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The bridge to possible

Understanding Wireless Security

And the Implications for Secure Wireless Network Design

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Principal Wireless Architect, Asia Pacific, Japan & Greater China

BRKEWN-3004

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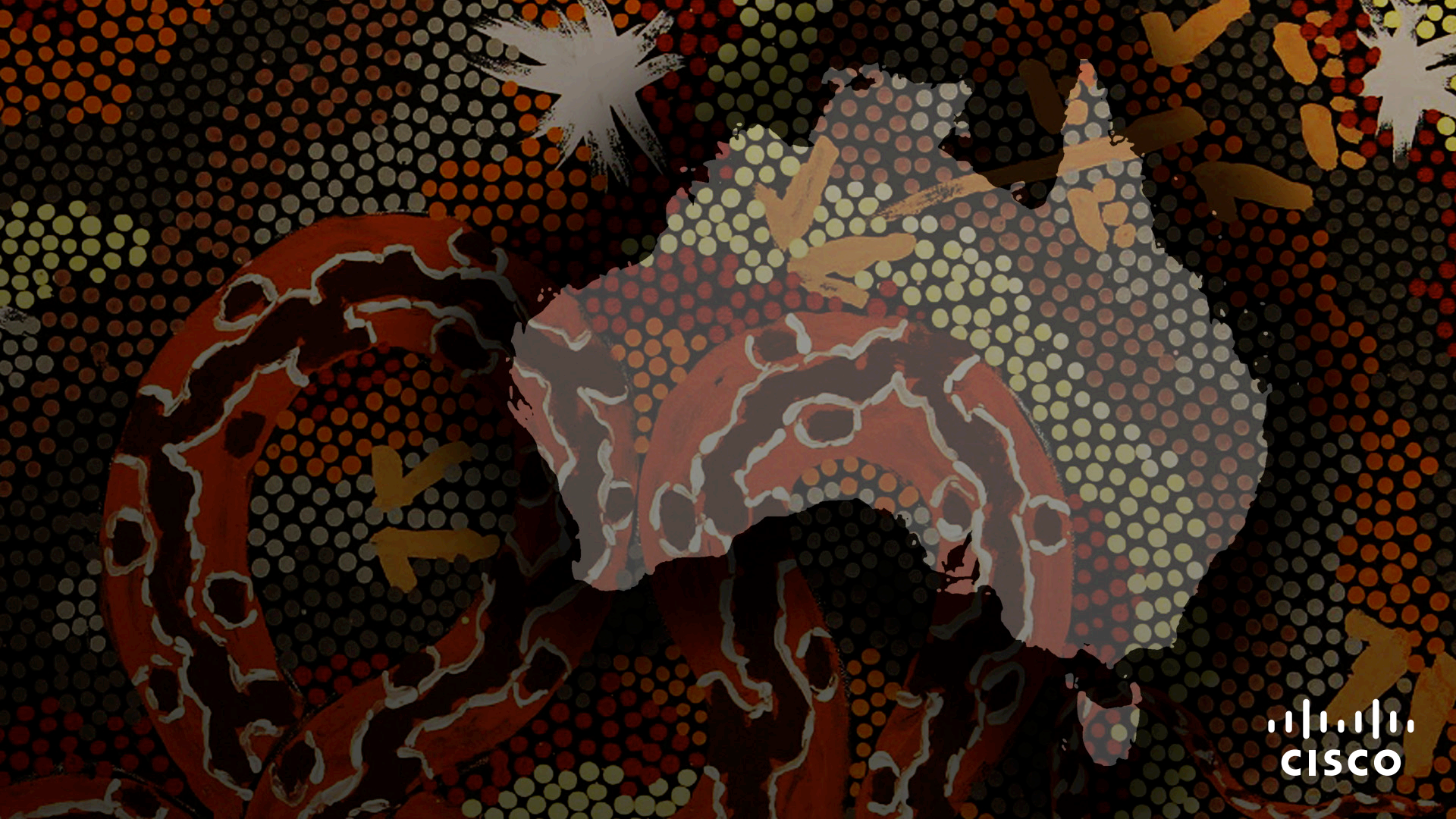
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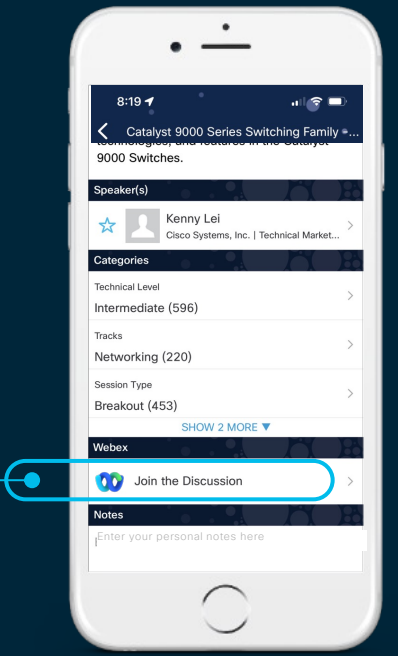

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Abstract

This session will explore secure wireless network design, with a key focus on the latest WPA3 and Wi-Fi 6 standards.

Mobility brings unique challenges to network security, such as the need for secure fast roaming. Participants will learn how 802.11 addresses theses requirements, and explore the changes WPA3 brings and the implications for wireless deployments.

This session will also explore how Cisco DNA Center expands upon the wireless security standards with Rogue AP detection and location, and Advanced Wireless Intrusion Detection and Prevention.

The intent is to provide a deeper understanding, not just about the security capabilities themselves, but to do so from the perspective of the attacks that they defend against.

Agenda

- Wireless Security Fundamentals
  - WPA3
  - Authentication and Authorisation
  - Wi-Fi 6E Security
- Rogue Detection and Advanced WIPS
  - Threat 360°
  - Rogue Detection and Containment
  - Advanced Wireless Intrusion Prevention

Wireless Security Fundamentals

Wireless Attack Surface

- Wireless networks propagate beyond the physical constraints of the wired network
- Attacks may originate from anywhere within the wireless coverage
  - Passive scanning attacks
  - Layer 2 active spoofing attacks
  - Layer 1 active jamming or DoS attacks
  - Rogue APs
    - Honeypot and Evil Twin APs
    - Unsecured backdoor access

Wireless Protected Access

WPA	• A snapshot of the 802.11i Wireless Security Standard • Commonly used with TKIP encryption
WPA2	• Final version of 802.11i Wireless Security Standard • Commonly used with AES encryption
Authentication Mechanisms	• Personal (PSK – Pre-Shared Key) • Enterprise (802.1X/EAP)
WPA3	• Wi-Fi Alliance security update • Includes new capabilities and new certification requirements

WPA3

- Mandatory for Wi-Fi 6 Certification
- Remove insecure legacy protocols
  - WEP
  - TKIP
  - SHA1
- Negative Testing
  - KRACK

- Protected Management Frames (802.11w)
- Simultaneous Authentication of Equals (SAE)

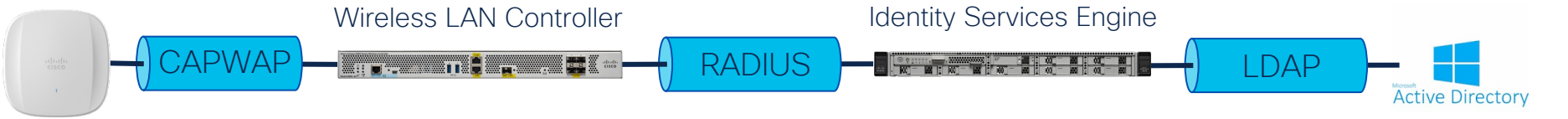
- Wi-Fi Certified Enhanced Open
  - Opportunistic Wireless Encryption (OWE)

802.11 Fundamentals

Authentication

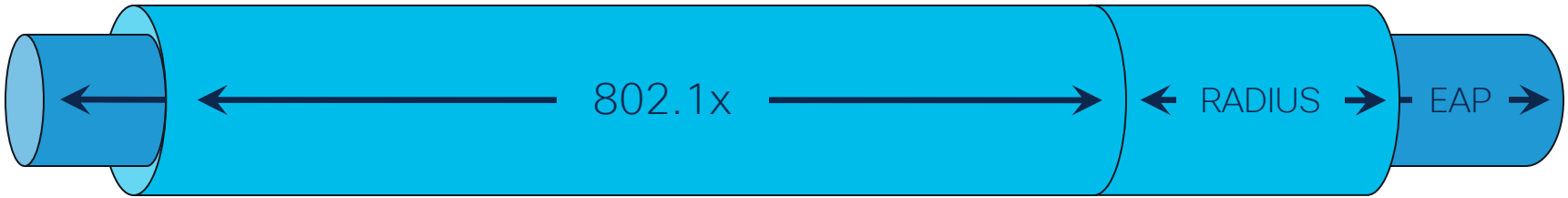
802.11 Fundamentals

Authentication



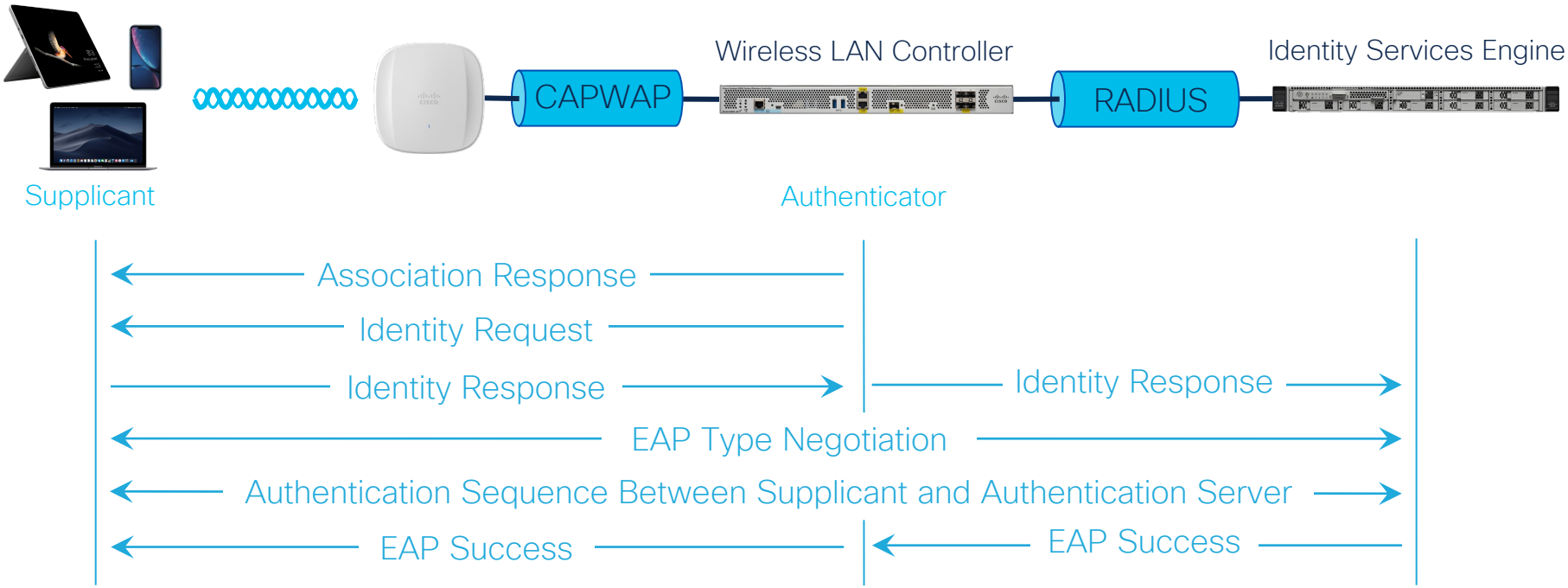
802.11 Fundamentals

Authentication



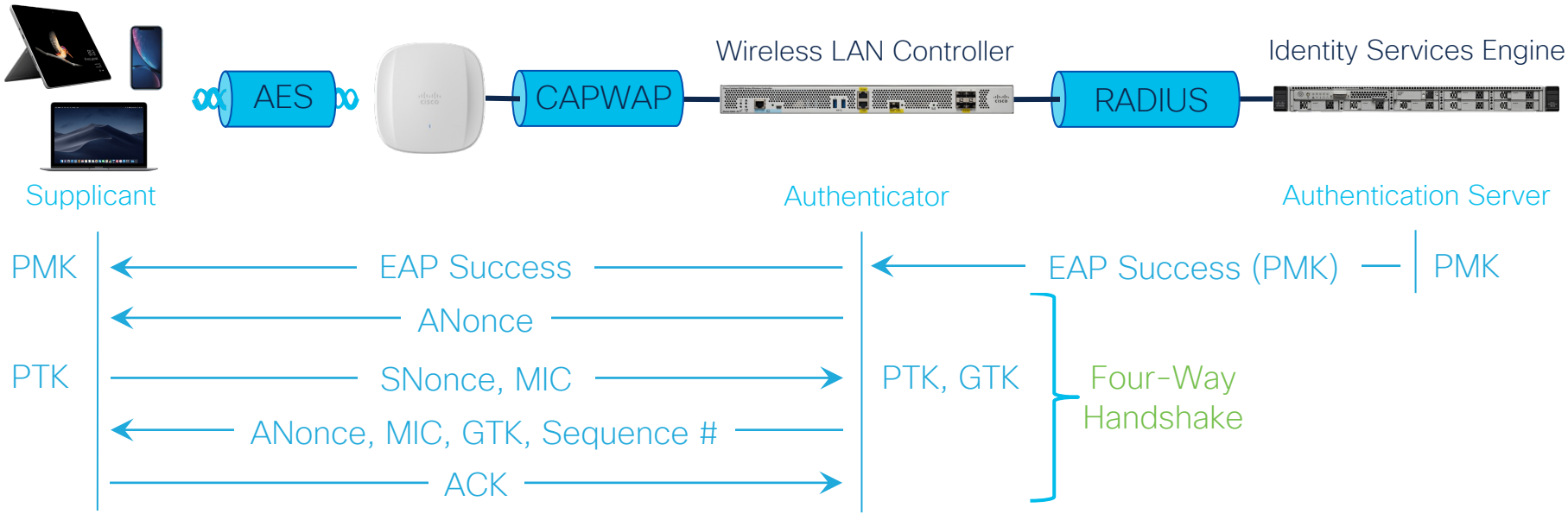
802.11 Fundamentals

Authentication



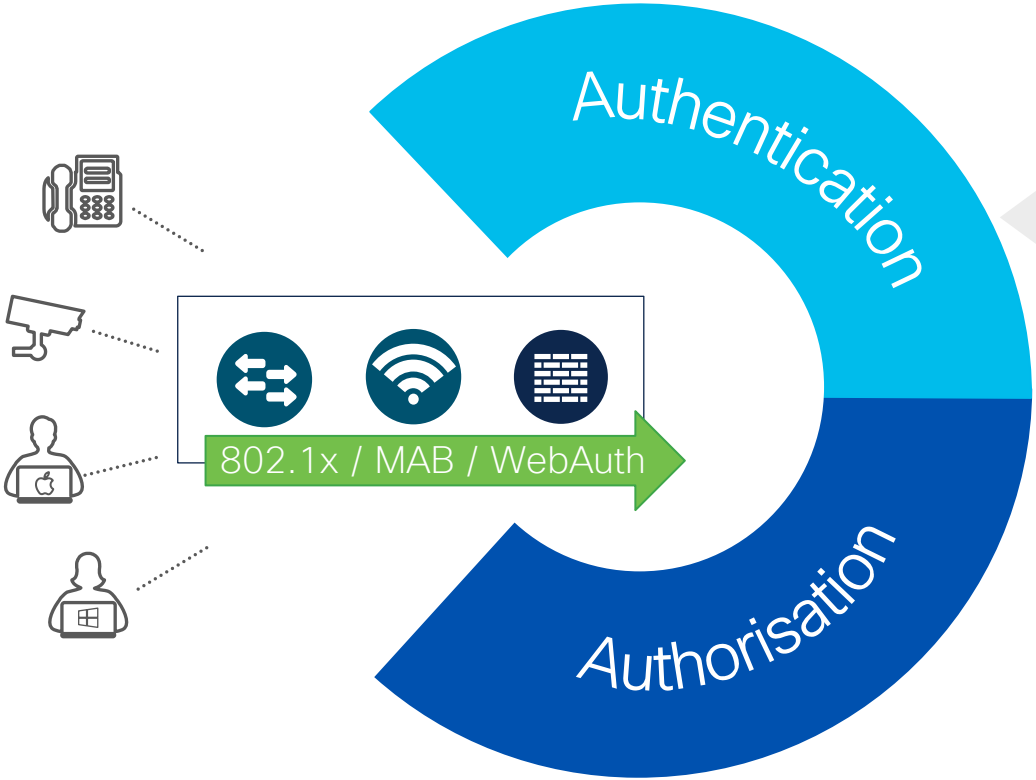
802.11 Fundamentals

Encryption



PTK = SHA(PMK + ANonce + SNonce + AP MAC + STA MAC)

Authentication and Authorisation



- Device Posture
- Device Type
- User Credentials
- MAC Address
- Identity Elements

- Location
- Day and Time
- Access Type
- Context

Policy Elements

- VLAN/VN
- SGT / Group Policy
- QoS / BDRL
- URL Redirect / Filter
- Bonjour Service Policy
- Application Control

Authorization Options

URL-Redirect

Provide conditional web redirect when traffic is blocked

URL-Filter

Controls which FQDNs the endpoint can reach or not

Bandwidth

Control maximum bandwidth and burst rate per endpoint/user

Calendar Profile

Controls active hours for endpoint access.

Timer

Control session, idle-timeout, active hours

QoS

QoS Profile is assigned per endpoint

AVC Profile

Application Visibility Profile is assigned per endpoint

mDNS Profile

Assigns mDNS profile to broker mDNS advertisement

Open DNS

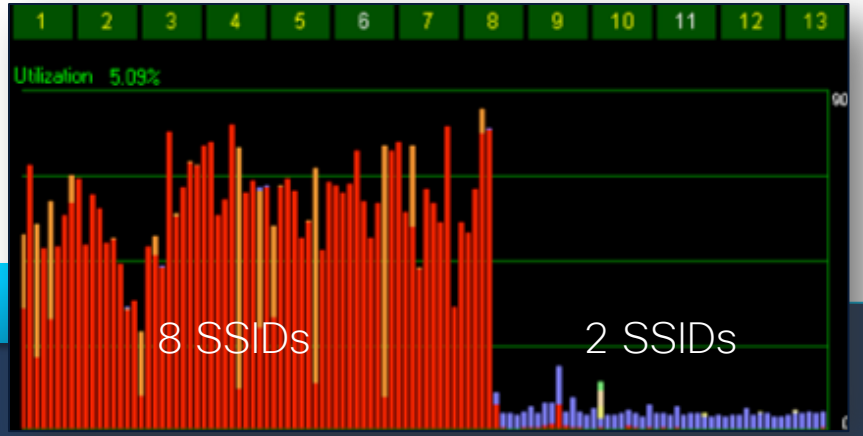
Assigns Open DNS profile to intercept DNS packets for custom response

Service Template & Roles

Assigns multiple access characteristics: VLAN, ACL, QoS, Timer, etc.

Authorisation

Network Segmentation



Static VLAN Assignment

- VLAN based on SSID
- VLAN segregation based on security policy

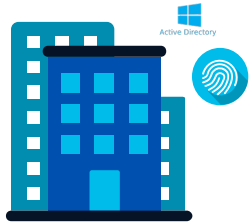
Dynamic VLAN Assignment

- VLAN based on authentication credentials
- VLAN segregation based on role

TrustSec / Group Based Policy / Software Defined Access

- Security based on TrustSec Scalable Group Tags instead of source and destination addresses
- ACLs applied at the packet level with enforcement across the network (or network fabric)

On-Prem and Cloud Identity Providers



On-Prem Identity Provider

802.1x, Network Access

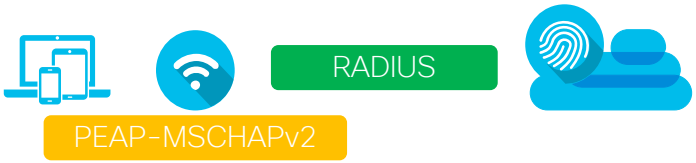
MSCHAPv2, PAP
EAP-FAST, EAP-TLS
MAC Filtering

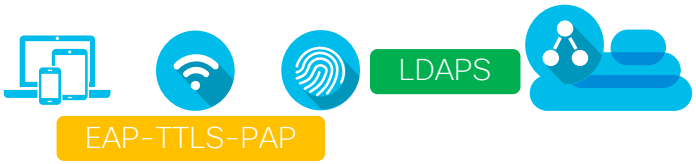
Cloud Identity Provider

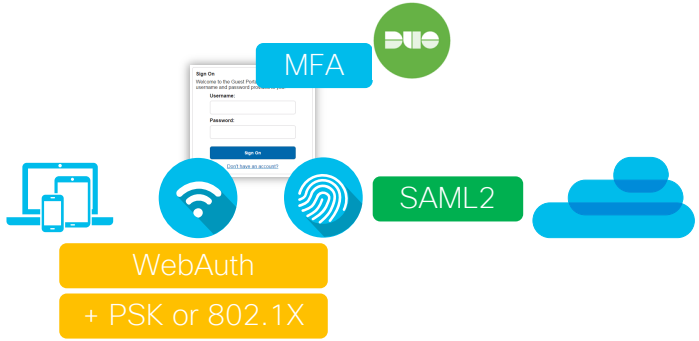
VPN, Applications

SAMLv2, OpenID Connect

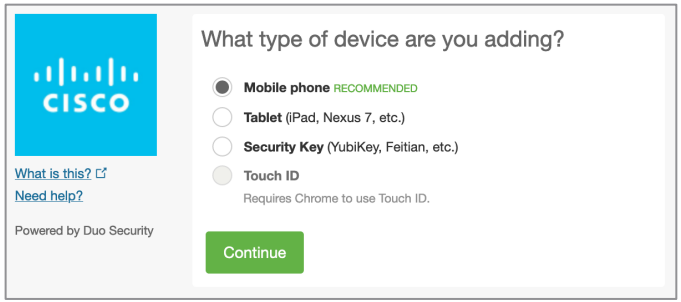
Cloud Identity and Multi-Factor Authentication

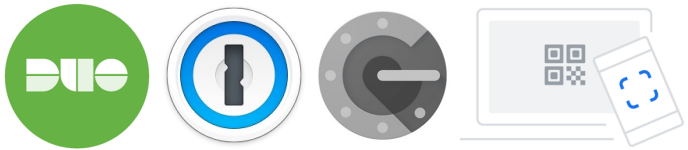






Multi-Factor Authentication



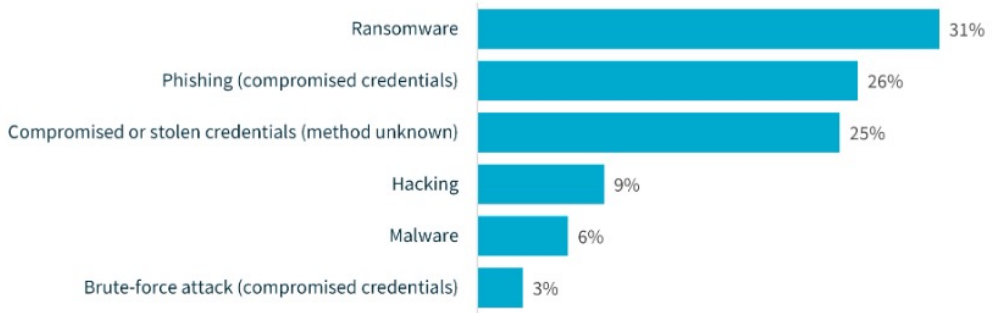


- Push notification for ease simplified access
  - Requires network access
- Traditional time based one-time passwords
  - Manual process

Zero Trust and Wireless Networking

41% of all data breaches resulted from cyber security incidents (162 notifications)

Cyber incident breakdown



- Ransomware
  - East/West Traversal
  - Authorisation
    - Micro-segmentation
- Phishing and compromised or stolen credentials
  - Username/Password
  - Digital Certificates

Secure Fast Roaming Challenges

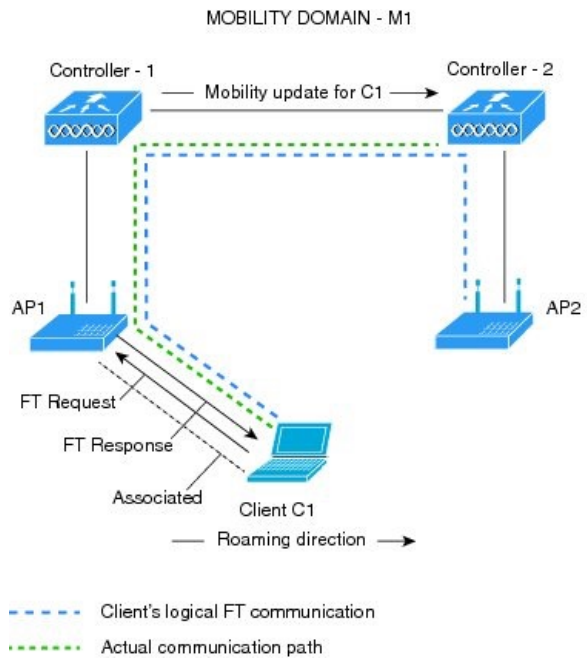
- Client channel scanning and AP selection
- Re-authentication of client device and re-keying

Secure Fast Roaming

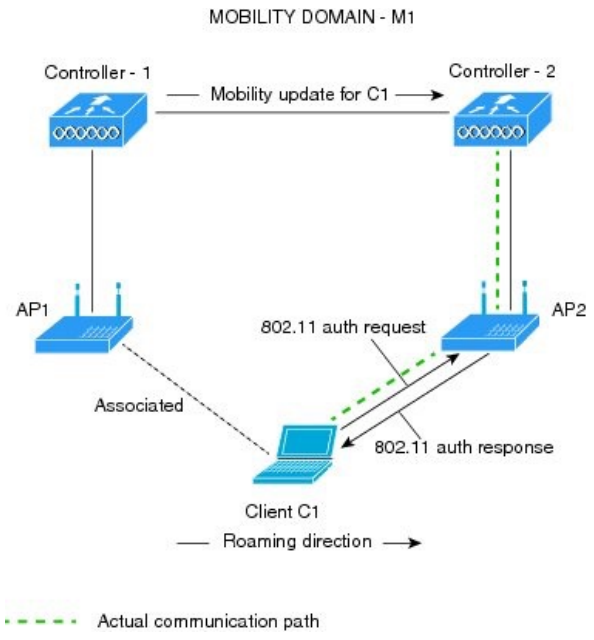
802.11k/v/r and Wi-Fi Agile Multiband

- Client channel scanning and AP selection
  - 802.11k Neighbor Lists based on CCX (Cisco Compatible Extensions)
  - 802.11v BSS Transition
- Re-authentication of client device and re-keying
  - 802.11r Fast BSS Transition based on CCKM (Cisco Centralised Key Management)

802.11r Fast Transition



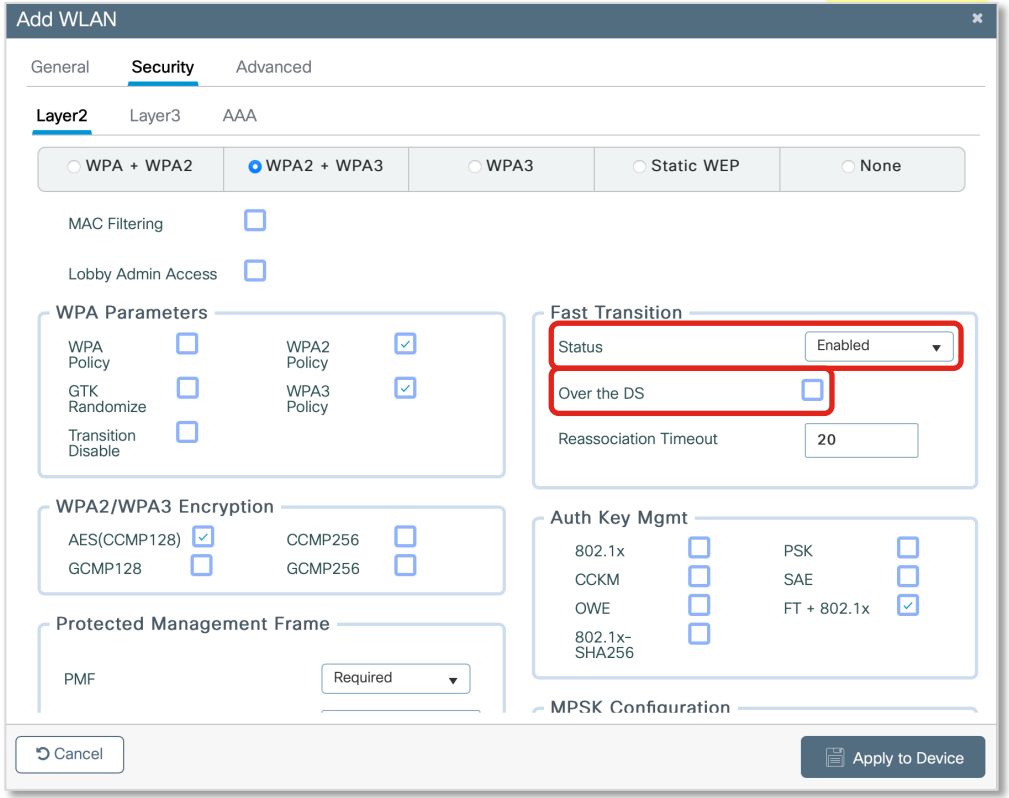
Over the DS



Over the Air

802.11r Fast Transition

- Over the Air is recommended for best client interoperability

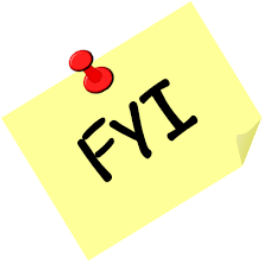


Key Reinstallation AttaCK

- 10 Vulnerabilities were discovered
  - May allow the reinstallation of keys already in use
- Only 1 impacts Access Points
  - Specific to 802.11r (Fast BSS Transition)
  - CVE-2017-13082

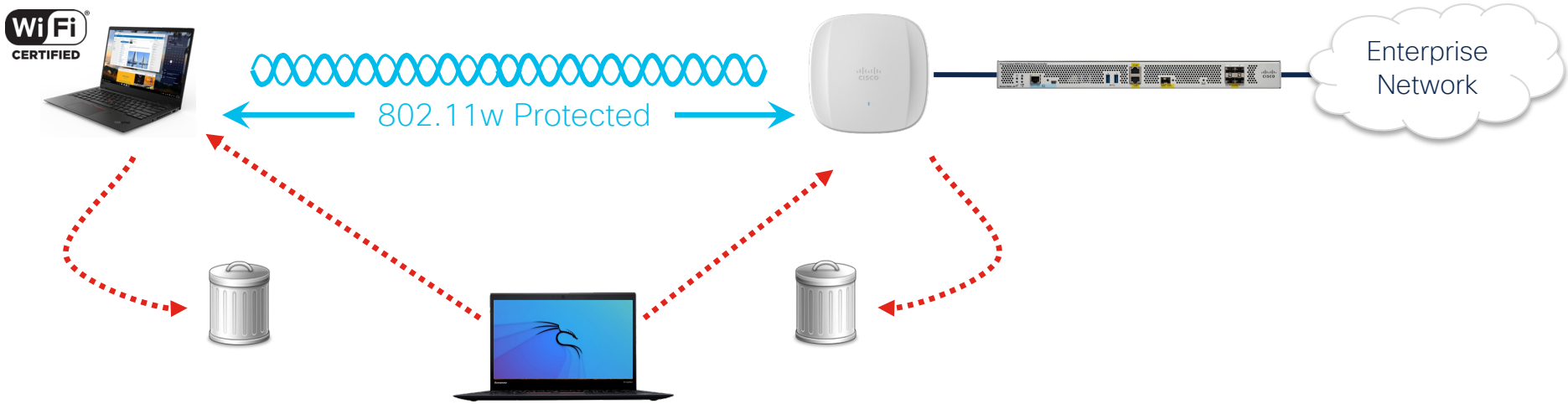
- This was an industry wide issue
  - Not specific to any one vendor
- WPA3 certification includes KRACK exploit testing
- The attacker positions a rogue AP clone to perform a MitM attack
  - This flaw causes all WPA2 encryption protocols to reuse the keystream when encrypting packets
- Rogue AP detection and WIDS/WIPS can detect potential attack vectors

KrØØk Vulnerability



- On February 26th, 2020, researchers Štefan Svorencík and Robert Lipovsky disclosed a vulnerability in the packet processing of certain Wi-Fi chipsets
- This vulnerability could allow an unauthenticated, adjacent attacker to decrypt Wi-Fi frames without the knowledge of the PTK
- After an affected device handles a disassociation event, it could send a limited number of Wi-Fi frames encrypted with a static, weak PTK
- An attacker could exploit this vulnerability by triggering a disassociation and then acquiring these frames and decrypting them with the static PTK
- WIDS/WIPS can detect potential attack vectors

802.11w Protected Management Frames



Central Web Authentication

URL Redirect

Any Packet

RADIUS Access Request

RADIUS Access Accept

Network Access Granted
Redirect ACL

HTTP Packet

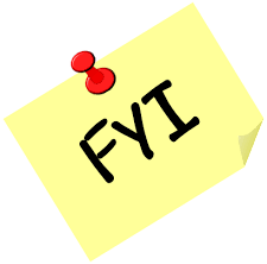
Redirect to ISE Web Page

Web Authentication Sequence

RADIUS CoA Request

RADIUS CoA ACK

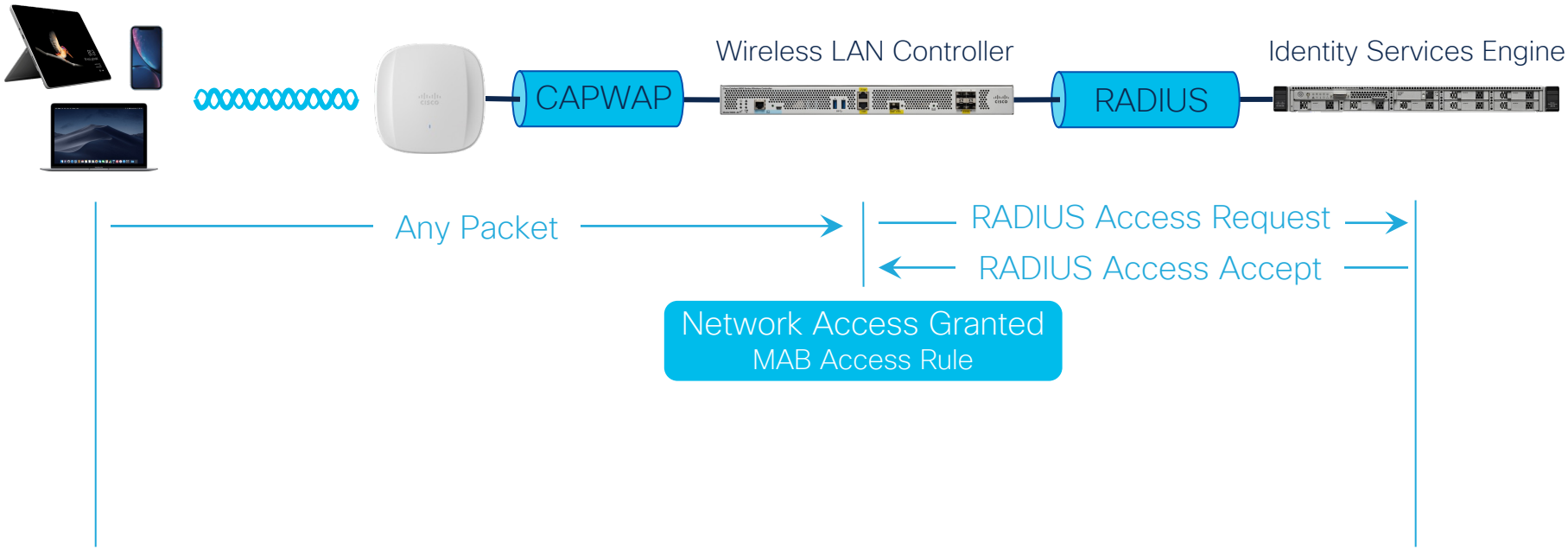
Captive Portal Detection



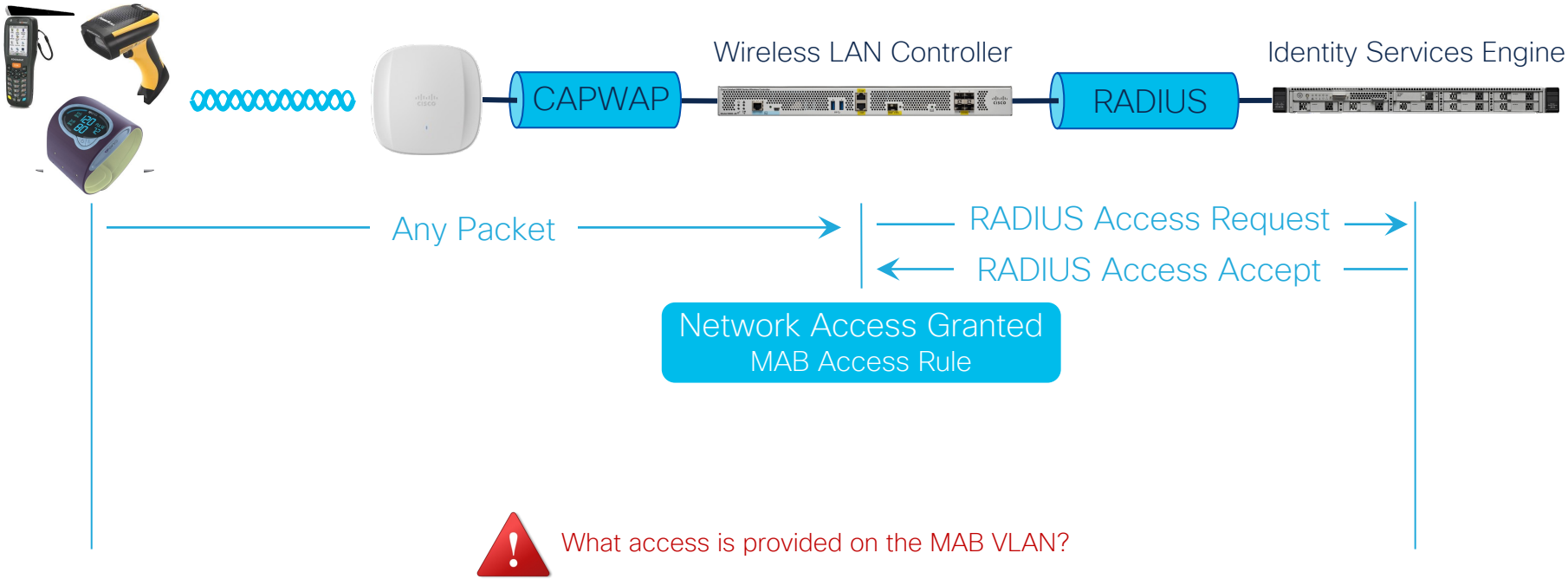
- Native operating system support to detect captive portals
- User is aware of captive portal even when not using browser
- Simplifies guest access adoption
- Avoids the need to redirect HTTPS traffic

Central Web Authentication

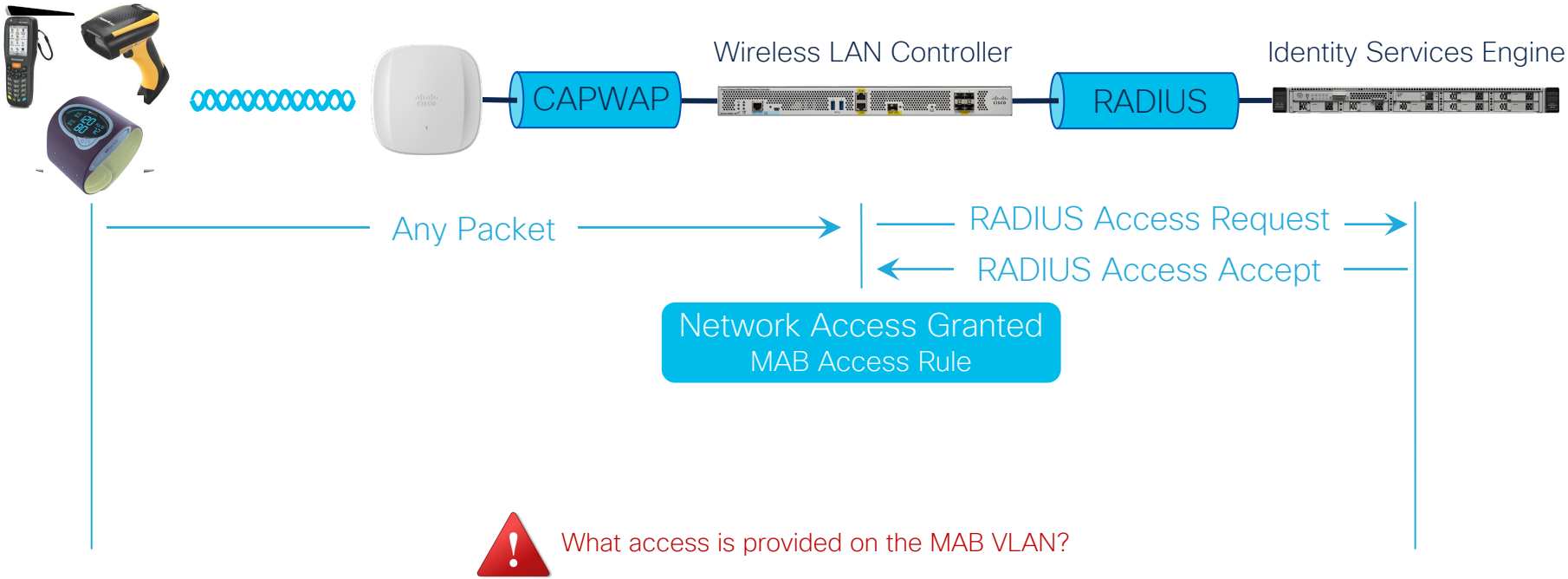
MAC Authentication Bypass



MAC Authentication Bypass



MAC Authentication Bypass



Wi-Fi Certified Easy Connect

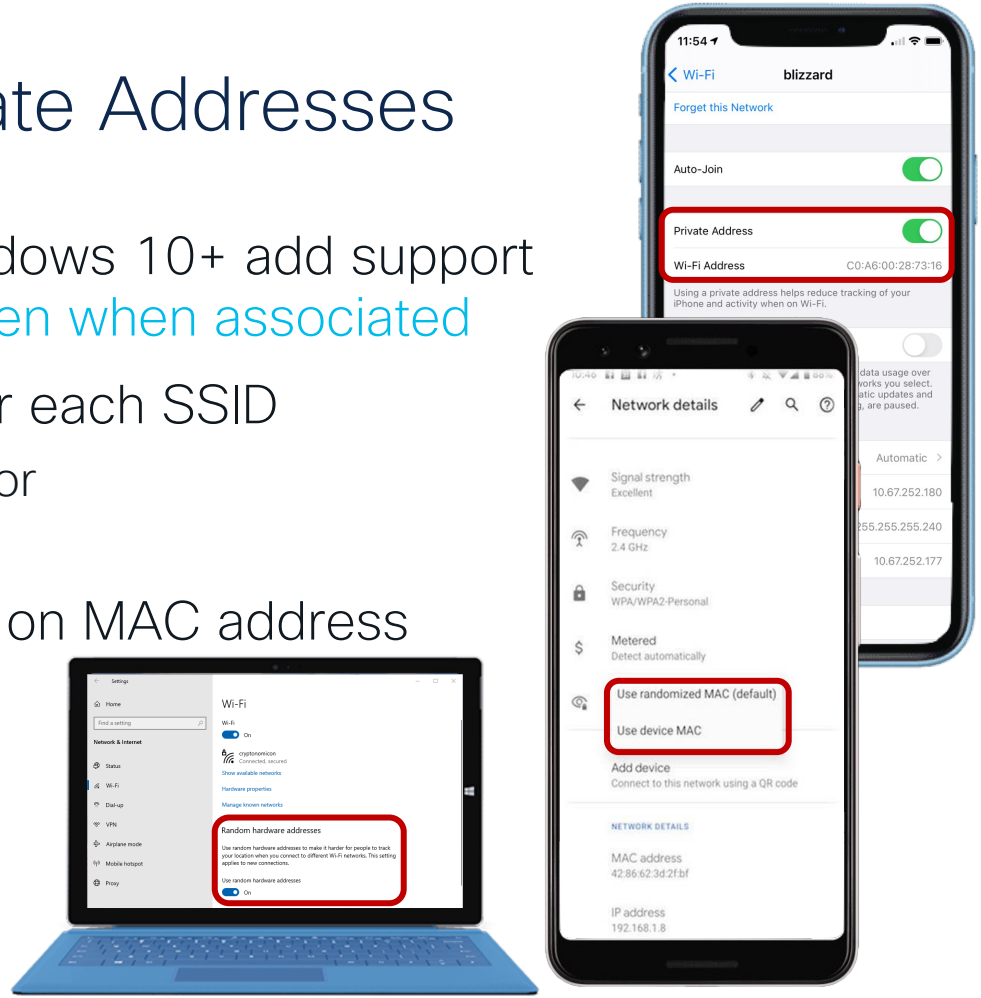
WPA3

Device Provisioning Protocol (DPP)

- 3 Phases
  - Bootstrapping
    - Obtains the public key of new device
  - Authentication and Provisioning
    - Public key is used to create a secure tunnel for credential exchange
  - Network Access
    - PMK derived
    - Four-Way Handshake used as normal
    - Supports Protected Management Frames

Random MAC and Private Addresses

- iOS 14+, Android 10+ and Windows 10+ add support for random MAC Addresses even when associated
- A random MAC is generated for each SSID
  - That MAC may remain constant for the saved profile
- This will impact services based on MAC address
  - MAC authentication bypass
  - Web authentication
  - Location analytics



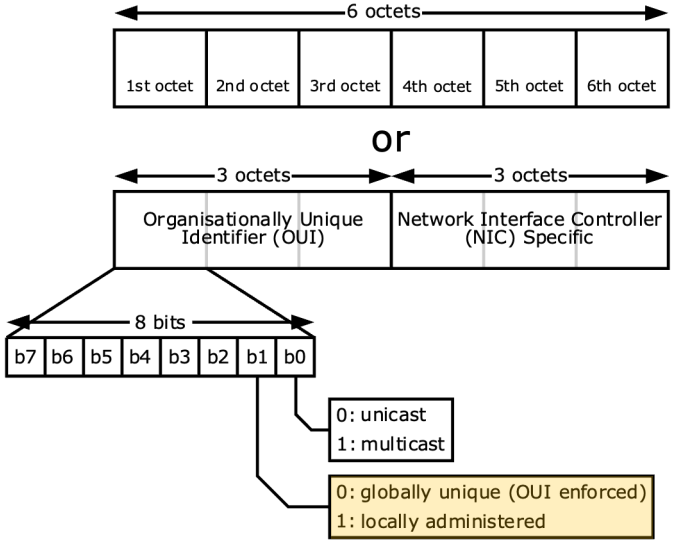
Different OS Implementations

	Windows 10+	Android 10+	iOS 14+, iPadOS 14+, watchOS 7+
Randomization enabled by default	No	Yes	Yes
Same random MAC used for subsequent connection	Yes	Yes	Yes
Randomization saved between device reboot	Yes	Yes	Yes
Random MAC saved when Wi-Fi profile recreated	No	Yes	Yes
Randomization per day and/or per association	Optional	Optional (Android 11 Developer Mode)	No
Randomization enabled upon upgrade for existing Wi-Fi profile	No	No	Yes
Can be enabled/disabled globally	Yes	No	No
API to control randomization exists	Unknown	Yes (Android 11+)	Yes
Randomization saved between factory reset	No	No	Unknown

Random MAC Implications

Profiling	BYOD	Whitelisting	MDM Flow	Guest
Location lookup	User Defined Network	Endpoint Analytics	Forensics	Quarantine

Detecting Random MAC Addresses



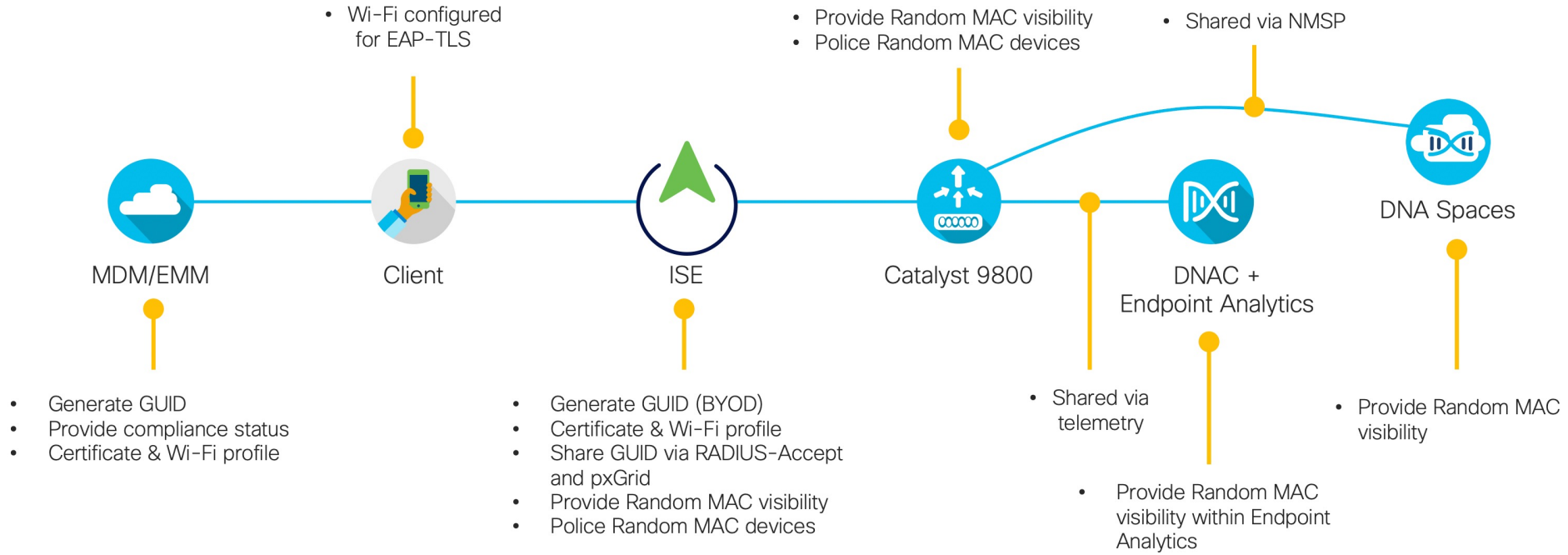
32-28-6D-51-13-AF

56-EF-68-F6-0D-30

0A-13-A8-8E-B5-EF

AE-83-37-55-A7-22

Addressing Random MAC Issues

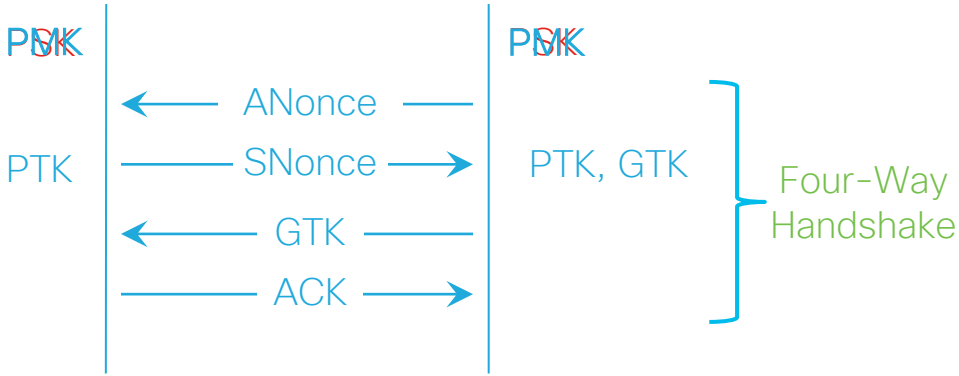


NMSP – Network Mobility Services Protocol

WPA Personal

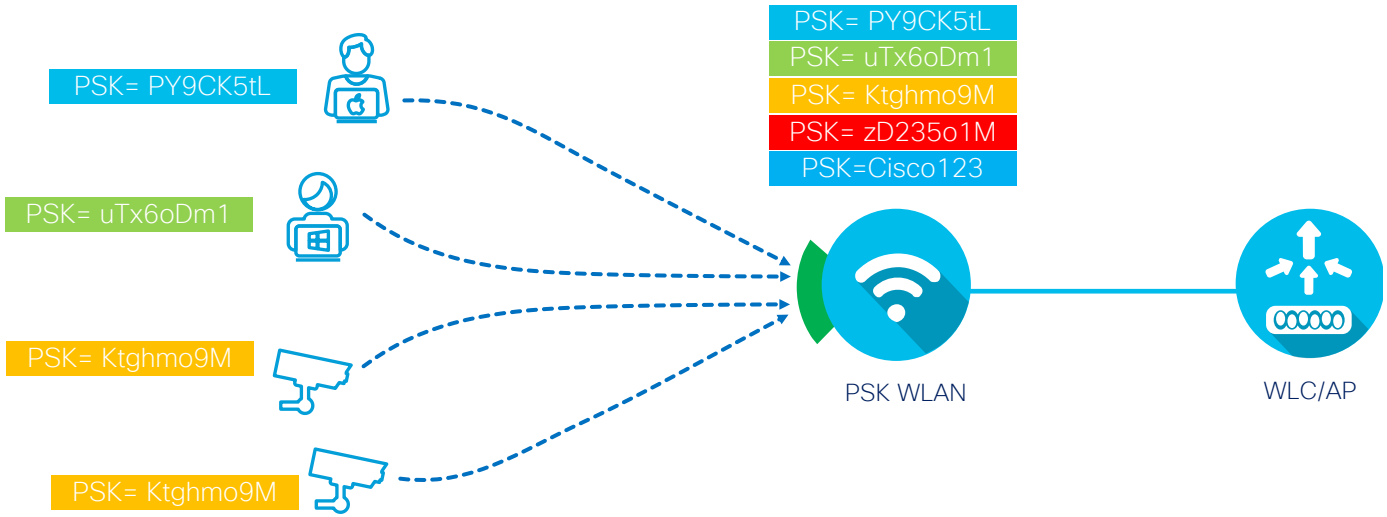
Pre-Shared Key

- Offline Attacks
  - Dictionary
  - Rainbow Table
- Strong Passwords Matter



PTK = SHA(PMK + ANonce + SNonce + AP MAC + STA MAC)

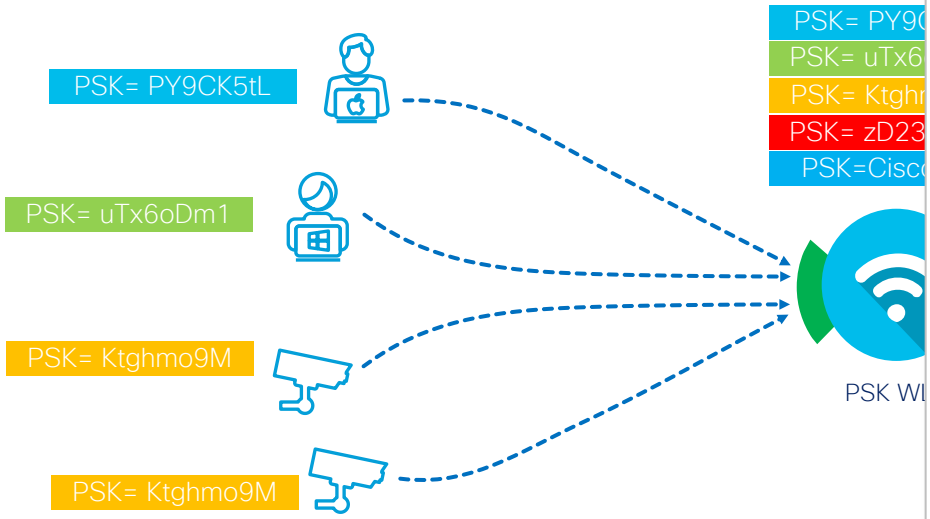
Multi Pre-Shared Key

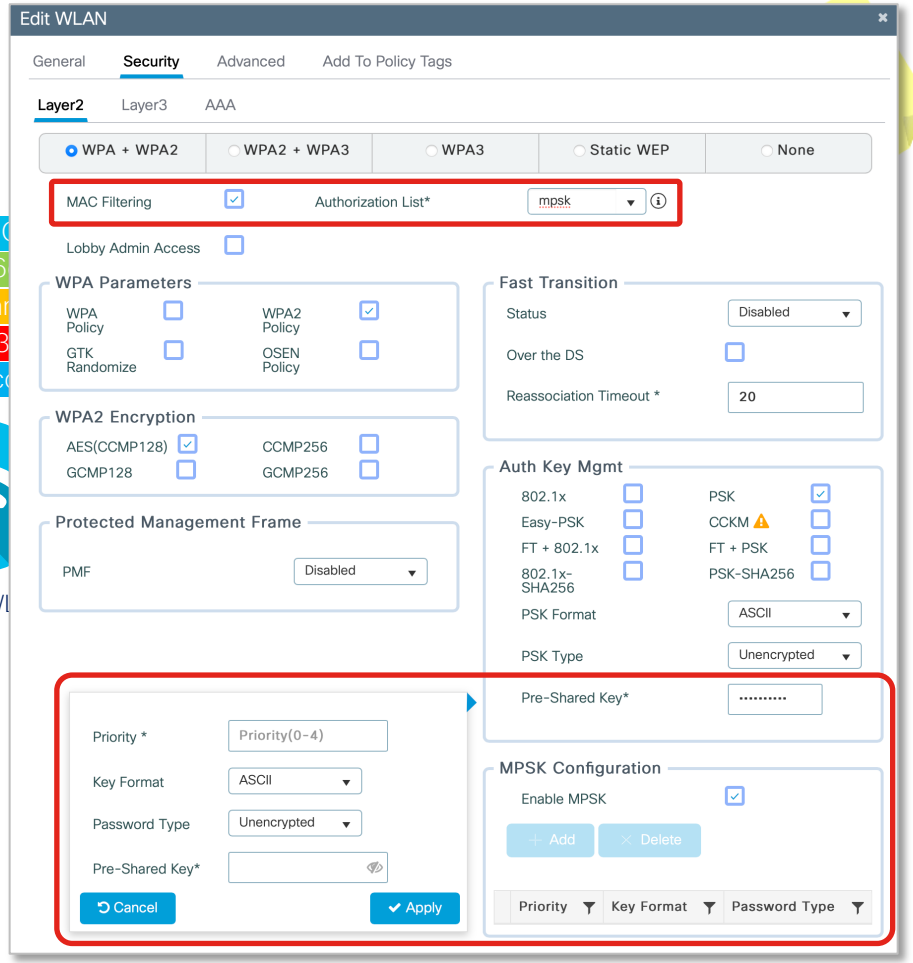


FYI

https://www.cisco.com/c/en/us/td/docs/wireless/controller/ewc/17-2/config-guide/ewc_cg_17_2/multi_preshared_key.pdf

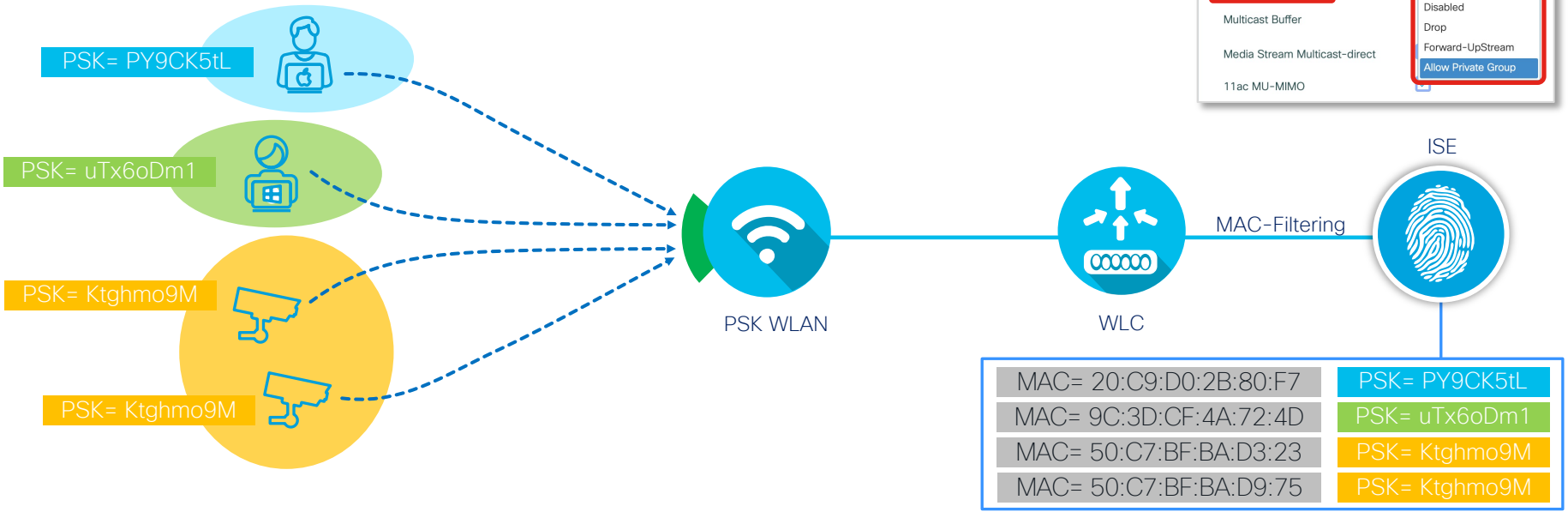
Multi Pre-Shared Key

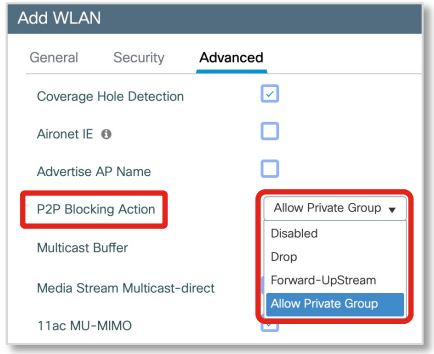




https://www.cisco.com/c/en/us/td/docs/wireless/controller/ewc/17-2/config-guide/ewc_cg_17_2/multi_preshared_key.pdf

Identity PSK





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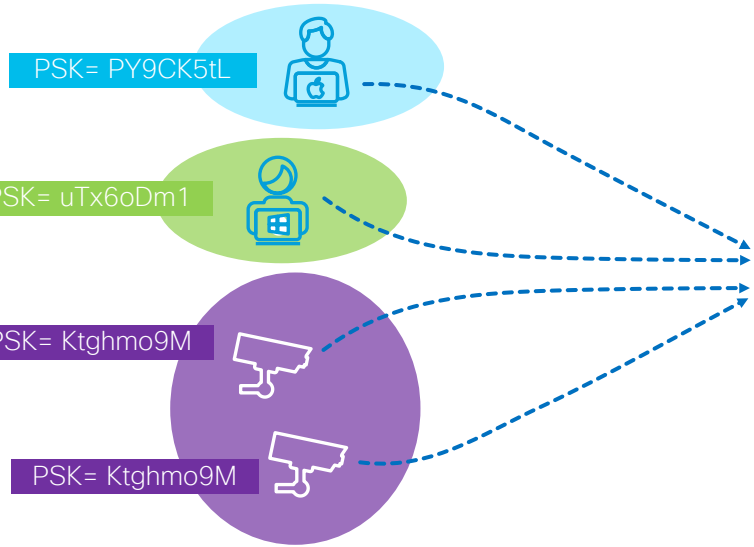
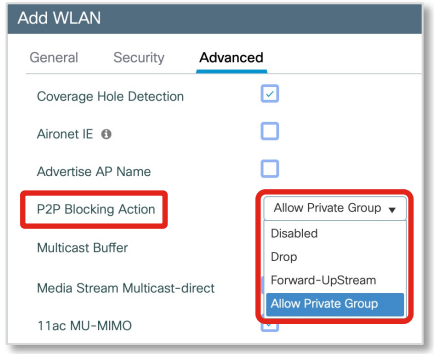
https://documentation.meraki.com/MR/Encryption_and_Authentication/IPSK_with_RADIUS_Authentication

Identity PSK



MAC-Filtering

MAC= 20:C9:D0:2B:80:F7	PSK= PY9CK5tL
MAC= 9C:3D:CF:4A:72:4D	PSK= uTx6oDm1
MAC= 50:C7:BF:BA:D3:23	PSK= Ktghmo9M
MAC= 50:C7:BF:BA:D9:75	PSK= Ktghmo9M
Group == Medical Cart	PSK= zD235o1M
Profile == Security Camera	PSK= 8GB10vaq



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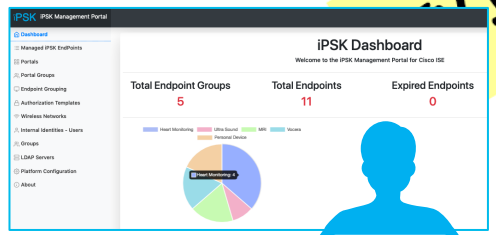
https://documentation.meraki.com/MR/Encryption_and_Authentication/IPSK_with_RADIUS_Authentication

iPSK Manager



Administration

Admin

RADIUS

CoA

SQL

API

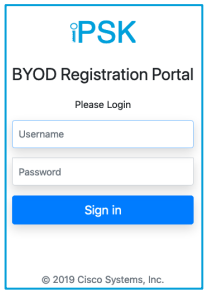
WLC / AP

ISE

iPSK Manager

- Linux
- Apache
- MySQL
- PHP

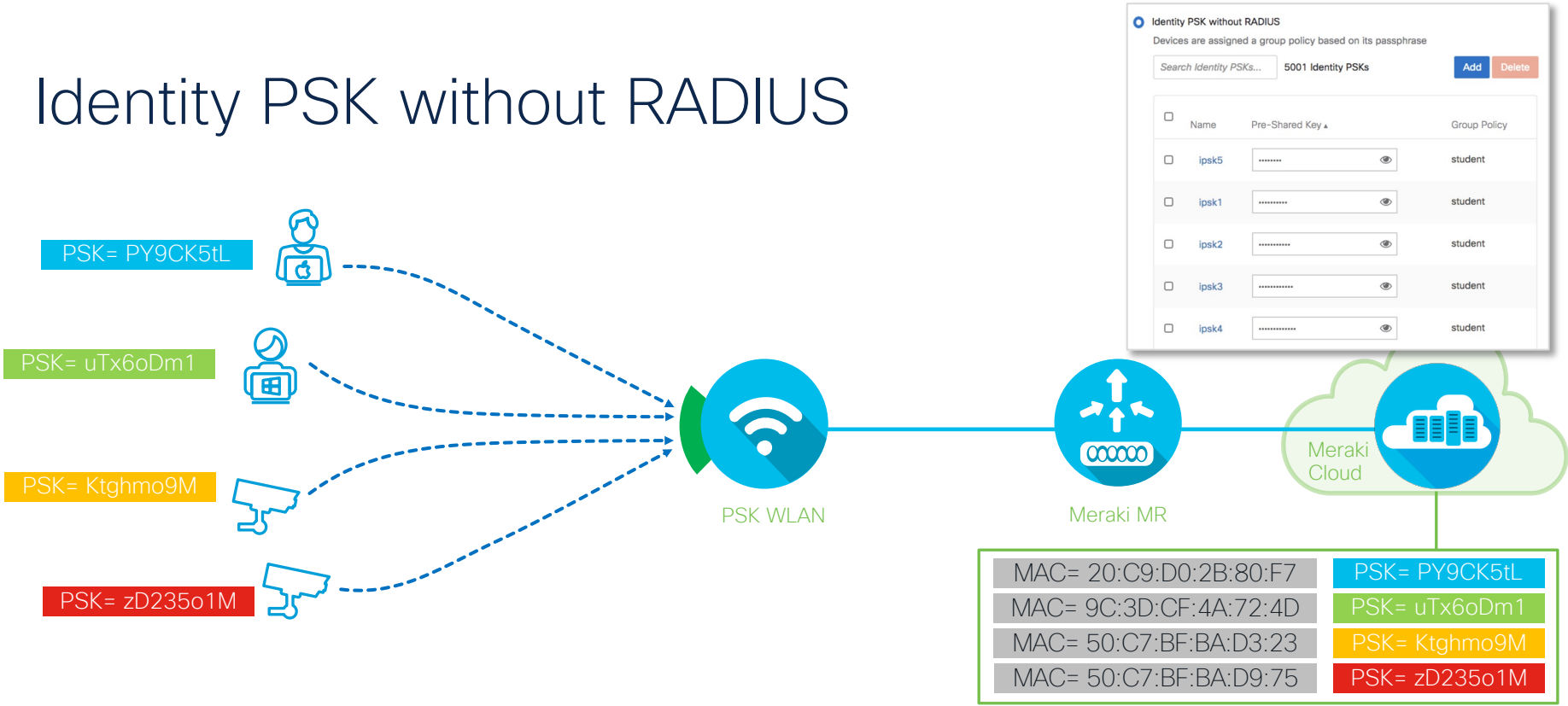
iPSK Lifecycle Management



End Users

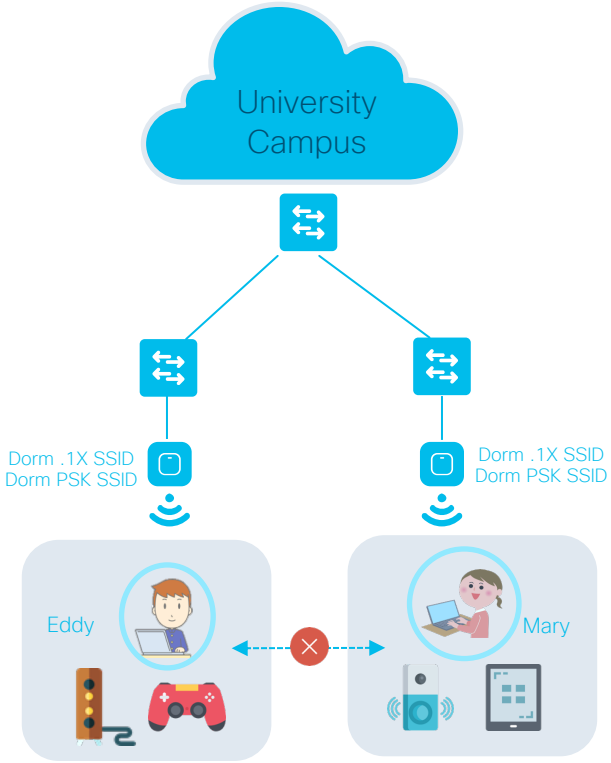
http://cs.co/iPSK-Manager

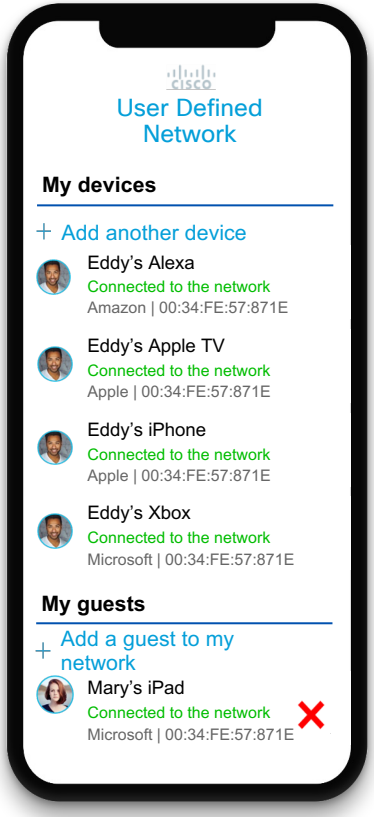
Identity PSK without RADIUS



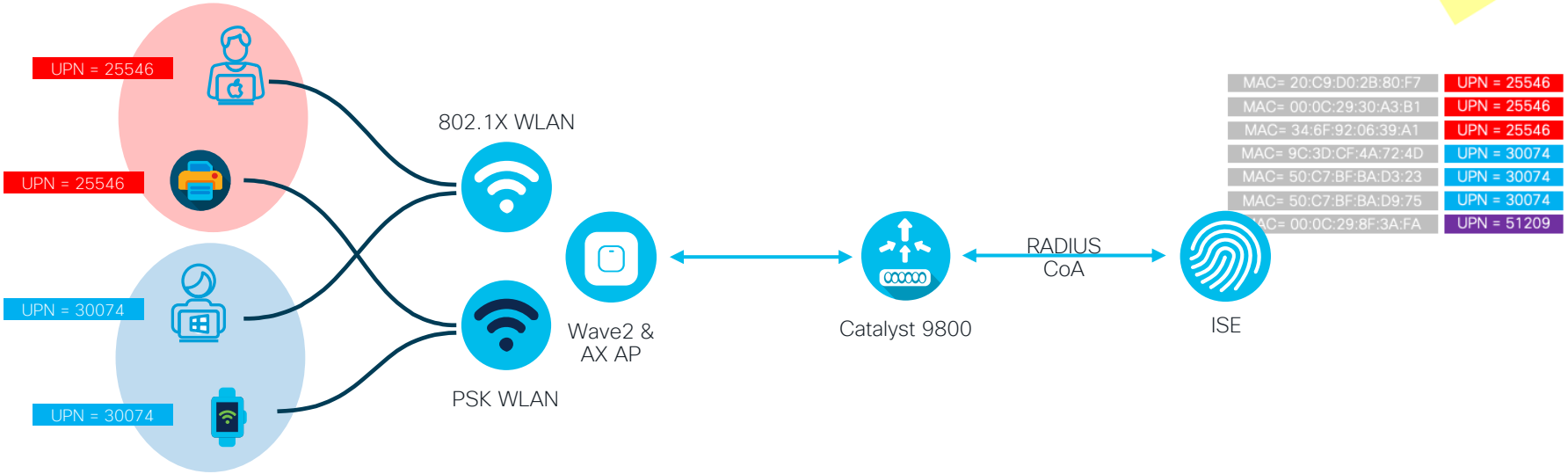
https://documentation.meraki.com/MR/Encryption_and_Authentication/IPSK_Authentication_without_RADIUS

User Defined Network



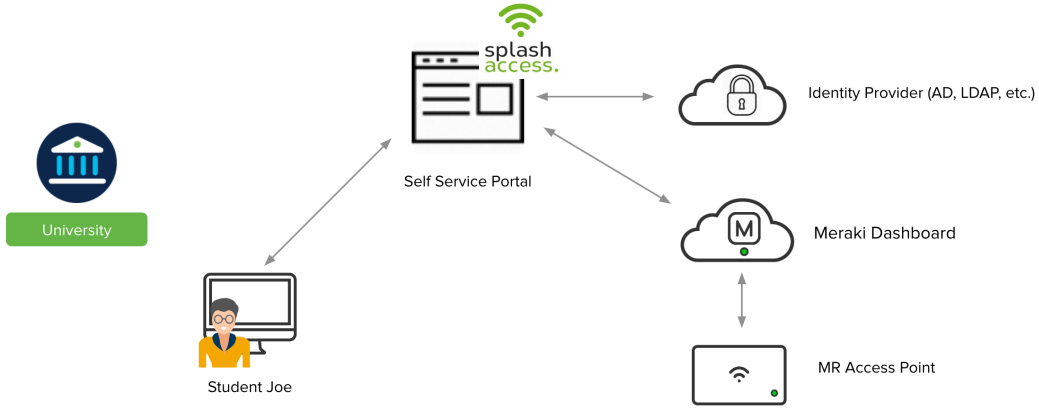


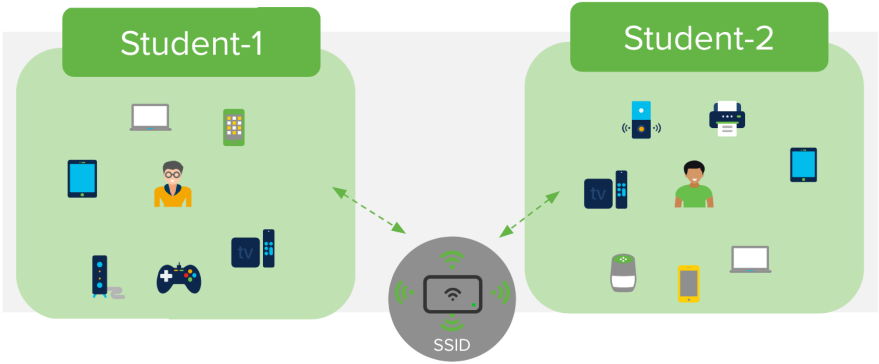
User Defined Network



- Each endpoint is assigned a UPN value via RADIUS
- Works across multiple WLANs and WLAN types
- Endpoint without UPN mapping gets UPN ID of 0
- Filtering can be for mDNS only or for any traffic

Wi-Fi Personal Network





https://documentation.meraki.com/MR/Encryption_and_Authentication/Wi-Fi_Personal_Network_(WPN)

Simultaneous Authentication of Equals

WPA3

- Based on the Dragonfly Key Exchange
  - Balanced Password Authenticated Key Exchange
    - Security of SAE not tied to the complexity of the shared secret
  - SAE exchanges results in a 32-byte PMK
    - Protects against offline dictionary attacks
    - Forward secrecy protects traffic if the password is compromised in future
    - Supports Protected Management Frames
  - WPA3-SAE Transition Mode supports both WPA2-PSK and WPA3-SAE on the same SSID

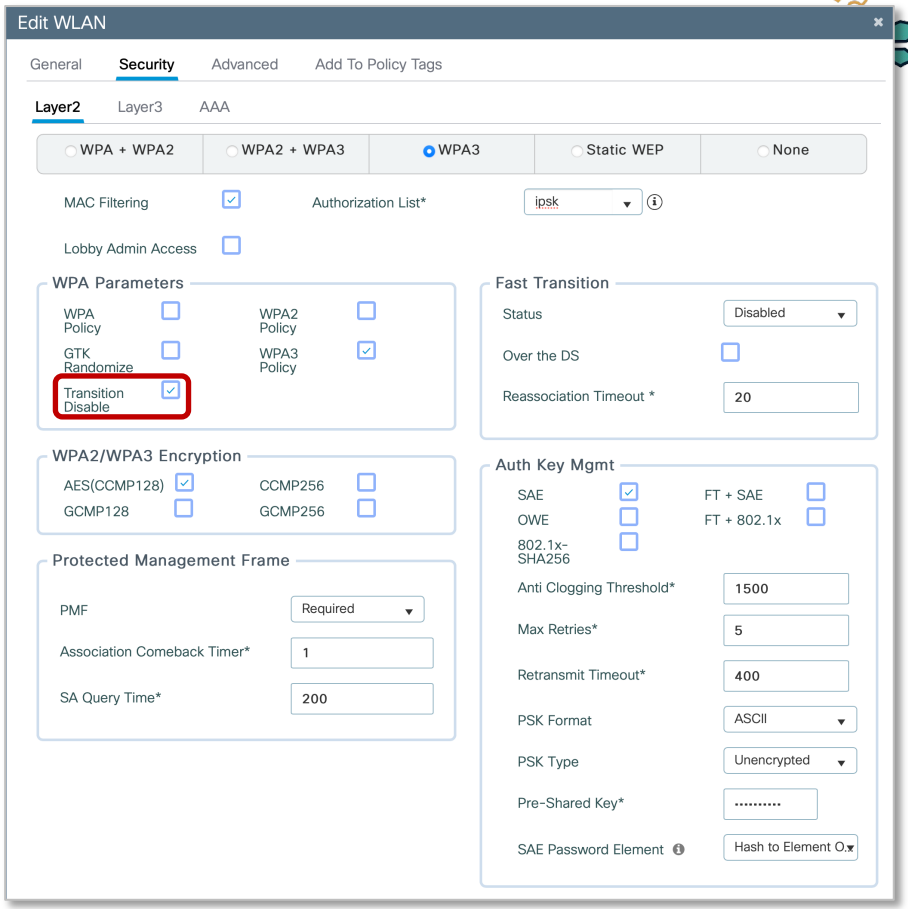
Dragonblood

- Backwards Compatibility Attack
  - Clients can be tricked into connecting to a Rogue WPA2 Personal only network
  - The attacker uses the partial WPA2 handshake for offline attacks
  - Certain devices, even when connected to WPA3 Personal only networks, could be tricked into using WPA2
- Denial of Services Attacks
  - APs should implement anti-exhaustion mechanisms
  - APs should implement detection mechanism and blacklist misbehaving clients

Dragonblood: Analysing WPA3's Dragonfly Handshake

Dragonblood

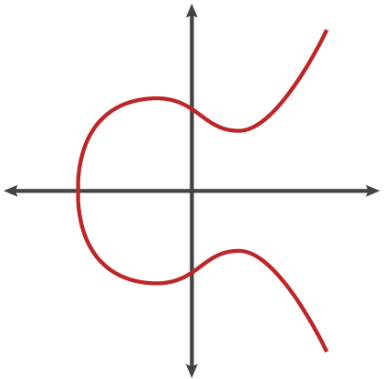
- Backwards Compatibility Attack
  - Clients can be tricked into connecting to a Rogue WPA2 Personal only network
  - The attacker uses the partial WPA2 handshake for offline attacks
  - Certain devices, even when connected to WPA3 Personal only networks, could be tricked into using WPA2



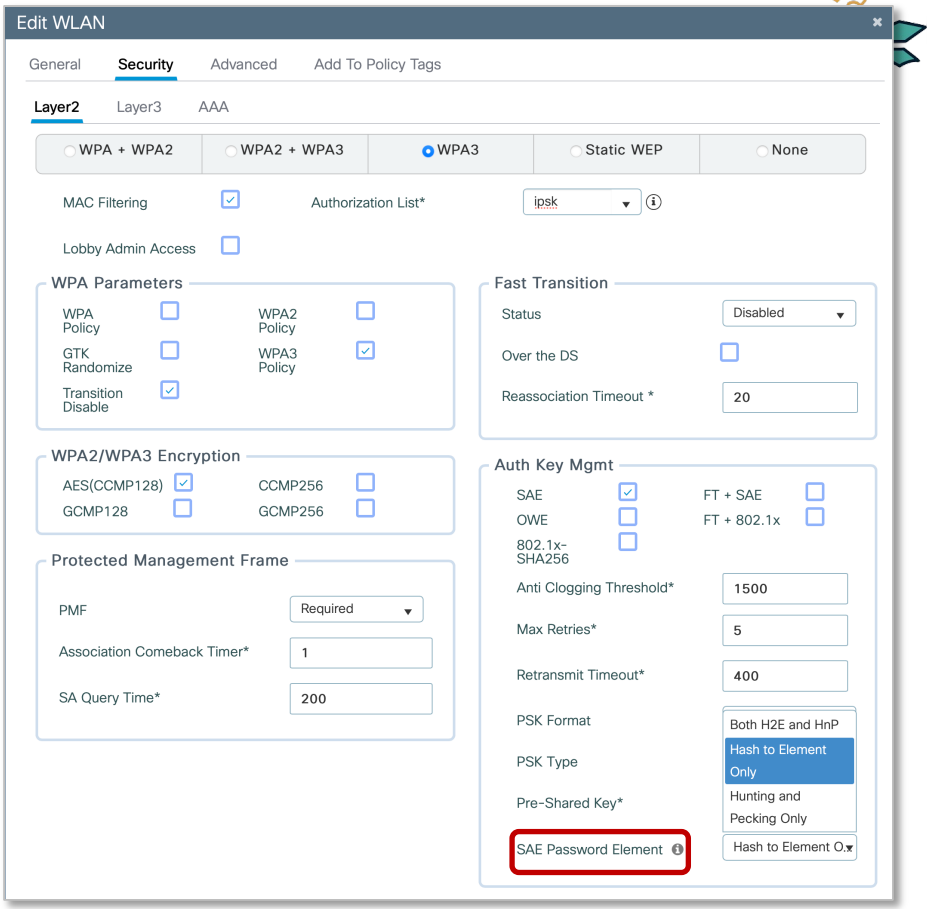
[Dragonblood: Analysing WPA3's Dragonfly Handshake]

Dragonblood

- Timing-Based Side-Channel Attacks
  - The time it takes an AP to respond to commit frames may leak information about the password



$$y^2 = x^3 + ax + b$$



Wi-Fi Certified Enhanced Open

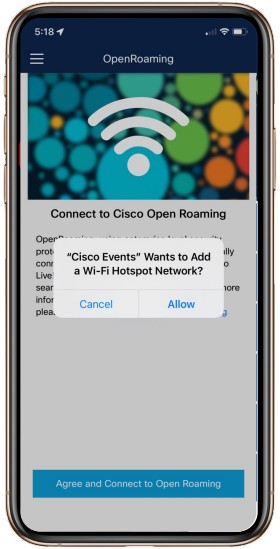
WPA3

- Opportunistic Wireless Encryption (OWE)
  - Replaces 802.11 “open” authentication support
  - Client and AP perform an unauthenticated Diffie-Hellman Key Exchange to establish a PMK
  - Four-Way Handshake used as normal
  - Supports Protected Management Frames
- Diffie-Hellman is susceptible to MitM attacks
  - Would allow the attacker same visibility as on an Open network

Decoupling Access and Identity

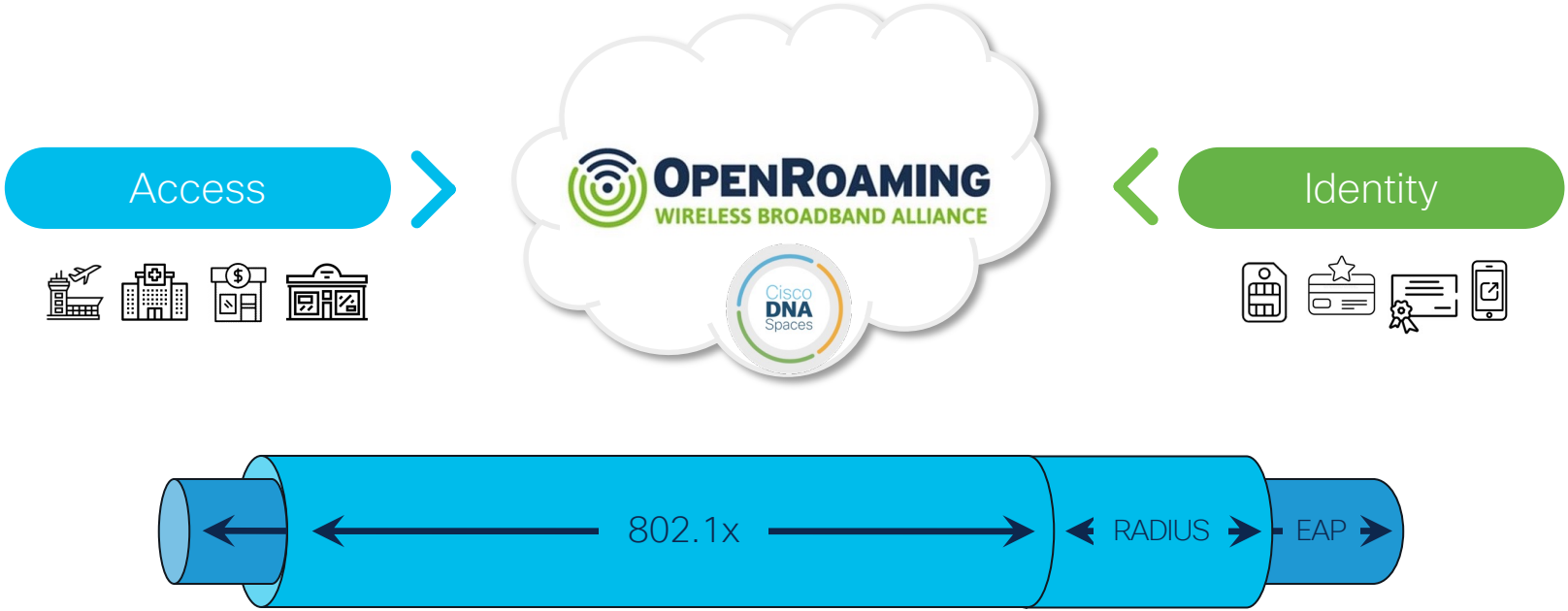
Decoupling Access and Identity

Access



Identity

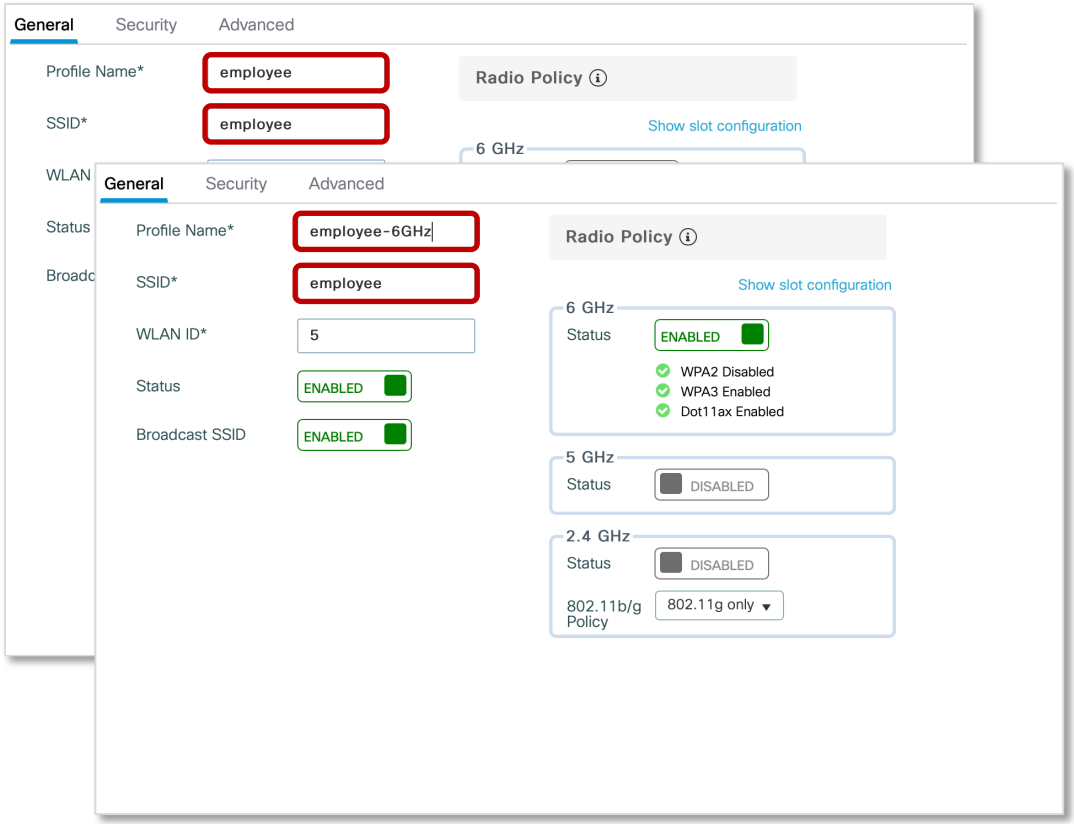
OpenRoaming



Wi-Fi 6E Security

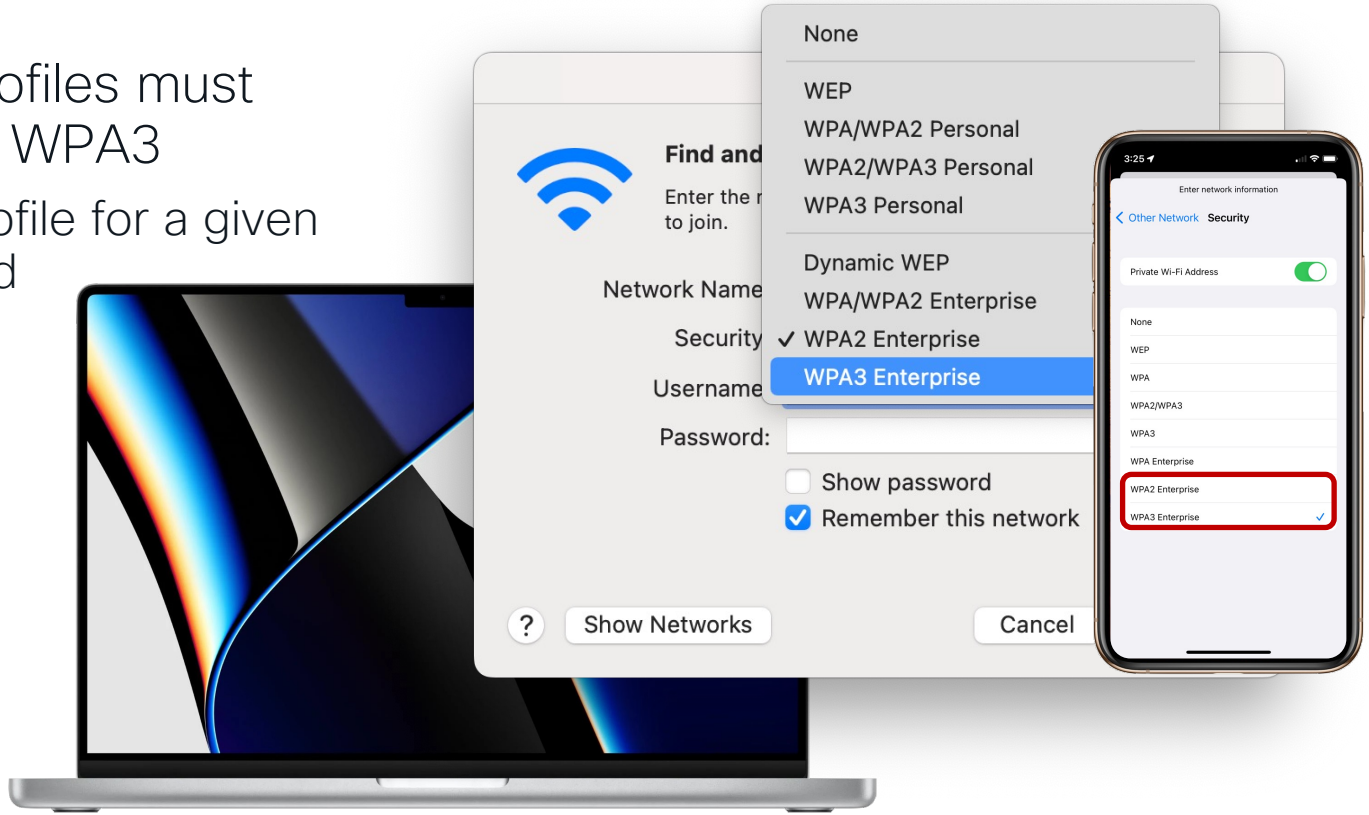
WPA3 and OWE are mandatory for Wi-Fi 6E

WPA2 and Open are not supported on 6GHz



Wi-Fi 6E Security

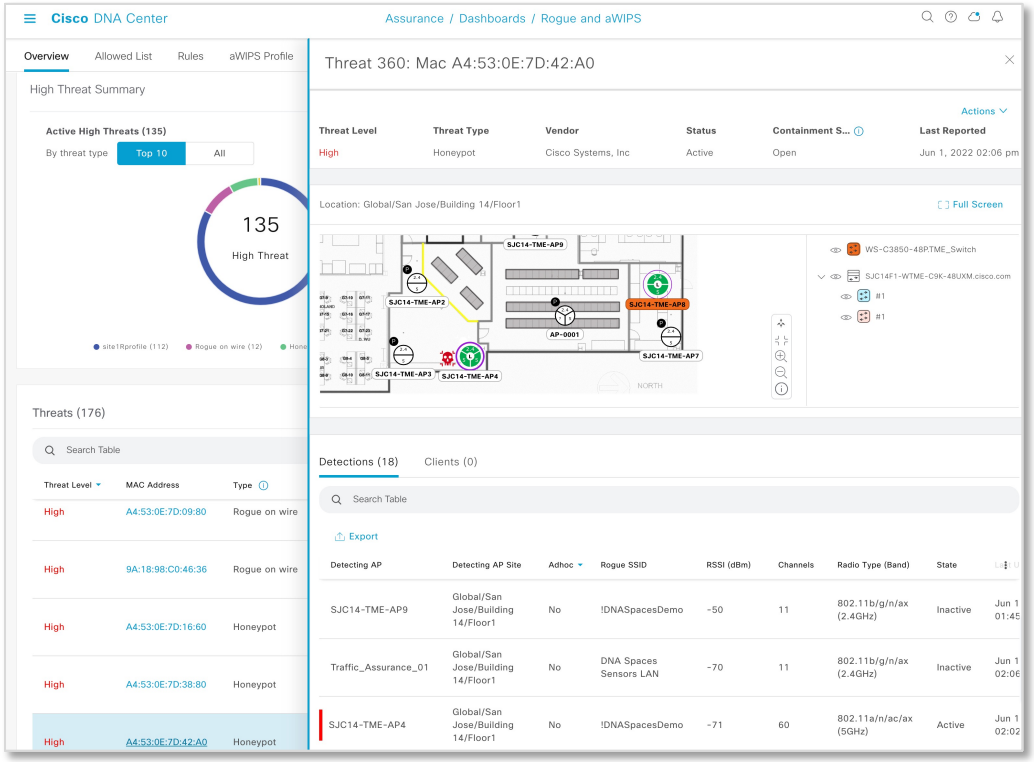
- Client device profiles must select WPA2 *or* WPA3
  - And only one profile for a given SSID is permitted



Rogue Detection and Advanced WIPS

Rogue Detection and Advanced WIPS

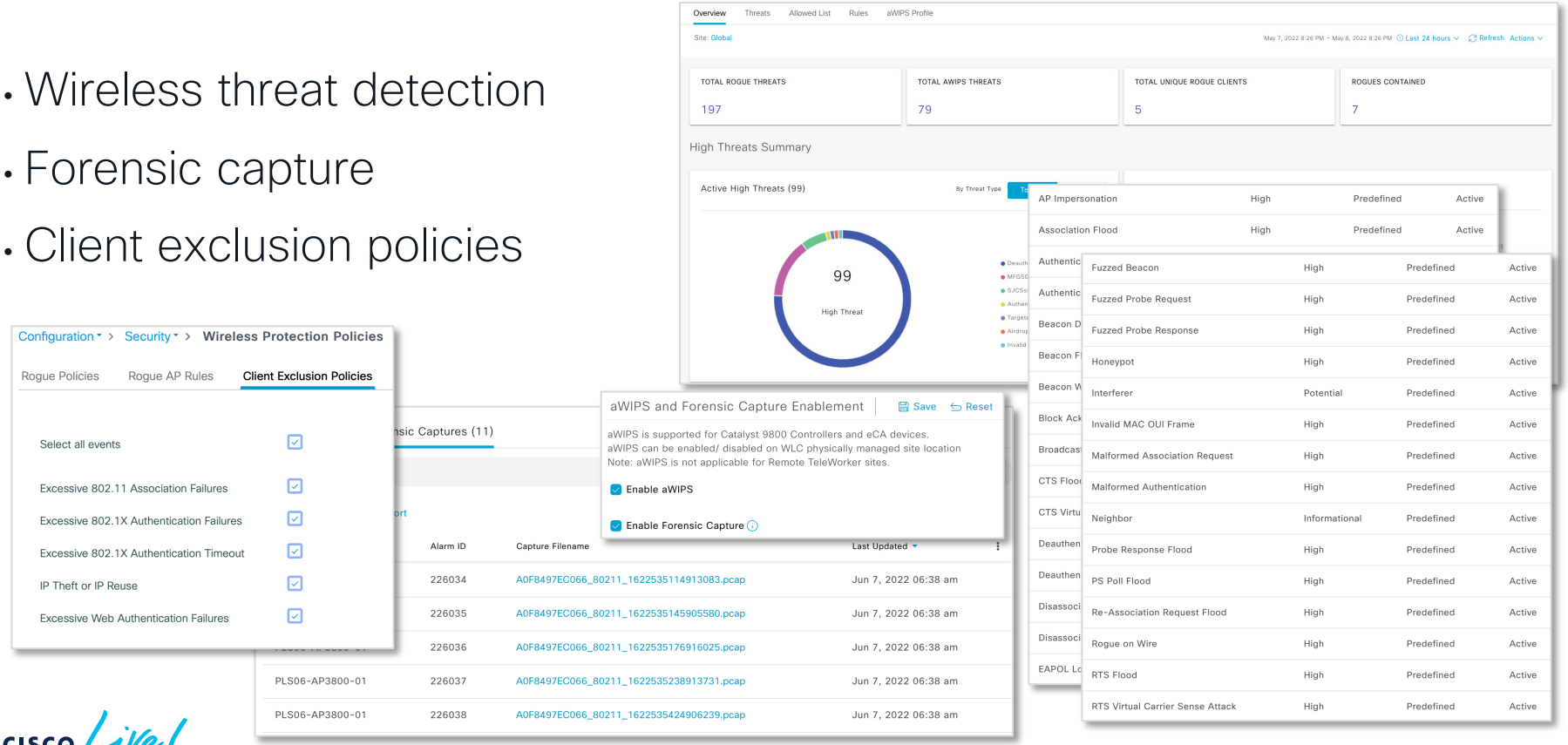
- Centralized wireless threat management
- Rogue detection
- Rogue location and mitigation
- Monitor and classify threats
- Event correlation
- Security compliance reporting



https://www.cisco.com/c/en/us/td/docs/cloud-systems-management/network-automation-and-management/dna-center-rogue-management-application/2-3-3/quick-start-guide/b_rogue_management_qsg_2_3_3.html

Rogue Detection and Advanced WIPS

- Wireless threat detection
- Forensic capture
- Client exclusion policies



Access Point Scanning Options

Off-Channel Scanning

- All channels scanned every 180s within a 3m period
- Dwell time is 50ms
- Channel change is 10 ms
- AP is off-channel for 60ms

Monitor Mode Access Point

- Continuous cycle 1200ms dwell across all channels
- Supports Rogue Detection & WIPS, RRM & CleanAir, and Fast Locate

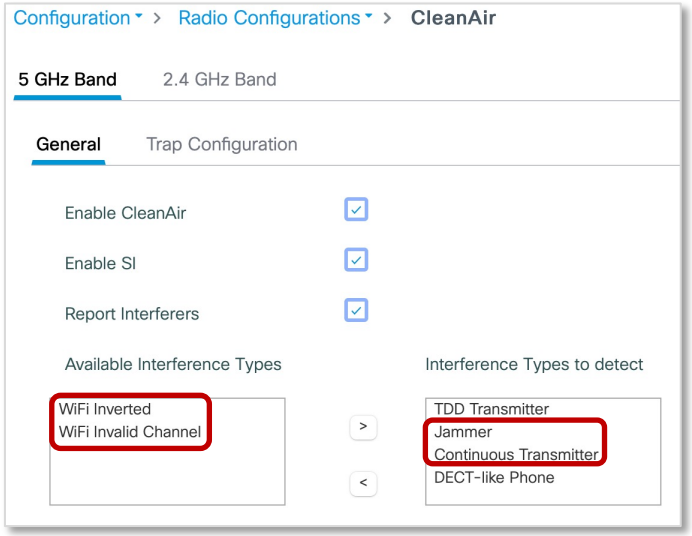
Dedicated Scanning Radio

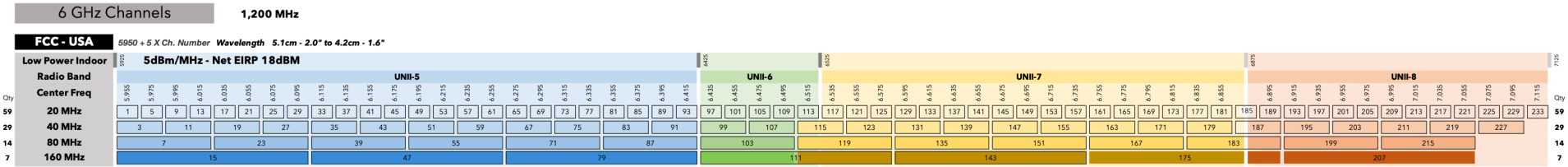
- Catalyst 9136
- Catalyst 9130
- Catalyst 9120

- Catalyst 9166
- Catalyst 9164
- Catalyst 9162

CleanAir Pro Dedicated Scanning Radio

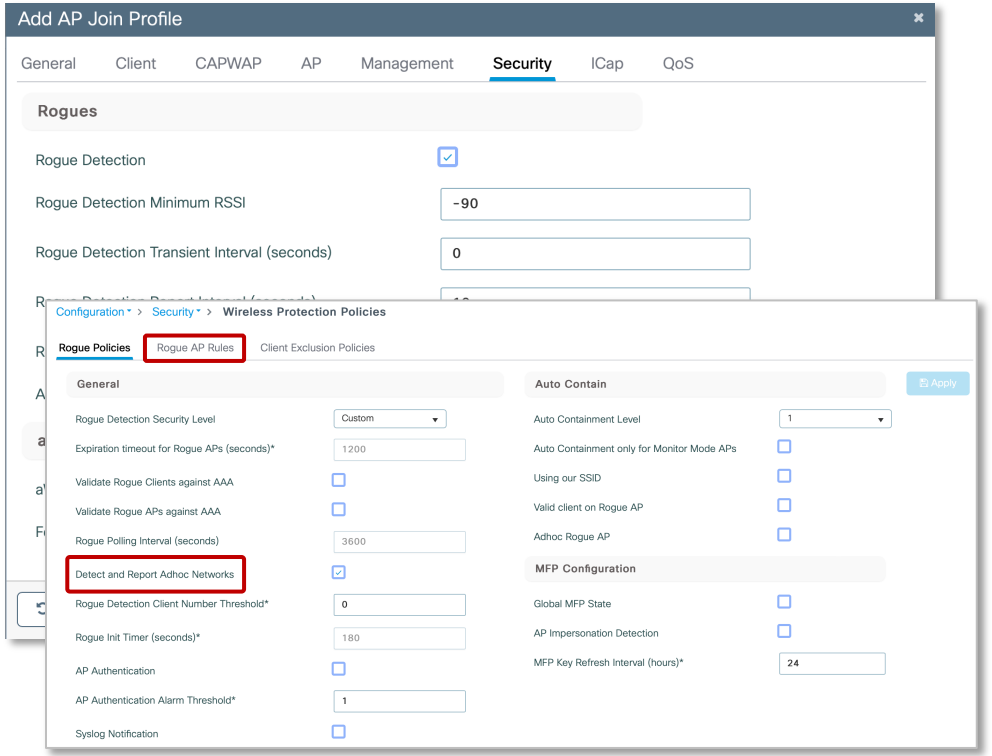
- Interferers
  - Layer 1 Denial of Service Attack
- Rogue AP Detection
  - Inverted
  - Invalid Channel
- 6GHz Support





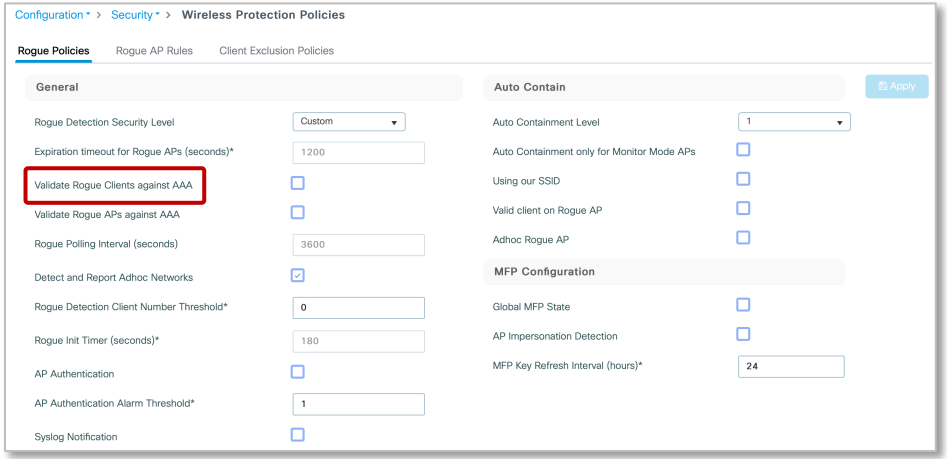
Rogue Access Points

- A Rogue AP is any AP which is not part of our infrastructure
  - Most of them will be legitimate
  - Some of them may be malicious
  - Correctly differentiating between the two is critical
  - Detecting APs on the wired network is hard
    - Wired 802.1x matters

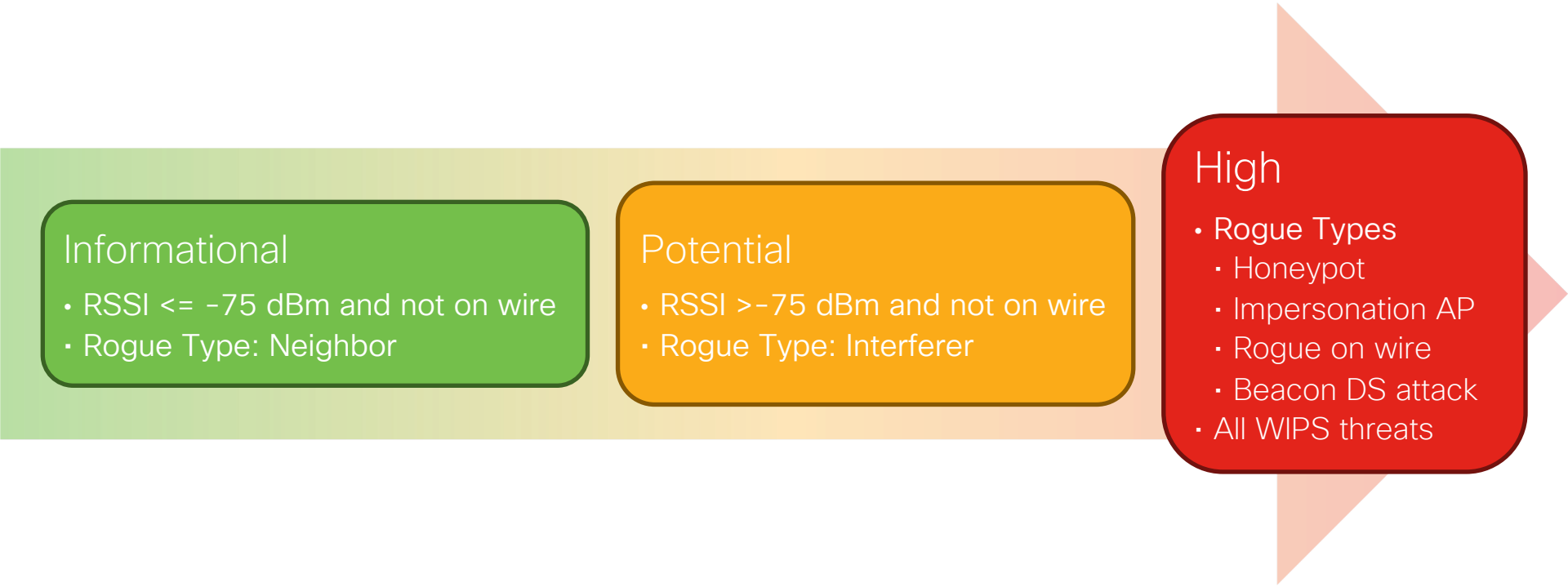


Rogue Clients

- A Rogue Client is any client which is connected to a Rogue AP
  - What we care about are our clients which have connected to the Rogue AP
  - But this is not necessarily a risk
- Clients may create ad-hoc wireless networks
  - This can be a risk if they have bridged to the wired network

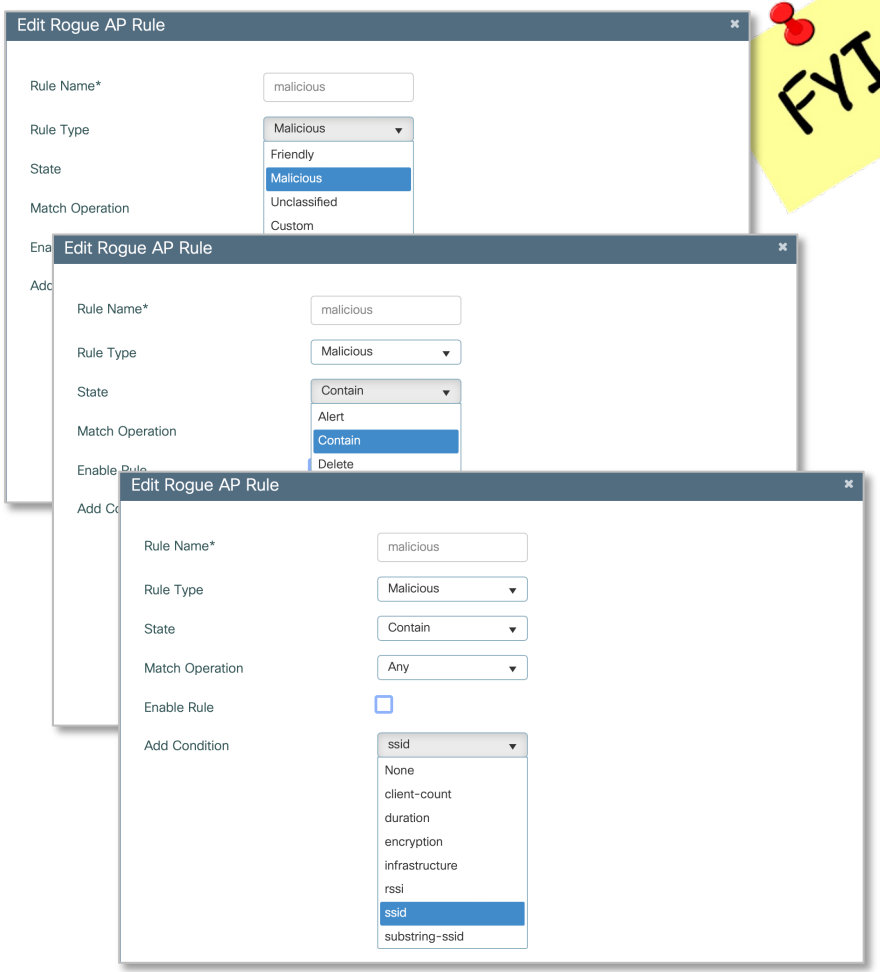


DNA Center Threat Levels

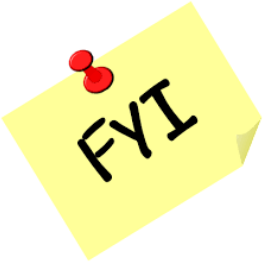


Rogue AP Rules

- Create Rogue Rules to classify rogues as Malicious or Friendly based on specific criteria
  - SSID name
  - RSSI value
  - Encryption condition
  - Minimum rogue client count
- Rules can also define actions
  - Alert
  - Contain



Rogue Notification Triggers

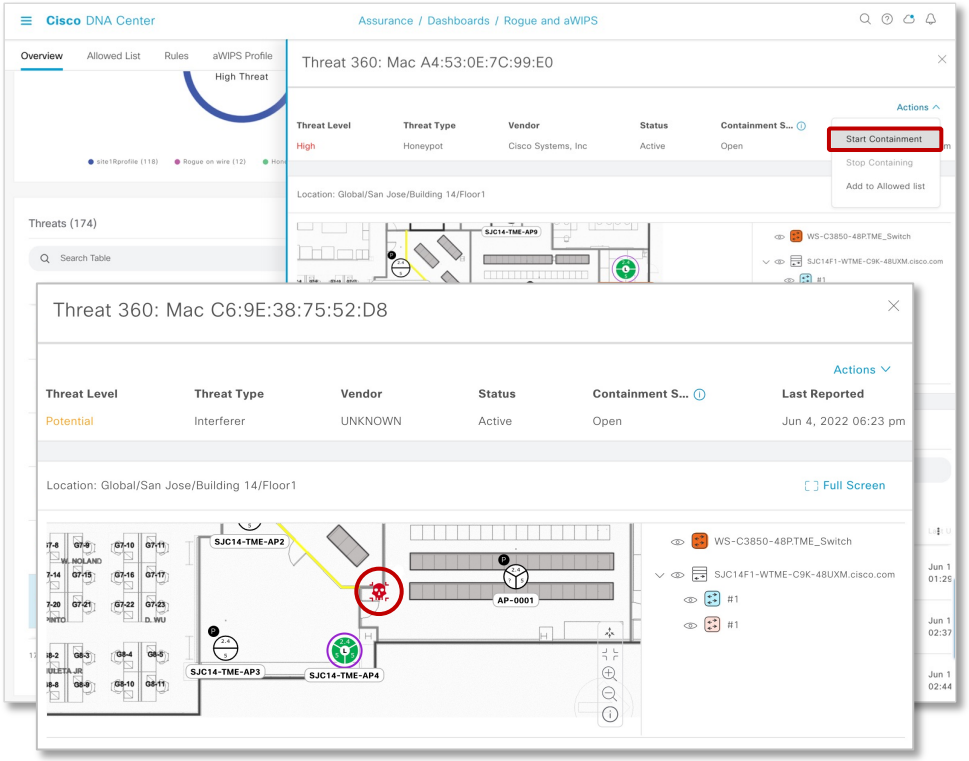


- The Catalyst 9800 has aggressive rogue notification thresholds by default
- In environments with a large number of Rogues, this may result in excessive notifications sent to the receiver
- In these scenarios, increase the Rogue AP and Client RSSI notification threshold
  - The default value is 0
  - Recommendation to increase to 5 or higher

```
C9800(config)#wireless wps rogue ap notify-rssi-deviation 5
C9800(config)#wireless wps rogue clients notify-rssi-deviation 5
```

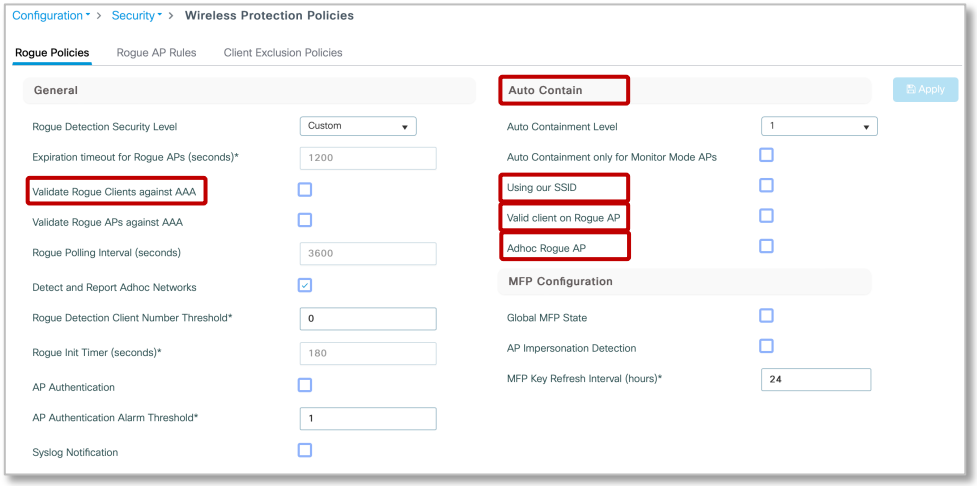
Rogue AP Containment

- How do we contain Rogue APs?
  - Containment is a spoofed 802.11 disassociation request attack
- How does WPA3 affect Rogue AP containment?
  - 802.11w will change how we can mitigate Rogue AP related threats
  - The ability to physically locate rogues will be key

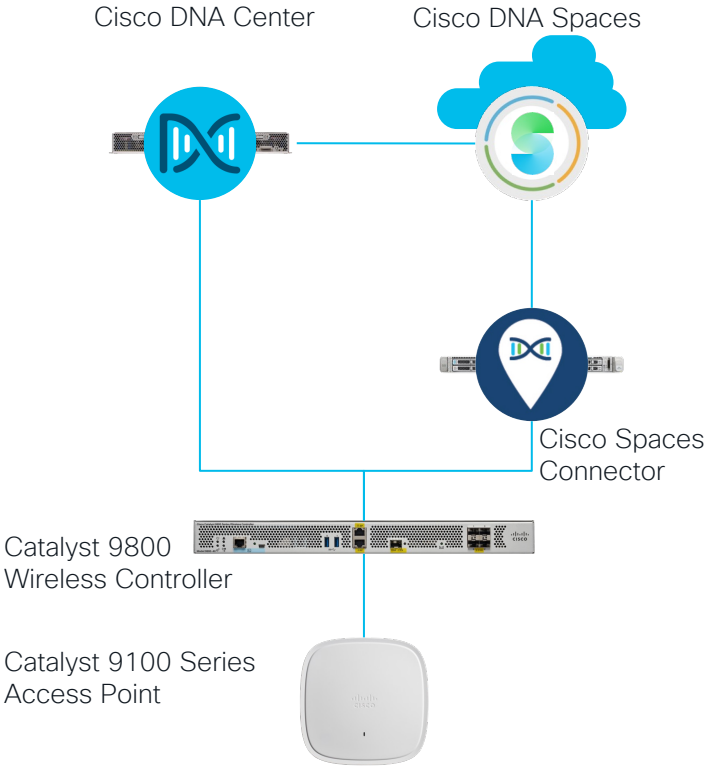


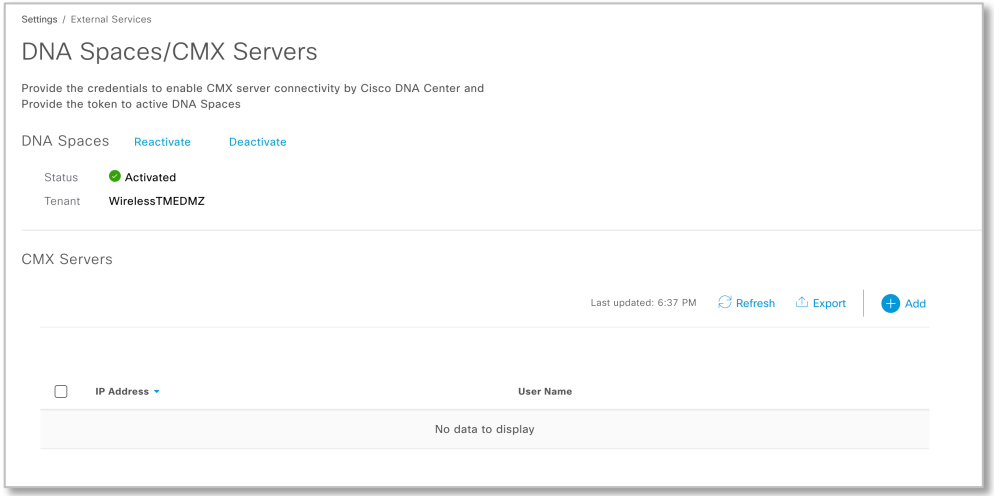
Rogue AP Auto Containment

- While we can configure the network to automatically contain detect Rogue APs, consider your environment and how to ensure that *only* malicious Rogues are being contained

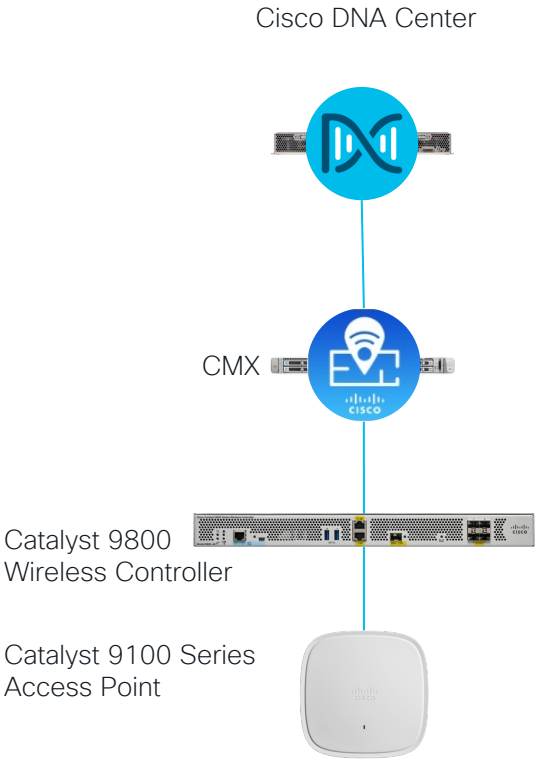


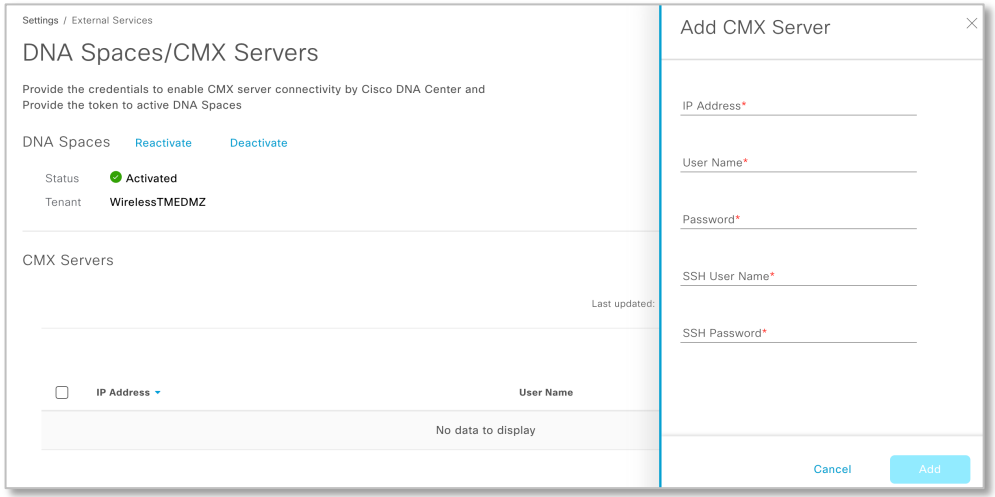
Enabling Location Services





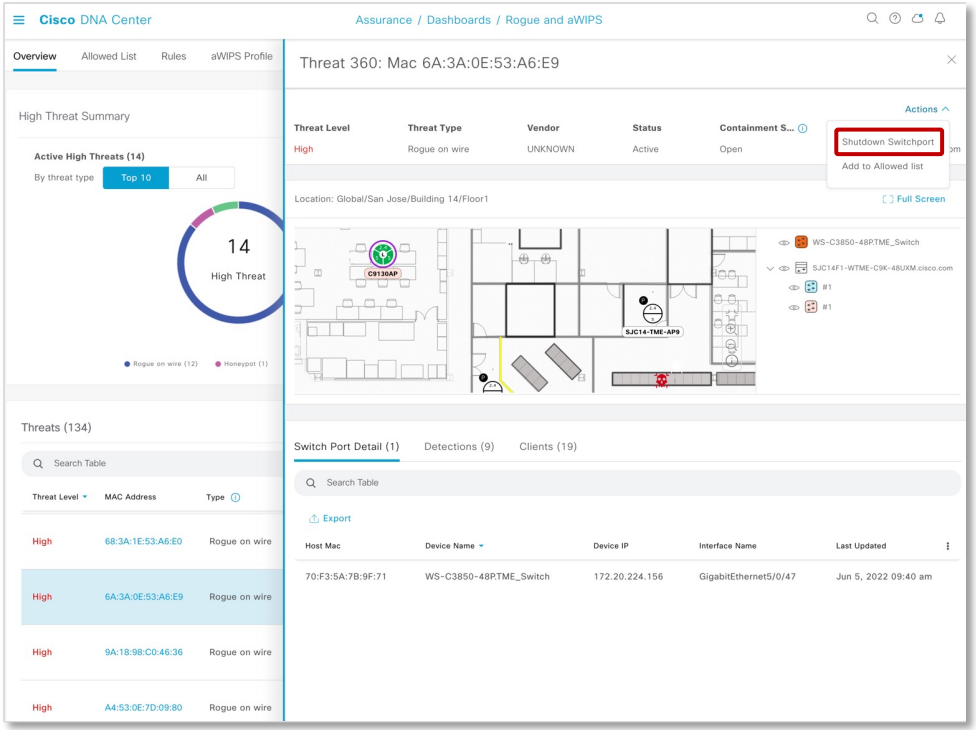
Enabling Location Services





Rogue on Wire

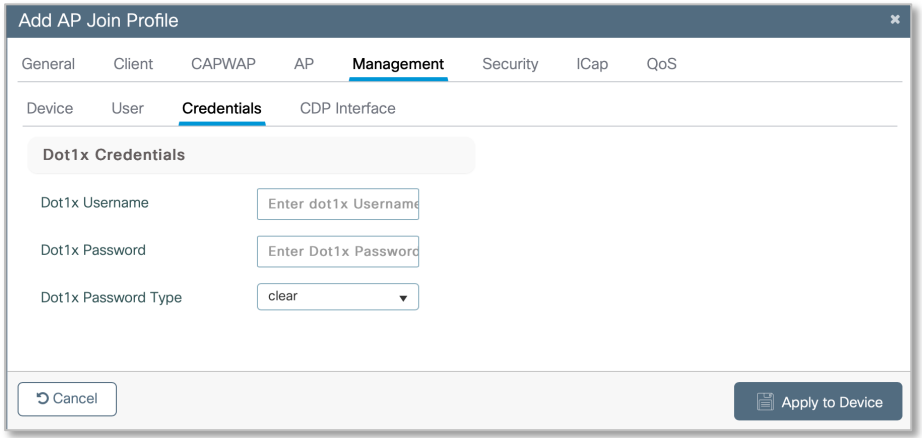
- Matching Algorithms
  - MAC Address ±2/±1
  - Vendor matching algorithms
- Rogue AP in Bridge Mode
  - Locate the Rogue AP via the Rogue Client MAC address and Gateway MAC Address



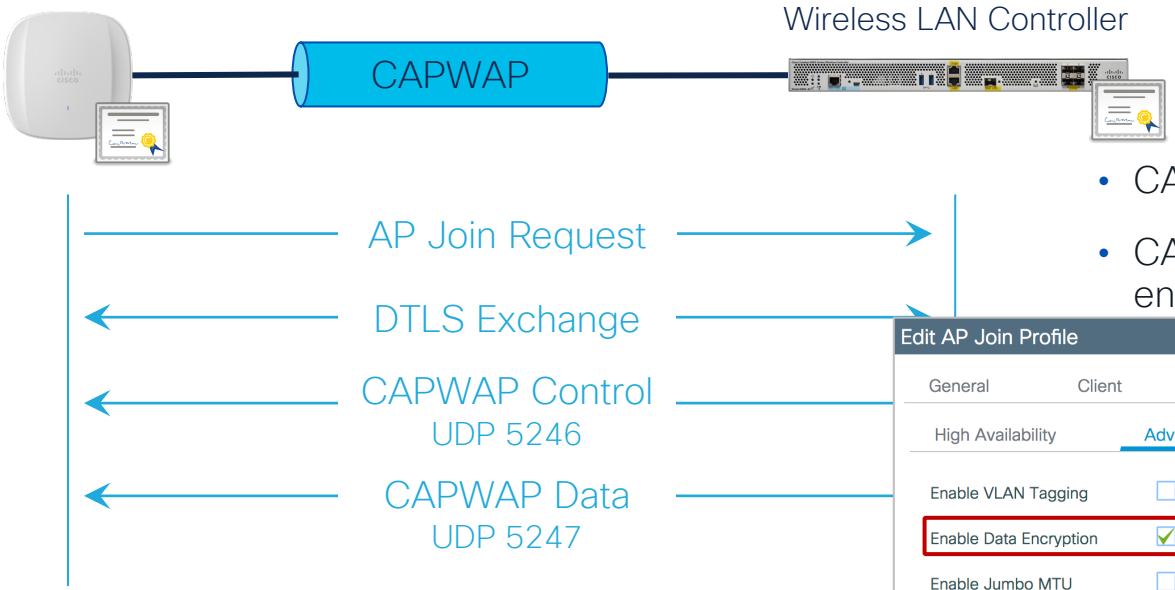
Securing AP Switch Port Access

802.1x
Authentication
(EAP-FAST)

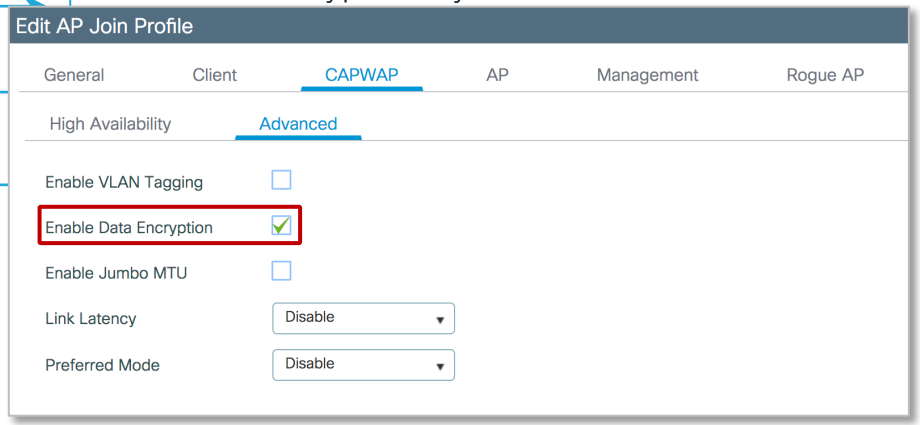
How do we bootstrap configure the AP?



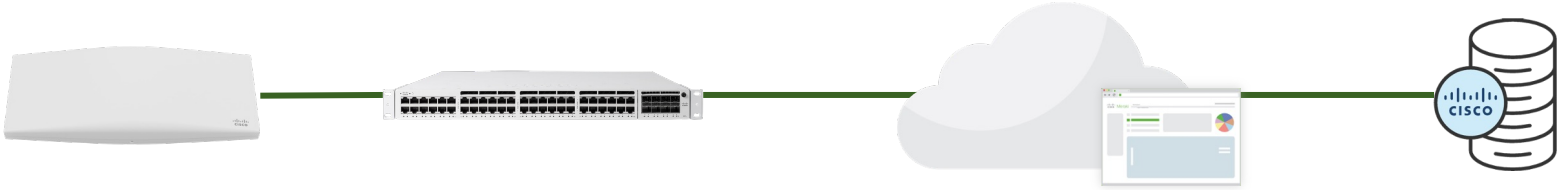
Securing AP to Controller Communication



- CAPWAP Control encrypted by default
- CAPWAP Data encapsulated but not encrypted by default



SecurePort

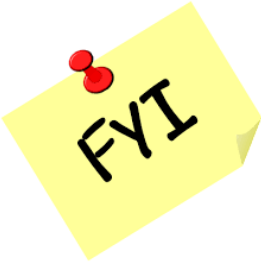


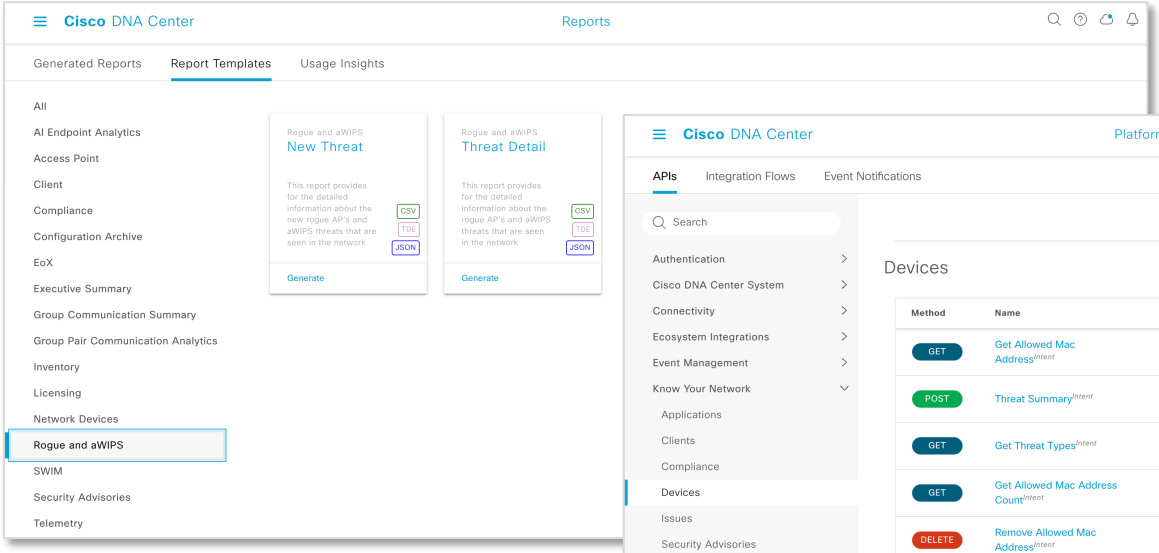
1. MR connected to MS
2. MS permits Meraki dashboard connection for MR
3. MR requests certificate from Cisco PKI
4. MR authenticates with acquired certificate
5. MS authorizes port based on configured profile

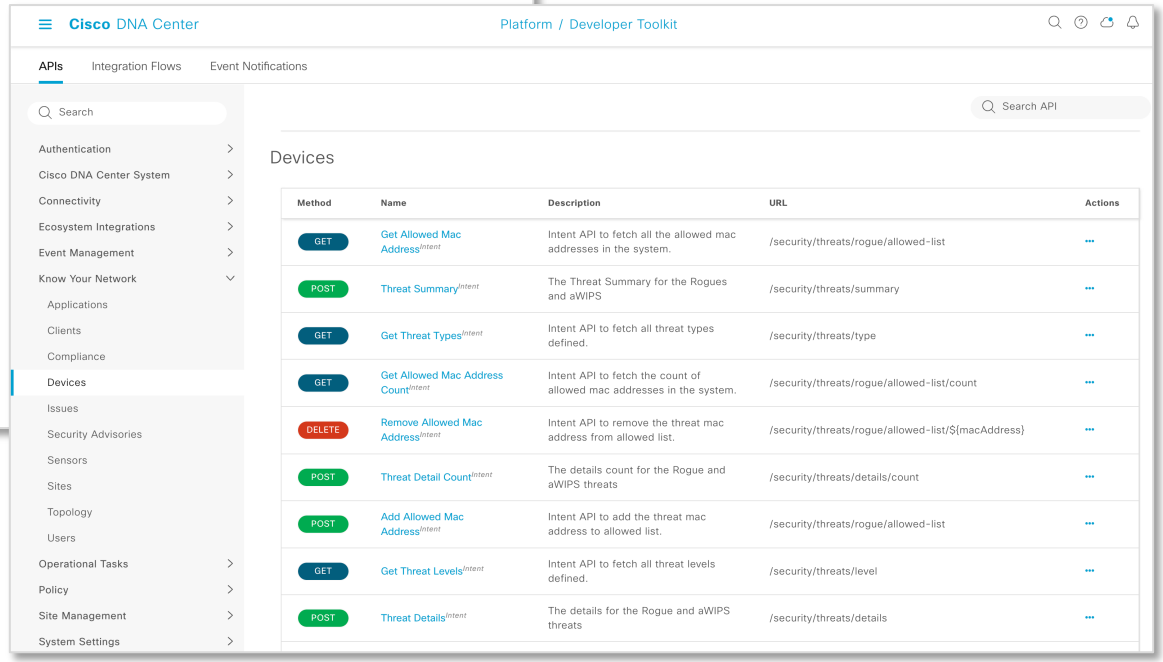
Air Marshal

- Rogue AP Detection
  - Wired Rogue
- WIDS/WIPS
  - Spoofed Management Frames
  - Malicious Broadcasts / DoS
  - Packet Floods

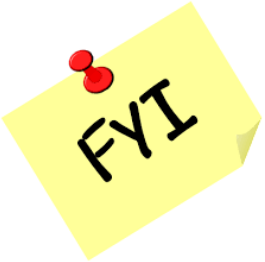
Rogue and WIPS Reporting and APIs





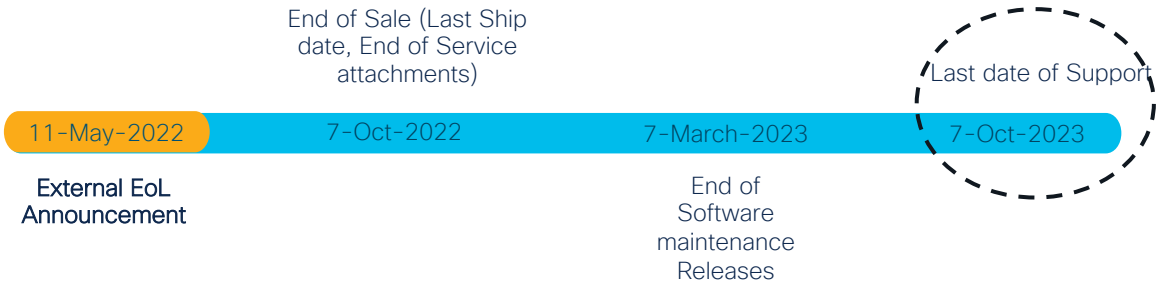


MSE WIPS End of Life



WIPS service on MSE is declared as EoL from 11th May 2022 onwards.

- MSE platform had already been declared EoL in Nov 2018.
- MSE 8.x had already been declared EoL Aug 2018.
- All the PIDs corresponding to WIPS license would be EoL.
- The EoL is applicable to all the MSE 7.x and 8.x releases

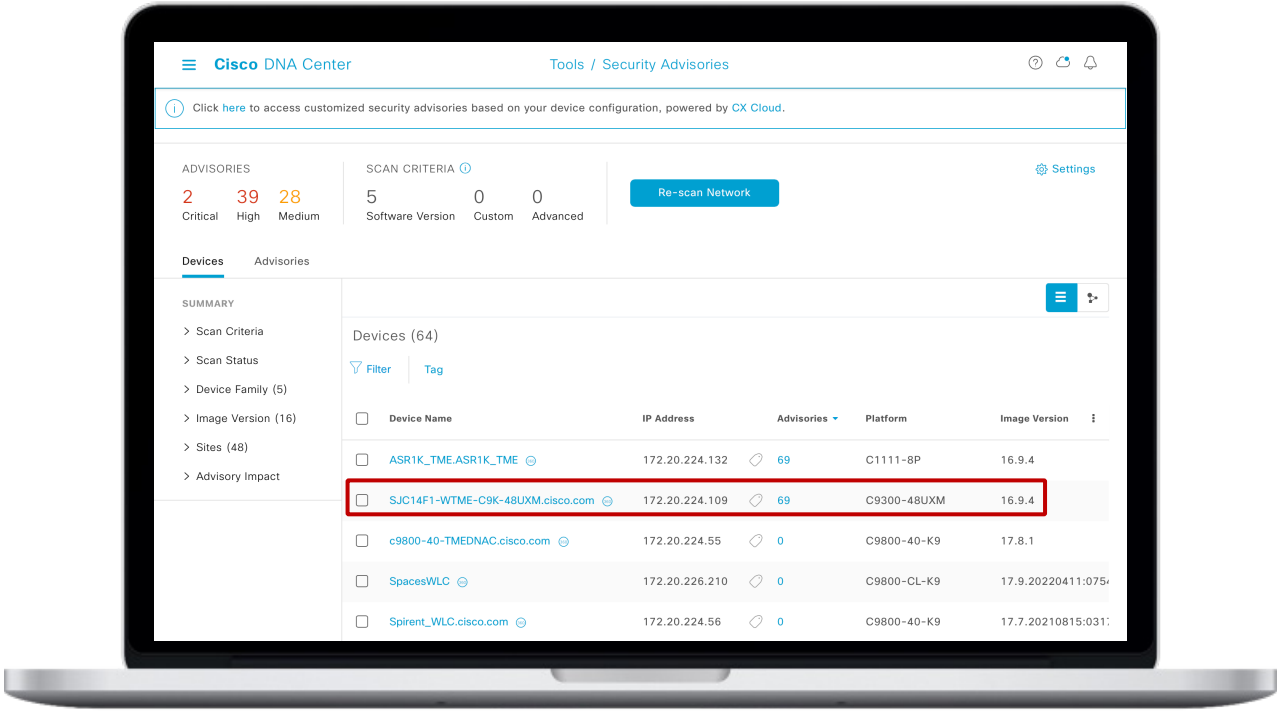


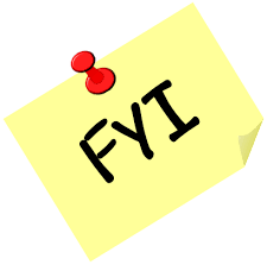
Product ID	Product Description
AIR-LM-WIPS-*	Cisco Enhanced Local Mode wIPS License
AIR-WIPS-*	Cisco wIPS License
C1-MSE-WIPS-*	Cisco ONE Mobility Svcs
L-LM-WIPS-*	Wireless IPS Lic For Enhanced Local Mode AP- E Delivery
L-MM-WIPS-*	Wireless IPS Lic For Monitor Mode AP- E Delivery
L-WIPS-*	WIPS Monitor Mode and Enhanced Local Mode licenses
MSE-WIPS-*	MSE WIPS Tracker Term

Next Steps

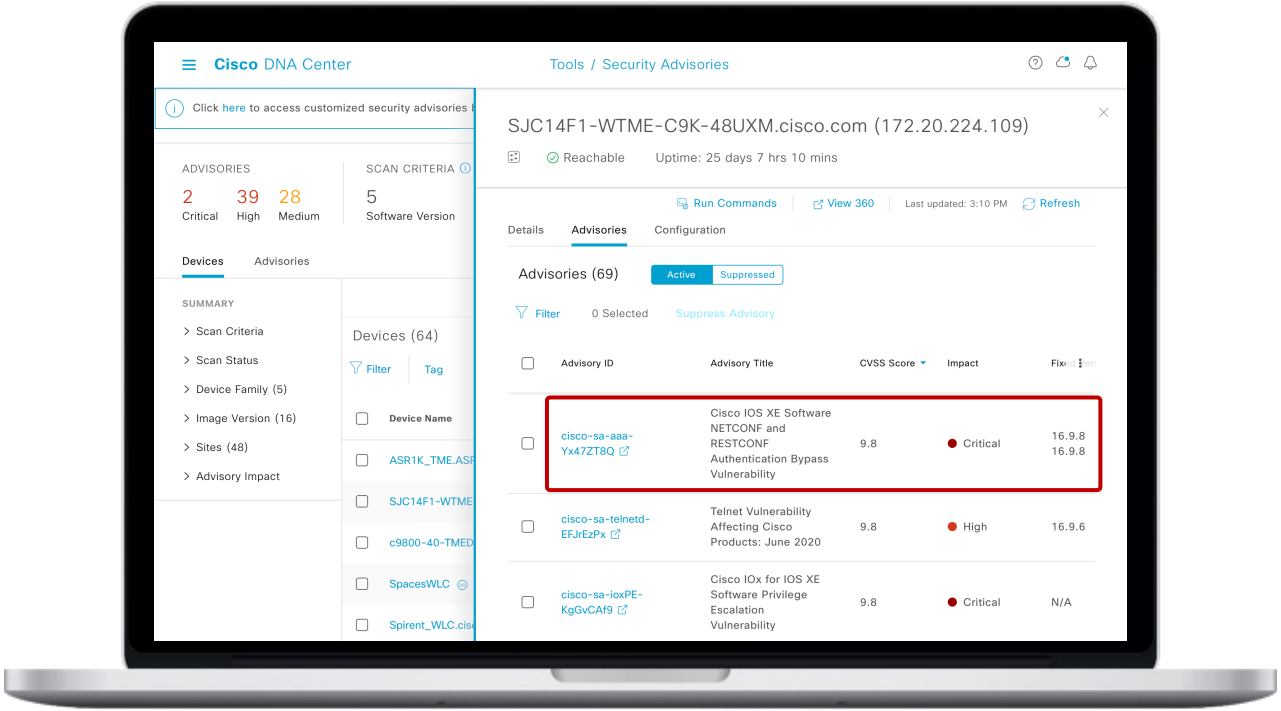
- NextGen aWIPS solution is available with DNA Center and WLC 9800 with DNA-A license.
- No separate local mode or monitor mode licenses are required for APs.
- High touch escalation support based on customer needs would be available.

Security Advisories





Security Advisories



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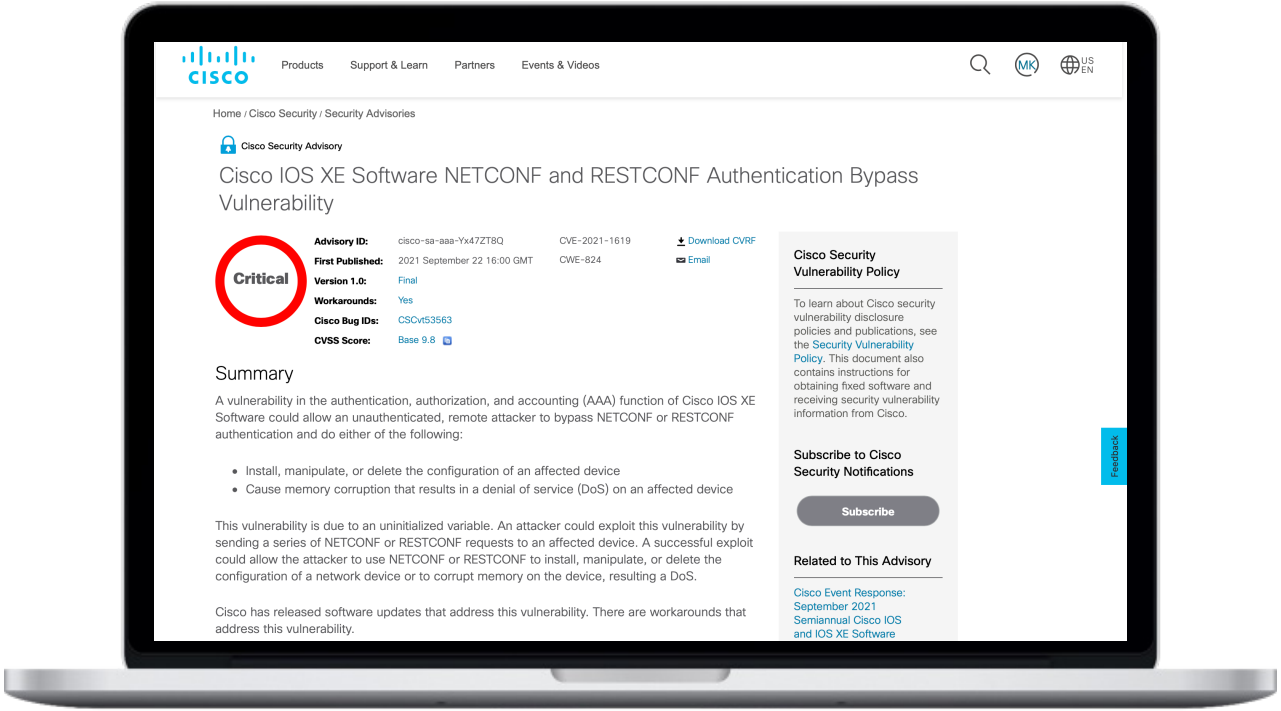
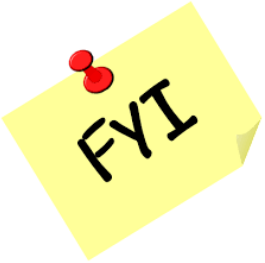
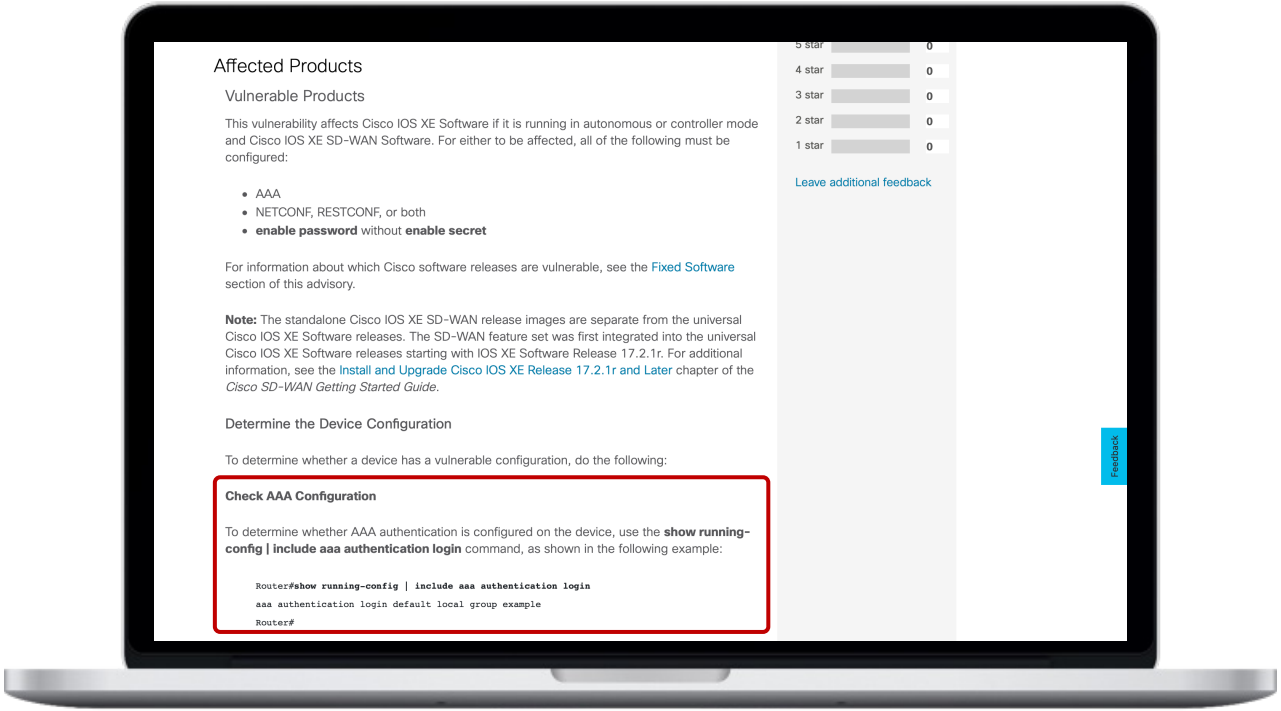
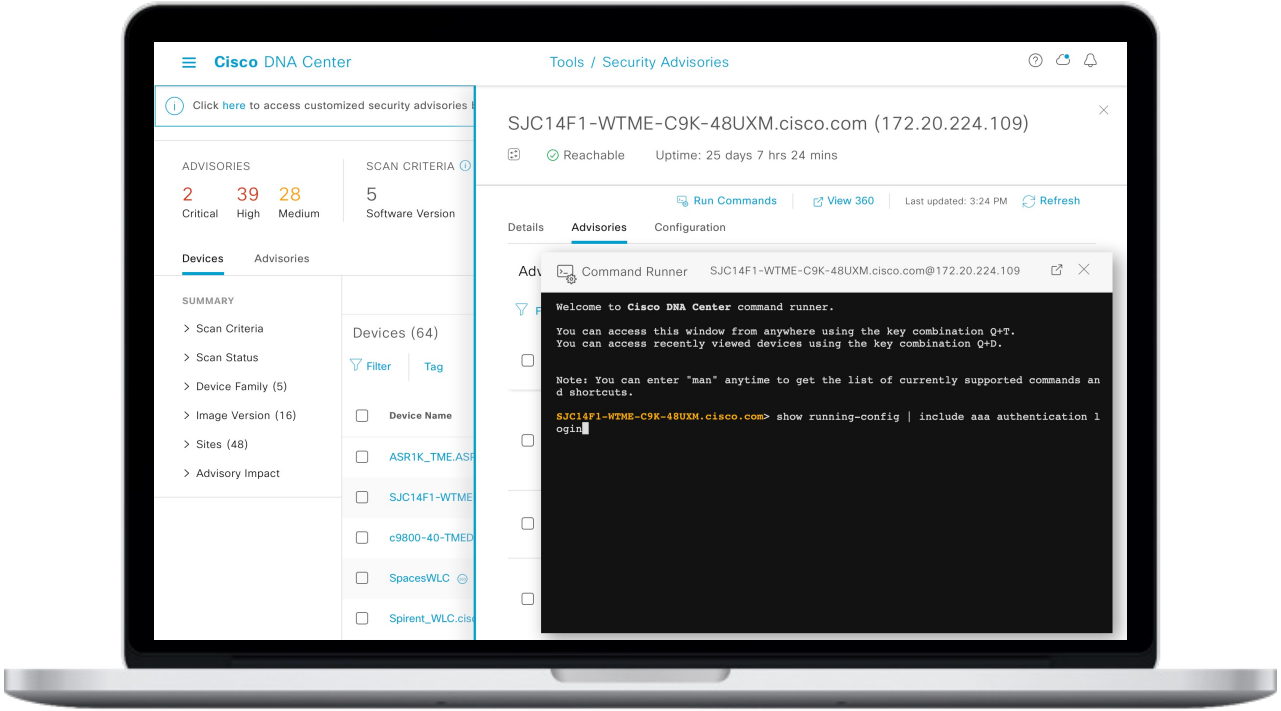




Security Advisories



Security Advisories



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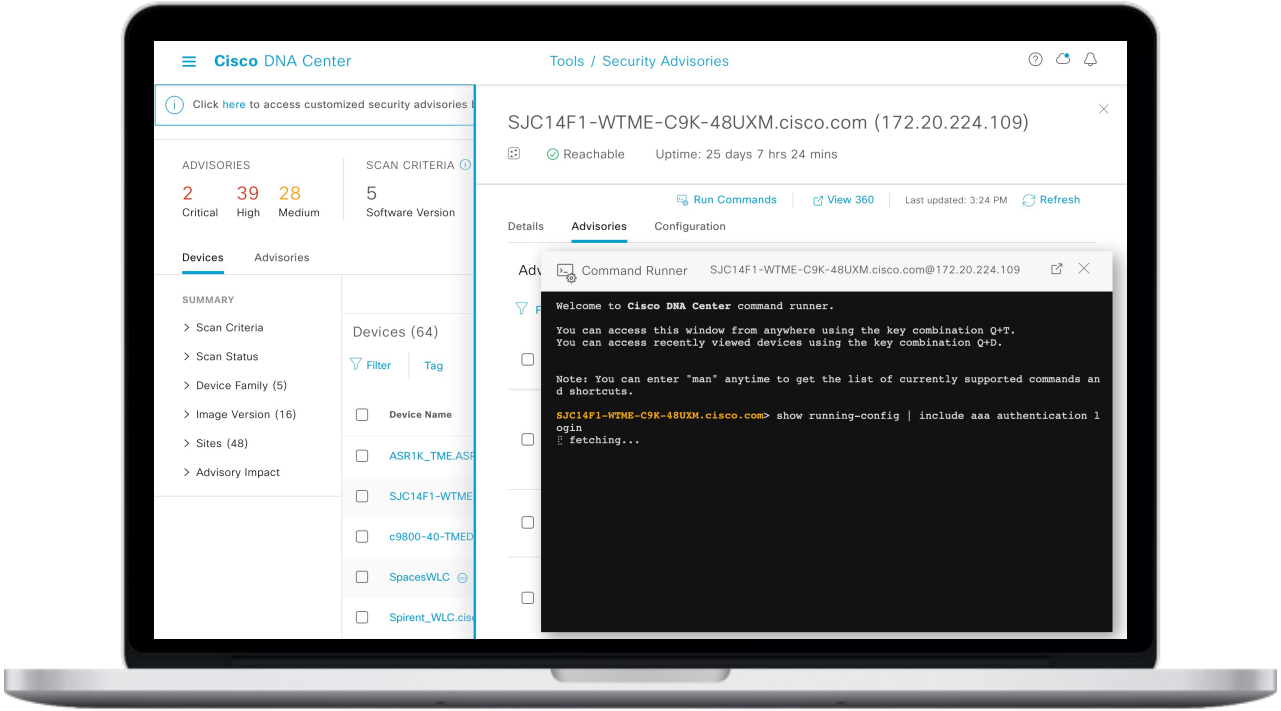

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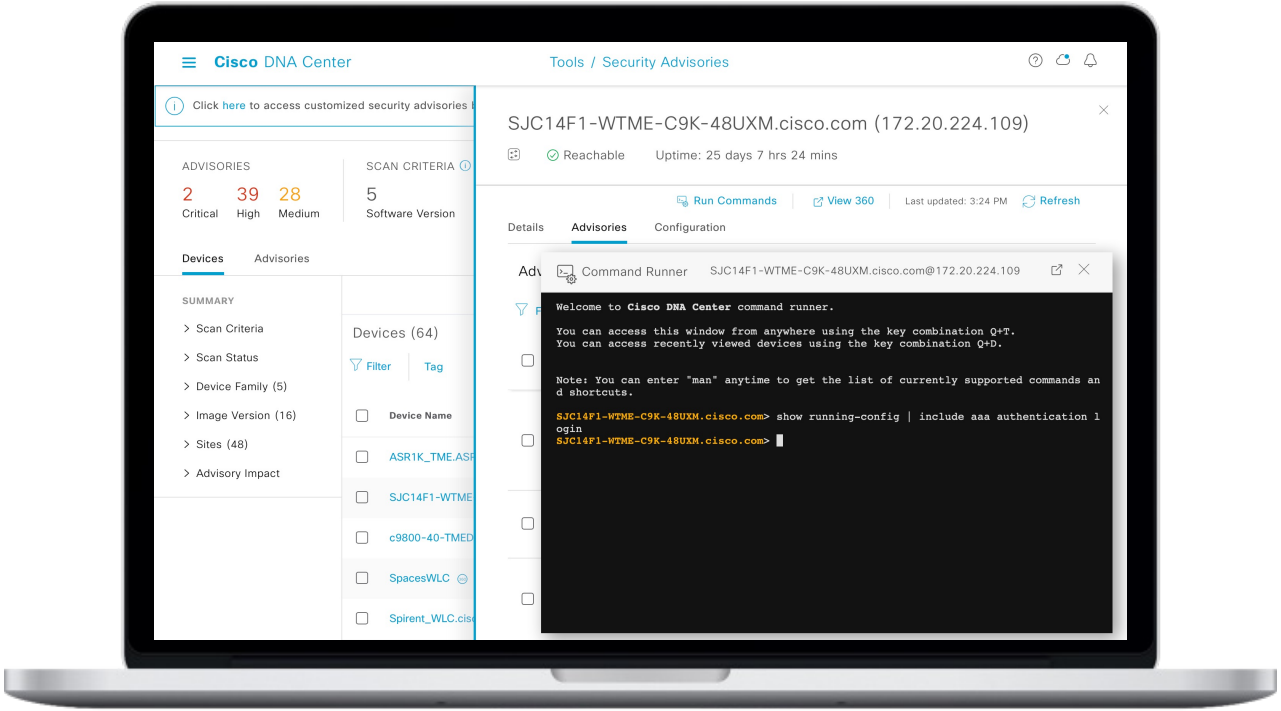
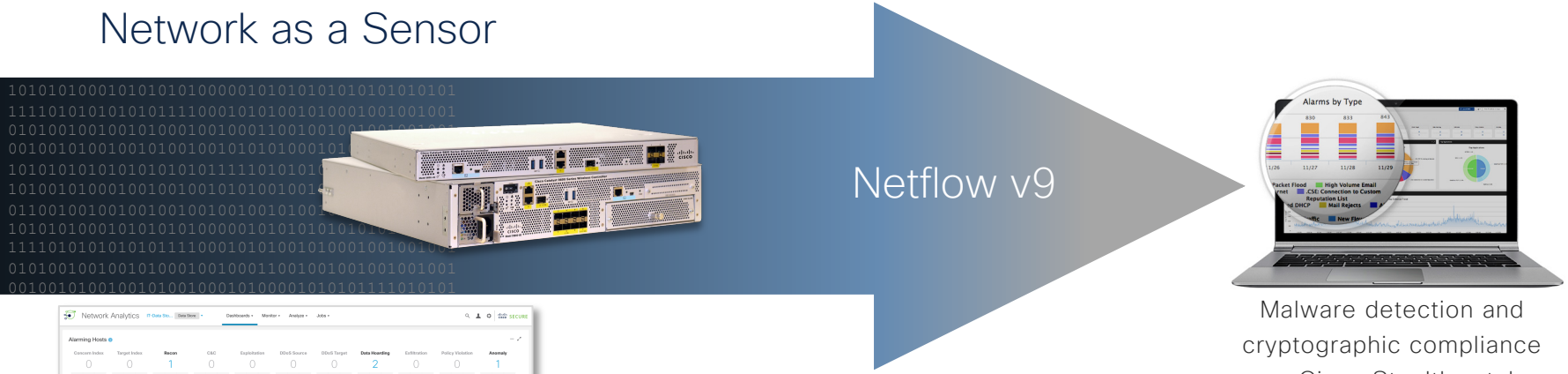
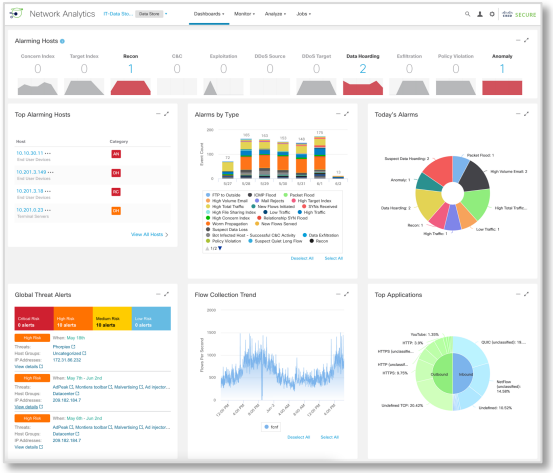


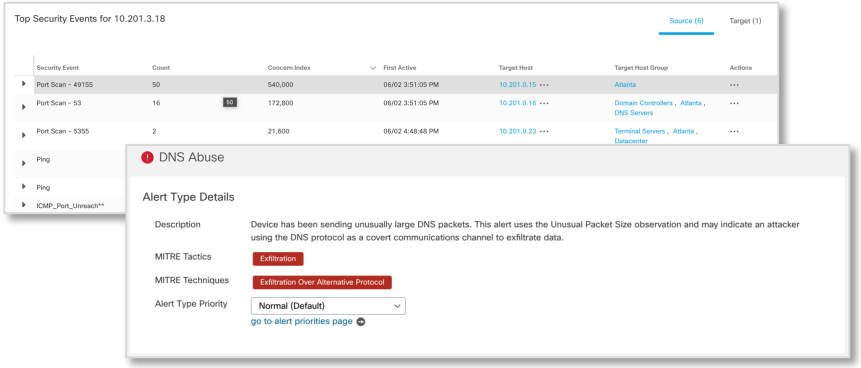
Secure Network Analytics Integration

Network as a Sensor



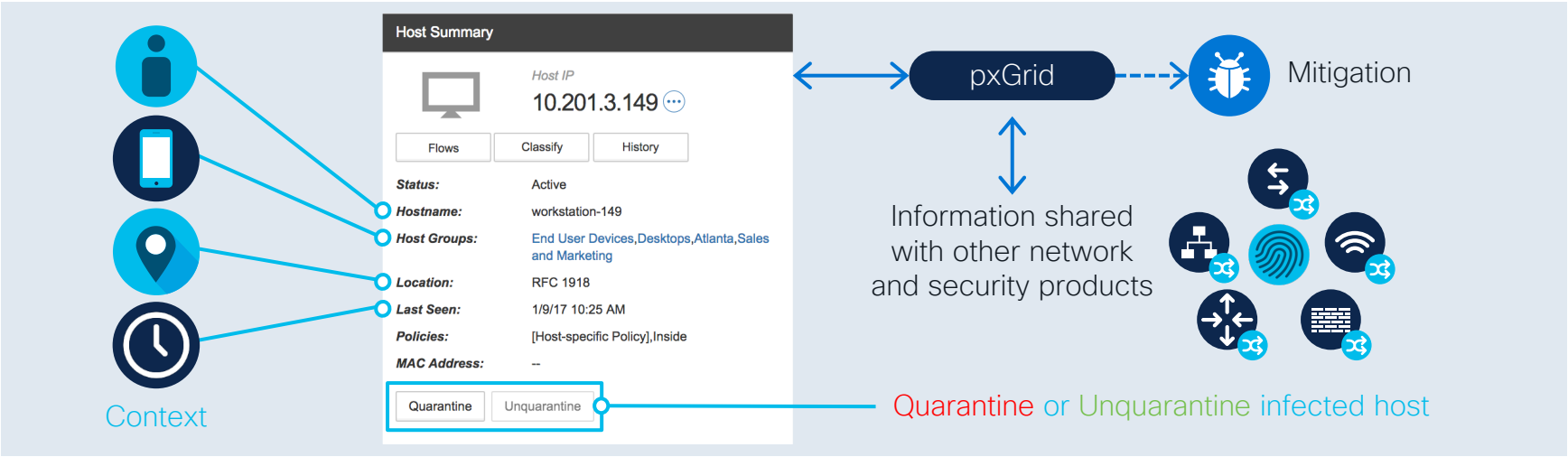
Malware detection and cryptographic compliance on Cisco Stealthwatch





Rapid Threat Containment

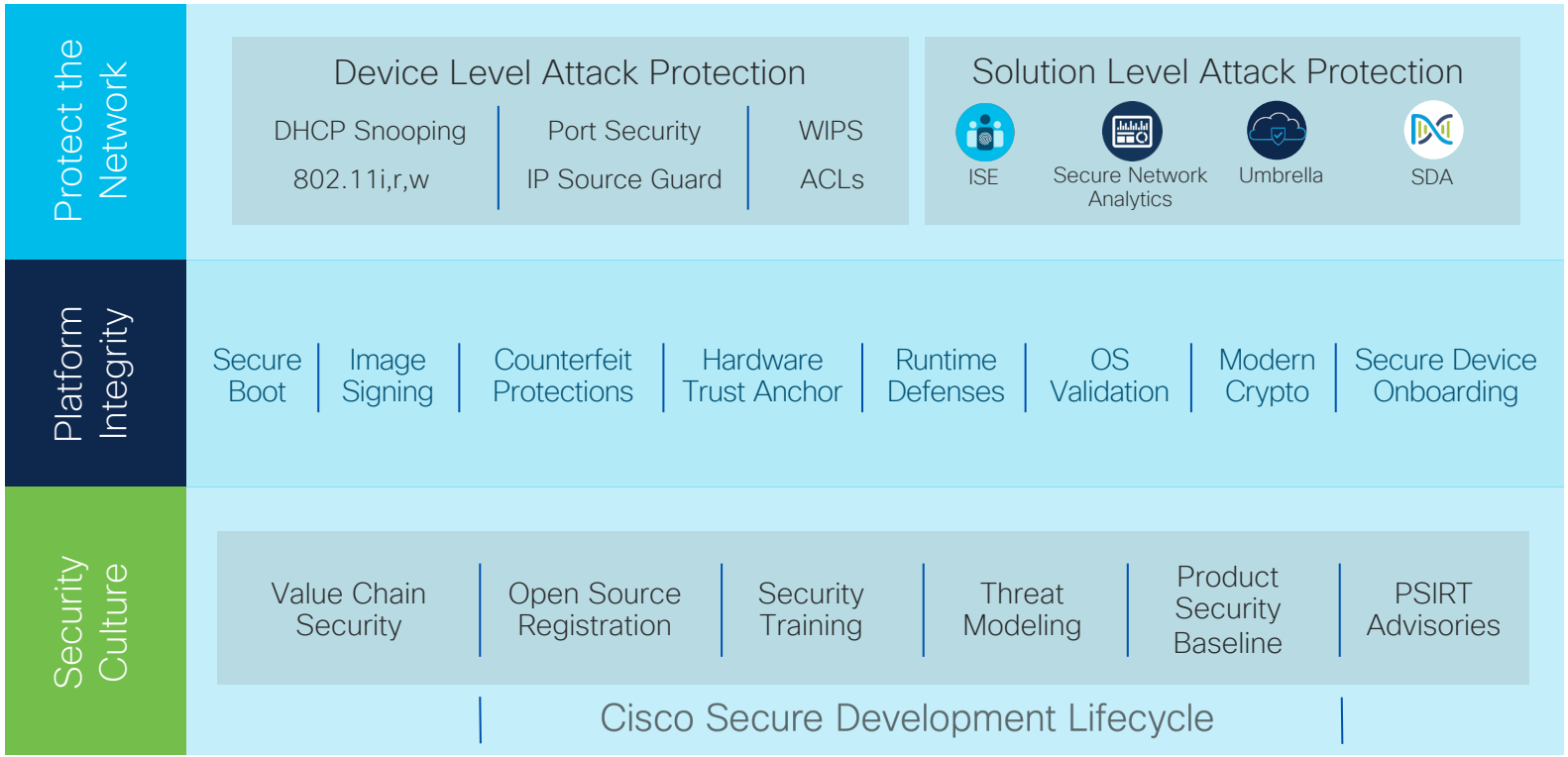
Network as an Enforcer



Identity Services Engine

Secure Network Analytics Management Console

Trustworthy Systems



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