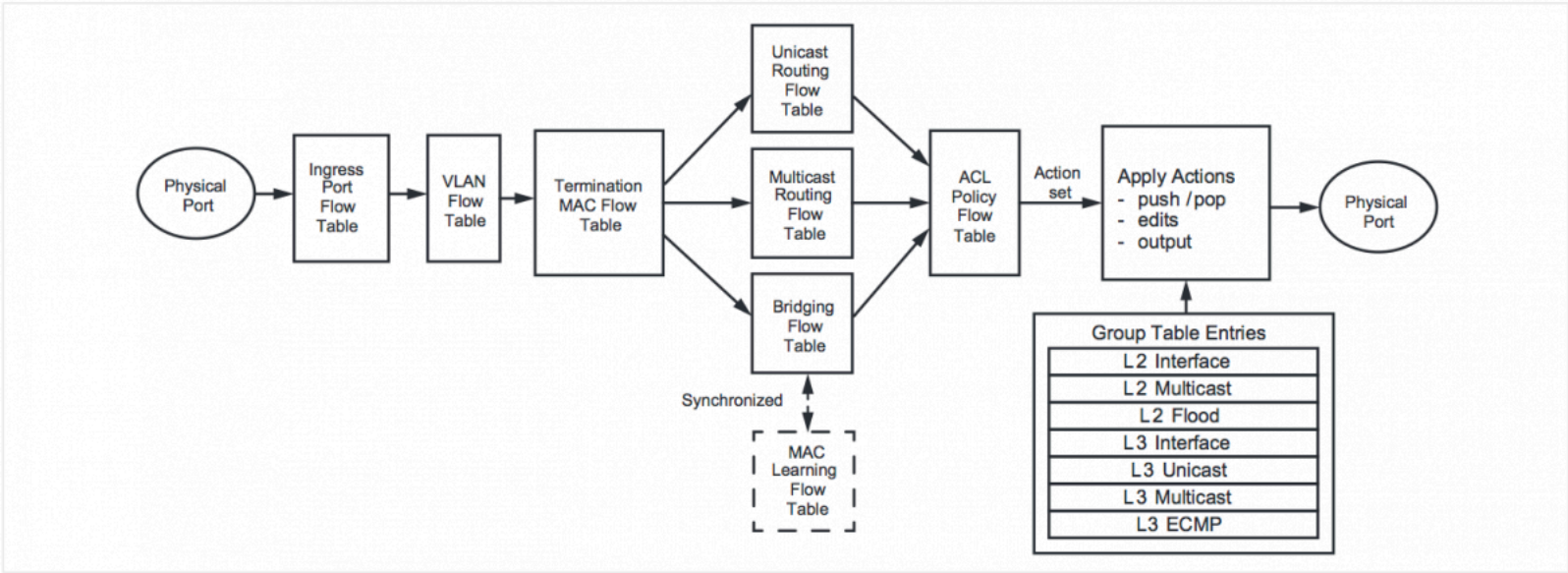
Broadcom abstract switch for OF-DPA



Abstract Switch Pipeline for Bridging and Routing

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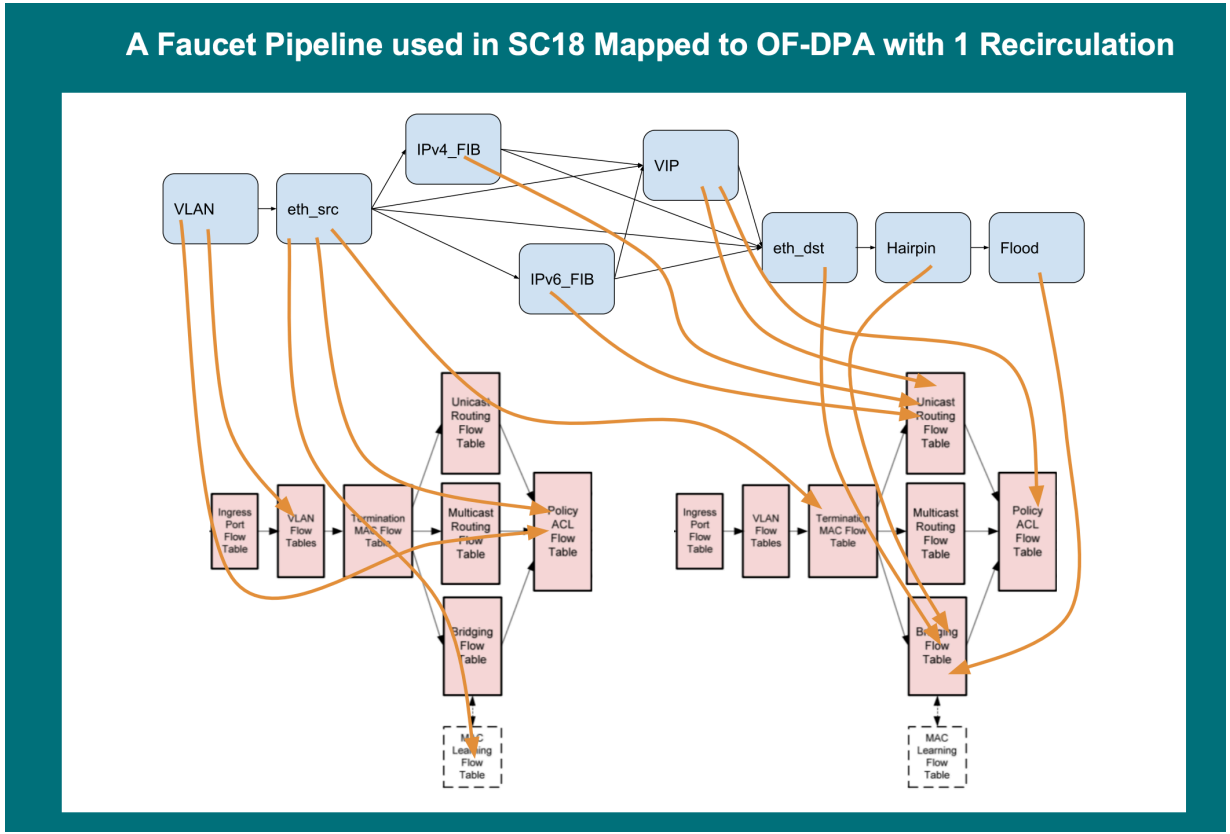
Example of Faucet with OF-DPA

Chris Lorier: https://wand.net.nz/~cml16/poster.pdf



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OpenFlow Table Feature Message

- Basic parameters
  - Number of tables
  - Table size
- Table parameters
  - Match fields
    - Exact, wildcard, maskable
  - Actions
    - Apply actions
    - Forwarding – output, drop, punt
    - GoTo table

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Outline of TFM algorithms

- Assign OpenFlow table to pipeline stage
  - Get next pipeline stage that matches the table's capabilities
    - Size, type of memory, matches and actions
  - If last pipeline stage, next pipeline stage is after recirculation
  - Some apply actions may force a recirculation

- Flow programming (add, delete, update)
  - Get pipeline stage associated with table
  - Program matches and actions

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Beyond OpenFlow: Hybrid behavior

LLDP and PoE

MacSec and MKA

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Native vs Hybrid behavior

Native behavior is fully specified by the OpenFlow pipeline and data plane

Hybrid behavior requires switch capabilities beyond what is specified by OpenFlow

OpenFlow can redirect packets to the switch CPU with “action=output:LOCAL”

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LLDP MED and Power over Ethernet

Media Endpoint Discovery extension of LLDP

- Auto-discovery of LAN policies
- Device location discovery
- Inventory management
- Extended and automated power management of *Power over Ethernet* (PoE) end points
  - How does the controller manage power levels of end-points?
  - Is it better for the switch to do this?

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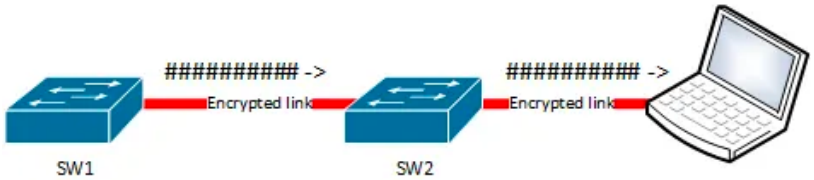
MacSec Key Agreement (MKA) – 802.1AE



- Key negotiation
- Rekeying
- EAPOL BPDUs

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What’s next?

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Future directions – devices and controllers

New features and capabilities must be driven by deployment needs and Faucet requirements

- Network architecture and solutions
  - Multipath - L2 and L3
  - Segmentation
  - Identity
  - Policy

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Q & A

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