Junos® Networking Technologies

DAY ONE: DYNAMIC SUBSCRIBER MANAGEMENT

Get a Dynamic Subscriber Management solution up and running in a day with an MX Series and Steel-Belted RADIUS server. The Junos OS and the MX Series make it all possible.

By Jeremy Schulman, Lenny Pollard, and John Rolfe

DAY ONE:
DYNAMIC SUBSCRIBER MANAGEMENT

This book introduces you to all the fundamentals of the Juniper Networks Dynamic Subscriber Management solution and shows you how to get it up and running in a day. By the end of the last chapter you'll know what is meant by *dynamic* and why it's different from legacy approaches that are so prevalent today. You'll see how Juniper creates a seamless subscriber management interworking between the MX Series, as a BRAS device, and the Juniper Steel-Belted RADIUS (SBR) server. You'll be introduced to the new MX configuration hierarchies and how they interrelate with existing hierarchies, and you'll review the SBR administration GUI and learn about creating service definitions.

This book provides hands-on exposure to actual MX configurations, driving the SBR administration GUI, looking through logs, and learning troubleshooting skills that can assist you in product demonstrations, proof-of-concept testing, and network pre-staging integration activities. So roll up your sleeves, get the lab prepped, and let's knock this one out of the park.

IT'S DAY ONE AND YOU HAVE A JOB TO DO, SO LEARN HOW TO:

- Identify a lab set up to work along with the samples and chapters of this book.
- Configure the MX for dynamic VLAN interfaces.
- Configure the Steel-Belted RADIUS Server.
- Set the MX dynamic interface profile for the dual-stacked Customer VLAN model.
- Set the MX dynamic interface profile for the single tag Service VLAN model.
- Add AAA to subscriber services.
- Configure dynamic subscriber services.
- Troubleshoot your deployment and use the logs to validate services.

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Send your suggestions, comments, and critiques by email to dayone@juniper.net.

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Welcome to Day One

This book is part of a growing library of *Day One* books, produced and published by Juniper Networks Books.

Day One books were conceived to help you get just the information that you need on day one. The series covers Junos OS and Juniper Networks networking essentials with straightforward explanations, step-by-step instructions, and practical examples that are easy to follow.

The *Day One* library also includes a slightly larger and longer suite of *This Week* books, whose concepts and test bed examples are more similar to a weeklong seminar.

You can obtain either series, in multiple formats:

- Download a free PDF edition at http://www.juniper.net/dayone.
- Get the ebook edition for iPhones and iPads from the iTunes Store. Search for Juniper Networks Books.
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What You Need to Know Before Reading This Book

You should be familiar with the basic administrative functions of the Junos operating system, including the ability to work with operational commands and to read, understand, and change the Junos configuration.

Other things that you will find helpful as you explore the pages of this book:

- VLAN architectures for BRAS networks (a Juniper Networks whitepaper on this topic can be download from: http://www.juniper.net/us/en/local/pdf/whitepapers/2000186-en.pdf).
- Junos Class-of-Service configurations (see *Day One: Deploying Basic QoS*, at www.juniper.net/dayone).
- Understanding DHCP protocol messages.
- Understanding RADIUS authentication/accounting protocol messages.

Essentials for Following Along With This Book

Much of *Day One: Dynamic Subscriber Management* cites configuration and output samples so you can follow along in your lab, test bed, or device. Here's what you'll need to follow along:

- A MX Series device with subscriber management licenses
- SBR Enterprise Edition running on a Windows computer
- An external DHCP server
- End devices or test equipment that can act as DHCP clients

About Dynamic Subscriber Management

The purpose of this book is to enable you to “turn up” a Juniper Networks Dynamic Subscriber Management solution that consists of the MX series router and the Juniper Steel-Belted RADIUS (SBR) server. You will also learn how to configure the MX as a DHCP local-server or use an external DHCP server.

The Juniper Networks solution enables you to deploy a wide range of network scenarios. For instance:

- Will your subscribers be using DHCP or PPPoE?
- Will the subscriber CPE devices support IPv4 and IPv6 simultaneously (aka dual stack)?
- What kinds of service offerings will you provide – tiered speed Internet, business grade Voice/Data, or Multiplay-Residential (Voice/Video/Data)?
- Does your network need to log user access for legal tracking requirements?
- Do you need to support fair-use policies that down-speed users that have used too much bandwidth?

Because covering all of these topics would require more than just one book, *Day One: Dynamic Subscriber Management* focuses on a set of features that represent common cases. It will point you to information on topics it doesn’t cover or that it covers only in brief. Much of the information, and many of the solutions illustrated, however, are building blocks for other solutions.

This book focuses on the following services:

- DHCP subscribers using IPv4.
- Subscriber services where each customer stream is uniquely identified by a stacked VLAN tag. The outer VLAN tag (S-TAG) typically identifies the Multi-Service Aggregation Node (MSAN), for example, a DSLAM, and the inner VLAN tag (C-TAG) typically identifies a port on the MSAN. This is referred to as the Customer VLAN model.

- Subscriber services where all customer streams for a given service type, basic Internet for example, share the same VLAN Tag. This Service VLAN model is fairly common in today's networks. While many service providers are migrating to the Customer VLAN model, others will want to maintain their existing network architecture.
- Subscriber services without any bandwidth restrictions or QoS, therefore the simplest cases, just to get things started.
- Subscriber services that have simple bandwidth service profiles, for example, differentiating a 5Mbps customer versus a 10Mbps customer.
- Subscriber services that have QoS settings to enable differentiated services such as integrated Voice and Data.

Chapter 1

Introducing Dynamic Subscriber Management

This chapter introduces you to all the fundamentals of the Juniper Networks subscriber management solution. It discusses what is meant by *dynamic* and how it's different from legacy approaches. You'll see how Juniper creates a seamless subscriber management interworking between the MX Series as a BRAS device and the Juniper Steel-Belted RADIUS (SBR) server. This chapter also introduces you to the new MX configuration hierarchies and how they interrelate with existing hierarchies.

The rest of this book provides hands-on exposure to actual MX configurations, driving the SBR administration GUI, looking through logs, and learning new troubleshooting skills that can assist you in product demonstrations, proof-of-concept testing, and network pre-staging integration activities. But first, let's briefly introduce the fundamentals of Dynamic Subscriber Management and then review Juniper's unique implementation of it.

The Fundamentals of Dynamic Subscriber Management

Figure 1.1 illustrates a typical service provider network. Starting at the left of the figure, a subscriber management network begins with the subscribers – the customers that are paying money for network services such as Internet Access, Voice, IPTV, and Video on Demand.

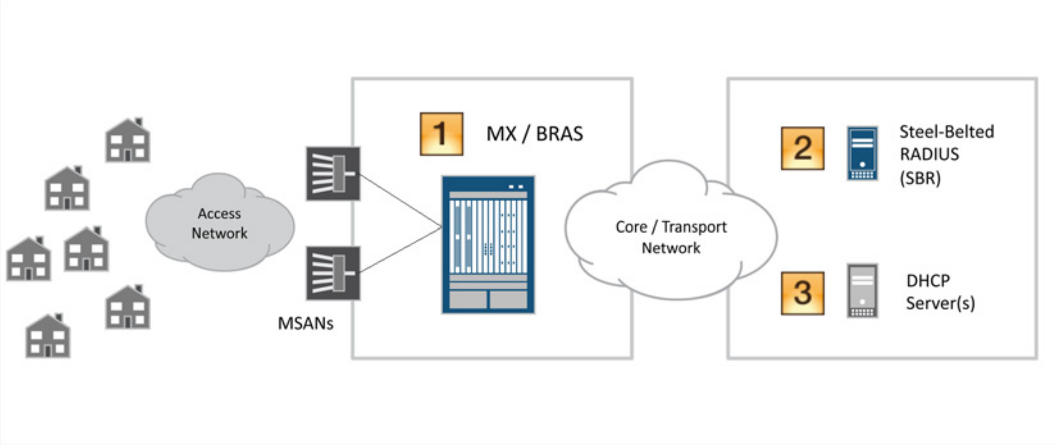


Figure 1.1 Typical Subscriber Management Network

Subscribers are connected via physical access technologies such as DSL, cable modems, and fiber into an aggregation device: the Multi Service Access Node (MSAN). MSANs transport this traffic to the

Broadband Remote Access Servers (BRAS) and are generally connected via 1GE or 10GE interfaces.

The BRAS devices terminate or *anchor* subscriber sessions and provide access to the network services. The Juniper Networks MX Series provides this BRAS functionality.

MORE? For more information on the MX Series family of products, visit Juniper's website: http://www.juniper.net/us/en/products-services/routing/mx-series/.

The MX is typically configured to use RADIUS servers for authentication, authorization, and accounting (AAA) services (*item 2* in Figure 1.1). The RADIUS server is also used to provide subscriber-specific session parameters, for example, bandwidth speed. This is accomplished using RADIUS Vendor Specific Attributes (VSAs). The interaction between the MX and RADIUS is part of the *Dynamic* in Dynamic Subscriber Management, and Juniper Networks offers the Steel-Belted RADIUS (SBR) server as part of its Dynamic Subscriber Management solution.

NOTE You are not required to use SBR – any RADIUS server that supports VSAs can be used. But the Juniper SBR has specific features and functionality designed for service provider networks. For instance, SBR can be deployed in a high-availability cluster, or SBR can also "talk to" existing service provider customer databases via LDAP, SQL, and other methods when validating and authenticating subscriber sessions. You'll learn more about the key SBR service provider features in a later section in this chapter.

MORE? To find more information on the Steel-Belted RADIUS product on Juniper's website, see http://www.juniper.net/us/en/products-services/software/ipc/sbr-series/service-provider/.

A service provider typically uses external DHCP servers for managing and assigning IP addresses to their subscribers (*item 3* in Figure 1.1). The MX can relay DHCP requests to multiple external DHCP servers, or the MX can also be configured as a local DHCP server, the specifics of which are covered later in this book.

NOTE Be aware that Juniper Networks does not resell external DHCP servers.

What is *Dynamic* About Subscriber Management?

The purpose of *Dynamic* Subscriber Management is to enable a service provider to deploy a BRAS solution without having to manually provision each customer.

Consider the case of a service provider needing to deploy 4,000 subscribers without Dynamic Subscriber Management. Traditionally, the network administrator would need to manually provision each subscriber, each VLAN sub interface, each set of class-of-service bandwidth controls, and more. This manual process results in a significant amount of configuration time, not to mention time spent on the effort to debug and troubleshoot resulting errors. Additionally, the administrator would need to keep track of which VLANs map to which customers, as well as managing other networking resources.

Juniper's dynamic approach enables a service provider to deploy a solution without manually provisioning each subscriber. To better understand this, let's look at two key Dynamic Subscriber Management concepts whose specific configurations and use-cases are used throughout the rest of this book: *dynamic VLAN interfaces* and *dynamic IP profiles*.

Dynamic VLAN Interfaces

The first concept is called a *dynamic VLAN interface*, or auto-configuration of VLAN sub-interfaces. This means that you no longer have to manually create the VLAN sub-interfaces that correspond to a subscriber or subscriber services – instead you configure the MX to automatically create VLAN sub-interfaces when it detects inbound traffic.

For example, when a DHCP subscriber attempts to access the service provider network, the MX detects the DHCP-DISCOVER packet, examines the VLANs in the packet, and dynamically creates a corresponding VLAN sub-interface. These packets could be either single VLAN tagged, or stacked VLAN tagged. The latter case is typically used when each subscriber is directly connected to a port on an MSAN device. The outer tag represents the MSAN device, and the inner VLAN tag represents the port on the MSAN. This specific MX configuration is covered in the next chapter.

When the MX auto configures VLAN sub-interfaces, the Junos OS generates a unique interface unit. For example, here is the output of a stacked VLAN interface that has an outer VLAN tag of 100 and an inner VLAN tag of 10:

```
admin@MX> show subscribers
Interface          IP Address/VLAN ID          User Name            LS:RI
ge-1/0/0.1073741825 0x8100.100 0x8100.10                            default:default
```

If you are familiar with Junos, then you know that the unit number follows the interface name, and in this case you can see that Junos dynamically allocated the unit number 1073741825.

Chapter 2 gets you started with configuring the MX for dynamic VLAN interfaces, but for now let's continue with the other key concept in Juniper's dynamic approach to subscriber management.

Dynamic IP Profiles

The other key concept is called a *dynamic IP profile*, meaning you no longer have to manually provision IP service definitions for each subscriber – instead you define a dynamic IP profile. You can think of it as a configuration template where you can have multiple profiles for different customer scenarios. Each profile looks just like a Junos configuration hierarchy, except you substitute Junos-defined variables where you would normally hardcode values such as interface names, VLAN-IDs, or a shaping bandwidth.

To help illustrate, let's take a look at a static configuration and then at the corresponding dynamic IP profile. This configuration example assigns a 5Mbps shaper on interface ge-1/0/5 whose packets are encapsulated with stacked VLANs: outer tag=100 and inner tag=10. The static configuration looks like this:

```
[edit interfaces ge-1/0/5]
admin@MX# show
hierarchical-scheduler;
flexible-vlan-tagging;
unit 10 {
   vlan-tags outer 100 inner 10;
   family inet {
      address 12.2.4.18/27;
   }
}

[edit class-of-service]
admin@MX# show
traffic-control-profiles {
   shape_5Mbps {
      shaping-rate 5m;
   }
}
interfaces {
   ge-1/0/5 {
      unit 10 {
         output-traffic-control-profile shape_5Mbps;
      }
   }
}
```

Let’s just focus on the `[class-of-service]` hierarchy. In the static configuration, the shaping rate is hard-coded to be 5Mbps. But let’s say you want the shaping rate to be a variable depending on the subscriber, so, perhaps one subscriber gets 5Mbps of service while another subscriber gets 7Mbps of service.

The purpose of a dynamic IP profile is to create a *template* configuration and have the specific variable values assigned in real time when the subscriber authenticates to the network. (Have you ever played Mad Libs, where one player prompts another for a list of words to substitute for blanks in a story, usually with funny results? Well, you can think of a dynamic profile as a Mad Lib and the `$junos` variables as the “blanks” that get filled in along the way.)

Take a look at an example dynamic IP profile named *DYNSUB-2VLANS-DHCP-INET* (just in the `[class-of-service]` hierarchy):

```
[edit dynamic-profiles DYNSUB-2VLANS-DHCP-INET class-of-service]
admin@MX # show
traffic-control-profiles {
   shape_variable {
      shaping-rate “$junos-cos-shaping-rate”;
   }
}
interfaces {
   “$junos-interface-ifd-name” {
      unit “$junos-underlying-interface-unit” {
         output-traffic-control-profile shape_variable;
      }
   }
}
```

First, notice the new top-level hierarchy `[dynamic-profiles]`. This stanza contains the configuration for both dynamic IP profiles and dynamic VLAN profiles – these are different but don’t let this confuse you – this book will illustrate both types and show you when to use each one.

The structure of a dynamic IP profile is the same as the main Junos configuration. Within the dynamic IP profile you have the same top-level hierarchy `[class-of-service]` as you would find in the main

Junos configuration. And under `[class-of-service]` you find the same `[traffic-control-profiles]` and `[interfaces]` stanzas. Throughout the profile you see the use of `$junos` variables.

The values of some variables are determined by Junos. In the static configuration, the interface name was hardcoded to `ge-1/0/5`. But since this is a dynamic IP profile, a placeholder is needed in the configuration, and that's what the `$junos-interface-ifd-name` does. When Junos applies the dynamic IP profile, it fills in the interface name value in real-time.

The values of some variables are also determined by RADIUS. The `$junos-cos-shaping-rate` is an example. When the subscriber authenticates with a RADIUS server, the RADIUS server uses the subscriber user-name to return a set of variable values via RADIUS attributes (VSAs). One subscriber may get a RADIUS VSA indicating a shaper value of 5Mbps, while another may get a value of 7Mbps. When Junos receives the RADIUS authentication response containing these VSAs, it binds them to the `$junos` variables defined in the dynamic IP profile in real-time.

Up and Running

The goal of this book is to get you started working with dynamic VLAN interfaces and dynamic IP profiles. Each chapter will walk you through various configuration scenarios explaining the use of variables and their corresponding RADIUS VSAs.

MORE? If you're interested in learning more about the Junos system variables before preceding further, take a moment to read about them here: http://www.juniper.net/techpubs/en_US/junos/topics/reference/general/junos-predefined-variables-table.html.

How Does Dynamic Subscriber Management Work?

Now that you've been introduced to a few of the core MX BRAS concepts – *dynamic VLAN interfaces* and *dynamic IP profiles* – and to the concept of using RADIUS to provide subscriber specific values for the MX dynamic IP profiles, let's illustrate how the many parts work together to create a seamless dynamic subscriber experience.

Figure 1.2 illustrates the interactions between each of the network elements, the associated configuration, and the resulting dynamic VLAN interfaces and subscriber sessions.

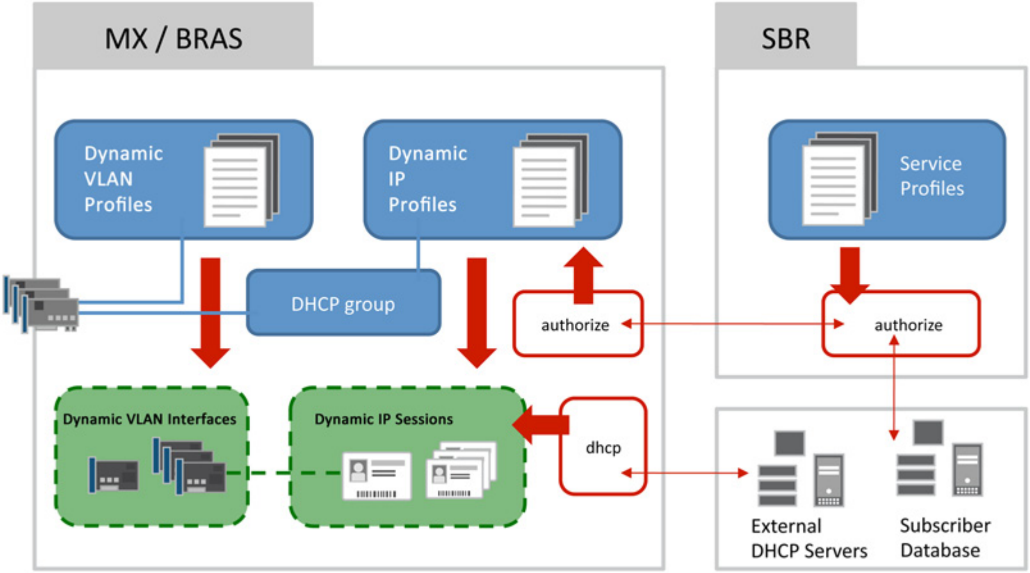


Figure 1.2 Interaction of DHCP Subscriber Management Solution

NOTE Figure 1.2 illustrates the DHCP subscriber management scenarios that are covered in this book. For PPPoE scenarios, the case would be similar, but different. For the sake of brevity and completeness, this book focuses only on the DHCP use-cases.

Note the three major *block* components of the Dynamic Subscriber Management solution in Figure 1.2: the MX / BRAS, the SBR, and the external DHCP server. Figure 1.2 also includes a service provider *subscriber database*, which will be discussed shortly.

Figure 1.3 highlights the relationship between the MX configured items. Physical interfaces, for example, ge-1/0/5 and xe-5/0/0 (represented as the NICs on the left), or even aggregated Ethernet ports, have a configured relationship with two other items: the first is the dynamic VLAN profile, and the second is the DHCP group (local or relay). In turn, the DHCP group has a relationship with a dynamic IP profile.

The interaction between the physical interface, the dynamic VLAN profile, the DHCP group, and the dynamic IP profile illustrated in Figure 1.3 results in the dynamic creation of a dynamic VLAN interface, and an active subscriber IP session. Let’s focus on this process in detail.

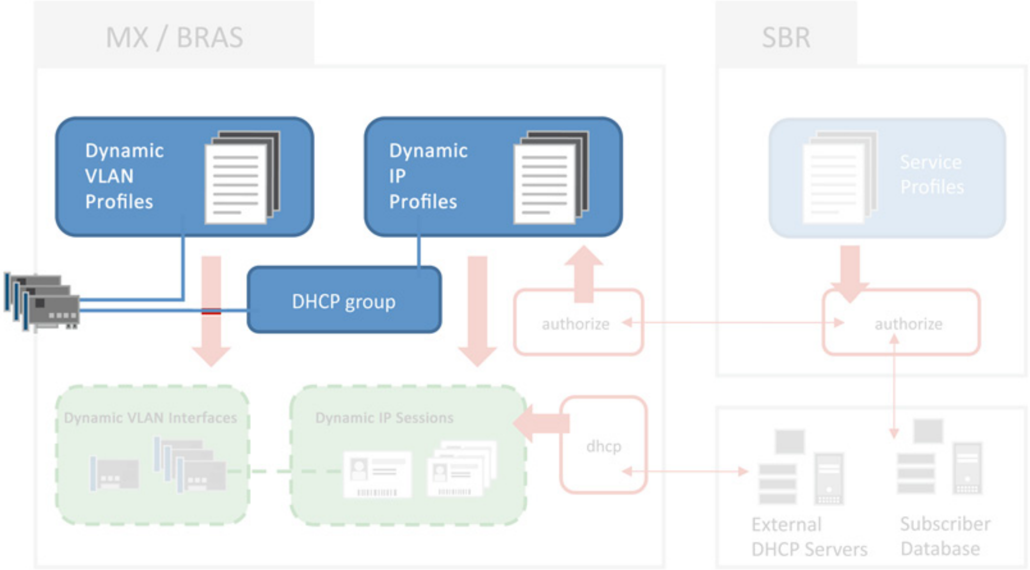


Figure 1.3 Interface Configuration Relationships

NOTE It is important to understand that you do not always need a dynamic IP profile. Simple use-case configurations do not require dynamic IP profiles as you will see in the upcoming chapter. The goal of this book is to get you started on the basics, and you can find many examples of more complex configuration on Juniper's technical publication website.

When an MX interface is configured for auto configuration, specific packets trigger the process and in the case of DHCP, it's the DHCP-DISCOVER packet. The physical interface is configured to use a dynamic VLAN profile and Junos uses the profile as a template to generate the same configuration you would otherwise have created statically. This dynamic configuration is not stored in the actual Junos configuration file, so you will not experience a *configure-and-commit* as you would if you were doing it manually.

When the MX is configured to use RADIUS, Junos attempts to authorize the subscriber with an external RADIUS server (for example, SBR). This process is highlighted in Figure 1.4. This step is performed prior to the DHCP address request, so Junos must first authorize the subscriber before it assigns an IP address via DHCP.

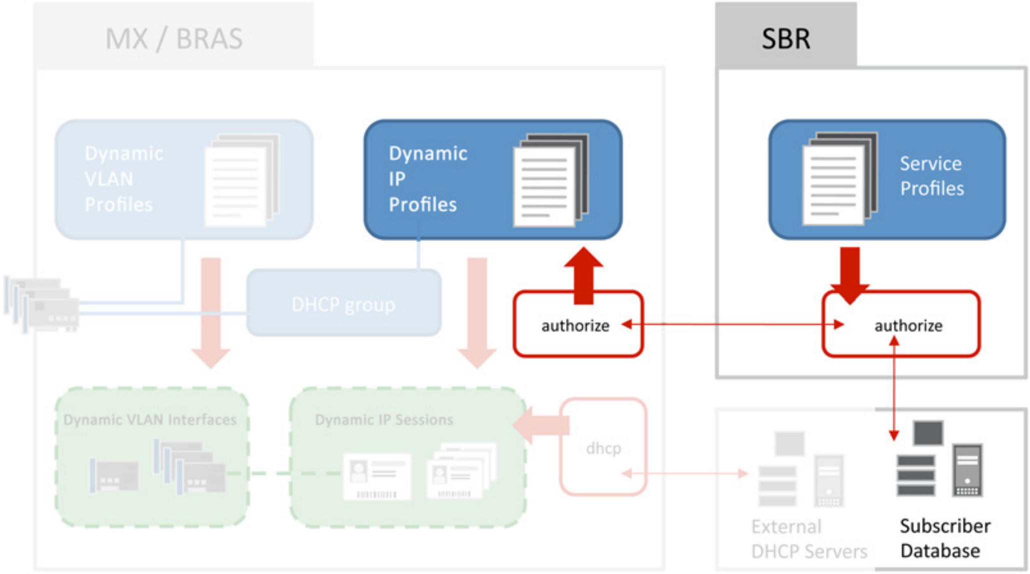


Figure 1.4 Authorizing Subscribers

When SBR receives the authorization request, it looks into a database to determine if: (a) the user is valid, and (b), which RADIUS attributes values should be returned to the MX. When authorizing the user, SBR can either examine a locally configured database or perform a database lookup on an external server; the latter scenario is the one illustrated in Figure 1.4. The subscriber database returns information about the subscriber, and one piece of the information is called the *SBR service profile*. The SBR service profile represents the service provider's service definition, for example, INET Best Effort 5Mbps, INET Best Effort 7Mbps, or Voice and Data 20Mbps, etc. The SBR service profile is simply a collection of RADIUS attribute values, and an example of the SBR service profile is discussed in a later section of this chapter.

Going back to our process, the SBR now returns the RADIUS attributes (VSAs) in the authorization acknowledge message back to the MX for further processing as shown in Figure 1.5.

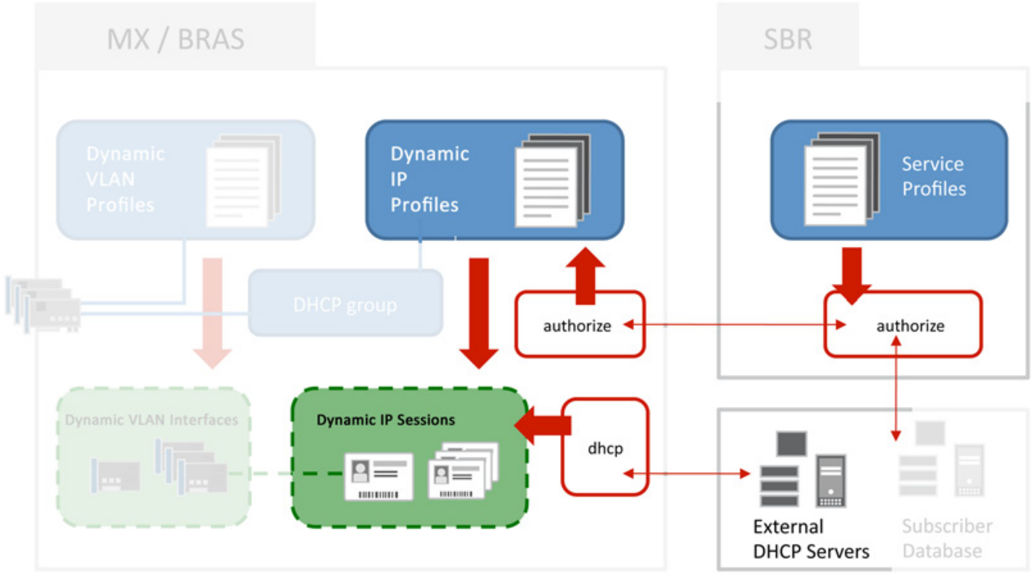


Figure 1.5 Instantiating Subscriber Sessions

When the MX receives the RADIUS access accept message, it then binds the RADIUS VSA values into the dynamic IP profile `$junos` variables, and creates a unique subscriber IP session. Junos then initiates the DHCP action since the subscriber is now an authorized user. Once the MX has completed the DHCP activity, the resulting subscriber IP address is associated with the subscriber session, and in turn, the dynamic VLAN interface.

The following MX output shows the end result for a DHCPv4 subscriber using their MAC-address as the user-name, and accessing the MX using the Customer VLAN stacked-tag model. The first entry is the dynamic VLAN interface for the subscriber, and the second entry is the dynamic IP interface for the subscriber. Notice how they share the same logical interface `ge-1/0/0.173741837`:

```
admin@SOUTHPARK> show subscribers
Interface           IP Address/VLAN ID         User Name           LS:RI
ge-1/0/0.1073741837  0x8100.100 0x8100.20                          default:default
ge-1/0/0.1073741837  12.1.1.12                  0000.6404.0102      default:default
```

Introduction to MX Configuration

Now, let's take a closer look at the MX configuration hierarchy in order to illustrate how the various hierarchy stanzas work together to create all the interworking illustrated in the subscriber process. Note that specific configuration examples will be presented in later chapters.

Figure 1.6 illustrates the relationships between the major Junos hierarchies necessary to configure the MX with dynamic VLAN interfaces, dynamic IP profiles, DHCP relay, and RAIDUS.

The arrows indicate *use*. For example, under the `[interfaces]` hierarchy, an interface configuration has an auto-configuration statement that *uses* or *refers to* a dynamic-profile name. The arrow starts (ball-end) with the auto-configure and ends (arrow-end) with the `<name-of-dynamic-VLAN-profile>` under the `[dynamic-profiles]` hierarchy.

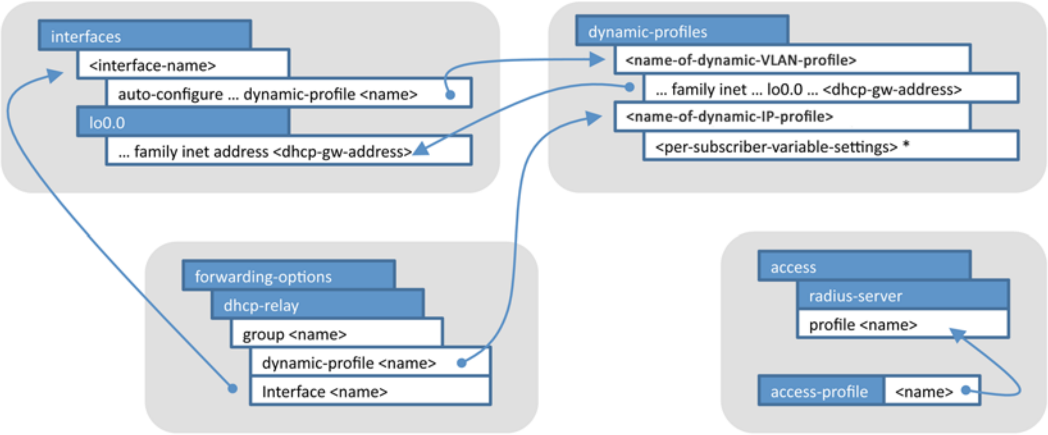

interfaces
<interface-name>
auto-configure ... dynamic-profile <name>
lo0.0
... family inet address <dhcp-gw-address>
dynamic-profiles
<name-of-dynamic-VLAN-profile>
... family inet ... lo0.0 ... <dhcp-gw-address>
<name-of-dynamic-IP-profile>
<per-subscriber-variable-settings> *
forwarding-options
dhcp-relay
group <name>
dynamic-profile <name>
Interface <name>
access
radius-server
profile <name>
access-profile
<name>

Figure 1.6 Relationships Between the Major Junos Hierarchies With Dynamic Subscriber Management

Interfaces

Starting with the `[interfaces]` hierarchy in Figure 1.6, each interface that uses a dynamic VLAN profile has an `[auto-configure]` stanza, and within the `[auto-configure]` stanza there is a reference to the associated dynamic-profile. This is a dynamic VLAN profile, and not a dynamic IP profile.

ALERT! You should notice that both dynamic VLAN profiles and dynamic IP profiles are located within the top-level `[dynamic-profiles]` hierarchy. They are both a form of dynamic configuration, but serve different functions. Be careful not to accidentally assign a dynamic IP profile to an interface `[auto-configure]` stanza.

Next, within the `[interfaces]` hierarchy, you need to configure an additional IP address on the loopback interface `lo0.0`, shown in Figure 1.6 as *dhcp-gw-address*. This address is used as the gateway for DHCP subscribers. You can have many secondary IP addresses assigned to `lo0.0`, and you can select which one you want to specifically use for a dynamic VLAN profile (an example of this configuration is shown in the next chapter).

ALERT! You may think that different loopback IP addresses should be assigned to a different lo0 unit number, for example, lo0.100, but this is not the case. The correct approach is to assign additional *secondary* IP addresses to the `lo0.0` interface. The configuration of multiple `lo0` units is used when you are creating multiple virtual routers or routing-instances (for example, for L2/L3 wholesale models) each having their own loopback interface. These types of configurations are outside the scope of this book, but you can find a number of references to these topics in the Appendices of this book.

Dynamic VLAN Profiles

Next, within the `[dynamic-profiles]` top-level hierarchy in Figure 1.6, you can see the dynamic VLAN profile being referenced by `[interfaces … auto-configure]`. Within the dynamic VLAN profile is a reference to use a specific `lo0.0` *preferred source address* – this is the default gateway address for DHCP subscribers, *dhcp-gw-address*.

DHCP Relay

The `[forwarding-options dhcp-relay]` stanza is used when you are using external DHCP servers. There is a similar stanza if you want to use the MX as the DHCP local-server, and an example of this is in the next chapter. You use a DHCP *group* in order to identify which set of interfaces use a specific dynamic IP profile.

ALERT! Be careful not to accidentally assign a dynamic VLAN profile to a DHCP group stanza. The DHCP group stanza must be configured with a dynamic IP profile. You cannot combine the two profiles or use the same one in both places.

MORE? Configuring multiple DHCP groups is used when you have multiple types of subscribers, or when you want to treat interfaces from different access networks differently. These configurations are also outside the scope of this book, and you can find a number of references to these topics, as well, in the Appendices of this book.

Dynamic IP Profiles

Going back to the `[dynamic-profiles]` top-level hierarchy in Figure 1.6, you can see the dynamic IP profile being referenced by the `[forwarding-options dhcp-relay group <name>]`. You define the per-subscriber variables within the dynamic IP profile, such as CoS and bandwidth controls, for example: `$junos-cos-shaping-rate`. These variable values are "downloaded" from the RADIUS server into the dynamic IP profile when the user authenticates with the network.

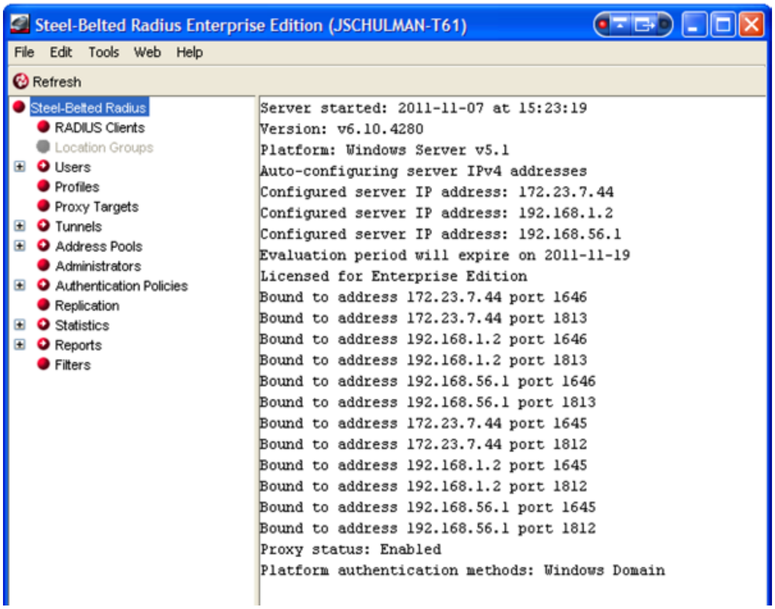
RADIUS

The `[access]` hierarchy is used for RADIUS configuration. Within this stanza you need your RADIUS servers and to define a `[profile]` that identifies specific RADIUS usage. Much like DHCP groups, the configuration of multiple access groups is found in virtual router and routing-instance configurations, and, for the purpose of our activities, there is only one.

Finally, you must configure which access profile is active by assigning the profile name to the top-level `[access-profile]` element.

Introduction to Steel-Belted RADIUS

Steel-Belted RADIUS (SBR) is configured through a graphical user interface client application as shown in Figure 1.7. The installation of SBR is covered in a later chapter, but for now let's just introduce the main topics you need to know for the rest of the activities in this book.



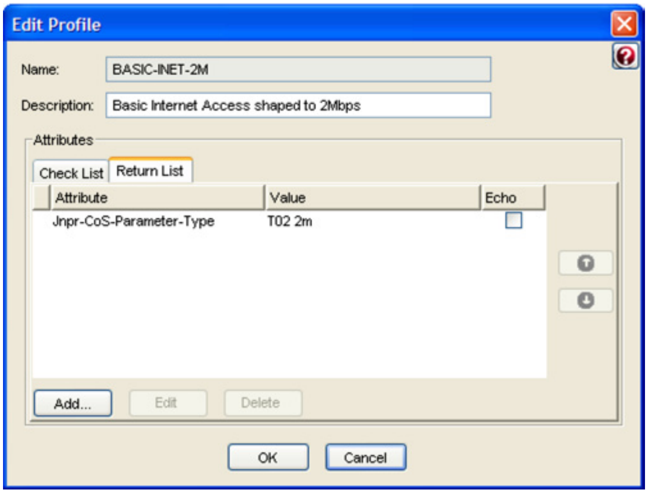
```
Server started: 2011-11-07 at 15:23:19
Version: v6.10.4280
Platform: Windows Server v5.1
Auto-configuring server IPv4 addresses
Configured server IP address: 172.23.7.44
Configured server IP address: 192.168.1.2
Configured server IP address: 192.168.56.1
Evaluation period will expire on 2011-11-19
Licensed for Enterprise Edition
Bound to address 172.23.7.44 port 1646
Bound to address 172.23.7.44 port 1813
Bound to address 192.168.1.2 port 1646
Bound to address 192.168.1.2 port 1813
Bound to address 192.168.56.1 port 1646
Bound to address 192.168.56.1 port 1813
Bound to address 172.23.7.44 port 1645
Bound to address 172.23.7.44 port 1812
Bound to address 192.168.1.2 port 1645
Bound to address 192.168.1.2 port 1812
Bound to address 192.168.56.1 port 1645
Bound to address 192.168.56.1 port 1812
Proxy status: Enabled
Platform authentication methods: Windows Domain
```

Figure 1.7 SBR Administration GUI

SBR Profiles

An SBR profile represents a collection of RADIUS attribute values that will be downloaded into an MX dynamic IP profile.

Consider the case where you have a dynamic IP profile that needs the VLAN shaping value set on a per-subscriber basis. The dynamic IP profile uses the `$junos-cos-shaping-rate variable.` An example of a SBR profile creating a 2Mbps shaping service would look like Figure 1.8.



Name: BASIC-INET-2M

Description: Basic Internet Access shaped to 2Mbps

Attribute	Value	Echo
Jnpr-CoS-Parameter-Type	T02 2m	□

Figure 1.8 2Mbps Shaping Service Profile Example

How do you know that the RADIUS attribute (VSA) *Jnpr-Cos-Parameter-Type* with a value of *T02 2m* will bind to the MX `$junos-cos-shaping-rate` variable and set the shaping-rate to 2Mbps? It's actually covered in detail in Chapter 5, so for now it's more important to understand the concept of the SBR service profile as a container for RADIUS attribute/values, and trust that the proof will come a little later.

Subscriber Username Authorization

When the SBR receives a RADIUS access-request from the MX, it attempts to authorize the subscriber and then maps the subscriber to a SBR profile, which in turn returns a set of RADIUS VSA if configured.

How do you know what the username value is? The user name is generated by the MX and can consist of a combination of many different fields, some from the packet and some from the MX device.

MORE? If you'd like to get a jump on understanding your options for creating a user name see http://www.juniper.net/techpubs/en_US/junos/topics/reference/configuration-statement/authentication-edit-forwarding-options.html.

There are two approaches for handling the user name mapping to service profile. The first is using your existing customer database, and the second is using the SBR native user database.

Using Your Existing Customer Database

If you have existing customers and maintain customer information in a database, for example MySQL, you may want SBR to query your database to determine the SBR service profile name.

You can configure the SBR to use a number of different external databases for the authentication and SBR profile mapping process. This book doesn't cover these steps, but it's important to know the options.

The most popular method used by service providers is an LDAP subscriber directory. SBR can access any LDAP V2, or V3, directory both to authenticate and authorize a subscriber request, as well as to retrieve the profile to return to the MX. SBR can also access any SQL database using JDBC (Java Database Connectivity), ODBC (Open Database Connectivity), or an Oracle-specific database using native Oracle drivers. Both SQL and LDAP support the process of looking up the subscriber user name and retrieving a profile value to be applied to the session.

Using SBR Native User Database

If you don't already have a customer database, or prefer to keep this mapping out of your database, you can create a *native customer database* on SBR.

This book actually uses the SBR native user database, so you will learn how to create these in a later chapter.

Other SBR Key Features

Customers typically ask about a number of other features offered by their RADIUS infrastructure, the most common one being accounting.

Accounting packets (start, stop, and interim) are generated by the MX and forwarded to the SBR server. Most environments use an accounting proxy to forward copies of these packets to various back-office systems such as billing, lawful intercept, and deep packet inspection systems. The accounting packets can also be used to track customer usage for usage-based billing or volume tracking. This book actually covers RADIUS accounting and shows you how to both configure the MX and view the records on the SBR.

Another key feature of SBR is *Change of Authorization* or CoA. This capability can modify the dynamic profile *while* the session is active. A good example used in many networks is a *self-service portal*. A subscriber can go to the self-service portal and select a new service rate for their connection, for example, going from a 5M service to a 10M service. A change to an existing established subscriber session is triggered from this self-service portal to send a RADIUS CoA message to the MX, specific to that subscriber, with the new shaping rate attribute. The MX overwrites the 5M shaper with the 10M shaper and acknowledges SBR. The subscriber won't see any issues on their connection since it's an *in session* change.

Redundancy in RADIUS is typically handled by an active/standby configuration. The MX has the capability of sending to the active RADIUS server until it detects that server is down, when at that point, it can use the secondary server. You can configure the MX to use many different RADIUS servers depending on your network requirements.

MORE? For more information on the SBR Carrier Edition, please see: http://www.juniper.net/us/en/products-services/software/ipc/sbr-series/service-provider/carrier/#features-benefits. For information on High Availability features, see the *Juniper Networks Steel-Belted Radius® Carrier Administration and Configuration Guide* at: http://www.juniper.net/techpubs/en_US/sbr-carrier7.3.1/information-products/pathway-pages/index.html.

Getting Started with the MX

Let's get started configuring the MX as a BRAS device. There are two steps to cover:

- Installing the correct licenses
- Enabling system logging for debug and troubleshooting purposes

Installing MX BRAS Licenses

There are two required licenses to support BRAS functionality:

- The first license enables the BRAS features such as the *Feature Pack*, for example. For the MX chassis family MX240/480/960, this license SKU is S-SA-FP. For the MX80/40/10/5 mid-range routers, you would use the S-MX80-SA-FP license.
- The second type of required license is for subscriber scaling, for example, how many subscriber sessions the MX supports. These licenses come in various increments and are additive. If you required 20K subscribers, for example, you could install an S-SA-16K license and an S-SA-4K license.

Use the `request system license add` command to install the licensees:

```
admin@MX> request system license add terminal
[Type ^D at a new line to end input,
 enter blank line between each license key]
                                       <… Cut & Paste your license here …>
^D
add license complete (no errors)
```

Once you have installed your licenses, you can display the license and usage information with `show system license` command:

```
admin@MX> show system license
License usage:
                                  Licenses     Licenses    Licenses    Expiry
  Feature name                        used    installed     needed
  subscriber-accounting                   0          1          0      permanent
  subscriber-authentication               0          1          0      permanent
  subscriber-address-assignment           0          1          0      permanent
  subscriber-vlan                          0          1         0     permanent
  subscriber-ip                           0          1          0      permanent
  scale-subscriber                        0        1000         0     permanent
  scale-l2tp                             0        1000          0    permanent
  scale-mobile-ip                         0       1000          0     permanent

Licenses installed:
  License identifier: E000185416
  License version: 2
  Features:
    subscriber-accounting - Per Subscriber Radius Accounting
      permanent
    subscriber-authentication - Per Subscriber Radius Authentication
      permanent
    subscriber-address-assignment - Radius/SRC Address Pool Assignment
      permanent
    subscriber-vlan  - Dynamic Auto-sensed Vlan
      permanent
    subscriber-ip   - Dynamic and Static IP
                            permanent
```

NOTE The MX is factory-equipped with a 30-day trial, subscriber-scale, 1K license. For lab or demo purposes, this may be sufficient, otherwise you will need to install additional scale licenses using the process discussed here.

Enabling Log Files (Traceoptions)

Now let's cover which traceoptions files you can use for troubleshooting purposes. Later sections in this book will cover in depth what to look for in these files, but for now let’s simply enable each of the traceoptions files.

ALERT! Keep in mind that logging consumes control processor (Route Engine) cycles and writes to system storage. Generally speaking, you only enable traceoptions when you are troubleshooting an issue and then disable them during normal production.

The following traceoptions are useful for troubleshooting BRAS deployments:

- Auto-creating VLAN interfaces
- Authentication services, for example for RADIUS
- Interface changes
- DHCP relay when using external DHCP servers
- DHCP local-server when the MX is providing DHCP services

Usually you configure either the DHCP relay, or the DHCP local-server, depending on your network requirements, but let’s show both traceoptions configurations.

As an *administration preference* the traceoptions configuration is put into a configuration group. By using a configuration group you can easily enable or disable logging. The following shows a group called *DEBUG-BRAS* (log-file names emphasized):

```
[edit groups DEBUG-BRAS]
admin@MX# show
system {
    auto-configuration {
        traceoptions {
            file autolog;
            flag all;
        }
    }
    services {
      dhcp-local-server {
         traceoptions {
            file dhcplog size 2m files 2;
            flag all;
         }
      }
   }
   processes {
      general-authentication-service {
         traceoptions {
            file authlog size 2m files 2;
            flag address-assignment;
            flag framework;
            flag local-authentication;
            flag radius;
            flag configuration;
         }
      }
   }
}
interfaces {
   traceoptions {
      file iflog size 2m files 2;
      flag change-events;
      flag config-states;
   }
}
forwarding-options {
   dhcp-relay {
      traceoptions {
         file dhcplog size 2m files 2;
         flag all;
      }
   }
}
```

This sample configures each of the traceoptions files to be a maximum size of 2MB and stores only two of these files on the MX. You can change these values to better suit your specific networking needs or lab work.

To enable or disable these traceoptions, you would add or remove this group at the top-level *apply-group* configurations:

```
[edit]
admin@MX# show apply-groups
apply-groups [ re0 re1 DEBUG-BRAS ];
```

How to use each of these traceoptions logs is covered in depth later in this book, but for now, you're set to start configuring the MX for BRAS services.

Summary

You should now have a solid understanding of how the Juniper Networks Dynamic Subscriber Management solution works from a top-down approach:

- How the MX uses dynamic VLAN and dynamic IP profiles for BRAS network applications.
- How the MX interacts with the SBR.
- How the MX configuration hierarchies work together.

You also should have installed SBR and the MX licenses in your network environment so you can follow along with the rest of the book.

The rest of the book starts simply, gradually adding more features and functionality as it progresses through each chapter. You should also learn some great troubleshooting skills to check and monitor your deployment along the way. Let's get started with the MX BRAS configuration in Chapter 2.

Chapter 2

Getting Started with the Customer VLAN Model

This chapter contains common examples that illustrate basic dynamic VLAN profiles, as well as how to configure the MX, either as a DHCP local-server or to use external DHCP servers . It utilizes the Customer VLAN model where each subscriber is uniquely encapsulated by stacked VLANs, that is, a packet with two VLAN tags.

Authentication and other per-subscriber IP variables are not used in this chapter. The focus, for now, is dynamic VLAN interfaces and assigning IP addresses to subscribers via DHCP. In later chapters SBR and per-subscriber IP variables will be covered in detail.

The first use-case contains the following attributes:

- Set the MX dynamic VLAN profile: Customer VLAN model, stacked VLANS.
- Configure the MX as a DHCP local-server.
- Note that the MX dynamic IP profiles are *not* used, and the SBR is *not used*.

And the second use-case shows you how to:

- Reconfigure MX to use external DHCP server.

You can see that only dynamic VLAN profiles, not dynamic IP profiles, are being used. A dynamic IP profile is not required since these examples are not assigning any IP specific parameters such as bandwidth, access-control-lists, or policers. Along the way you should learn various Junos CLI commands to support the turn-up activity as well as how to examine log files to aid in troubleshooting.

Configuration Cookbook: MX as DHCP Server

The example network for this use-case is illustrated in Figure 2.1. Here, the MX is configured with a DHCP local-server that offers addresses in the 12.1.1.0/24 subnet. The ge-1/0/0 interface uses IP address 12.1.1.1 as the gateway, and the subscriber’s CPE MAC address is used as the subscriber’s user-name.

Our checklist is comprised of the following steps:

- Configure the loopback interface with 12.1.1.1
- Configure DHCP local-server
- Configure ge-1/0/0 to create dynamic VLAN interfaces
- Configure the associated dynamic VLAN profile

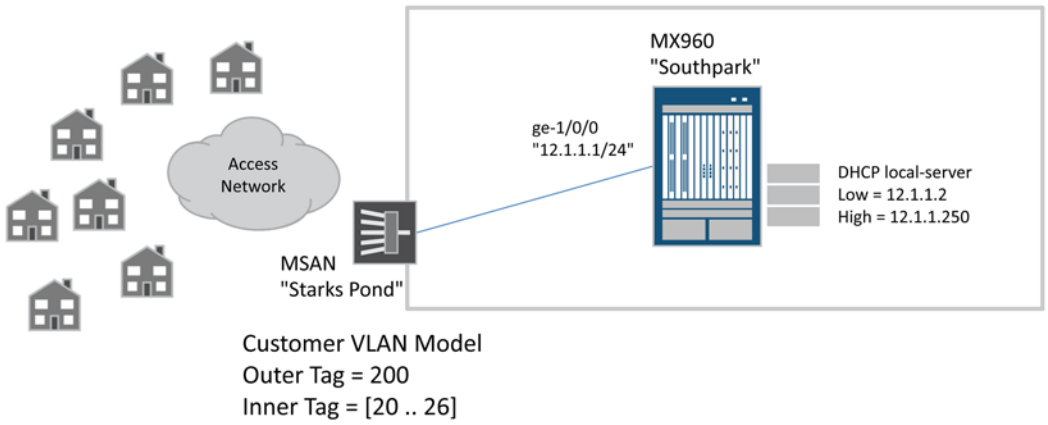


Figure 2.1 Use-Case 1: Configuration Cookbook Topology:

The map of the MX configuration hierarchies for this use-case is illustrated in Figure 2.2.

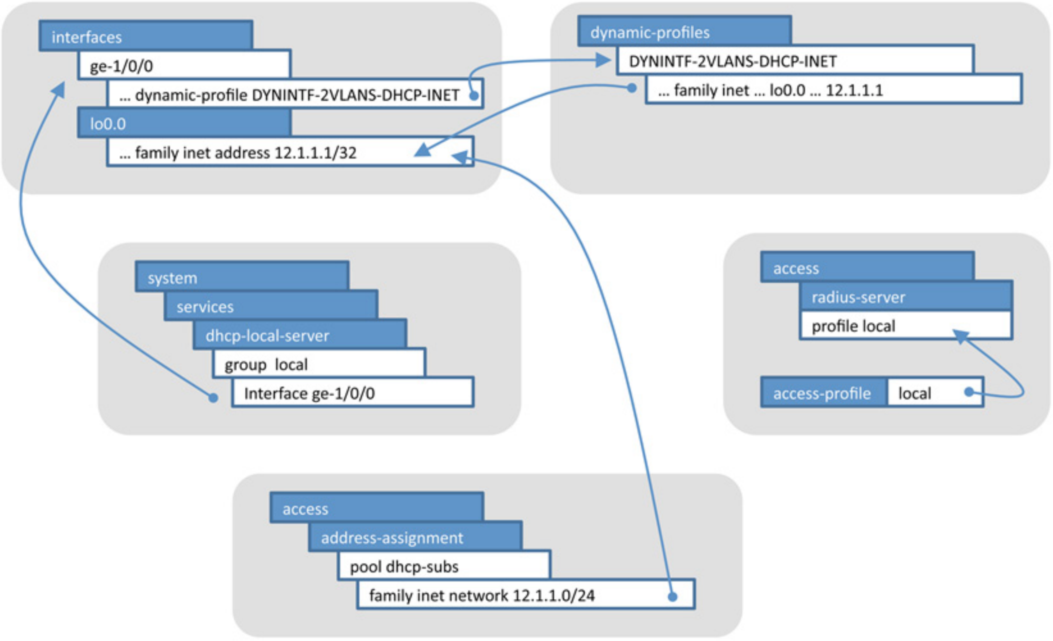


Figure 2.2 MX Configuration Hierarchy Map

Step 1: Configure the Loopback Interface

In DHCP use-cases a physical interface "borrows" an IP address from the loopback interface and this technique is referred to as *unnumbered interface addressing*. In the Junos OS you do this by configuring a secondary IP address on the loopback interface, lo0.0. The DHCP server also uses this IP address to identify the DHCP address pool by matching it to the pool network value. If your network requires multiple address pools on different subnets, you would configure additional secondary loopback addresses for each one.

```
[edit]
admin@SOUTHPARK# show interfaces lo0.0
family inet {
   address 66.127.93.17/32 {
      primary;
      preferred;
   }
   address 12.1.1.1/32;
}
```

Here, you can see that the router's primary loopback address is 66.127.93.17, as indicated by the `primary` and `preferred` keywords. The secondary address, 12.1.1.1, is added to the *borrowed* IP address for our DHCP subscribers.

MORE? For more information on unnumbered interfaces, see: http://www.juniper.net/techpubs/en_US/junos11.2/topics/usage-guidelines/interfaces-configuring-an-unnumbered-interface.html.

Step 2: Configure the DHCP Local-Server

The DHCP local address pool settings are stored in the `[access address-assignment]` hierarchy as shown here:

```
[edit access address-assignment]
admin@SOUTHPARK# show
pool dhcp-subs {
   family inet {
      network 12.1.1.0/24;
      range 1 {
         low 12.1.1.2;
         high 12.1.1.250;
      }
      dhcp-attributes {
         maximum-lease-time 3600;
         domain-name dayonebooks.juniper.net;
         router {
            12.1.1.1;
         }
      }
   }
}
```

The DHCP local-service controls are located in the `[system services]` hierarchy:

```
[edit system services dhcp-local-server]
admin@SOUTHPARK# show
pool-match-order {
   ip-address-first;
}
authentication {
   username-include {
      mac-address;
   }
}
group local {
   interface ge-1/0/0.0;
}
```

Here, you can see that the subscriber's MAC address is used to create the subscriber's user-name.

ALERT! Since the configuration is using the DHCP *authentication* hierarchy to use the MAC address as the user-name, you *must* configure authentication access controls. Since this configuration does not use RADIUS, you set the authentication order to *none* in the access profile:

```
[edit access]
admin@SOUTHPARK# show
profile local {
   authentication-order none;
}
[edit]
admin@SOUTHPARK# set access-profile local
```

Step 3: Interface Auto-Configuration

To use dynamic VLAN interfaces you must assign a dynamic VLAN profile to an interface. Here is the configuration that allows any set of stacked VLAN tags to trigger the creation of a dynamic VLAN interface using the dynamic VLAN profile called DYNINTF-2VLANS-DHCP-INET:

```
[edit interfaces ge-1/0/0]
admin@SOUTHPARK# show
description “>> Stark’s Pond <<”;
flexible-vlan-tagging;
auto-configure {
        stacked-vlan-ranges {
            dynamic-profile DYNINTF-2VLANS-DHCP-INET {
                accept any;
                ranges {
                    any,any;
                }
            }
        }
    }
```

Notice the use of the new [auto-configure] stanza. This instructs the Junos OS to dynamically create VLAN interfaces based on specific packets. The [stacked-vlan-ranges] hierarchy instructs Junos to look for packets with two VLAN tags. The dynamic VLAN profile *DYNINTF-2VLANS-DHCP-INET*, which is presented in the next section, is used as the configuration template for any packets that match the criteria under its hierarchy.

Within the [dynamic-profile] stanza, the *accept any* statement indicates that Junos will trigger the auto-configure action on all known packet types.

ALERT! The Junos OS does look for specific types of packets to trigger the dynamic VLAN creation process. Junos OS looks for DHCP-DISCOVER packets, for example, for DHCP v4. For more information on the types of packets that trigger dynamic VLAN interfaces, refer to: http://www.juniper.net/techpubs/en_US/junos/topics/reference/configuration-statement/accept-edit-interfaces.html.

If you wanted to explicitly limit packets to DHCP v4, for example, you could have set accept specifically to dhcp-v4.

Also under the [dynamic-profile] stanza, the [ranges] hierarchy is used to filter the specific outer and inner VLAN tags. The use of any, any indicates that any stacked VLAN tags are valid. You could configure the [ranges] stanza with more specific values for one of two reasons:

- To prevent unwanted VLANs from being accepted by the MX.
- To create multiple [dynamic-profile] hierarchies mapping different VLAN ranges into different dynamic VLAN profiles.

Step 4: Configure the Dynamic VLAN Profile

Finally, let's configure the dynamic VLAN profile that ge-1/0/0 is using, *DYNINTF-2VLANS-DHCP-INET*. The profile is defined under the new [dynamic-profiles] hierarchy:

```
[edit dynamic-profiles DYNINTF-2VLANS-DHCP-INET]
admin@SOUTHPARK# show
interfaces {
   “$junos-interface-ifd-name” {
      unit “$junos-interface-unit” {
         proxy-arp restricted;
         vlan-tags outer “$junos-stacked-vlan-id” inner “$junos-vlan-id”;
         family inet {
            unnumbered-address lo0.0 preferred-source-address 12.1.1.1;
         }
      }
   }
}
```

As discussed in Chapter 1, `$junos` variables act as placeholders in what would normally be a static configuration.

- `$junos-interface-ifd-name` is a placeholder for the interface name where the packet was received, for example ge-1/0/0.
- `$junos-interface-unit` is a placeholder for the unit number. The Junos OS dynamically allocates the unit number when the packet triggers the auto-configure action.
- `$junos-stacked-vlan-id` is a placeholder for the outer VLAN tag of the packet, for example tag-ID 100. The Junos OS reads the outer VLAN tag from the packet and substitutes the value in the dynamic VLAN profile.
- `$junos-vlan-id` is a placeholder for the inner VLAN tag of the packet, for example, tag-IDs 20-26. The Junos OS reads the inner VLAN tag from the packet and substitutes the value in the dynamic VLAN profile.

The use of `prox-arp restricted` is needed in some DHCP use-cases so the MX responds to ARP requests, but not to IP addresses that it distributes.

You can also see in the above dynamic VLAN profile how the interface will use/borrow the lo0.0 address 12.1.1.1.

MORE? A table containing a complete listing of all Junos variables can be found at: http://www.juniper.net/techpubs/en_US/junos/topics/reference/general/junos-predefined-variables-table.html .You can also review the *Subscriber Access Configuration Guide* at: http://www.juniper.net/techpubs/en_US/junos/information-products/topic-collections/config-guide-subscriber-access/config-guide-subscriber-access.pdf.

Step 5: Checkpoint - Validate the Configuration

Now let's review the commands you can use to validate the configuration. If you find that your dynamic VLAN interfaces are not being created, or DHCP is not working, jump ahead to the *Looking at Logs* section in this chapter for help.

The first command you can use is the `show subscribers` command, which displays dynamic VLAN interfaces as well as subscriber IP sessions. In our example network, there are seven (7) subscribers, and the output looks like this:

```
admin@SOUTHPARK> show subscribers
Interface         IP Address/VLAN ID          User Name           LS:RI
ge-1/0/0.1073741837 0x8100.100 0x8100.20                          default:default
ge-1/0/0.1073741838 0x8100.100 0x8100.21                          default:default
ge-1/0/0.1073741839 0x8100.100 0x8100.22                          default:default
ge-1/0/0.1073741840 0x8100.100 0x8100.23                          default:default
ge-1/0/0.1073741841 0x8100.100 0x8100.24                          default:default
ge-1/0/0.1073741842 0x8100.100 0x8100.25                          default:default
ge-1/0/0.1073741843 0x8100.100 0x8100.26                          default:default
ge-1/0/0.1073741837 12.1.1.12                 0000.6404.0102      default:default
ge-1/0/0.1073741838 12.1.1.13                 0000.6404.0103      default:default
ge-1/0/0.1073741839 12.1.1.14                 0000.6404.0104      default:default
ge-1/0/0.1073741840 12.1.1.15                 0000.6404.0105      default:default
ge-1/0/0.1073741841 12.1.1.16                 0000.6404.0106      default:default
ge-1/0/0.1073741842 12.1.1.17                 0000.6404.0107      default:default
ge-1/0/0.1073741843 12.1.1.18                 0000.6404.0108      default:default
```

The first seven line items are the dynamic VLAN interfaces the MX auto-created using the dynamic VLAN profile. You can see that these are stacked VLAN tagged interfaces, each with an outer VLAN tag of 100 and a different inner VLAN tag [20 … 26]. The last seven line items are the subscriber IP sessions. You can see that the user-name values are the DHCP client MAC-Addresses. The LS:RI field indicates the logical-system and routing-instance. These values would be something other than default if you were creating L2/L3 wholesale network configurations.

There are a number of *filtering* parameters to the `show subscribers` command that are very critical to use when you have thousands of subscribers on your MX. Use the help prompt:

```
admin@SOUTHPARK> show subscribers ?
Possible completions:
  <[Enter]>           Execute this command
  address             IPv4 or IPv6 address of subscriber
  client-type         Client type of subscriber
  count                 Display number of subscribers
  detail                Display detailed output
  extensive             Display extensive output
  interface             Interface name, or with wildcards (e.g. fe-0/0/*, fe-0/*/*)
  logical-system        Logical system where subscriber resides
  mac-address           MAC address of subscriber
  profile-name          Profile with which subscriber has been activated
  routing-instance      Routing instance where subscriber resides
  stacked-vlan-id       Stacked VLAN identifier of subscriber (0..4094)
  subscriber-state      State of subscriber
  summary               Display subscriber summary
  terse                 Display terse output
  vlan-id               VLAN identifier of subscriber (0..4094)
```

The following are a few useful examples of the `show subscriber` command.

1. Show a summary of the subscribers:

```
admin@SOUTHPARK> show subscribers summary

Subscribers by State
   Active: 14
   Total: 14

Subscribers by Client Type
   DHCP: 7
   VLAN: 7
   Total: 14
```

2. Show a subscriber by their MAC-address:

```
admin@SOUTHPARK> show subscribers mac-address 0000.6404.0108
Interface          IP Address/VLAN ID       User Name               LS:RI
ge-1/0/0.1073741843 12.1.1.18              0000.6404.0108         default:default
```

3. Show a subscriber by their IP address:

```
admin@SOUTHPARK> show subscribers address 12.1.1.17
Interface          IP Address/VLAN ID      User Name               LS:RI
ge-1/0/0.1073741842 12.1.1.17             0000.6404.0107         default:default
```

4. Show only DHCP subscribers on a specific interface:

```
admin@SOUTHPARK> show subscribers client-type dhcp interface ge-1/0/0.*
Interface          IP Address/VLAN ID       User Name               LS:RI
ge-1/0/0.1073741837 12.1.1.12              0000.6404.0102         default:default
ge-1/0/0.1073741838 12.1.1.13              0000.6404.0103         default:default
ge-1/0/0.1073741839 12.1.1.14              0000.6404.0104         default:default
```

```
ge-1/0/0.1073741840 12.1.1.15            0000.6404.0105         default:default
ge-1/0/0.1073741841 12.1.1.16            0000.6404.0106         default:default
ge-1/0/0.1073741842 12.1.1.17            0000.6404.0107         default:default
ge-1/0/0.1073741843 12.1.1.18            0000.6404.0108
```

The next command you can use to validate services is the `show network-access aaa subscribers` command:

```
admin@SOUTHPARK> show network-access aaa subscribers
Username          Logical system/Routing instance  Client type   Session-ID
0000.6404.0102    default:default                  dhcp          0
0000.6404.0103    default:default                  dhcp          0
0000.6404.0104    default:default                  dhcp          0
0000.6404.0105    default:default                  dhcp          0
0000.6404.0106    default:default                  dhcp          0
0000.6404.0107    default:default                  dhcp          0
0000.6404.0108    default:default                  dhcp          0
```

While this command has information similar to `show subscribers` it does not have as much filtering support. However, it does show you valuable information when you expand on a specific user:

```
admin@SOUTHPARK> show network-access aaa subscribers username 0000.6404.0108
Logical system/Routing instance   Client type   Session uptime    Accounting
default:default                  dhcp          00:19:10          off
```

Here, you can see the session uptime value, for example, how long the user has been logged into the system, as well as whether or not RADIUS accounting is enabled.

A similar, but different, command is `show dhcp server binding`, which can only be used when the MX is the DHCP local-server:

```
admin@SOUTHPARK> show dhcp server binding

IP address    Session Id  Hardware address   Expires    State   Interface
12.1.1.19     76         00:00:64:04:01:02  3527       BOUND   ge-1/0/0.1073741844
12.1.1.20     77         00:00:64:04:01:03  3527       BOUND   ge-1/0/0.1073741845
12.1.1.21     78         00:00:64:04:01:04  3527       BOUND   ge-1/0/0.1073741846
12.1.1.22     79         00:00:64:04:01:05  3527       BOUND   ge-1/0/0.1073741847
12.1.1.23     80         00:00:64:04:01:06  3527       BOUND   ge-1/0/0.1073741848
12.1.1.24     81         00:00:64:04:01:07  3527       BOUND   ge-1/0/0.1073741849
12.1.1.25     82         00:00:64:04:01:08  3527       BOUND   ge-1/0/0.1073741850
```

Finally, if you want to remove entries from the subscriber table, you can use the `clear auto-configuration` command:

```
admin@SOUTHPARK> clear auto-configuration interfaces ge-1/0/0
```

```
7 interfaces removed from device ge-1/0/0

admin@SOUTHPARK> show subscribers
Total subscribers: 0, Active Subscribers: 0
```

ALERT! If you attempt to clear a dynamic VLAN interface which still has a DHCP binding, the interface will not be removed. You must first clear the DHCP binding using the `clear dhcp server binding` command.

Another way to validate services is to examine the routing table. Junos adds subscriber sessions as `access-internal` routes:

```
admin@SOUTHPARK> show route protocol access-internal

inet.0: 17 destinations, 17 routes (17 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

12.1.1.3/32        *[Access-internal/12] 00:10:35
                > to #0 0.0.64.4.1.2 via ge-1/0/0.1073741851
12.1.1.4/32        *[Access-internal/12] 00:10:35
                > to #0 0.0.64.4.1.3 via ge-1/0/0.1073741852
12.1.1.5/32        *[Access-internal/12] 00:10:35
                > to #0 0.0.64.4.1.4 via ge-1/0/0.1073741853
12.1.1.6/32        *[Access-internal/12] 00:10:35
                > to #0 0.0.64.4.1.5 via ge-1/0/0.1073741854
12.1.1.7/32        *[Access-internal/12] 00:10:35
                > to #0 0.0.64.4.1.6 via ge-1/0/0.1073741855
12.1.1.8/32        *[Access-internal/12] 00:10:35
                > to #0 0.0.64.4.1.7 via ge-1/0/0.1073741856
12.1.1.9/32        *[Access-internal/12] 00:10:35
                > to #0 0.0.64.4.1.8 via ge-1/0/0.1073741857
```

This output is particularly interesting because you have three pieces of important information together: the subscriber IP address, the subscriber MAC address, and the underlying interface. The MAC address is the “to” value.

For example `12.1.1.9` is going to `0.0.64.4.1.8,` which is MAC address `0000.6404.0108`:

```
admin@SOUTHPARK> show subscribers address 12.1.1.9
Interface         IP Address/VLAN ID           User Name            LS:RI
ge-1/0/0.1073741857 12.1.1.9                   0000.6404.0108       default:default
```

Configuration Cookbook: MX using External DHCP Server

The next use-case changes the configuration from using a DHCP local-server to using an external DHCP server. The new network diagram for this use-case is illustrated in Figure 2.3.

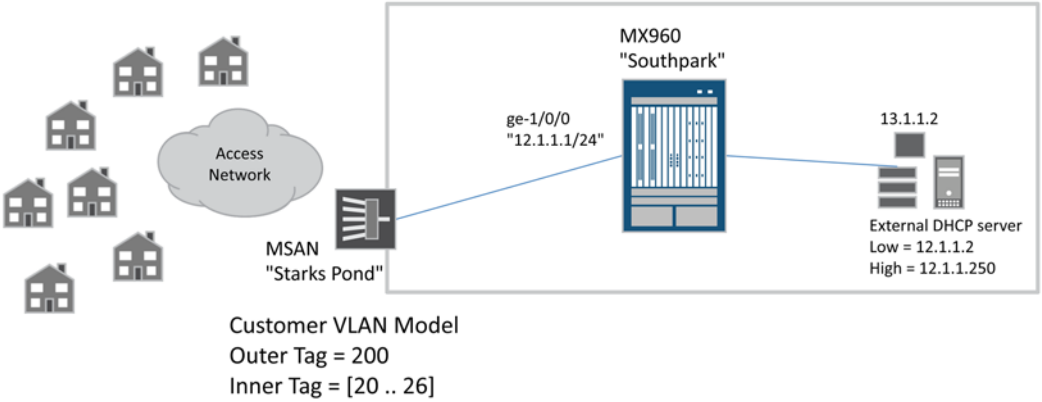


Figure 2.3 Network Using External DHCP Server

Our checklist is comprised of the following steps:

- Remove DHCP local-server configuration
- Configure the DHCP relay

The map of the MX configuration hierarchies for this use-case is illustrated in Figure 2.4.

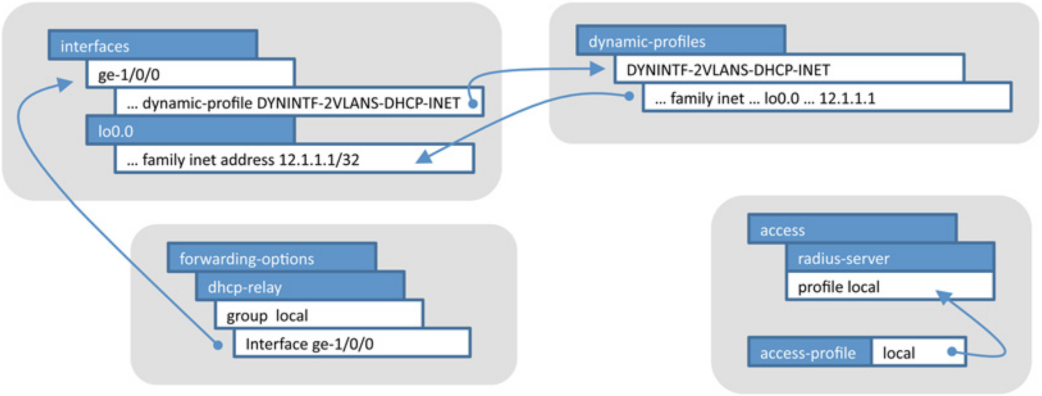


Figure 2.4 MX Configuration Hierarchy for Use-Case 2

Step 1: Change DHCP

First remove the DHCP local-server configuration:

```
admin@SOUTHPARK# delete access address-assignment
admin@SOUTHPARK# delete system services dhcp-local-server
```

Now add the DHCP relay configuration under the `[forwarding-options dhcp-relay]` hierarchy:

```
[edit forwarding-options dhcp-relay]
admin@SOUTHPARK# show
server-group {
   dayoneDHCP {
      13.1.1.2;
   }
}
group local {
   active-server-group dayoneDHCP;
   authentication {
      username-include {
         mac-address;
      }
   }
   interface ge-1/0/0.0;
}
```

That's it!

NOTE It is possible to have multiple DHCP servers defined in a specific server-group. You can also define multiple DHCP relay groups as associates, each one with a server-group. In a "Multiplay Network" you might configure one set of DHCP servers to support IPTV/set-top-boxes, and another set of DHCP servers to support different types of devices.

MORE? For more information on different DHCP relay scenarios and configuration examples, see: http://www.juniper.net/techpubs/en_US/junos/information-products/pathway-pages/subscriber-access/dhcp/subscriber-management-dhcp-relay.html#configuration . A particularly interesting topic is using the DHCP-Option60 (for example, device type) value to select the DHCP server-group. This technique is specifically used for the Multiplay example mentioned in the prior paragraph.

Step 2: Checkpoint - Validate the Configuration

Once you've committed the changes to support DHCP relay, you can revalidate your network results using the same commands as used in the previous Checkpoint in Use-Case 1.

When you run through the commands, you should notice that the only difference is that the `show dhcp server binding` command no longer has any entries, since the MX is no longer a DHCP local server. Instead you would use `show dhcp relay binding` and `clear dhcp relay` binding.

The `show network-access aaa subscribers` command will always show you your DHCP subscriber sessions.

Looking at the Logs

Now let's walk though a few common troubleshooting activities using the traceoptions log files you enabled in Chapter 1. Just make sure that you have these enabled before you start testing!

Generally speaking, you can look for errors or failures in log files using the `show log` command:

```
admin@SOUTHPARK> show log dhcplog | match “(error|failure|bad|missing|unconfigured)”

Oct 28 12:54:49 BOOTPREQUEST arrived on unconfigured interface ge-1/0/0.1073741858,
flags 3
Oct 28 12:55:19 BOOTPREQUEST arrived on unconfigured interface ge-1/0/0.1073741858,
flags 3
```

Since this chapter is focused on dynamic VLAN interfaces and DHCP services, the focus here is on their related log files.

Checking the Auto-Configuration Log

In Chapter 1 you should have configured the log file *autolog* to capture traceoptions from the auto-configuration process. This is generally the first place to start looking when you *do not* see a dynamic VLAN interface being created.

When the MX detects a packet for auto-configure, you will see a log entry similar to this:

```
Oct 28 11:06:41 L2 Input: svlan packet, index 70, svtpid 0x8100, vtpid 0x8100
Oct 28 11:06:41 autoconfd_vlan_create: vtype 2, ge-1/0/0, DYNINTF-2VLANS-DHCP-INET,
(100/20)
```

The log entry indicates that a dual-stacked packet was received on ge-1/0/0 with an outer tag of 100 and an inner tag of 20. You can also see the EtherType values (0x8100) on both of the tags. The MX has determined that the dynamic VLAN profile for this packet is DYNINTF-2VLANS-DHCP-INET.

ALERT! Recall that the DHCP-DISCOVER packet triggers the auto-configuration action. If you do not see the above log entry, check the DHCP log file, and jump to the next section.

A common mistake is configuring an interface with a dynamic VLAN profile that does not exist, often due to misspelling the profile name. If this profile doesn't exist, you will see the following in the logfile:

```
Oct 28 11:06:41 sdb_ack_callback: session 56, result 0
Oct 28 11:06:41 profile_request_add: profile request failed: error 205, session 56
```

Here you can see that the profile add failed. Double-check your configuration to make sure the profile exists in [dynamic-profiles] and that there wasn't a spelling mistake.

When the dynamic VLAN interface is successfully created you should see something similar to the following:

```
Oct 28 11:19:44 sdb_ack_callback: session 58, result 0
Oct 28 11:19:44 profile_request_add: profile request sent, session 58
Oct 28 11:19:44 sdb_ack_callback: session 58, request add, error 0
Oct 28 11:19:44 Received async msg for ifl ge-1/0/0.1073741857
Oct 28 11:19:44 Received add async msg for ifl ge-1/0/0.1073741857
Oct 28 11:19:44 attach ifl ge-1/0/0.1073741857, index 74 to session 58
Oct 28 11:19:44 autoconfd_add_ifl: ifl ge-1/0/0.1073741857 added, index 0x4a, gen num 
172 iflm session 58, ifl session 58
```

NOTE Use the following command to quickly find success or fail information:

```
admin@SOUTHPARK> show autolog | match profile_request_add
```

Checking the DHCP Log

In Chapter 1 you configured the log file *dhcplog* to capture traceoptions from the DHCP local-server or relay process. This is generally the first place to start looking when you *do not* see an IP address assigned via DHCP.

The log file will display the DHCP packet information, so you will know if or when the MX processes a DHCP-DISCOVER packet:

```
Oct 28 12:19:42 LOCAL : recv sa 255.255.255.255 da 255.255.255.255, src_port 68, dst_
port 67 if name ge-1/0/0.1073741858 len 244
Oct 28 12:19:42 --[ OPTION code  53, len   1, data DHCP-DISCOVER ]--
Oct 28 12:19:42 --[ OPTION code 255, len   0 ]–
```

This log file entry indicates that a DHCP-DISCOVER packet was received on ge-1/0/0 and you can tell that it's on a dynamic VLAN interface because of the unit number value.

ALERT! Remember that it is only the DHCP-DISCOVER packet that triggers the auto-configuration for DHCPv4 packets. If you happen to be testing your configuration and your DHCP client does not issue the DHCP-DISCOVER, you will see the other type of packet in the log file, but it will not trigger the auto-configure action. This scenario is very common if you are using a Windows computer as your DHCP client – in repetitive tests Windows may not send the DHCP-DISCOVER message, but will instead send the DHCP-OFFER/RENEW message.

Another common mistake is forgetting to add the interface to a DHCP group. If the interface is not configured in a DHCP group, you will see a log entry similar to:

```
Oct 28 12:19:42 BOOTPREQUEST arrived on unconfigured interface ge-1/0/0.1073741858,
flags 3
```

To double-check that your interface is in a DHCP group, you can do the following:

```
admin@SOUTHPARK> show configuration forwarding-options dhcp-relay | display set |
match ge-1/0/0
```

If you don't see anything, it means that the interface is not configured in a group.

ALERT! Recall that the DHCP packet is what will trigger the dynamic VLAN interface; so if you forget to include the interface in a DHCP group the auto-configuration will never get triggered.

The next common mistake is forgetting to assign a DHCP *active-server-group* within the DHCP group. The active-server-group identifies the specific external DHCP server(s) the MX should use. If you were experiencing this mis-configuration, you would see a log entry similar to:

```
Oct 28 12:30:17 No Server Group configured
Oct 28 12:30:17 No Server Group to use
```

Yet another common mistake is forgetting to configure an `[access profile]` when you are using the `[authentication]` stanza in your DHCP group. The examples in this chapter use this hierarchy so that the MAC address will be used as the subscriber's user-name. You can tell that authentication is in use because you will see a log entry similar to:

```
Oct 28 12:34:45 Client 00-00-64-01-01-02 got event CLIENT_EVENT_DISCOVER_PDU in state
RELAY_STATE_INIT
Oct 28 12:34:45 AUTHENTICATION configured when received Discover pkt in state RELAY_
STATE_INIT
```

If you forget to properly configure an `[access profile]`, you will see a log entry similar to:

```
Oct 28 12:34:45 auth request reply failed err: 5 RELAY_STATE_WAIT_AUTH_REQ
Oct 28 12:34:45 dropping packet
```

Summary

This chapter covered the basics for setting up a simple Dynamic Subscriber Management solution. And it's *up and running*!

You should have learned these fundamentals:

- Understanding the Customer VLAN model.
- Creating and using a basic dynamic VLAN profile.
- Using the MX as a DHCP local-server.
- Configuring the MX to use an external DHCP server.

And along the way you should have become familiar with key trouble-shooting skills using Junos commands and traceoptions log files. Do you recognize these Junos commands?

```
> show subscribers
> clear auto-configure interface

> show network-access aaa subscriber
> clear network-access aaa subscriber username
> show route protocol access-internal

> show dhcp server binding
> clear dhcp server binding

> show dhcp relay binding
> clear dhcp relay binding
```

The next chapter builds on these core concepts as it investigates the Service VLAN model. The Service VLAN model requires the use of basic dynamic IP profiles and the special Junos `demux0` interface. So save your current configuration now, and roll up your sleeves for more topics and techniques.

Chapter 3

Getting Started with the Service VLAN Model

Now that you have the basics of dynamic VLAN interfaces under your belt, it's time to learn a few new techniques. This chapter investigates the Service VLAN model, a model where many subscribers are using (sharing) the same VLAN.

Legacy MSAN devices typically have an "Internet VLAN," a "Voice VLAN," a "Video VLAN," etc., and the BRAS is responsible for anchoring the subscriber session by their assigned IP address. Compare this to what you just learned using the Customer VLAN model in Chapter 2, where subscriber sessions are anchored to their dynamic stacked VLAN tagged interfaces.

With the Service VLAN model, the subscribers share the same MX dynamic VLAN interface, and the subscriber sessions are anchored on a Junos *IP-demux* interface. If you are not familiar with the IP-demux interface don't worry, in this chapter you'll learn everything you need to know to make it work.

This chapter also introduces you to basic dynamic IP profiles (finally!). When using dynamic VLAN interfaces that use the IP-demux interfaces, you must also use dynamic IP profiles. You'll see why as you get into the specific configurations.

In order to stay focused on learning about dynamic IP profiles and IP-demux, this chapter does *not* use SBR or any fancy per-subscriber IP service variables. These are covered in subsequent chapters.

There is only one use-case scenario in this chapter and it requires these attributes:

- MX dynamic VLAN profile: Service VLAN model, single tag
- MX dynamic IP profile: for using IP-demux interface
- MX using DHCP relay to external DHCP servers
- SBR is *not-used*

NOTE This chapter uses the DHCP relay configuration from Chapter 2 as a starting point. If you skipped Chapter 2, be sure to read through that chapter and configure the MX to support DHCP relay services, as these crucial first steps are not be covered or repeated in this chapter.

Configuration Cookbook

The example network scenario:

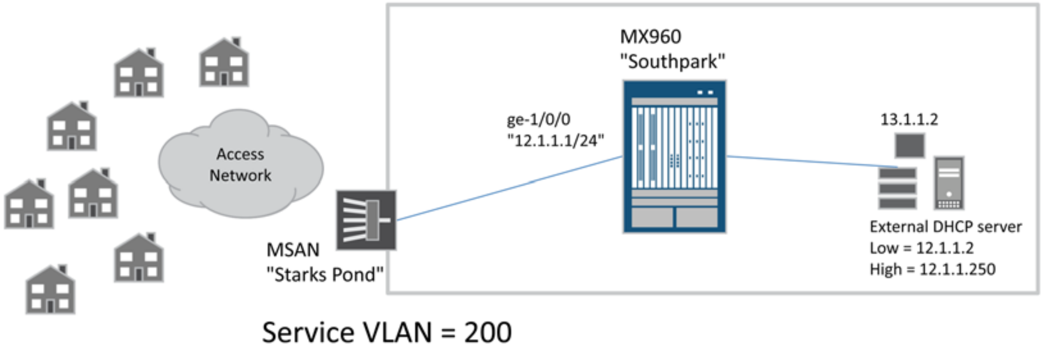


Figure 3.1 Chapter 3 Use-Case Configuration Cookbook Topology

Our checklist is comprised of the following steps:

- Reconfigure ge-1/0/0 to create dynamic VLAN interfaces for a Service VLAN model.
- Configure the associated dynamic VLAN profile.
- Update the DHCP relay group to use a dynamic IP profile.
- Configure the dynamic IP profile to use the IP-demux interface.

And the map of the MX configuration hierarchies for this use-case is illustrated in Figure 3.2.

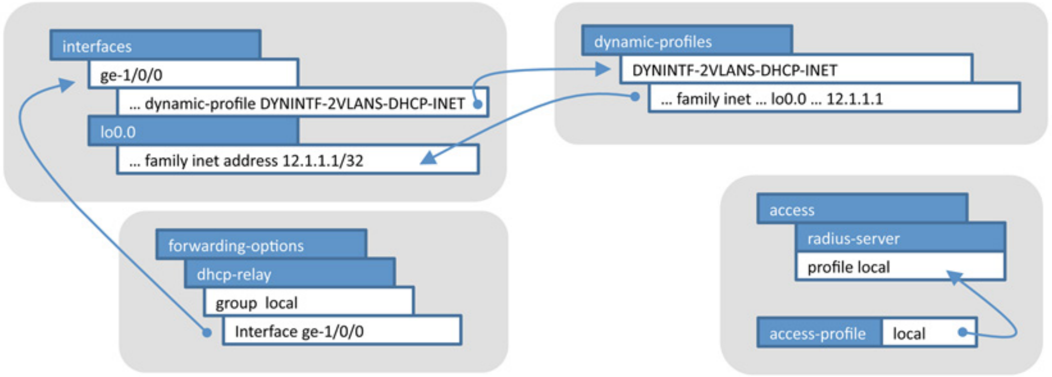


Figure 3.2 Chapter 3 Use-Case MX Configuration Hierarchy Map

Step 1: Interface Auto-Configuration

First, let's reconfigure ge-1/0/0 to dynamically create VLAN interfaces for single VLAN tagged packets:

```
[edit interfaces ge-1/0/0]
admin@SOUTHPARK# show
description ">> Stark's Pond <<";
flexible-vlan-tagging;
auto-configure {
   vlan-ranges {
      dynamic-profile DYNINTF-SVLAN-DHCP-INET {
         accept any;
         ranges {
            any;
         }
      }
   }
}
```

The key difference between this configuration and the configuration in Chapter 2 is replacing the `stacked-vlan-ranges` stanza, with the `vlan-ranges` stanza, or packets with a single VLAN tag.

Step 2: Dynamic VLAN profile

Next, configure the dynamic VLAN profile DYNINTF-SVLAN-DHCP-INET that ge-1/0/0 is using:

```
[edit dynamic-profiles DYNINTF-SVLAN-DHCP-INET]
admin@SOUTHPARK# show
interfaces {
   "$junos-interface-ifd-name" {
      unit "$junos-interface-unit" {
         demux-source inet;
         proxy-arp restricted;
         vlan-id "$junos-vlan-id";
         family inet {
            unnumbered-address lo0.0 preferred-source-address 12.1.1.1;
         }
      }
   }
}
```

The key difference between this configuration and the one in Chapter 2, of course, is the inclusion of the *demux-source inet* statement. This instructs Junos to use the IPv4 address of the packet to create a unique subscriber session anchor. You should also notice that under the unit hierarchy the configuration has changed from using two VLANs to a single tag via the *vlan-id* statement.

Step 3: Dynamic IP Profile

A dynamic IP profile is needed for IP demux. Junos provides the `demux0` interface for this purpose. As you can see from the configuration below, each subscriber is uniquely anchored as a unit of demux0. If you can recall, the Junos OS dynamically allocates the `$junos-interface-unit` during the dynamic VLAN interface creation. Therefore each subscriber requires a unique interfaces piece of configuration above and beyond the dynamic VLAN interface. And that is why a dynamic IP profile is required when using IP-demux interfaces:

```
[edit dynamic-profiles]
admin@SOUTHPARK# show
DYNSUB-SVLAN-IPDEMUX {
   interfaces {
      demux0 {
         unit “$junos-interface-unit” {
            demux-options {
               underlying-interface “$junos-underlying-interface”;
            }
            family inet {
               demux-source {
                  $junos-subscriber-ip-address;
               }
            }
         }
      }
   }
}
```

You’ve seen most of these `$junos` variables in Chapter 2, and the only new one is `$junos-subscriber-ip-address`. This variable is a placeholder for the IP address provided by DHCP when using the `demux0` interface.

Step 4: Bind Dynamic IP Profile via DHCP Group

The way you bind a dynamic IP profile to an interface is through the DHCP group. Here is the complete configuration DHCP-relay hierarchy:

```
[edit forwarding-options dhcp-relay]
admin@SOUTHPARK# show
server-group {
   dayoneDHCP {
      13.1.1.2;
   }
}
group local {
   active-server-group dayoneDHCP;
   authentication {
      username-include {
         mac-address;
      }
   }
   dynamic-profile DYNSUB-SVLAN-IPDEMUX;
   interface ge-1/0/0.0;
}
```

The only difference between this and Chapter 2 is the inclusion of the `dynamic-profile` statement, which instructs Junos to use the *DYNSUB-SVLAN-IPDEMUX* dynamic profile when creating DHCP subscribers.

ALERT! Be careful when you set the dynamic-profile statement that you assign the dynamic IP profile name, and not the dynamic VLAN profile name. This is a common mistake.

Step 5: Checkpoint - Validate the Configuration

All the commands you learned in Chapter 2 to validate the configuration apply to IP-demux based subscribers too, so let's highlight just a few differences.

In our example network, there are seven (7) subscribers, and the output looks like:

```
admin@SOUTHPARK> show subscribers
Interface         IP Address/VLAN ID    User Name               LS:RI
ge-1/0/0.1073741824  200                                       default:default
demux0.1073741834   12.1.1.32           0000.6405.0102          default:default
demux0.1073741835   12.1.1.33           0000.6405.0103          default:default
demux0.1073741836   12.1.1.34           0000.6405.0104          default:default
demux0.1073741837   12.1.1.35           0000.6405.0105          default:default
demux0.1073741838   12.1.1.36           0000.6405.0106          default:default
demux0.1073741839   12.1.1.37           0000.6405.0107          default:default
demux0.1073741840   12.1.1.38           0000.6405.0108          default:default
```

Notice how there is only one dynamic VLAN interface for VLAN 200 that is shared by all of the subscriber demux0 interfaces.

ALERT! If you are not seeing demux0 interfaces, but rather just more ge-1/0/0 dynamic VLAN interfaces, it means that you forgot to include the `demux-source inet` statement in your dynamic VLAN profile configuration, or did not add the `dynamic-profile` statement to your DHCP group configuration. The resulting `show subscribers` in this case would look like this:

```
admin@SOUTHPARK> show subscribers
Interface         IP Address/VLAN ID   User Name                LS:RI
ge-1/0/0.1073741859  200                                        default:default
ge-1/0/0.1073741859 12.1.1.32           0000.6405.0102          default:default
ge-1/0/0.1073741859 12.1.1.33           0000.6405.0103          default:default
ge-1/0/0.1073741859 12.1.1.34           0000.6405.0104          default:default
ge-1/0/0.1073741859 12.1.1.35           0000.6405.0105          default:default
ge-1/0/0.1073741859 12.1.1.36           0000.6405.0106          default:default
ge-1/0/0.1073741859 12.1.1.37           0000.6405.0107          default:default
ge-1/0/0.1073741859 12.1.1.38           0000.6405.0108          default:default
```

ALERT! Notice how all of the subscribers are now sharing the same interface: ge-1/0/0.1073741859. This means that there is no per-subscriber anchor, and you will run into trouble.

You can obtain interface information, for example, if you wanted to examine the packet statistics for a dynamic IP interface session:

```
admin@SOUTHPARK> show interfaces demux0.1073741840 extensive
  Logical interface demux0.1073741840 (Index 81) (SNMP ifIndex 577) (Generation 155)
   Flags: SNMP-Traps 0x0 Encapsulation: ENET2
   Demux:
     Underlying interface: ge-1/0/0.1073741824 (Index 74)
     Family Inet Source prefixes, total 1
        Prefix: 12.1.1.38/32
   Traffic statistics:
    Input  bytes  :              700
    Output bytes  :              650
    Input  packets:                3
    Output packets:                3
   Local statistics:
    Input  bytes  :              700
    Output bytes  :              650
    Input  packets:                3
    Output packets:                3
   Transit statistics:
    Input  bytes  :                0                0 bps
    Output bytes  :                0                0 bps
    Input  packets:                0                0 pps
    Output packets:                0                0 pps
   Protocol inet, MTU: 1986, Generation: 170, Route table: 0
     Flags: Sendbcast-pkt-to-re, Unnumbered
     Donor interface: lo0.0 (Index 64)
     Preferred source address: 12.1.1.1
```

Since this configuration is using DHCP relay, you can use the `show dhcp relay binding` command:

```
admin@SOUTHPARK> show dhcp relay binding

IP address    Session Id  Hardware address  Expires   State   Interface
12.1.1.32     18         00:00:64:05:01:02  3008      BOUND   ge-1/0/0.1073741824
12.1.1.33     19         00:00:64:05:01:03  3008      BOUND   ge-1/0/0.1073741824
12.1.1.34     20         00:00:64:05:01:04  3008      BOUND   ge-1/0/0.1073741824
12.1.1.35     21         00:00:64:05:01:05  3008      BOUND   ge-1/0/0.1073741824
12.1.1.36     22         00:00:64:05:01:06  3008      BOUND   ge-1/0/0.1073741824
12.1.1.37     23         00:00:64:05:01:07  3008      BOUND   ge-1/0/0.1073741824
12.1.1.38     24         00:00:64:05:01:08  3008      BOUND   ge-1/0/0.1073741824
```

And if you need to forcibly release a subscriber session, you can use the `clear dhcp relay binding` command:

```
admin@SOUTHPARK> clear dhcp relay binding 12.1.1.32
```

Bonus: Using DHCP-Option82

As a chapter bonus, let's show you how to change the configuration to use the DHCP Option82 field for the subscriber user-name. This configuration isn't specific to the Service VLAN model, but hey, why not learn it now?

Two common scenarios occur when using the Option82 field, the first is when the MSAN device is setting this value, and the second is when the MX device is setting the value. Both approaches are covered here.

For when the MSAN sets the Option82 value, here is the DHCP group configuration:

```
[edit forwarding-options dhcp-relay group local]
admin@SOUTHPARK# show
active-server-group dayoneDHCP;
authentication {
   username-include {
      option-82 circuit-id;
   }
}
dynamic-profile DYNSUB-SVLAN-IPDEMUX;
overrides {
   trust-option-82;
}
interface ge-1/0/0.0;
```

There are two key differences in this configuration when you use the Option82 value. The first difference is the change to the `[username-include]` stanza. You can see that the `Option82 circuit-id` value is used instead of the MAC address. The second difference is that the MX must *trust* the provided Option82 from the MSAN, as shown in the `[overrides]` stanza. If you forget to do this, the MX discards the packets that have the Option82 field set (see the *Looking at Logs* section later in this chapter for details).

If you want the MX to set the Option82 value, you would use the following configuration:

```
[edit forwarding-options dhcp-relay group local]
admin@SOUTHPARK# show
active-server-group dayoneDHCP;
authentication {
    username-include {
        option-82 circuit-id;
    }
}
dynamic-profile DYNSUB-SVLAN-IPDEMUX;
overrides {
    always-write-option-82;
    trust-option-82;
}
relay-option-82 {
    circuit-id {
        prefix {
            host-name;
        }
    }
}
interface ge-1/0/0.0;
```

Note the new `[relay-option-82]` stanza. You must include this stanza for the MX to write the Option82 field in the packet. The underlying `[prefix]` stanza is optional, but it's nice to have the MX hostname included (see the output example in next section *Bonus: Checkpoint*).

ALERT! In the Service VLAN model, all of the subscribers are sharing the same dynamic VLAN interface, and therefore the Option82 circuit-id value is the same for all subscribers. In this case, the user-name field is the same for everyone, and this is definitely not what you want; see output example in next validating services section. Having the MX set the Option82 `circuit-id` field is really only useful in the Customer VLAN model where each subscriber has a unique set of VLAN tags. You can see an example output of this use-case in the next section as well.

Bonus: Checkpoint - Validate The Configuration

Here is the output when the MX uses the `Option82 circuit-id` field provided by the MSAN. Assume that the MSAN circuit-id value format is the MSAN IP-address followed by the slot and port identifier. It should look similar to:

```
admin@SOUTHPARK> show subscribers
Interface         IP Address/VLAN ID    User Name                   LS:RI
ge-1/0/0.1073741859  200                                             default:default
demux0.1073741883   12.1.1.73           66.127.90.8:slot-3/port-0    default:default
demux0.1073741884   12.1.1.74           66.127.90.8:slot-3/port-1    default:default
demux0.1073741885   12.1.1.75           66.127.90.8:slot-3/port-2    default:default
demux0.1073741886   12.1.1.76           66.127.90.8:slot-3/port-3    default:default
demux0.1073741887   12.1.1.77           66.127.90.8:slot-3/port-4    default:default
demux0.1073741888   12.1.1.78           66.127.90.8:slot-3/port-5    default:default
demux0.1073741889   12.1.1.79           66.127.90.8:slot-3/port-6    default:default
```

Let's inspect the DHCP relay binding information:

```
admin@SOUTHPARK> show dhcp relay binding

IP address     Session Id  Hardware address  Expires    State    Interface
12.1.1.73      98         00:00:64:05:01:02  3491       BOUND    ge-1/0/0.1073741859
12.1.1.74      99         00:00:64:05:01:03  3491       BOUND    ge-1/0/0.1073741859
12.1.1.75      100        00:00:64:05:01:04  3491       BOUND    ge-1/0/0.1073741859
12.1.1.76      101        00:00:64:05:01:05  3491       BOUND    ge-1/0/0.1073741859
12.1.1.77      102        00:00:64:05:01:06  3491       BOUND    ge-1/0/0.1073741859
12.1.1.78      103        00:00:64:05:01:07  3491       BOUND    ge-1/0/0.1073741859
12.1.1.79      104        00:00:64:05:01:08  3491       BOUND    ge-1/0/0.1073741859
```

ALERT! Here is the output when the MX sets the Option82 circuit-id value in a Service VLAN model. Notice how all of the subscribers have the same user-name; *this is not what you want!*

```
admin@SOUTHPARK> show subscribers
Interface         IP Address/VLAN ID    User Name                   LS:RI
ge-1/0/0.1073741859  200                                            default:default
demux0.1073741918   12.1.1.108          SOUTHPARK:ge-1/0/0:200      default:default
demux0.1073741919   12.1.1.109          SOUTHPARK:ge-1/0/0:200      default:default
demux0.1073741920   12.1.1.110          SOUTHPARK:ge-1/0/0:200      default:default
demux0.1073741921   12.1.1.111          SOUTHPARK:ge-1/0/0:200      default:default
demux0.1073741922   12.1.1.112          SOUTHPARK:ge-1/0/0:200      default:default
demux0.1073741923   12.1.1.113          SOUTHPARK:ge-1/0/0:200      default:default
demux0.1073741924   12.1.1.114          SOUTHPARK:ge-1/0/0:200      default:default
```

What if you go back and reconfigure the MX to use the Customer VLAN model? *Let's try that*. Now, when you have the MX set the Option82 field, you will see unique user-name values somewhat similar to this:

```
admin@SOUTHPARK> show subscribers
Interface         IP Address/VLAN ID      User Name                 LS:RI
ge-1/0/0.1073741925 0x8100.100 0x8100.                              default:default
ge-1/0/0.1073741926 0x8100.100 0x8100.21                            default:default
ge-1/0/0.1073741927 0x8100.100 0x8100.22                            default:default
ge-1/0/0.1073741928 0x8100.100 0x8100.                              default:default
ge-1/0/0.1073741929 0x8100.100 0x8100.24                            default:default
ge-1/0/0.1073741930 0x8100.100 0x8100.25                            default:default
ge-1/0/0.1073741931 0x8100.100 0x8100.26                            default:default
ge-1/0/0.1073741925 12.1.1.115            SOUTHPARK:ge-1/0/0:100-20
default:default
ge-1/0/0.1073741926 12.1.1.116            SOUTHPARK:ge-1/0/0:100-21
default:default
ge-1/0/0.1073741927 12.1.1.117            SOUTHPARK:ge-1/0/0:100-22
default:default
ge-1/0/0.1073741928 12.1.1.118            SOUTHPARK:ge-1/0/0:100-23
default:default
ge-1/0/0.1073741929 12.1.1.119            SOUTHPARK:ge-1/0/0:100-24
default:default
ge-1/0/0.1073741930 12.1.1.120            SOUTHPARK:ge-1/0/0:100-25
default:default
ge-1/0/0.1073741931 12.1.1.121            SOUTHPARK:ge-1/0/0:100-26
default:default
```

Here you can see that the user-name values are unique, and the MX standard circuit-id field is in the format of *interface-name:outerVlanTag-innerVlanTag*. Since the DHCP group configuration also included the *circuit-id prefix host-name* statement, the MX host name was prefixed to the standard circuit-id value.

Looking at the Logs

This time as we look at the logs, let's build on what was discussed in Chapter 2, focusing on troubleshooting dynamic IP profiles and IP-demux interfaces.

A common mistake is forgetting to include the `dynamic profile` statement in the DHCP group. Unfortunately, you will not see a specific error in the DHCP traceoptions logfile. Refer to the previous section, *Bonus: Checkpoint*, for an example of output of the `show subscribers` command and what to look out for.

When you are using Option82 for the subscriber user-name, you must "trust" packets that have Option82 set. If you do not, then you will see a log entry similar to:

```
Oct 28 15:32:45 Client 00-00-64-05-01-02 got event CLIENT_EVENT_
DISCOVER_PDU in state RELAY_STATE_INIT
```

```
Oct 28 15:32:45 Do not trust Packet with Option-82, discarding
Oct 28 15:32:45 dropping packet
```

Summary

This chapter should have reinforced topics you learned in Chapter 2 while exposing you to some new techniques and features, such as:

- Understanding the Service VLAN model.
- Creating and using basic dynamic IP profiles.
- Using the DHCP Option82 field to set the user-name.

And along the way you should have acquired key troubleshooting skills by using Junos commands and traceoptions log files, such as:

```
> show subscribers
> clear auto-configure interface

> show network-access aaa subscriber
> clear network-access aaa subscriber username

> show route protocol access-internal

> show dhcp relay binding
> clear dhcp relay binding

> show interface
… any interface related commands …
```

The next chapter gets you working with Juniper's Steel-Belted RADIUS (SBR) product, where you knit together the RADIUS attributes that correspond to the MX `$junos` variables. Once you've learned those concepts, you'll go on to Chapter 5, which shows you how to create a Dynamic Subscriber Management Solution with per-subscriber IP definitions.

Chapter 4

Adding AAA to Dynamic Subscriber Management

This chapter adds subscriber authentication/authorization and accounting via Steel-Belted RADIUS (SBR) to our Dynamic Subscriber Management solution. It builds on the previous two chapters adding AAA to either the C-VLAN or the S-VLAN model configurations.

From the perspective of the MX, it's a relatively straightforward process of adding AAA configuration for authentication/authorization and, separately, accounting. The AAA configuration is completely independent from the C-VLAN or the S-VLAN model or existing dynamic-profiles. But with just a few lines of Junos configurations, your MX will be "up and running" with AAA.

From the SBR perspective, you are going to create user profiles locally, meaning you will not be integrating with an external customer database via LDAP or SQL. This approach should keep things focused for the chapter's activities.

Also, note that this chapter holds off on creating dynamic IP profiles that use RADIUS Vendor Specific Attributes. For now, it focuses on making sure authentication and accounting are up and running and then shows off some new troubleshooting techniques.

Getting Started with SBR

When you deploy SBR in a production service provider network, you use the *Carrier* edition. For the purposes of lab demonstrations, or test labs, you can use the *Enterprise* edition as it can run on a Windows computer and it comes with a 30-day evaluation license.

If you haven't already, download the Windows installer directly from the Juniper website: http://www.juniper.net/support/products/sbr/ee/6.1/#sw.

ALERT! You need a valid Juniper customer portal login to download SBR.

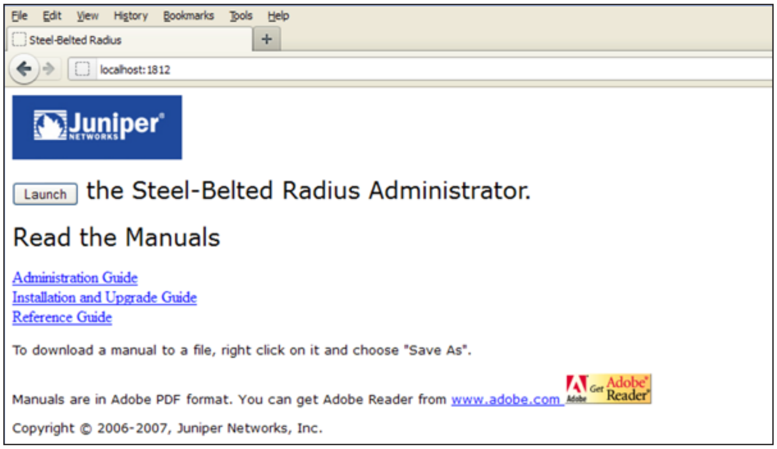
Installing SBR Enterprise Edition

To install SBR on a Windows computer, simply run the installer and follow the Wizard prompts. When asked if you would like to run SBR as a Windows Service, answer *Yes*, unless you would prefer to manually start the process.

By default the SBR software is installed in C:/Program Files/Juniper

Networks/Steel- Belted Radius/Service.

The SBR administration tool is a native Windows application that you launch from a web browser; the simplest way is to open *http://localhost:1812*, and you should see a page that looks similar to Figure 4.1.



the Steel-Belted Radius Administrator.

Read the Manuals

Administration Guide
Installation and Upgrade Guide
Reference Guide

To download a manual to a file, right click on it and choose "Save As".

Manuals are in Adobe PDF format. You can get Adobe Reader from www.adobe.com

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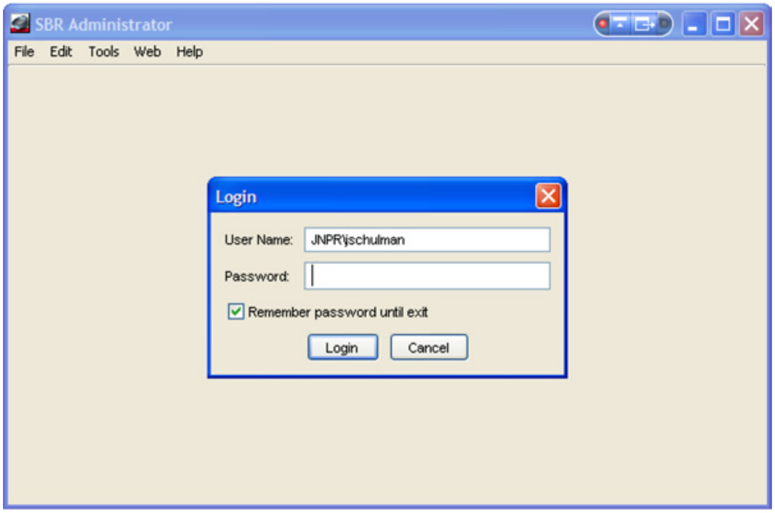
Figure 4.1 SRB Enterprise Edition Home Page

Click on the Launch button and you should be presented with the SBR Administrator Login Panel shown in Figure 4.2.



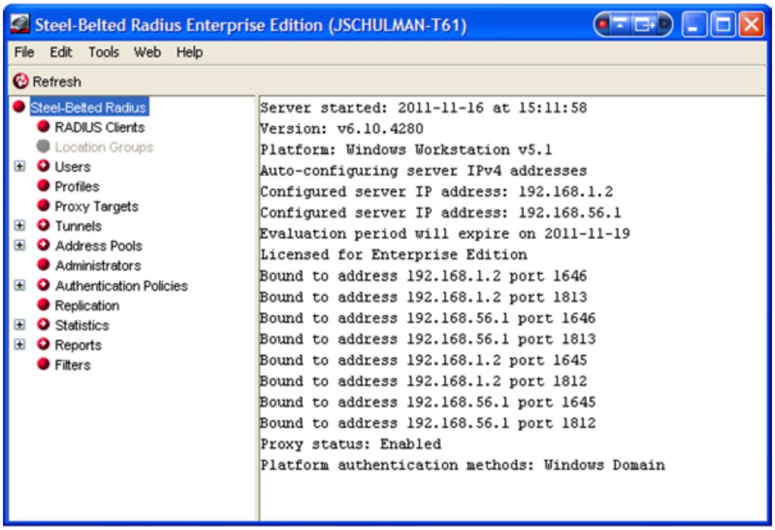
User Name: JNPR\jschulman

Password:

☑ Remember password until exit

Figure 4.2 SBR Administrator Login Panel

Once you have successfully logged in, you will see the main Administration window looking something like Figure 4.3.



```
Server started: 2011-11-16 at 15:11:58
Version: v6.10.4280
Platform: Windows Workstation v5.1
Auto-configuring server IPv4 addresses
Configured server IP address: 192.168.1.2
Configured server IP address: 192.168.56.1
Evaluation period will expire on 2011-11-19
Licensed for Enterprise Edition
Bound to address 192.168.1.2 port 1646
Bound to address 192.168.1.2 port 1813
Bound to address 192.168.56.1 port 1646
Bound to address 192.168.56.1 port 1813
Bound to address 192.168.1.2 port 1645
Bound to address 192.168.1.2 port 1812
Bound to address 192.168.56.1 port 1645
Bound to address 192.168.56.1 port 1812
Proxy status: Enabled
Platform authentication methods: Windows Domain
```

Figure 4.3 Main SBR Panel

ALERT! If you have a firewall enabled on the Windows machine, ensure that ports 1812 and 1813 are open so that the MX device can access the SBR service. If you notice ports 1645 and 1646 in Figure 4.3, it's because these are used in legacy radius environments and have been replaced with 1812 and 1813 in RFC's 2865 and 2866.

Installing Juniper MX/BRAS RADIUS Dictionary

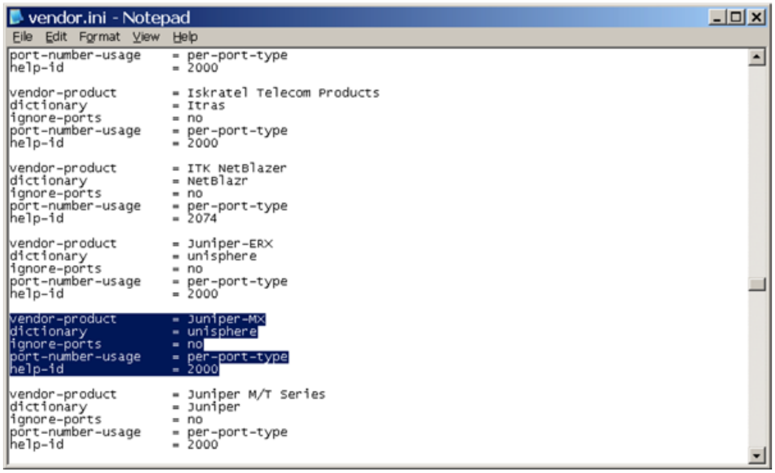
The SBR Enterprise Edition installer does not have the latest RADIUS dictionary file for MX / BRAS. You need to download this file from the Juniper Networks website at: http://www.juniper.net/techpubs/software/junos/junos112/radius-dictionary/unisphereDictionary_for_JUNOS_v11-2.dct.

You should save this file as *unisphere.dct* and overwrite the existing file in the directory: C:/Program Files/Juniper Networks/Steel-Belted Radius/Service. The attributes used by the MX are the same vendor ID as the ERX – that's why we are using *unishphere.dct*.

And you will need to restart SBR to activate these changes, but let's hold off on that for right now since there are two more things to do first: *add* the new dictionary and *enable logging*.

Assigning Juniper MX to the Unisphere Dictionary

Now that the unisphere dictionary is installed, you need to assign it to a device type called Juniper_MX. SBR uses a drop down menu when defining access clients (e.g., MX devices), the device types in this drop down menu come from a file called vendor.ini located in C:/Program Files/Juniper Networks/Steel-Belted Radius/Service. SBR uses two dictionaries for every device type – the first is the standard *radius.dct,* which includes the RADIUS attributes defined in the RADIUS RFC. The second dictionary contains the Vendor Specific Attributes (VSAs), and these are included in *unisphere.dct*. Add the following lines to the `vendor.ini` file as shown in Figure 4.5.

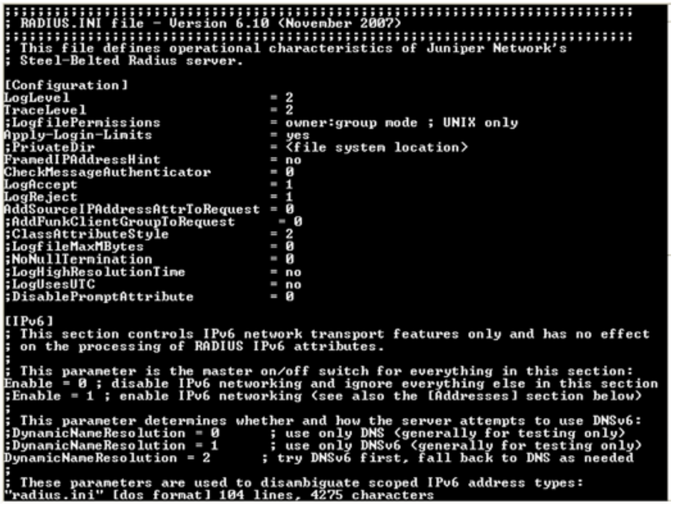


```
port-number-usage     = per-port-type
help-id               = 2000

vendor-product        = Iskratel Telecom Products
dictionary            = Itras
ignore-ports          = no
port-number-usage     = per-port-type
help-id               = 2000

vendor-product        = ITK NetBlazer
dictionary            = NetBlazr
ignore-ports          = no
port-number-usage     = per-port-type
help-id               = 2074

vendor-product        = Juniper-ERX
dictionary            = unisphere
ignore-ports          = no
port-number-usage     = per-port-type
help-id               = 2000

vendor-product        = Juniper-MX
dictionary            = unisphere
ignore-ports          = no
port-number-usage     = per-port-type
help-id               = 2000

vendor-product        = Juniper M/T Series
dictionary            = Juniper
ignore-ports          = no
port-number-usage     = per-port-type
help-id               = 2000
```

Figure 4.4 Adding to the vendor.ini File

Enabling Log and Tracing

For lab demos and testing purposes you should also enable logging. To do this you have to edit the file *radius.ini* in the directory: C:/Program Files/Juniper Networks/Steel-Belted Radius/Service. There are two items under the [Configuration] heading called *LogLevel* and *TraceLevel*, a sample of which is shown in Figure 4.5. Setting both values to 2 will give the most verbose logging. Valid settings are 0 (production), 1 (minor), and 2 (verbose). The LogLevel affects internal SBR process logging and the TraceLevel enables a log of all radius packets parsed showing each of the attributes.



```
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
; RADIUS.INI file - Version 6.10 (November 2007)
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
; This file defines operational characteristics of Juniper Network's
; Steel-Belted Radius server.

[Configuration]
LogLevel                        = 2
TraceLevel                      = 2
;LogfilePermissions             = owner:group mode ; UNIX only
Apply-Login-Limits              = yes
;PrivateDir                     = <file system location>
FramedIPAddressHint             = no
CheckMessageAuthenticator       = 0
LogAccept                       = 1
LogReject                       = 1
AddSourceIPAddressAttrToRequest = 0
;AddFunkClientGroupToRequest      = 0
;ClassAttributeStyle            = 2
;LogfileMaxMBytes               = 0
;NoNullTermination              = 0
;LogHighResolutionTime          = no
;LogUsesUTC                     = no
;DisablePromptAttribute         = 0

[IPv6]
; This section controls IPv6 network transport features only and has no effect
; on the processing of RADIUS IPv6 attributes.
;
; This parameter is the master on/off switch for everything in this section:
Enable = 0 ; disable IPv6 networking and ignore everything else in this section
;Enable = 1 ; enable IPv6 networking (see also the [Addresses] section below)
;
; This parameter determines whether and how the server attempts to use DNSv6:
;DynamicNameResolution = 0      ; use only DNS (generally for testing only)
;DynamicNameResolution = 1      ; use only DNSv6 (generally for testing only)
DynamicNameResolution = 2      ; try DNSv6 first, fall back to DNS as needed
;
; These parameters are used to disambiguate scoped IPv6 address types:
"radius.ini" [dos format] 104 lines, 4275 characters
```

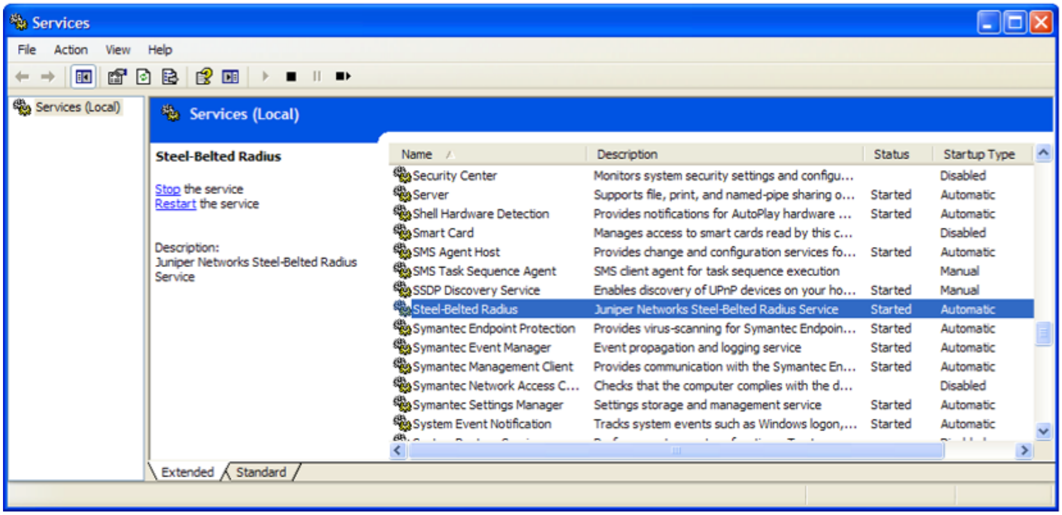
Figure 4.5 Editing the Radius.ini File

MORE? If you'd like to know more about SBR logs and troubleshooting configuration, see the *SBR Administration Guide* at: http://www.juniper.net/techpubs/en_US/sbr6.1/information-products/pathway-pages/sbr-enterprise/index.html.

Restarting SBR Service

Anytime you make any changes to the SBR control files, such as the unisphere.dct or radius.ini files, you must restart the SBR service. On Windows XP do this by opening the Control Panel, then selecting Administrative Tools, then Services. Once the Service tool is opened, find the Steel-Belted Radius entry and click the Restart option as shown in Figure 4.6.

Once you've restarted the service, you can check the log-file for updates. Log files are located in the SBR root directory, and they have the file name of *YYYYMMDD.log* where: YYYY = year, MM = month, and DD = day. A log file for October 25, 2011, for example, would be named *20111025.log*. The log files are text files.



Steel-Belted Radius

Stop the service
Restart the service

Description:
Juniper Networks Steel-Belted Radius Service

Name	Description	Status	Startup Type
Security Center	Monitors system security settings and configu...		Disabled
Server	Supports file, print, and named-pipe sharing o...	Started	Automatic
Shell Hardware Detection	Provides notifications for AutoPlay hardware ...	Started	Automatic
Smart Card	Manages access to smart cards read by this c...		Disabled
SMS Agent Host	Provides change and configuration services fo...	Started	Automatic
SMS Task Sequence Agent	SMS client agent for task sequence execution		Manual
SSDP Discovery Service	Enables discovery of UPnP devices on your ho...	Started	Manual
Steel-Belted Radius	Juniper Networks Steel-Belted Radius Service	Started	Automatic
Symantec Endpoint Protection	Provides virus-scanning for Symantec Endpoin...	Started	Automatic
Symantec Event Manager	Event propagation and logging service	Started	Automatic
Symantec Management Client	Provides communication with the Symantec En...	Started	Automatic
Symantec Network Access C...	Checks that the computer complies with the d...		Disabled
Symantec Settings Manager	Settings storage and management service	Started	Automatic
System Event Notification	Tracks system events such as Windows logon,...	Started	Automatic

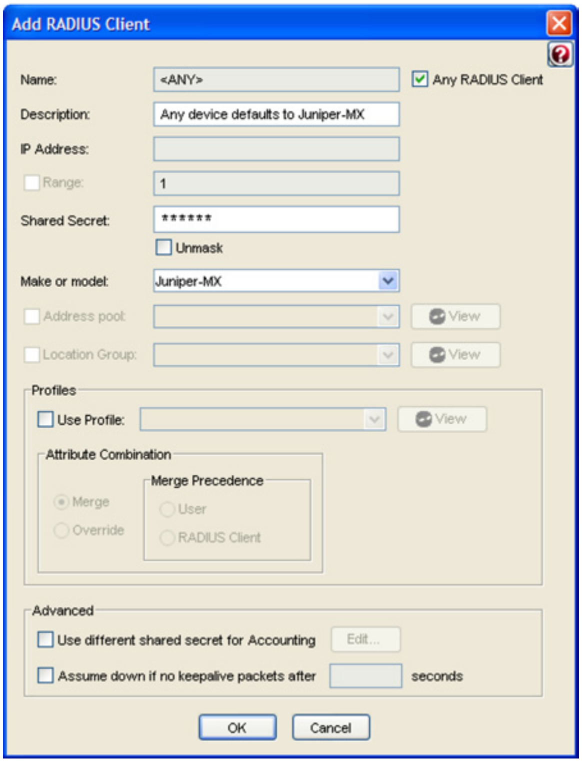
Figure 4.6 Restarting SBR Service in Windows XP

Adding RADIUS Clients

Once SBR has been restarted to use the updated dictionary, logging, and vendor file you need to configure SBR to allow requests from network clients, such as the MX or other BRAS clients. By default SBR will listen for RADIUS requests on UDP ports 1812 and 1813, but will only process them if the IP address and shared secret are correct. Let's add the MX as a RADIUS client.

From the main SBR admin screen, http://localhost:1812, click on RADIUS Clients and then click on Add. Figure 4.7 shows a SBR panel for adding a new RADIUS client, configuring the Make or model field to "Juniper-MX," which was defined in vendor.ini to use the unisphere dictionary.

ALERT! The *Shared Secret* value you enter in this window must match the RADIUS secret value you configure on the MX device.



Name: <ANY> ☑ Any RADIUS Client

Description: Any device defaults to Juniper-MX

IP Address:

□ Range: 1

Shared Secret: ******

□ Unmask

Make or model: Juniper-MX

□ Address pool: View

□ Location Group: View

Profiles

□ Use Profile: View

Attribute Combination

● Merge

○ Override

Merge Precedence

○ User

○ RADIUS Client

Advanced

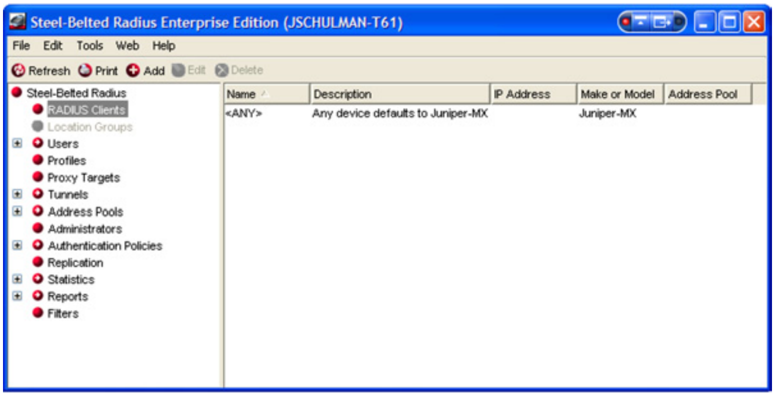
□ Use different shared secret for Accounting Edit...

□ Assume down if no keepalive packets after seconds

Figure 4.7 Adding a New RADIUS Client

After you've filled all the fields shown in Figure 4.8, click OK and do the same for the BRAS clients.

The Add RADIUS Client window above has a number of fields that we are not using in this book. The Any RADIUS Client checkbox means SBR will not care about the source IP address, it will only care that the Shared Secret is correct. The Shared Secret must be configured the same on the MX – we'll get to that later — but remember what you enter there. You can enter a specific IP address that must match what's configured in the MX, if you wish. The most important setting is the Make or Model drop down menu, which is pulled from the vendor.ini file edited earlier. Select *Juniper-MX* and click OK. This will return you to the main admin screen and you should see the client as shown in Figure 4.8.



Name	Description	IP Address	Make or Model	Address Pool
<ANY>	Any device defaults to Juniper-MX		Juniper-MX	

Figure 4.8 Main SBR Panel with Any RADIUS Client Access

You've now completed the necessary steps to use SBR in MX/BRAS applications:

- Installed the SBR Enterprise Edition on your Windows computer.
- Installed the Juniper-MX BRAS dictionary file.
- Configured SBR for Logging and Tracing.
- Configured SBR to allow access from any client (MX) and use the Juniper-MX BRAS dictionary file.

Now it's time to configure the MX to use the SBR.

Configuration Cookbook

Let's configure the MX to use the SBR server in your Dynamic Subscriber Management solution. Our network scenario is shown in Figure 4.9.

Our use-case checklist is comprised of:

- Update the MX configuration to support RADIUS Authentication and Accounting services.
- Create SBR users in the Native User database.
- Validate the configuration.
- Check the logs.

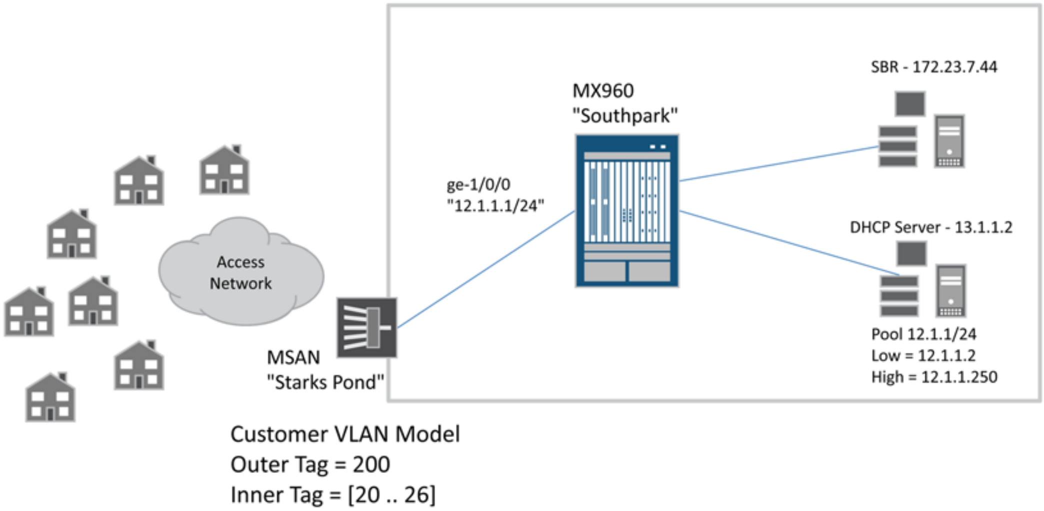


Figure 4.9 Chapter 4's Use Case Topology

Step 1: MX DHCP Authentication

The MX formulates the subscriber username value, as you learned in Chapter 3. The following configures the user name to be comprised of the MX host name and the Option82 circuit-id as provided by the MX:

```
[edit forwarding-options dhcp-relay group local]
admin@SOUTHPARK# show
active-server-group dayoneDHCP;
authentication {
    password password;
    username-include {
        option-82 circuit-id;
    }
}
overrides {
    always-write-option-82;
    trust-option-82;
}
relay-option-82 {
    circuit-id {
        prefix {
            host-name;
        }
    }
}
interface ge-1/0/0.0;
```

For example, when a subscriber accesses the MX with a Customer VLAN-Tag of [outer=100, inner=20] then the formulated user name will be `SOUTHPARK:ge-1/0/0:100-20`.

MORE? For more options on formulating the user name, see: http://www.juniper.net/techpubs/en_US/junos/topics/reference/configuration-statement/authentication-edit-forwarding-options.html.

In order to have RADIUS Authorize DHCP users, there must be a matching password value set between the MX and the RADIUS server. You can think of this like a "shared secret" except that the value is not hidden on the MX. The password is required since a RADIUS access request message must contain a password. Otherwise, it's an invalid message.

If you look carefully in the `[authentication]` stanza the `password` statement is set to the value *password*. Keep this in mind when you create SBR user's records in an upcoming section.

Step 2: MX: RADIUS Authentication

The RADIUS access controls are in the `[access]` hierarchy:

```
[edit access]
admin@SOUTHPARK# show
radius-server {
   172.23.7.44 {
      secret "$9$T3CuREyKvLRheW8Xws"; ## SECRET-DATA
      source-address 10.8.1.126;
   }
}
profile sbr {
   authentication-order radius;
   radius {
      authentication-server 172.23.7.44;
      options {
         revert-interval 0;
      }
   }
}
```

Once you have created an access profile you need to make it active by setting the top-level `access-profile` statement:

```
[edit]
admin@SOUTHPARK# set access-profile sbr
```

MORE? The MX can support L2 and L3 wholesale Subscriber Management solutions. In these cases, there would be different access profiles for each wholesale customer, and the setting would be defined with the specific L2/L3VPN routing-instance. For more information on these scenarios, see: http://www.juniper.net/techpubs/en_US/junos/information-products/pathway-pages/subscriber-access/index.html.

MORE? And additional information on access profile and RADIUS configuration can be found at: http://www.juniper.net/techpubs/en_US/junos/information-products/pathway-pages/subscriber-access/aaa/subscriber-management-aaa.html.

Step 3: MX: RADIUS Accounting

If you want to generate RADIUS accounting records, add additional configuration statements to your access profile:

```
admin@SOUTHPARK# show
profile sbr {
   accounting-order radius;
   authentication-order radius;
   radius {
      authentication-server 172.23.7.44;
      accounting-server 172.23.7.44;
      options {
         revert-interval 0;
      }
   }
   accounting {
      order radius;
      immediate-update;
      update-interval 15;
   }
}
```

Here you can see the `accounting-order` and `accounting-server` statement as well as the `[accounting]` stanza.

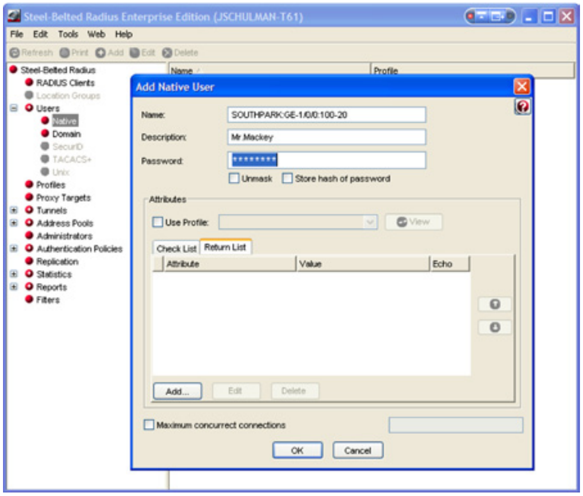
The *Looking at the Logs* section of this chapter has examples of the SBR accounting records.

Step 4: SBR User Profiles

When the SBR receives an Authentication Request message from the MX, it queries the SBR *Native User* database by default. This database is locally stored on the SBR server. In order to keep this book focused, only Native Users are used in the examples.

MORE? If you are interested in learning how to have SBR query your existing databases, see the *SBR Administrative Guide*. There is a link to this guide from the SBR Home page, see Figure 4.1.

The process to create a Native User is straightforward. As shown in Figure 4.10, from the main SBR panel, select Users> Native > Add button.



Steel-Belted Radius Enterprise Edition (JSCHULMAN-T61)

Add Native User

Name: SOUTHPARK:GE-1/0/0:100-20

Description: Mr Mackey

Password: ********

□ Unmask □ Store hash of password

Attributes

□ Use Profile:

Attribute	Value	Echo

□ Maximum concurrect connections

Figure 4.10 Adding a Native User

In Figure 4.10 you can see an example of a native user with a name of SOUTHPARK.GE-1/0/0.100-20.

The *Password* field must be configured with the same value used in Step 1 when you configured the MX DHCP Authentication ("password").

The *User Profile* checkbox and the *Return List* selection list is used to return RADIUS attribute values back to the MX. You will learn how to use SBR profiles to bind per-subscriber values into the MX dynamic IP profile `$junos` variables in Chapter 5.

Step 5: Checkpoint – Validate the Configuration

In order to validate MX and SBR configuration you will need to activate a DHCP subscriber and then review both the MX authlog and the SBR log-file. See the next section for what you should look for in the logs.

Looking at the Logs

It's time to review a few troubleshooting techniques when using SBR RADIUS and MX RADIUS configurations.

Steel-Belted RADIUS Authentication Logs

Authentication logs are stored in the general log files that SBR maintains on a daily basis. The name of the log file is *YYYYMMDD.log*, so, the log file name for November 7, 2011 would be *20111107.log*.

When the SBR receives an Authentication Request from the MX, you will see a log entry similar to the following example. Note that you can see the user-name value in the Raw Packet contents; in this case SOUTHPARK:GE-1/0/0:100-21:

```
1/07/2011 13:55:36 ------------------------------------------------------------
11/07/2011 13:55:36 Authentication Request
11/07/2011 13:55:36 Received from: ip=10.8.1.126 port=62833
11/07/2011 13:55:36
11/07/2011 13:55:36 Raw Packet :
11/07/2011 13:55:36 000: 015e00da 5847c42b d5c24fea 424f973a |.^..XG.+..O.BO.:|
11/07/2011 13:55:36 010: 6e62be7a 011b534f 55544850 41524b3a |nb.z..SOUTHPARK:|
11/07/2011 13:55:36 020: 67652d31 2f302f30 3a313030 2d323102 |ge-1/0/0:100-21.|
11/07/2011 13:55:36 030: 12480bb1 a1179124 abceea1b 6b194486 |.H.....$....k.D.|
11/07/2011 13:55:36 040: 42060600 00000259 03002c04 37301a28 |B......Y..,.70.(|
11/07/2011 13:55:36 050: 0000130a 37223501 01521b01 19534f55 |....7"5..R...SOU|
11/07/2011 13:55:36 060: 54485041 524b3a67 652d312f 302f303a |THPARK:ge-1/0/0:|
11/07/2011 13:55:36 070: 3130302d 32311a0c 0000130a 39060c01 |100-21......9...|
11/07/2011 13:55:36 080: 01011a16 0000130a 38103030 30302e36 |........8.0000.6|
11/07/2011 13:55:36 090: 3430342e 30313033 200b534f 55544850 |404.0103 .SOUTHP|
11/07/2011 13:55:36 0a0: 41524b05 06100640 15572567 652d312f |ARK....@.W%ge-1/|
11/07/2011 13:55:36 0b0: 302f302e 67652d31 2f302f30 2e313037 |0/0.ge-1/0/0.107|
11/07/2011 13:55:36 0c0: 33373431 3833333a 3130302d 32313d06 |3741833:100-21=.|
11/07/2011 13:55:36 0d0: 0000000f 04060a08 017e            |.........~     |
```

The SBR either accepts or rejects the user.

Next you can see that the accept response is sent back to the MX:

```
11/07/2011 13:55:36 ------------------------------------------------------------
11/07/2011 13:55:36 Sent accept response for user SOUTHPARK:GE-1/0/0:100-21 to client
SOUTHPARK
11/07/2011 13:55:36 ------------------------------------------------------------
11/07/2011 13:55:36 Authentication Response
11/07/2011 13:55:36 Packet : Code = 0x2 ID = 0x5e
11/07/2011 13:55:36 Vector =
11/07/2011 13:55:36 000: 057889e0 04869a0d a4166ec6 f3dbafbc |.x........n.....|
11/07/2011 13:55:36 Class : Value =
11/07/2011 13:55:36 000: 53425232 434cb8d6 eab9cbfc c0c39a80 |SBR2CL..........|
11/07/2011 13:55:36 010: 11803901 80028198 8002801d 81a9d3ea |..9.............|
11/07/2011 13:55:36 020: d5a2a1a0 c1a992e7 a4ba94da b197cc85 |................|
11/07/2011 13:55:36 030: f381e8e2 b0988ba6 a3881280 0e81b8d6 |................|
11/07/2011 13:55:36 040: eab9cbfc c0c39a80 80808088         |............   |
11/07/2011 13:55:36 ------------------------------------------------------------
```

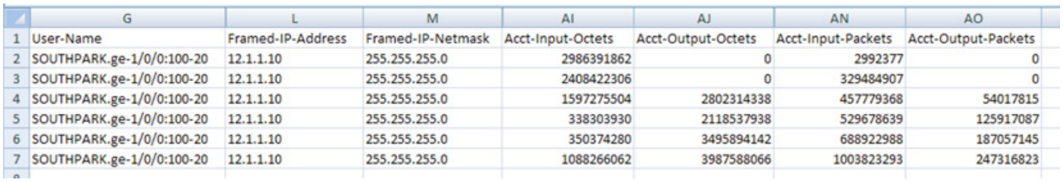
If the SBR is unable to find the user name, or validate the password, you will see something similar to the following in the SBR logs:

```
11/07/2011 14:02:08 Authenticating user SOUTHPARK:GE-1/0/0:100-21 with authentication
method Native User
11/07/2011 14:02:08 Authenticating user SOUTHPARK:ge-1/0/0:100-21 with authentication
method Windows Domain User
11/07/2011 14:02:08 Authenticating user SOUTHPARK:ge-1/0/0:100-21 with authentication
method Windows Domain Group
11/07/2011 14:02:08 Unable to find user SOUTHPARK:ge-1/0/0:100-21 with matching
password
11/07/2011 14:02:08 ------------------------------------------------------------
11/07/2011 14:02:08 Authentication Response (reject)
11/07/2011 14:02:08 Packet : Code = 0x3 ID = 0xe4
11/07/2011 14:02:08 Vector =
11/07/2011 14:02:08 000: 8aa615f5 e7d944c7 472471f4 17ab1d6f |......D.G$q....o|
11/07/2011 14:02:08 ------------------------------------------------------------
```

Steel-Belted RADIUS Accounting Logs

Accounting logs are stored in a separate file that SBR maintains on a daily basis. The format-name of the log file is *YYYYMMDD.act*, so the accounting log file name for November 7, 2011 would be *20111107.act*.

Each entry in the log file is a Comma-Separate-Value (CSV) list that you can easily import into Excel, or other database applications, for further processing. Figure 4.11 depicts a screenshot with the Accounting Records for a given user. You can see that the accounting records include the user-name, the IP-address assigned to the user, and the packet usage information.



	G	L	M	AI	AJ	AN	AO
1	User-Name	Framed-IP-Address	Framed-IP-Netmask	Acct-Input-Octets	Acct-Output-Octets	Acct-Input-Packets	Acct-Output-Packets
2	SOUTHPARK.ge-1/0/0:100-20	12.1.1.10	255.255.255.0	2986391862	0	2992377	0
3	SOUTHPARK.ge-1/0/0:100-20	12.1.1.10	255.255.255.0	2408422306	0	329484907	0
4	SOUTHPARK.ge-1/0/0:100-20	12.1.1.10	255.255.255.0	1597275504	2802314338	457779368	54017815
5	SOUTHPARK.ge-1/0/0:100-20	12.1.1.10	255.255.255.0	338303930	2118537938	529678639	125917087
6	SOUTHPARK.ge-1/0/0:100-20	12.1.1.10	255.255.255.0	350374280	3495894142	688922988	187057145
7	SOUTHPARK.ge-1/0/0:100-20	12.1.1.10	255.255.255.0	1088266062	3987588066	1003823293	247316823

Figure 4.11 SBR Accounting Log in Excel

In most service provider networks, accounting is proxied to external systems. We are not covering radius proxy configuration in this book, however, it's a simple configuration for which SBR is commonly used.

MX Logs

RADIUS related log messages are stored in the `[system services processes general-authentication-service traceoptions]` file. The log file name was configured in the initial chapter of this book.

There are a few issues to look out for when using RADIUS. The first is making sure that you have the correct RADIUS server address configured in `[access radius-servier <server-ip-address>]`. If you do not, you will see something like the following in the file:

```
Nov  5 08:57:06 Radius result is CLIENT_REQ_TIMEOUT
```

You will also see this, regardless of the reason, when you cannot access the RADIUS server – it could be a firewall blocking ports 1812 and 1813, for example.

The next issue to look out for occurs when you are configuring the `[access radius-servier <server-ip-address> source-address]` for the RADIUS originated packets. You must ensure that this address is valid on the MX, or you will see something like the following:

```
Nov  5 08:59:27 Verify source address a08047e (10.8.4.126) in routing instance index=0
Nov  5 08:59:27 ignoring server, non-existent source address ‘10.8.4.126’
Nov  5 08:59:27 authd_radius_server_add: Failed to verify source address a08047e
Nov  5 08:59:27 authd_create_application_specific_radius_server: Failed to add radius
server info
```

Summary

This chapter introduced you the Juniper Steel-Belted RADIUS (SBR) based authorization model for dynamic subscriber management, and several techniques for:

- Understanding the MX configuration for RADIUS.
- Installing and configuring SBR.
- Configuring native users in SBR based on MX user name configuration options.

You should also be familiar with the key troubleshooting skills that use Junos commands and SBR log files.

The next chapter continues using the Juniper Steel-Belted RADIUS product. It also knits together the RADIUS attributes that correspond to the MX `$junos` variables. Once you've learned those concepts, you'll go on to create a Dynamic Subscriber Management Solution with per-subscriber IP definitions.

Chapter 5

Getting Started with Dynamic IP Profiles and QoS

Dynamic IP profiles are all about Quality of Service (QoS), bandwidth, and Service Level Agreement (SLA) controls. This chapter shows you how to create dynamic IP profiles and how to work with the common `$junos` variables. You will also learn to configure RADIUS/SBR profiles to bind per-subscriber values into the `$junos` variables.

This is the big finale!

The use-case in this chapter is a Voice+Internet service offering, and the customer can select one of three bandwidth packages: 2Mbps, 5Mbps, or 10Mbps. The service offering will also allow for up to two phone lines worth of VoIP traffic; another 512Kbps of high-priority real-time traffic.

Our use-case checklist is comprised of:

- Configure the MX dynamic VLAN profile: Customer VLAN model.
- Configure the MX dynamic IP profile for Voice+Internet service.
- Configure the MX DHCP relay to external DHCP server.
- Configure SBR to provide per-subscriber values to dynamic IP profile.

This chapter assumes you have a general working knowledge of Junos QoS configurations, but there is a brief overview of the packet flow and hierarchical QoS building blocks before beginning the use-case configurations.

MORE? If you are new to Junos QoS, there is an excellent *Day One* book on this topic, *Day One: Configuring Basic QoS*, by Guy Davies, and you can download a free copy at http://www.juniper.net/dayone.

Once you have completed this chapter you will have covered all the major topics for building a complete Dynamic Subscriber Management solution, so let's get to it and get this last chapter completed.

Junos Variables and RADIUS VSAs

Dynamic IP profiles are all about using Junos class-of-service (CoS) capabilities. Before this chapter digs into teaching you the `$junos` variables and how they are configured via RADIUS, it is important to understand how and where each of these variables will be used throughout the packet flow. Figure 5.1 illustrates the Junos packet flow where each of the CoS actions occur.

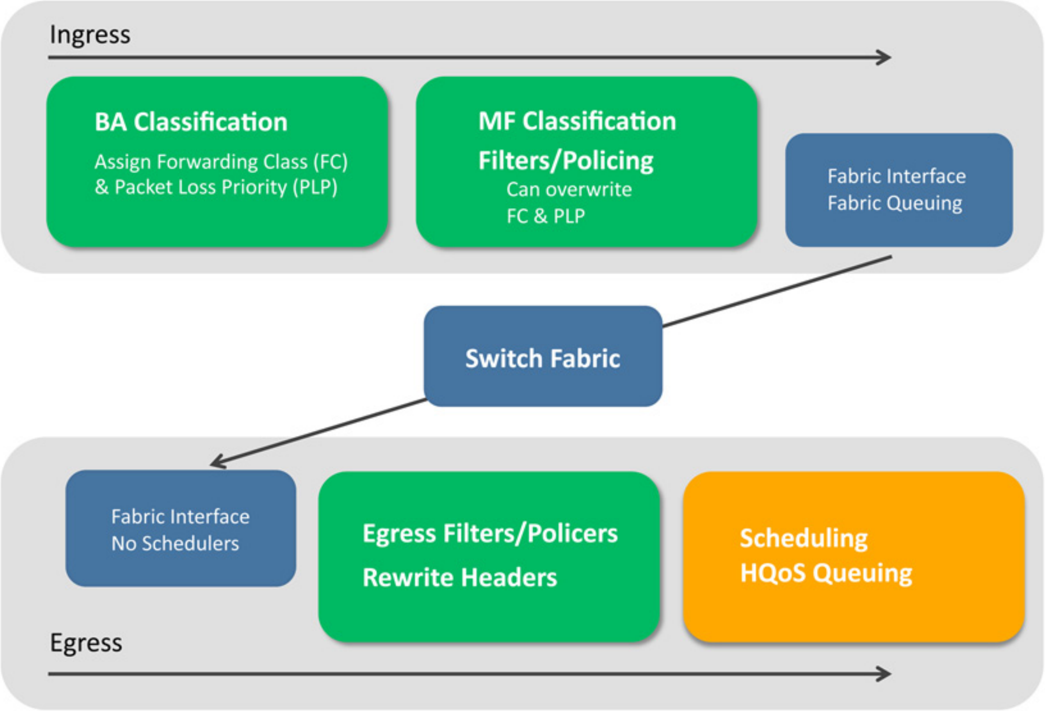


Figure 5.1 Junos Packet Flow for Hierarchical QoS

This chapter focuses on the `$junos` variables for filtering/policing and Scheduler/Queuing. You can see from Figure 5.1 that there are steps for both ingress and egress filtering/policing, and the egress scheduler/queuing action occurs last.

The key to understanding Juniper's Dynamic Management Solution is how `$junos` variables are mapped to RADIUS VSA values. This chapter teaches you this technique using Juniper's Steel-Belted RADIUS (SBR) product.

The MX configuration map, relating to the CoS settings you will learn in this chapter, is shown in Figure 5.2.

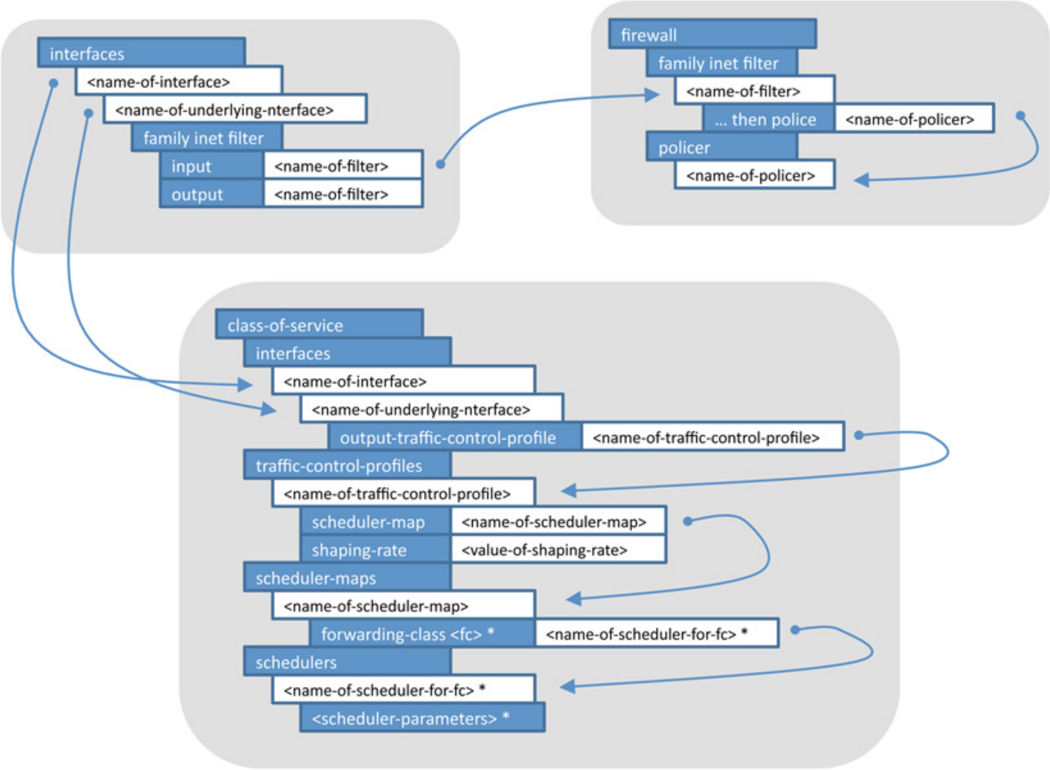


Figure 5.2 Chapter 5 MX Configuration Hierarchy Map for Subscriber Profile QoS

Interface Filters and Policers

Let's first focus on using firewall filters/policers with subscriber profiles. You can see from Figure 5.2 that you include both ingress and egress filters using $junos variables in your profile. In order to use filters, you must first create them on the MX within the [firewall] hierarchy. For example, here is an example of a 5Mbps policer for IPv4 traffic:

```
[edit firewall]
admin@SOUTHPARK# show
family inet {
    filter police-5M {
        interface-specific;
        term all {
            then policer police-5M;
        }
```

```
      }
   }
   policer police-5M {
      if-exceeding {
         bandwidth-limit 5m;
         burst-size-limit 32k;
      }
      then discard;
   }
```

Notice that there are two parts to this configuration: the firewall *filter* and the associated *policer*. You can tell that this firewall is for IPv4 packets since it is defined under the `[family inet]` stanza.

ALERT! You should also notice the use of the `interface-specific` statement in the firewall filter. This setting is required for dynamic VLAN interfaces since each interface will require a unique copy of the firewall policer. A latter section shows you how to display the filter/policers so you can see how Junos creates unique identifiers for each subscriber interface.

Table 5.1 presents the `$junos` variables and the corresponding RADIUS VSA attribute names for IPv4 filters:

Table 5.1 IPv4 Filter Variables and RADIUS VSAs

Description	Junos Variable	RADIUS VSA
IPv4 Input Filter	`$junos-input-filter`	Unisphere-Ingress-Policy-Name
IPv4 Output Filter	`$junos-output-filter`	Unisphere-Egress-Policy-Name

ALERT! As you can see from Table 5.1, the RADIUS variable definition for firewall filters only allows you to specify the *name* of the filter, and not the filter contents. This means that you must pre-create the firewall configuration on the MX device before you use the name of the filter in the SBR profile. This chapter's *Cookbook* section contains specific MX configuration examples and SBR profile screenshots.

MORE? Junos provides a very feature rich set of ACL and policing capabilities, including two-rate and three-rate color policers. For more information on Junos firewall filters and policers, refer to: http://www.juniper.net/techpubs/en_US/junos11.2/information-products/pathway-pages/config-guide-firewall-filter/index.html

While this book does not go into IPv6 examples, it is worth noting that Juniper's Dynamic Subscriber Management solution supports IPv6 today, and that Table 5.2 lists the IPv6 variables and VSA attribute names.

Table 5.2 IPv6 Filter Variables and RADIUS VSAs

Description	Junos Variable	RADIUS VSA
IPv6 Input Filter	`$junos-input-ipv6-filter`	IPv6-Ingress-Policy-Name
IPv6 Output Filter	`$junos-output-ipv6-filter`	IPv6-Egress-Policy-Name

MORE? For more information on dual-stack solutions, see the whitepaper: http://www.juniper.net/techpubs/en_US/junos11.2/information-products/topic-collections/design-guide-subscriber-dual-stack/subscriber-access-ipv4-ipv6-dual-stack.pdf

Egress Scheduling and Shaping

MX/BRAS network deployments commonly take advantage of the hierarchical QoS features of the MX "-Q" and "-EQ" line cards. If you want to do per-customer or per-VLAN *shaping*, then you will need these types of line cards. Figure 5.2 illustrates the various hierarchical levels. This chapter shows you how to use *traffic-control profiles* and *scheduler* controls to implement the Voice+Internet service.

Figure 5.3 illustrates how Junos uses traffic-control profiles and schedulers in packet egress processing.

Traffic Control Profiles

A Junos *traffic-control-profile* is used to define the per-VLAN QoS parameters, and this output shows the available values you can define for each traffic control profile:

```
[edit class-of-service traffic-control-profiles TRAFFIC-PROFILE]
admin@SOUTHPARK# set ?
Possible completions:
> delay-buffer-rate    Delay buffer rate
> excess-rate         Excess bandwidth sharing proportion
> guaranteed-rate      Guaranteed rate
> overhead-accounting  Overhead accounting
  scheduler-map       Mapping of forwarding classes to packet schedulers
> shaping-rate        Shaping rate
> shaping-rate-excess-high  Shaping rate for excess high traffic
> shaping-rate-excess-low  Shaping rate for excess log traffic
> shaping-rate-priority-high  Shaping rate for high priority traffic
> shaping-rate-priority-low  Shaping rate for low priority traffic
> shaping-rate-priority-medium  Shaping rate for medium priority traffic
```

Since this book is focused on the essentials, it only covers the `shaping-rate` parameter. The other parameters follow the same methodology, so learning this one provides a basis for using the others if you need them.

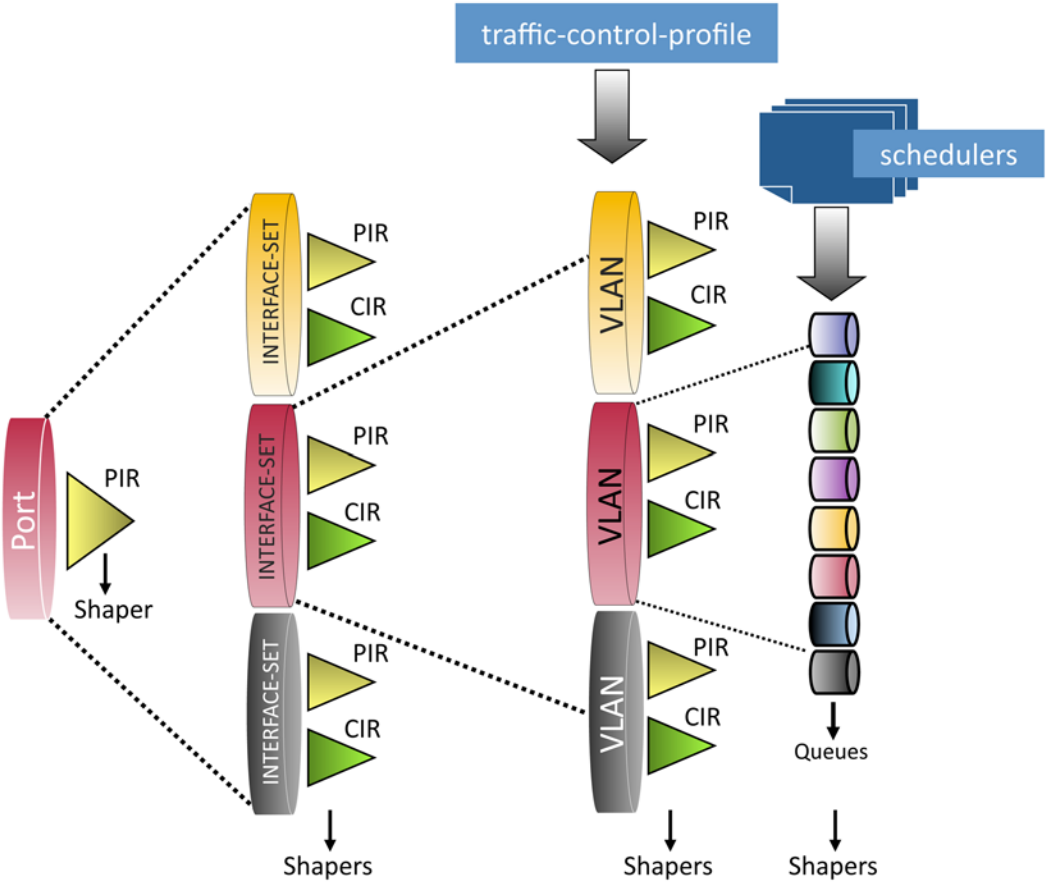


Figure 5.3 MX Hierarchical QoS

Here is an example of a static Junos configuration that creates a traffic control profile with a 5 Mbps shaper:

```
[edit class-of-service]
admin@SOUTHPARK# show
traffic-control-profiles {
   TRAFFIC-PROFILE {
      shaping-rate 5m;
   }
}
```

All of the `traffic-control-profile` parameters are provided through the same RADIUS VSA called `Jnpr-Cos-Parameter-Type`. How, then, does the Junos OS know which specific traffic control profile parameter you want to set? The answer is RADIUS will return multiple `Jnpr-Cos-Parameter-Type` VSA values, and each value will begin with a *type-identifier* (for example, T01, T02, etc.) to uniquely identify the specific traffic-control-profile parameter. And how does the Junos OS know which traffic-control-profile is used for the subscriber? The answer is you configure this in the dynamic IP profile, and a section later in this chapter shows you an example of a configuration.

T02 identifies the traffic control profile shaping-rate and Table 5.3 presents the `$junos` variable and the associated RADIUS VSA used to configure the traffic control profile shaping rate value.

Table 5.3 Traffic-Control-Profile Shaping-Rate

Description	Junos Variable	RADIUS VSA
Traffic Control Profile shaping-rate	`$junos-cos-shaping-rate`	Jnpr-Cos-Parameter-Type T02 <value>

This chapter's *Cookbook* section contains specific MX configuration examples and SBR profile screenshots.

MORE? For more about traffic control profile settings, see http://www.juniper.net/techpubs/en_US/junos11.2/topics/usage-guidelines/cos-configuring-traffic-control-profiles-for-shared-scheduling-and-shaping.html.

Schedulers

Junos *schedulers* are used to control the output flow of queued packets. In a hierarchical application, each VLAN can have multiple output queues (up to 8), and each one would be assigned to use a specific scheduler.

You can configure a number of parameters for each scheduler and here are some of the available values you can define:

```
[edit class-of-service schedulers my-scheduler]
admin@SOUTHPARK# set ?
Possible completions:
> buffer-size            Queue transmission buffer size
> drop-profile-map       Assign drop profile to a loss priority and protocol
  excess-priority        Priority in the excess region
> excess-rate            Excess bandwidth sharing proportion
  priority               Scheduling priority
> shaping-rate           Shaping rate
> transmit-rate          Transmit rate
```

Since this book is focused on the essentials, it only covers the `shaping-rate` and `transmit-rate` parameters.

The transmit-rate setting is expressed as either a percentage or an absolute bits-per-second value. If packets egress the MX in excess of this rate they are considered *discard eligible*. You can think of the transmit-rate as the *committed-rate*.

The shaping-rate is expressed as either a percentage or an absolute bits-per-second value. If packets egress the MX in excess of this rate, packets are buffered such that they will not leave the box above the shaping-rate value. You can think of shaping-rate as the *peak-rate*.

Here is an static example of a scheduler with a defined transmit-rate and shaping-rate:

```
[edit class-of-service]
admin@SOUTHPARK# show
schedulers {
   my-scheduler {
       transmit-rate 10m;
       shaping-rate 15m;
   }
}
```

All scheduler parameters are provided through the same RADIUS VSA called `Jnpr-Cos-Scheduler-Pmt-Type`. So how does the Junos OS know which scheduler you want, and which parameter within the scheduler you want? The answer is very similar to the traffic-control-profile methodology. RADIUS will return multiple `Jnpr-Cos-Scheduler-Pmt-Type` VSA values, and each value will begin with the *scheduler-name*, followed by a *type-identifier*:

- T01 identifies *transmit-rate*
- T10 identifies the *shaping-rate*

Table 5.4 presents the `$junos` variable and the associated RADIUS VSA used to configure Junos scheduler values.

Table 5.4 Scheduler Transmit-Rate and Shaping-Rate

Description	Junos Variable	RADIUS VSA
Scheduler <XYZ> transmit-rate	`$junos-cos-scheduler-tx`	Jnpr-Cos-Scheduler-Pmt-Type <XYZ> T01 <value>
Scheduler <XYZ> shaping-rate	`$junos-cos-scheduler-shaping-rate`	Jnpr-Cos-Scheduler-Pmt-Type <XYZ> T10 <value>

The *Cookbook* section of this chapter contains specific MX configuration examples and SBR profile screenshots.

MORE? To learn more about scheduler settings, see http://www.juniper.net/techpubs/en_US/junos11.2/information-products/pathway-pages/cos/schedulers.html#configuration.

Configuration Cookbook

In this section let's use the Customer VLAN model with the MX setting the Option82 field in the packet.

The goal of this use-case is to create a Voice+Internet service offering. A customer can purchase one of three bandwidth packages: 2Mbps, 5Mbps, or 10Mbps, and the package will also allow for up to two phone-lines' worth of VoIP traffic; another 512Kbps of high-priority real-time traffic.

In order to implement this service offering, you must create a dynamic IP profile that uses hierarchical traffic shaping and multiple forwarding-class schedulers.

Our checklist consists of the following steps:

- Review the baseline MX configuration before you add dynamic IP profiles.
- Create a dynamic IP profile that will use ingress policing and egress shaping.
- Bind the dynamic IP profile to the DHCP group.
- Create an SBR profile for each of the service definitions.
- Bind SBR users to the SBR profiles.

Step 1: Review the MX Baseline Configuration

First let’s review the interface that creates dynamic VLAN interfaces:

```
[edit interfaces ge-1/0/0]
admin@SOUTHPARK# show
description “>> Stark’s Pond <<”;
hierarchical-scheduler;
flexible-vlan-tagging;
auto-configure {
   stacked-vlan-ranges {
      dynamic-profile DYNINTF-2VLANS-DHCP-INET {
         accept any;
         ranges {
            any,any;
         }
      }
   }
}
mtu 2000;
```

Next let's review the dynamic VLAN profile used by the physical interface:

```
[edit dynamic-profiles DYNINTF-2VLANS-DHCP-INET]
admin@SOUTHPARK# show
interfaces {
   “$junos-interface-ifd-name” {
      unit “$junos-interface-unit” {
         proxy-arp restricted;
         vlan-tags outer “$junos-stacked-vlan-id” inner “$junos-vlan-id”;
         family inet {
            unnumbered-address lo0.0 preferred-source-address 12.1.1.1;
         }
      }
   }
}
```

Next the DHCP relay configuration to use an external DHCP server, have the MX set the Option82 circuit-id, and use a subscriber password = “password” for RADIUS/SBR:

```
[edit forwarding-options dhcp-relay]
admin@SOUTHPARK# show
server-group {
   dayoneDHCP {
      13.1.1.2;
   }
}
```

```
group local {
   active-server-group dayoneDHCP;
   authentication {
      password password;
      username-include {
         option-82 circuit-id;
      }
   }
   overrides {
      always-write-option-82;
      trust-option-82;
   }
   relay-option-82 {
      circuit-id {
         prefix {
            host-name;
         }
      }
   }
   interface ge-1/0/0.0;
}
```

Finally, the RADIUS and authorization sections to use the SBR:

```
[edit access]
admin@SOUTHPARK# show
radius-server {
   10.8.4.90 {
      secret “$9$lgpMxd2gJDjq24UHk.F3”; ## SECRET-DATA
      source-address 10.8.1.126;
   }
}
profile sbr {
   authentication-order radius;
   radius {
      authentication-server 10.8.4.90;
      options {
         revert-interval 0;
      }
   }
}

[edit]
admin@SOUTHPARK# show access-profile
sbr;
```

Step 2: Dynamic IP Profile

Now let's illustrate how to create a dynamic IP profile for the Voice+Internet service offering. The map of the MX configuration hierarchy for this use-case is shown in Figure 5.4.

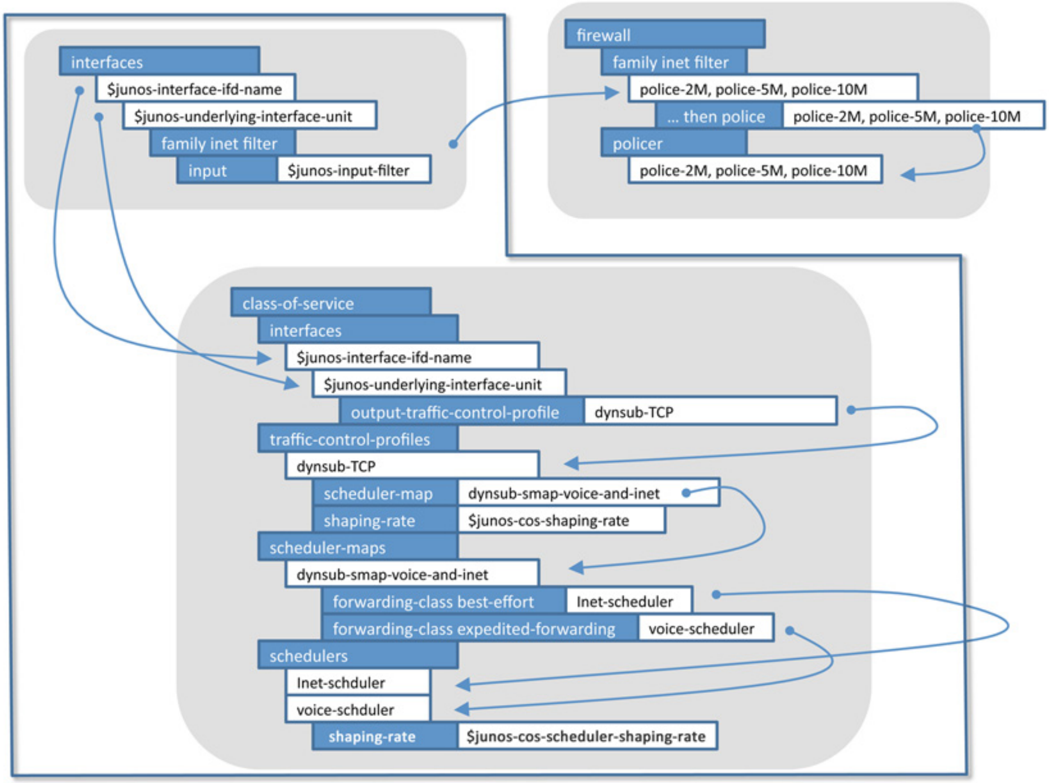

interfaces
$junos-interface-ifd-name
$junos-underlying-interface-unit
family inet filter
input
$junos-input-filter
firewall
family inet filter
police-2M, police-5M, police-10M
... then police
police-2M, police-5M, police-10M
policer
police-2M, police-5M, police-10M
class-of-service
interfaces
$junos-interface-ifd-name
$junos-underlying-interface-unit
output-traffic-control-profile
dynsub-TCP
traffic-control-profiles
dynsub-TCP
scheduler-map
dynsub-smap-voice-and-inet
shaping-rate
$junos-cos-shaping-rate
scheduler-maps
dynsub-smap-voice-and-inet
forwarding-class best-effort
Inet-scheduler
forwarding-class expedited-forwarding
voice-scheduler
schedulers
Inet-schduler
voice-schduler
shaping-rate
$junos-cos-scheduler-shaping-rate

Figure 5.4 Chapter 5 Use-Case MX Configuration Hierarchy Map

The dynamic IP profile called DYNSUB-DHCP-VOICE-AND-INET is the focus of this section. You can see that this profile has two major stanzas to review: `[interfaces]` and `[class-of-service]`. Rather than showing you the entire dynamic IP profile at once, let's break down each stanza into bite-size chunks.

ALERT! The dynamic IP profile is in addition to the existing dynamic VLAN profile. The complete configuration uses a dynamic VLAN profile called *DYNINTF-2VLANS-DHCP-INET* and a dynamic IP profile called *DYNSUB-DHCP-VOICE-AND-INET*. You cannot combine these two into one profile.

NOTE This section does not cover the configuration for the three filters/policers shown outside the dynamic profile box in Figure 5.5: *police-2M*, *police-5M,* and *police-10M*. You can use the example presented in the earlier section as a template to create these filters/policers on your own. If you need this in your lab setup, go ahead and do it now.

Interfaces

First let's configure the [interfaces] stanza:

```
[edit dynamic-profiles DYNSUB-DHCP-VOICE-AND-INET interfaces]
admin@SOUTHPARK# show
“$junos-interface-ifd-name” {
    unit “$junos-underlying-interface-unit” {
        family inet {
            filter {
                input “$junos-input-filter”;
            }
        }
    }
}
```

The purpose of the [interfaces] stanza is to include an ingress policer to limit the amount of bandwidth from the subscriber. So each service bandwidth profile offering (2Mbps, 5Mbps, 10Mbps) requires a Junos firewall filter/policer similar to the one you saw in an earlier section.

When the Junos OS instantiates this dynamic IP profile, the resulting [class-of-service traffic-control-profile] section is merged with the existing dynamic interface configuration. You should notice the use of the $junos-underlying-interface-unit variable to identify the existing interface unit, and you do not need to include the VLAN(s) or other configuration(s) you previously had in the dynamic VLAN profile.

Class-of-Service

Next is the [class-of-service] stanza. This stanza has a number of sub-hierarchies, which are also presented in bite-size chunks.

Up first is the `[class-of-service traffic-control-profile]` stanza, used to set the overall bandwidth shaping rate. It’s also used to identify a scheduler-map, which is used in turn to direct the VoIP and Internet traffic to different output scheduler/queues.

```
[edit dynamic-profiles DYNSUB-DHCP-VOICE-AND-INET class-of-service]
admin@SOUTHPARK# show
traffic-control-profiles {
   dynsub-TCP {
      scheduler-map dynsub-smap-voice-and-inet;
      shaping-rate “$junos-cos-shaping-rate”;
   }
}
```

Next let’s associate the traffic-control-profile to the subscriber’s underlying interface, and therefore the subscriber’s anchor interface. This is done in the `[class-of-service interfaces]` stanza:

```
interfaces {
   “$junos-interface-ifd-name” {
      unit “$junos-underlying-interface-unit” {
         output-traffic-control-profile dynsub-TCP;
      }
   }
}
```

NOTE The Junos OS will instantiate a session specific traffic-control-profile to keep the settings unique per subscriber (a latter section illustrates how to *see* the existing traffic-control-profiles and run-time values).

The next two stanzas are used to direct the subscribers VoIP and Internet traffic into different scheduler queues:

```
scheduler-maps {
   dynsub-smap-voice-inet {
      forwarding-class best-effort scheduler inet-scheduler;
      forwarding-class expedited-forwarding scheduler voice-scheduler;
   }
}
```

NOTE Here the default Junos forwarding-classes `best-effort` and `expedited-forwarding` are used. The assumption is that the VoIP traffic is classified into the expedited-forwarding class, and everything else goes into the best-effort forwarding class.

```
schedulers {
   inet-scheduler {
      transmit-rate remainder;
      priority low;
   }
   voice-scheduler {
      shaping-rate "$junos-cos-scheduler-shaping-rate”;
      priority strict-high;
   }
}
```

Here you can see the scheduler configuration for the Internet/best effort traffic and the VoIP traffic, using scheduler `inet-scheduler` and `voice-scheduler` respectively. Note that the VoIP shaping rate is variable, enabling you to allow for multiple phone lines of VoIP traffic by assigning different traffic rate values. So, perhaps the default service is two-lines using 512Kbps, but maybe some customers want more. Up-sell!

NOTE In this example the `inet-scheduler transmit-rate` is set to `remainder`. This means that best-effort/Internet traffic can use the bandwidth allocated to VoIP providing there is no VoIP in use. You could configure the `inet-scheduler transmit-rate` and/or `shaping-rate` settings if you want to explicitly control the bandwidth and prevent the `remainder` behavior.

NOTE This example illustrates the use of two transmit scheduler/queues. The MX can support a maximum of eight queues per VLAN when you use the -Q or -EQ line cards.

NOTE For many CoS/SLA network scenarios, the MX is typically configured with additional class-of-service settings that reside outside the scope of the dynamic IP profile. Because this book focuses on MX/BRAS topics, these types of class-of-service configuration have been omitted. Please see the *Appendices* for pointers to on-line documentation for further reading on CoS topics.

Step 3: Bind Dynamic IP Profile

Now that you have created the dynamic IP profile, you must associate it to the interface via the DHCP group. The only addition is the `dynamic-profile` statement that identifies the profile you created in the prior section:

```
[edit forwarding-options dhcp-relay group local]
admin@SOUTHPARK# show
active-server-group dayoneDHCP;
authentication {
   password password;
   username-include {
      option-82 circuit-id;
   }
}
dynamic-profile DYNSUB-DHCP-VOICE-AND-INET;
overrides {
   always-write-option-82;
   trust-option-82;
}
relay-option-82 {
   circuit-id {
      prefix {
         host-name;
      }
   }
}
interface ge-1/0/0.0;
```

ALERT! Again, keep in mind that there are two dynamic profiles in this use case, the dynamic VLAN profile and the dynamic IP profile. Make sure you configure the DHCP group to use the dynamic IP profile.

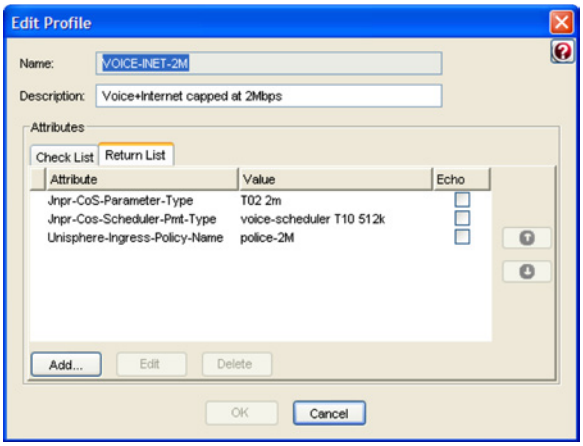
Step 4: Create SBR Profiles

Now it's time to create the SBR profiles for each of the service definitions. Table 5.5 summarizes the `$junos` variables and corresponding RADIUS VSAs used by the dynamic IP profile. Then it's three quick edits to the SBR profile.

Table 5.5 Example Return Values

Junos Variable Name	RADIUS VSA	Example Return Value
`$junos-input-filter`	Unisphere-Ingress-Policy-Name	police-2M
`$junos-cos-shaping-rate`	Jnpr-Cos-Parameter-Type	T02 2m
`voice-scheduler` `$junos-cos-scheduler-shaping-rate`	Jnpr-Cos-Scheduler-Pmt-Type	voice-scheduler T10 512k

And Figure 5.5 shows the SBR profile for the 2Mbps service offering.



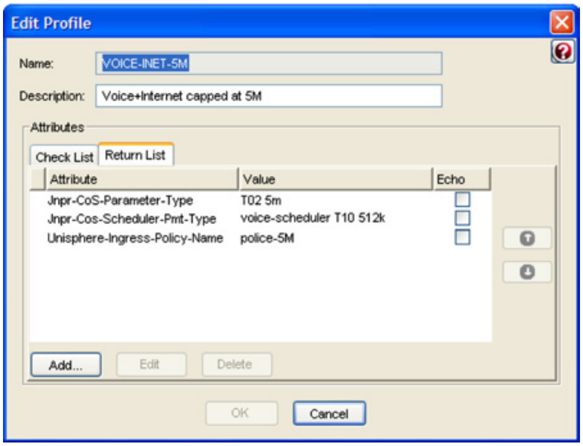
Name: VOICE-INET-2M

Description: Voice+Internet capped at 2Mbps

Attribute	Value	Echo
Jnpr-CoS-Parameter-Type	T02 2m	□
Jnpr-Cos-Scheduler-Pmt-Type	voice-scheduler T10 512k	□
Unisphere-Ingress-Policy-Name	police-2M	□

Figure 5.5 SBR Profile for 2Mbps

Figure 5.6 shows the SBR profile for the 5Mbps service offering.



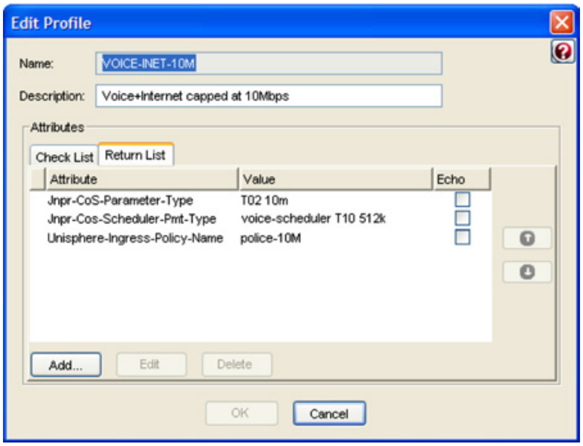
Name: VOICE-INET-5M

Description: Voice+Internet capped at 5M

Attribute	Value	Echo
Jnpr-CoS-Parameter-Type	T02 5m	□
Jnpr-Cos-Scheduler-Pmt-Type	voice-scheduler T10 512k	□
Unisphere-Ingress-Policy-Name	police-5M	□

Figure 5.6 SBR Profile for 5Mbps

And finally, Figure 5.7 shows the SBR profile for the 10Mbps service offering.



Name: VOICE-INET-10M

Description: Voice+Internet capped at 10Mbps

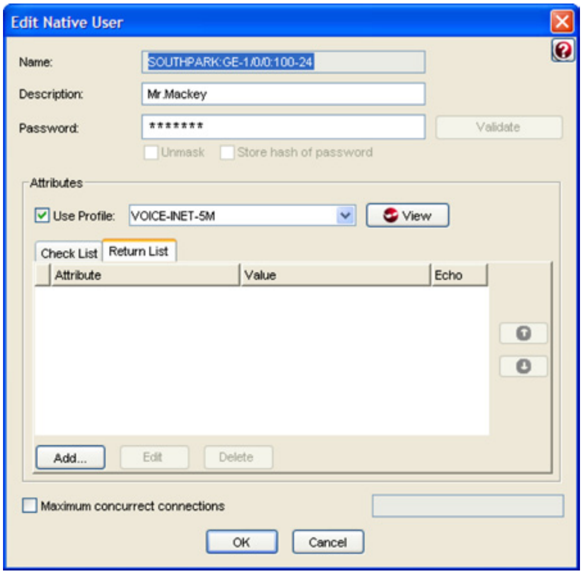
Attributes

Attribute	Value	Echo
Jnpr-CoS-Parameter-Type	T02 10m	□
Jnpr-Cos-Scheduler-Pmt-Type	voice-scheduler T10 512k	□
Unisphere-Ingress-Policy-Name	police-10M	□

Figure 5.7 SBR Profile for 10Mbps

Step 5: Bind SBR Native Users to SBR Profiles

The final step is to bind the SBR Native Users to each of the SBR service profiles. Figure 5.8 shows an example of a subscriber bound to the 5Mbps service offering.



Name: SOUTHPARK:GE-1/0/0:100-24

Description: Mr.Mackey

Password: *******

□ Unmask □ Store hash of password

Attributes

☑ Use Profile: VOICE-INET-5M

Attribute	Value	Echo

□ Maximum concurrect connections

Figure 5.8 Example of Binding SBR Native Users to SBR Service Profiles

Now that you have completed all of the MX configuration and the SBR configuration you are ready to test your network setup.

Step 6: Checkpoint – Validate the Configuration

Use the `show subscribers client-type dhcp` command to verify that your subscribers are active:

```
admin@SOUTHPARK> show subscribers client-type dhcp
Interface         IP Address/VLAN ID      User Name                 LS:RI
ge-1/0/0.1073741831 12.1.1.15             SOUTHPARK:ge-1/0/0:100-20
default:default
ge-1/0/0.1073741832 12.1.1.9              SOUTHPARK:ge-1/0/0:100-21
default:default
ge-1/0/0.1073741833 12.1.1.10             SOUTHPARK:ge-1/0/0:100-22
default:default
ge-1/0/0.1073741834 12.1.1.12             SOUTHPARK:ge-1/0/0:100-23
default:default
ge-1/0/0.1073741835 12.1.1.11             SOUTHPARK:ge-1/0/0:100-24
default:default
ge-1/0/0.1073741836 12.1.1.13             SOUTHPARK:ge-1/0/0:100-25
default:default
ge-1/0/0.1073741837 12.1.1.14             SOUTHPARK:ge-1/0/0:100-26
default:default
```

The `show dynamic-configuration` command displays the bindings between the variables and the RADIUS VSAs. This is a hidden command as of Junos 11.2, but a very handy debugging command! Hidden commands are not TAB/SPACE name-completed automatically on the CLI; so you must type in the command fully. In order to use the `show dynamic-configuration` command, you first need to know the subscriber session-id. The subscriber session-id can be found by showing a subscriber record with the detail option:

```
admin@SOUTHPARK> show subscribers address 12.1.1.15 detail
Type: DHCP
User Name: SOUTHPARK:ge-1/0/0:100-20
IP Address: 12.1.1.15
Logical System: default
Routing Instance: default
Interface: ge-1/0/0.1073741831
Interface type: Static
Dynamic Profile Name: DYNSUB-DHCP-VOICE-AND-INET
MAC Address: 00:00:64:04:01:02
State: Active
DHCP Relay IP Address: 12.1.1.1
Radius Accounting ID: 135
Session ID: 135
```

```
Agent Circuit ID: SOUTHPARK:ge-1/0/0:100-20
Login Time: 2011-11-02 08:25:46 EDT
```

Note the `Session ID` field (third from bottom and boldface. Now let's use it in the `show dynamic-configuration` command:

```
admin@SOUTHPARK> show dynamic-configuration session information session-id 135
Session info:
  Accounting session ID: 135
  IP address: 12.1.1.15
  Logical system name: default
  Profile name: DYNSUB-DHCP-VOICE-AND-INET
  MAC address: 00:00:64:04:01:02
  NAS port type: 15
  Routing instance: default
  User name: SOUTHPARK:ge-1/0/0:100-20
  Interface name: ge-1/0/0.1073741831
  Dynamic-configuration state: 2
  Client session type: 1
  DHCP relay agent IP address: 12.1.1.1
  IFL type: 1
  Underlying logical-interface: ge-1/0/0.1073741831
  Client login time: 2011-11-02 08:25:46 EDT
  DHCP option: 35:01:01:52:1b:01
  VLAN tag: 20
  SVLAN tag: 100
  Agent Circuit ID: SOUTHPARK:ge-1/0/0:100-20
  Configuration bits: 0x87 0 0 0
Dynamic configuration:
      junos-cos-scheduler: voice-scheduler
          junos-cos-scheduler-tx: 512k
  junos-cos-shaping-rate: 5m
  junos-input-filter: police-5M
  junos-phy-ifd-name: ge-1/0/0
  junos-underlying-interface: ge-1/0/0.1073741831
```

Here you can see the `Dynamic configuration` as populated via the RADIUS VSAs. To validate that each subscriber is allocated a unique firewall policer, use the `show firewall` command:

```
admin@SOUTHPARK> show firewall
Filter: police-5M-ge-1/0/0.1073741831-in
Policers:
Name                                        Bytes           Packets
police-5M-all-ge-1/0/0.1073741831-in                  0                0

Filter: police-2M-ge-1/0/0.1073741832-in
Policers:
Name                                        Bytes           Packets
police-2M-all-ge-1/0/0.1073741832-in                  0                0
```

```
Filter: police-10M-ge-1/0/0.1073741833-in
Policers:
Name                                              Bytes              Packets
police-10M-all-ge-1/0/0.1073741833-in                  0                    0
---(more)---
```

To validate that each subscriber is allocated a unique traffic control profile, use the `show class-of-service traffic-control-profile` command:

```
admin@SOUTHPARK> show class-of-service traffic-control-profile
Traffic control profile: dynsub-TCP.o.ge-1/0/0.1073741831, Index: 503162287
  Shaping rate: 5000000
  Scheduler map: ge-1/0/0.1073741831.dynsub-smap-voice-and-inet

Traffic control profile: dynsub-TCP.o.ge-1/0/0.1073741832, Index: 503162284
  Shaping rate: 2000000
  Scheduler map: ge-1/0/0.1073741832.dynsub-smap-voice-and-inet

Traffic control profile: dynsub-TCP.o.ge-1/0/0.1073741833, Index: 503162285
  Shaping rate: 10000000
  Scheduler map: ge-1/0/0.1073741833.dynsub-smap-voice-and-inet
---(more)---
```

You can also use the `show class-of-service scheduler-map`. Here is an example of output for one of the subscribers:

```
Scheduler map: ge-1/0/0.1073741835.dynsub-smap-voice-and-inet, Index: 2167487620

Scheduler: inet-scheduler.ge-1/0/0.1073741835, Forwarding class: best-effort, Index:
662975508
  Transmit rate: remainder, Rate Limit: none, Buffer size: remainder, Buffer Limit:
none, Priority: low
  Excess Priority: unspecified
  Drop profiles:
    Loss priority   Protocol    Index    Name
    Low            any           1      <default-drop-profile>
    Medium low      any          1      <default-drop-profile>
    Medium high     any          1     <default-drop-profile>
    High           any           1     <default-drop-profile>

Scheduler: voice-scheduler.ge-1/0/0.1073741835, Forwarding class: expedited-
forwarding, Index: 331738323
Transmit rate: 512000 bps, Rate Limit: none, Buffer size: remainder, Buffer Limit:
none, Priority: strict-high
  Excess Priority: unspecified
  Drop profiles:
    Loss priority   Protocol    Index    Name
    Low            any           1   <default-drop-profile>
    Medium low     any          1   <default-drop-profile>
    Medium high    any          1   <default-drop-profile>
    High           any          1   <default-drop-profile>
```

You can use the `show interfaces` command on a subscriber's underlying interface to view the per-subscriber information:

```
admin@SOUTHPARK> show interfaces extensive ge-1/0/0.1073741844
  Logical interface ge-1/0/0.1073741844 (Index 334) (SNMP ifIndex 590) (Generation 165)
    Flags: SNMP-Traps 0x0 VLAN-Tag [ 0x8100.100 0x8100.24 ]  Encapsulation: ENET2
    Traffic statistics:
     Input  bytes  :          42497596
     Output bytes  :               604
     Input  packets:           1062428
     Output packets:                 2
    Local statistics:
     Input  bytes  :               652
     Output bytes  :               604
     Input  packets:                 2
     Output packets:                 2
    Transit statistics:
     Input  bytes  :          42496944          10000184 bps
     Output bytes  :                 0                 0 bps
     Input  packets:           1062426             31250 pps
     Output packets:                 0                 0 pps
    Protocol inet, MTU: 1978, Generation: 207, Route table: 0
      Flags: Sendbcast-pkt-to-re, Unnumbered
      Donor interface: lo0.0 (Index 322)
      Preferred source address: 12.1.1.1
      Input Filters: police-5M-ge-1/0/0.1073741844-in
    Protocol multiservice, MTU: Unlimited, Generation: 208, Route table: 0
      Policer: Input: __default_arp_policer__
```

And here you can see that this subscriber is sending 10Mbps to the MX; therefore, the Input bytes field is reporting about 10Mbps.

Another handy command is the `show interfaces queue` command, which shows you information about packet usage/queuing for a given customer, such as if packets are waiting to be transmitted, tail-dropped, etc. The following is the output for a subscriber's best-effort queue. You can display all of the forwarding-classes as well if you omit the forwarding-class filter.

```
admin@SOUTHPARK> show interfaces queue ge-1/0/0.1073741845 forwarding-class best-
effort
  Logical interface ge-1/0/0.1073741845 (Index 335) (SNMP ifIndex 591)
Forwarding classes: 16 supported, 4 in use
Egress queues: 8 supported, 4 in use
Burst size: 0
Queue: 0, Forwarding classes: best-effort
```

```
Queued:
  Packets           :            3112345              15627 pps
  Bytes             :          267661670           10752200 bps
Transmitted:
  Packets           :            2899946               14535 pps
  Bytes             :          249395356           10000664 bps
  Tail-dropped packets :             212399              1092 pps
  RED-dropped packets  :                 0                0 pps
   Low              :                0                  0 pps
   Medium-low        :                 0                 0 pps
   Medium-high       :                 0                 0 pps
   High             :                0                  0 pps
  RED-dropped bytes   :                 0                 0 bps
   Low              :                0                  0 bps
   Medium-low        :                 0                 0 bps
   Medium-high       :                 0                 0 bps
   High             :                0                  0 bps
```

Looking at the Logs

Let's cover a few common mistakes and how you can use the Junos traceoptions log files to troubleshoot dynamic IP profiles.

Missing RADIUS VSA

A common error occurs when RADIUS does not return an expected VSA value. For example, say you forgot to include the RADIUS VSA for the `$junos-cos-shaping-rate` value required by the traffic-control-profile configuration.

Here is what you would see if RADIUS *was successfully* returning all of the variables for the use-case in this chapter:

```
Nov  2 09:52:24 authd_update_session_dynamic_attributes: Client-session response-dyn-
attr:: name:junos-cos-shaping-rate, len:3, value: 5m, encode 0
Nov  2 09:52:24 authd_update_session_dynamic_attributes: Client-session response-dyn-
attr:: name:junos-cos-scheduler, len:16, value: voice-scheduler, encode 2
Nov  2 09:52:24 authd_update_session_dynamic_attributes: Client-session response-dyn-
attr:: name:junos-cos-scheduler-tx, len:5, value: 512k, encode 3
Nov  2 09:52:24 authd_update_session_dynamic_attributes: Client-session response-dyn-
attr:: name:junos-input-filter, len:10, value: police-5M, encode 0
```

If RADIUS does not send a VSA, then you will not see an entry in the log-file for it. For example, if RADIUS did not return the VSA for the `$junos-cos-shaping-rate`, all you would find in the log would be:

```
Nov  2 09:57:14 authd_update_session_dynamic_attributes: Client-session response-dyn-
attr:: name:junos-cos-scheduler, len:16, value: voice-scheduler, encode 2
Nov  2 09:57:14 authd_update_session_dynamic_attributes: Client-session response-dyn-
attr:: name:junos-cos-scheduler-tx, len:5, value: 512k, encode 3
Nov  2 09:57:14 authd_update_session_dynamic_attributes: Client-session response-dyn
attr:: name:junos-input-filter, len:10, value: police-5M, encode 0
```

Go back and include the proper RADIUS VSA for the `$junos-cos-shaping-rate` value required by the traffic-control-profile configuration.

Misconfigured Dynamic Profile

Another common mistake is accidentally misspelling something in your dynamic IP profile. For example, let's say you have a traffic-control-profile called *dynsub-TCP*:

```
[edit dynamic-profiles DYNSUB-DHCP-VOICE-AND-INET class-of-service]
admin@SOUTHPARK# show traffic-control-profiles
dynsub-TCP {
    scheduler-map dynsub-smap-voice-and-inet;
    shaping-rate "$junos-cos-shaping-rate";
}
```

But when you configure the `[interfaces]` stanza, you accidentally forget to capitalize the TCP in the name:

```
[edit dynamic-profiles DYNSUB-DHCP-VOICE-AND-INET class-of-service interfaces]
admin@SOUTHPARK# show
"$junos-interface-ifd-name" {
    unit "$junos-underlying-interface-unit" {
        output-traffic-control-profile dynsub-tcp;
    }
}
```

Note the difference in the two names: one is *dynsub-TCP* and the other is *dynsub-tcp*. Whoops! Junos commits this change without a warning or error.

To fix this kind of error, check the dhcplog for the keyword `NACK`:

```
admin@SOUTHPARK> show log dhcplog | match NACK
Nov  2 10:35:47 Profile Addition NACK (FAILED) for client 168, res 7, Errored daemon
"cosd", msg "Invalid configuration", retry "FALSE"
```

This entry indicates that there was something wrong with the class-of-service section of the dynamic IP profile, as indicated by the message: `Errored daemon "cosd"`.

You can check the cosd log file, and you would find the entry:

```
Nov  2 10:36:17 cos_dynamic_config_parse_basic: There is no tcp handle for tcp_name
dynsub-tcp
```

This entry indicates that there is no traffic-control-profile (tcp handle) for *dynsub-tcp*, because the real name, of course, is *dynsub-TCP*.

RADIUS Returns Invalid VSA Value

What happens if RADIUS returns a VSA with an invalid value? For example, say you have a SBR profile that returns a VSA for `$junos-input-filter` with an invalid value of *policer-5M,* rather than the correct value *police-5M* (error was additional "r" at the end). The value policer-5M is not a valid filter/policer since it's not in your configuration.

Again, check the dhcplog file for the keyword `NACK`:

```
admin@SOUTHPARK> show log dhcplog | match NACK
Nov  2 10:47:16 Profile Addition NACK (FAILED) for client 171, res 16, Errored daemon
"dfwd", msg "Could not find inet filter policer-5M.", retry "FALSE"
```

Another type of invalid VSA value occurs when you forget to put a space between value options. For example, let's say for the scheduler voice-scheduler `$junos-cos-scheduler-shaping-rate` VSA you accidentally entered in SBR "voice-scheduler T10512k," missing the space between *T10* and *512k*. If you look in the authlog file, you would find something like this:

```
Nov  2 11:13:48 Vendor-Id: 4874 Attribute Type:ERX-CoS-Scheduler-Parameter-Type(146)
Value:string-type  Length:24
Nov  2 11:13:48 authd_radius_parse_message:juniper-BRAS type:146
Nov  2 11:13:48 authd_lookup_int_var_mapping:Entering function:
Nov  2 11:13:48  variable name junos-cos-scheduler, flag 6, toggle , value 0
Nov  2 11:13:48 parse_tag_based_vsa: Tag based VSA contains no space
Nov  2 11:13:48 Tag-based VSA parsing failed vendor-id: 4874 type: 146
Nov  2 11:13:48 authd_radius_parse_message: Error parsing ERX avps
```

Notice the line stating `Tag based VSA contains no space!`

Logs are always revealing, and this book has tried to encourage you to use them as you fine tune your Dynamic Subscriber Management deployment.

Summary

Congratulations, you've reached the end of a very busy book filled with the fundamentals of creating dynamic IP profiles. You should now grasp the fundamentals of Juniper's Dynamic Subscriber Management solution, and be able to deploy it in your own network.

Along the way, in this last chapter, there were new troubleshooting skills using Junos commands and traceoptions log files, such as:

```
> show subscribers client-type dhcp
> show dynamic-configuration
> show firewall
> show class-of-service traffic-control-profile
> show class-of-service scheduler-map
> show interfaces
```

Let's recap everything you've covered in just one day!

- You should now understand the Juniper Network's Dynamic Subscriber Management solution, and how all the pieces work together.
- You should be able to install and use Juniper's Steel-Belted RADIUS.
- You can configure the MX Series with dynamic VLAN profiles for Customer VLAN and Service VLAN BRAS network applications.
- You can configure the MX to use DHCP local-server and external DHCP external services.
- And you can configure the MX with dynamic IP profiles to support differentiated services on a per-subscriber basis.

Remember this book is intended to get you *Up and Running*, not fully deployed. There's much more in the technical documentation, on J-Net, and on the Juniper web site. And the appendices that follow contain even more information and resources for you to read through. Check out the *Day One* and *This Week* libraries, too, and write to us on this book's web page at http://www.juniper.net/dayone.

Happy deploying! – Jeremy Schulman, Lenny Pollard, and John Rolfe

Appendix

Helpful Junos Commands to Remember

Commands relating to all dynamic VLAN interfaces and dynamic IP profile sessions:

```
> show subscribers
> show subscribers client-type dhcp
> show dynamic-configuration
> clear auto-configure interface
```

Commands relating to the subscriber sessions from AAA and DHCP:

```
> show network-access aaa subscriber
> clear network-access aaa subscriber username
> show dhcp server binding
> clear dhcp server binding
> show dhcp relay binding
> clear dhcp relay binding
```

Miscellaneous common Junos commands:

```
> show system license
> show route protocol access-internal
> show interface
> show firewall
> show class-of-service traffic-control-profile
> show class-of-service scheduler-map
```

Resources and Additional Reading

Chapter 2: Getting Started With the Customer VLAN Model

The main Juniper Networks techpubs webpage for all MX Subscriber Management documentation is: http://www.juniper.net/techpubs/en_US/junos/information-products/pathway-pages/subscriber-access/index.html.

The primary manual for MX Subscriber Management is the *Subscriber Access Configuration Guide*: http://www.juniper.net/techpubs/en_US/junos/information-products/topic-collections/config-guide-subscriber-access/config-guide-subscriber-access.pdf.

For information on VLAN based dynamic-interfaces, see: http://www.juniper.net/techpubs/en_US/junos/topics/task/configuration/vlan-dynamic-interfaces.html.

For information on packets that trigger auto-configuration, see: http://www.juniper.net/techpubs/en_US/junos/topics/reference/configuration-statement/accept-edit-interfaces.html.

For more information on DHCP local-server configurations, see: http://www.juniper.net/techpubs/en_US/junos/information-products/pathway-pages/subscriber-access/dhcp/subscriber-management-dhcp-local.html.

Information on DHCP relay configurations can be found at: http://www.juniper.net/techpubs/en_US/junos/information-products/pathway-pages/subscriber-access/dhcp/subscriber-management-dhcp-relay.html#configuration.

For information on unnumbered interfaces, see: http://www.juniper.net/techpubs/en_US/junos11.2/topics/usage-guidelines/interfaces-configuring-an-unnumbered-interface.html.

Information on basic dynamic VLAN interface profiles is here: http://www.juniper.net/techpubs/en_US/junos/topics/task/configuration/dynamic-profile-basic-subscriber-access.html.

For more information on Junos variables used by dynamic profiles, see: http://www.juniper.net/techpubs/en_US/junos/topics/reference/general/junos-predefined-variables-table.html.

Chapter 3: Getting Started with the Service VLAN Model

For more information on using IP-demux interfaces for dynamic IP profiles, go to: http://www.juniper.net/techpubs/en_US/junos/topics/task/configuration/subscriber-management-ip-demux-dynamic.html.

For information on IP-demux interfaces in general, refer to: http://www.juniper.net/techpubs/en_US/junos10.4/information-products/pathway-pages/config-guide-network-interfaces/ip-demultiplexing-interfaces.html#overview.

For information on the `$junos-subscriber-ip-address` variable, refer to: http://www.juniper.net/techpubs/en_US/junos/topics/task/configuration/subscriber-management-ip-demux-dynamic.html.

For more on DHCP groups using a dynamic-profile setting, see: http://www.juniper.net/techpubs/en_US/junos/topics/concept/dhcp-subscriber-access-dynamic-profile-attachment-overview.html and http://www.juniper.net/techpubs/en_US/junos/topics/task/configuration/dhcp-subscriber-access-dynamic-profiles-attaching.html.

And for more information on using Option82, see: http://www.juniper.net/techpubs/en_US/junos/topics/task/configuration/dhcp-subscriber-access-dhcp-relay-using-option-82-overview.html.

Chapter 5: Dynamic IP Profiles

For a completed listing of all Junos variables, see: http://www.juniper.net/techpubs/en_US/junos11.2/topics/reference/general/subscriber-management-predefined-variables-corresponding-radius.html.

For the *Day One* book on QoS, go to: http://www.juniper.net/us/en/community/junos/training-certification/day-one/fundamentals-series/deploying-basic-qos/.

For more on Interface Firewall Filters and Policers, see: http://www.juniper.net/techpubs/en_US/junos11.2/information-products/pathway-pages/config-guide-firewall-filter/index.html.

For information on traffic-control-profile settings, see: http://www.juniper.net/techpubs/en_US/junos11.2/topics/usage-guidelines/cos-configuring-traffic-control-profiles-for-shared-scheduling-and-shaping.html.

For information on scheduler settings, go to: http://www.juniper.net/techpubs/en_US/junos11.2/information-products/pathway-pages/cos/schedulers.html#configuration.

And for more information on dual-stack solutions, read this whitepaper: http://www.juniper.net/techpubs/en_US/junos11.2/information-products/topic-collections/design-guide-subscriber-dual-stack/subscriber-access-ipv4-ipv6-dual-stack.pdf.