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# NGFW Clustering Deep Dive

Andrew Ossipov, Distinguished Engineer

BRKSEC-3032

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# Your Speaker

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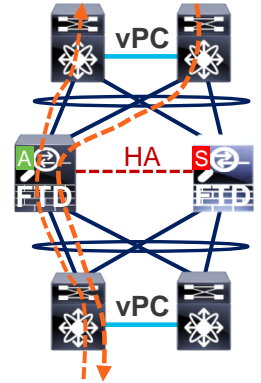
# Agenda

- Clustering Overview
- Unit Roles and Functions
- Packet Flow
- Control and Data Interfaces
- Configuring Clustering
- Multi-Site Clustering
- Closing Remarks

# Clustering Overview

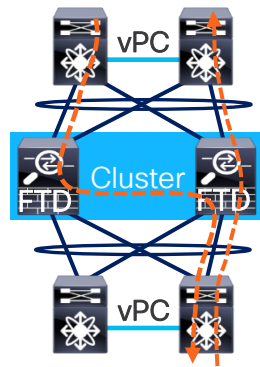
# High Availability on ASA and FTD

- A **pair** of identical **ASA** or **FTD** devices can be configured in Failover/HA
  - Managed as a single entity
  - Data interface connections must be mirrored between the units **with** L2 adjacency
  - Virtual IP and MAC addresses on data interfaces move with **Active** unit
  - Stateful connection table is replicated to **Standby** in real time
- Failover/HA deliver high availability rather than scalability
  - Limited to two physical appliances/modules or virtual instances
  - **Active/Standby** for **asymmetry avoidance** in ASA or FTD
  - **Active/Active** with multiple contexts in ASA is impractical for scaling



# ASA and FTD Clustering

- **Up to 16** appliances or modules combine in one traffic processing system
- Preserve failover benefits by configuring and operating as a single entity
  - Virtual IP and MAC addresses for first-hop redundancy
  - Connection states are preserved after a single member failure
- Implement true **scalability** in addition to high availability
  - Fully distributed data plane for new and existing connections
  - Elastic scaling of throughput and maximum concurrent connections
  - Stateless external load-balancing through standard Etherchannel
  - Out-of-band Cluster Control Link for **asymmetry normalization**
  - No member-to-member communication on data interfaces





# System Requirements

- **ASA** scales up to 16 **identical** appliances or modules
  - Up to 16 Firepower 4100 or 9300 modules with matching **Export Compliance**
  - Up to 16 ASA5585-X with **Cluster** and same **3DES** and **10GE I/O** licenses
  - Up to 2 ASA5500-X with **Security Plus** and matching **3DES** licenses
- **FTD** scales up to 6 **identical** appliances or modules **as documented**
  - Up to 16 Firepower 4100 appliances or 9300 modules is **configurable**
  - Multi-instance capability in **FTD 6.6** will no longer require identical hardware
  - Some advanced cluster settings **must** use **FlexConfig**
- Any standard-based switch is supported, some are explicitly validated

# Unsupported Features

- Remote Access VPN: TLS VPN, Clientless SSL VPN, and IPsec
- S2S VPN on **FTD only** until **6.2.3.3**
- DHCP client, DHCP server, DHCP Proxy
- Advanced Application Inspection and Redirection
  - CTIQBE, WAAS, MGCP, MMP, RTSP, Skinny/SCCP, H.323
  - Dead Connection Detection (DCD) until **ASA 9.13**, Botnet Traffic Filter, and WCCP
- Interfaces: Integrated Routing/Bridging (IRB), Virtual Tunnel Interface (VTI)
- Intermediate System-to-Intermediate System (IS-IS)
- Firepower Multi-Instance Capability until **FTD 6.6**

# Scalability

- Throughput scales at 70-80% of the aggregated capacity **on average**
  - ASA**: 16 Firepower 4145 at 50Gbps → **640Gbps** of Multiprotocol Throughput
  - FTD**: 6 Firepower 9300 SM-44 at 50Gbps → **240Gbps** of NGFW AVC Throughput
- Replicated** concurrent **conn**(ection)s scale at 60% of aggregated capacity
  - FTD**: 6 Firepower 4150 at 35M → **126M** concurrent **conns**
  - Firepower 9300 supports **120M** (**ASA**) or **60M** (**FTD**) **conns** per clustered chassis
- Conn** rate with **full replication** scales at 50% of the aggregated capacity
  - ASA**: 16 ASA5585-X SSP-60 at 350K CPS → 2.8M CPS
  - Short-lived connections may scale at 100% with delayed replication

```
asa(config)# cluster replication delay 10 match tcp any any eq www
```

Delay by 10 seconds

Match All HTTP connections

# Centralized Features

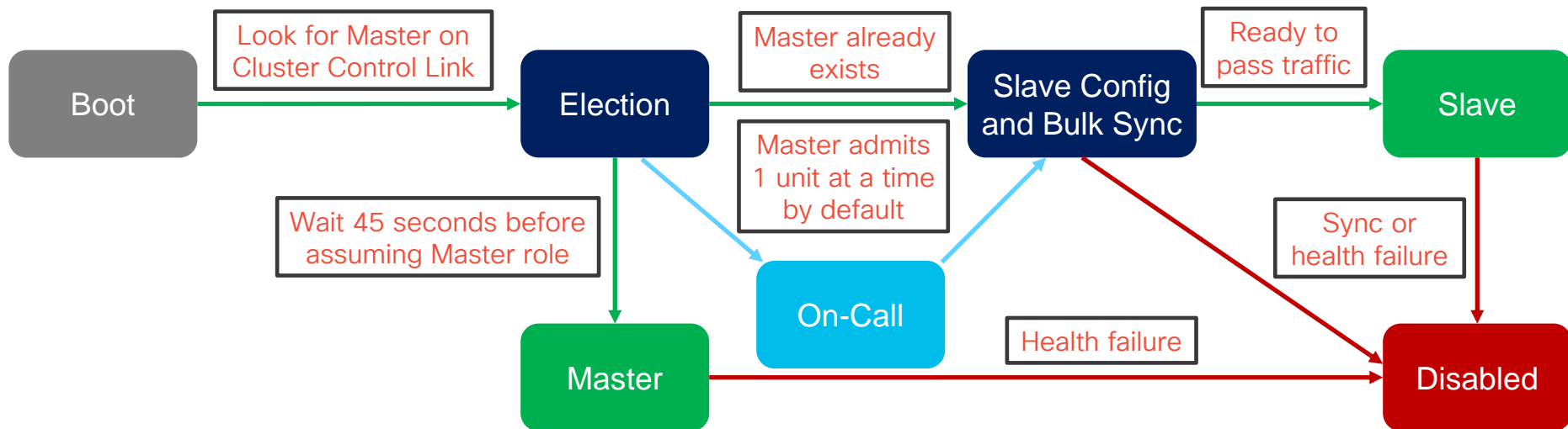
- Not all features are distributed, some are **Centralized**
  - Control and management connections
  - Non-Per-Session Xlates with PAT (e.g. ICMP)
  - DCERPC, ESMTP, IM, Netbios, PPTP, RADIUS, RSH, SNMP, SQLNet, SunRPC, TFTP, and XDMCP inspection engines
  - Site-to-site VPN until **ASA 9.9(1)** with optional distribution on Firepower 9300
  - Multicast in rare scenarios
- Any connections with these features always land on one cluster member
  - Switchover of such connections is **not seamless**

# Unit Roles and Functions

# Master and Slaves

- One cluster member is elected as the **Master**; others are **Slaves**
  - First unit joining the cluster or based on configured **priority**
  - New master is elected **only** upon a departure of the existing one
- Master unit handles all management and centralized functions
  - Configuration is blocked on all other members
  - Virtual IP address ownership for to-the-cluster connections
- Master and slaves process all regular transit connections equally
  - Management and centralized connections must reestablish upon Master failure
  - Disable or reload Master to transition the role

# State Transition



ASA/master# **show cluster history**

```
=====
From State      To State      Reason
=====
15:36:33 UTC Dec 3 2018
DISABLED        DISABLED        Disabled at startup
15:37:10 UTC Dec 3 2018
DISABLED        ELECTION       Enabled from CLI
15:37:55 UTC Dec 3 2018
ELECTION        MASTER        Enabled from CLI
=====
```

ASA/master# **show cluster info**

```
Cluster sjfw: On
Interface mode: spanned
This is "A" in state MASTER
ID       : 0
Version  : 9.10(1)
Serial No.: JAF1434AERL
CCL IP    : 1.1.1.1
CCL MAC   : 5475.d029.8856
Last join : 15:37:55 UTC Dec 3 2018
Last leave: N/A
```

# Member Admission Optimization

- **ASA 9.10(1)** and **FTD 6.3** allow parallel cluster join on Firepower 9300
- Each chassis optionally bundles data interfaces only when all modules are ready

```
asa(cfg-cluster)# unit parallel-join 3 max-bundle-delay 5
```

How many modules must replicate configuration and state before enabling chassis data plane

Maximum wait time in minutes



# Flow Owner

- All packets for a single **stateful** connection go through a single member
  - Unit receiving the first packet for a new connection typically becomes **Flow Owner**
  - Ensures symmetry for state tracking purposes and NGFW/NGIPS inspection

```
ASA/master# show conn
18 in use, 20 most used
Cluster stub connections: 0 in use, 0 most used
TCP outside 10.2.10.2:22 inside 192.168.103.131:35481, idle 0:00:00, bytes 4164516, flags UIO
```

- Another unit will become **Flow Owner** if the original one fails
  - Receiving packet for an existing connection with no owner
- The **conn-rebalance ASA** feature should be enabled with caution
  - An overloaded member may work even harder to redirect new connections
- Existing connections move **only** on unit departure or with **Flow Mobility**

# Flow Director

- **Flow Owner** for a connection must be discoverable by all cluster members
  - Each possible connection has a deterministically assigned **Flow Director**
  - Compute hash of {**SrcIP**, **DstIP**, **SrcPort**, **DstPort**} for a flow to determine **Director**
  - Hash mappings for all possible flows are evenly distributed among members
  - All members share the same hash table and algorithm for consistent lookups
  - **SYN Cookies** reduce lookups for TCP flows with **Sequence Number Randomization**
- Other units ask **Flow Director** to identify **Owner** or restore flow from backup
  - New **Owner** can recover connection state from director upon original **Owner** failure
- Create **Backup Flow** when **Director** and **Owner** is same member or in same chassis

```
TCP outside 172.18.254.194:5901 inside 192.168.1.11:54397, idle 0:00:08, bytes 0, flags Y
```

```
TCP outside 172.18.254.194:5901 inside 192.168.1.11:54397, idle 0:00:08, bytes 0, flags Y
```

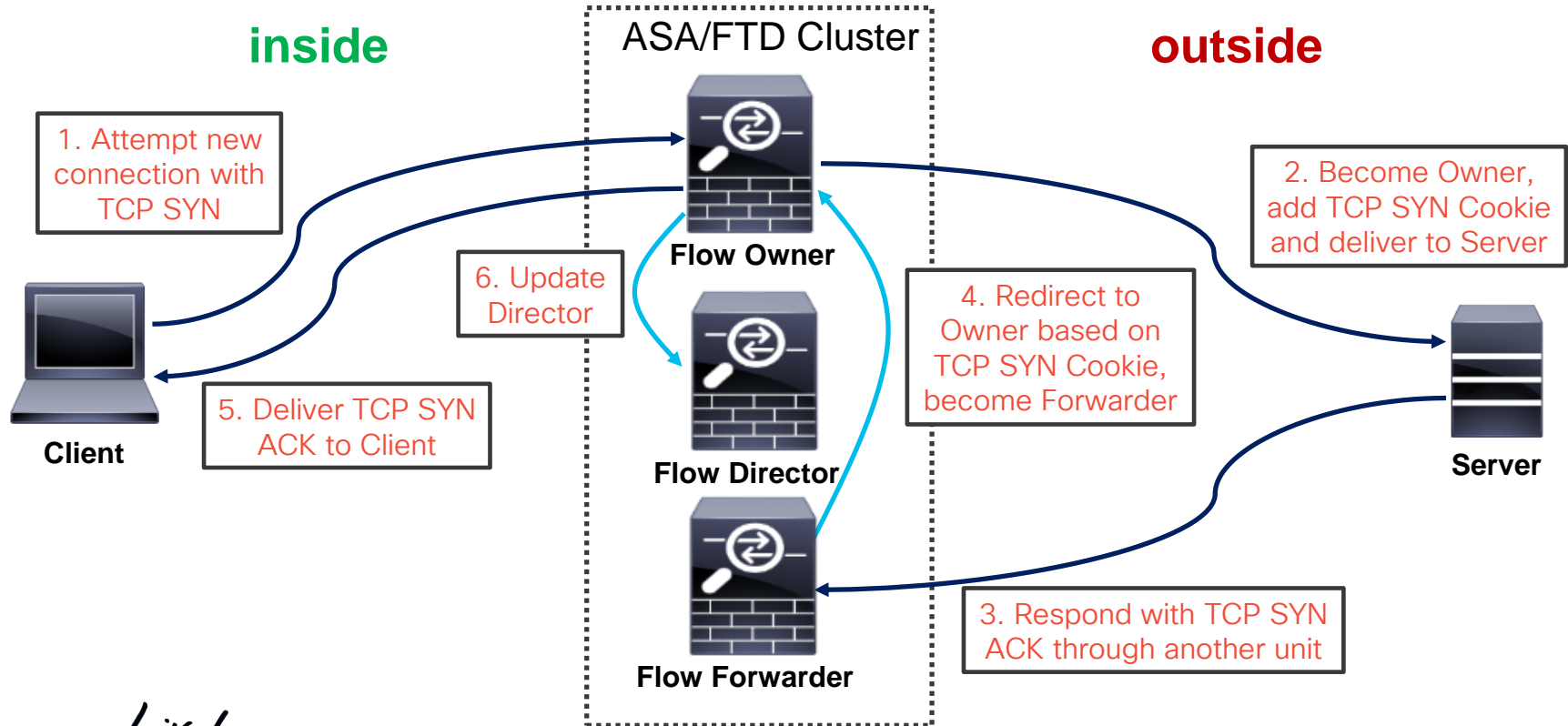
# Flow Forwarder

- External stateless load-balancing does not guarantee symmetry
  - Only TCP SYN packets can reliably indicate that the connection is new
- Cluster member receiving a non-TCP-SYN packet must ask **Flow Director**
  - No existing connection → Drop if TCP, become **Flow Owner** if UDP
  - Existing connection with no **Owner** → Become **Flow Owner**
  - Existing connection with active **Owner** → Become **Flow Forwarder**
- **Flow Forwarder** maintains stub connection entry to avoid future lookups
  - Asymmetrically received packets are redirected to **Owner** via **Cluster Control Link**

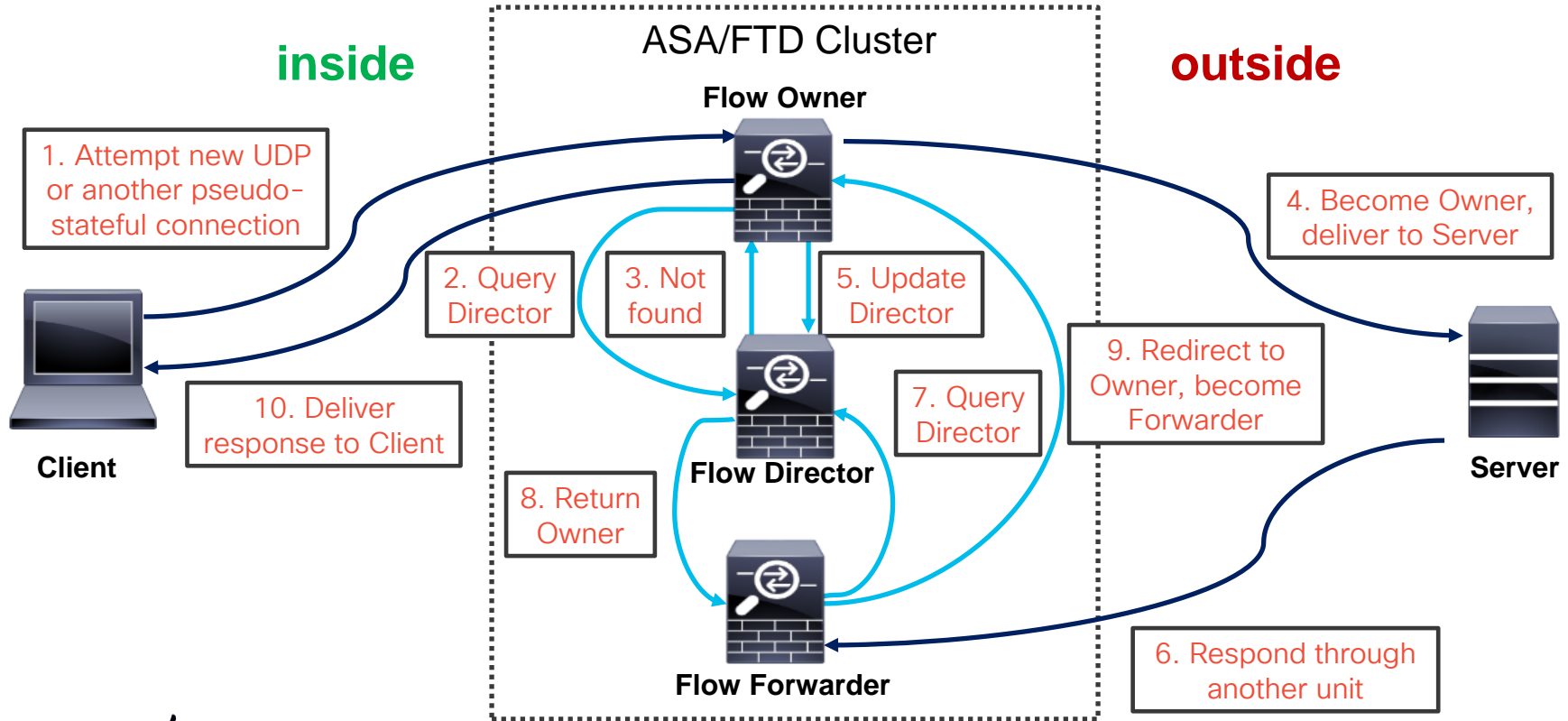
```
ASA/slave# show conn detail
[...]  
TCP inside: 192.168.103.131/52033 NP Identity Ifc: 10.8.4.10/22,  
  flags z, idle 0s, uptime 8m37s, timeout -, bytes 0,  
  cluster sent/rcvd bytes 25728/0, cluster sent/rcvd total bytes 886204/0, owners (1,255)
```

# Packet Flow

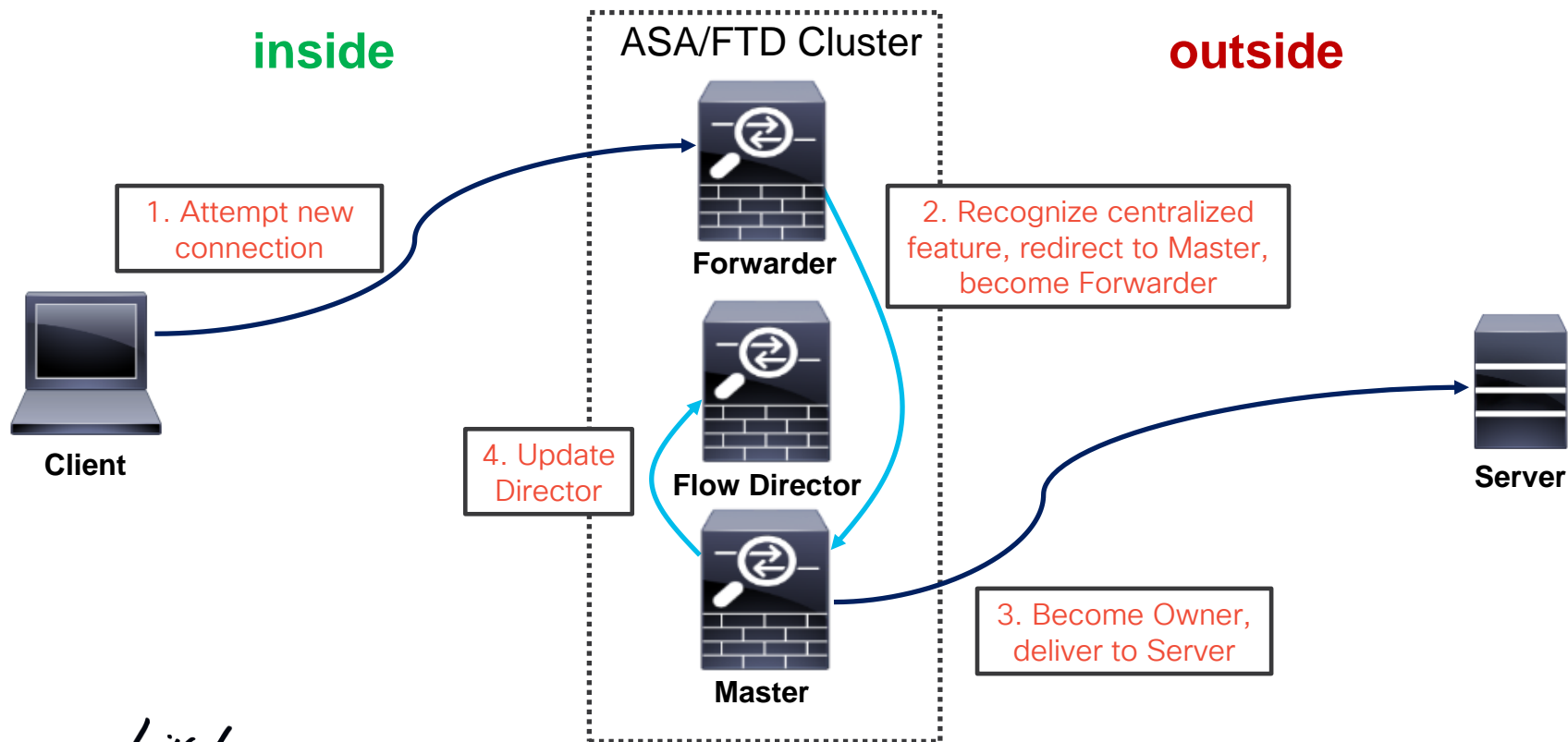
# New TCP Connection



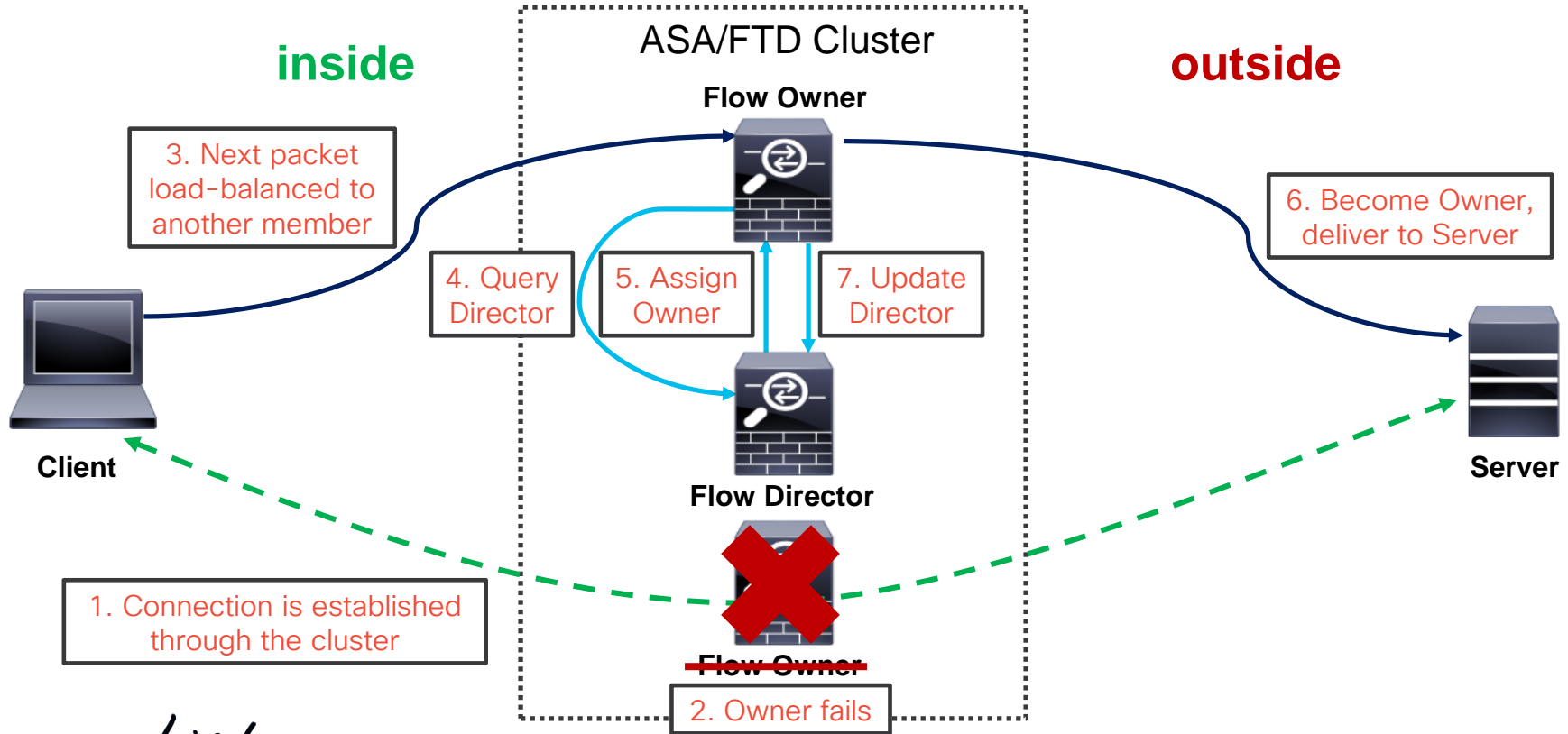
# New UDP-Like Connection



# New Centralized Connection



# Owner Failure





# Basic Application Inspection

- **Centralized**

- All packets for control and associated data connections are redirected to Master
- Examples: **ESMTP**, **SQLNet**, **TFTP**

- **Fully Distributed**

- Control and associated data connections are processed independently by all units
- Examples: **HTTP** on **ASA**, **FTP**, **GTP**

- **Semi Distributed**

- Control connections are processed independently by all units
- Data connections are redirected to the associated control connections' Owners
- Examples: **SIP**, **SCTP**, **M3UA**

# Per-Session Port Address Translation (PAT)

- By default, dynamic PAT xlates have a 30-second idle timeout
  - Single global IP (65535 ports) allows about 2000 conn/sec for TCP and UDP
- **Per-Session Xlate** feature allows immediate reuse of the mapped port
- Enabled by default for all TCP and DNS connections

```
ftd# show run all xlate
xlate per-session permit tcp any4 any4
xlate per-session permit tcp any4 any6
xlate per-session permit tcp any6 any4
xlate per-session permit tcp any6 any6
xlate per-session permit udp any4 any4 eq domain
xlate per-session permit udp any4 any6 eq domain
xlate per-session permit udp any6 any4 eq domain
xlate per-session permit udp any6 any6 eq domain
```

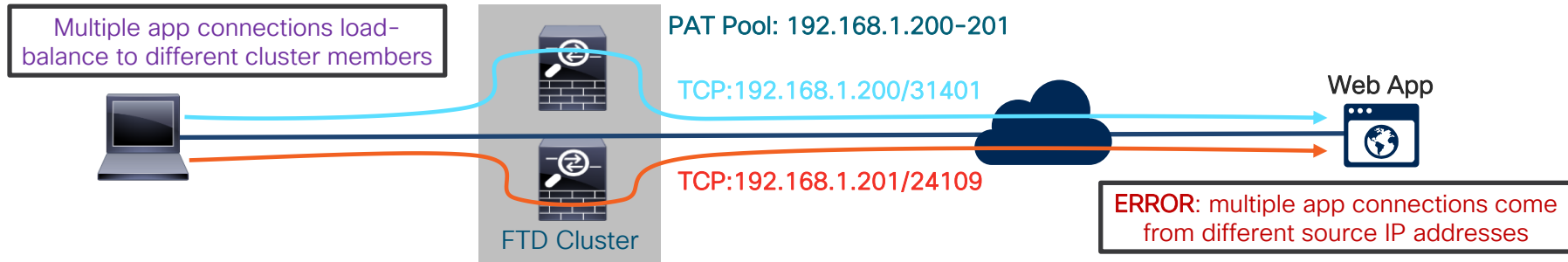
- TCP Reset is generated to force immediate termination

# Network Address Translation (NAT)

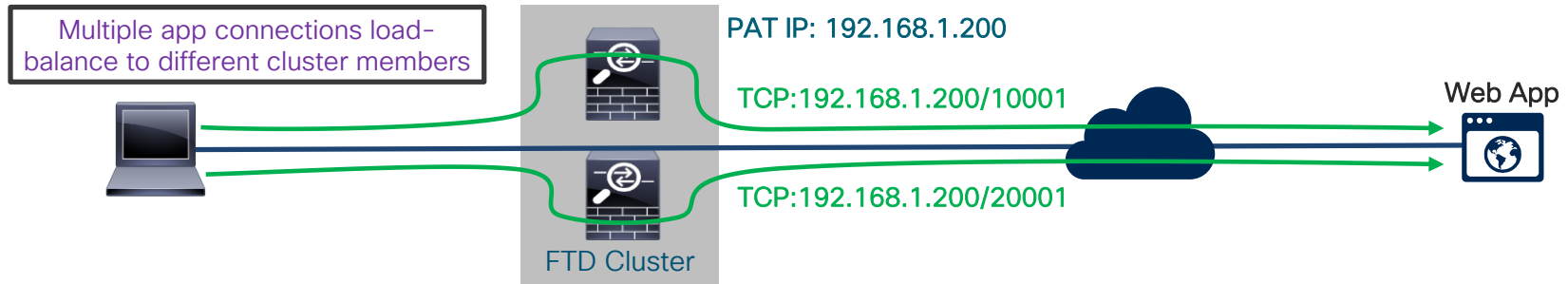
- **Static NAT** is performed by all cluster members based on configuration
- Master creates one-to-one **Dynamic NAT** xlates and replicates to Slaves
- **Dynamic PAT** is distributed to individual members
  - Master evenly allocates PAT addresses from the configured pools to each member
  - Provision **at least** as many pool IPs as cluster members to avoid centralization
  - Per-session xlates are local to the Owner with an **Xlate Backup**
- NAT limits clustering scalability with nearly guaranteed flow asymmetry
  - NAT and PAT pools are not advertised
  - No interface PAT or Proxy ARP in **Individual** mode

# Distributed PAT in Clustering

- Today PAT pool is uniformly distributed to all cluster members at IP level



- **FTD 6.7** and **ASA 9.15** will distribute each PAT pool IP at port block level



# Site-to-Site (S2S) IKEv2 VPN in Distributed Mode

- Supported on Firepower 9300 with **ASA 9.9(1)** and **Carrier** license only

```
asa(cfg-cluster)# vpn-mode distributed backup flat
```

- Tunnel establishment (IKEv2) is done through per-session **VPN Director**
- VPN Session Owner** handles IPsec and clear text traffic for a single tunnel
  - Backup Owner** assures uninterrupted forwarding on failure
  - Optional **Remote Chassis Backup** protects against full chassis failure

```
asa(cfg-cluster)# vpn-mode distributed backup remote-chassis
```

- Scalability is constrained by multiple factors
  - Concurrent S2S VPN tunnels scale at ~45% of aggregated capacity
  - Throughput impact from cleartext traffic redirection to VPN session owner
  - Runtime manual tunnel redistribution with **cluster redistribute vpn-sessiondb**

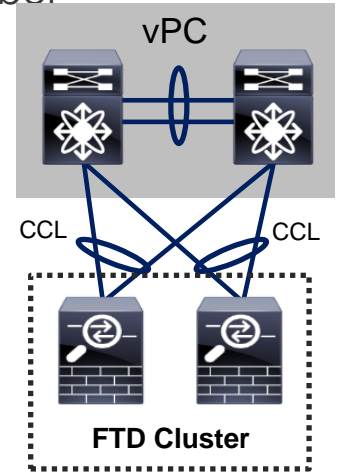
# Control and Data Interfaces

# Cluster Control Link (CCL)

- Carries all data and control communication between cluster members
  - Master discovery, configuration replication, keepalives, interface status updates
  - Centralized resource allocation (such as PAT/NAT, pinholes)
  - Flow Director updates and Owner queries
  - Centralized and asymmetric traffic redirection from Forwarders to Owners
- **Must use** same dedicated interfaces on each member
  - Separate physical interface(s), no sharing or VLAN sub-interfaces
  - An isolated non-overlapping subnet with a switch in between members
  - No packet loss or reordering; up to 10ms of one-way latency
- CCL loss **forces** the member out of the cluster
  - No direct back-to-back connections

# CCL Best Practices

- Use a **per-unit LACP** Etherchannel for link redundancy and aggregation
  - Bandwidth **should** match maximum forwarding capacity of each member
  - 40Gbps of data traffic on Firepower 4140 AVC+IPS → 4x10GE CCL
  - Dual-connect to different physical switches in vPC/VSS
- Set MTU 100 bytes above largest data interface MTU
  - Avoids fragmentation of redirected traffic due to extra trailer
  - Minimum supported value is 1400 bytes
- Ensure that CCL switches do not verify L4 checksums
- Enable **Spanning Tree Portfast** and align MTU on the switch side





# Data Interface Modes

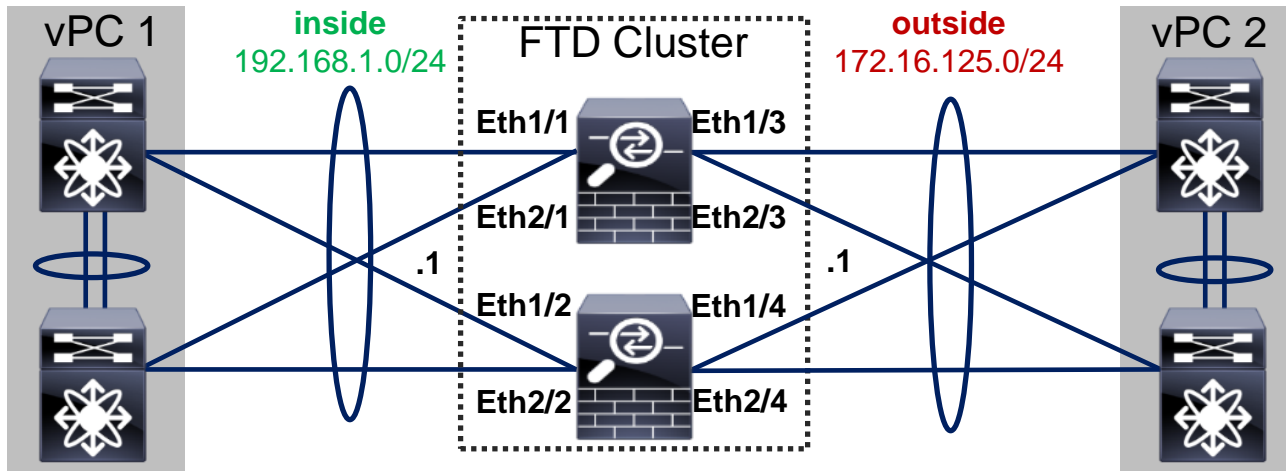
- Recommended data interface mode is **Spanned Etherchannel “L2”**
  - Multiple physical interfaces across all members bundle into a single Etherchannel
- External Etherchannel load-balancing algorithm defines per-unit load
- All units use the same virtual IP and MAC on each logical data interface
- Each member has unique IP on each data interface in **Individual “L3”** mode
  - Available **only** on ASA5500-X and ASA5585-X appliances running **ASA** image
  - Use **Nexus ITD** or **PBR** or dynamic routing protocols to load-balance traffic
  - Virtual IPs are owned by Master, interface IPs are assigned from configured pools

```
asa5585(config)# interface Port-Channell  
asa5585(config-if)# port-channel span-cluster
```

```
asa5585(config)# ip local pool INSIDE 192.168.1.2-192.168.1.17  
asa5585(config-if)# interface Port-Channell  
asa5585(config-if)# ip address 192.168.1.1 255.255.255.0 cluster-pool INSIDE
```

# Spanned Etherchannel Interface Mode

- Transparent and routed mode on **ASA/FTD**; NGIPS interfaces in **FTD**
- Must use Etherchannels: “firewall-on-a-stick” VLAN trunk or separate
- Use symmetric Etherchannel hashing algorithm with different switches
- Seamless load-balancing and unit addition/removal with cLACP



# Clustering LACP (cLACP)

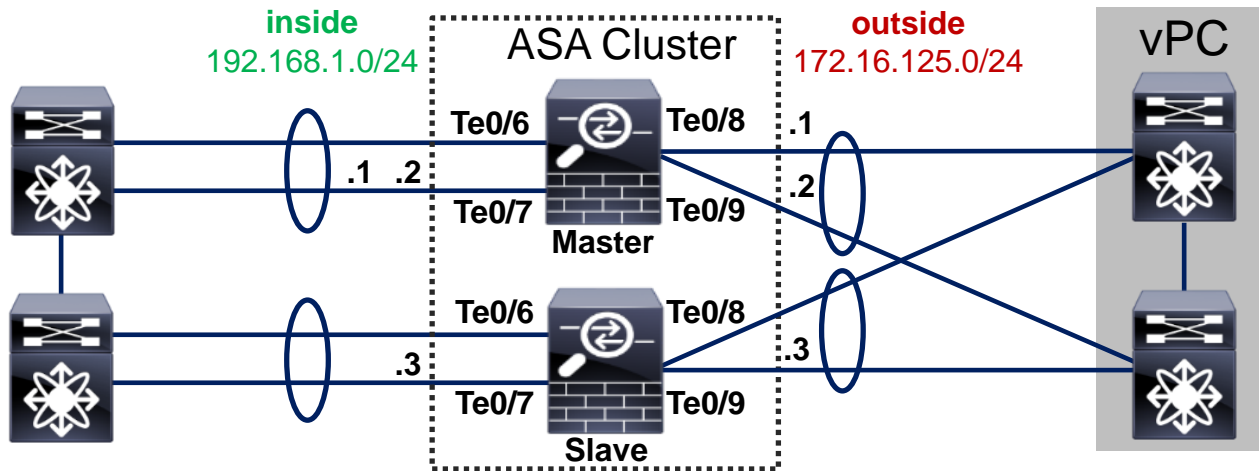
- Spanned Etherchannel is preferred for **data** interfaces on **ASA appliances**
  - Up to 32 (16 per unit) active total links with global static port priorities

```
asa(config)# cluster group DC_ASA  
asa(cfg-cluster)# clacp static-port-priority
```

- Disable LACP Graceful Convergence** and **Adaptive Hash** on adjacent NX-OS
- Supervisor bundles data and CCL interfaces on **Firepower 4100 and 9300**
  - Spanned Etherchannel **only** with up to 32 active total (up to 16 per chassis) links
  - Disable only Adaptive Hash** on adjacent NX-OS
- Always configure virtual MAC for each data Etherchannel to avoid instability
- cLACP **assumes** a Spanned Etherchannel connects to one logical switch
  - LACP actor IDs between member ports are not strictly enforced, allowing creativity

# Individual Interface Mode

- **Not supported** on Firepower 4100 or 9300; **routed** ASA only elsewhere
- Master owns virtual IP on data interfaces for management purposes only
- All members get data interface IPs from the pools in the order of admission
- Per-unit Etherchannel support up to 16 members



# Traffic Load Balancing in Individual Mode

- Each unit has a separate IP/MAC address pair on its data interfaces
  - Traffic load-balancing is not as seamless as with Spanned Etherchannel mode
- **Policy Based Routing (PBR)** with route maps is very static by definition
  - Simple per-flow hashing or more elaborate distribution using ACLs
  - Difficult to direct return connections with NAT/PAT
  - Must use SLA with Object Tracking to detect unit addition and removal
  - Nexus **Intelligent Traffic Director (ITD)** simplifies configuration process
- Dynamic routing with **Equal Cost Multi Path (ECMP)**
  - Per-flow hashing with no static configuration
  - Easier to detect member addition and removal
  - Preferred approach with some convergence caveats

# Dynamic Routing

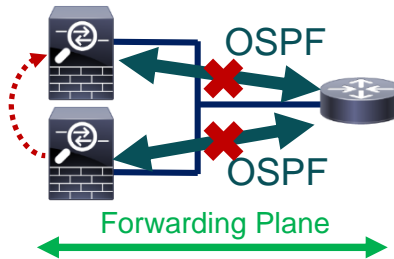
- Master unit runs dynamic routing in Spanned Etherchannel mode
  - RIP, EIGRP, OSPFv2, OSPFv3, BGP-4 (IPv4 and IPv6), PIM
  - Routing and ARP tables are synchronized to other members, like in failover
  - Possible external convergence impact **only** on Master failure
- Each member forms independent adjacencies in Individual mode
  - Same protocols as in Spanned Etherchannel, but multicast data is **centralized**
  - Higher overall processing impact from maintaining separate routing tables
  - Slower external convergence on any member failure

# Non Stop Forwarding (NSF)

- **Routing Information Base (RIB)** is replicated in Spanned Etherchannel mode
  - Master establishes dynamic routing adjacencies and keeps Slaves up-to-date
  - When Master fails, the cluster continues traffic forwarding based on RIB
  - New Master re-establishes the dynamic routing adjacencies and updates the RIB
  - Adjacent routers flush routes and cause momentary traffic blackholing
- **Non Stop Forwarding (NSF)** and **Graceful Restart (GR)** avoid blackholing

1. Cluster Master fails; new Master initiates adjacency with the peer router indicating that traffic forwarding should continue.

4. FTD/ASA cluster continues normal traffic forwarding until the primary RP restarts or the backup takes over or the timeout expires.



2. Router re-establishes adjacency with Master while retaining the stale routes; these routes are refreshed when the adjacency reestablishes.

3. Primary Route Processor undergoes a restart, signals the peer cluster to continue forwarding while the backup re-establishes adjacencies.

# NSF and GR Configuration on ASA

- Feature has to be enabled on all adjacent devices to work
- Use **Cisco** with all Cisco peers (default) or **IETF NSF** for third-party in OSPFv2

```
router ospf 1
nsf cisco enforce-global
nsf cisco helper
```

(Optional) Disable NSF if any adjacent device is

(Default) Help other NSF devices restart gracefully.

```
router ospf 1
nsf ietf restart-interval 260
nsf ietf helper strict-lsa-checking
```

Default graceful restart time is 120 seconds.

(Optional) Helper aborts peer's NSF restart on impactful LSA changes

- Common Graceful Restart configuration for OSPFv3

```
router ospf 1
graceful-restart restart-interval 180
graceful-restart helper strict-lsa-checking
```

- BGPv4 Graceful Restart is enabled globally and configured for each neighbor

```
! System Context
router bgp 65001
  bgp graceful-restart restart-time 180 stalepath-time 720
! Context A
router bgp 65001
  address-family ipv4 unicast
    neighbor 192.168.1.101 ha-mode graceful-restart
```

Default maximum wait time for a restarting peer is 120 seconds.

Default wait time before flushing routes toward a GR capable peer is 360 seconds.

Enable GR for each neighbor.



# Faster Dynamic Routing Convergence on ASA

- Reduce protocol timers on **all adjacent segments** to improve convergence
  - OSPF timers **must** match between peers
  - **Do not** lower dead interval in Spanned Etherchannel mode with NSF/GR
- **ASA 9.1 and earlier** software uses higher minimum timers

```
asa(config)# interface GigabitEthernet0/0
asa(config-if)# ospf hello-interval 1
asa(config-if)# ospf dead-interval 3
asa(config-if)# router ospf 1
asa(config-router)# timers spf 1 1
```

Generate OSPF hello packets every 1 second

Declare neighbor dead with no hello packets for 3 seconds

Delay before and between SPF calculations for 1 second

- **ASA 9.2(1)+** provides faster convergence

```
asa(config)# interface GigabitEthernet0/0
asa(config-if)# ospf dead-interval minimal hello-multiplier 3
asa(config-if)# router ospf 1
asa(config-router)# timers throttle spf 500 1000 5000
```

Generate 3 OSPF FastHello packets per second; 1 second to detect a dead neighbor

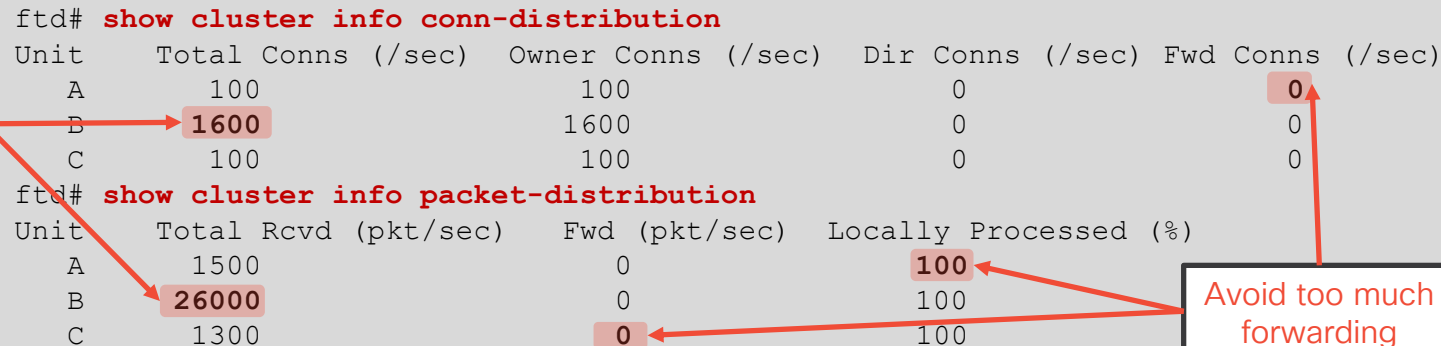
Delay SPF calculation by 500 ms, delay between calculations for 1 second and no more than 5 seconds

# Verifying Load Distribution

- Uneven Owner connection distribution implies a load-balancing issue
  - Use a more granular Etherchannel hashing algorithm on connected switches
- High Forwarder connection count implies flow asymmetry
  - Always match Etherchannel hashing algorithms between all connected switches
  - Cannot avoid asymmetry with NAT/PAT

```
ftd# show cluster info conn-distribution
Unit      Total Conns (/sec)  Owner Conns (/sec)  Dir Conns (/sec)  Fwd Conns (/sec)
A         100          100          0                0
B         1600         1600         0                0
C         100          100         0                0

ftd# show cluster info packet-distribution
Unit      Total Rcvd (pkt/sec)  Fwd (pkt/sec)  Locally Processed (%)
A         1500            0             100
B         26000         0             100
C         1300            0             100
```



# Cluster Management

- Dedicated management interface is required on **FTD** and preferred on **ASA**
  - SNMP typically requires per-unit IP, syslog/NSEL can share IP on a data interface
  - **management-only** allows MAC/IP pools in Spanned Etherchannel mode on **ASA**
- A regular data interface can be used for managing an **ASA** cluster in-band
  - Connecting to cluster data interface IP always reaches the master
- Use **cluster exec** for non-configuration commands on some/all members

```
asa/master# cluster exec show version | include Serial
A(LOCAL):*****
Serial Number: JAF1434AERL

B:*****
Serial Number: JAF1511ABFT
```

# Health Monitoring

- A unit shuts down all data interfaces and disables clustering on CCL failure
- Each member generates keepalives on CCL every 1 second by default
  - Master removes a unit from the cluster after 3 missed keepalives (holdtime)
  - Member leaves cluster if its interface/SSP is down and another member has it up
  - Rejoin attempted 3 times (after 5, 10, 20 minutes), then the unit disables clustering

```
a/master# cluster group sjfw
a/master(cfg-cluster)# health-check holdtime 1
a/master(cfg-cluster)# no health-check monitor-interface Management0/0
a/master(cfg-cluster)# health-check cluster-interface auto-rejoin 5 2 1
a/master(cfg-cluster)# health-check data-interface auto-rejoin 10 2 1
a/master(cfg-cluster)# health-check system auto-rejoin 5 2 1
```

Keepalive is always 1/3 of the configured holdtime

Exempt non-critical interfaces from monitoring

Configurable re-join attempts, interval, and interval multiplier

Re-join on internal system failures in ASA 9.9(2) and FTD 6.2.3

# Configuring Clustering

# Preparation Checklist for ASA Appliances

- Get **serial console** access to all future cluster members
- Clear the existing configuration and configure appropriate boot images
- Switch to the multiple-context mode if desired
- Install Cluster (ASA5580/5585-X) and matching 3DES/10GE I/O licenses
- Designate a dedicated management interface (same on all members)
- Designate one or more physical interfaces per unit for CCL
- Assign an isolated subnet for CCL on a separate switch or VDC
- Configure **jumbo-frame reservation** command and reload each ASA
- Pick Spanned Etherchannel or Individual interface mode for entire cluster

# Setting Interface Mode on ASA Appliances

- Use **cluster interface-mode** command before configuring clustering
  - The running configuration is checked for incompatible commands
  - Interface mode setting is stored outside of the startup configuration
  - Use **show cluster interface-mode** to check current mode
  - Use **no cluster interface-mode** to return to standalone mode
- Clearing interface configuration and reloading each ASA is **recommended**
  - You can display the list of conflicts and resolve them manually

```
asa(config)# cluster interface-mode spanned check-details  
ERROR: Please modify the following configuration elements that are incompatible with  
'spanned' interface-mode.  
- Interface Gi0/0 is not a span-cluster port-channel interface, Gi0/0(outside) cannot  
be used as data interface when cluster interface-mode is 'spanned'.
```

- It is **not recommended** to bypass the check and force the mode change

# Management Access to ASA Appliances

- ASDM High Availability and Scalability Wizard simplifies deployment
  - Only set the interface mode on Master, then add Slaves automatically over HTTPS
  - Requires basic management connectivity to all members

```
ip local pool CLUSTER_MANAGEMENT 172.16.162.243-172.16.162.250
```

```
!
```

```
interface Management0/0
```

```
description management interface
```

```
management-only
```

```
nameif mgmt
```

```
security-level 0
```

```
ip address 172.16.162.242 255.255.255.224
```

```
cluster-pool CLUSTER_MANAGEMENT
```

```
!
```

```
route mgmt 0.0.0.0 0.0.0.0 172.16.162.225 1
```

```
http server enable
```

```
http 0.0.0.0 0.0.0.0 mgmt
```

```
aaa authentication http console LOCAL
```

```
username cisco password cisco privilege 15
```

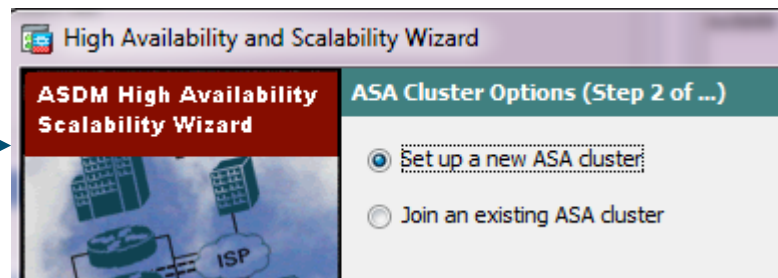
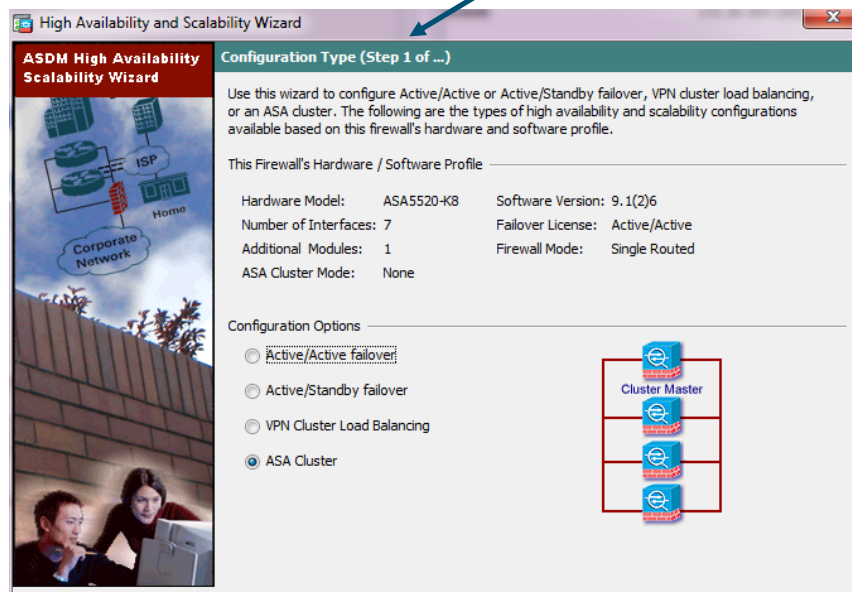
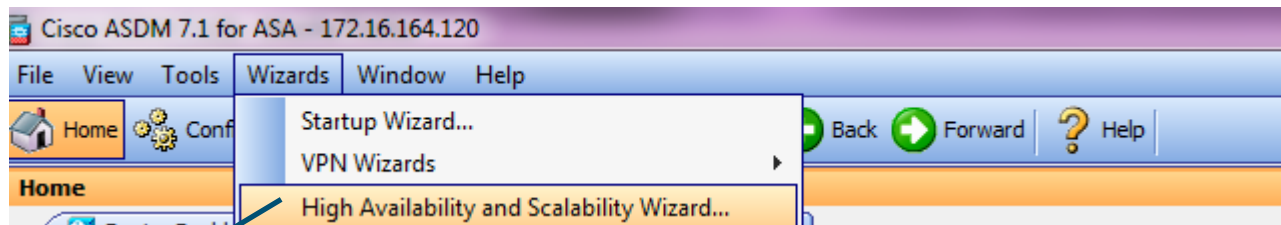
**Master:** Management IP address pool for all units; do **not** configure on Slaves

Dedicated management interface allows individual IP addressing in all modes

**Master:** Configure the IP pool under management interface  
**Slaves:** Use individual IP addresses from the pool (starting from **.244** in this example) on the same management interfaces



# ASDM Wizard



Fully configure Master in 4 easy steps, then have ASDM add Slaves one by one over basic HTTPS management connection.

... or use good old CLI ;-)

# ASA CLI: CCL Etherchannel

- Create an Etherchannel interface for CCL on each member separately
  - Same physical interface members across all units
  - Use LACP for quicker failure detection or static **on** mode for less complexity
  - Use system context in the multiple-context mode
- Connect one physical interface to each logical switch in VSS/vPC

```
ciscoasa(config)# interface TenGigabitEthernet 0/6
ciscoasa(config-if)# channel-group 1 mode on
INFO: security-level, delay and IP address are cleared on TenGigabitEthernet0/6.
ciscoasa(config-if)# no shutdown
ciscoasa(config-if)# interface TenGigabitEthernet 0/7
ciscoasa(config-if)# channel-group 1 mode on
INFO: security-level, delay and IP address are cleared on TenGigabitEthernet0/7.
ciscoasa(config-if)# no shutdown
```

# ASA CLI: Cluster Group

All Members:  
Cluster group name  
must match

All Members: Unique  
name on each

All Members: Use same CCL interface and  
subnet; each member will have a unique IP

```
cluster group DC-ASA
local-unit terra
cluster-interface Port-channel1 ip 10.0.0.1 255.255.255.0
priority 1
key ClusterSecret100
health-check holdtime 3
clacp system-mac auto system-priority 1
clacp static-port-priority
enable
mtu cluster 1600
```

All Members: Lower  
numerical priority wins  
Master election

All Members: Same optional  
secret key to encrypt CCL  
control messages

Master: CCL keepalives  
are enabled by default  
with 3 second hold time

Automatic: cLACP  
system MAC

Master: 8+ active  
Spanned Etherchannel  
links require static LACP  
port priorities in 9.2(1)

All Members:  
Enable clustering  
as the last step

Master: Set CCL MTU 100  
bytes above all data interfaces

# ASA CLI: Data Interfaces on Master

## Spanned Etherchannel Mode

```
interface TenGigabitEthernet0/8
  channel-group 20 mode active
interface TenGigabitEthernet0/9
  channel-group 20 mode active
interface Port-channel20
  port channel span-cluster
  mac-address 0001.000a.0001
  nameif inside
  security-level 100
  ip address 10.1.1.1 255.255.255.0
```

Spanned Etherchannel bundles ports across entire cluster

Single virtual IP for all members

Up to 32 ports with cLACP in 9.2(1)

Virtual MAC is required for Etherchannel stability

## Individual Mode

```
ip local pool INSIDE 10.1.1.2-10.1.1.17
interface TenGigabitEthernet0/8
  channel-group 20 mode active
interface TenGigabitEthernet0/9
  channel-group 20 mode active
interface Port-channel20
  nameif inside
  security-level 100
  ip address 192.168.1.1 255.255.255.0 cluster-pool INSIDE
```

Every member bundles a separate Etherchannel

Virtual IP is owned by Master for management only

Up to 16 ports with LACP in 9.2(1)

Traffic load-balanced to each member based on individually assigned IP addresses from the pool

# ASA CLI: Adding Slave Units

- Verify that the Master is operational before adding **Slave** members

```
asa# show cluster info
Cluster DC-ASA: On
  Interface mode: spanned
  This is "terra" in state MASTER
    ID          : 1
    Version     : 9.1(3)
    Serial No.: JAF1511ABFT
    CCL IP      : 10.0.0.1
    CCL MAC     : 5475.d05b.26f2
    Last join   : 17:20:24 UTC Sep 26 2013
    Last leave  : N/A
```

- Add one **Slave** at a time by configuring the cluster group

```
cluster group DC-ASA
  local-unit sirius
  cluster-interface Port-channel1 ip 10.0.0.2 255.255.255.0
  priority 100
  key ClusterSecret100
  enable
```

# ASA: Spanned Etherchannel Verification

- Each cluster member shows only local Etherchannel member ports

```
asa# show port-channel summary
```

```
Flags:  D - down          P - bundled in port-channel
        I - stand-alone  s - suspended
        H - Hot-standby (LACP only)
        U - in use       N - not in use, no aggregation/nameif
        M - not in use, no aggregation due to minimum links not met
        w - waiting to be aggregated
```

```
Number of channel-groups in use: 2
```

```
Group  Port-channel  Protocol  Span-cluster  Ports
```

Group	Port-channel	Protocol	Span-cluster	Ports
1	Po1 (U)	LACP	No	Te0/6 (P) Te0/7 (P)
20	Po20 (U)	LACP	Yes	Te0/8 (P) Te0/9 (P)

Port-Channel20 is a cluster-spanned data Etherchannel; it will **only** come up when clustering is enabled

Port-Channel1 is the Cluster Control Link Etherchannel; it is bundled **separately** by each member

# Clustering on Firepower 4100 and 9300

- **Only** Spanned Etherchannel interface mode is supported
- Supervisor pushes cluster configuration during logical device deployment
  - Site ID for inter-site clustering is optional
  - Firewall context mode and TLS/SSL ciphers are replicated in **ASA**
- Remote flow backup for N+1 chassis fault tolerance on Firepower 9300
- Module- and chassis-level overflow warning syslogs

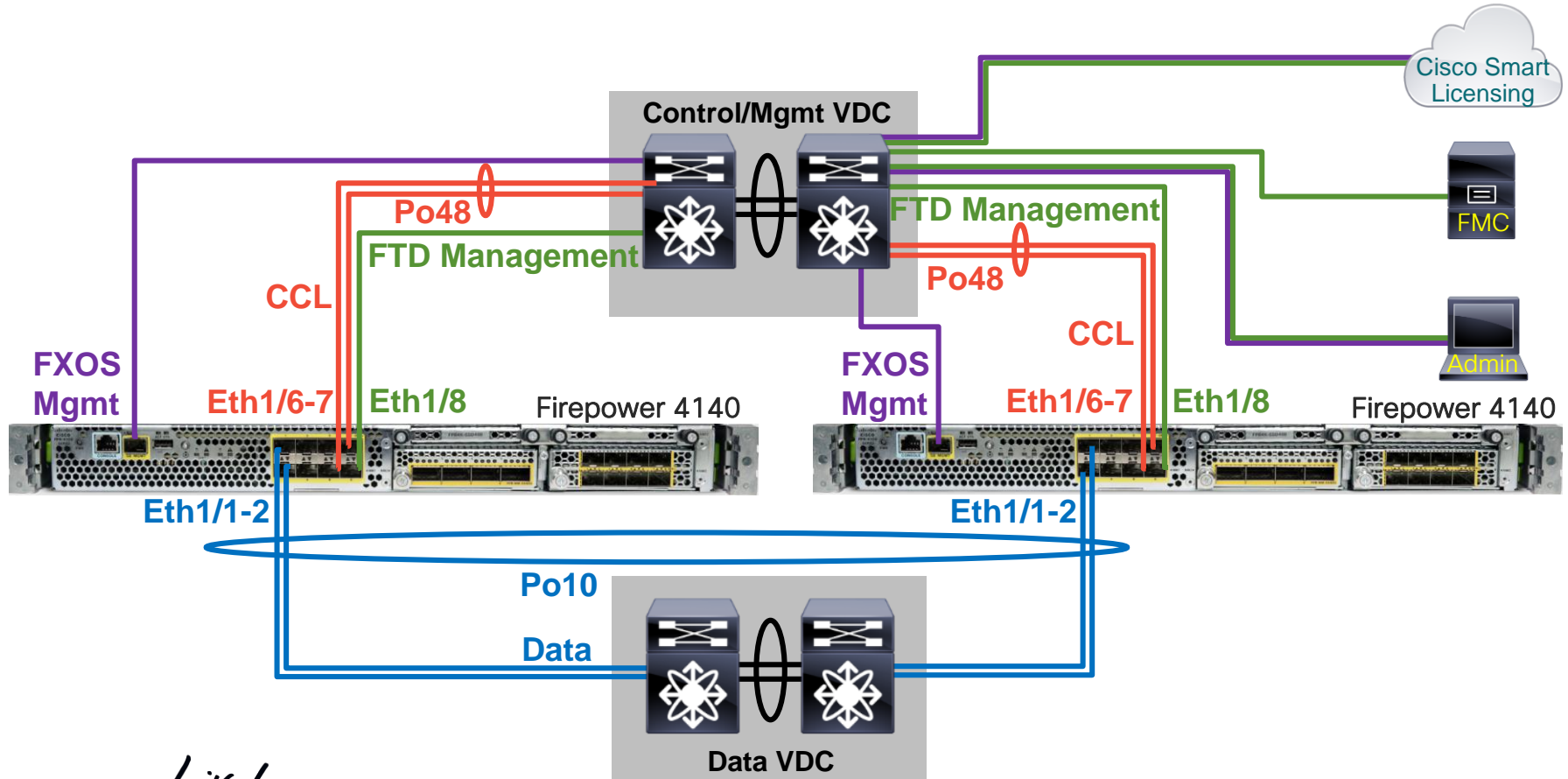
```
%ASA-6-748008: CPU load 80% of module 1 in chassis 1 (unit-1-1) exceeds overflow protection threshold CPU 75%. System may be oversubscribed on member failure.  
%ASA-6-748009: Memory load 80% of chassis 1 exceeds overflow protection threshold memory 78%. System may be oversubscribed on chassis failure.
```

# Preparation Checklist for Firepower Appliances

- Set up and cable **identical** Firepower chassis and modules for the cluster
- Ensure over-the-network Supervisor management access
- Bring up Firepower Management Center for **FTD**
- Generate device token and enable Smart Licensing on chassis **and/or** FMC
- Delete all pre-existing logical devices from the chassis
- Download application images for **FTD** or **ASA**
- Designate a dedicated application management interface (one per chassis)
- Designate one or more physical interfaces per chassis for CCL
- Assign an isolated subnet for CCL on a separate switch or VDC



# Sample FTD Cluster Deployment Topology



# Chassis Manager: Interface Configuration

Overview

**Interfaces**

Logical Devices

Security Engine

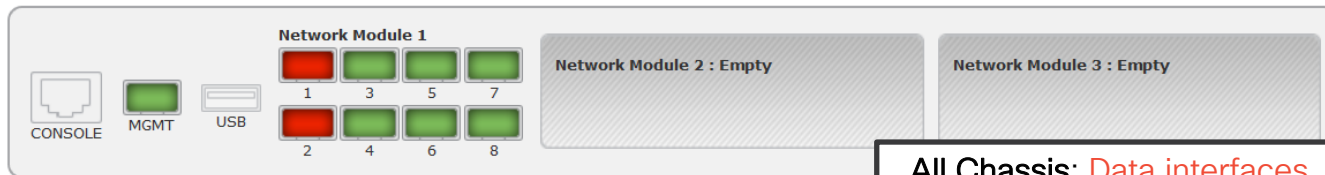
Platform Settings

System

Tools

Help

admin



All Chassis: Data interfaces will remain suspended until cluster is formed

All Interfaces

Hardware Bypass

Interface	Type	Admin Speed	Operational Speed	Instances	VLAN	Admin Duplex	Auto Negotiation	Operation State	Admin State
MGMT	Management								<input checked="" type="checkbox"/>
Port-channel10	data	10gbps					no	failed	<input checked="" type="checkbox"/>
Ethernet1/1								suspended	
Ethernet1/2								suspended	
Port-channel48	cluster	10gbps					no	up	<input checked="" type="checkbox"/>
Ethernet1/6								up	
Ethernet1/7								up	
Ethernet1/3	data	10gbps					no	up	<input checked="" type="checkbox"/>
Ethernet1/4	data	10gbps					no	up	<input checked="" type="checkbox"/>
Ethernet1/5	data	10gbps	10gbps			Full Duplex	no	up	<input checked="" type="checkbox"/>
Ethernet1/8	mgmt	10gbps	10gbps			Full Duplex	no	up	<input checked="" type="checkbox"/>

All Chassis: Create at least one Spanned Etherchannel for data

All Chassis: Add CCL member ports to special Etherchannel

All Chassis: Application management port for FTD/ASA

cisco Live!

# Chassis Manager: Add Logical Device

The screenshot shows the Cisco Chassis Manager interface with the 'Logical Devices' tab selected. A modal dialog titled 'Add Device' is open, showing configuration fields for a new logical device. Red arrows point from text boxes on the right to specific fields in the dialog.

**Logical Device List**

No logical devices available. Click on Add Device to add a new logical device.

**Add Device**

Device Name: FTD-Cluster

Template: Cisco Firepower Threat Defense

Image Version: 6.3.0.83

Instance Type: Native

Usage: ☐ Standalone ☒ Cluster

Do you want to: ☒ Create New Cluster ☐ Join Existing Cluster

OK Cancel

**Annotations:**

- All Chassis: Add new device
- All Chassis: Locally significant logical device name
- All Chassis: Application type
- All Chassis: Application version from locally loaded images
- All Chassis: Only Native instances support clustering
- All Chassis: Clustered device
- Master Chassis: Build a new cluster configuration

# Chassis Manager: FTD Interface Assignment

Overview Interfaces **Logical Devices** Security Engine Platform Settings System Tools Help admin

Provisioning - FTD-Cluster Save Cancel

Clustered | Cisco Firepower Threat Defense | 6.3.0.83

**Data Ports**

- Ethernet1/3
- Ethernet1/4
- Ethernet1/5
- Port-channel10
- Port-channel48

**Decorators**

- VDP

**All Chassis: Verify and assign any additional data interfaces. Do **not** un-assign Po48 (inter-chassis CCL).**

Port-channel48

Port-channel10

**FTD - 6.3.0.83**  
Click to configure

**All Chassis: Configure logical device properties for chassis (4100) or modules (9300)**

Application	Version	Resource	Status
FTD	6.3.0.83		

Interface Name	Type
Port-channel10	data
Port-channel48	cluster

# Chassis Manager: FTD Cluster Bootstrap

**Provisioning - FTD-Cluster**  
Clustered | Cisco Firepower Threat Defense | 6.3.0.83

**Data Ports**

- Ethernet1/3
- Ethernet1/4
- Ethernet1/5
- Port-channel10
- Port-channel48

**Decorators**

- VDP

**Application** | **Version** | **Resource Profile**

Application	Version	Resource Profile
FTD	6.3.0.83	

**Interface Name**

- Port-channel10
- Port-channel48

**Cisco Firepower Threat Defense - Bootstrap Configuration**

**Cluster Information** | Settings | Interface Information | Agreement

**Interface Information**

Chassis ID: 1

Site ID: 1

Cluster Key: •••••

Confirm Cluster Key: •••••

Cluster Group Name: NGFW

Management Interface: Ethernet1/8

CCL Subnet IP: Eg:x.x.0.0

OK Cancel

**All Chassis:** Each chassis must have a unique numerical ID

**All Chassis:** Multiple chassis may share same site ID with inter-site clustering

**All Chassis:** CCL control plane encryption key must match

**Master Chassis:** Globally significant cluster name

**Master Chassis:** Dedicated application management interface

**Master Chassis:** Optionally change default 127.2.x.x/16 CCL prefix in **FXOS 2.4.1**

# Chassis Manager: FTD Device Settings

**Provisioning - FTD-Cluster**  
Clustered | Cisco Firepower Threat Defense | 6.3.0.83

**Data Ports**

- Ethernet1/3
- Ethernet1/4
- Ethernet1/5
- Port-channel10
- Port-channel48

**Decorators**

- VDP

**Application** | **Version** | **Resource Profile**

Application	Version	Resource Profile
FTD	6.3.0.83	

**Interface Name**

- Port-channel10
- Port-channel48

**Cisco Firepower Threat Defense - Bootstrap Configuration**

Cluster Information | **Settings** | Interface Information | Agreement

Registration Key: [.....]

Confirm Registration Key: [.....]

Password: [.....]

Confirm Password: [.....]

Firepower Management Center IP: 192.168.0.170

Search domains: cisco.com

Firewall Mode: Routed

DNS Servers: 192.168.0.254

Firepower Management Center NAT ID: [.....]

Fully Qualified Hostname: ngfw.cisco.com

Eventing Interface: None

OK Cancel

**All Chassis:** FMC management registration key must match

**All Chassis:** Application management password for CLI

**Master Chassis:** FMC real IP address to connect with

**Master Chassis:** Optional default domain name

**Master Chassis:** NGFW operating mode

**Master Chassis:** Optional default DNS server

**Master Chassis:** Optional unique identification string to use instead of IP

**Master Chassis:** Optional cluster FQDN

**Master Chassis:** Optional interface for FTD events

# Chassis Manager: FTD Management Interface

The screenshot displays the Chassis Manager interface for FTD Management. The main window shows the 'Logical Devices' tab with a list of data ports (Ethernet1/3, Ethernet1/4, Ethernet1/5, Port-channel10, Port-channel48) and decorators (VDP). A modal dialog titled 'Cisco Firepower Threat Defense - Bootstrap Configuration' is open, showing the 'Interface Information' tab. The dialog contains the following fields:

- Address Type: IPv4 only
- Security Module 1: IPv4
- Management IP: 192.168.0.180
- Network Mask: 255.255.255.0
- Gateway: 192.168.0.254

Four callout boxes with red arrows point to specific fields in the dialog:

- All Chassis: Management interface addressing: IPv4, IPv6, or both (points to Address Type)
- All Chassis: Local member application management IP (4100) or pool (9300) (points to Management IP)
- All Chassis: Application management interface subnet (points to Network Mask)
- All Chassis: Default gateway for application management interface (points to Gateway)

The background interface includes a top navigation bar with 'Overview', 'Interfaces', 'Logical Devices', 'Security Engine', and 'Platform Settings'. The 'Logical Devices' tab is active. The bottom of the interface shows a table with columns 'Application', 'Version', and 'Resource Profile'. The 'Application' column lists 'FTD' with version '6.3.0.83'. Below this, there is a section for 'Interface Name' with entries 'Port-channel10' and 'Port-channel48'.

# Chassis Manager: FTD Device Installation

Overview Interfaces **Logical Devices** Security Engine Platform Settings System Tools Help admin

Refresh Add Device

## Logical Device List




Security Module1		Clustered	Status:ok					
Application	Version	Resource Profile	Management IP	Gateway	Management Port	Status		
FTD	6.3.0.83		192.168.0.180	192.168.1.254	Ethernet1/8	installing		



Overview Interfaces **Logical Devices** Security Engine Platform Settings

All Chassis: Monitor  
logical device  
deployment status

## Logical Device List

Security Module1		Clustered	Status:ok		   	
Application	Version	Resource Profile	Management IP	Gateway	Management Port	Status
 FTD	6.3.0.83		192.168.0.180	192.168.0.254	Ethernet1/8	 online    
Interface Name		Type	Attributes			
 Port-channel10		data	Cluster Operational Status : in-cluster			
 Port-channel48		cluster	FIREPOWER-MGMT-IP : 192.168.0.180			
			CLUSTER-ROLE : master			
			CLUSTER-IP : 127.2.1.1			
			MGMT-URL : https://192.168.0.170/			
			UUID : 1f6a6732-1055-11e9-a573-b97759579cc			



# Chassis Manager: Export Cluster Configuration

## Logical Device List

Master Chassis: "Clone" common cluster configuration elements to other chassis

Security Module1	Clustered	Status					
Application	Version	Resource Profile	Management IP	Gateway	Management Port	Status	
FTD	6.3.0.83		192.168.0.180	192.168.0.254	Ethernet1/8	online	
Interface Name		Type	Attributes				
Port-channel10		data	Cluster Operational Status: in-cluster				
Port-channel48		cluster	FIREPOWER-MGMT-IP : 192.168.0.180				
			CLUSTER-ROLE : master				
			CLUSTER-IP : 127.2.1.1				
			168.0.170/				
			055-11e9-a573-b97759579cc				

## Cluster Configuration(copy to clipboard)

```
{
  "smLogicalDevice": [
    {
      "smExternalPortLink": [
        {
          "smSystemMac": null,
          "appName": "ftd",
          "portName": "Ethernet1/8",
          "description": ""
        }
      ],
      "smSystemMac": [
        {
          "macAddress": "B0:AA:77:35:79:3E"
        }
      ],
      "smMgmtBoot": [
        {
          "value": null,
          "key": "REGISTRATION_KEY",
          "r": "encrypted-key-REGISTRATION_KEY"
        },
        {
          "value": null,
          "key": "PASSWORD",
          "r": "encrypted-key-PASSWORD"
        }
      ],
      "smMgmtIP": [
        {
          "value": "192.168.0.170",
          "key": "FIREPOWER_MGMT_IP",
          "r": "key-FIREPOWER_MGMT_IP"
        }
      ]
    }
  ]
}
```

OK

Cancel

# Chassis Manager: Adding Chassis to Cluster

Overview Interfaces **Logical Devices** Security Engine Platform Settings

System Tools Help admin

## Logical Device List

No logical devices available. Click on Add Device to add a new logical device.

Refresh Add Device

### Add Device

Device Name: FTD-Cluster

Template: Cisco Firepower Threat Defense

Image Version: 6.3.0.83

Instance Type: Native

Usage: ☐ Standalone ☒ Cluster

Do you want to: ☐ Create New Cluster ☒ Join Existing Cluster

Copy config: ☒

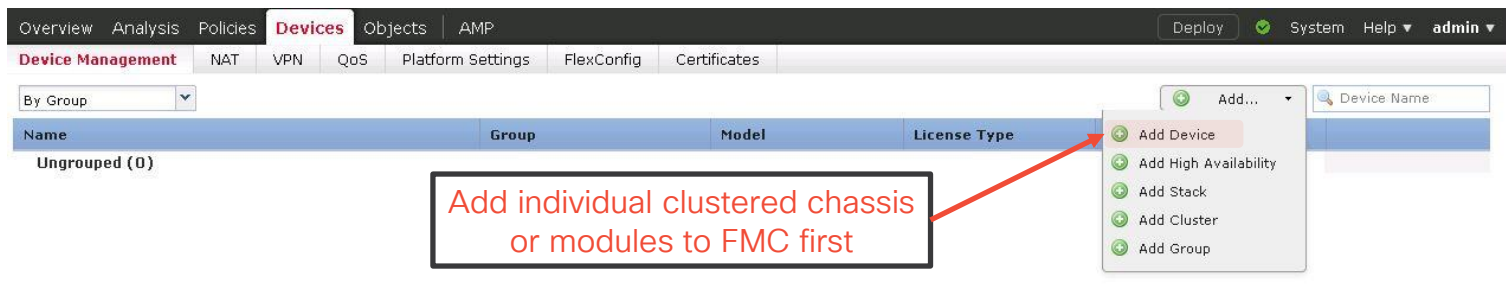
### Copy Cluster Details

```
{
  "fullDuplex": "autoNeg",
  "autoNeg": "no",
  "fabricSubIf": null,
  "adminSpeed": "10gbps",
  "adminState": "up",
  "dn": "ports",
  "ep/Ethernet1_API_SLASH_4": {
    "dtagVlan": "104",
    "flowCtrlPolicy": "default",
    "ifType": "pl",
    "Ethernet1": {
      "portId": "4",
      "slotId": "1",
      "ssaPortType": "data",
      "ssaVlanId": "10",
      "udldOperState": "admin-disabled",
      "urlink": "https://171.69.247.85:4436/api/ports",
      "ep/Ethernet1_API_SLASH_4": {
        "vlanStatus": "ok",
        "operSpeed": "10gbps",
        "inlineState": "fullDuplex",
        "autoNeg": "no",
        "fabricSubIf": null,
        "adminSpeed": "10gbps",
        "adminState": "up",
        "dn": "ports",
        "ep/Ethernet1_API_SLASH_3": {
          "dtagVlan": "103",
          "flowCtrlPolicy": "default",
          "ifType": "pl",
          "Ethernet1": {
            "portId": "3",
            "slotId": "1",
            "ssaPortType": "data",
            "ssaVlanId": "10",
            "udldOperState": "admin-disabled",
            "urlink": "https://171.69.247.85:4436/api/ports",
            "ep/Ethernet1_API_SLASH_3": {
              "vlanStatus": "ok",
              "operSpeed": "10gbps",
              "inlineState": "fullDuplex",
              "autoNeg": "no",
              "fabricSubIf": null
            }
          }
        }
      }
    }
  }
}
```

OK Cancel

Other Chassis: Clone the cluster configuration from master chassis when adding a new chassis

# Before FMC 6.3: Add Individual Cluster Members



**Add Device**

Host: 10.0.0.12

Display Name: FP4100-1

Registration Key: Cisco123

Group: None

Access Control Policy: Default Policy

Smart Licensing

Malware: ☒

Threat: ☒

URL Filtering: ☒

Advanced

On version 5.4 devices or earlier, the licensing options will need to be specified from [licensing page](#).

Register Cancel

All Chassis/Modules: FTD application management IP

All Chassis/Modules: Unique display name in FMC

All Chassis: FMC registration key **must** match logical device configuration

All Chassis/Modules: Feature licenses must match across entire cluster

**Add Device**

Host: 10.0.0.13

Display Name: FP4100-2

Registration Key: Cisco123

Group: None

Access Control Policy: Default Policy

Smart Licensing

Malware: ☒

Threat: ☒

URL Filtering: ☒

Advanced

On version 5.4 devices or earlier, the licensing options will need to be specified from [licensing page](#).

Register Cancel

# Before FMC 6.3: Add Cluster

Proceed **only** when cluster is formed and all members are added to FMC

Add Cluster

Master: FP4100-1

Name: NGFW

Slave Devices: FP4100-2

Add Cancel

Select master chassis or module

Choose cluster name in FMC

Verify that all slave chassis or modules are automatically populated

Overview Analysis Policies **Devices** Objects AMP

Device Management NAT VPN QoS Platform Settings FlexConfig Certificates

By Group

Name Group Model License Type Access Control Policy

Ungrouped (1)

NGFW  
Cisco Firepower 4110 Threat Defense Cluster

FP4100-1 (Master)  
10.0.0.12 - Cisco Firepower 4110 Threat Defense - v6.2

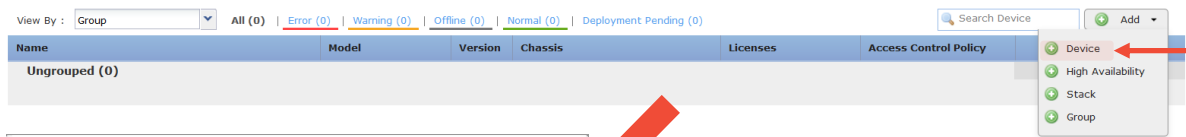
FP4100-2  
10.0.0.13 - Cisco Firepower 4110 Threat Defense - v6.2

# FMC 6.3: Add Entire Cluster



## Device Management

List of all the devices currently registered on the Firepower Management Center.



Add **master** unit only, other cluster members are discovered automatically

FTD application **real** management IP

Master unit unique display name in FMC

FMC registration key must match logical device configuration across all members

Must assign a default **Main Access Control Policy**

Feature licenses must match across entire cluster

Optional matching identification string to use instead of IP

**Add Device**

Host:† 192.168.0.180

Display Name: FTD-Cluster

Registration Key:\* cisco123

Group: None

Access Control Policy:\* Default Policy

**Smart Licensing**

Malware: ☒

Threat: ☒

URL Filtering: ☒

**Advanced**

Unique NAT ID:†

Transfer Packets: ☒

On Firepower Threat Defense devices version 6.2.1 onwards, AnyConnect VPN licenses can be enabled from [smart license page](#)

Register Cancel

Name	Model	Version	Chassis	Licenses	Access Control Policy
Ungrouped (1)					
NGFW Cluster					
192.168.0.181 192.168.0.181 - Routed	FTD on Firepower 4140	6.3.0	firepower2.cisco.com:443	Base, Threat (2 more...)	None
FTD-Cluster(Master) 192.168.0.180 - Routed	FTD on Firepower 4140	6.3.0	firepower3.cisco.com:443 Security Module - 1	Base, Threat (2 more...)	None

# FMC: Change CCL MTU Settings

Overview Analysis Policies **Devices** Objects AMP Intelligence

Device Management NAT VPN QoS Platform Settings FlexConfig Certificates

NGFW

Cisco Firepower 4140 Threat Defense

Cluster Device Routing **Interfaces** Inline Sets DHCP

Search by name Sync Device Add Interfaces

Interface	Logical Name	Type	Security Zones	MAC Address (Active/Standby)	IP Address
Ethernet1/8	diagnostic	Physical			
Port-channel10		EtherChannel			
Port-channel48		EtherChannel			

1. Edit CCL interface under cluster device properties

2. Set IP MTU at 100 bytes above highest data interface MTU

3. Save and Deploy

**Edit Ether Channel Interface**

General IPv4 IPv6 Advanced

Name:  ☒ Enabled ☐ Management Only

Description:  Clustering Interface

Mode:  None

Security Zone:

MTU:  1600 (164 - 9184)

Ether Channel ID \*:  48 (1 - 48)

OK Close

# Monitoring and Troubleshooting Clustering

- **show cluster** command group displays aggregated statistics
  - **show cluster history** helps to understand state transitions and failure reasons
  - **show cluster cpu** helps to check CPU utilization across cluster
- **show cluster info** command group displays cluster subsystem information
  - **show cluster info health** helps to monitor aggregated unit health data
  - **show cluster info loadbalance** relates to optional Conn Rebalance feature
  - **show cluster info trace** shows cluster state machine debug data for Cisco TAC
- Leverage syslog messages to understand failure reasons

```
%ASA-3-747022: Clustering: Asking slave unit terra to quit because it failed interface health check 3 times (last failure on Port-channell), rejoin will be attempted after 20 min.
```

- Use **logging device-id** to identity reporting members for connection events

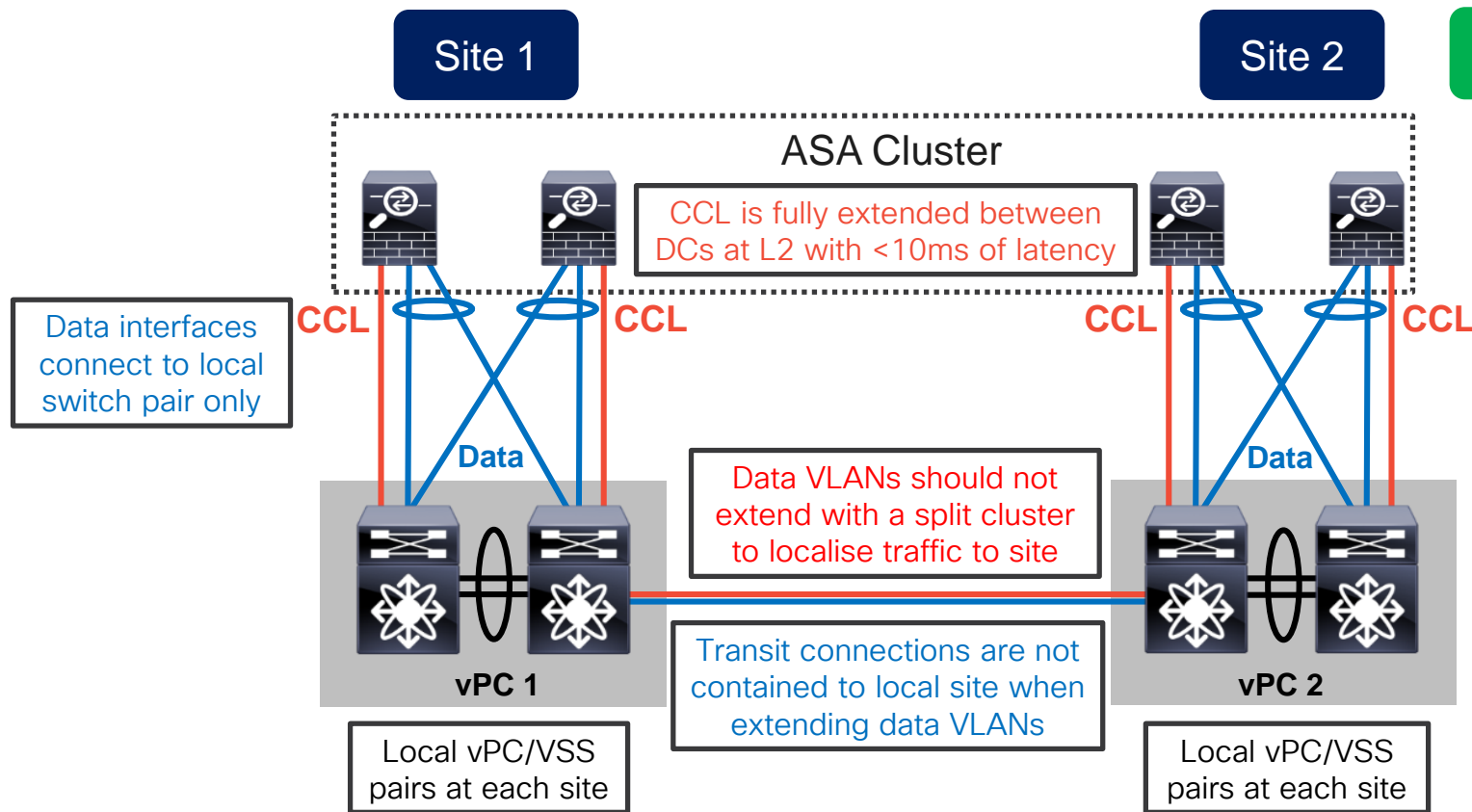
# Multi-Site Clustering



# Inter Data Center (DC) Clustering

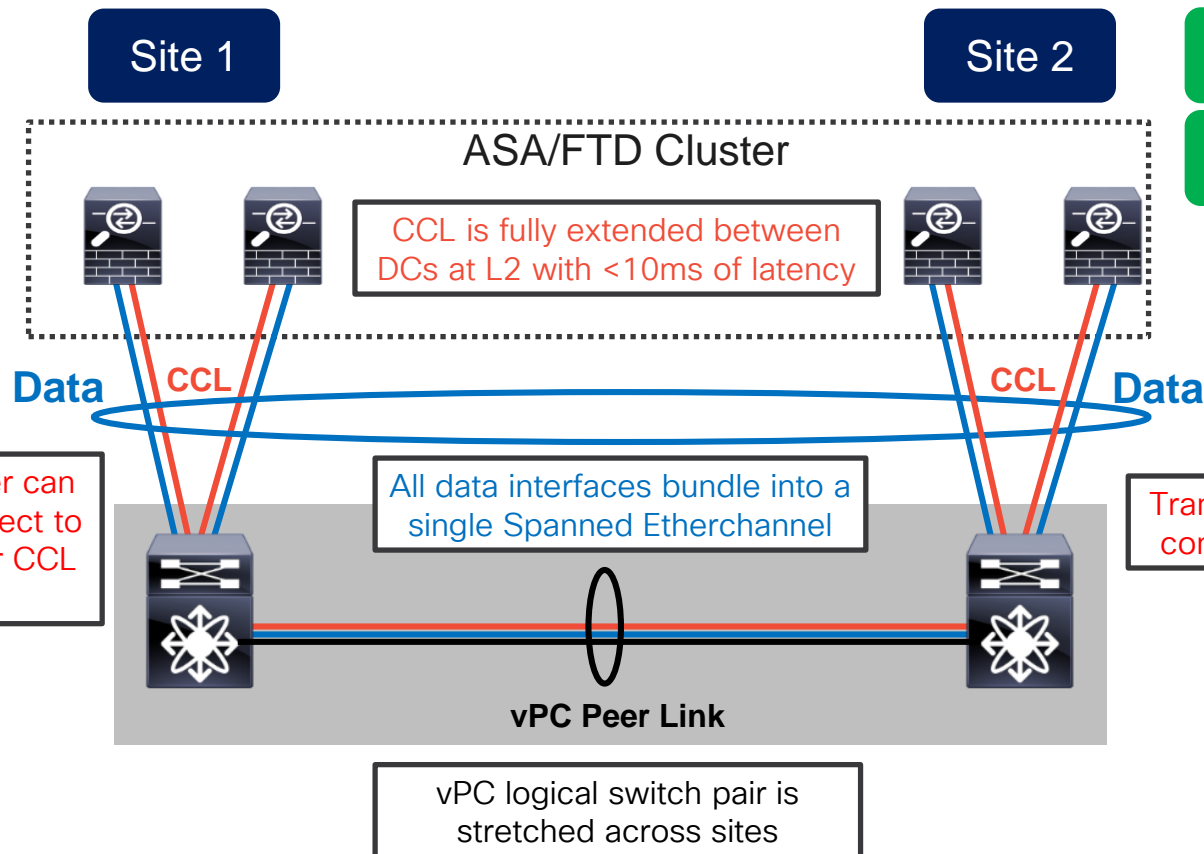
- Clustering **assumes, but not requires** data interface adjacency at Layer 2
- Geographically separated clusters supported in **ASA 9.1(4)+**
  - “Dark Media” CCL with up to 10ms of one-way latency and no packet loss
  - Routed firewall in Individual interface mode **only**
- **ASA 9.2(1)** extends inter-DC clustering to Spanned Etherchannel mode
  - Transparent firewall **only**
  - Routed firewall support presented design challenges
- **ASA 9.5(1)** adds inter-DC Spanned Etherchannel clustering in routed mode
- **FTD 6.2** adds NGFW inter-site clustering through **FlexConfig only**
- **ACI 3.2** Anycast Services for routed **ASA** and **FTD** clusters with Multi-Pod

# Split or Single Individual Mode Cluster



ASA 9.2(1)

# Extended Spanned Etherchannel Cluster



ASA 9.1(4)

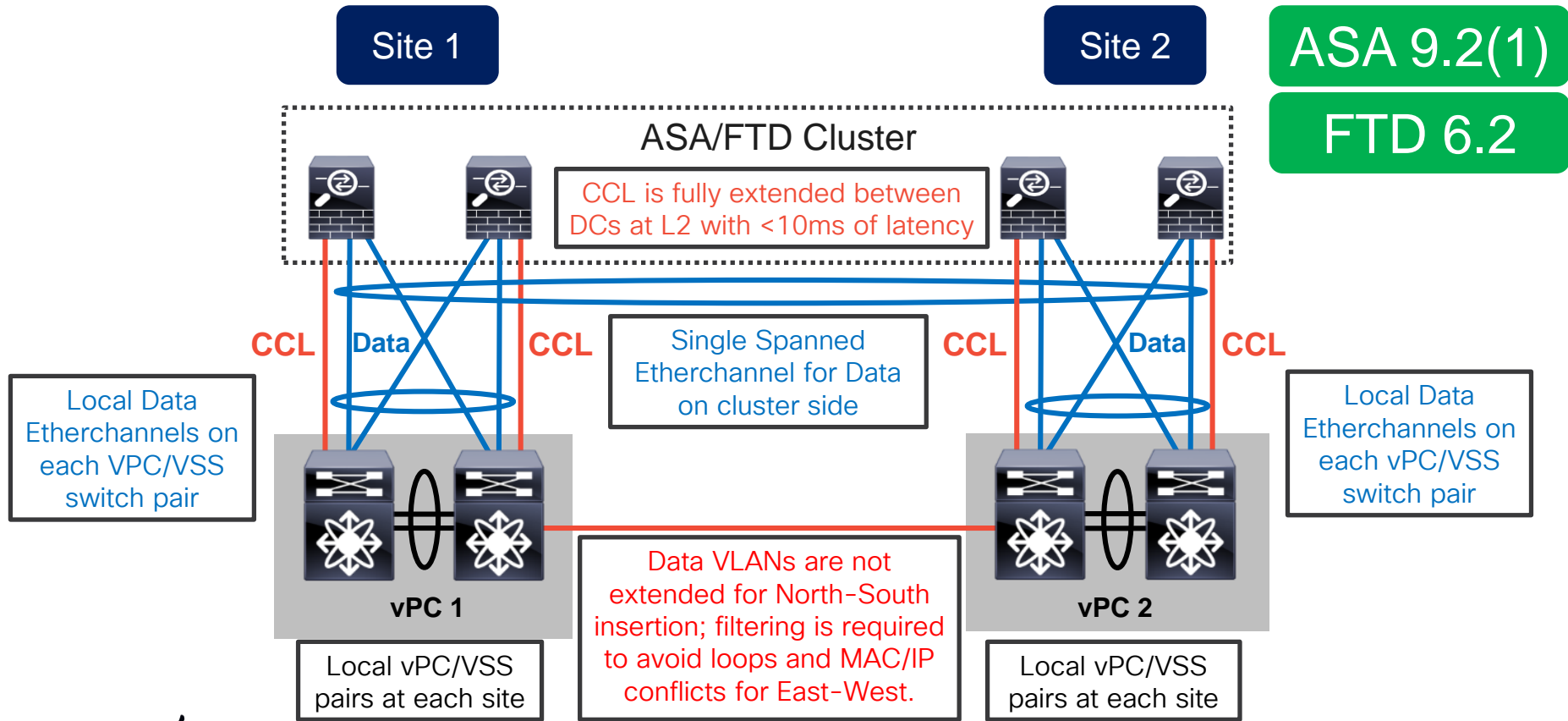
FTD 6.2

Each cluster member can single- or dual-connect to the VSS/vPC pair for CCL and Data

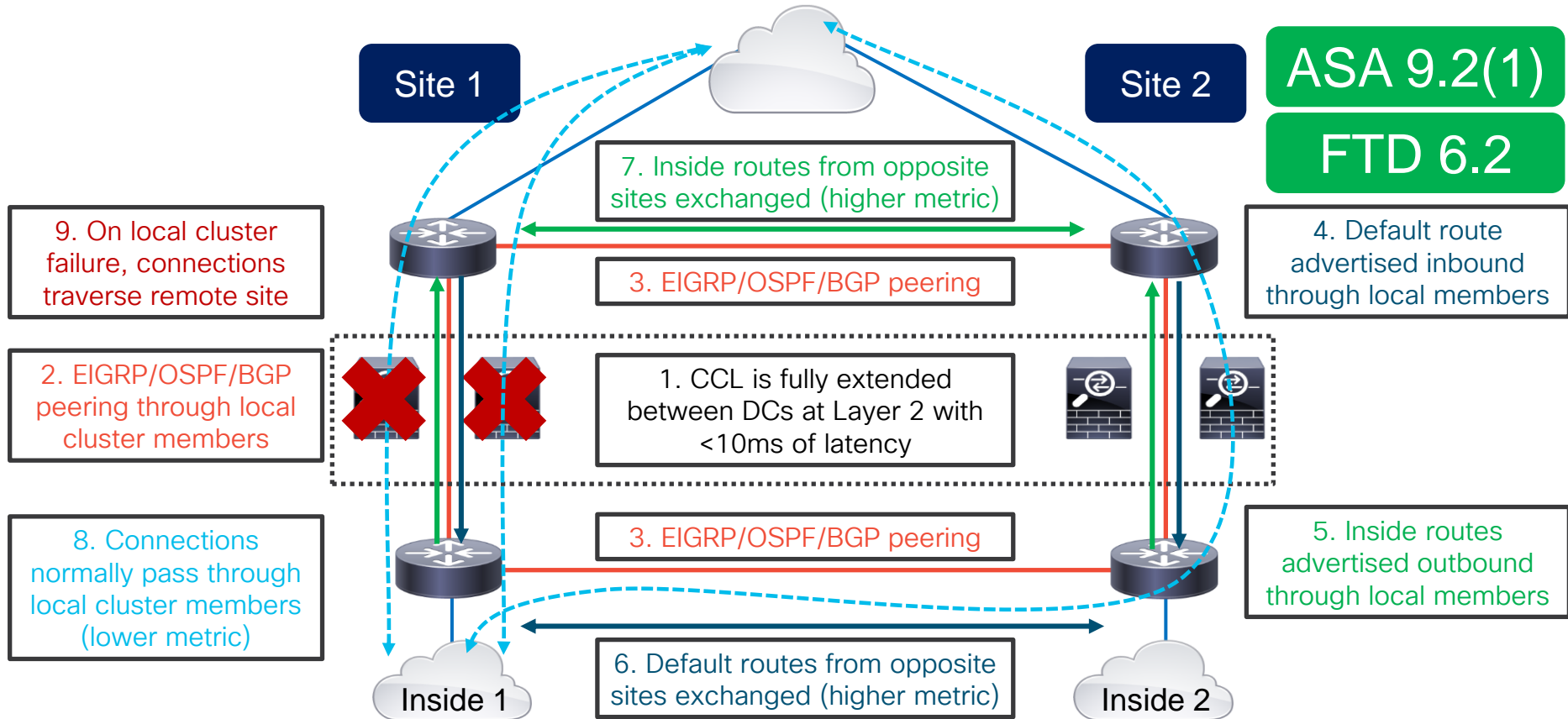
All data interfaces bundle into a single Spanned Etherchannel

Transit connections are not contained to the local site

# Split Spanned Etherchannel Cluster

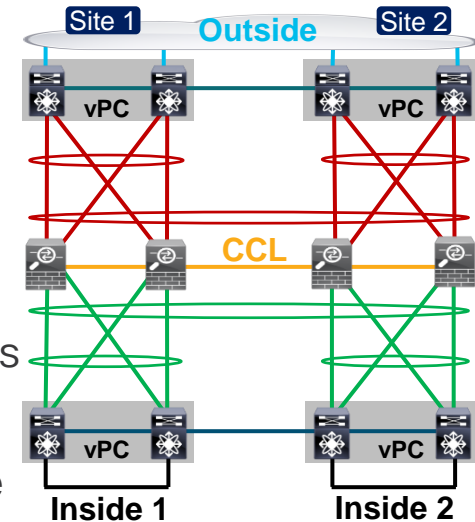


# North-South (NS) Inter DC Cluster



## Example: NS Split Spanned Etherchannel Cluster

- A vPC pair of Nexus switches at each site
  - Split Spanned Etherchannel cluster in transparent mode
  - Separate Etherchannel to local cluster members per vPC pair
  - VRF sandwich “through” the cluster with static PBR and SLA
- Non-overlapping inside subnets between sites
  - Mirrored SVI MAC addresses between two cluster transit VLANs
  - Dual-homed cluster members on each vPC pair localize traffic
  - Inter-site Layer 3 links (higher cost) to re-route traffic on failure
  - Bi-directional connection symmetry without NAT
  - Inbound asymmetry only between same-site members with NAT

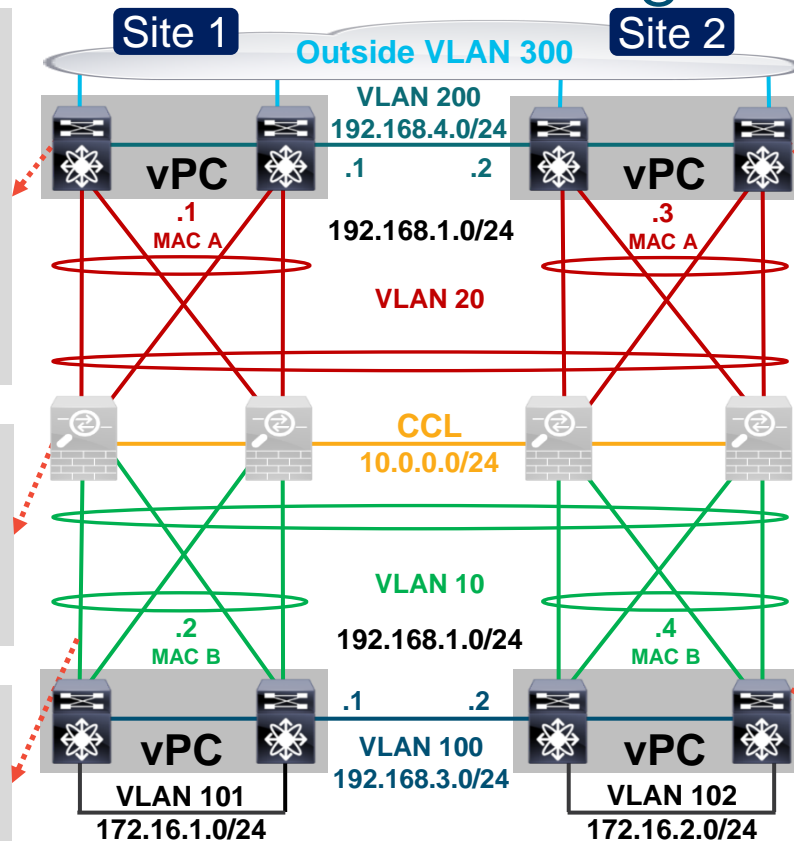


# NS Split Spanned Cluster Configuration

```
ip sla 1
  icmp-echo 192.168.1.2
ip sla schedule 1 life forever start-
time now
track 1 ip sla 1 reachability
ip access-list PBR
  permit ip any 172.16.1.0 255.255.255.0
route-map PBR
  match ip address PBR
  set ip next-hop verify-availability
    192.168.1.2 track 1
  set ip next-hop 192.168.4.2
interface Vlan300
  ip policy route-map PBR
```

```
interface Port-Channel10.10
  vlan 10
  nameif FW-inside
  bridge-group 1
interface Port-Channel10.20
  vlan 20
  nameif FW-outside
  bridge-group 1
```

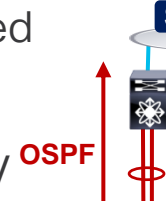
```
interface Ethernet3/1
  channel-group 1 mode active
interface Ethernet3/2
  channel-group 1 mode active
interface Port-Channel1
  switchport trunk allowed vlans 10,20
  vpc 10
```

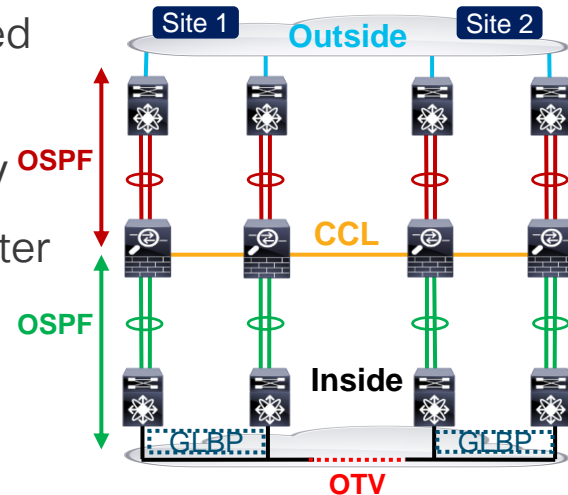


```
ip sla 1
  icmp-echo 192.168.1.4
ip sla schedule 1 life forever start-
time now
track 1 ip sla 1 reachability
ip access-list PBR
  permit ip any 172.16.2.0 255.255.255.0
route-map PBR
  match ip address PBR
  set ip next-hop verify-availability
    192.168.1.4 track 1
  set ip next-hop 192.168.4.1
interface Vlan300
  ip policy route-map PBR
```

```
ip sla 1
  icmp-echo 192.168.1.3
ip sla schedule 1 life forever start-
time now
track 1 ip sla 1 reachability
ip access-list PBR
  permit ip any any
route-map PBR
  match ip address PBR
  set ip next-hop verify-availability
    192.168.1.3 track 1
  set ip next-hop 192.168.3.1
interface Vlan102
  ip policy route-map PBR
```

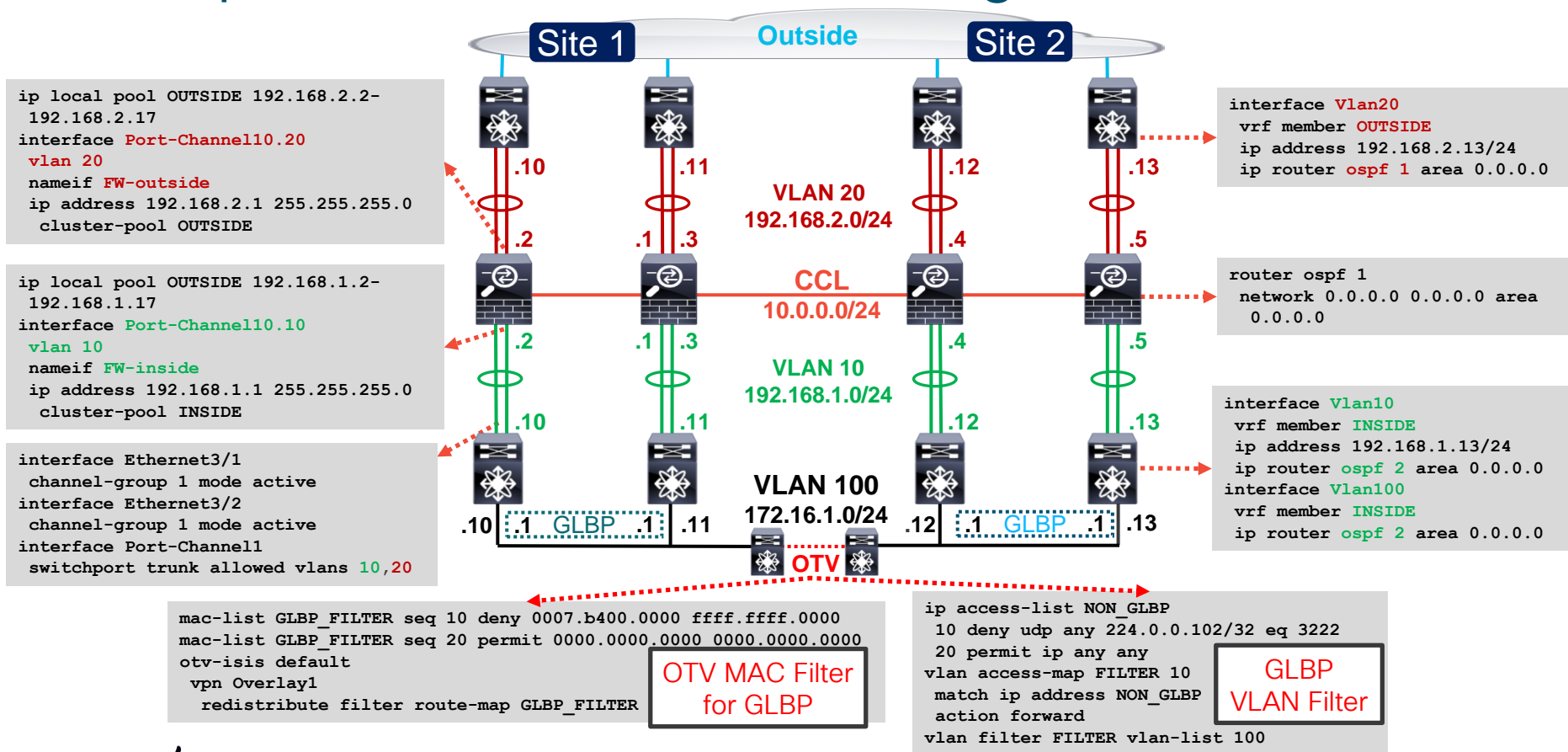
## Example: NS Split Individual Mode Cluster

- A pair of standalone (non-vPC) Nexus switches at each site
    - One Individual mode cluster unit per switch, single attached
    - Routed firewall-on-a-stick VRF sandwich with OSPF
  - Inside VLAN is fully extended between sites with OTV
    - Each pair of switches uses localized GLBP as first hop router
    - GLBP traffic is blocked between sites
    - OSPF allows re-routing in case of local cluster unit failure
  - Traffic symmetry is achievable without NAT
    - Outbound connections use the directly attached cluster member
    - Inbound traffic requires LISP to eliminate tromboning due to ECMP
- 
- The diagram illustrates a multi-site network architecture. It shows two sites, each represented by a vertical stack of three server icons. The top server in each stack is connected to a central cloud icon. A red double-headed arrow labeled 'OSPF' connects the top servers of the two sites. A green double-headed arrow labeled 'OSPF' connects the bottom servers of the two sites. The middle server in each stack is connected to the top server of the same stack by a red line, and to the bottom server by a green line. The top server in each stack is also connected to the central cloud icon by a red line. The bottom server in each stack is connected to the central cloud icon by a green line. The central cloud icon is connected to the top server of the left site by a red line and to the bottom server of the right site by a green line.

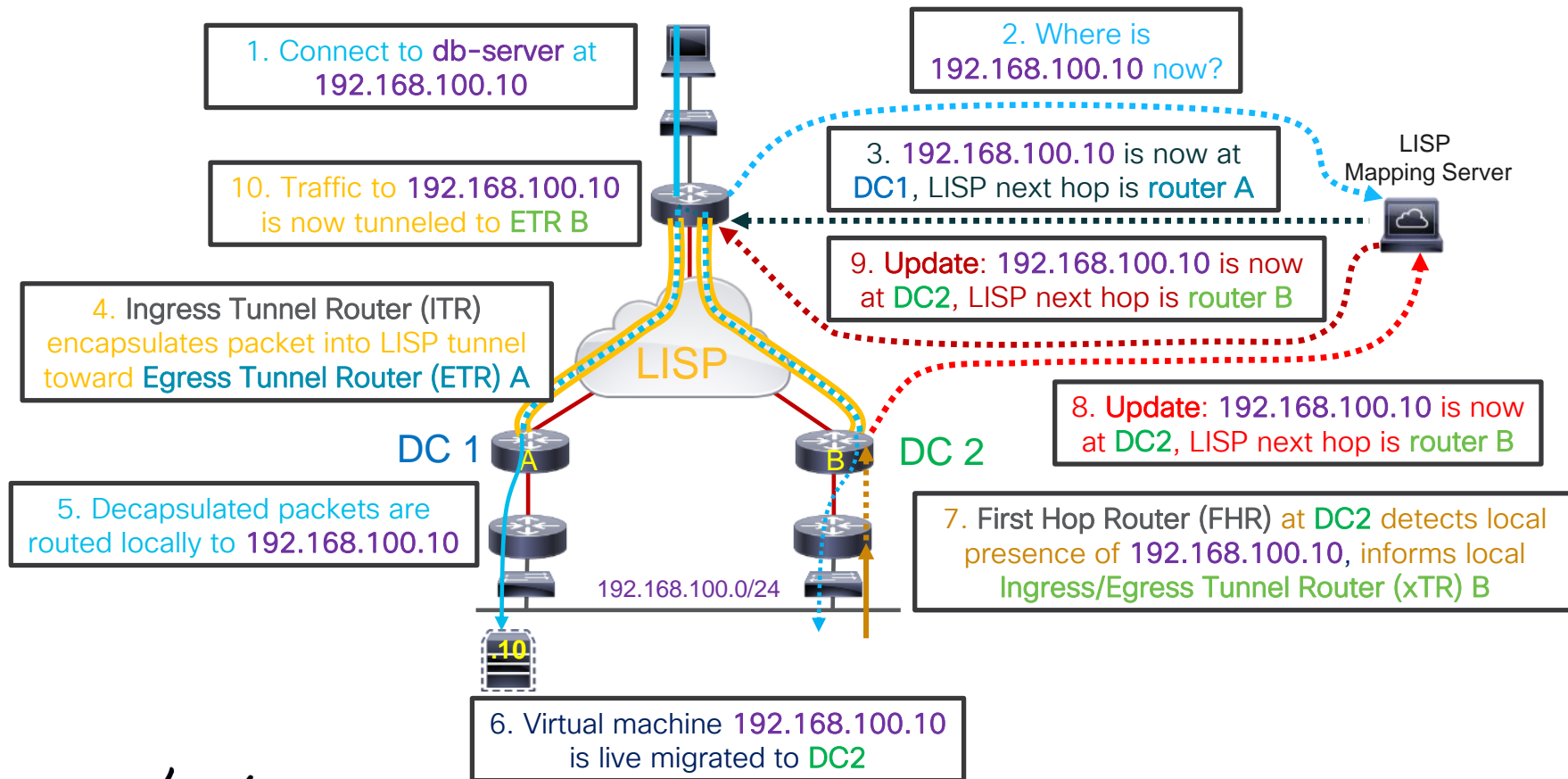




# NS Split Individual Cluster Configuration



# Locator/Identifier Separation Protocol (LISP)



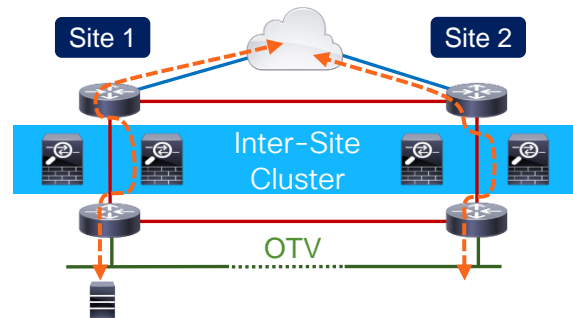
# Dynamic Owner Reassignment with LISP

- Move flow ownership with Virtual Machines
- Only supported with North-South clustering
- Based on inspection of LISP FHR→xTR updates

```
access-list MOBILITY_APP permit tcp any any eq 8443
class-map MOBILITY_APP
match access-list MOBILITY_APP

cluster group DC-ASA
  site-id 2

policy-map global_policy
class inspection_default
  inspect lisp
class MOBILITY_APP
  cluster flow-mobility lisp
```



Select specific applications or flows that are eligible for owner reassignment

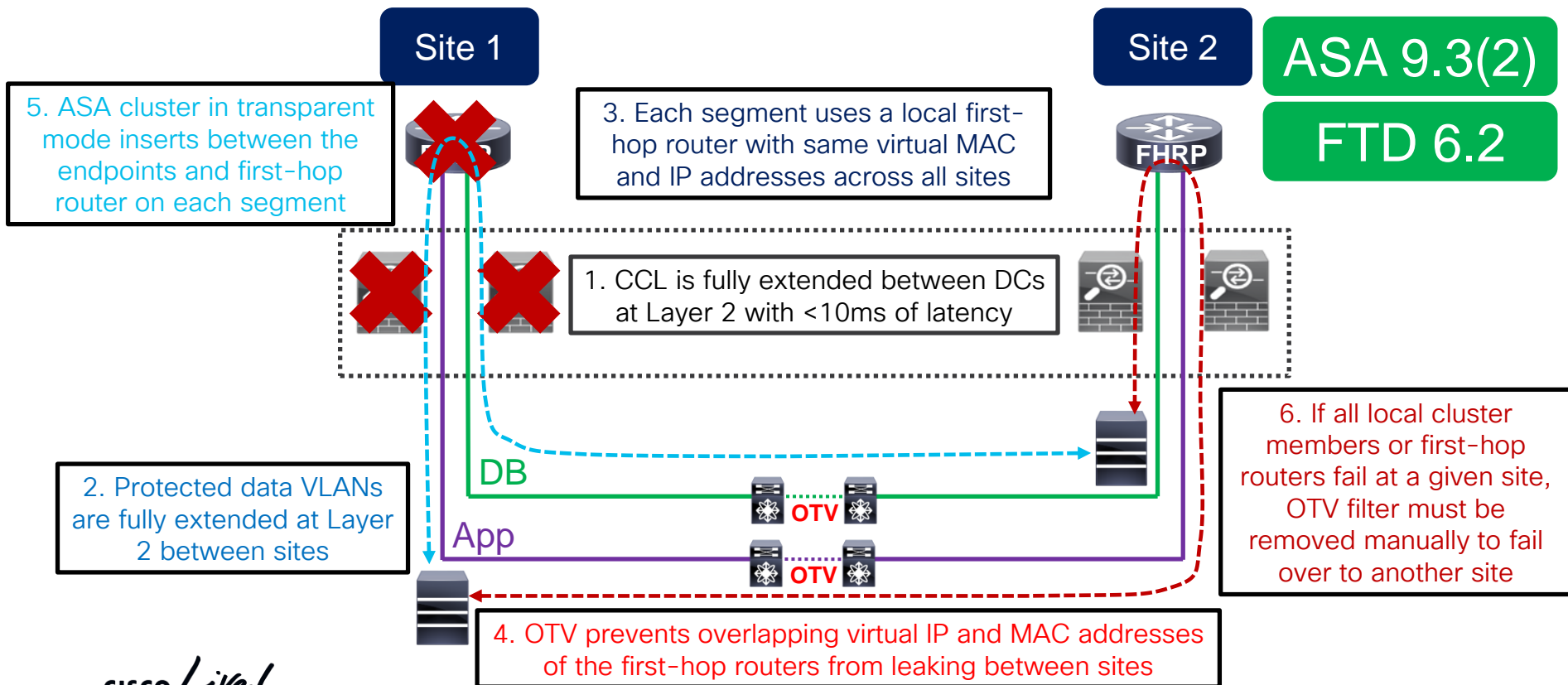
Up to 8 sites in a single cluster

UDP/4342 traffic is inspected for LISP by default

Other triggers for owner reassignment will be added in the future

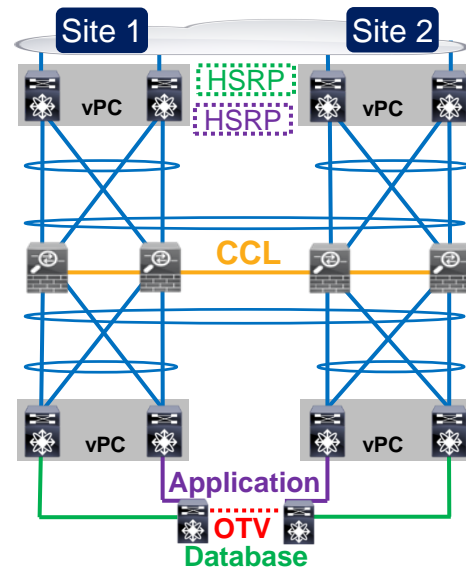
# Transparent East-West (EW) Inter DC Cluster

Not recommended due to OTV filtering complexity; use Routed East-West insertion instead.



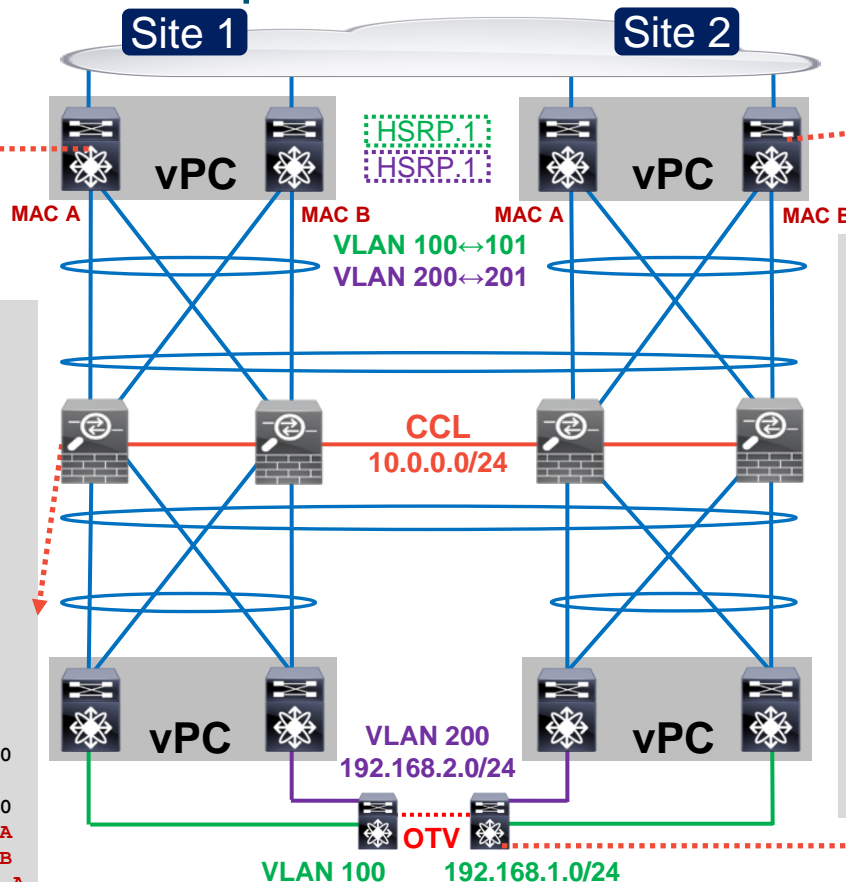
# Example: EW Transparent Spanned Cluster

- A vPC pair of Nexus switches at each site
  - Transparent Split Spanned Etherchannel cluster in to separate internal segments
  - Separate Etherchannel to local cluster members per vPC pair
  - Passing firewall twice between segments is acceptable
- Internal VLANs are fully extended between sites with OTV
  - Each site uses localized HSRP as first hop router
  - HSRP traffic is blocked between sites
  - Upstream SVI/HSRP MAC statically bound to outside on cluster
  - Full Layer 2 reachability from each router to remote site
  - Must manually remove OTV filters on full upstream path failure
- Must implement LISP to avoid excessive flow redirection



```
interface Vlan101
 ip address 192.168.1.2/24
 hsrp 10
 preempt
 ip 192.168.1.1
interface Vlan201
 ip address 192.168.2.2/24
 hsrp 20
 preempt
 ip 192.168.2.1
```

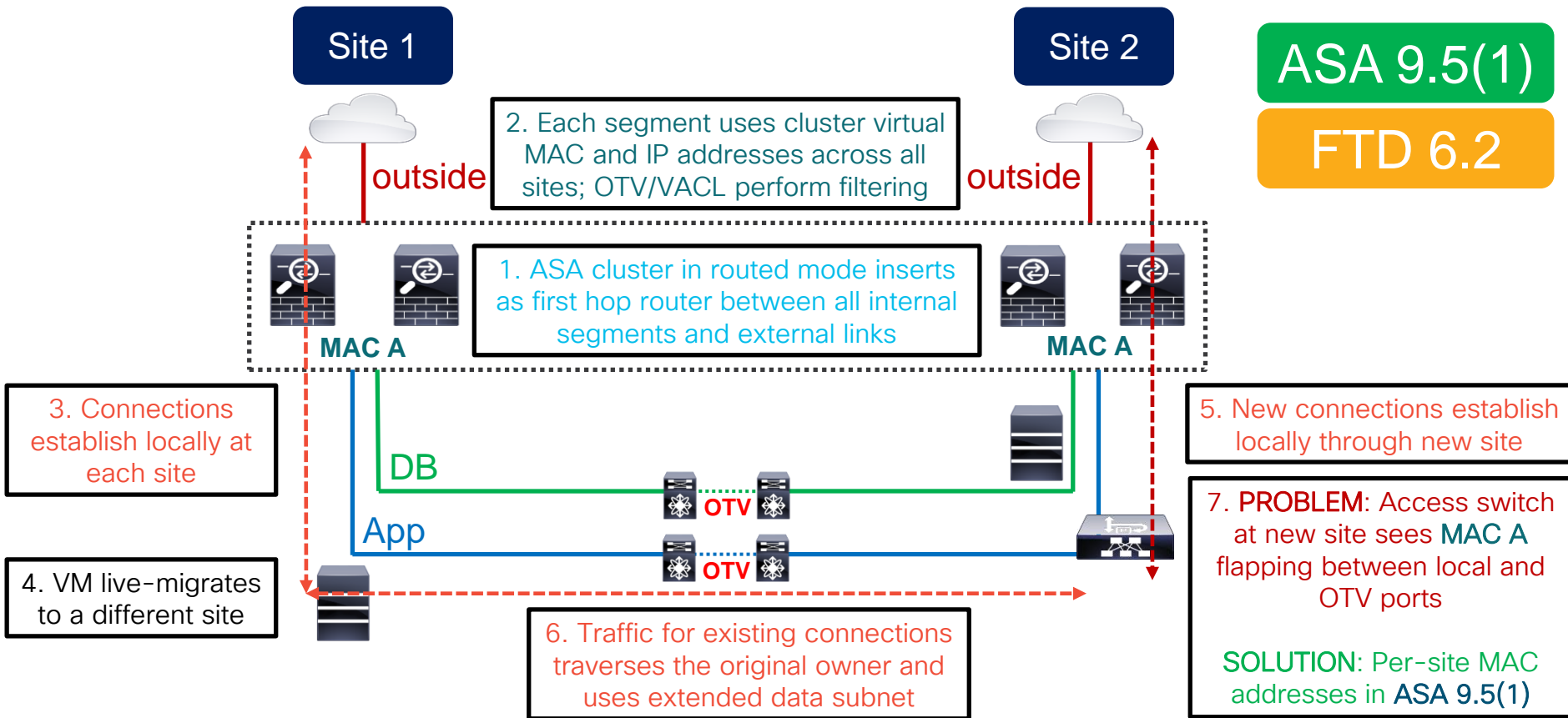
```
interface Port-Channel10.100
  vlan 100
  nameif DB-inside
  bridge-group 1
interface Port-Channel10.101
  vlan 101
  nameif DB-outside
  bridge-group 1
interface Port-Channel10.200
  vlan 200
  nameif App-inside
  bridge-group 2
interface Port-Channel10.201
  vlan 201
  nameif App-outside
  bridge-group 2
interface BVI1
  ip address 192.168.1.4 255.255.255.0
interface BVI2
  ip address 192.168.2.4 255.255.255.0
mac-address-table static DB-outside A
mac-address-table static DB-outside B
mac-address-table static App-outside A
mac-address-table static App-outside B
```



```
interface Vlan101
 ip address 192.168.1.3/24
 hsrp 10
 ip 192.168.1.1
interface Vlan201
 ip address 192.168.2.3/24
 hsrp 20
 ip 192.168.2.1
```

```
mac-list HSRP_MAC seq 10 deny
    0000.0c07.ac00 ffff.ffff.ff00
mac-list HSRP_MAC seq 20 deny
    0000.0c9f.f000 ffff.ffff.ff00
mac-list HSRP_MAC seq 30 permit
    0000.0000.0000 0000.0000.0000
otv-isis default
vpn Overlay1
    redistribute filter route-map HSRP_MAC
!
ip access-list HSRP_TRAFFIC
    10 permit udp any 224.0.0.2/32 eq 1985
    20 permit udp any 224.0.0.102/32 eq 1985
ip access-list ALL
    10 permit ip any any
vlan access-map HSRP_FILTER 10
    match ip address HSRP_TRAFFIC
    action drop
vlan access-map HSRP_FILTER 20
    match ip address ALL
    action forward
vlan filter HSRP_FILTER vlan-list 100, 200
```

# Routed East-West (EW) Inter DC Cluster



# Per-Site MAC Addresses

- Routed Spanned Etherchannel cluster extends MAC addresses in 9.5(1)
  - Global interface MAC address is used to receive and source frames by default
  - Per-site MAC addresses can be used to source frames on extended segments

```
asa(config)# cluster group DC-ASA
asa(cfg-cluster)# site-id 1
asa(cfg-cluster)# interface Port-Channel1.1000
asa(config-if)# mac-address 0001.aaaa.0001 site-id 1 site-ip 192.168.1.10
asa(config-if)# mac-address 0001.aaaa.0002 site-id 2 site-ip 192.168.1.20
asa(config-if)# mac-address 0001.aaaa.aaaa
```

Site-specific MAC address is used to forward data frames and source ARP

Global MAC address is used across all sites to receive traffic as default gateway

ARP inspection for localization requires ASA 9.6(1) with optional per-site IP for sourcing ARP packets only

- Dynamic routing is centralized, but possible with a shared outside segment
- Global MAC address localization is required by OTV or similar mechanisms



# OTV Silent Host Problem

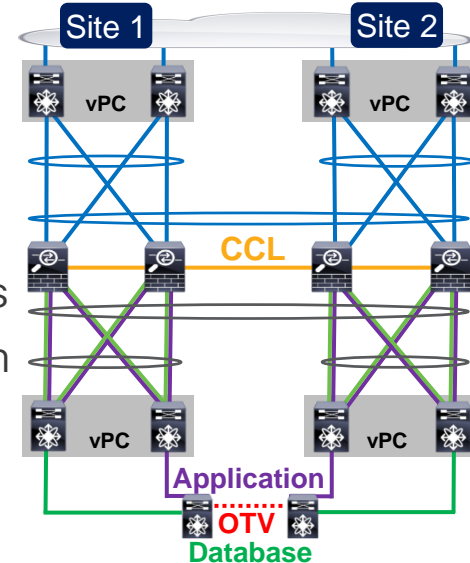
- OTV suppresses **unicast flooding** for unknown MAC addresses by default
  - Hosts that mostly generate local traffic quickly become unreachable across OTV
  - Recommended to set ARP timeout below MAC address table timeout
- **ASA 9.8(3)** and **FTD 6.2.2.2** replicate ARP replies to all sites
  - Refresh MAC table entries in OTV to **partially** combat the **Silent Host** problem
- Cluster global MAC becomes a silent host when per-site MAC is used
  - **ASA 9.12(1)** and **FTD 6.4** generate a periodic GARP for global MAC/IP

```
asa(cfg-cluster)# site-periodic-garp interval 280
```

One unit at each site generates a GARP at this frequency in seconds; default is 280

# Example: EW Routed Spanned Cluster

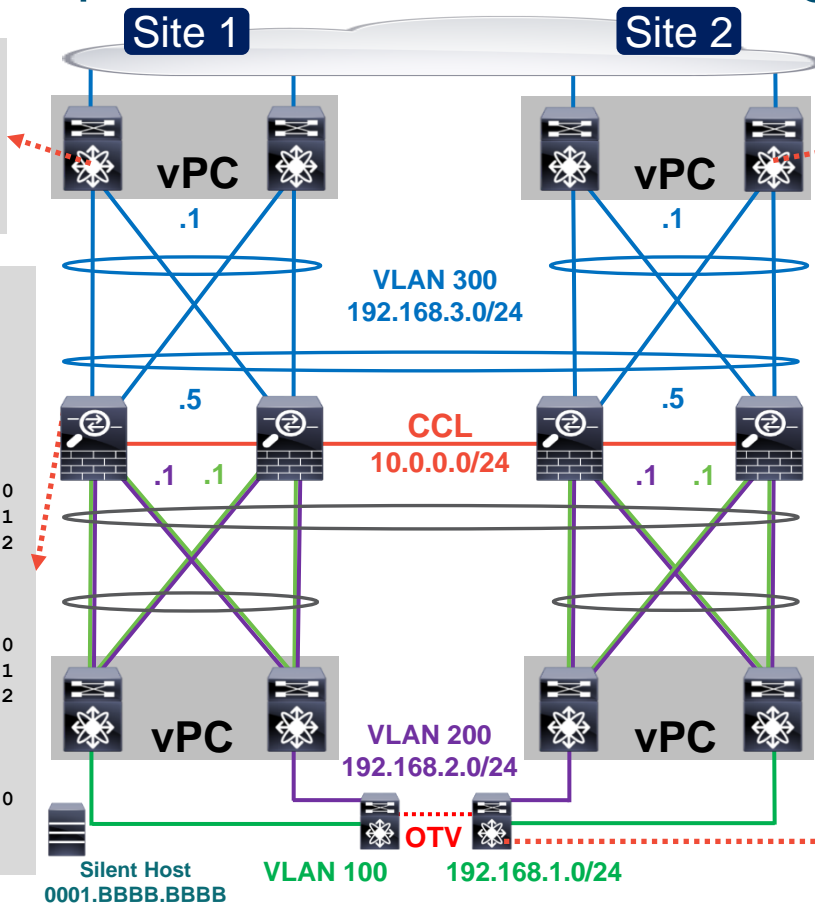
- A vPC pair of Nexus switches at each site
  - Split Spanned Etherchannel cluster in routed mode to separate internal segments
  - Separate Etherchannel to local cluster members per vPC pair
  - Static routing between distribution and core is acceptable
- Internal VLANs are fully extended between sites with OTV
  - Each site uses localized cluster as first hop router
  - Traffic to and from global cluster MAC is blocked between sites
  - Nexus F2 line cards allow VACL filtering without ARP Inspection
  - Must manually remove OTV filters on full upstream path failure
  - One silent host with a very long ARP timeout at site 1



# EW Routed Spanned Cluster Configuration

```
interface Vlan300
 ip address 192.168.3.2/24
 hsrp 10
 preempt
 ip 192.168.3.1
 ip route 192.168.1.0/24 192.168.3.5
 ip route 192.168.2.0/24 192.168.3.5
```

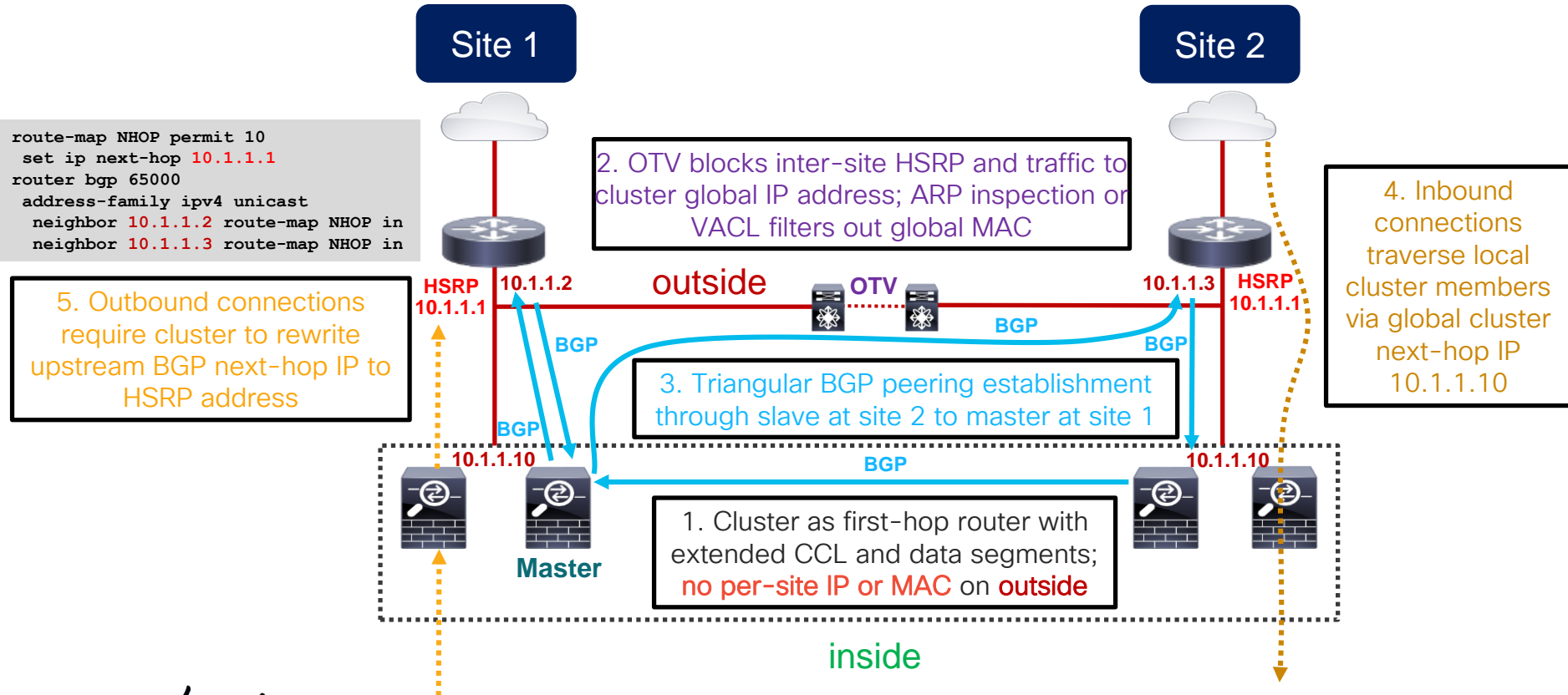
```
cluster-group DC-ASA
 site-id 1
 interface Port-Channel10
 port-channel span-cluster
 mac-address 0001.aaaa.aaaa
 interface Port-Channel10.100
 vlan 100
 nameif DB
 ip address 192.168.1.1 255.255.255.0
 mac-address 0001.aa01.0001 site-id 1
 mac-address 0001.aa01.0002 site-id 2
 interface Port-Channel10.200
 vlan 200
 nameif App
 ip address 192.168.2.1 255.255.255.0
 mac-address 0001.aa02.0001 site-id 1
 mac-address 0001.aa02.0002 site-id 2
 interface Port-Channel10.300
 vlan 300
 nameif outside
 ip address 192.168.3.5 255.255.255.0
 route outside 0.0.0.0 0.0.0.0
 192.168.3.1
```



```
interface Vlan300
 ip address 192.168.3.3/24
 hsrp 10
 ip 192.168.3.1
 ip route 192.168.1.0/24 192.168.3.5
 ip route 192.168.2.0/24 192.168.3.5
```

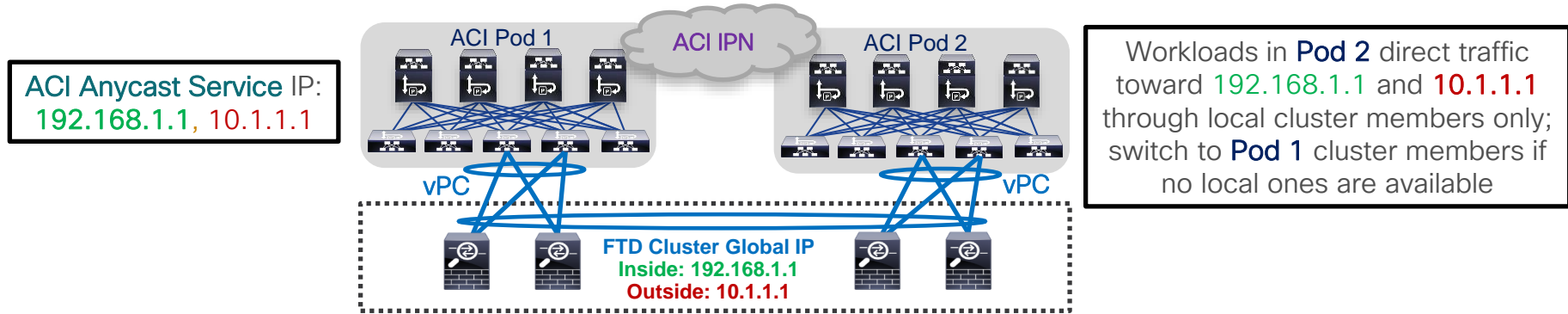
```
mac-list GMAC_FILTER seq 10 deny
 0001.aaaa.aaaa ffff.ffff.ffff
mac-list GMAC_FILTER seq 20 permit
 0000.0000.0000 0000.0000.0000
otv-isis default
 vpn Overlay1
 redistribute filter route-map GMAC_FILTER
 !
mac access-list GMAC_TRAFFIC
 10 permit 0001.aaaa.aaaa 0000.0000.0000 any
 20 permit any 0001.aaaa.aaaa 0000.0000.0000
mac access-list ALL
 10 permit any any
vlan access-map FILTER 10
 match mac address GMAC_TRAFFIC
 action drop
vlan access-map FILTER 20
 match mac address ALL
 action forward
vlan filter FILTER vlan-list 100, 200
 !
otv flood mac 0001.bbbb.bbbb vlan 100
```

# EW Routed Cluster with Upstream BGP



# Inter DC Cluster with ACI Anycast Services

- Routed **ASA** or **FTD** as first-hop gateway or PBR node in **ACI Multipod**
  - Split Spanned Etherchannel insertion with each pod as a separate vPC
- Cluster global interface IP/MAC are configured as **Anycast** gateways
  - No need for per-site IP/MAC addresses or FTD FlexConfig
  - ACI always directs outgoing traffic to closest cluster member group in local pod
  - Automatic switchover to next closest cluster member group with no manual filters on failure



# Director Localization and Site Redundancy

- Flow Director selection logic is not site-aware by default
  - A flow owned at one site **may** select Flow Director at a different site
  - Excessive inter-site traffic on CCL for director lookups is expensive

- **Director Localization** can be enabled to create two Directors

```
asa(cfg-cluster)# site-id 1  
asa(cfg-cluster)# director-localization
```

- **Local Director** is at the same site as Flow Owner, primary lookup path

```
TCP outside 85.2.2.123:22 inside 85.2.1.122:58772, idle 0:00:07, bytes 0, flags yl
```

- **Global Director** is at a different site from Flow Owner, backup lookup path
- Lookups for NAT/PAT, IP fragments, or SCTP inspected flows are **not** localized

- **Site Redundancy** adds a Director at remote site in **ASA 9.9 and FTD 6.2.3**

```
asa(cfg-cluster)# site-redundancy
```

# Closing Remarks

# Clustering Best Practices

- Use a validated switch or verify documented requirements
- Leverage LACP Etherchannel for CCL and dual-connect to VSS/vPC
  - Match the data forwarding capacity of each member
  - Set CCL MTU to 100 bytes above all data interfaces and no less than 1400 bytes
- Speed up switching and routing convergence
  - Enable Spanning Tree Portfast on CCL and data interfaces
  - Use NSF/GR or lower dead interval and SPF throttle timers on cluster and peers
- Reduce asymmetry to increase scale
  - Use firewall-on-a-stick in Spanned Etherchannel mode for best load distribution
  - Minimize centralized features and NAT/PAT



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