atmosphere'23
BELGIUM

CX Switching Application Recognition and Control

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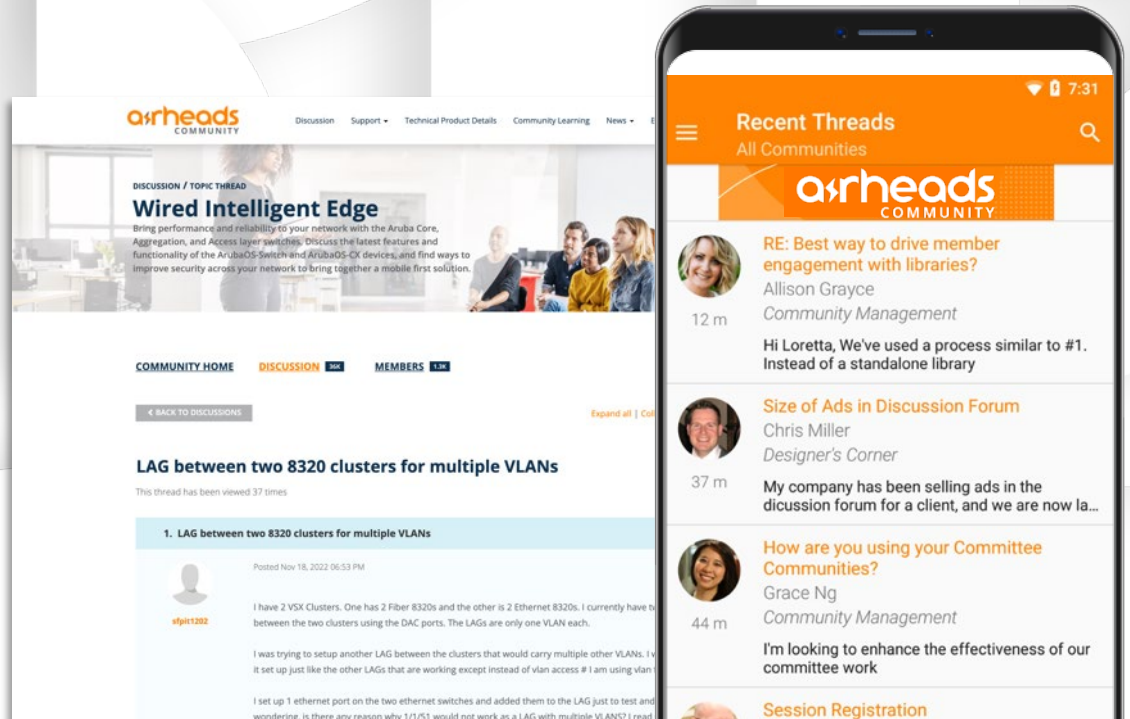
HPE aruba networking



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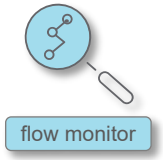
Agenda

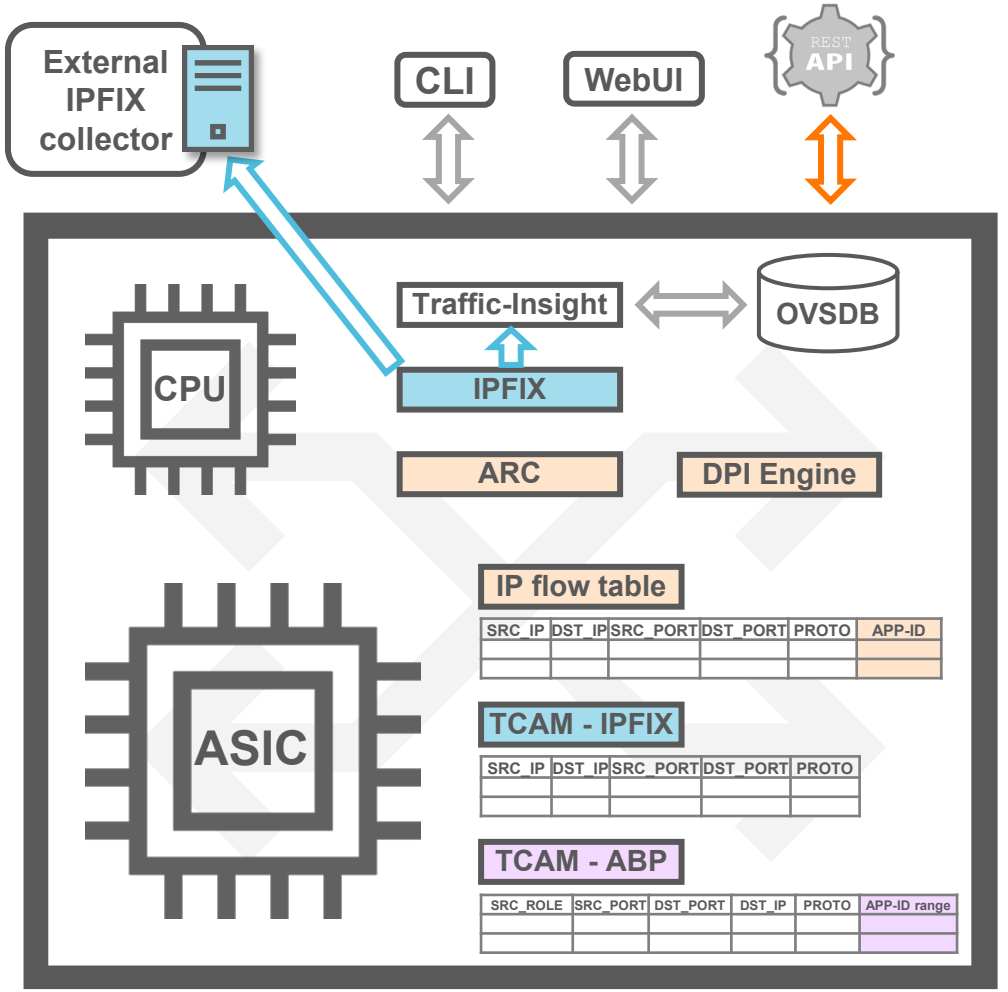
1. Aruba CX Edge Insights Overview
2. Application Recognition
3. IPFIX
4. Traffic Insight
5. Application-Based Policy

Aruba CX Edge Insights Overview

Aruba CX Edge Insights

- **Application Recognition**
  - Application identification with DPI engine
  - set the app-id in the IP flow table
- **IP Flow Information Export (IPFIX)**
  - Record and export flow information
  - include the application information (when app-recognition enabled)
  - Export to external collector and/or to traffic-insight
- **Traffic-Insight**
  - Collect and aggregate IPFIX data
  - Extract and report topN talkers and app-flows
  - CLI and webUI display.
  - Flow Telemetry API
  - Client-Insight (DNS latency)
- **Application-based Policy**
  - Allow or block specific applications identified by ARC per authenticated user access role





Aruba CX Edge Insights

	Supported platforms	Application Recognition	App-based Policy	IPFIX	Traffic Insight	Results / Outcomes
1	6300/6400	●	●	●	●	**Best experience for application analytics reporting and application filtering.**
2	6300/6400	●	●	●		Application visibility report to external collector and application filtering.
3	6300/6400	●	●			Application filtering.
4	6300/6400	●				No operational outcome: troubleshooting only
5	6300/6400	●		●	●	**Best experience for application analytics reporting.**
6	6300/6400	●		●		Application visibility report to external collector.
7	6300/6400		●			Invalid use-case (app-recognition must be enabled for DPI)
8	6300/6400/8100/8360			●		**IPFIX traditional reporting to external collector** (well-known ports, no app-id)
9	6300/6400/8360			●	●	**IPFIX traditional reporting to external collector and internal analytics reports** (well-known ports, no app-id). (DNS-only TI monitor on 8360).
10	6300/6400/8360				●	No outcome as TI requires IPFIX.

- Aruba CX Edge Insights in AOS-CX 10.11 provides, with **Application Recognition + IPFIX + Traffic Insight,** the best experience for **Application Visibility** and analytics at the access layer.
- With Aruba CX Edge Insights addition in AOS-CX 10.12, **Application-Based Policy** allows to **Control Application** usage with permit/deny rules based on recognized applications.

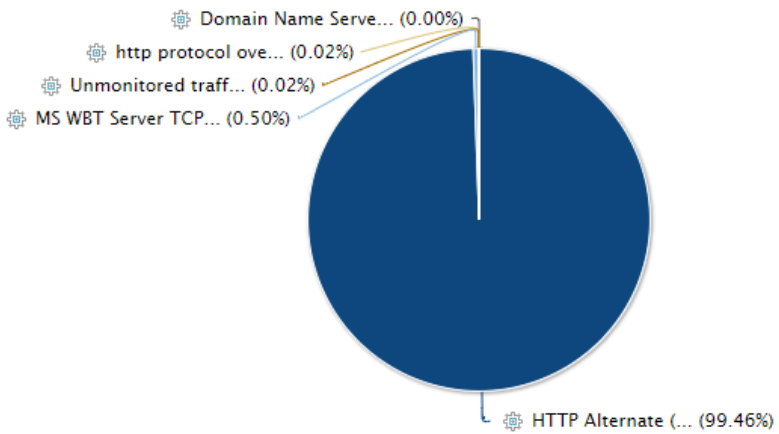
Application Recognition

Outcome for Network Admin: Application Visibility

IPFIX

Top 10 Applications
INGRESS AND EGRESS, LAST 1 HOURS

NetFlow | EDIT | HELP



APPLICATION	INGRESS BYTES	EGRESS BYTES	INGRESS PACKETS	EGRESS PACKETS	PERCENT
HTTP Alternate (see port 80) (8080)	122.7 Mbytes	0 bytes	113.52 k	0	99.46%
MS WBT Server (3389)	621.7 kbytes	0 bytes	7.26 k	0	0.5%
Unmonitored traffic	22.0 kbytes	0 bytes	100	0	0.02%
http protocol over TLS/SSL (443)	18.9 kbytes	0 bytes	273	0	0.02%
Domain Name Server (53)	4.6 kbytes	0 bytes	21	0	0%
Remaining traffic	0 bytes	0 bytes	0	0	0%

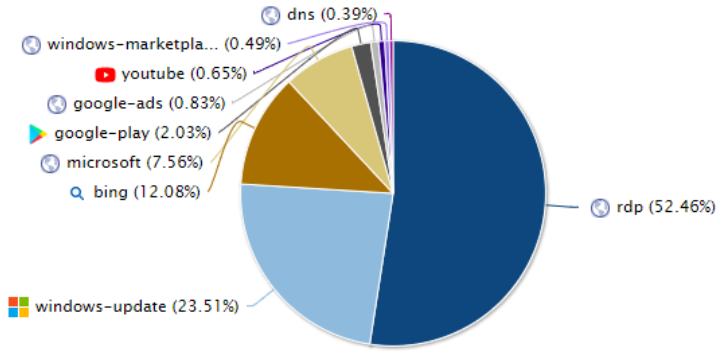
Traffic report with **IPFIX only**

enable application recognition

APPs

Top 10 Applications
INGRESS AND EGRESS, LAST 1 HOURS

NBAR2 | EDIT | HELP



APPLICATION	INGRESS BYTES	EGRESS BYTES	INGRESS PACKETS	EGRESS PACKETS	PERCENT
rdp	621.7 kbytes	0 bytes	7.26 k	0	52.46%
windows-update	278.7 kbytes	0 bytes	334	0	23.51%
bing	143.1 kbytes	0 bytes	145	0	12.08%
microsoft	89.6 kbytes	0 bytes	165	0	7.56%
google-play	24.0 kbytes	0 bytes	103	0	2.03%
google-ads	9.8 kbytes	0 bytes	38	0	0.83%
youtube	7.7 kbytes	0 bytes	28	0	0.65%
windows-marketplace	5.8 kbytes	0 bytes	22	0	0.49%
dns	4.6 kbytes	0 bytes	21	0	0.39%
Remaining traffic	0 bytes	0 bytes	0	0	0%

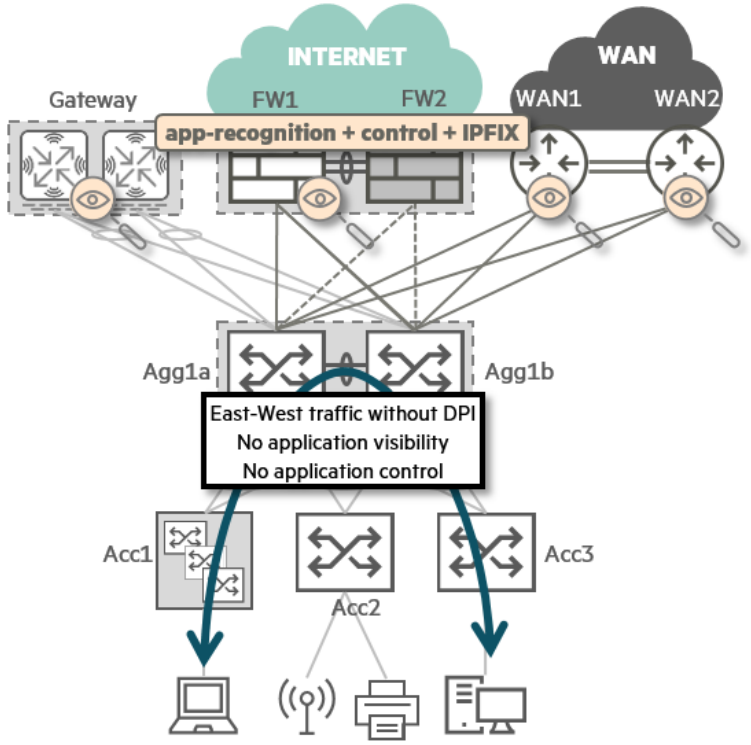
IPFIX + **APP-RECOGNITION**

Application Recognition Overview

- **D**eep **P**acket **I**nspection @ Layer7:
  - HTTPs-based applications: L4-port based identification is not possible.
  - DPI engine analyses information like certificates, SNI, signature patterns...
- Application Recognition allows to:
  - report per flow, the application-name, application-ID, and application category as defined by the DPI engine.
  - embed this application information in IPFIX export-data
  - provide applications visibility with traffic statistics exported to external IPFIX collector or to Cloud platforms
  - deploy application control per user role with application-based policy
- Available for wired-client directly connected to a switch port.
  Feature is enabled **on the port** or **on the port-access role**.
- **IPv4 and IPv6 Unicast** traffic only. **UDP/TCP** based applications.
- ~ **3800** supported applications: Office365, Skype, Sharepoint, Facebook, Gmail, Yahoo, Twitter, Instagram, Youtube.
- Supported on **6300** (incl. VSF) and **6400**v2.

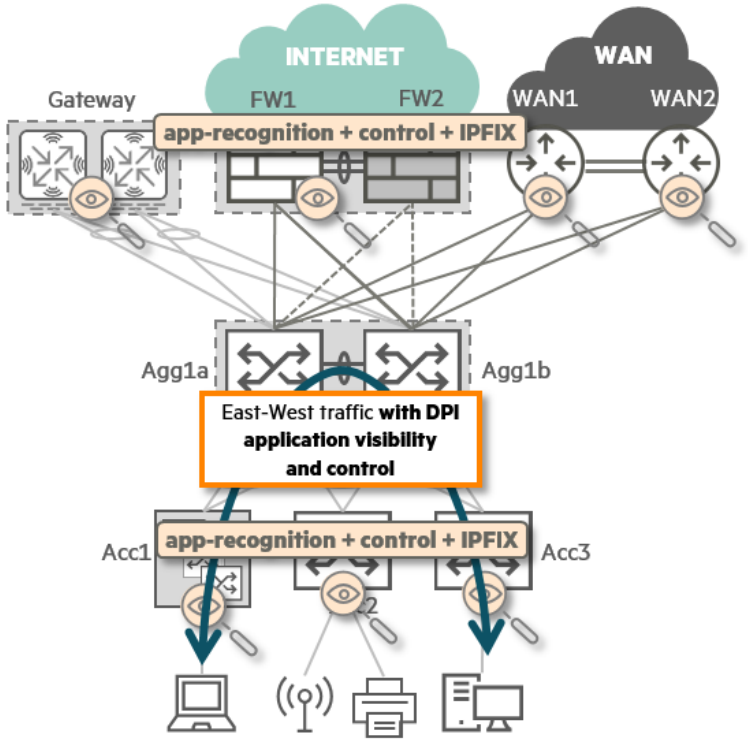
Deep Packet Inspection (DPI) at the Network Edge

Centralized model (legacy)



- DPI and IPFIX only at a centralized function: mobility-gateway for User Based Tunneling (UBT) or firewall or WAN router will inspect North/South traffic
- East/West non UBT traffic at access layer is NOT inspected

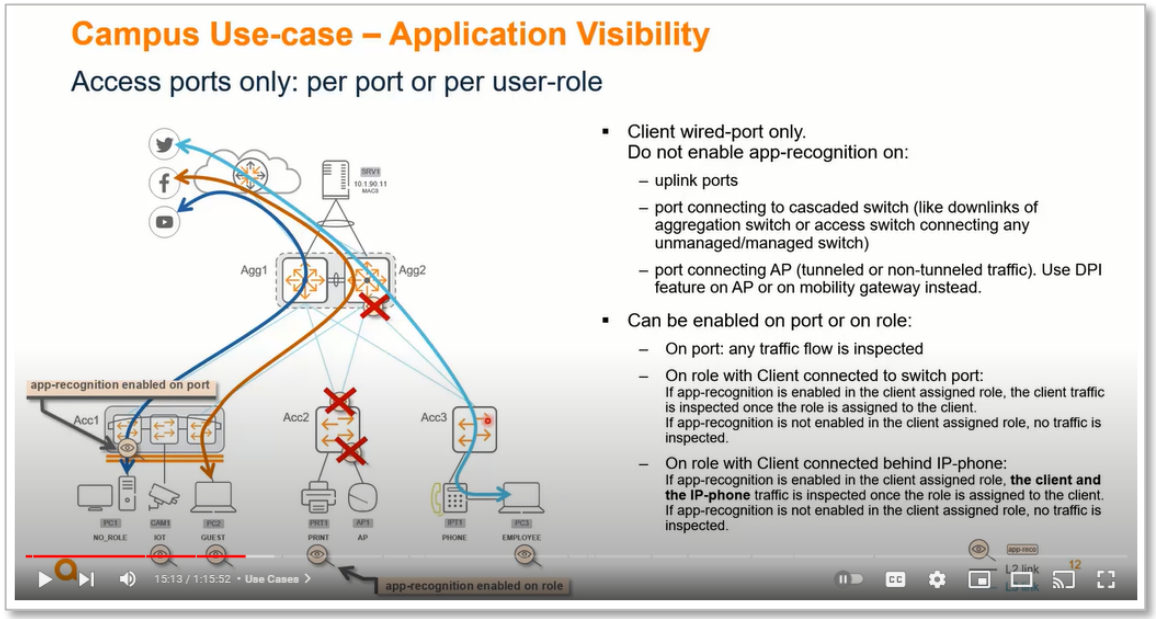
Distributed model (new)



- Distributed DPI and IPFIX at the access layer
- Complement Centralized model
- East/West non UBT traffic at access layer is inspected for application visibility and reporting within the Campus

Campus Use Case and DPI Process Details

Campus Use-case



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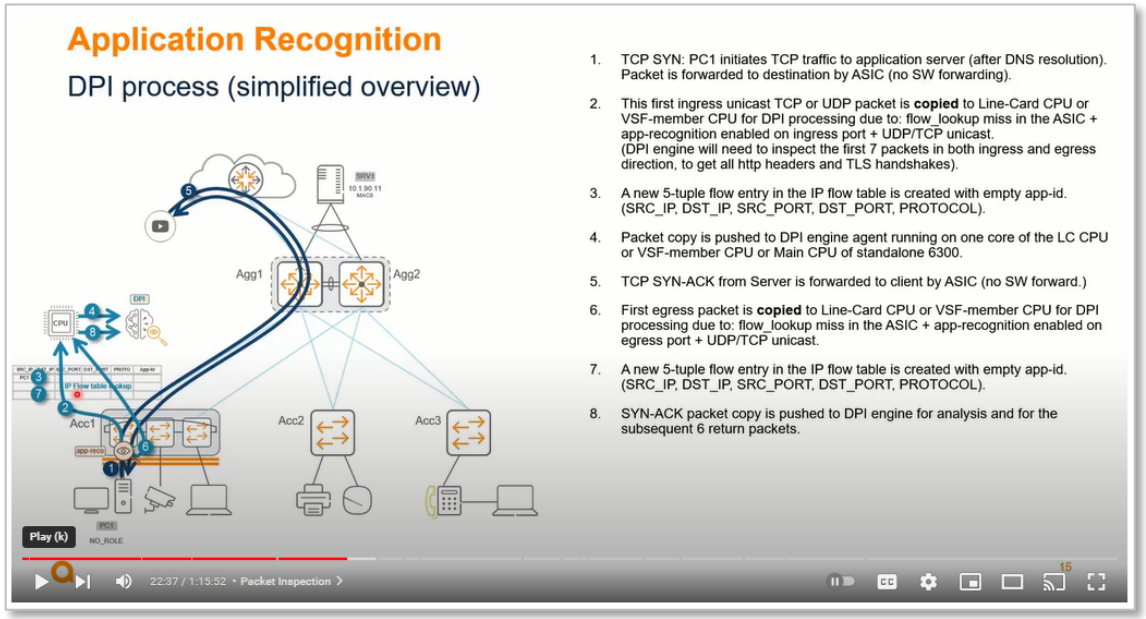
DPI Process details



https://youtu.be/C1kogaM07l8?t=1064

Platform Support, Scale and Performance

Platform	6300	6400 (v2)
Application Recognition	Yes	Yes (v2-default profile only)
Max flows * (IP flow hash-table)	**24,576**	Acc LC: 24,576 Core LC: 61,440
Max bidi-flows (IP pairs/connections)	12,288	Acc LC: 12,288 Core LC: 30,720
Max pps (COPP) (packets of new flows copied to LC CPU)	3,500 ingress + 3,500 egress	3,500 ingress + 3,500 egress
Max new connection/s per LC (new conn. processed by LC CPU)	**500 cps**	500 cps

* *IPv4 and/or IPv6. IPv6 scale is the same than IPv4.*

1 cps = 1 ingress flow/s + 1 egress flow/s

Application Recognition

Examples

```
6300# show app-recognition app ssh
NAME           : ssh
ID             : 198
CATEGORY       : encrypted
DESCRIPTION    : Secure Shell

6300# show app-recognition app youtube
NAME           : youtube
ID             : 240
CATEGORY       : streaming
DESCRIPTION    : Youtube.com

6300# show app-recognition app facebook
NAME           : facebook
ID             : 244
CATEGORY       : social-networking
DESCRIPTION    : Facebook

6300# show app-recognition app twitter
NAME           : twitter
ID             : 503
CATEGORY       : social-networking
DESCRIPTION    : Twitter
```

```
6300# show app-recognition app | count
3831
```

~ 3800 recognized applications

```
6300# show app-recognition app | include zoom
zoomtanzania                    2785  web                          ZoomTanzania
zoom                            2928  instant-messaging            Zoom

6300# show app-recognition app zoom
NAME           : zoom
ID             : 2928
CATEGORY       : instant-messaging
DESCRIPTION    : Zoom
```

```
===  ARCD Global FLOW Data  ===
=========================================
 SRC IP                                  DST IP                                  SRC Port   Dst Port   Proto   VRF   Agent   State      App Id
-----------------------------------------------------------------------------------------------------------------------------------------------
 10.80.2.217                             10.6.100.10                             8080       53651      6       1     0       READY      240
 10.6.100.10                             10.80.2.217                             3389       52676      6       1     0       READY      159
 10.6.100.10                             10.80.2.217                             53631      8080       6       1     0       READY      562
 10.80.2.217                             10.6.100.10                             8080       53650      6       1     0       READY      0
 10.6.100.10                             10.80.2.217                             53629      8080       6       1     0       READY      2821
 10.80.2.193                             10.6.100.10                             52676      3389       6       1     0       READY      159
 10.80.2.217                             10.6.100.10                             8080       53652      6       1     0       READY      240
 10.6.100.10                             10.80.2.217                             53651      8080       6       1     0       READY      240
 10.6.100.10                             10.80.2.217                             53652      8080       6       1     0       READY      0
 10.6.100.10                             10.80.2.217                             53639      8080       6       1     0       READY      1122
 10.80.2.217                             10.6.100.10                             8080       53639      6       1     0       READY      1122
 10.80.2.217                             10.6.100.10                             8080       53643      6       1     0       READY      0
 10.80.2.219                             10.6.100.10                             53         52491      17      1     0       READY      32
 10.6.100.10                             10.80.2.219                             52491      53         17      1     0       READY      32
 10.6.100.10                             10.80.2.217                             53652      8080       6       1     0       READY      240
 10.80.2.193                             10.6.100.10                             60926      3389       17      1     0       READY      159
 10.6.100.10                             10.80.2.217                             53643      8080       6       1     0       READY      0
 10.6.100.10                             10.80.2.193                             3389       60926      17      1     0       READY      159

Total Number of Flows : 18
```

web-proxy client client web-proxy youtube youtube

Extract from “diag-dump arc basic”

IPFIX

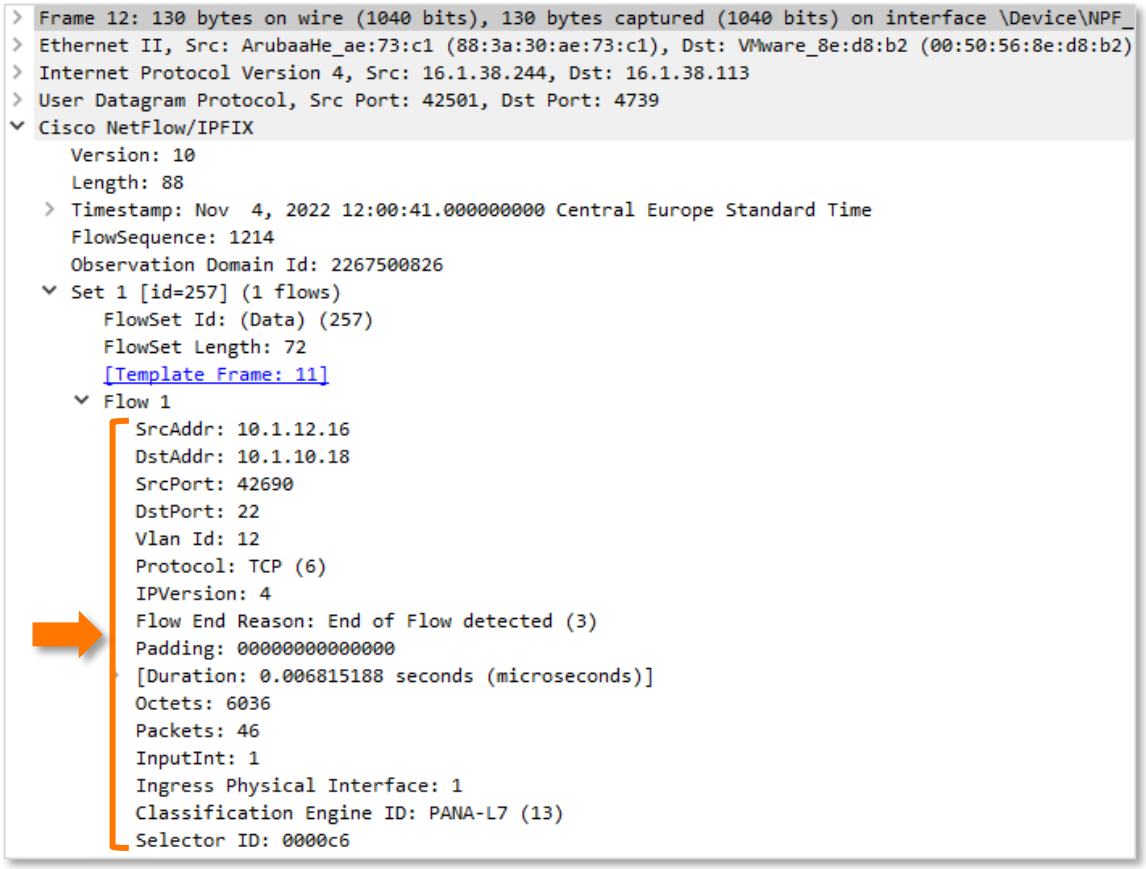
IP Flow Information Export (IPFIX) Overview

- IPFIX is an IETF standard-based monitoring technology (RFC7011 and more). Sometime called Netflow v10.
- IPFIX monitoring solution comprises:
  - **IPFIX exporter** that runs on a switch/router.
  - **IPFIX collector** that receives monitoring information from IPFIX exporters.
- IPFIX defines **flow records** with **match fields** and **collect fields**:
  - match key fields defining IPv4 or IPv6 5-tuple flow and exported in the IPFIX export-data
    src_ip, dst_ip, src_port, dst_port, protocol
  - collect non-key fields specifying what flow information is collected such as:
    *flow volume (bytes and/or packets), flow start-time, flow end-time, **application identity***
- **CX Switching IPFIX support**:
  - ingress direction only
  - IPv4 and IPv6 version
  - unicast and multicast traffic
  - ICMP
  - L2 port, L2 LAG, VSX LAG, L3 port (ROP), L3 LAG
  - platforms: **6300** (incl. VSF), **6400**v1/v2, **8100** and **8360**
- No sampling: 1 counted packet out of 1 packet seen on data-plane (new flow < max COPP)

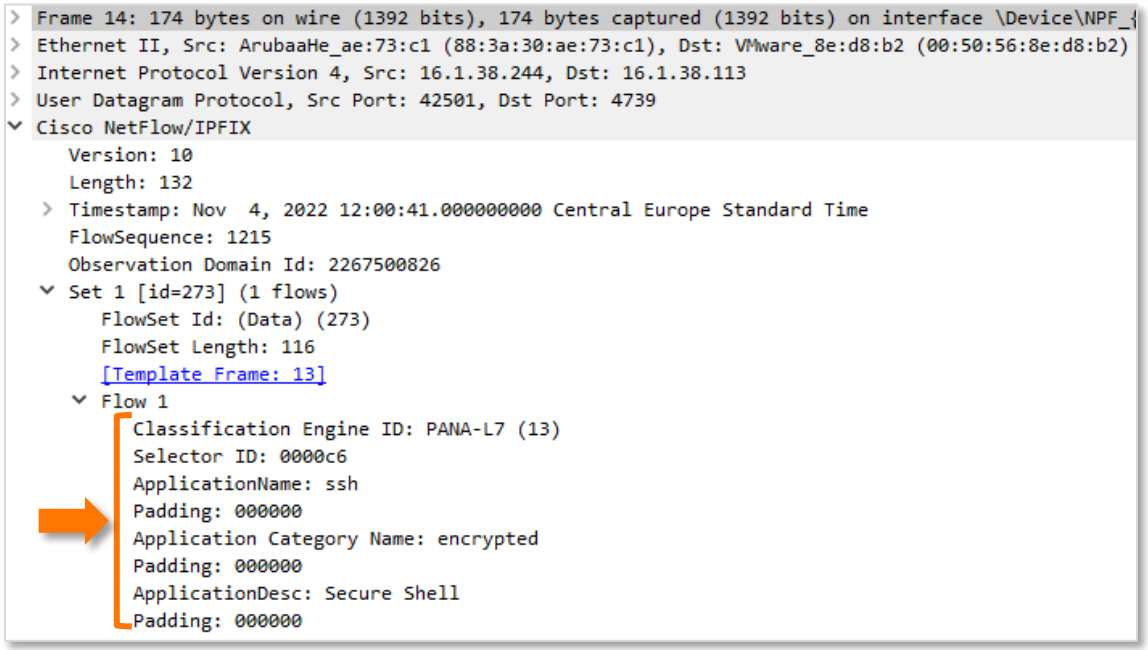
IPFIX exported DATA

with Application recognition

IPFIX EXPORT DATA



IPFIX EXPORT OPTIONS DATA with app-recognition enabled



IPFIX / sFlow comparison

sFlow

- Flow **sampling** (1 out of n packets) technology
- Does not report flow duration
- Sample includes datagram (up to 9000 bytes payload)
- No URL tracking
- No ASIC-table resource consumed
- **CPU intensive** (protected by COPP)

Port Speed	sFlow Sampling Rate
10 Mb/s	1 in 200
100 Mb/s	1 in 500
1 Gb/s	1 in 1000
10 Gb/s	1 in 2000
25 Gb/s	Default (1 in 4096)
40 Gb/s or 100G/b	Default or less frequent

IPFIX

- **No sampling**: 1 out of 1.
  Once flow is programmed in TCAM, any packet of that flow is counted. Even a “single-packet flow” is reported.
- Provides flow duration
- Allows to specify proprietary information into a Flow and export it out to the collector for further analysis.
- Allows variable length fields for information export such as URLs.
- IPFIX will export a summary of every flow seen on a port once flow is terminated (TCP FIN or timeout)
- Consumes ASIC resource
- **Not CPU intensive**

IPFIX

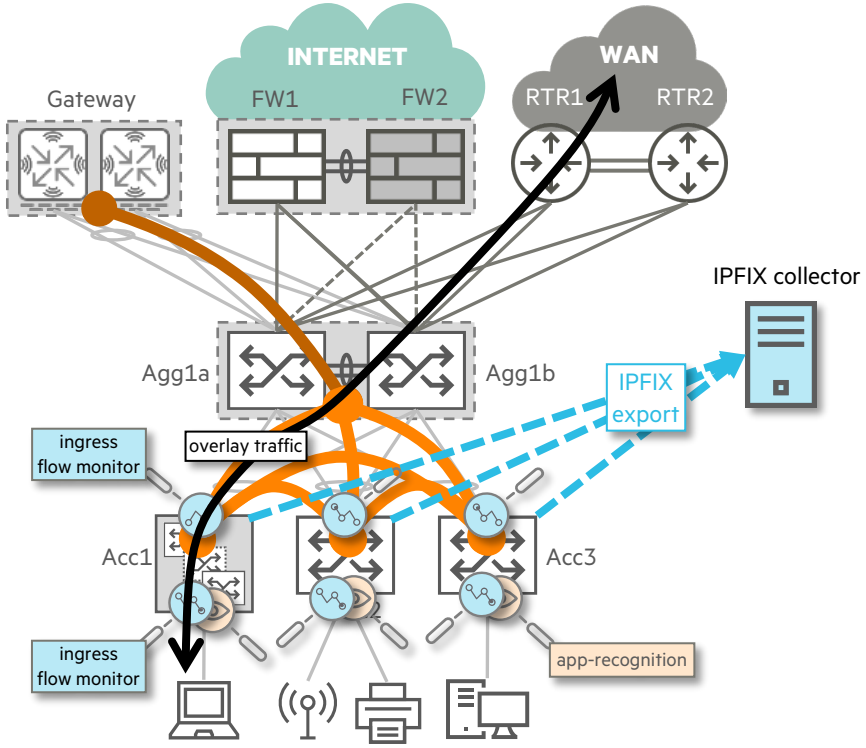
sFlow versus IPFIX for VXLAN traffic

Platform	sFlow		IPFIX	
	Ingress sFlow on port receiving VXLAN	**Egress** sFlow on port sending VXLAN	**Ingress** IPFIX on port receiving VXLAN	**Egress** IPFIX on port sending VXLAN
6300 **6400** **8100** **8360**	Sampling done **before** VXLAN decapsulation. **sFlow statistics are related to underlay.**	Sampling done after VXLAN encapsulation. **sFlow statistics are related to underlay.**	Monitoring done **after** VXLAN decapsulation. **IPFIX statistics are related to overlay.**	*Not available*
8325 **8400** **9300** **10000**		*Not available*	*Not available*	*Not available*

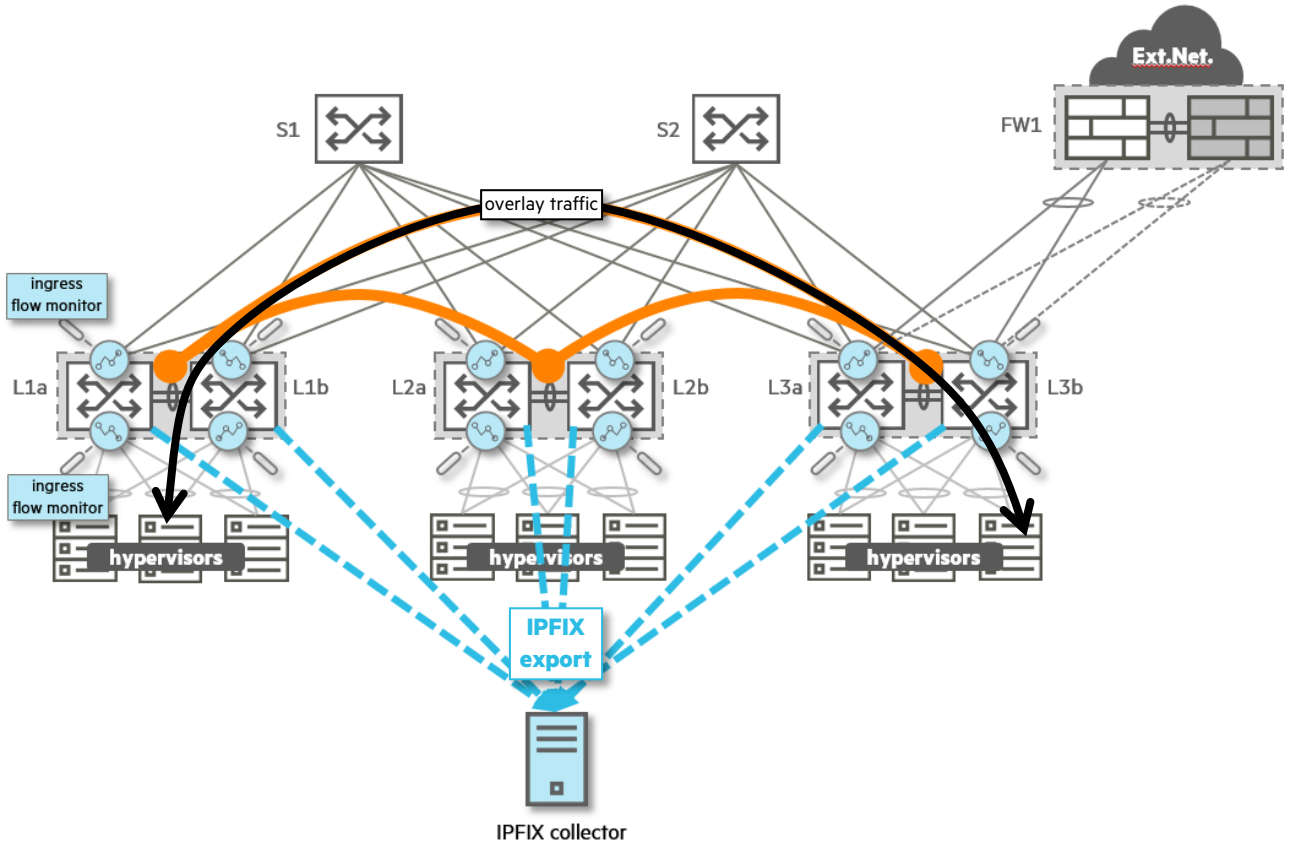
- For **underlay** VXLAN encapsulated traffic: use **sFlow**.
- For **overlay** traffic visibility inside VXLAN tunnels: use **IPFIX**
- Both sFlow and IPFIX can be enabled on the same interface.

Use Cases

Campus



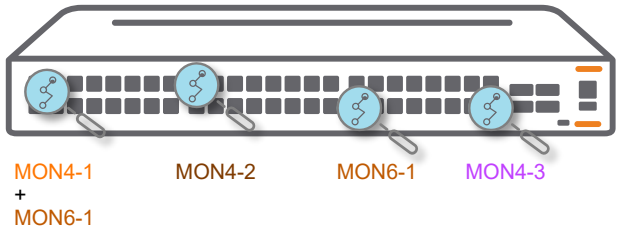
Data Center



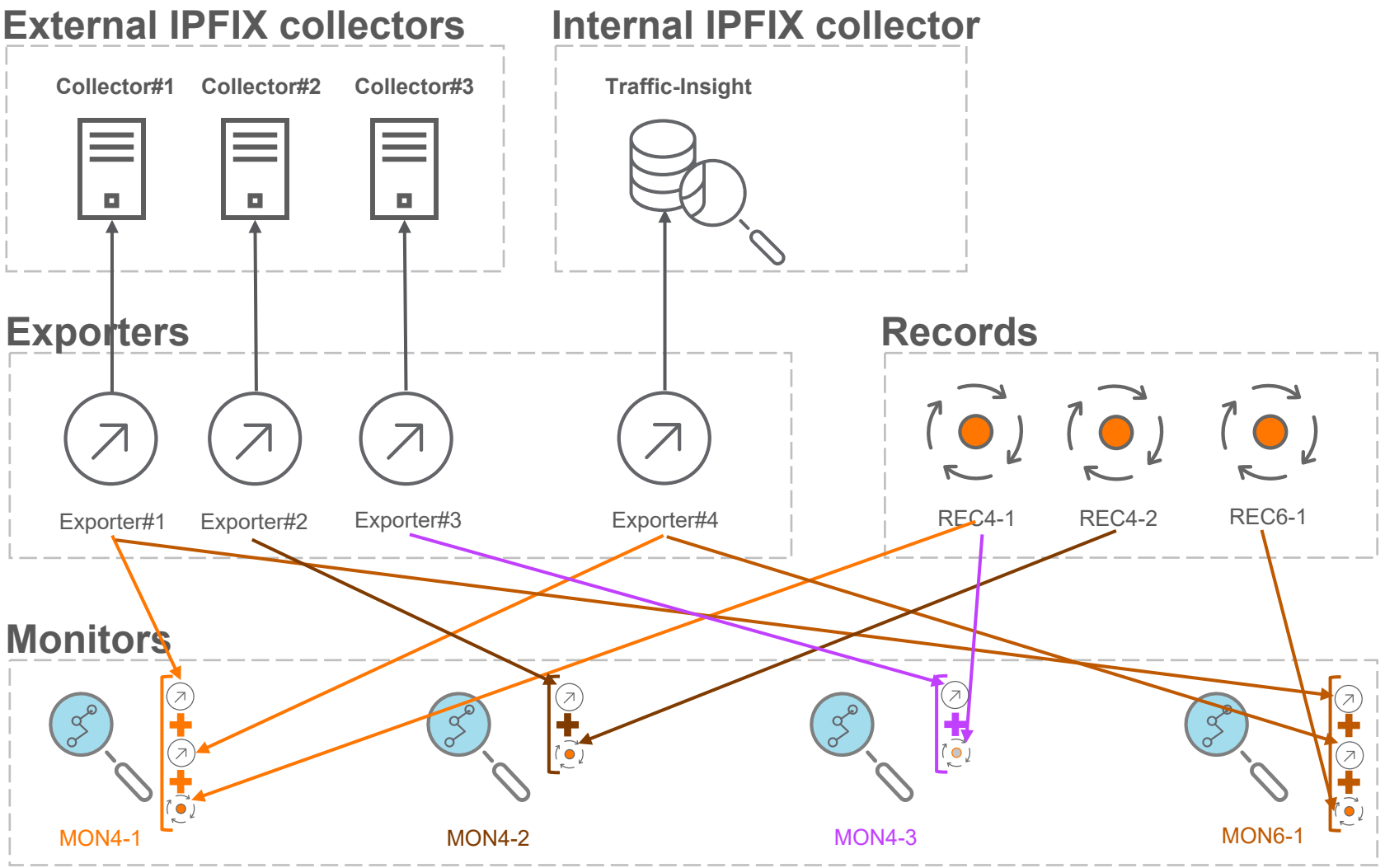
IPFIX

Component relation

Ingress IPFIX monitors / port



- A flow exporter can only send flow reports to one destination.
- Only one record can be attached to a flow monitor.
- A flow exporter can be assigned to one or more flow monitors
- Up to 2 flow exporters can be assigned to a flow monitor.



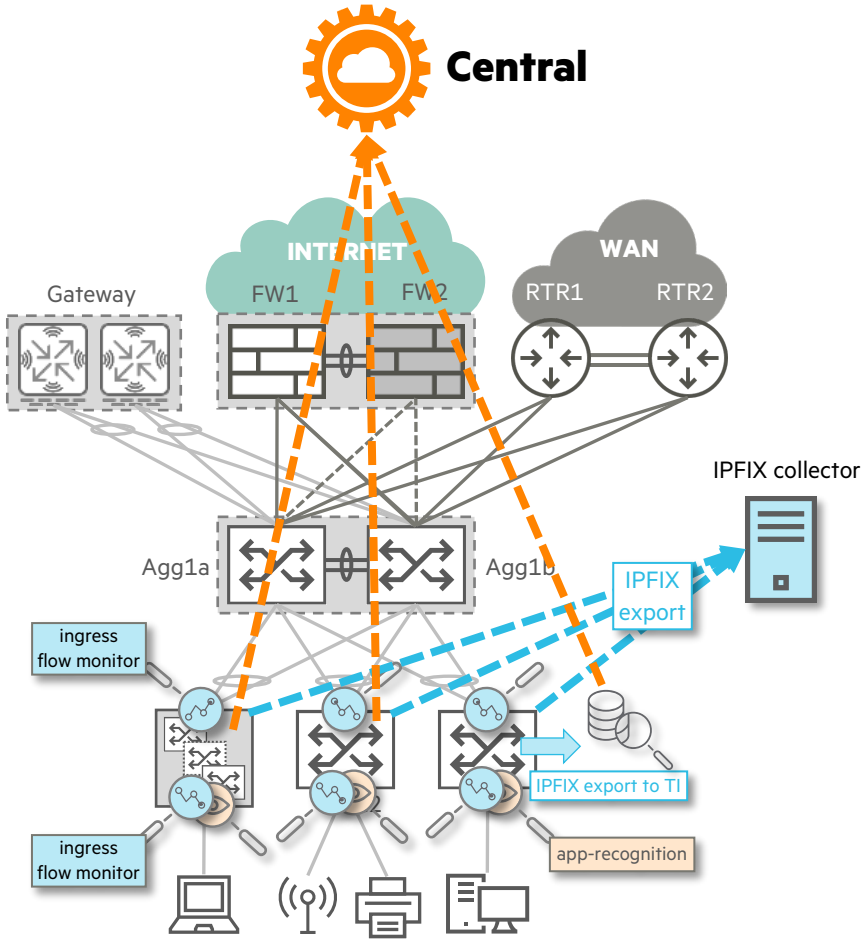
Platform Support, Scale and Performance

Platform	6300	6400 (v1/v2)	8100	8360 (v1/v2)
Ingress IPFIX	**Yes**	**Yes**	**Yes**	**Yes**
Egress IPFIX	No	No	No	No
Max IP flows (IPFIX TCAM)	IPv4: **19,632** IPv6: 4,908	IPv4: **64,688** IPv6: 16,172	IPv4: **15,536** IPv6: 3,884	IPv4: **64,688** IPv6: 16,172
Max IP bidi-flows (IP pairs/connections)	IPv4: 9,816 IPv6: 2,454	IPv4: 32,344 IPv6: 8,086	IPv4: 7,768 IPv6: 1,942	IPv4: 32,344 IPv6: 8,086
Max pps (COPP) (packets of new flows copied to LC CPU)	2,500 (default)	2,500 (default)	2,500 (default)	2,500 (default)

Traffic Insight

Use Case for Traffic Insight

IPFIX aggregator and flow analytics offload



- **IPFIX external collector**
  receives all exported flow reports from all edge switches

- **On-premise versus Cloud**
  - IPFIX external collector is appropriate for on-premise
  - Not so scalable for a multi-tenant Cloud-based solution

- **Flow aggregator and analytics at the edge switch**
  - reduce the amount of data to be exported
  - provide API for Cloud platform consumption

Traffic Insight Overview

- **CX Internal IPFIX collector**
  TI receives the same data set than an external IPFIX collector configured in the same flow monitor + SRC/DST MAC.

- **Aggregates** flow data information into OVSDB which can then be consumed through **API** by Aruba Central for analytics reporting.

- **Visualization** of the topN flows report for easy monitoring and troubleshooting in **web-UI**.

- Filters, aggregates and sorts the data based on user flow monitor requests:
  - tracks different "**monitor requests**" simultaneously
  - provides "**monitor reports**" per request

- 3 monitor types: **topN flows**, **application-flows** and **DNS average latency**.

- Up to **5 monitors**, among which:
  - one single "DNS latency" monitor
  - one single "application flows" monitor

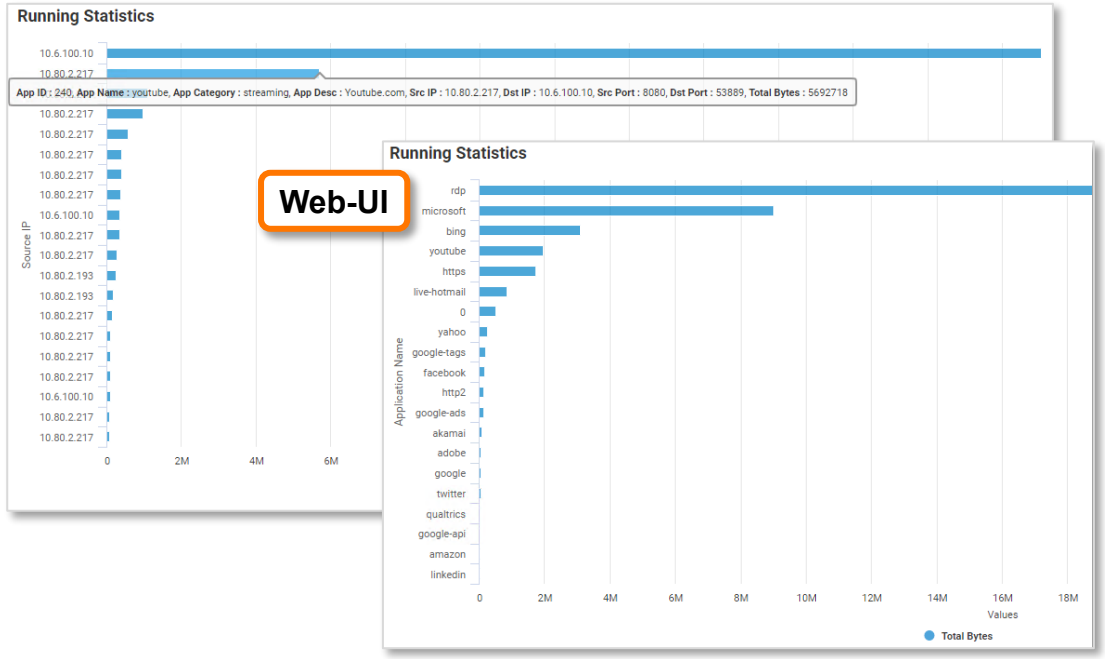
Traffic Insight

topN-flows

CLI

```
Name       : topN1
Group By   : None
Entries    : 20
Filter By  : None
Running Statistics Timeout   : 2700

Dataset    : Running Statistics
Rank    srcip                dstip             ipproto     srcport     dstport     appname           Bytes
-------------------------------------------------------------------------------------------------------------
1       10.6.100.10          10.80.2.193       udp         3389        52457       rdp               1821807
2       10.80.2.217          10.6.100.10       tcp         8080        61979       youtube           1569700
3       10.80.2.217          10.6.100.10       tcp         8080        61938       bing              793565
```

Web-UI



- Monitors IPv4 and IPv6 traffic flowing through the switch and captures **topN volume flows** (by bytes).
- Number of top captured flows: 5 (default), up to **20**.
- Top-N flow reports are generated **every 5 min** once (timer not configurable).
- The running-statistics period is 45 min (by default), configurable down to 6 min.
  After this period, the statistics are cleared.
- To get **app-id**, ***application-name*** and ***application category*** populated, **app-recognition must be enabled** on the client-facing port; otherwise reported values will be zero or unknown.
- "**Filter-by**" is a filter that can be used to reduce the displayed data set based on the filter category.
- "**Group-by**" can be used to group flows based on the grouping category.

Traffic Insight

Application flows

```
show traffic-insight TI monitor-type application-flows app

Name       : app
Type       : application-flows
Dataset    : Last 14 mins
client_mac        src_ip                  dst_ip                  app_id      Rx(Bytes)          Tx(Bytes)
-------------------------------------------------------------------------------------------------------------
00:50:56:9e:2c:48 10.6.100.10             10.80.2.193             159         4975828            10108622
00:50:56:9e:2c:48 10.6.100.10             10.80.2.217             68          1537525            229327
00:50:56:9e:2c:48 10.6.100.10             10.80.2.219             32          284                156
00:50:56:9e:2c:48 10.6.100.10             10.80.2.217             1284        61450              24153
00:50:56:9e:2c:48 10.6.100.10             10.80.2.217             3662        34669              4950
```

```
show traffic-insight TI monitor-type application-flows app app-details

Name       : app
Type       : application-flows
Dataset    : Last 14 mins
client_mac         app_id app_name                        app_category                  app_description                  Rx(Bytes)       Tx(Bytes)
-------------------------------------------------------------------------------------------------------------------------------------------
00:50:56:9e:2c:48  159    rdp                             thin-client                   Remote Desktop Protocol (Windows 4975828          10108622
00:50:56:9e:2c:48  68     https                           web                           HyperText Transfer Protocol Secu 1537525          229327
00:50:56:9e:2c:48  32     dns                             network-service               Domain Name Service              284              156
00:50:56:9e:2c:48  1284   akamai                          web                           Akamai Technologies CDN          61450            24153
00:50:56:9e:2c:48  3662   qualtrics                       web                           Qualtrics                        34669            4950
```

- Analyze **all the IPv4/IPv6 flows** that is collected by IPFIX.
- Aggregates both **Client-to-Server** and **Server-to-Clients** ingress flows to merge them into **one single bi-directional flow** of the client/server connection per application, providing Rx and Tx byte details.
- Traffic Insight update this bidirectional flow **into the OVSDB database** which will be exported via APIs in order to report the application traffic per client (to Central for instance).
- To get **app-id**, **application-name** and **application category** populated, **app-recognition must be enabled** on the client-facing port, otherwise reported value will be zero for app-id and unknown for application-name.

Traffic Insight

dns-average-latency

Traffic-Insight

```
Name                                  : dns
Type                                  : dns-average-latency
Start time for latency calculation    : 10/18/2022 10:11:15.564822 UTC
End time for latency calculation      : 10/18/2022 10:16:15.592663 UTC
client_mac        dns_server_ip     dns_average_latency(usec)     number_of_dns_requests
------------------------------------------------------------------------------------------
00:50:56:9e:2c:48 10.80.2.219       50928                         4
```

- Measure the average latency of the DNS request and response **from the client viewpoint**.
- The DNS traffic data is extracted from IPFIX data.
- The DNS average latency is calculated from DNS request and response packets from the servers for different clients.
- When enabled, **Client-Insight** will use this DNS average latency, which can then be consumed through Client-Insight API for reporting to Central.

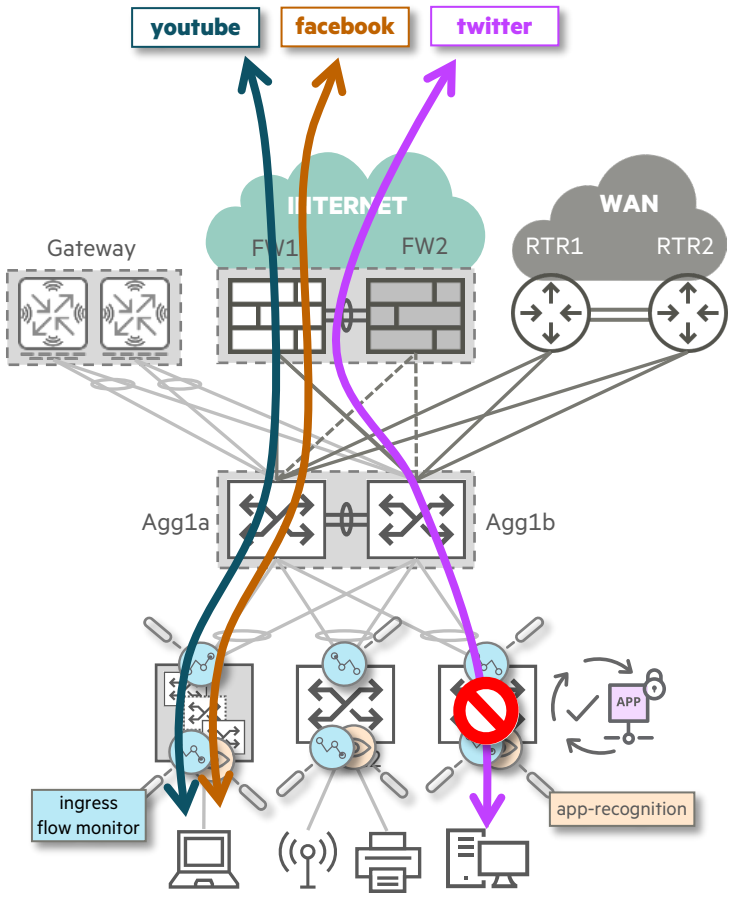
Client-Insight

```
  Displaying client entries with (mac) as key.
  Total number of entries: 1

MAC : 00:50:56:9e:2c:48
-----------------------
Overall on-boarding status         : timeout
Overall on-boarding failure reason : l3_onboarding_failed

  L2 on-boarding detail
  ---------------------
    L2 on-boarding status         : successful
    L2 on-boarding failure reason : -
    L2 on-boarding start time     : 10/13/2022 17:25:05.023453 UTC
    L2 on-boarding end time       : 10/13/2022 17:25:05.105563 UTC
    L2 on-boarding latency        : 0 min, 0 sec, 82110 us
    802.1x RADIUS latency         : -
    MAC-Auth RADIUS latency       : 0 min, 0 sec, 80911 us

  L3 on-boarding detail
  ---------------------
    IP on-boarding status           : timeout
    IP on-boarding failure reason   : no-dhcp
    L3 on-boarding latency          : -

    VLAN : 1006
    -----------
      IP details
      ----------
        IPv4 on-boarding status         : -
        IPv6 on-boarding status         : -

        DHCPv4                                          DHCPv6
        ------                                          ------
          Status         : -                            Status         : -
          Failure reason : -                            Failure reason : -
          Start time     : -                            Start time     : -
          End time       : -                            End time       : -

  DNS details
  -----------
    Server IP: 10.80.2.219
    ----------------------
      Average latency                          : 50928
      DNS start time for latency calculation   : 10/18/2022 10:11:15.564822 UTC
      DNS end time for latency calculation     : 10/18/2022 10:16:15.592663 UTC
      Number of DNS requests                   : 4
```

Application-Based Policy

AOS-CX 10.12
policy action = { drop }

Application-Based Policy Overview



- **Allow or block** authenticated user access to **specific applications** or protocols identified by app-recognition.
- Policy is applied on **user role**.
- Port access authentication (802.1X or MAC auth) must be configured, with **local** or **downloadable** user roles.
- **IPv4 and IPv6 Unicast** traffic only. **UDP/TCP** based applications.
- Application Control **operation** overview:
  - ABP rules use application-name
  - Hence, first few packets (max 7) of each new flow are allowed until the application is recognized by DPI engine.
  - Once flow classification is completed, ABP actions are applied via rules being programmed in the ASIC TCAM.
  - An implicit deny rule is applied if the traffic flow doesn't match any configured ABP rules.

Configuration and ABP Session Limit Exceed Action

- Configuration:

```
class abp-ip abp-class1
    10 match udp any any app-category web app youtube-music count
    20 match tcp any any app-category any app facebook
    30 ignore any any 10.0.0.10/255.255.255.0 app-category standard app unknown
    40 match udp any any any app-category standard app unknown
class abp-ip abp-permit
    10 match any any any app-category any app any
!
port-access abp abp-policy
    10 class abp-ip abp-class1 action drop
    20 class abp-ip abp-permit
```

```
gbp role test 100
!
port-access role test
    app-recognition enable
    associate abp abp-policy
    vlan access 12
```

- If the number of app flows exceed the size limit of the flow table
  => ABP rule enforcement for flows in excess of the table size would fail (missing app-id)

- This is a potential network security vulnerability:
  a malicious user could bypass ABP by flooding the switch with flows and overflowing the flow table

- User-configurable flow table overflow behavior when max threshold (80% of flow table size) is exceeded:
  - By default, drop new flows for source roles on affected system, line card, or VSF member
  - Or generate warning messages in switch event log

Policies combination

- Port access supports three different traffic policy types to associate with a port access role:
  - **Port access policy**, applied on traffic sourced from user role
  - **Group based policy**, applied on traffic destined to user-role
  - **App-based policy**, applied on traffic sourced from user-role with actions based on application identity

- ABP, GBP and port-access policies can co-exist.

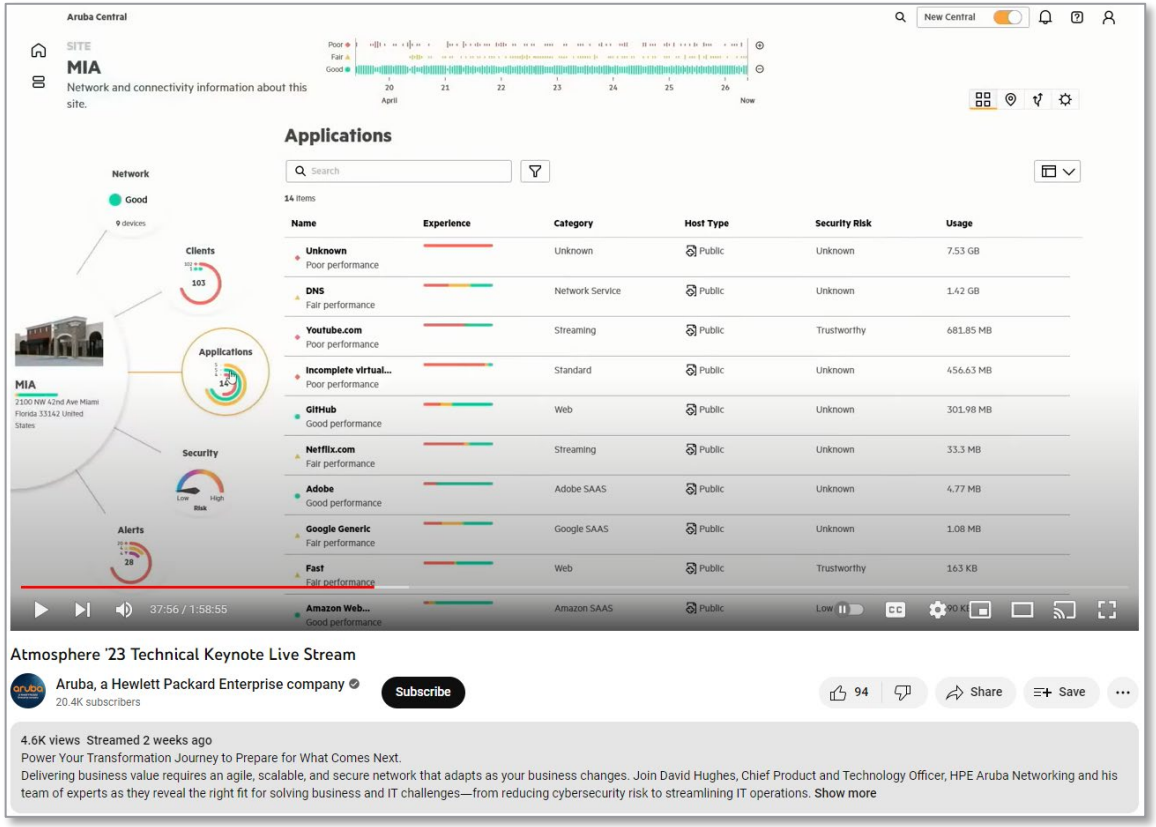
- Since **ABP** matches and acts based on the layer 7 application information, it is a more specific policy and hence has **higher precedence over the GBP or PAC policies**.

- When multiple policies match a packet and at least one of them intends to drop it, then the packet is dropped.

Conclusion

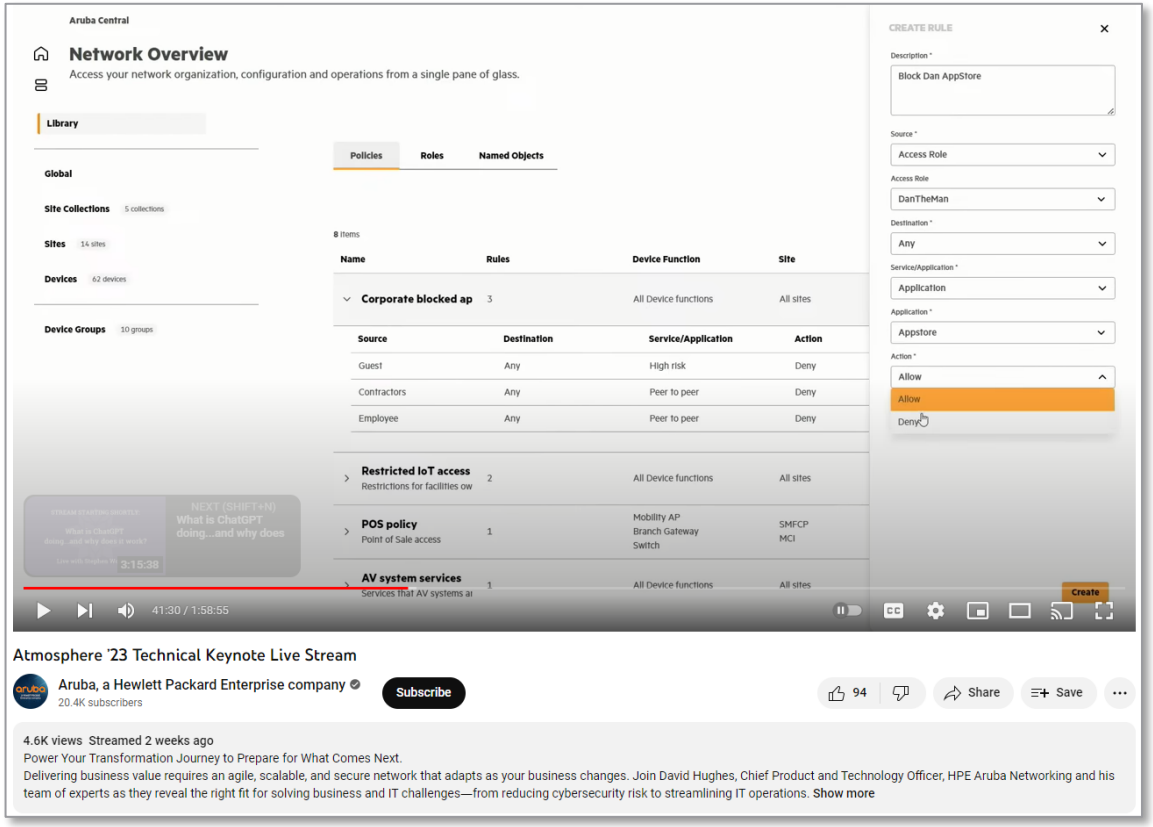
Next-Gen Aruba Central – Atmosphere 2023 keynote demonstration

Application Visibility with data from Traffic-Insight



https://youtu.be/Yui5w56MIKs?t=1957

Role/Application Policies



https://youtu.be/Yui5w56MIKs?t=2115

Airheads Broadcasting – YouTube channel

AOS-CX Software Release Technical Update

https://www.youtube.com/playlist?list=PLsYGHuNuBZcbWPEjjHuVMqP-Q_UL3CskS

Thank You

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