Configuring AVC with DNS-AS

The Application Visibility Control (AVC) with Domain Name System as an Authoritative Source (DNS-AS) feature (AVC with DNS-AS) provides a centralized means of controlling the identification and classification of trusted network traffic in an organization. It accomplishes this by using—network metadata stored in a DNS server that is authoritative to the domain in question, to identify applications, Modular QoS CLI (MQC), to classify the corresponding traffic and apply suitable policies, and Flexible NetFlow (FNF), to monitor and export application information to an external collector.

Starting with Cisco IOS XE Release 3.9.0E, the feature is available on Catalyst 4500E Series Switches with Supervisor Engine 8-E, 8L-E, 7-E, 7L-E, and Catalyst 4500-X Series Switches. The ability to export application information using FNF is supported beginning with Cisco IOS XE Release 3.9.2E.

Benefits of the feature:

- Application Visibility—Ensuring unambiguous visibility of applications.

  The DNS-AS mechanism snoops requests and does not require a CPU-intensive, deep packet inspection (DPI). Since traffic classification is by means of a DNS request and not DPI, this feature is compatible in scenarios where network traffic is encrypted.

- Metadata Driven—Using information about applications.

  This enables you to holistically program the network so it behaves like a self-driving car. You now have information about all the required applications in your network, irrespective of whether traffic is encrypted or not.

- Centralized Control—Using a cross-domain application intent policy controller.

  The feature leverages an existing, universally available query-response mechanism, to enable local DNS servers within an organization to act as authoritative servers and propagate application classification information to client devices (switches) in an enterprise network.

- Control without Administrative Access—Proving alternatives to controller-based approaches.

  The feature supports scenarios where your network may be in the cloud and you may not own it. You can still control network devices across the Internet, even though you may not have administrative control of these devices.

This chapter describes how to configure AVC with DNS-AS. It includes the following major sections:

About AVC with DNS-AS

Overview

The process starts with an organization's requirements relating to management and control of network traffic. You begin by assessing—the software applications that run on the various hosts (phones, PCs etc.) in your network, the domains (websites) and applications accessed by these devices, and the business-relevance of these domains and applications in your organization.

The assessment helps you arrive at a list of domains and applications that are "trusted" by your organization - designating all remaining domains and applications as untrusted.

With DNS-AS enabled on your network and the list of trusted domains at hand, the networking devices or DNS-AS clients in your network identify which applications the network traffic belongs to or which domains are being requested. As long as the traffic is part of the trusted list, the switch requests the DNS server for metadata and IP address information. This request is sent in the form of a DNS-query. The response, once received, is cached locally until the Time-to-Live (TTL) for that resource record expires. The response is bound to the traffic and allows the DNS-AS client to now identify, classify, and forward traffic accordingly.

Key Concepts

Metadata (RFC6759)	In the context of the AVC with DNS-AS feature, this includes traffic classification information, application identification information, and business relevance information. Metadata is maintained in the form of TXT records. The following is a sample metadata record in the prescribed format: `CISCO-CLS=app-name:example|app-class:TD|business:YES|app-id:CU/28202`
Forward look-up	A request for an IP address or a request for an "A" record, originating from a host. Being able to snoop these forward lookups in the network traffic is fundamental to the DNS-AS feature.
Host	A PC or mobile where users run software applications, access websites and so on. Only hosts with a wired connection to the network are considered. Forward look-up requests originate from hosts.

Client or DNS-AS client	Networking devices throughout your network. Host traffic is always routed through such a client. **Note** This configuration chapter deals with DNS-AS configuration on Cisco Catalyst Switches that are deployed as access switches only. Throughout this document, the term client, DNS-AS client, refers to the switch where AVC with DNS-AS is enabled. DNS-AS Clients receive metadata from an authoritative DNS server and maintain a database of this information in the form of records. How long the record remains in the client's database, is determined by the record's TTL.
Binding table	A table that resides in the client and serves as a database of parsed DNS server responses [TXT records and "A" records]. Every client has a binding table of its own.
An "A" record	A record containing the domain name and IP address information [Only IPv4 address]. This is one of the DNS-Server responses (the other being the TXT record) and has a predefined lifespan. A forward lookup request from a host is a request for an "A" record.
TXT DNS-AS resource record or TXT record	A record containing metadata. This is one of the DNS-Server responses (the other being the "A" record) and has a predefined lifespan. A TXT record is limited to 255 characters. For AVC with DNS-AS, the TXT attribute is always **CISCO-CLS**. Any TXT record that starts with **CISCO-CLS=** can be recognized as a DNS-AS message. Syntax— **CISCO-CLS=<option>:<val>{|<option>:<val>}***
Time-to-Live (TTL)	The lifespan of an "A" record and TXT record in the binding table. TTL values are configured on the DNS server. While a TTL accompanies both TXT and "A" record responses, the DNS client only goes by the "A" record response from the DNS server.
Authoritative DNS server	The go-to DNS server for all client metadata and "A" record requests. Every DNS domain has only one authoritative DNS server. Such a server maintains records of application metadata in the form of a TXT record, and only returns responses to queries about domain names that have been maintained in the required format. The following is a sample metadata record in the prescribed format: **CISCO-CLS=app-name:example|app-class:TD|business:YES|app-id:CU/28202**

AVC with DNS-AS Process Flow

This involves the DNS snooping process and the DNS-AS client process—both of which are loosely coupled, but independent processes. Figure 45-1 is a representation of both processes.

Part -I: DNS Snooping Process

Step 1 The host initiates an “A” record request.

A user from your organization is in a meeting room in an office building. The associated DNS-AS client here is a switch (the wired network traffic from this meeting room is routed through this switch). The user looks up a website www.example.com, which initiates the request for an “A” record.

Step 2 The authoritative DNS-server responds with an “A” record response.

Part-II: DNS-AS Client Process

Step 1 The DNS-AS client sends a DNS query (TXT request) to the authoritative DNS server.

The DNS-AS client, which is constantly snooping for requests (based on the trusted domain list), finds the host’s forward look-up request.

Note The DNS-AS client receives a copy of the host’s “A” record request, and does not alter the host’s original request in any manner.

Based on the snooped result, the DNS-AS client sends a TXT request to the authoritative DNS server.

Step 2 The authoritative DNS-server responds with a TXT record response.

Step 3 A successful TXT response is followed by an “A” record request.

Step 4 The authoritative DNS-server responds with an “A” record response.

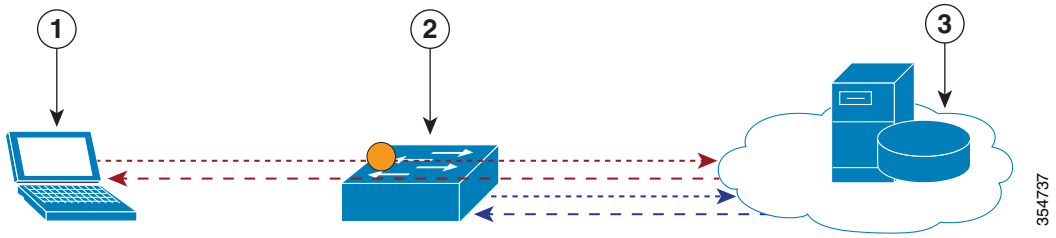
Step 5 The DNS-AS client parses and saves the response in its binding table.

The DNS-AS client saves the TXT record and “A” record in its binding table. The response will remain saved in the binding table for the duration specified by the TTL of the “A” record. The system automatically checks and prevents duplicate entries for a fully qualified domain name in the binding table.

The DNS-AS client applies a QoS policy based on the metadata from the DNS server, and exports application information to a collector, based on how the flow record is configured.

The DNS-AS client forwards information about identified applications to FNF, enabling you to export this information.

Figure 45-1 AVC with DNS-AS Process Flow



1	Host	3	Authoritative DNS Server
2	DNS-AS Client		

	An “A” record request from the host to the DNS server		An “A” record response from the DNS server to the host
	A copy of the host’s “A” record request that the DNS-AS client saves	—	—
	TXT record and “A” record request from the DNS-AS client to the DNS server		TXT record and “A” record response from the DNS server to the DNS-AS client

High Availability and ISSU for AVC with DNS-AS

The AVC with DNS-AS feature supports High Availability and ISSU.

For High Availability, the binding table database of the active DNS-AS client is synchronized with the standby DNS-AS client. As long as AVC with DNS-AS is enabled, no additional user configuration is required.

The binding table entries are synchronized when:

- The standby comes up (bulk synchronization).
- New entries are added to the binding table database.
- One or more entries are cleared from the database.

Note AVC with DNS-AS is also supported in the VSS mode, and Quad-Supervisor VSS Mode.

Default Configuration

AVC with DNS-AS is disabled.

Configuring AVC with DNS-AS

Prerequisites for Configuring AVC with DNS-AS

- The DNS-AS client can snoop forward look-up requests originating from hosts.
- To ensure DNS packet logging or snooping, you must attach the policy map to the interface, by using the **service-policy input** command.
- You have maintained metadata in the authoritative DNS server and reachability exists - before you enable AVC with DNS-AS.

Restrictions and Guidelines for Configuring AVC with DNS-AS

- Only a forward look-up is supported.
- Two DNS servers are supported, in case of a failover. One is considered the primary DNS server and other, the secondary DNS server.
- IPv6 is not supported—AAAA requests, and IPv6 DNS servers are not supported.
- AVC with DNS-AS is supported only on physical interfaces, in the ingress direction.
- AVC with DNS-AS is not supported on wireless traffic.
- Virtual Routing and Forwarding (VRF) is not supported.
- We recommend a maximum of 300 AVC with DNS-AS applications (domain names) in the binding table, because of its effect on the ternary content addressable memory (TCAM). To know how the addition of applications affects the TCAM see the Troubleshooting AVC with DNS-AS, page 45-24 section of this chapter

Generating Metadata Streams

Application metadata is configured and saved on the local, authoritative DNS server. You configure application classification information, for each trusted domain, in a prescribed format (a metadata stream). This is the information that the server propagates to switches when queried for application metadata. When the switch sends a TXT query regarding an application, the DNS server sends the relevant metadata in the TXT response.

To generate metadata streams, perform the following task:

	Command or Action	Purpose
Step 1	Go to the AVC Resource Record Generator at: https://www.dns-as.org/support/avc-rdata	Helps you generate a metadata stream for an application or domain, in a TXT record format. You can specify the following metadata fields: • (Optional) Domain Name • (Mandatory)Application Name—A value is mandatory. This can be an existing application name or custom application name. – Existing Application Name (**app-name:**)—Select from the list of standard applications. – Custom Application Name(**app-name:**)—If you enter a custom application name, you must also maintain the Traffic Class and Business Relevance information in the metadata stream. • (Optional) Selector ID (**app-id:**)—Consists of a classification engine ID (first eight bits) and a selector ID (the next twenty-four bits). – Classification Engine ID—Defines the context for the selector ID. Only these engine IDs are allowed: L3—IANA layer 3 protocol number L4—IANA layer 4 well-known port number L7—Cisco global application ID CU—Custom protocol. Use this engine ID for custom application names. – Selector ID—An application identifier, for a given classification engine ID. Enter a numeric value between 1 and 65535. **Note** When you enter the engine ID and selector ID for existing application names, be sure to align with the Network Based Application Recognition (NBAR) standard. Only then will the FNF exporters report with a common ID and in a consistent manner. • (Optional) Port Range (**server-port:**) • (Optional) Traffic Class (**app-class:**) • (Optional) Business Relevance (**business:**)—If you do not select yes or no, the business relevance value is set based on the app-class or app-name — in that order. For information about how traffic class and business relevance fields here map to QoS traffic classification, see Table 45-1app-class and QoS Traffic Mapping. Sample metadata stream: **CISCO-CLS=app-name:example|app-class:TD|business:YES|app-id:CU/28202**

	Command or Action	Purpose
Step 2	Click **Generate predefined** OR Click **Generate custom**	**Generate predefined—**Generates a predefined metadata stream for standard applications, using best practice defaults. **Generate custom—**Generates a custom metadata stream for your applications, using the custom values you have entered.
Step 3	Copy metadata into the corresponding TXT Resource Record of the DNS server in charge of the DNS domain that you have marked as a trusted domain.	Copy and paste the metadata stream from the website, to the authoritative DNS server you are using.

Configuring a DNS Server as the Authoritative Server

All DNS-AS clients in the network should be configured to send all DNS queries to one authoritative DNS server. On a Cisco Catalyst switch, perform the following task:

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**ip name-server** *server-address* **Example:** `Switch(config)# ip name-server 192.0.2.1 192.0.2.2`	Specifies the address of the authoritative DNS server. The port number is always 53. You can configure up to two DNS servers, in case of a failover. **Note** The command allows you configure up to six name servers (IPv4 and IPv6). Ensure that at least the first two IP addresses in the sequence are IPv4 addresses, because the AVC with DNS-AS feature will use only these. See the example below, here the first two addresses are IPv4 (192.0.2.1 and 192.0.2.2), the third one (2001:DB8::1) is an IPv6 address. AVC with DNS-AS will use the first two. `Switch(config)# ip name-server 192.0.2.1 192.0.2.2 2001:DB8::1`

Enabling AVC with DNS-AS

DNS-AS is disabled by default. To enable the feature on a Cisco Catalyst switch, perform the following task:

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**[no] avc dns-as client enable** **Example:** `Switch(config)# avc dns-as client enable`	Enables AVC with DNS-AS on the switch (DNS-AS client). The system then creates a binding table where parsed DNS server responses are stored till the TTL expires. **Note** To ensure DNS packet logging or snooping, you must attach the policy map (containing the relevant class maps that will determine traffic class) to the interface by using the **service-policy input** command. For more information see Configuring QoS for AVC with DNS-AS, page 45-11.

Making an Entry in the Trusted Domain List

When AVC with DNS-AS is first enabled on the switch, the trusted domain list is empty. You must maintain the list of trusted domains on the switch. The switch snoops only for network traffic that is maintained in this list. To make entries in this list, perform the following task

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**[no] avc dns-as client trusted-domains** **Example:** `Switch(config)# avc dns-as client trusted-domains`	Enters the trusted domain configuration mode.
Step 3	**[no] domain** *domain-name* **Example:** `Switch(config-trusted-domains)# domain www.example.com`	Enter the domain name. This forms part of the list of trusted domains for the DNS-AS client. All remaining domains are ignored and will follow default forwarding behavior. You can enter up to 50 domains. You can use regular expressions to match the domain name. For example, to represent all the domains for an organization, if you enter: `Switch(config-trusted-domains)# domain *.example.*` The DNS-AS client matches www.example.com, ftp.example.org and any other domain that pertains to the organization “example”. But use such an entry at your discretion, because it could increase the size of the binding table considerably.

Configuring QoS for AVC with DNS-AS

In order to isolate and classify trusted traffic as defined in the metadata stream, you must complete this sequence of tasks—create class maps (one for each traffic class), define traffic-class match criteria and business-relevance match criteria, create a policy map, attach the policy map to the interface. This sub-section provides the following information:

- Class Map Configuration in the Easy QoS Model, page 45-11
- Policy Map Definitions in the Easy QoS Model, page 45-12
- App-Class and QoS Traffic Mapping, page 45-12
- Sample QoS Configuration for AVC with DNS-AS: Classifying Network Control Traffic, page 45-13

For more QoS information, see the Classification, page 44-6 section of the Configuring QoS chapter in this guide.

Class Map Configuration in the Easy QoS Model

In order to determine how many traffic classes should be provisioned, you can use the 12-class Easy QoS Model. This model provides uniform, standards-based recommendations to help ensure that QoS designs and deployments are unified and consistent across an organization.

The following shows the class map configuration for traffic class and business relevance as per the 12-class Easy QoS Model:

```
class-map match-all VOICE
   match protocol attribute traffic-class voip-telephony
   match protocol attribute business-relevance business-relevant
class-map match-all BROADCAST-VIDEO
   match protocol attribute traffic-class broadcast-video
   match protocol attribute business-relevance business-relevant
class-map match-all REAL-TIME-INTERACTIVE
   match protocol attribute traffic-class real-time-interactive
   match protocol attribute business-relevance business-relevant
class-map match-all MULTIMEDIA-CONFERENCING
   match protocol attribute traffic-class multimedia-conferencing
   match protocol attribute business-relevance business-relevant
class-map match-all MULTIMEDIA-STREAMING
   match protocol attribute traffic-class multimedia-streaming
   match protocol attribute business-relevance business-relevant
class-map match-all SIGNALING
   match protocol attribute traffic-class signaling
   match protocol attribute business-relevance business-relevant
class-map match-all NETWORK-CONTROL
   match protocol attribute traffic-class network-control
   match protocol attribute business-relevance business-relevant
class-map match-all NETWORK-MANAGEMENT
   match protocol attribute traffic-class ops-admin-mgmt
   match protocol attribute business-relevance business-relevant
class-map match-all TRANSACTIONAL-DATA
   match protocol attribute traffic-class transactional-data
   match protocol attribute business-relevance business-relevant
class-map match-all BULK-DATA
   match protocol attribute traffic-class bulk-data
   match protocol attribute business-relevance business-relevant
class-map match-all SCAVENGER
   match protocol attribute business-relevance business-irrelevant
```

Policy Map Definitions in the Easy QoS Model

The following sample output displays the policy map definitions, with traffic attribute marking for all the traffic classes in the 12-class Easy QoS Model:

```
policy-map MARKING
class VOICE
  set dscp ef
class BROADCAST-VIDEO
  set dscp cs5
class REAL-TIME-INTERACTIVE
  set dscp cs4
class MULTIMEDIA-CONFERENCING
  set dscp af41
class MULTIMEDIA-STREAMING
  set dscp af31
class SIGNALING
  set dscp cs3
class NETWORK-CONTROL
  set dscp cs6
class NETWORK-MANAGEMENT
  set dscp cs2
class TRANSACTIONAL-DATA
  set dscp af21
class BULK-DATA
  set dscp af11
class SCAVENGER
  set dscp cs1
class class-default
  set dscp default
```

App-Class and QoS Traffic Mapping

The following table shows how the app-class field in the metadata stream maps to the 12-class Easy QoS Model of traffic classification:

Note The DNS-AS client applies default forwarding behavior in these cases:

- If the match attributes that you specify for the traffic class and business relevance do not match what you have defined in the metadata stream.
- If the binding table entry is no longer active. This refers to the age of the entry. Use the **show avc dns-as client binding-table** command to display the age of an entry

Table 45-1 app-class and QoS Traffic Mapping

app-class: <Long Text>	app-class: <Short text>	Corresponding Traffic Class and Business Relevance Label in the 12-Class Easy QoS Model
app-class: VOIP-TELEPHONY	app-class: VO	Traffic-class = voip-telephony Business-relevance = YES
app-class: BROADCAST-VIDEO	app-class: BV	Traffic-class = broadcast-video Business-relevance = YES

Table 45-1 app-class and QoS Traffic Mapping

app-class: REALTIME-INTERACTIVE	app-class: RTI	Traffic-class = real-time-interactive Business-relevance = YES
app-class: MULTIMEDIA-CONFERENCING	app-class: MMC	Traffic-class = multimedia-conferencing Business-relevance = YES
app-class: MULTIMEDIA-STREAMING	app-class: MMS	Traffic-class = multimedia-streaming Business-relevance = YES
app-class: NETWORK-CONTROL	app-class: NC	Traffic-class = network-control Business-relevance = YES
app-class: SIGNALING	app-class: CS	Traffic-class = Signaling Business-relevance = YES
app-class: OPS-ADMIN-MGMT	app-class: OAM	Traffic-class = ops-admin-mgmt Business-relevance = YES
app-class: TRANSACTIONAL-DATA	app-class: TD	Traffic-class = Transactional-Data Business-relevance = YES
app-class: BULK-DATA	app-class: BD	Traffic-class = bulk-data Business-relevance = YES
app-class: BEST-EFFORT	app-class: BE	Traffic-class = <no change> Business-relevance = default
app-class: SCAVENGER	app-class: SCV	Traffic-Class = <no change> Business-relevance = NO

Sample QoS Configuration for AVC with DNS-AS: Classifying Network Control Traffic

The following example shows how to classify network-control traffic based on the 12-class Easy QoS model. It shows how the DNS-AS client allows “example.org” to be classifed under class-map NETWORK-CONTROL.

For this example, the corresponding metadata that should be maintained is:

```
CISCO-CLS=app-name:example|app-class:NC|business:YES
```

Create class maps and match attributes

```
Switch# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)# class-map NETWORK-CONTROL
Switch(config-cmap)# match protocol attribute traffic-class network-control
Switch(config-cmap)# match protocol attribute business-relevance business-relevant
Switch(config-cmap)# end
```

Create the policy map, attach the class map to it and specify priority

```
Switch# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)# policy-map MARKING
Switch(config-pmap)# class NETWORK-CONTROL
Switch(config-pmap-c)# set dscp ef
Switch(config-pmap-c)# end
Switch#
```

Attach the policy map to an interface

```
Switch# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)# interface tengigabitethernet 1/0/1
Switch(config-if)# service-policy input MARKING
Switch(config-if)# end
```

Configuring FNF for AVC with DNS-AS

With FNF, you can gain visibility into the applications running on your network, and use FNF option templates to export application ID, description, and attribute information.

You must configure these FNF settings on the DNS-AS client:

- Configure a flow record to collect nonkey field **application-name**, and the key fields **ipv4 source address** and **ipv4 destination address**
- Configure a flow exporter and the two option templates, to fetch application information.

  Option template **application-table**, exports only applications resolved by the DNS-AS client, that is, the application ID and name from the binding table. The corresponding application descriptions come from Network Based Application Recognition (NBAR) definition for standard applications. A constructured help string is used for custom applications.

  Option **application-attributes** fetches attribute information by mapping it to the application name. Where standard application names are used, the option template uses standard NBAR attribute definitions; where custom application names are used, user-defined application names and only certain attribute fields are guaranteed to carry values.
- Configure a flow monitor and apply it to an interface to enable network traffic monitoring.

FNF Interaction with DNS-AS—With every flow that is created in the flow table, the DNS-AS client resolves the application name for the flow (if the entry exists in the binding table), by using the destination IP address (and if not available), the source IP address.

At periodic, configured intervals (600 seconds, by default), FNF exports option template data, that is mapped to the corresponding application name, to an external collector.

For more informattion about FNF, see the Configuring Flexible NetFlow chapter in this guide.

These sections provide more information:

- Option Templates, page 45-15
- Sample FNF Configuration for AVC with DNS-AS, page 45-17

Option Templates

The **application-table** and **application-attributes** options templates are supported. These templates determine the information that will be exported to an external collector.

option application-table

Exports the application name, application tag, and description to the external collector.

On a device where AVC with DNS-AS is enabled, only applications resolved by the DNS-AS client are exported. But in addition, the application-table template exports two applications called *unclassified* and *unknown*, irrespective of whether the feature is enabled or not.

- Application Name—For custom and standard applications, this information is derived from the TXT response (**`app-name:`**) that is saved in the binding table.
- Application Tag—This is same as application ID in the context of the AVC with DNS-AS feature and consists of the engine ID and selector ID.
  - Engine ID or Classification Engine ID—Defines the context for the selector ID. Only these values are supported:

    L3—IANA layer 3 protocol number (IANA_L3_STANDARD, ID: 1)

L4—IANA layer 4 well-known port number (IANA_L4_STANDARD, ID: 3)

L7—Cisco global application ID (CISCO_L7_GLOBAL, ID: 13)

CU—Custom protocol, (NBAR_CUSTOM, ID: 6). For custom applications, the DNS-AS client automatically uses this engine ID.

– Selector ID—Uniquely identifies the application or classification.

For standard applications, the application tag information is derived from these sources, in the given order of precedence:

1. TXT response (**app-id**:)
2. The NBAR definition for standard applications (if the TXT response does not carry a value)

For custom applications, the following applies to application tag information:

1. It is derived only from the TXT response (**app-id**:)
2. For the engine ID, the DNS-AS client automatically uses CU—Custom protocol, (NBAR_CUSTOM, ID: 6).
3. For the selector ID, the DNS-AS client allots a custom selector ID. A maximum of 120 custom applications are supported - out of which 110 are available to the DNS-AS client. Starting with selector ID value 243, IDs are assigned in descending order. When there are no remaining IDs to assign, the entry is not saved in the binding table.

- Description—This information is derived from the NBAR definition for standard applications. For custom applications, the DNS-AS client uses: User Defined Protocol <app-name>.

option application-attributes

Enables the collector to map the application names (from the **option application-table**) to their attributes. Attributes are statically assigned to each protocol or application, and are not dependent on traffic.

For standard applicatons—

- Application Tag—Guidelines that apply this field as part of the option application-table template apply here as well.
- Category—Groups applications based on the first level of categorization for each protocol as the match criteria. Similar applications are grouped together under one category. For example, the email category contains all email applications such as, Internet Mail Access Protocol (IMAP), Simple Mail Transfer Protocol (SMTP), Lotus Notes, and so on.
- Sub-category—Groups applications based on the second level of categorization for each protocol as the match criteria. For example, clearcase, dbase, rda, mysql and other database applications are grouped under the database group.
- Application Group—Groups the same networking applications together. For instance, Example-Messenger, Example-VoIP-messenger, and Example-VoIP-over-SIP are grouped together under the example-messenger-group
- Peer-to-peer (p2p)—Groups protocols based on whether or not they use p2p technology.
- Tunnel—Groups protocols based on whether or not a protocol tunnels the traffic of other protocols. Protocols for which the NBAR does not provide any value are categorized under the unassigned tunnel group. For example, Layer 2 Tunneling Protocols (L2TP).
- Encryption—Groups applications based on the encrypted and nonencrypted status of the applications. Protocols for which the NBAR does not provide any value are categorized under the unassigned encrypted group.

- Traffic class—Groups applications and protocols based on the traffic class they belong to. For example, all applications that have traffic class `TD`.

  Traffic class information is derived from these sources, in the given order of precedence:

  1. TXT response (**`app-class:`**)
  2. The NBAR definition for standard applications (if the TXT response does not carry a value)

- Business relevance—Groups applications based on whether or not they have been marked as business-relevant. For example, all applications that have business relevance as `YES`.

  Business relevance information is derived from these sources, in the given order of precedence:

  1. TXT response (**`business:`**)
  2. The NBAR definition for standard applications (if the TXT response does not carry a value)

For custom applications—

Only these attributes of the application-attributes option template are guaranteed to carry a value:

- Application Tag—See the Application Tag info in section option application-table, page 45-15 above. The same applies here as well.
- Traffic class—This information is derived from the TXT response (**`app-class:`**)
- Business Relevance—This information is derived from the TXT response (**`business:`**)

Sample FNF Configuration for AVC with DNS-AS

The following example shows how you can configure FNF for AVC with DNS-AS:

1. Create a flow record. As in the example, you must configure:
   - The source and destination IP addresses as key fields, in order to resolve application names.
   - The use of the application name as a nonkey field in flow record.

   Additionally (not mandatory), you can also configure the number of bytes or packets in a flow as a nonkey field, to display the number of applications sent to the collector.

```
Switch# configure terminal
Switch(config)# flow record example-record1
Switch(config-flow-record)# match ipv4 source address
Switch(config-flow-record)# match ipv4 destination address
Switch (config-flow-record)# collect application name
Switch (config-flow-record)# collect counter packets
Switch (config-flow-record)# exit

Switch# show flow record example-record1
flow record example-record1
 match ipv4 source address
 match ipv4 destination address
 collect application name
 collect counter packets
```

2. Create a flow exporter. Also configure the **application-table** and **application-attributes** option templates in the exporter. Without option templates, the collector cannot retrieve meaningful application information. At a minimum we recommend that you configure the application-table option. For attribute information, also configure the application-attribute option.

   You can also change the frequency of template export in seconds (the allowed range is 1 to 86400 seconds; the default is 600 seconds)

```
Switch(config)# flow exporter example-exporter1
```

```
Switch(config-flow-exporter)# option application-table
Switch(config-flow-exporter)# option application-attributes
Switch(config-flow-exporter)# template data timeout 500
Switch(config-flow-exporter)# exit

Switch#show flow exporter example-exporter1
Flow Exporter example-exporter1:
  Description:              User defined
  Export protocol:          NetFlow Version 9
  Transport Configuration:
    Destination IP address: 192.0.1.254
    Source IP address:      192.51.100.2
    Transport Protocol:     UDP
    Destination Port:       9995
    Source Port:            54964
    DSCP:                   0x0
    TTL:                    255
    Output Features:        Not Used
  Options Configuration:
    application-table (timeout 500 seconds)
    application-attributes (timeout 500 seconds)

Switch# show flow exporter example-exporter1 statistics
Flow Exporter example-exporter1:
  Packet send statistics (last cleared 00:00:48 ago):
    Successfully sent:         2                     (924 bytes)

  Client send statistics:
    Client: Option options application-name
      Records added:           4
        - sent:                4
      Bytes added:             332
        - sent:                332

    Client: Option options application-attributes
      Records added:           2
        - sent:                2
      Bytes added:             388
        - sent:                388
```

3. Create a flow monitor and apply it to an interface to perform network traffic monitoring.

   The interface you apply the flow monitor to, can also be the same interface you have applied the QoS policy to. This example applies the QoS policy created as part of the sample QoS configuration Sample QoS Configuration for AVC with DNS-AS: Classifying Network Control Traffic, page 45-13.

```
Switch# configure terminal
Switch(config)# flow monitor example-monitor1
Switch(config-flow-monitor)# record example-record1
Switch(config-flow-monitor)# exporter exporter-export1
Switch(config-flow-monitor)# exit
Switch(config)# interface tengigabitethernet 1/0/1
Switch(config)# switchport acceess vlan 100
Switch(config)# switchport mode access
Switch(config-if)# ip flow monitor example-monitor1 input
Switch(confif-if)# service-policy input MARKING
Switch(config-if)# end

Switch# show flow monitor
flow monitor example-monitor1
 record example-record1
 exporter example-exporter1
!
```

```
!
interface tengigabitethernet1/0/1
 switchport access vlan 100
 switchport mode access
ip flow monitor example-monitor1 input

Switch# show flow monitor example-monitor1 cache
  Cache type:                               Normal
  Cache size:                                16640
  Current entries:                               3
  High Watermark:                                3

  Flows added:                                   6
  Flows aged:                                    3
    - Active timeout      (  1800 secs)          0
    - Inactive timeout    (    30 secs)          3
    - Event aged                                 0
    - Watermark aged                             0
    - Emergency aged                             0

IPV4 SOURCE ADDRESS:       192.0.1.254
IPV4 DESTINATION ADDRESS:  192.51.100.2
counter packets long:      7479
application name:          appexample1

IPV4 SOURCE ADDRESS:       192.51.100.11
IPV4 DESTINATION ADDRESS:  203.0.113.125
counter packets long:      445
application name:          appexample2

IPV4 SOURCE ADDRESS:       192.51.51.51
IPV4 DESTINATION ADDRESS: 203.0.113.100
counter packets long:      14325
application name:          appexample3
Switch#
```

4. Other related show commands:

```
Switch# show avc dns-as client binding-table detail
DNS-AS generated protocols:
 Max number of protocols      :50
 Customization interval [min] :N/A

 Age            :   The amount of time that the entry is active
 TTL            :   Time to live which was learned from DNS-AS server
 Time To Expire :   Entry expiration time in case device does not see DNS traffic for
the entry host

Protocol-Name        : appexample1
 VRF                 : <default>
 Host                : www.appexample1.com
 Age[min]            : 2
 TTL[min]            : 60
 Time To Expire[min] : 58
 TXT Record          : app-name:appexample1|app-class:VO|business:YES
 Traffic Class       : voip-telephony
 Business Relevance  : business relevant
 IP                  : 192.0.1.254

Protocol-Name        : appexample2
 VRF                 : <default>
 Host                : www.appexample2.com
 Age[min]            : 2
 TTL[min]            : 60
```

```
 Time To Expire[min] : 58
 TXT Record          : app-name:appexample2|app-class:VO|business:YES
 Traffic Class       : voip-telephony
 Business Relevance  : business relevant
 IP                  : 192.51.100.11

<output truncated>

Switch# show flow exporter option application engines
Engine: prot (IANA_L3_STANDARD, ID: 1)
Engine: port (IANA_L4_STANDARD, ID: 3)
Engine: NBAR (NBAR_CUSTOM, ID: 6)
Engine: cisco (CISCO_L7_GLOBAL, ID: 13)

Switch# show flow exporter option application table

Engine: prot (IANA_L3_STANDARD, ID: 1)
appID   Name        Description
-----   ----        -----------

Engine: port (IANA_L4_STANDARD, ID: 3)
appID   Name        Description
-----   ----        -----------

Engine: NBAR (NBAR_CUSTOM, ID: 6)
appID   Name        Description
-----   ----        -----------
6:28202appexample1 User defined protocol dns-as-www

Engine: cisco (CISCO_L7_GLOBAL, ID: 13)
appID   Name        Description
-----   ----        -----------
13:0    unclassified Unclassified traffic
13:1    unknown      Unknown application
13:518  appexample2 appexample2, social web application and service
```

Monitoring AVC with DNS-AS

To display the various AVC with DNS-AS settings you have configured, use these **show** commands in the privileged EXEC mode:

Table 45-2 AVC with DNS-AS Monitoring Commands

Command	Purpose	Example
show avc dns-as client status	Displays current status of the DNS-AS client—whether AVC with DNS-AS is enabled or not.	Example: show avc dns-as client status
show avc dns-as client trusted-domains	Displays list of trusted domains configured.	Example: show avc dns-as client trusted-domains
show avc dns-as client binding-table and **show avc dns-as client binding-table detail**	Displays AVC with DNS-AS metadata for the list of trusted domains and resolved entries. You can filter the output by application name, domain name, and so on. Both commands display the same information, in different formats.	Example: show avc dns-as client binding-table detail

Table 45-2 AVC with DNS-AS Monitoring Commands

Command	Purpose	Example
show avc dns-as client statistics	Displays packet logging information—the number of DNS queries sent and the number of responses received.	Example: show avc dns-as client statistics
show avc dns-as client name-server brief	Displays information about the DNS server to which the metadata request was sent.	Example: show avc dns-as client name-server brief
show ip name-server	Displays all the name server IP addresses that have been maintained	Example: show ip name-server

Example: show avc dns-as client status

```
Switch# show avc dns-as client status
DNS-AS client is enabled
```

Back to Table 45-2.

Example: show avc dns-as client trusted-domains

```
Switch #show avc dns-as client trusted-domains
 Id  | Trusted domain
-----------------------------------------------------
    1| example.com
    2| www.example.com
    3| example.net
    4| www.example.net
    5| example.org
```

Back to Table 45-2.

Example: show avc dns-as client binding-table detail

```
Switch# show avc dns-as client binding-table detailed
DNS-AS generated protocols:
 Max number of protocols      :50
 Customization interval [min] :N/A

 Age             :   The amount of time that the entry is active
 TTL             :   Time to live which was learned from DNS-AS server
 Time To Expire :   Entry expiration time in case device does not see DNS traffic for the
entry host

Protocol-Name         : example
 VRF                  : <default>
 Host                 : www.example.com
 Age[min]             : 2
 TTL[min]             : 60
 Time To Expire[min]  : 58
 TXT Record           : app-name:example|app-class:VO|business:YES
 Traffic Class        : voip-telephony
 Business Relevance   : business relevant
 IP                   : 192.0.2.121
                      : 192.0.2.254
                      : 198.51.100.1
                      : 198.51.100.254
                      : 192.51.100.12
                      : 203.0.113.125
<output truncated>
```

Back to Table 45-2.

Example: show avc dns-as client statistics

Note Two DNS servers are configured in this example.

```
Switch# show avc dns-as client statistics
```

```
Server details: vrf-id = 0 vrf-name = <default> ip = 192.0.2.1
 AAAA  Query    Error packets 0
 AAAA  Query    TX    packets 0
 AAAA  Response RX    packets 0
 TXT   Query    Error packets 0
 TXT   Query    TX    packets 8
 TXT   Response RX    packets 0
 A     Query    Error packets 0
 A     Query    TX    packets 6
 A     Response RX    packets 0
Server details: vrf-id = 0 vrf-name = <default> ip = 192.0.2.2
 AAAA  Query    Error packets 0
 AAAA  Query    TX    packets 0
 AAAA  Response RX    packets 0
 TXT   Query    Error packets 0
 TXT   Query    TX    packets 2
 TXT   Response RX    packets 2
 A     Query    Error packets 0
 A     Query    TX    packets 4
 A     Response RX    packets 2
 Total Drop           packets 0

 avc_dns_as_pkts_logged          = 2
 avc_dns_as_q_pkts_processed     = 2
```

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Example: show avc dns-as client name-server brief

```
Switch# show avc dns-as client name-server brief
Server-IP | Vrf-name
-----------------------------------------------------
192.0.2.1 | <default>
192.0.2.2 | <default>
```

Back to Table 45-2.

Example: show ip name-server

```
Switch# show ip name-server
192.0.2.1
192.0.2.2
2001:DB8::1
```

Back to Table 45-2.

Troubleshooting AVC with DNS-AS

Problem	Possible Causes and Solutions
There are no entries in the binding table	The binding table may be empty because of one or both of these reasons: • Metadata is not maintained in DNS server—complete task Generating Metadata Streams, page 45-7 • The entry is not maintained in the trusted domain list—complete task Making an Entry in the Trusted Domain List, page 45-10
Unsuccessful DNS snooping or packet logging.	To ensure DNS snooping and packet logging, you must attach the policy map (containing the relevant class maps that will determine traffic class) to the interface—See the example in the Configuring QoS for AVC with DNS-AS section.

The DNS server does not return correct values	Verify that the correct DNS-AS metadata is maintained in the DNS system
	• Using Linux dig:
	`dig TXT +short www.example.org [dns-server-ip]`
	`"CISCO-CLS=app-name:example|app-class:TD|business:YES|app-id:CU/28202"`
	• Using Windows nslookup:
	`C:\Windows\system32>NSLookup.exe -q=TXT www.example.org [dns-server-ip]`
	`www.example.org text =`
	`"CISCO-CLS=app-name:example|app-class:TD|business:YES|app-id:CU/28202"`

The QoS policy you applied to the port is removed.	When the DNS-AS client recognises an application, along with saving the "A" record response in the binding table, the system utilises the TCAM to save the IP address of the application. A single application can in effect have multiple IP addresses, each utilising additional space in the TCAM. When the TCAM is exhausted, QoS policies cease to be applied. To avoid the problem, monitor TCAM utilisation on a regular basis. Enter the **show platform tcam utilisation** command in privilege EXEC mode, to display information about TCAM availability.