Configure ZBFW Using FQDN ACL Pattern Matching in C8300 Series

Contents

Introduction

This document describes the procedure to configure ZBFW with FQDN ACL pattern matching in autonomous mode on the C8300 platform.

Prerequisites

Requirements

Cisco recommends that you have knowledge of this topic:

- Zone-Based Policy Firewall (ZBFW)
- Virtual Routing and Forwarding (VRF)
- Network Address Translation (NAT)

Components Used

The information in this document is based on these software and hardware versions:

- C8300-2N2S-6T 17.12.02

The information in this document was created from the devices in a specific lab environment. All of the devices used in this document started with a cleared (default) configuration. If your network is live, ensure that you understand the potential impact of any command.

Background Information

Zone-Based Policy Firewall (ZBFW) is an advanced method of firewall configuration on Cisco IOS® and Cisco IOS XE devices that allows for creating security zones within the network.

ZBFW allows administrators to group interfaces into zones and apply firewall policies to traffic moving between these zones.

FQDN ACLs (Fully Qualified Domain Name Access Control Lists), used with a ZBFW in Cisco routers, allow administrators to create firewall rules that match traffic based on domain names instead of only IP addresses.

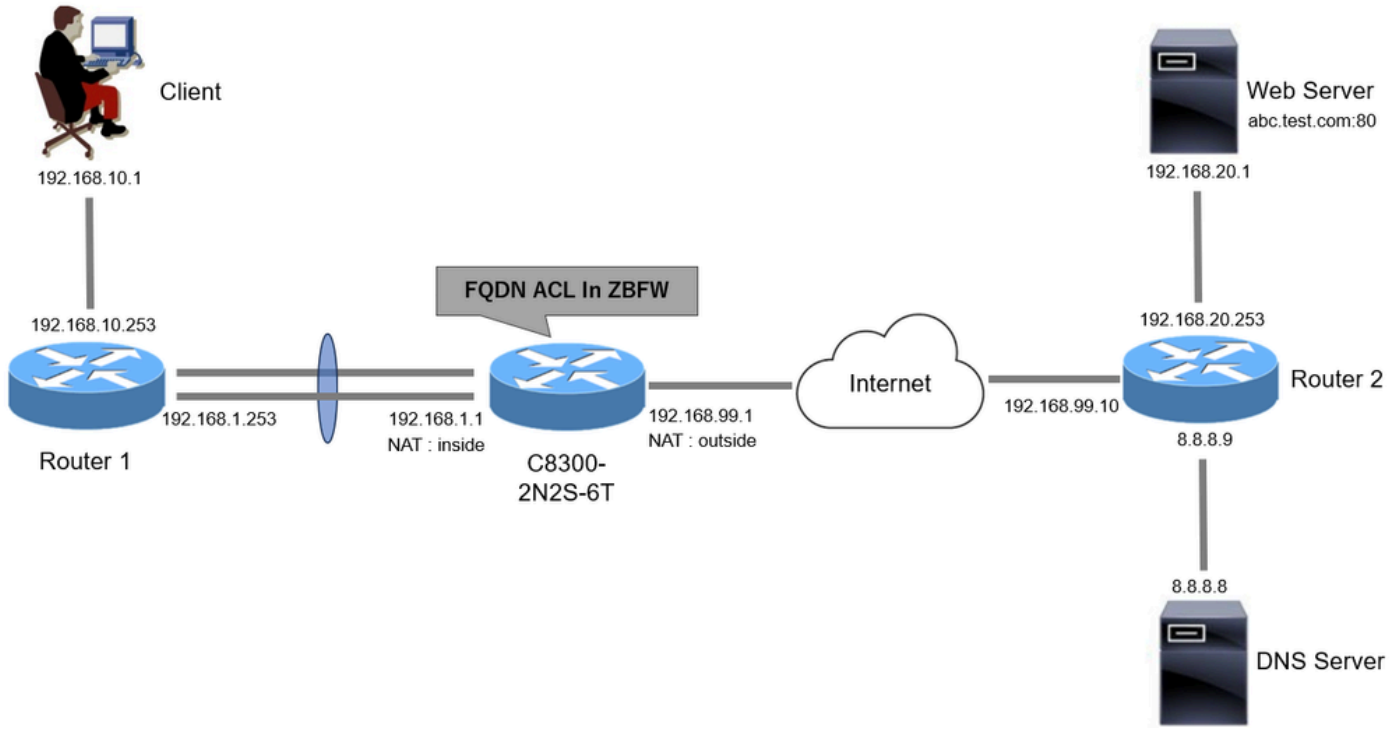
This feature is particularly useful when dealing with services hosted on platforms such as AWS or Azure, where the IP address associated with a service can change frequently.

It simplifies the management of access control policies and improves the flexibility of security configurations within the network.

Configure

Network Diagram

This document introduces the configuration and verification for ZBFW base on this diagram. This is a simulated environment using BlackJumboDog as a DNS server.



Network Diagram

Configurations

This is the configuration to permit communication from the client to the web server.

Step 1. (Optional) Configure VRF

The VRF (Virtual Routing and Forwarding) feature allows you to create and manage multiple independent routing tables within a single router. In this example, we create a VRF called WebVRF and perform routing for related communications.

```
vrf definition WebVRF
rd 65010:10
!
address-family ipv4
route-target export 65010:10
route-target import 65010:10
exit-address-family
!
address-family ipv6
route-target export 65010:10
route-target import 65010:10
exit-address-family

ip route vrf WebVRF 8.8.8.8 255.255.255.255 GigabitEthernet0/0/3 192.168.99.10
ip route vrf WebVRF 192.168.10.0 255.255.255.0 Port-channel1.2001 192.168.1.253
ip route vrf WebVRF 192.168.20.0 255.255.255.0 GigabitEthernet0/0/3 192.168.99.10
```

Step 2. Configure Interface

Configure basic information such as zone-member, VRF, NAT and IP addresses for the Inside and Outside interfaces.

```
interface GigabitEthernet0/0/1
no ip address
negotiation auto
lacp rate fast
channel-group 1 mode active

interface GigabitEthernet0/0/2
no ip address
negotiation auto
lacp rate fast
channel-group 1 mode active

interface Port-channel1
no ip address
no negotiation auto

interface Port-channel1.2001
encapsulation dot1Q 2001
vrf forwarding WebVRF
ip address 192.168.1.1 255.255.255.0
ip broadcast-address 192.168.1.255
no ip redirects
no ip proxy-arp
ip nat inside
zone-member security zone_client

interface GigabitEthernet0/0/3
vrf forwarding WebVRF
ip address 192.168.99.1 255.255.255.0
ip nat outside
zone-member security zone_internet
speed 1000
no negotiation auto
```

Step 3. (Optional) Configure NAT

Configure NAT for Inside and Outside interfaces. In this example, the source IP address from the Client (192.168.10.1) is translated to 192.168.99.100.

```
ip access-list standard nat_source
10 permit 192.168.10.0 0.0.0.255

ip nat pool natpool 192.168.99.100 192.168.99.100 prefix-length 24
ip nat inside source list nat_source pool natpool vrf WebVRF overload
```

Step 4. Configure FQDN ACL

Configure FQDN ACL to match the target traffic. In this example, use the wildcard '*' in the pattern matching of the FQDN object group to match the destination FQDN.

```
object-group network src_net
192.168.10.0 255.255.255.0

object-group fqdn dst_test_fqdn
pattern .*\.test\.com

object-group network dst_dns
host 8.8.8.8

ip access-list extended Client-WebServer
1 permit ip object-group src_net object-group dst_dns
5 permit ip object-group src_net fqdn-group dst_test_fqdn
```

Step 5. Configure ZBFW

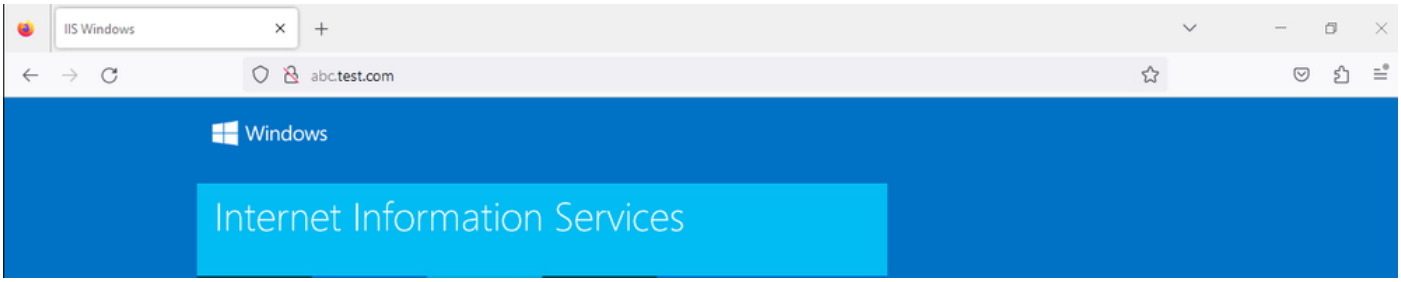
Configure zone, class-map, policy-map for ZBFW. In this example, by using parameter-map, logs is generated when the traffic is permitted by ZBFW.

```
zone security zone_client
zone security zone_internet

parameter-map type inspect inspect_log
audit-trail on

class-map type inspect match-any Client-WebServer-Class
match access-group name Client-WebServer

policy-map type inspect Client-WebServer-Policy
class type inspect Client-WebServer-Class
inspect inspect_log
class class-default
drop log

zone-pair security Client-WebServer-Pair source zone_client destination zone_internet
service-policy type inspect Client-WebServer-Policy
```

Verify

Step 1. Initiate HTTP Connection From Client

Verify that HTTP communication from the Client to the WEB server is successful.



HTTP Connection

Step 2. Confirm IP Cache

Run show platform hardware qfp active feature dns-snoop-agent datapath ip-cache all command to confirm that the IP cache for the target FQDN is generated in C8300-2N2S-6T.

```
<#root>

02A7382#

show platform hardware qfp active feature dns-snoop-agent datapath ip-cache all


IP Address Client(s) Expire RegexId Dirty VRF ID Match
-----------------------------------------------------------------------------------------------------------
192.168.20.1 0x1 117 0xdbccd400 0x00 0x0 .*\.test\.com
```

Step 3. Confirm ZBFW Log

Confirm that the IP address (192.168.20.1) is matching to the FQDN (.*\.test\.com), and verify that the HTTP communication in step 1 is permitted by ZBFW.

```
*Mar 7 11:08:23.018: %IOSXE-6-PLATFORM: R0/0: cpp_cp: QFP:0.0 Thread:003 TS:00000551336606461468 %FW-6-

*Mar 7 11:08:24.566: %IOSXE-6-PLATFORM: R0/0: cpp_cp: QFP:0.0 Thread:002 TS:00000551338150591101 %FW-6-
```

Step 4. Confirm Packet Capture

Confirm that the DNS resolution for target FQDN and the HTTP connection between the Client and the WEB server are successful.

Packet Capture in Inside :

No.	Time	Identification	Source	S.Port	Destination	D.Port	Time to Live	Protocol	Length	TCP.Seq	Next sequence	TCP.Ack	Info
15	2024-03-07 11:50:36.775945	0x0511 (1297)	192.168.10.1	64078	8.8.8.8	53	127	DNS	76				Standard query 0xa505 A abc.test.com
18	2024-03-07 11:50:36.782949	0xe036 (57398)	8.8.8.8	53	192.168.10.1	64078	126	DNS	92				Standard query response 0xa505 A abc.test.com A 192.168.20.1

DNS Packets in Inside

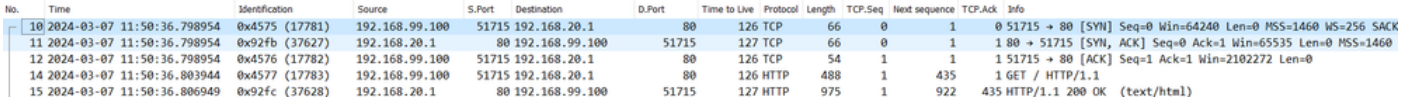
No.	Time	Identification	Source	S.Port	Destination	D.Port	Time to Live	Protocol	Length	TCP.Seq	Next sequence	TCP.Ack	Info
22	2024-03-07 11:50:36.798954	0x4575 (17781)	192.168.10.1	51715	192.168.20.1	80	127	TCP	70	0	1	0	51715 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM
23	2024-03-07 11:50:36.798954	0x92fb (37627)	192.168.20.1	80	192.168.10.1	51715	126	TCP	70	0	1	1	80 → 51715 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1460 WS=256
24	2024-03-07 11:50:36.798954	0x4576 (17782)	192.168.10.1	51715	192.168.20.1	80	127	TCP	58	1	1	1	51715 → 80 [ACK] Seq=1 Ack=1 Win=2102272 Len=0
26	2024-03-07 11:50:36.803944	0x4577 (17783)	192.168.10.1	51715	192.168.20.1	80	127	HTTP	492	1	435	1	GET / HTTP/1.1
27	2024-03-07 11:50:36.806949	0x92fc (37628)	192.168.20.1	80	192.168.10.1	51715	126	HTTP	979	1	922	435	HTTP/1.1 200 OK (text/html)

HTTP Packets in Inside

Packet Capture in Onside (192.168.10.1 is NAT to 192.168.19.100) :

No.	Time	Identification	Source	S.Port	Destination	D.Port	Time to Live	Protocol	Length	TCP.Seq	Next sequence	TCP.Ack	Info
3	2024-03-07 11:50:36.775945	0x0511 (1297)	192.168.99.100	64078	8.8.8.8	53	126	DNS	72				Standard query 0xa505 A abc.test.com
6	2024-03-07 11:50:36.782949	0xe036 (57398)	8.8.8.8	53	192.168.99.100	64078	127	DNS	88				Standard query response 0xa505 A abc.test.com A 192.168.20.1

DNS Packets in Outside



No.	Time	Identification	Source	S.Port	Destination	D.Port	Time to Live	Protocol	Length	TCP.Seq	Next sequence	TCP.Ack	Info
10	2024-03-07 11:50:36.798954	0x4575 (17781)	192.168.99.100	51715	192.168.20.1	80	126	TCP	66	0	1	0	51715 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK
11	2024-03-07 11:50:36.798954	0x92fb (37627)	192.168.20.1	80	192.168.99.100	51715	127	TCP	66	0	1	1	80 → 51715 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1460
12	2024-03-07 11:50:36.798954	0x4576 (17782)	192.168.99.100	51715	192.168.20.1	80	126	TCP	54	1	1	1	51715 → 80 [ACK] Seq=1 Ack=1 Win=2102272 Len=0
14	2024-03-07 11:50:36.803944	0x4577 (17783)	192.168.99.100	51715	192.168.20.1	80	126	HTTP	488	1	435	1	GET / HTTP/1.1
15	2024-03-07 11:50:36.806949	0x92fc (37628)	192.168.20.1	80	192.168.99.100	51715	127	HTTP	975	1	922	435	HTTP/1.1 200 OK (text/html)

HTTP Packets in Outside

Troubleshoot

For troubleshooting communication issues related to ZBFW using FQDN ACL pattern matching, you can collect the logs during the issue and provide them to Cisco TAC. Please note that the logs for troubleshooting depend on the nature of the issue.

Example of logs to be collected :

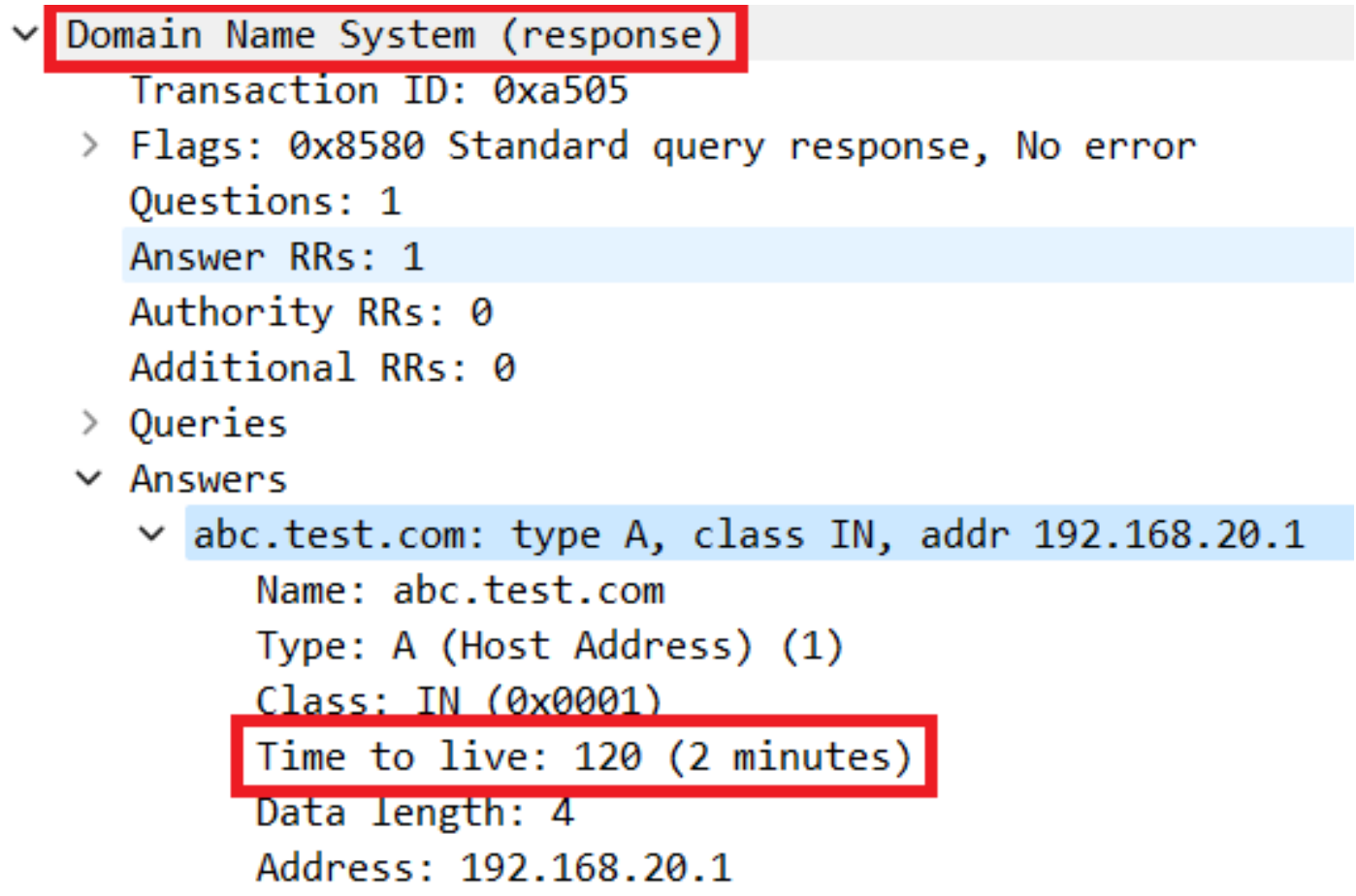
```
!!!! before reproduction
!! Confirm the IP cache
show platform hardware qfp active feature dns-snoop-agent datapath ip-cache all

!! Enable packet-trace
debug platform packet-trace packet 8192 fia-trace
debug platform packet-trace copy packet both
debug platform condition ipv4 access-list Client-WebServer both
debug platform condition feature fw dataplane submode all level verbose

!! Enable debug-level system logs and ZBFW debug logs
debug platform packet-trace drop
debug acl cca event
debug acl cca error
debug ip domain detail
!! Start to debug
debug platform condition start

!! Enable packet capture on the target interface (both sides) and start the capture
monitor capture CAPIN interface Port-channel1.2001 both
monitor capture CAPIN match ipv4 any any
monitor capture CAPIN buffer size 32
monitor capture CAPIN start

monitor capture CAPOUT interface g0/0/3 both
monitor capture CAPOUT match ipv4 any any
monitor capture CAPOUT buffer size 32
monitor capture CAPOUT start

!! (Optional) Clear the DNS cache on the client
ipconfig/flushdns
ipconfig /displaydns

!! Run the show command before reproduction
show platform hardware qfp active feature firewall drop all
show policy-map type inspect zone-pair Client-WebServer-Pair sessions
show platform packet-trace statistics
show platform packet-trace summary
show logging process cpp_cp internal start last boot
show platform hardware qfp active feature dns-snoop-agent client hw-pattern-list
show platform hardware qfp active feature dns-snoop-agent client info
show platform hardware qfp active feature dns-snoop-agent datapath stats
show ip dns-snoop all
show platform hardware qfp active feature dns-snoop-agent datapath ip-cache all
show platform software access-list F0 summary
```

```
!!!! Reproduce the issue - start

!! During the reproductionof the issue, run show commands at every 10 seconds
!! Skip show ip dns-snoop all command if it is not supported on the specific router
show ip dns-snoop all
show platform hardware qfp active feature dns-snoop-agent datapath ip-cache all

!!!! After reproduction
!! Stop the debugging logs and packet capture
debug platform condition stop
monitor capture CAPIN stop
monitor capture CAPOUT stop

!! Run the show commands
show platform hardware qfp active feature firewall drop all
show policy-map type inspect zone-pair Client-WebServer-Pair sessions
show platform packet-trace statistics
show platform packet-trace summary
show logging process cpp_cp internal start last boot
show platform hardware qfp active feature dns-snoop-agent client hw-pattern-list
show platform hardware qfp active feature dns-snoop-agent client info
show platform hardware qfp active feature dns-snoop-agent datapath stats
show ip dns-snoop all
show platform hardware qfp active feature dns-snoop-agent datapath ip-cache all
show platform software access-list F0 summary

show platform packet-trace packet all decode
show running-config
```

Frequently Asked Questions

Q: How is the timeout value of the IP cache determined on the router ?

A: The timeout value of the IP cache is determined by the TTL (Time-To-Live) value of the DNS packet returned from the DNS server. In this example, it is 120 seconds. When the IP cache times out, it is automatically removed from the router. This is the detail of packet capture.



Packet Detail of DNS Resolution

Q: Is it acceptable when the DNS server returns CNAME record rather than A record ?

A: Yes, it is not a problem. DNS resolution and HTTP communication is proceeded without any issues when CNAME record is returned by DNS Server. This is the detail of packet capture.

No.	Time	Identification	Source	S.Port	Destination	D.Port	Time to Live	Protocol	Length	TCP.Seq	Next sequence	TCP.Ack	Info
350	2024-03-07 12:09:55.625959	0x0bc5 (3013)	192.168.10.1	63777	8.8.8.8	53	127	DNS	76				Standard query 0x6bd8 A abc.test.com
352	2024-03-07 12:09:55.629957	0xe4fe (58622)	8.8.8.8	53	192.168.10.1	63777	126	DNS	114				Standard query response 0x6bd8 A abc.test.com CNAME def.test.

DNS Packets in Inside

```
Domain Name System (response)
    Transaction ID: 0x6bd8
  > Flags: 0x8580 Standard query response, No error
    Questions: 1
    Answer RRs: 2
    Authority RRs: 0
    Additional RRs: 0
  > Queries
  v Answers
    v abc.test.com: type CNAME, class IN, cname def.test.com
        Name: abc.test.com
        Type: CNAME (Canonical NAME for an alias) (5)
        Class: IN (0x0001)
        Time to live: 120 (2 minutes)
        Data length: 6
        CNAME: def.test.com
    v def.test.com: type A, class IN, addr 192.168.20.1
        Name: def.test.com
        Type: A (Host Address) (1)
        Class: IN (0x0001)
        Time to live: 120 (2 minutes)
        Data length: 4
        Address: 192.168.20.1
```

Packet Detail of DNS Resolution

No.	Time	Identification	Source	S.Port	Destination	D.Port	Time to Live	Protocol	Length	TCP.S	Next :	TCP.A	Info
356	2024-03-07 12:09:55.644955	0x4589 (17801)	192.168.10.1	51801	192.168.20.1	80	127	TCP	70	0	1	0	51801 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=2
357	2024-03-07 12:09:55.644955	0x9349 (37705)	192.168.20.1	80	192.168.10.1	51801	126	TCP	70	0	1	1	80 → 51801 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MS
358	2024-03-07 12:09:55.644955	0x458a (17802)	192.168.10.1	51801	192.168.20.1	80	127	TCP	58	1	1	1	51801 → 80 [ACK] Seq=1 Ack=1 Win=2102272 Len=0
359	2024-03-07 12:09:55.645962	0x458b (17803)	192.168.10.1	51801	192.168.20.1	80	127	HTTP	492	1	435	1	GET / HTTP/1.1
362	2024-03-07 12:09:55.646954	0x934a (37706)	192.168.20.1	80	192.168.10.1	51801	126	HTTP	979	1	922	435	HTTP/1.1 200 OK (text/html)

HTTP Packets in Inside

Q: What is the command to transfer packet captures collected on a C8300 router to an FTP server ?

A: Use monitor capture <capture name> export bootflash:<capture name>.pcap and copy bootflash:<capture name>.pcap ftp://<user>:<password>@<FTP IP Address> commands to transfer packet captures to an FTP server. This is an example to transfer CAPIN to an FTP server.

<#root>

```
monitor capture CAPIN export bootflash:CAPIN.pcap
```

```
copy bootflash:CAPIN.pcap ftp://<user>:<password>@<FTP IP Address>
```

Reference

Understand the Zone-Based Policy Firewall Design