digitalscepter

PAN-OS Best Practices Workshop

SEAN DAVIS - SYSTEMS ENGINEER, DIGITAL SCEPTER

April 29th, 2025

Service Catalog

- Firewall migrations
- Firewall operations - mass upgrades, backups, change/remove/add
- Firewall Healthchecks
- Panorama design
- Zero Trust Network Access
- Network Segmentation
- MFA
- SSL Decryption
- Inbound SSL Inspection
- Remote Access (“Always on”)
- Securing Cloud infrastructure
- Dual ISP redundancy
- Network engineering
- Endpoint Security/EDR/MDR

Contracts

- CMAS
- NASPO
- SPURR
- OMNIA Partners

Vendors

- Palo Alto Networks
- Crowdstrike
- SentinelOne
- Okta
- Arista
- Juniper
- HPe/Aruba
- Island
- AWS
- Microsoft/Azure
- Proofpoint
- Zscaler
- Gigamon
- Rapid7
- Knowbe4
- Netskope

Agenda

- **Advanced Subscriptions** - difference compared to original subscriptions
- **Best Practices** - recommendations for different features across the platform
- **Zero Trust** - defined and how to configure
- **SSL Decryption** - breakdown of SSL outbound and inbound inspection
- **Network Segmentation** - brief overview of benefits to network segmentation and methods of implementation
- **GUI Walkthrough/Demos** - Review location of configuration items discussed and feature demonstrations

digitalscepter

Advanced Subscriptions

Advanced Subscriptions and Machine Learning

- Palo Alto has a cloud-native system of machine learning models that they can train and retrain using the massive amounts of data they collect from all of the 85,000+ customer around the globe and 42,000+ Wildfire users
- These models are focused on certain threats, e.g. command and control, SQLi, social engineering, etc.
- The architecture takes advantage of Intel 3rd gen Xeon CPUs and ML software development frameworks
- This ML powered analysis is incorporated in the cloud threat analysis and inline on the firewall in aspects of Advanced Wildfire, Advanced URL, Advanced Threat and DNS Security

Advanced URL Filtering

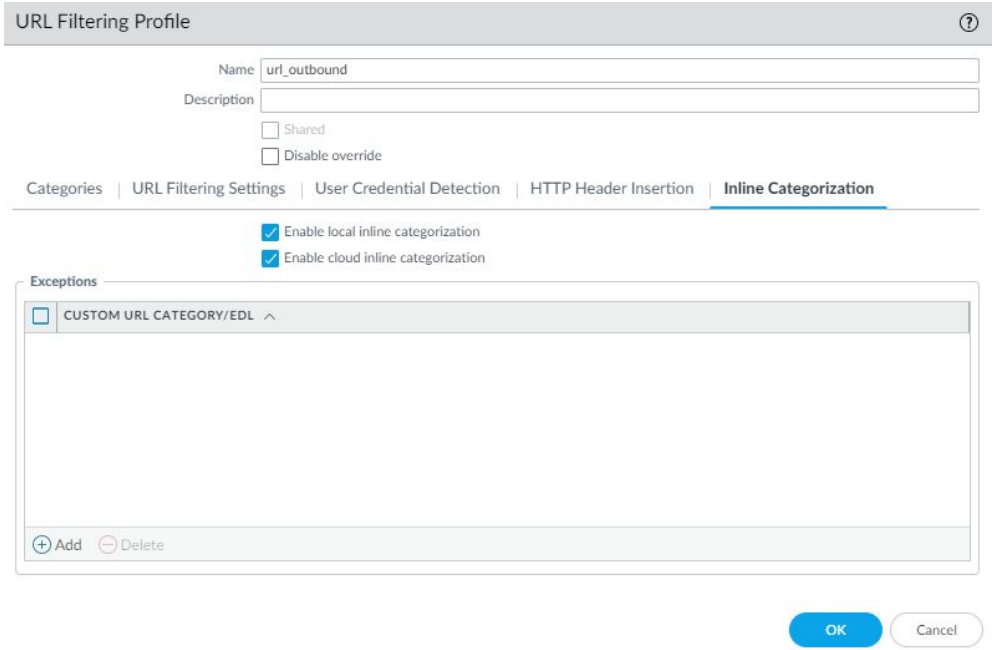
- Adds inline analysis for javascript exploits and phishing attacks
- Adds inline analysis of the SSL handshake to block traffic sooner based on SNI
- Delivered in real-time, without impacting the user
- These will be expanded in the future

Advanced URL Filtering will uncover attackers that were cloaking their attacks from web-crawlers and attacks that use new and unknown domains and URLs for phishing attacks.

Advanced URL Filtering

Configuration:

- Enabled via **Objects** > **Security Profiles** > **URL Filtering** > **Inline Categorization**
- Ensure Enable local inline categorization and Enable cloud inline categorization are checked



digitalscepter

Advanced URL Filtering

- This will obviously be enhanced by SSL decryption.
- Palo Alto has risk-categories now that can be used to selectively apply SSL decryption short of a complete roll-out. For example, perform SSL Decryption on high and medium risk URL categories only.

- Previously malicious and is now benign; 30-days
- Bulletproof ISP hosted & IPs from "bad" ASNs
- Suspect by association

- Previously confirmed high risk; 60-days
- Online-storage-and-backup by default

- Everything else!
- Benign activity for at least 90-days (or no events of malicious activity ever)

digitalscepter

Advanced Threat Prevention

- Advanced Threat Prevention is integrated with Palo Alto's cloud-based threat analysis infrastructure, like Advanced URL filtering
- The ML-Models now run deep-learning on live traffic
- First ML-models focus on command-and-control (C2) tactics like those used by Cobalt Strike. Stops 96% of these new tactics. 48% improvement over regular TP tactics
- PAN-OS Nova (11.0) adds ML models to focus on injection attacks. 90% of attacks stopped on unpatched systems and 60% improvement on 0-day injection attacks.
- ML models have to be trained. Palo Alto has the largest pile of threat analysis thanks to Wildfire and a huge customer base. The cloud security infrastructure will be improved with more threat models in the future.

Advanced Threat Prevention

- Unknown C2 detection is focused on http, ssl, unknown-tcp, and unknown-udp apps

Advanced Threat Prevention

https://www.bleepingcomputer.com/news/security/alleged-source-code-of-cobalt-strike-toolkit-shared-online/

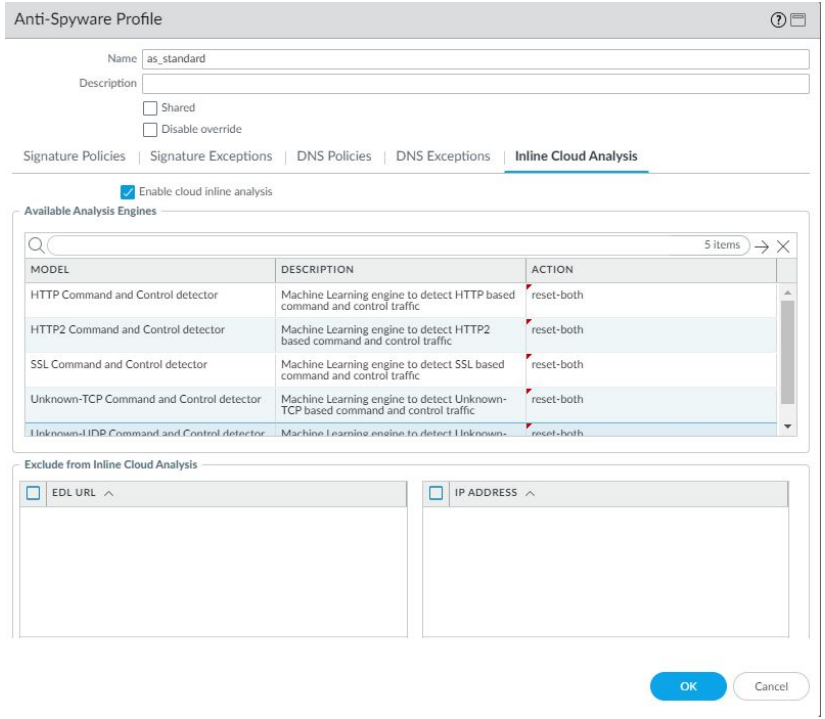
- Cobalt Strike source code leaked in 2020. This allowed anyone to more easily fire up attack networks, command-and-control servers, and distribute ransomware
- Cobalt Strike was used in multiple attacks including Solarwinds, Colonial Pipeline, Microsoft Exchange and Kaseya.
- Cobalt Strike is evasive and makes it easy to perform zero-day exploits
- Attackers use Cobalt Strike and other tools to automate attacks that look like normal traffic to old methods of Threat Prevention

Advanced Threat Prevention

Configuration:

- Enable inline ML models on anti-spyware and vulnerability protection security profiles
- Enable outbound/inbound SSL Decrypt to ensure threat prevention is applied to encrypted traffic

Advanced Threat Prevention



Advanced Threat Prevention

Vulnerability Protection Profile

Name: vp_standard

Description:

☐ Shared

☐ Disable override

Rules | Exceptions | **Inline Cloud Analysis**

☑ Enable cloud inline analysis

Available Analysis Engines

2 items

MODEL	DESCRIPTION	ACTION
	attacker inserts SQL queries into an applications request	
Command Injection	Detects a common hacking technique that allows an attacker to execute arbitrary operating system (OS) commands on the server	reset-both

Exclude from Inline Cloud Analysis

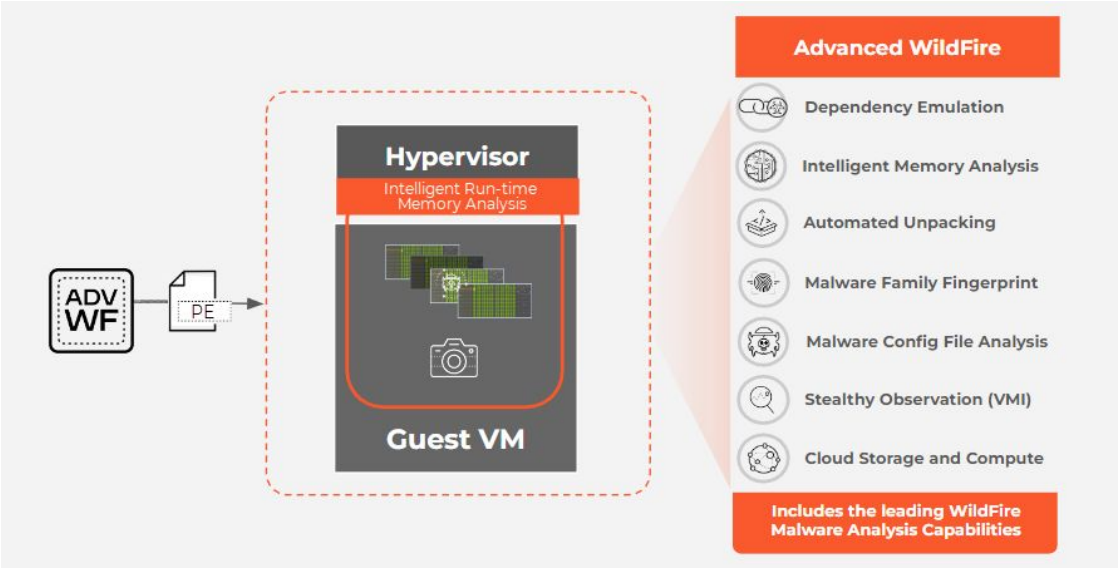
EDL URL	EDL IP

OK Cancel

digitalscepter

Advanced Wildfire

- Adds Intelligent Run-time Memory Analysis to Wildfire submissions



digitalscepter

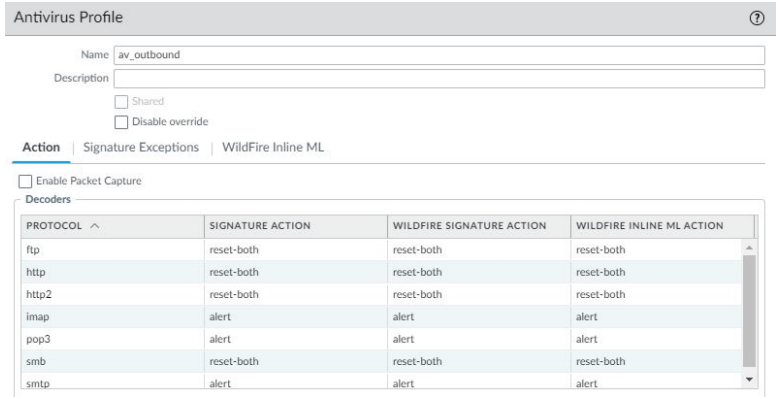
Best Practices

Security Profiles

- Create security profiles based on direction of traffic flow, e.g. inbound, outbound, or internal traffic
- Likewise, create security profile groups based on direction and attach these to appropriate policies
- Exceptions on security profiles should be made as specific as possible to avoid broadly disabling protections

Antivirus

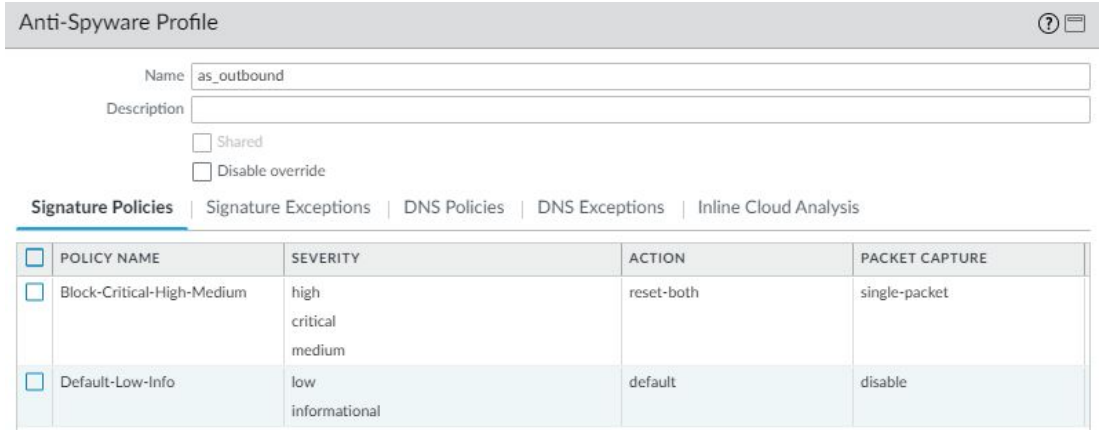
- Reset-both should be default for http, http2, ftp, and smb
- Reset-both can and should be set for imap, pop3, and smtp if it won't interfere with corporate mail flow–this should be handled by spam filter so you don't lose quarantine capability
- Signature Action column requires TP or advanced TP subscription, Wildfire Action columns require WF subscription



PROTOCOL	SIGNATURE ACTION	WILDFIRE SIGNATURE ACTION	WILDFIRE INLINE ML ACTION
ftp	reset-both	reset-both	reset-both
http	reset-both	reset-both	reset-both
http2	reset-both	reset-both	reset-both
imap	alert	alert	alert
pop3	alert	alert	alert
smb	reset-both	reset-both	reset-both
smtp	alert	alert	alert

Anti-Spyware

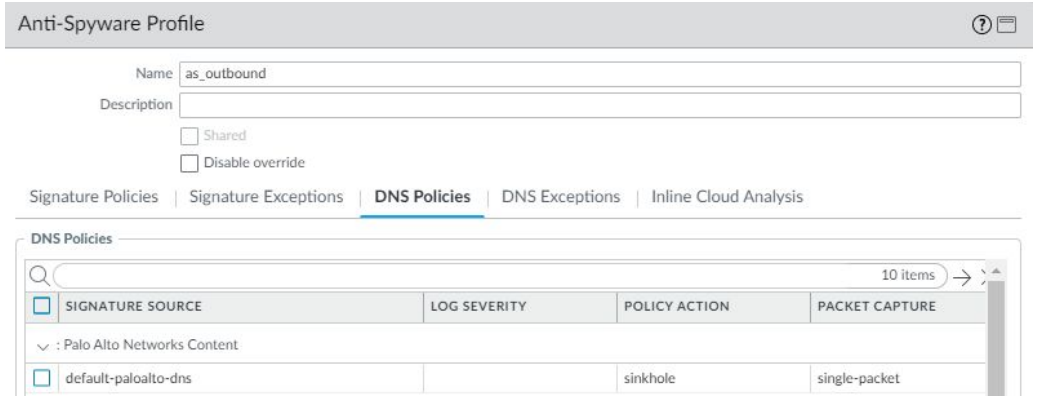
- Reset-both should be used for critical, high, and medium
- Default (not alert) should be set for low and informational
- This requires Threat Prevention or Advanced Threat Prevention subscription



digitalscepter

Anti-Spyware

- Default-paloalto-dns signature source should be set to sinkhole. Block is also okay here, but sinkhole can offer additional visibility into infected endpoints on your network
- This requires Threat Prevention or Advanced Threat Prevention subscription



digitalscepter

URL Filtering

At a minimum, it is recommended to block the following URL categories:

- Adult
- Command-and-control
- Compromised-website
- Copyright-infringement
- Dynamic-dns
- Encrypted-dns
- Extremism
- Grayware
- Hacking
- Malware
- Parked
- Phishing
- Proxy-avoidance-and-anonymizers
- Ransomware
- Scanning-activity
- Unknown (should review unknown URL logs prior to blocking this category)
- High Risk

URL Filtering

A note on blocking unknown URLs:

This is a great way to block new URLs that phishing attacks are using, but any of your apps using IP addresses instead of domain names may be categorized as unknown. Public sites that utilize source-based whitelisting will also show as unknown. Run a report ahead of time to see what this will block and make adjustments to security profiles to except them. Using separate profiles for internet traffic from datacenter traffic is recommended.

URL Filtering

It is recommended to consider blocking these URL categories:

- Newly-registered-domain
- Questionable

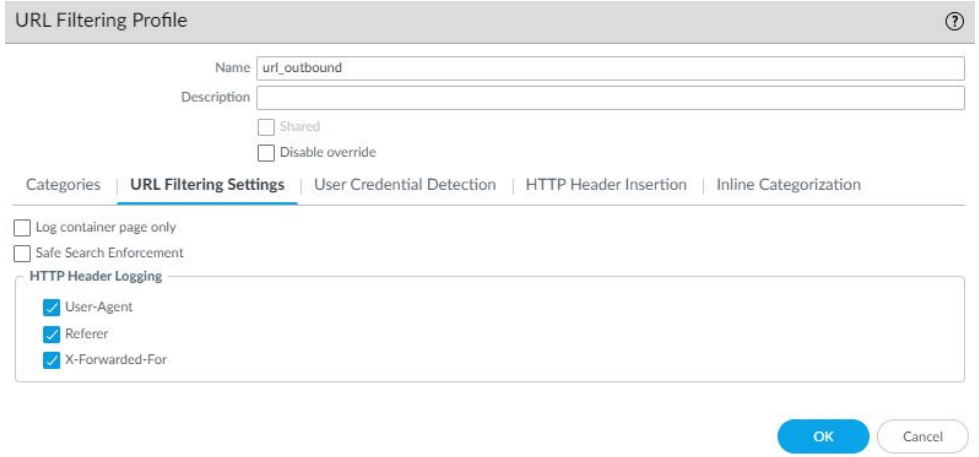
URL Filtering

It is recommended to alert on the remaining URL categories:

Important Note: Real-time-detection (requires Advanced URL sub) should be set to alert

URL Filtering

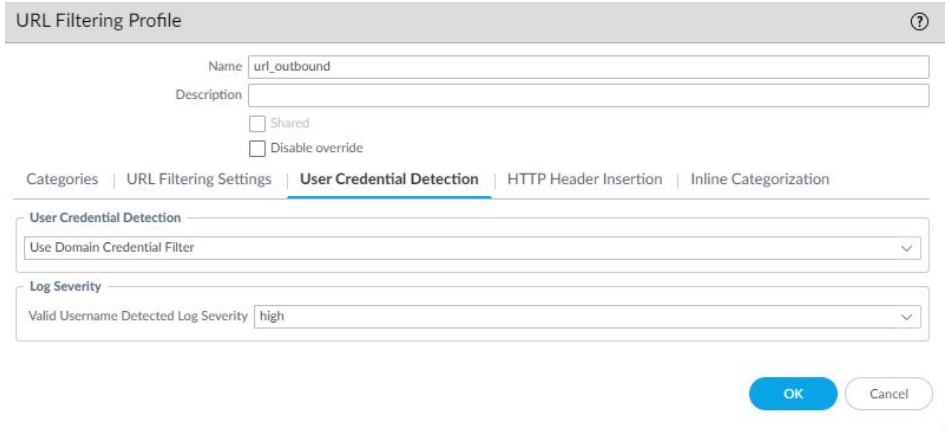
- Log container page only should be turned off if you want to maximize visibility
- HTTP Header Logging should be used if there are proxies on the network



digitalscepter

URL Filtering

- Credential Theft Prevention should be enabled utilizing domain credential filter
- This requires a Server 2019 RODC on your network and works best in tandem with SSL Decryption



digitalscepter

URL Filtering

Action plan:

- Make sure categories are not set to ‘allow’ (use ‘alert’ instead)
- Make sure any rules that permit traffic to leave your network have your outbound security profile group applied
- Leverage User-ID groups for permitting varying levels of internet access
- Enable Credential Theft Prevention to further reduce risk of phishing attacks and password reuse

File Blocking

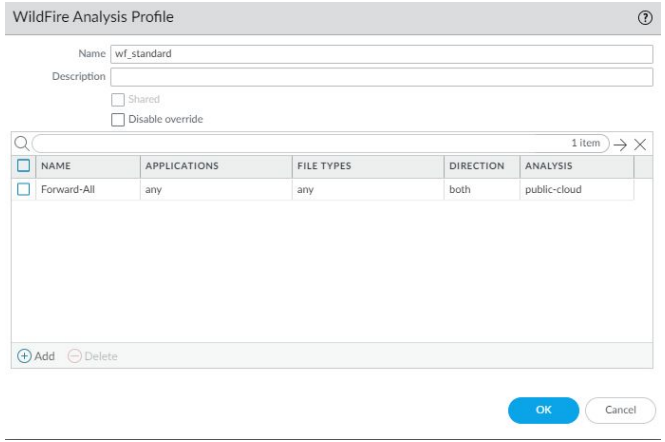
At a minimum, it is recommended to block the following file types:

- Chm - Microsoft Compiled HTML Help file
- Hlp - Windows Help file
- Multi-level-encoding - File that’s been compressed 4+ times
- Ocx - Windows ActiveX Control file
- Scr - Windows screensaver file
- Torrent

Everything else should be set to alert

Wildfire

- Forward all supported file types to Wildfire for analysis
- Wildfire submission isn't necessarily required for internal traffic, although there are benefits



digitalscepter

Wildfire

- Wildfire Signature action and inline ML action should be set identically to your antivirus signature action
- Wildfire Inline ML models should all be enabled

Antivirus Profile

Name: av_outbound

Description:

Shared

Disable override

Action | Signature Exceptions | WildFire Inline ML

Enable Packet Capture

Decoders

PROTOCOL	SIGNATURE ACTION	WILDFIRE SIGNATURE ACTION	WILDFIRE INLINE ML ACTION
ftp	reset-both	reset-both	reset-both
http	reset-both	reset-both	reset-both
http2	reset-both	reset-both	reset-both
imap	alert	alert	alert
pop3	alert	alert	alert
smb	reset-both	reset-both	reset-both
smtp	alert	alert	alert

Antivirus Profile

Name: av_outbound

Description:

Shared

Disable override

Action | Signature Exceptions | WildFire Inline ML

Available Models

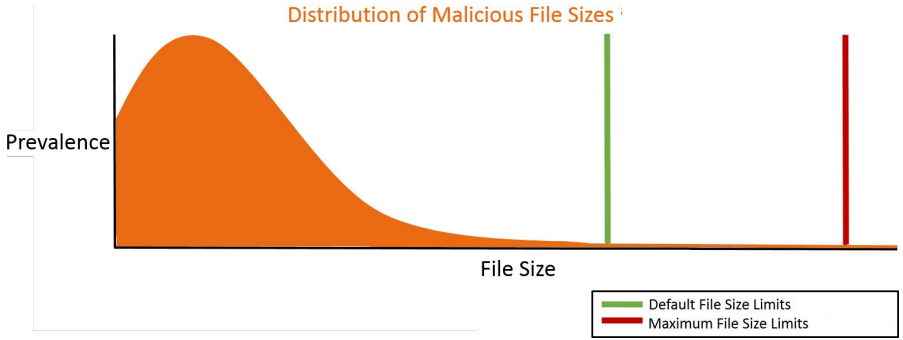
6 items

MODEL	DESCRIPTION	ACTION SETTING
Windows Executables	Machine Learning engine to dynamically identify malicious PE files	enable (inherit per-protocol actions)
PowerShell Script 1	Machine Learning engine to dynamically detect malicious PowerShell scripts with known length	enable (inherit per-protocol actions)
PowerShell Script 2	Machine Learning engine to dynamically detect malicious PowerShell scripts without known	enable (inherit per-protocol actions)

digitalscepter

Wildfire

- PAN recommends setting file size limits to default values based on observed distribution of malware

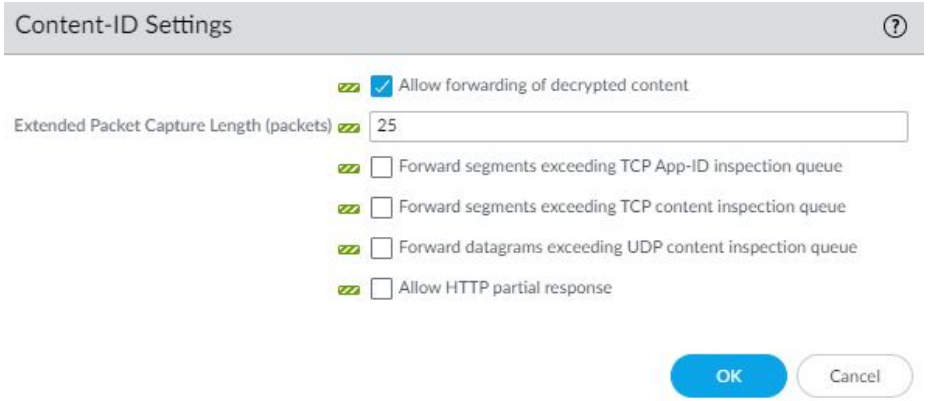


FILE TYPE	PAN-OS 9.0 AND LATER FILE-FORWARDING MAXIMUM SIZE RECOMMENDATIONS	PAN-OS 8.1 FILE-FORWARDING MAXIMUM SIZE RECOMMENDATIONS
pe	16MB	10MB
apk	10MB	10MB
pdf	3,072KB	1,000KB
ms-office	16,384KB	2,000KB
jar	5MB	5MB
flash	5MB	5MB
MacOSX	10MB	1MB
archive	50MB	10MB
linux	50MB	10MB
script	20KB	20KB

digitalscepter

Wildfire

- Allow forwarding of decrypted content
  - Device > Setup > Content-ID



DNS Security

- DNS is fundamental to using any network
- Controlling DNS you can stop attacks at the beginning of the attack lifecycle but also in the middle and the end
- Palo Alto had a list of bad domains on the firewall based on intel from Wildfire, etc. but DNS Security now moves it to the cloud-based security architecture, which means the list size is basically infinite and takes advantage of the ML model architecture like the other subscriptions

DNS Security

- More than just blocking bad domains
- Looks at malicious usage of the protocol, e.g. tunneling
- Can see all DNS traffic through the box, not just from systems configured to use your approved DNS servers

DNS Security

Callback Domains

DNS-based indirection for reliable phone-home

- Malware & C2 Domains
- Botnet Domains
- Fast-flux Domains
- Random DGA
- Dictionary DGA ★

High Risk Domains

Proactive protection from likely malicious domains

- Grayware
- Newly Registered Domains
- Parked Domains
- Proxy Avoidance
- Dynamic DNS
- Predictive Detection ★
- NEW Strategically Aged Domains ★

DNS Record Attacks

Domain takeovers through DNS zone hacks and abuse

- Domain Squatting ★
- Dangling DNS ★
- NEW Compromised DNS Zone ★
- NEW Wildcard DNS ★
- NEW CNAME Cloaking

DNS Protocol Attacks

DDoS, exploitation, and lateral movement

- DNS Rebinding
- NXNSAttack

Covert Channels

Abuse of DNS protocol for stealthy data theft and C2

- DNS Tunneling
- Ultra-slow DNS Tunneling ★
- NEW DNS Infiltration

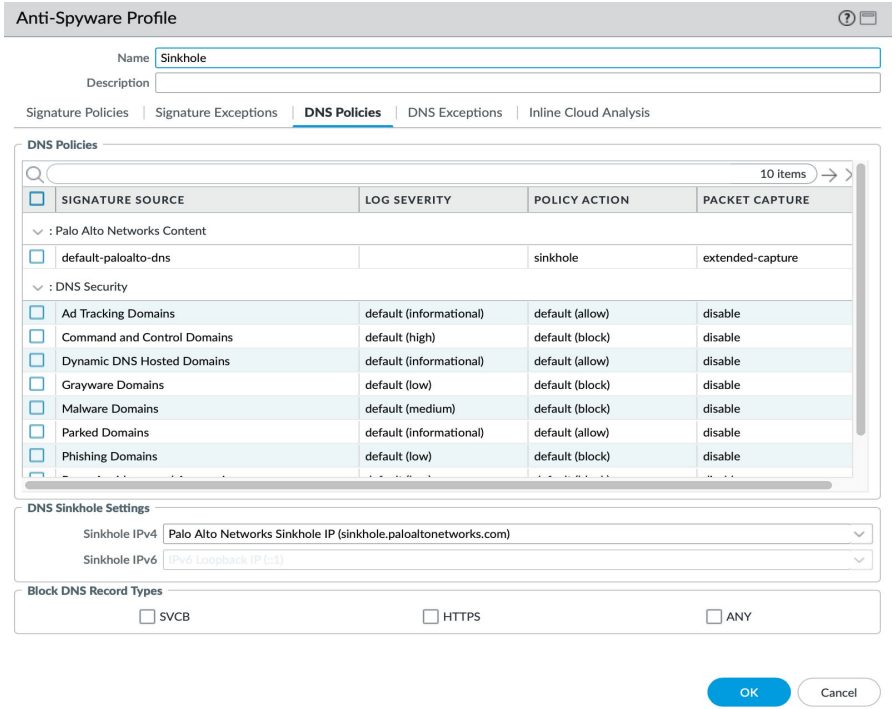
★ Industry First

digitalscepter

DNS Security

- Since malicious DNS requests are indicators of compromise, it's a good input for automating response, e.g. adding the IP address to a block list for limited network access, send to endpoint tools, etc.

DNS Security



External Dynamic Lists

- Make sure you have rules blocking the predefined EDL's inbound and outbound

NAME	LOCATION	DESCRIPTION	SOURCE
Dynamic IP Lists			
Palo Alto Networks - Tor exit IP addresses	Predefined	IP addresses supplied by multiple providers and validated with Palo Alto Networks threat intelligence data as active Tor exit nodes. Traffic from Tor exit nodes can serve a legitimate purpose, however, is disproportionately associated with malicious activity, especially in enterprise environments.	Palo Alto Networks - Tor exit IP addresses
Palo Alto Networks - Bulletproof IP addresses	Predefined	IP addresses that are provided by bulletproof hosting providers. Because bulletproof hosting providers place few, if any, restrictions on content, attackers can use these services to host and distribute malicious, illegal, and unethical material.	Palo Alto Networks - Bulletproof IP addresses
Palo Alto Networks - High risk IP addresses	Predefined	IP addresses that have recently been featured in threat activity advisories distributed by high-trust organizations. However, Palo Alto Networks does not have direct evidence of maliciousness for these IP addresses.	Palo Alto Networks - High risk IP addresses
Palo Alto Networks - Known malicious IP addresses	Predefined	IP addresses that are currently used almost exclusively by malicious actors for malware distribution, command-and-control, and for launching various attacks	Palo Alto Networks - Known malicious IP addresses

digitalscepter

Device Settings

Check	Location	Recommended Setting	Default?
Rematch Sessions	Device > Setup > Session > Session Settings	Enabled	Yes (as of PAN-OS 5.0)
Management TLS Mode set to TLS 1.3 only	Device > Setup > Management > General Settings	TLS 1.3 only (1.2 if pre-PAN-OS 11)	No
Enable log on high DP load	Device > Setup > Management > Logging and Reporting > Log Export and Reporting	Enabled	No
Log Admin Activity (sends to a syslog server)	Device > Setup > Management > Logging and Reporting > Log Export and Reporting	Enabled	No
Forward segments exceeding content inspection queues	Device > Setup > Content-ID > Content-ID Settings	Disabled	No
Forward segments exceeding TCP out of order queue	Device > Setup > Session > TCP Settings	Enabled	No

digitalscepter

Device Settings

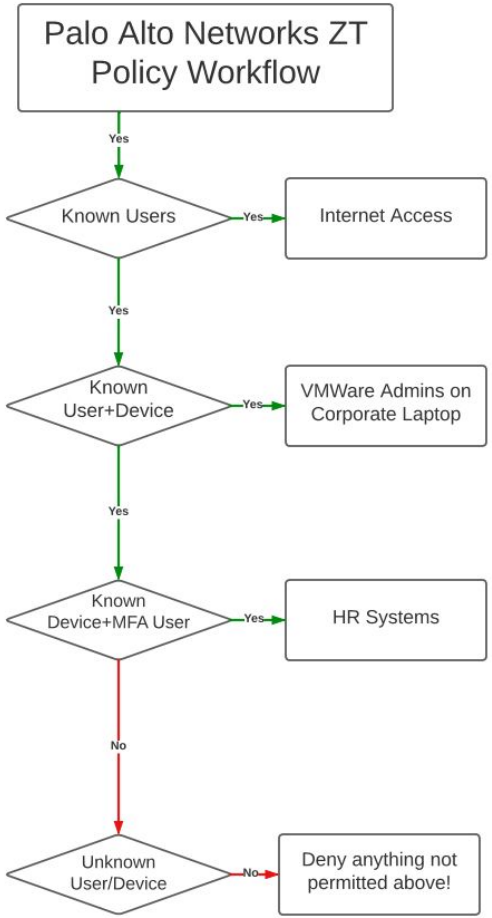
Check	Location	Recommended Setting	Default?
Log traffic not scanned	Device > Setup > Content-ID > URL Inline Cloud Categorization Device > Setup > Content-ID > Threat Prevention Inline Cloud Analysis	Enabled	No
Strip-X-Forwarded-For header	Device > Setup > Content-ID > X-Forwarded-For-Headers	Enabled	No

Zero Trust

What is Zero Trust?

- Zero trust is a concept that no user or device should be inherently trusted, whether inside or outside of a corporate network. Instead **all** traffic should be, by default, dropped. Required traffic flows should then be explicitly permitted based on principles of least privilege. Traffic should be validated against the following:
  - **Known User** - authenticated frequently with multiple factors
  - **Known Device** - corporate managed and secured with next-gen antivirus
  - **Source/Destination** - specific source and destination address
  - **Service** - nailed down for static ports, or application-default for dynamic ports
  - **Application** - static list of applications as required for inbound/internal traffic, application filters for outbound access
  - **URL Category** - an optional match condition that can be used in place of or in conjunction with a destination address

Zero Trust Policy Flow



Session has been identified with valid credentials

			Source				Destination							
NAME	TAGS	TYPE	ZONE	ADDRESS	USER	DEVICE	ZONE	ADDRESS	DEVICE	APPLICATI...	SERVICE	ACTION	PROFILE	OPTIONS
Known Users Internet Access	none	universal	inside	any	known-user	any	outside	any	any	any	application-default	Allow		

Valid Credentials and known device

			Source				Destination							
NAME	TAGS	TYPE	ZONE	ADDRESS	USER	DEVICE	ZONE	ADDRESS	DEVICE	APPLICATI...	SERVICE	ACTION	PROFILE	OPTIONS
Allow VMware Admins to vCenter	none	universal	inside	any	company\vmware_admins	corporate_secured	vmware	any	any	any	any	Allow		

Valid Credentials and known device

			Source				Destination							
NAME	TAGS	TYPE	ZONE	ADDRESS	USER	DEVICE	ZONE	ADDRESS	DEVICE	APPLICATI...	SERVICE	ACTION	PROFILE	OPTIONS
Allow HR Staff to HR Systems	none	universal	inside	any	company\hr_staff	corporate_secured	hr	hr_sy...	any	any	any	Allow		

		Source				Destination				
NAME	TAGS	ZONE	ADDRESS	USER	DEVICE	ZONE	ADDRESS	DEVICE	SERVICE	AUTHENTICATION ENFORCEMENT
Force MFA for HR Systems	none	inside	any	company\hr_staff	any	hr	hr_systems	any	any	force_mfra

MFA Enforced for Access

			Source				Destination							
NAME	TAGS	TYPE	ZONE	ADDRESS	USER	DEVICE	ZONE	ADDRESS	DEVICE	APPLICATI...	SERVICE	ACTION	PROFILE	OPTIONS
Deny All Unknown	none	universal	inside	any	any	any	any	any	any	any	any	Deny	none	

digitalscepter

Zero Trust Journey

The idea of getting to a zero trust model can be overwhelming. Try to break it into manageable chunks of work. For example:

- Enable inbound inspection and convert inbound rules to use App-id
- Create internet access rules based on application filters
- Add User-ID to policies that enable access to critical systems
- Add MFA to GlobalProtect
- Analyze the rulebase and try to find 3 things that you can change to improve security

Zero Trust Prioritization

1. MFA for remote access
    - Email or SMS alerts for successful logins from outside of the US

      (status eq 'success') and (srcregion neq 'US') and ((eventid eq 'portal-auth') or (eventid eq 'gateway-auth'))
2. Security Profiles
3. User-ID
4. SSL Decryption
5. App-ID
6. Device-ID

digitalscepter

SSL Decryption

SSL Decryption Benefits

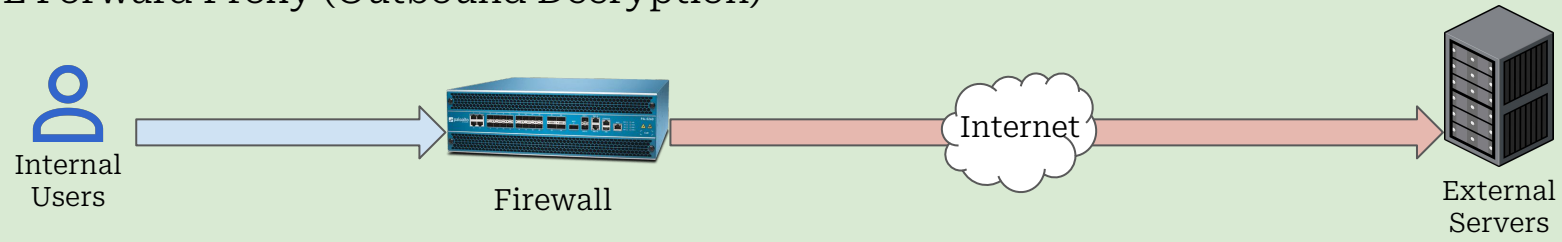
- App-ID visibility
- Granular app control
- Threat Prevention
- Full URL visibility
- File download/upload visibility

Types of Decryption

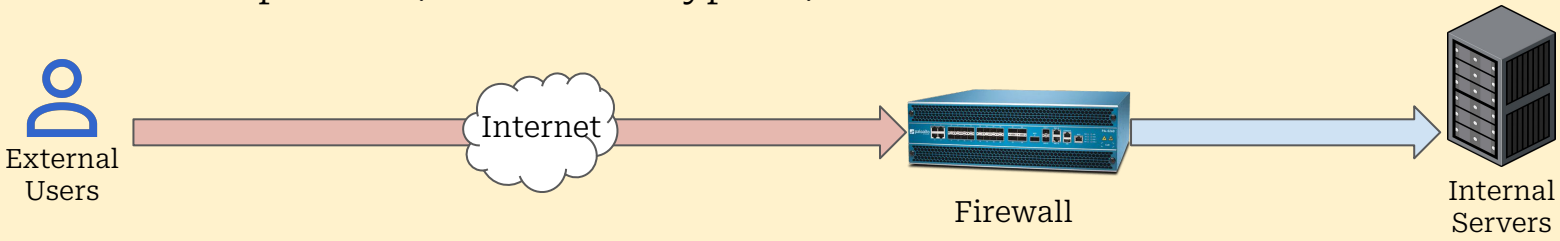
- SSL Forward Proxy (Outbound Decryption)
  - Provides the firewall with visibility into encrypted traffic originating from users within your network
- SSL Inbound Inspection (Inbound Decryption)
  - Provides the firewall with visibility into encrypted traffic originating from the internet destined to servers on your network

Inbound vs Outbound

SSL Forward Proxy (Outbound Decryption)



SSL Inbound Inspection (Inbound Decryption)



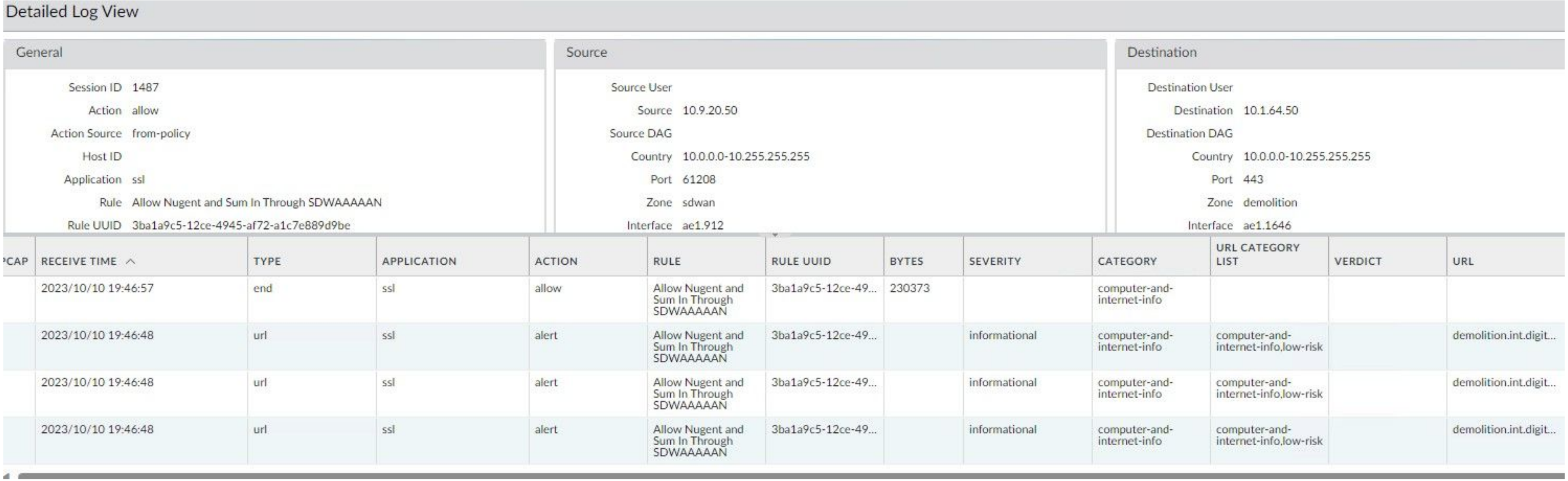
digitalscepter

What the firewall sees *without* decryption

```
...........uJ...l.>k.;..;....g......1...... ...k.}..>l.h.>..o0...|......~
..."......+./.....,.0.
.           ...../.5.............example.com..........
.......................#.........h2.http/1.1..........".
...........3.k.i...
X.-DS..!c..>...d......fG.9..}.....A...Q...      }.[G.......Nr}r....6S!.y.....5.!,..'....o..E.S.Zte\../....+........
...........................-........@.......................................................................................................x..{.t....'.{.....*..bs
j.S ...k.}..>l.h.>..o0...|......~
......O.+.....3.E...A..r....0{.(.....!.@..L.........0:...........-.......~....Loep.\."........... .<k.T.7v...u....Mm.H|.
tal.lXB...........a_.M[.K...!...*...9................5..U........^/.W.b :.r....s..].n.@.....d...5.w....
......5...dx..0..O.Lm......w.yo......Ep......c1EL...2.q.f.3.O..t.=C.Y..k.n...fw..r.?9.=T..>......O~...d,QB.m.kl.a.Q.
...YUM.y.n....4=..[.g...h....}......<..6.&7...".B.T.;.L.i.E.<r.""../.Snx..K..
.rj..zBX.sE.u.....{~.A.Z@L.Y.
..{....`Ynh..*;;!......&.2.T.V2e.,B....J...^.!"v.teC..W.'..k....   .
..X.L..~NUw.....S..Hc"|....7....9._...7A.@.+....F....u..d...6.Q...z..R.5.C..........z_..*.D...F.....*Ct9J.....by...,...jh.|.&./E.GfOY]...;-...(.kE.a........
..s...?....&.d.).....C.....e.#3f.a...:D.........U...1...Ut..).?....P..V\".....
....<....`r3[...._,R.
```


digitalscepter

What the firewall sees *without* decryption



Detailed Log View

General

Session ID	1487
Action	allow
Action Source	from-policy
Host ID	
Application	ssl
Rule	Allow Nugent and Sum In Through SDWAAAAAN
Rule UUID	3ba1a9c5-12ce-4945-af72-a1c7e889d9be

Source

Source User	
Source	10.9.20.50
Source DAG	
Country	10.0.0.0-10.255.255.255
Port	61208
Zone	sdwan
Interface	ae1.912

Destination

Destination User	
Destination	10.1.64.50
Destination DAG	
Country	10.0.0.0-10.255.255.255
Port	443
Zone	demolition
Interface	ae1.1646

CAP	RECEIVE TIME	TYPE	APPLICATION	ACTION	RULE	RULE UUID	BYTES	SEVERITY	CATEGORY	URL CATEGORY LIST	VERDICT	URL
	2023/10/10 19:46:57	end	ssl	allow	Allow Nugent and Sum In Through SDWAAAAAN	3ba1a9c5-12ce-49...	230373		computer-and-internet-info			
	2023/10/10 19:46:48	url	ssl	alert	Allow Nugent and Sum In Through SDWAAAAAN	3ba1a9c5-12ce-49...		informational	computer-and-internet-info	computer-and-internet-info,low-risk		demolition.int.digit...
	2023/10/10 19:46:48	url	ssl	alert	Allow Nugent and Sum In Through SDWAAAAAN	3ba1a9c5-12ce-49...		informational	computer-and-internet-info	computer-and-internet-info,low-risk		demolition.int.digit...
	2023/10/10 19:46:48	url	ssl	alert	Allow Nugent and Sum In Through SDWAAAAAN	3ba1a9c5-12ce-49...		informational	computer-and-internet-info	computer-and-internet-info,low-risk		demolition.int.digit...

What the firewall sees *with* decryption

```
GET /classes/details?id=CS101 DROP TABLE STUDENTS; HTTP/1.1
Host: example.com
User-Agent: Mozilla/5.0 (X11; Ubuntu; Linux x86_64; rv:98.0) Gecko/20100101 Firefox/98.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/avif,image/webp,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
Connection: keep-alive
Upgrade-Insecure-Requests: 1
Pragma: no-cache
Cache-Control: no-cache

HTTP/1.1 200 OK
Content-Encoding: gzip
Accept-Ranges: bytes

Age: 460608
Cache-Control: max-age=604800
Content-Type: text/html; charset=UTF-8
Date: Mon, 21 Mar 2022 23:54:11 GMT
```


digitalscepter

What the firewall sees *with* decryption

Detailed Log View

General

Session ID	11533
Action	allow
Action Source	from-policy
Host ID	
Application	web-browsing
Rule	Allow Nugent and Sum In Through SDWAAAAAN
Rule UUID	3ba1a9c5-12ce-4945-af72-a1c7e889d9be
Session End Reason	threat

Source

Source User	
Source	10.6.0.100
Source DAG	
Country	10.0.0.0-10.255.255.255
Port	53776
Zone	nugent
Interface	tunnel.3
X-Forwarded-For IP	0.0.0.0

Destination

Destination User	
Destination	10.1.64.50
Destination DAG	
Country	10.0.0.0-10.255.255.255
Port	443
Zone	demolition
Interface	ae1.1646

PCAP	RECEIVE TIME	TYPE	APPLICATION	ACTION	RULE	RULE UUID	BYTES	SEVERITY	CATEGORY	URL CATEGORY LIST	VERDICT	URL
	2023/10/10 20:03:12	end	web-browsing	allow	Allow Nugent and Sum In Through SDWAAAAAN	3ba1a9c5-12ce-4...	83820		computer-and-internet-info			
	2023/10/10 20:01:51	vulnerability	web-browsing	reset-both	Allow Nugent and Sum In Through SDWAAAAAN	3ba1a9c5-12ce-4...		high	computer-and-internet-info			demolition.int.digit...
	2023/10/10 20:01:51	url	incomplete	alert	Allow Nugent and Sum In Through SDWAAAAAN	3ba1a9c5-12ce-4...		informational	computer-and-internet-info	computer-and-internet-info,low-risk		demolition.int.digit...
	2023/10/10 20:01:51	url	web-browsing	alert	Allow Nugent and Sum In Through SDWAAAAAN	3ba1a9c5-12ce-4...		informational	computer-and-internet-info	computer-and-internet-info,low-risk		demolition.int.digit...

digitalscepter

SSL Forward Proxy - What’s Required

- Private CA Certificate trusted by all endpoints/browsers
- Periodic exclusions for sites that don’t support decryption
  - Certificate pinning
  - Client-cert authentication

SSL Forward Proxy - Certificate Authority Options

- PAN firewall Self-Signed Certificate
  - Less secure, but doesn’t require in-house certificate infrastructure
  - Requires distribution of PAN certificate to machines
- Subordinate CA template to PAN firewall from enterprise CA
  - Simple revocation if PAN private key is compromised
  - Does not need to be distributed to domain-joined machines since enterprise CA should already be trusted

SSL Forward Proxy - What to Decrypt

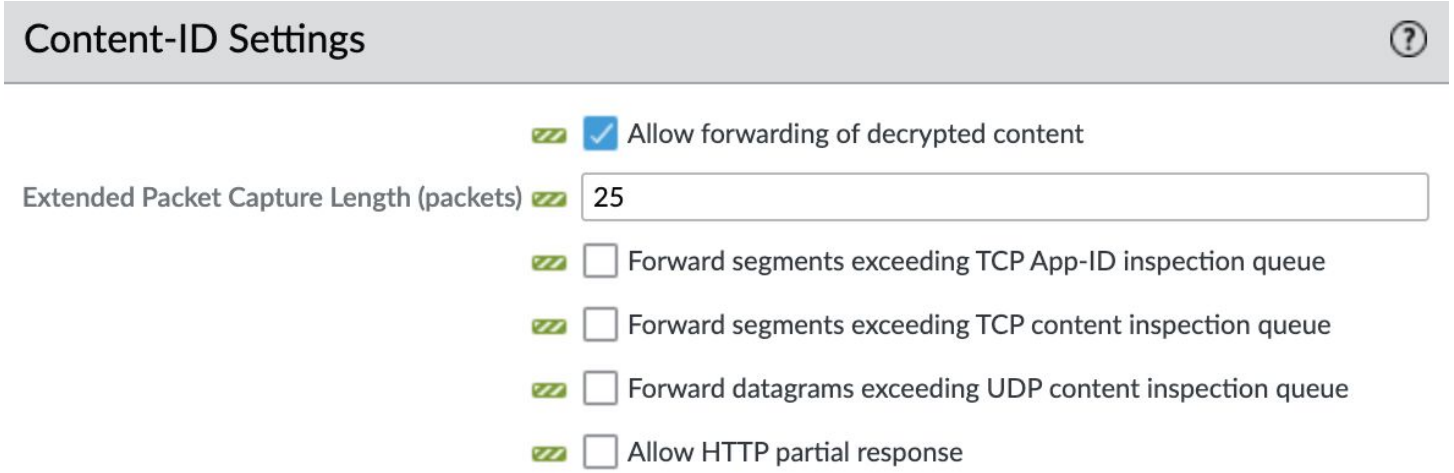
- Decrypt all URL categories except those that contain sensitive, private data, such as:
  - Financial-services
  - Health-and-medicine
  - Shopping
- Start with a test group as shown below. Only three users are being decrypted. As testing progresses, expand test group

			Source			Destination					
	Name	Tags	Zone	Address	User	Zone	Address	URL Category	Service	Action	Type
1	Protect Confidential	none	inside vpn	any	any	outside	any	financial-services health-and-medic... shopping	any	no-decrypt	ssl-forward-proxy
2	Decrypt Users	none	inside vpn	any	ds\jrobinson ds\maverick ds\zsum	outside	any	any	any	decrypt	ssl-forward-proxy

digitalscepter

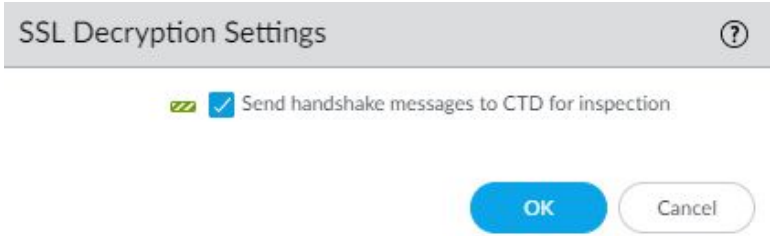
SSL Forward Proxy - Important Settings

- Decrypted files should be sent to WildFire
  - Device > Setup > Content-ID > Content-ID Settings



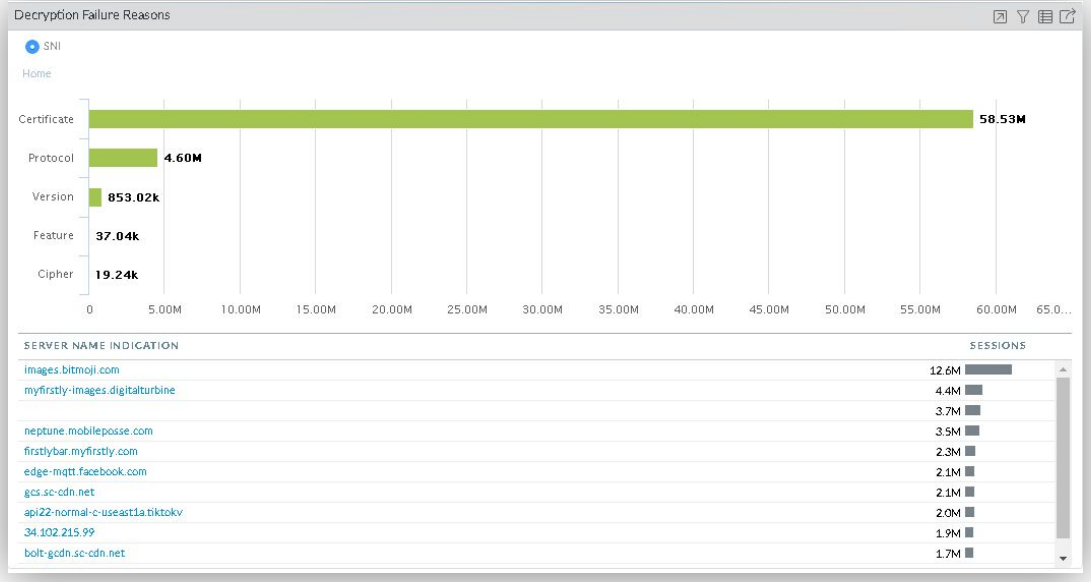
SSL Forward Proxy - Important Settings

- (PAN-OS 11 only) Enable inspection of SSL handshake messages
  - Device > Setup > Session > SSL Decryption Settings



SSL Forward Proxy - Decryption Failures

- Find unsupported sites
- Decide if exclusions should be made
- Create exclusion globally or on a per-user/per-IP basis



digitalscepter

SSL Inbound Inspection - What's Required

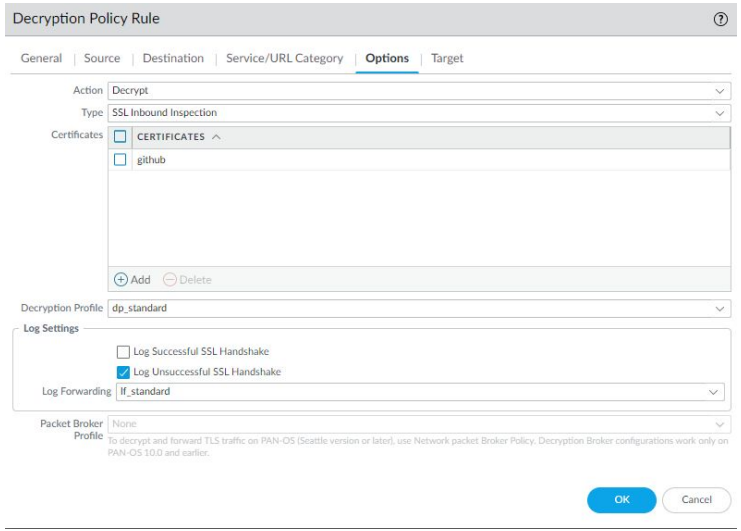
- Certificates for servers you want to inspect, e.g. company wildcard, www, etc.
- Endpoint, PAN firewall, and server all need to support common cipher suite

SSL Decryption - Time to Configure

- It is recommended to be running PAN-OS ≥ 10.1.0 for better cipher support with inbound inspection
- Get a list of all the services you want to decrypt
- Identify any need for specific TLS versions or ciphers
- Gather certificates for all services
- Import all certificates into the firewall
- Create a decryption profile
- Create decryption rules to decrypt inbound/outbound connections
- Validate that applications work as expected

SSL Decryption - Time to Configure

NAME	LOCATION	TAGS	Source				Destination			URL CATEGORY	SERVICE	ACTION	TYPE
			ZONE	ADDRESS	USER	DEVICE	ZONE	ADDRESS	DEVICE				
inspect github	labfw01	none	globalprote...	any	any	any	inside	10.1.131.35/32	any	any	any	decrypt	ssl-inbound-inspection



GENERATE TIME	TYPE	FROM ZONE	TO ZONE	SOURCE	SOURCE USER	DESTINATION	DECRYPTED	TO PORT	APPLICATION	ACTION	RULE	SESSION END REASON
03/31 17:13:57	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	443	websocket	allow	Allow Admins to Inside	tcp-fin
03/31 16:51:45	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	443	git-base	allow	Allow Admins to Inside	aged-out
03/31 16:51:34	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	443	github-base	allow	Allow Admins to Inside	aged-out
03/31 16:51:33	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	443	github-base	allow	Allow Admins to Inside	aged-out
03/31 16:46:28	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	443	github-base	allow	Allow Admins to Inside	aged-out
03/31 16:41:54	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	443	websocket	allow	Allow Admins to Inside	tcp-fin
03/31 16:41:23	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	443	github-base	allow	Allow Admins to Inside	aged-out
03/31 16:36:20	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	443	github-base	allow	Allow Admins to Inside	aged-out
03/31 16:31:17	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	443	github-base	allow	Allow Admins to Inside	aged-out
03/31 16:26:45	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	8443	github-base	allow	Allow Admins to Inside	aged-out
03/31 16:26:45	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	8443	github-base	allow	Allow Admins to Inside	aged-out
03/31 16:26:13	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	443	github-base	allow	Allow Admins to Inside	aged-out
03/31 16:21:19	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	443	git-base	allow	Allow Admins to Inside	aged-out
03/31 16:21:08	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	443	github-base	allow	Allow Admins to Inside	aged-out
03/31 16:21:07	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	443	github-base	allow	Allow Admins to Inside	aged-out
03/31 16:16:03	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	443	github-base	allow	Allow Admins to Inside	aged-out
03/31 16:10:59	end	vpn	inside	172.21.2.7	ds\zsum	10.1.131.35	yes	443	github-base	allow	Allow Admins to Inside	aged-out

digitalscepter

Network Segmentation

Overview

- Network segmentation is the process of classifying assets into unique subnets on your network with the intent of firewalling between these subnets.
- Firewalling these subnets is generally achieved by making the firewall the default gateway for the subnets assets are on, but another common option is using VRFs to force inter-VRF traffic through a firewall.

Benefits

- Content inspection between subnets
- Prevent lateral spread of threats
- App-ID and User-ID between subnets
- Visibility into traffic flows between subnets
- Ability to easily isolate assets that may be compromised
- Foundation of a Zero Trust Architecture

digitalscepter

Methods of Implementation

Depending on your network topology, we would suggest taking one of the following design options:

1. Firewall on a stick model, with SVIs migrated to firewalls
2. VRF-Lite using different transit VLANs
3. L2 VNIs over VXLAN*
4. L3VPN Technologies (L3VPN / EVPN)*

* - Requires >1500 MTU or TCP MSS Clamping

Note on MTU

The default Internet MTU is 1500 bytes.

- Clients will use this MTU to negotiate their TCP Maximum Segment Size.
  - 1460 bytes is typical: MTU(1500) - IP Header(20) - TCP Header(20)

If you use an overlay technique, there's additional per packet overhead.
To accommodate this, either jumbo frames or TCP Clamping may be used.
If MTU isn't increased - or client's aren't aware - fragmentation will occur (Bad).

Most switches support Jumbo frames up to 9000 bytes, some further (9200+).
Most ISPs also support Jumbo frames on their Ethernet service connections.

MTU/TCP-MSS Examples

- Switch MTU defines the maximum frame size a switch will cary before it is dropped. (Default is 1500 bytes).
- This can typically be increased without impact, although the switch may require a reload.
- Care should also be taken if the switch functions as a router.

```
interface Ethernet1/3
  no switchport
  mtu 9216
```

```
SW1(config)#system mtu jumbo 9198
```

- TCP MSS Clamping is typically automatic on tunnel interfaces. Though it may need to be manually defined.
- This configures the router to alter the TCP Maximum Segment Size negotiated during the TCP 3-way handshake between a client and host.

```
SW(config-if)#ip tcp adjust-mss 1380
```


digitalscepter

Choosing a Solution

Supported Condition	FW on a Stick	VRF Lite	L2 VNIs	L3VPN
Layer 2 between sites	Yes	Yes	Yes	Yes
Layer 3 between sites	No	Yes	Yes	Yes
Standard MTU	Yes	Yes	No	No
Jumbo frames	Yes	Yes	Yes	Yes
Low latency Intrasite	No	Yes	No	Yes
Scalability	Yes	No	No	Yes

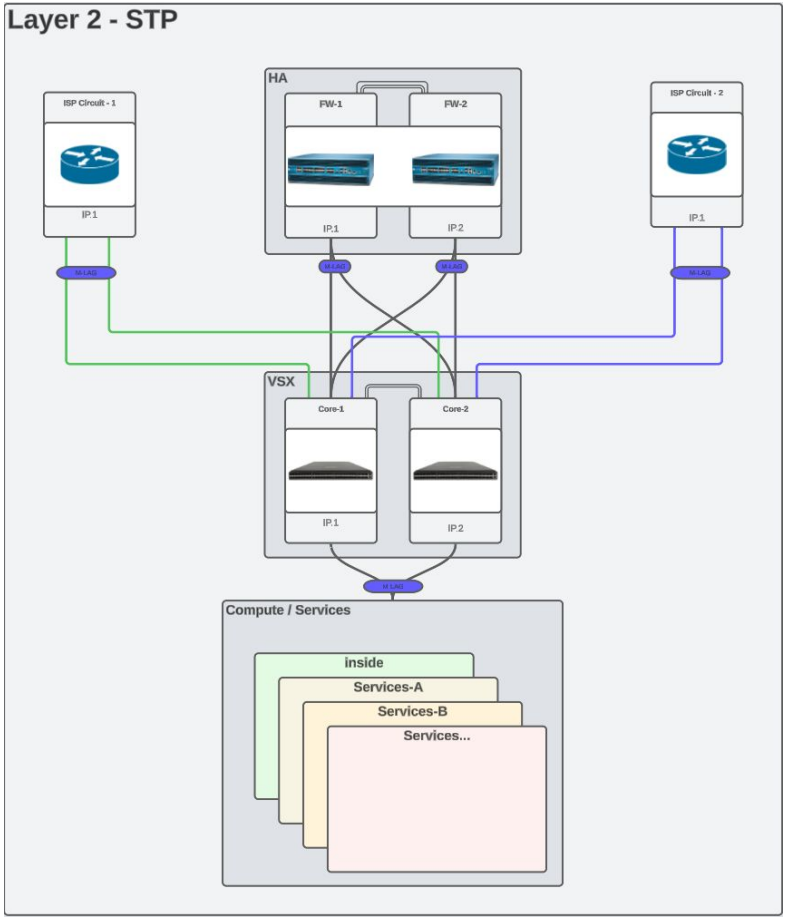
digitalscepter

Methods of Implementation

Firewall on a stick

+Simple design
+Quick migration
-Dependency on L2 links to remote sites for firewalling remote site networks
-VLANs can't overlap*
-MAC Limitations on Leased Circuits

*-802.1ad Q-in-Q may be a work-around.



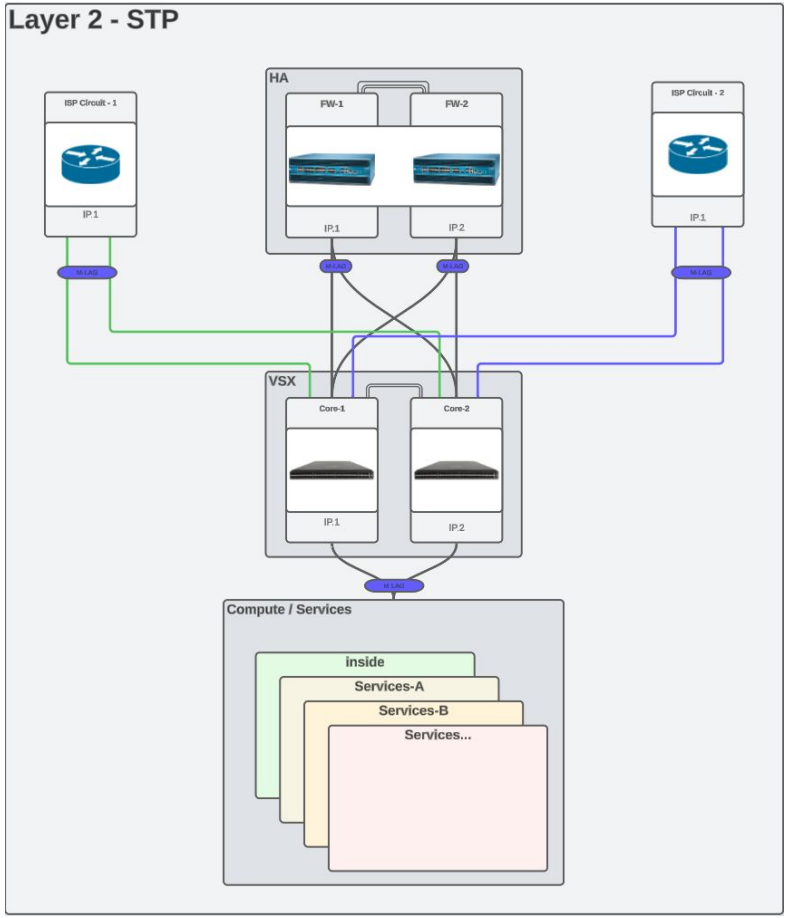
digitalscepter

Methods of Implementation

Firewall on a stick

Sample Scope

1. Configure aggregate group between firewalls and core
2. Migrate ACL's from core subnets to firewalls
3. Migrate SVI's from core to firewalls
4. Commit and push changes
5. Clear ARP tables and validate functionality

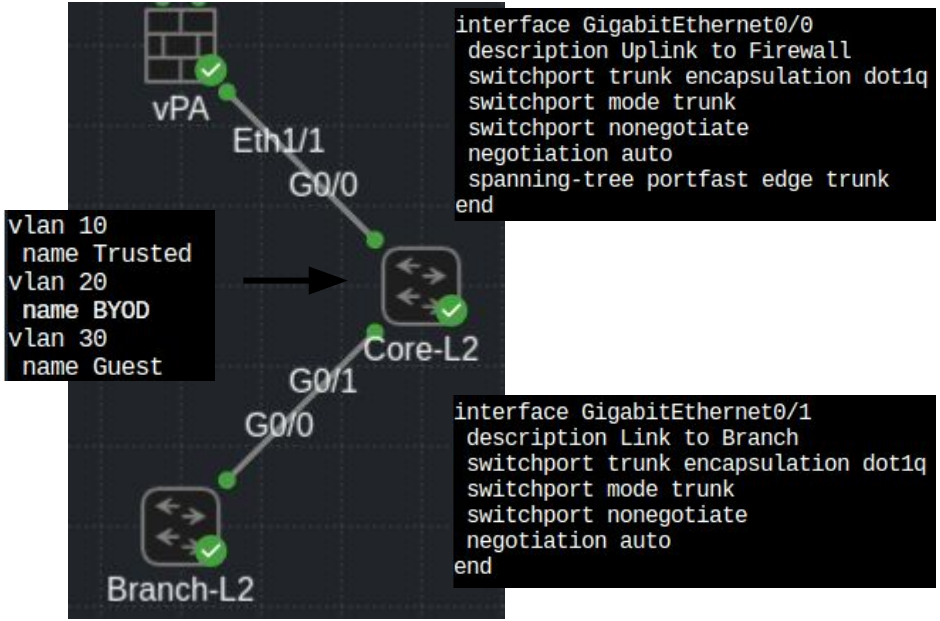


digitalscepter

Methods of Implementation

Firewall on a stick

INTERFACE	INTERF... TYPE	LINK STATE	IP ADDRESS	SECURI... ZONE
ethernet1/1	Layer3		none	none
ethernet1/1.10	Layer3		10.1.10.254/24	Trusted
ethernet1/1.20	Layer3		10.1.20.254/24	BYOD
ethernet1/1.30	Layer3		10.1.30.254/24	Guest



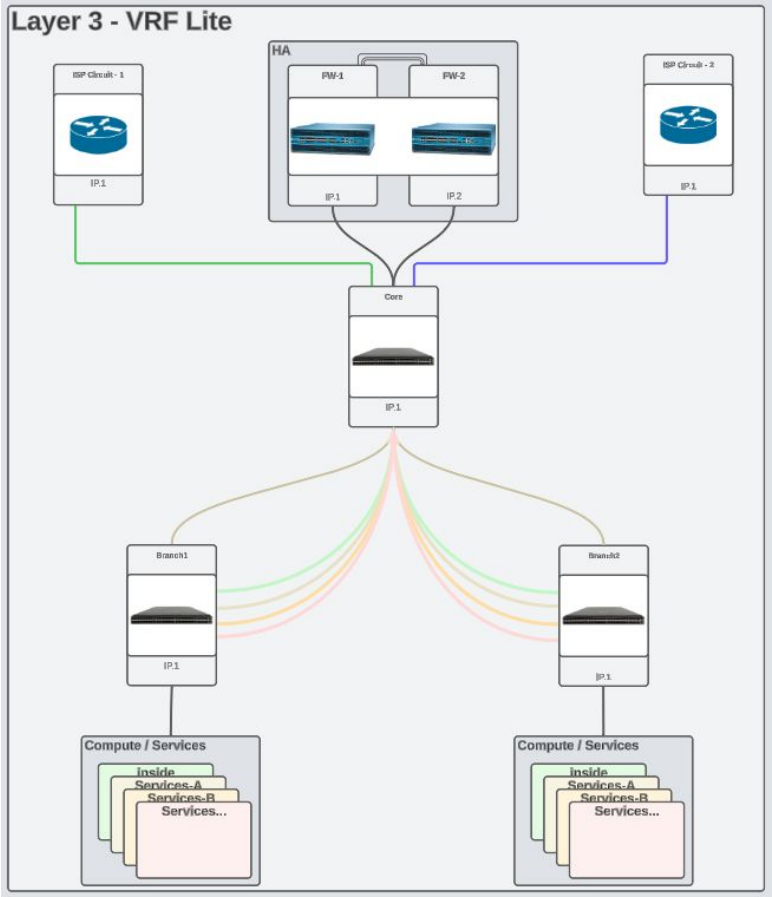
Firewall on a Stick/VLAN Extension:
You only need Layer 2 VLANs and Trunks configured.

digitalscepter

Methods of Implementation

VRF-Lite

+VLANs can overlap
+Smaller broadcast domains
+Widely supported
+VRF-Lite + Tunnel can act as a basic overlay.
+/- VRF-Lite using 802.1q has no overlay overhead. Tunnel based overlay has high overhead.
-Possible Dependency on 802.1q L2 links to remote site
-Not scalable - Dedicated routing protocol per VRF/Zone.



digitalscepter

Methods of Implementation

VRF-Lite

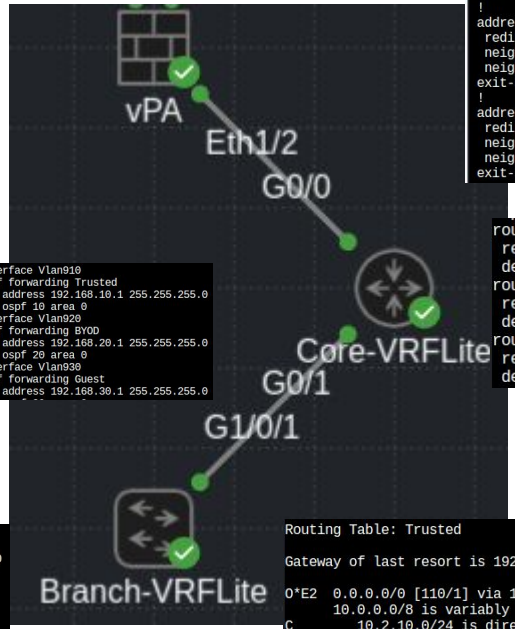
INTERF...	COMMENT	IP ADDRESS	SECURI... ZONE
vlan		none	none
vlan.10	Trust - L3 Peer	172.20.10.254/24	Trusted
vlan.20	BYOD - L3 Peer	172.20.20.254/24	BYOD
vlan.30	Guest - L3 Peer	172.20.30.254/24	Guest

VRF Lite:

- Each VRF needs its own router process and path.
- Each router in the path needs to have VRF configuration.

```
interface Tunnel10
 vrf forwarding Trusted
 ip address 192.168.210.1 255.255.255.254
 ip ospf network point-to-point
 ip ospf 10 area 0
 tunnel source Loopback0
 tunnel destination 10.255.2.1
 tunnel key 10
!
interface Tunnel20
 vrf forwarding BYOD
 ip address 192.168.220.1 255.255.255.254
 ip ospf network point-to-point
 ip ospf 20 area 0
 tunnel source Loopback0
 tunnel destination 10.255.2.1
 tunnel key 20
!
interface Tunnel30
 vrf forwarding Guest
 ip address 192.168.230.1 255.255.255.254
 ip ospf network point-to-point
 ip ospf 30 area 0
 tunnel source Loopback0
 tunnel destination 10.255.2.1
 tunnel key 30
```

```
router bgp 65002
 bgp router-id interface Loopback0
 no bgp transport path-mtu-discovery
 bgp log-neighbor-changes
 no bgp default ipv4-unicast
 !
 address-family ipv4 vrf BYOD
  redistribute ospf 20
  neighbor 172.20.20.254 remote-as 65535
  neighbor 172.20.20.254 activate
 exit-address-family
 !
 address-family ipv4 vrf Guest
  redistribute ospf 30
  neighbor 172.20.30.254 remote-as 65535
  neighbor 172.20.30.254 activate
 exit-address-family
 !
 address-family ipv4 vrf Trusted
  redistribute ospf 10
  neighbor 172.20.10.254 remote-as 65535
  neighbor 172.20.10.254 activate
 exit-address-family
```




```
interface Vlan910
 vrf forwarding Trusted
 ip address 192.168.10.1 255.255.255.0
 ip ospf 10 area 0
interface Vlan920
 vrf forwarding BYOD
 ip address 192.168.20.1 255.255.255.0
 ip ospf 20 area 0
interface Vlan930
 vrf forwarding Guest
 ip address 192.168.30.1 255.255.255.0
```

```
router ospf 10 vrf Trusted
 redistribute bgp 65002 subnets
 default-information originate
router ospf 20 vrf BYOD
 redistribute bgp 65002 subnets
 default-information originate
router ospf 30 vrf Guest
 redistribute bgp 65002 subnets
 default-information originate
```

```
interface Vlan10
 vrf forwarding Trusted
 ip address 10.2.10.254 255.255.255.0
 ip ospf 10 area 0
 no autostate
!
interface Vlan20
 vrf forwarding BYOD
 ip address 10.2.20.254 255.255.255.0
 ip ospf 20 area 0
 no autostate
!
interface Vlan30
 vrf forwarding Guest
 ip address 10.2.30.254 255.255.255.0
 ip ospf 30 area 0
 no autostate
```

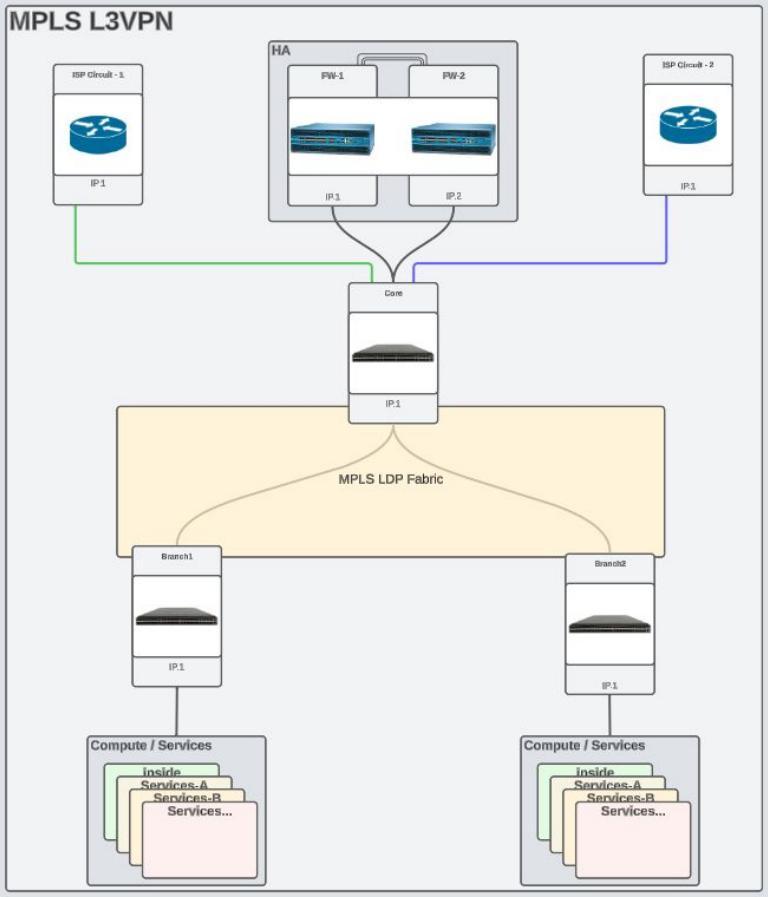
```
Routing Table: Trusted

Gateway of last resort is 192.168.210.0 to network 0.0.0.0

O*E2  0.0.0.0/0 [110/1] via 192.168.210.0, 1d11h, Tunnel10
      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.2.10.0/24 is directly connected, Vlan10
L        10.2.10.254/32 is directly connected, Vlan10
O     192.168.10.0/24 [110/1001] via 192.168.210.0, 1d11h, Tunnel10
      192.168.210.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.210.0/31 is directly connected, Tunnel10
L        192.168.210.1/32 is directly connected, Tunnel10
```


digitalscepter

Methods of Implementation

MPLS L3VPN

+VLANs can overlap
+Smaller broadcast domains
+Highly Scalable (ISPs use it Globally)
+Low Overlay Overhead (8 bytes)
-All devices in labeled path need to support MPLS.
-Not a common skillset.
-TCP Clamping Not Easily Implemented (Use Jumbo MTU)



digitalscepter

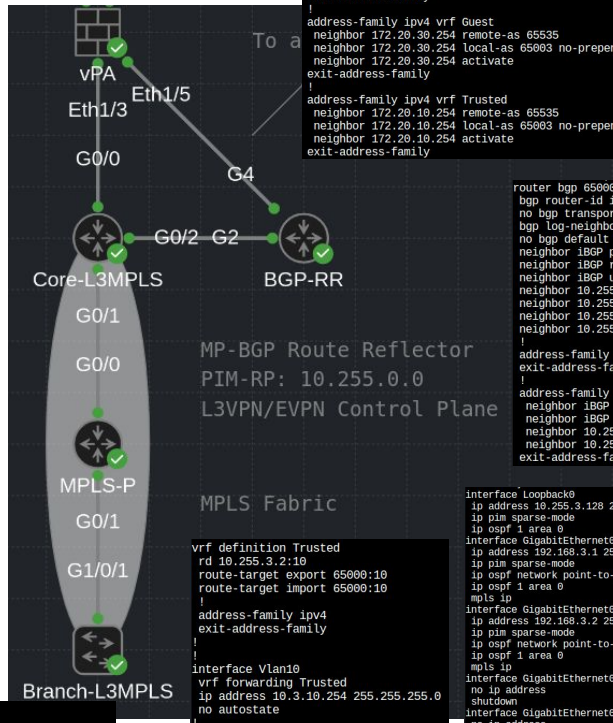
Methods of Implementation

MPLS L3VPN

INTERF...	COMMENT	IP ADDRESS	SECURI... ZONE
vlan		none	none
vlan.10	Trust - L3 Peer	172.20.10.254/24	Trusted
vlan.20	BYOD - L3 Peer	172.20.20.254/24	BYOD
vlan.30	Guest - L3 Peer	172.20.30.254/24	Guest

MPLS L3VPN:
iBGP Extended Communities are used to Import/Export Routes per VRF. MPLS LDP will dynamically build a path to carry the data.

- OSPF is used in the underlay to provide reachability between loopbacks
- BGP-Route Reflector is used for easy scalability.




```
address-family ipv4 vrf BYOD
 neighbor 172.20.20.254 remote-as 65535
 neighbor 172.20.20.254 local-as 65003 no-prepend replace-as
 neighbor 172.20.20.254 activate
exit-address-family
!
address-family ipv4 vrf Guest
 neighbor 172.20.30.254 remote-as 65535
 neighbor 172.20.30.254 local-as 65003 no-prepend replace-as
 neighbor 172.20.30.254 activate
exit-address-family
!
address-family ipv4 vrf Trusted
 neighbor 172.20.10.254 remote-as 65535
 neighbor 172.20.10.254 local-as 65003 no-prepend replace-as
 neighbor 172.20.10.254 activate
exit-address-family
```

```
router bgp 65000
 bgp router-id interface Loopback0
 no bgp transport path-mtu-discovery
 bgp log-neighbor-changes
 no bgp default ipv4-unicast
 neighbor iBGP peer-group
 neighbor iBGP remote-as 65000
 neighbor iBGP update-source Loopback0
 neighbor 10.255.3.1 peer-group iBGP
 neighbor 10.255.3.2 peer-group iBGP
 neighbor 10.255.4.1 peer-group iBGP
 neighbor 10.255.4.2 peer-group iBGP
 !
 address-family ipv4
 exit-address-family
 !
 address-family vpnv4
  neighbor iBGP send-community extended
  neighbor iBGP route-reflector-client
  neighbor 10.255.3.1 activate
  neighbor 10.255.3.2 activate
 exit-address-family
```

```
interface Loopback0
 ip address 10.255.3.128 255.255.255.255
 ip pim sparse-mode
 ip ospf 1 area 0
interface GigabitEthernet0/0
 ip address 192.168.3.1 255.255.255.254
 ip pim sparse-mode
 ip ospf network point-to-point
 ip ospf 1 area 0
 mpls ip
interface GigabitEthernet0/1
 ip address 192.168.3.2 255.255.255.254
 ip pim sparse-mode
 ip ospf network point-to-point
 ip ospf 1 area 0
 mpls ip
interface GigabitEthernet0/2
 no ip address
 shutdown
interface GigabitEthernet0/3
 no ip address
 shutdown
router ospf 1
 router-id 10.255.3.128
```

```
vrf definition Trusted
 rd 10.255.3.2:10
 route-target export 65000:10
 route-target import 65000:10
 !
 address-family ipv4
 exit-address-family
!
!
interface Vlan10
 vrf forwarding Trusted
 ip address 10.3.10.254 255.255.255.0
 no autostate
!
router bgp 65000
 !
 address-family ipv4 vrf Trusted
  redistribute connected
 exit-address-family
!
end
```

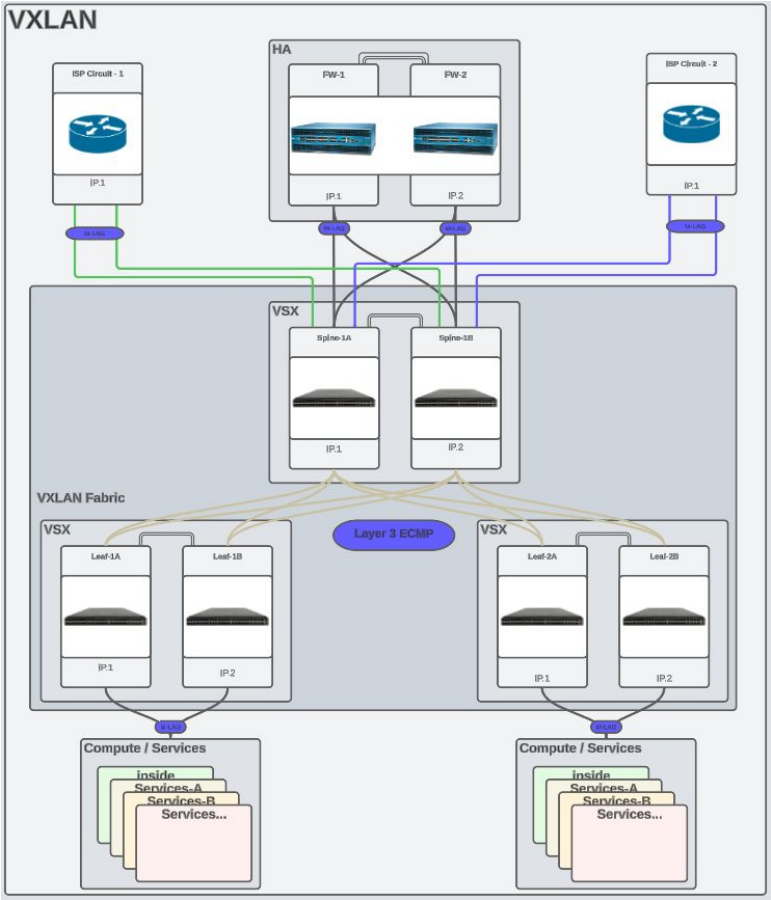
```
Routing Table: Trusted

Gateway of last resort is 10.255.3.1 to network 0.0.0.0

B*    0.0.0.0/0 [200/0] via 10.255.3.1, 03:54:25
      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.3.10.0/24 is directly connected, Vlan10
L        10.3.10.254/32 is directly connected, Vlan10
```


digitalscepter

Methods of Implementation

BGP EVPN

+VLANs can overlap
+Smaller broadcast domains
+Highly Scalable (DC/Colos use it Globally)
+Data carried by UDP datagram - No special transport requirements.
+Can function as both L2 and L3 extension.
-High Overlay Overhead (## bytes)
-Not a common skillset.
-TCP Clamping Not Easily Implemented (Use Jumbo MTU)



digitalscepter

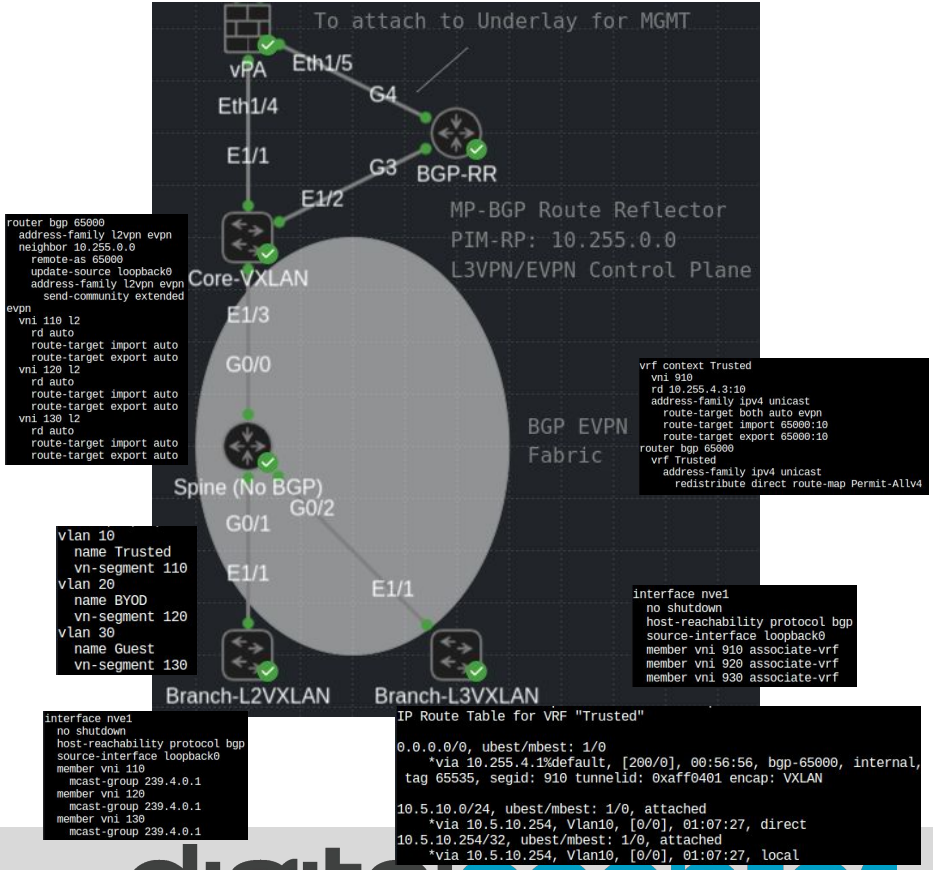
Methods of Implementation

BGP EVPN

INTERF...	COMMENT	IP ADDRESS	SECURI... ZONE
vlan		none	none
vlan.10	Trust - L3 Peer	172.20.10.254/24	Trusted
vlan.20	BYOD - L3 Peer	172.20.20.254/24	BYOD
vlan.30	Guest - L3 Peer	172.20.30.254/24	Guest

BGP EVPN:
iBGP Extended Communities are used to Import/Export Routes per VRF/VNI. VXLAN NVEs will dynamically forward traffic to peer switches.

- OSPF is used in the underlay to provide reachability between loopbacks.
- PIM is used to create multicast underlay for flood BUM traffic. (Broadcast, Unknown-unicast, and Multicast)
*Non-Multicast options are also available (Ingress-Replication)
- BGP-Route Reflector is used for easy scalability.



Note on MTU (Examples)

- 802.1q

```
▶ Frame 8: 118 bytes on wire (944 bits), 118 bytes captured (944 bits)
▶ Ethernet II, Src: RealtekU_00:12:27 (52:54:00:00:12:27), Dst: RealtekU_0f:d8:65 (52:54:00:0f:d8:65)
▶ 802.1Q Virtual LAN, PRI: 0, DEI: 0, ID: 910
▶ Internet Protocol Version 4, Src: 10.2.10.254, Dst: 8.8.8.8
▶ Internet Control Message Protocol
```

- MPLS

```
▶ Frame 7: 122 bytes on wire (976 bits), 122 bytes captured (976 bits)
▶ Ethernet II, Src: RealtekU_01:5c:0b (52:54:00:01:5c:0b), Dst: RealtekU_15:6d:ef (52:54:00:15:6d:ef)
▶ MultiProtocol Label Switching Header, Label: 17, Exp: 0, S: 0, TTL: 255
▶ MultiProtocol Label Switching Header, Label: 56, Exp: 0, S: 1, TTL: 255
▶ Internet Protocol Version 4, Src: 10.3.10.254, Dst: 8.8.8.8
▶ Internet Control Message Protocol
```

- GRE

```
▶ Frame 10: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits)
▶ Ethernet II, Src: RealtekU_00:12:0d (52:54:00:00:12:0d), Dst: RealtekU_0f:d8:65 (52:54:00:0f:d8:65)
▶ Internet Protocol Version 4, Src: 10.255.2.2, Dst: 10.255.2.1
▶ Generic Routing Encapsulation (IP)
▶ Internet Protocol Version 4, Src: 10.2.10.254, Dst: 8.8.8.8
▶ Internet Control Message Protocol
```

- VXLAN

```
▶ Frame 6: 148 bytes on wire (1184 bits), 148 bytes captured (1184 bits)
▶ Ethernet II, Src: RealtekU_18:f4:60 (52:54:00:18:f4:60), Dst: 52:10:d7:d6:1b:08 (52:10:d7:d6:1b:08)
▶ Internet Protocol Version 4, Src: 10.255.4.3, Dst: 10.255.4.1
▶ User Datagram Protocol, Src Port: 52215, Dst Port: 4789
▶ Virtual eXtensible Local Area Network
▶ Ethernet II, Src: 52:1d:4b:d9:1b:08 (52:1d:4b:d9:1b:08), Dst: 52:10:d7:d6:1b:08 (52:10:d7:d6:1b:08)
▶ Internet Protocol Version 4, Src: 10.5.10.254, Dst: 8.8.8.8
▶ Internet Control Message Protocol
```

- IPSEC

```
▶ Frame 6: 194 bytes on wire (1552 bits), 194 bytes captured (1552 bits)
▶ Ethernet II, Src: RealtekU_08:a5:9a (52:54:00:08:a5:9a), Dst: RealtekU_1e:8a:ad (52:54:00:1e:8a:ad)
▶ Internet Protocol Version 4, Src: 10.255.2.3, Dst: 10.255.2.1
▶ Encapsulating Security Payload
```

Different frame sizes using different overlay techniques.

Base ICMP ping frame size is 114 bytes.

802.1q and MPLS are the smallest as they sit in front of the original IP header.

The other techniques encapsulate the original IP packet inside of a new IP packet.

digitalscepter

Methods of Implementation

- Option 1 - Migrate server vlan interfaces from core switch and place them on firewall
  - Quicker to implement
  - May need to migrate ACLs from switch
  - May need to further segment existing subnets
- Option 2 - Create new server subnets on firewall and migrate applications to new subnets
  - Migrating applications to new subnets is a large effort that carries risk (services using IP address versus hostname will break)
  - Will require rulebase updates for IP changes, but will lead to cleaner rulebase
  - Applications can be moved one at a time allowing slow, methodical approach

Recommendations

- If there are just a few server subnets
  - Option 1, followed by option 2
  - This will allow instant improvement of security posture by getting subnets on the firewall
  - Option 2 can then be implemented over time to continue improving posture
- If there are significant server subnets
  - Option 1
  - If assets are already properly categorized into subnets, migrating the subnets straight to the firewall should be all that is needed
  - Make sure ACLs are properly migrated prior to migrating

Considerations

- Security and NAT policies will need to be updated to reflect changes to zones
- Load balancers can lead to asymmetric routes and will need to be considered before migrating subnets

What is Falco?

- A tool to detect configuration issues
- A managed service to assist with fixing them

FALCO

FALCO

Sample Falco Report

Falco Plus

Summary | Policies | Objects | Network | Device

Device PA5250-1

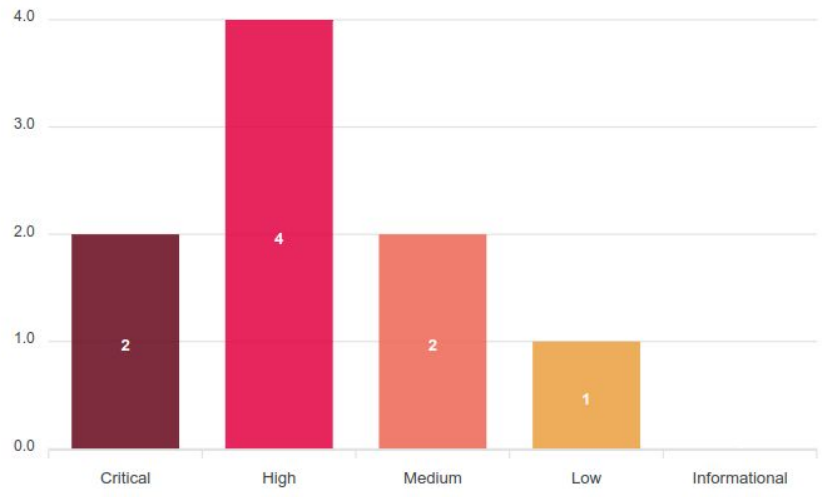
80% passed
1 Devices Audited

1/1 devices
Recommended Releases

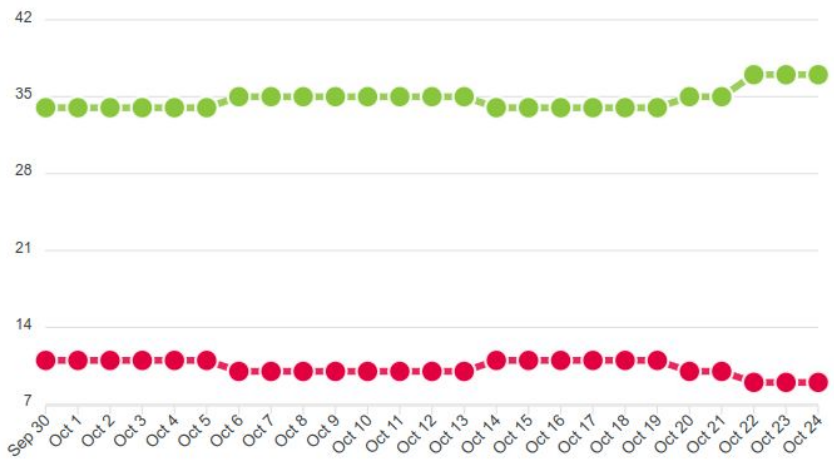
No Vulnerabilities
No Known Vulnerabilties Found

Support Licenses
All Devices Have Valid Support Licenses

Failed Check Severity



Report History



digitalscepter

sales@digitalscepter.com
(888) 299-3718

digitalscepter.com