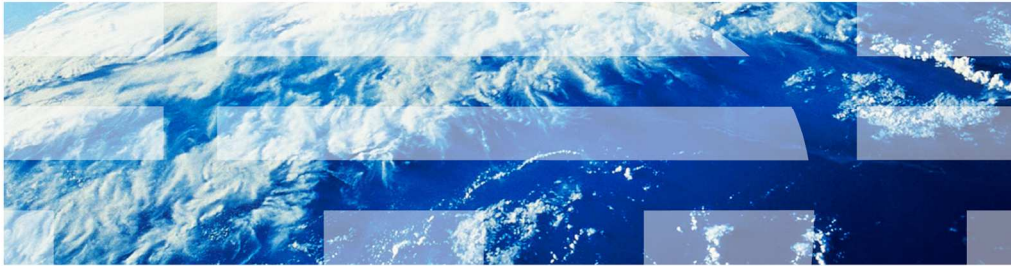


# z/OS V2R1 Communications Server

## IPv6 support for policy-based routing - Part 2



This presentation covers the IPv6 support that is added to z/OS® Communications Server V2R1 for the policy-based routing function. It is a continuation of another presentation which focuses on background information, the problem and solution. This presentation focuses on functional externals and provides some tips for common problems.

## Defining routing policy rules

- Configured in policy agent flat file using RoutingRule statement
- Information that can be configured
  - Source and destination IP address
  - Rule time condition and priority
  - Traffic descriptor

The definition of routing policy rules in the policy agent flat file is accomplished using the RoutingRule statement. Using this statement, you can configure the characteristics of the traffic for which the rule and its associated route tables are to be used. You can also specify the days and times when the rule is to be in effect and the priority of the rule relative to other overlapping rules.

## Defining routing policy rules continued

- Information that can be configured
  - Traffic descriptor
    - Protocol
    - Source and destination port
    - Job/application name
    - NetAccess security zone
    - Multi-level security (MLS) label

Traffic descriptor information that can be configured includes Protocol, Source and destination port, Job or application name, NetAccess security zone, and Multi-level security label.

## RoutingRule statement

- A routing rule can now match IPv4 traffic, IPv6 traffic, or both
- Two **existing** parameters indicate the IP version of a rule
  - IpSourceAddr
    - An IPv6 address or IPv6 prefix | **All**
  - IpDestAddr
    - An IPv6 address or IPv6 prefix | **All**

For both parameters, existing value 0.0.0.0/0 = All IPv4 addresses

To define a routing rule that will match IPv6 traffic, you will specify IPv6 values on two existing parameters of the RoutingRule statement. You can specify an IPv6 address for either the source address or the destination address of the rule. You can also specify the new value All, which is now the default, for either value. The value All indicates that the rule will match traffic with any IP address value (IPv4 or IPv6). The value ::/0 indicates that the rule will match traffic with any IPv6 address value. The value 0.0.0.0/0 indicates that the rule will match traffic with any IPv4 address value.

## Configuration Assistant – routing rule

**Do you want to match this rule based on the source IP address**

No - rule matching is not dependent on the source address

Yes - Specify the IP address:

Examples: x.x.x.x, x.x.x.x/yy, x.x.x.x-y.y.y.y  
x::x, x::x/yyyy, x::x-y::y (available beginning with V2R1)

Yes - Specify a group of addresses:

List of addresses

Address
Filter

There is no data to display.

Total: 0, Selected: 0

Yes - Select an address group from the list:

This slide shows the Configuration Assistant panel that you use to configure a source IP address value for a routing rule. The panel for configuring a destination IP address for a routing rule is very similar. You can now specify an IPv6 address for the IP address on both of these panels and you can include IPv6 addresses if you specify a group of IP addresses.

## Defining policy-based route tables

- Configured in policy agent flat file using RouteTable statement
- Information that can be configured
  - Static routes
  - Dynamic routing parameters
    - Specify the interfaces and next hop routers allowed for dynamic routes

The definition of policy-based route tables in the policy agent flat file is accomplished using the RouteTable statement. Using this statement, you can configure the static routes and dynamic routing parameters for the table, and a few advanced parameters for the table. The dynamic routing parameters that can be configured for a table limit the set of interfaces and next hop routers that can appear in dynamic routes added to the table.

## Defining policy-based route tables continued

- Information that can be configured
  - Table advanced parameters
    - What multipath algorithm is to be used for the route table?
    - Are path MTU updates to be applied to the route table?
    - Are routes to dynamic XCF addresses on other stacks to be added to the route table?

There are three advanced parameters that can be configured for a table. First, you can specify the multipath algorithm that you want to be used when multiple equal-cost routes exist for a destination. Next, you can indicate whether you want path MTU updates to be applied to the table. Finally, you can indicate whether you want routes to dynamic XCF addresses on other stacks in the sysplex to be added to the table.

## RouteTable statement for static routes

A static route can now be an IPv6 route

Three **existing** route parameters indicate the IP version of a route

- Destination IP address
  - An IPv6 address, an IPv6 prefix, an IPv6 default route
- Interface
  - An IPv6 interface name
- First hop IP address
  - An IPv6 address

To define an IPv6 static route for a policy-based route table, you will specify IPv6 values on three existing parameters of the RouteTable statement. For an IPv6 route on the RouteTable statement, you will specify an IPv6 address or an IPv6 prefix for the destination address or you will specify an IPv6 default route. You will specify the name of an IPv6 interface for the route interface. And finally, you will specify an IPv6 address for the route first hop address.



## Configuration Assistant for static routes

Configuration Assistant > PBR > Route Table > Static Entry

### New Static Route Table Entry

Details | Advanced

Entry is for:  IPv4  IPv6(available beginning with V2R1)

\* Destination address:  
 DEFAULT   
Examples: x::x, x::x/yyy


\* First hop address:  
 DIRECT   
Examples: x::x

\* Interface name:

\* MTU size:  
 DEFAULTSIZE  (bytes)

Allow this route entry to be replaced by OMPROUTE or router advertisements

OK Cancel



This slide shows the Configuration Assistant panel that you use to configure a static route for a policy-based route table. You can now indicate whether a route is an IPv4 route or an IPv6 route. You can specify IPv6 values in both the destination address field and the first hop address field. And finally, you can specify the name of an IPv6 interface in the interface name field.

## RouteTable statement for dynamic routing parameters

- Dynamic routing parameters can now specify the interfaces and next hop routers allowed for dynamic IPv6 routes
  - Dynamic IPv6 routes are routes from OMPROUTE and from IPv6 router advertisements
- Two **existing** parameters indicate the IP version of a dynamic routing parameter
  - Interface
    - An IPv6 interface name
  - First hop address
    - An IPv6 link-local address

To define an IPv6 dynamic routing parameter for a policy-based route table, you specify IPv6 values on two existing parameters of the RouteTable statement.

You specify the name of an IPv6 interface for the interface parameter.

If you choose to specify a first hop router for the dynamic routing parameter, you should specify an IPv6 address for the first hop address parameter. This address must be a link-local IPv6 address on the router.

IPv6 dynamic routing parameters control which IPv6 routes are added by OMPROUTE and which IPv6 routes are added as the result of router advertisement messages that are received by the stack. An IPv6 route will only be added to the route table if it uses an interface that is specified in one of the dynamic routing parameters defined for the table. If the dynamic routing parameter specifies a first hop address, that address must also match the first hop address of the route for the route to be added.

## Configuration Assistant for dynamic routing parameters

Configuration Assistant > PBR > Route Table > Dynamic Entry

### New Dynamic Route Table Entry

Entry is for:  IPv4  IPv6(available beginning with V2R1)

\*Interface name:

First hop address:  (optional)

Examples: x::x



This slide shows the Configuration Assistant panel that you use to configure a dynamic routing parameter for a policy-based route table. You can now indicate whether a dynamic routing parameter is an IPv4 parameter or an IPv6 parameter. You can specify the name of an IPv6 interface in the interface name field and an IPv6 address in the first hop address field.

## RouteTable statement – advanced settings

Each advanced setting is configured separately for IPv4 and IPv6

Three **new** advanced settings for IPv6

- Multipath6
  - Values are **UseGlobal**, PerConnection, PerPacket, or Disable
- IgnorePathMtuUpdate6
  - Values are **No** or Yes
- DynamicXCFRoutes6
  - Values are **No** or Yes
  
- Default value for each parameter shown in red

To indicate the IPv6 advanced settings for a policy-based route table you use one of three new parameters on the RouteTable statement. These parameters have names and functions that are similar to the parameters used to specify the IPv4 advanced settings for a table.

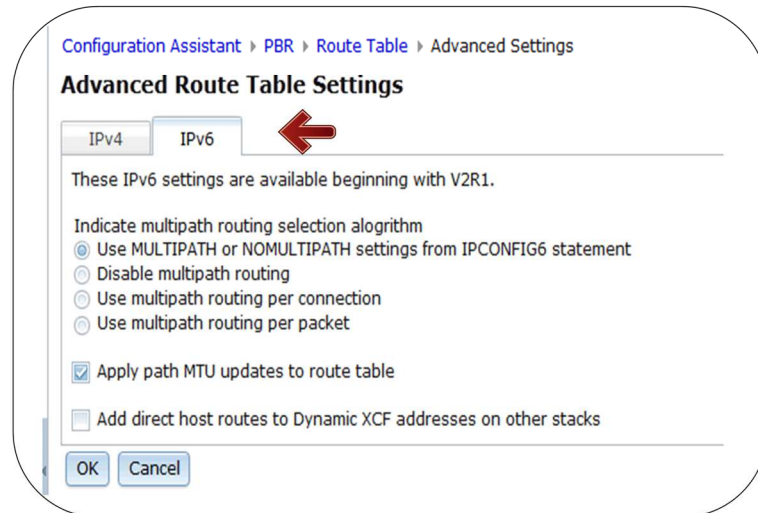
The new parameters are shown on this slide, along with the values that can be specified for each parameter. The default value for each parameter, used when the parameter is not configured, is shown in red.

The Multipath6 parameter allows you to indicate when the multipath algorithm used for IPv6 routes in a policy-based route table should be different from the algorithm being used for IPv6 routes in the main route table. You can indicate that either the perpacket or the perconnection multipath algorithm is to be used for the table. You can also indicate that no multipath processing is to be used for the table.

The IgnorePathMtuUpdate6 parameter allows you to control whether IPv6 ICMP Packet Too Big messages are applied to the routes in the table. You might want to ignore path MTU updates for a policy-based route table containing routes known to use paths that support large MTU values. If routes are in another route table for the same destinations and those routes might require a smaller path MTU value, you can use the IgnorePathMtuUpdate6 parameter. IgnorePathMtuUpdate6 Yes will ensure that a path MTU update that results from sending data on a small MTU route will not cause an update to the path MTU for the routes in the policy-based route table.

The DynamicXCFRoutes6 parameter allows you to control whether direct routes to IPv6 dynamic XCF addresses on other TCP/IP stacks are added to the route table.

## Configuration Assistant advanced route table settings



This slide shows the Configuration Assistant panel that you use to configure the advanced route table settings for a policy-based route table. As you can see, there are now separate tabs on this panel for configuring the IPv4 and IPv6 advanced table settings.

## Netstat ROUTE/-r (1 of 2)

- Existing Netstat ROUTE/-r command parameters
  - **PR** modifier displays policy-based (PBR) route tables
  - **ADDRTYPE IPV6** modifier displays only IPv6 routes
  - **RADV** modifier displays only IPv6 router advertisement routes
  - **IPAddr/-I** filter filters output using specified IP address

The Netstat ROUTE command displays stack routing information. Using four existing parameters on this command, you can display either policy-based routing information or IPv6 routing information.

## Netstat ROUTe/-r (2 of 2)

- Parameter combinations now allowed
  - **PR + ADDRTYPE IPv6** displays only IPv6 routes in PBR tables
  - **PR + RADV** displays only IPv6 router advertisement routes in PBR route tables
  - **PR + IPAddr/-I** (with IPv6 address) filters output in PBR route tables using specified IPv6 address

You can now use combinations of these four parameters to display IPv6 policy-based routing information. One new combination allows you to display only the IPv6 routes in policy-based route tables. Another new combination allows you to display only the IPv6 router advertisement routes in a policy-based route table. The final new combination allows you to filter the display of a policy-based route table to include only the routes to specific IPv6 destinations.

## Netstat ROUTE/-r report for PBR route table (long format - stack IPv6 enabled or long format requested)

- IPv6 table characteristics, IPv4 and IPv6 dynamic routing parameters, and IPv6 routes are now included

```

MVS TCP/IP NETSTAT CS V2R1          TCPIP Name: TCPCS          14:24:09
Policy Routing Table: prttable1
IgnorePathMtuUpdate: IPv4: No          IPv6: No
MultiPath:           IPv4: Conn(Policy) IPv6: Pkt(Profile)
DynamicXCFRoutes:   IPv4: No          IPv6: No
IPv4 Dynamic Routing Parameters
Interface            NextHop
-----
OSAQDIOLINK         9.67.115.65
IPv4 Destinations
Destination          Gateway          Flags          Refcnt          Interface
-----
Default             9.67.115.65    UGS           0000000002    OSAQDIOLINK
9.67.115.65/32     0.0.0.0        UHS           0000000000    OSAQDIOLINK
IPv6 Dynamic Routing Parameters
Interface            NextHop
-----
OSAQDIO46           fe80::9:67:115:65
IPv6 Destinations
DestIP:             Default
Gw:                 2001:0db8::206:2aff:fe71:4400
Intf:               OSAQDIO46          Refcnt: 0000000000
Flgs:               UGS                MTU: 1492
DestIP:             2001:0db8::9:67:115:13/128
Gw:                 ::
Intf:               OSAQDIO46          Refcnt: 0000000000
Flgs:               UD                 MTU: 1492

```

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The format of the Netstat ROUTE long format report has been modified to include IPv6 information. This is the report format that is displayed when the stack is enabled for IPv6 or the long format report is requested by the command.

The top of the report contains the characteristics of the table and has been modified to include both the IPv4 and the IPv6 characteristics.

The IPv4 dynamic routing parameters are not new for policy-based route tables, but they were previously not included in the Netstat ROUTE report. Any IPv4 dynamic routing parameters for the table are now displayed before any IPv4 routes in the table.

Following the IPv4 dynamic routing parameters and routes for the table, the report now displays any IPv6 dynamic routing parameters for the table, followed by any IPv6 routes in the table.



## Netstat ROUTE/-r report for PBR route table (short format – stack not IPv6 enabled)

- The dynamic routing parameters for the table are now included

```

MVS TCP/IP NETSTAT CS V2R1      TCP/IP Name: TCPCS          14:24:09
Policy Routing Table: prtable1
IgnorePathMtuUpdate: Yes      MultiPath: Conn(Policy)
DynamicXCFRoutes: No
Dynamic Routing Parameters
Interface      NextHop
-----
OSAQDIOLINK   9.67.115.65
Destination   Gateway      Flags      Refcnt      Interface
-----
Default       9.67.115.65 UGS        0000000002  OSAQDIOLINK
9.67.115.65/32 0.0.0.0     UHS        0000000000  OSAQDIOLINK
9.67.115.69/32 0.0.0.0     UH         0000000000  OSAQDIOLINK

```

The format of the Netstat ROUTE short format report has also been modified to include the IPv4 dynamic routing parameters. This is the report format that is displayed when the stack is not enabled for IPv6.

## DISPLAY TCPIP,,OMPROUTE

- Existing DISPLAY TCPIP,,OMPROUTE command parameters:
  - **RTTABLE** parameter displays IPv4 route table data
  - **RT6TABLE** parameter displays IPv6 route table data
  - **RTTABLE + PRtable** modifier
    - **PRtable ALL** displays IPv4 data from all PBR route tables
    - **PRtable name** displays IPv4 data from one PBR route table

The OMPROUTE display command displays OMPROUTE routing information. Using three existing parameters on this command, you can display either policy-based routing information or IPv6 routing information.

## DISPLAY TCPIP,,OMPROUTE continued

- Parameter combinations now allowed
  - **RT6TABLE + PRtable** modifier
    - **PRtable ALL** displays IPv6 data from all PBR route tables
    - **PRtable name** displays IPv6 data from one PBR route table

You can now use a new combination of these parameters to display IPv6 policy-based routing information. You can either display IPv6 routing information for all policy-based route tables or you can display IPv6 routing information for a single policy-based route table.

## OMPROUTE report for PBR route table

```
EZZ7979I IPV6 ROUTING TABLE 214
TABLE NAME: SECLOW2
DESTINATION: 6:6:6:6:6:6:6:6/128
NEXT HOP: FE80::6:7
TYPE: RIP          COST: 2          AGE: 10
DESTINATION: 2001:DB8:0:103::6/128
NEXT HOP: FE80::6:7
TYPE: RIP          COST: 2          AGE: 10
DESTINATION: 2001:DB8:0:103::7/128
NEXT HOP: ::
TYPE: DIR*        COST: 1          AGE: 66
DESTINATION: 2001:DB8:0:A10::/60
NEXT HOP: FE80::6:7
TYPE: RIP          COST: 2          AGE: 10
DESTINATION: 2001:DB8:0:A1B::/64
NEXT HOP: FE80::6:7
TYPE: RIP          COST: 2          AGE: 10
DESTINATION: 2001:DB8:0:A1C::/64
NEXT HOP: FE80::6:7
TYPE: RIP          COST: 2          AGE: 10
DESTINATION: 2001:DB8:0:C1C::/64
NEXT HOP: FE80::6:7
TYPE: RIP          COST: 2          AGE: 10
0 NETS DELETED
DYNAMIC ROUTING PARAMETERS
INTERFACE: MPCPTP7TO6      NEXT HOP: ANY
```

This example shows the format of a report displaying the OMPROUTE IPv6 information for a single policy-based route table. The table is identified at the top of the report, followed by the IPv6 routes in the table, and then the IPv6 dynamic routing parameters defined for the table.

## Policy agent

- Policy agent log files required for debugging problems
  - Policy agent should be run with a LogLevel of at least 127
  - If there is a policy problem, start policy agent with -d 32 which will log policies sent from policy agent to the stack
- Console log
- Use pasearch to view the routing rules, routing actions and route tables configured in policy
- For configuration problems, provide the policy agent configuration files
- For connectivity and other problems between policy agent and the TCP/IP stack, provide TCP/IP CTRACE (POLICY, INTERNET, and IOCTL options)

You can use the pasearch command to view the policies as they are known by policy agent. This is useful if you experience a problem with the processing of the policy configuration files by policy agent or the installation of the policies into the TCP/IP stack. The console log and the policy agent log files are useful in verifying each configuration statement that was processed, any errors encountered, and each policy that was installed in the TCP/IP stack.

For problem determination, the documentation provided should include any dumps generated. If the problem is configuration related, include the policy agent configuration files. If the problem seems to be in the communication between policy agent and the TCP/IP stack, include the TCP/IP CTRACE.

## TCP/IP stack

- Use Netstat commands to display policy-based routing information
- Use TCP/IP CTRACE with options POLICY and INTERNET
- When processing a dump with TCPIPSC
  - TCPIPSC ROUTE
    - PR option displays policy-based route tables
    - PD option displays policy-based route tables that have been recently deleted from policy
  - TCPIPSC POLICY, which includes routing policy information installed in the stack

You can use the Netstat command to view the route tables in addition to the policy rule and route table being used by each connection. This is useful if you experience a problem with the contents of the policy-based route tables in the stack or the way in which IP Routing is using the route tables. For problem determination, the documentation provided should include the TCP/IP CTRACE with options POLICY and INTERNET active.

If you have a dump of the TCP/IP address space, you can use TCPIPSC ROUTE and TCPIPSC POLICY to access policy-based routing data. The PR and PD options of TCPIPSC ROUTE allow for the display of policy-based route tables. The TCPIPSC POLICY report includes any Routing policy information installed in the stack.

## OMPROUTE

- Use OMPROUTE Display commands to view the policy-based route tables that are being managed by OMPROUTE
- Many OMPROUTE messages include the name of the route table being processed
  - EZBMAIN is the name used for the main route table

You can use the OMPROUTE Display command to view the versions of the route tables within OMPROUTE. This might be useful if you experience a problem with the management of the dynamic routes in policy-based route tables by OMPROUTE.

When diagnosing OMPROUTE it is often helpful to review OMPROUTE messages on the MVS console or in the OMPROUTE debug files. Many of the OMPROUTE messages include the name of the associated route table. The name of the main route table is EZBMAIN. This allows you to focus on the messages that apply to the route table with which you have a concern.

## Things to think about (1 of 2)

- If you are presently using policy-based routing on a stack that is being run as a dual-mode stack (IPv4 and IPv6)
  - Be aware of routing policy rules. Any rules that specify neither source IP addresses nor destination IP addresses apply to both IPv4 and IPv6 packets that match the other rule characteristics
  - To make the rule to continue to apply to only IPv4 packets, modify the rule. The rule should be modified to specify either a source or destination IP address of 0.0.0.0/0

If you have already implemented policy-based routing for your IPv4 traffic and you are running your stack as a dual-mode stack, be aware of the routing policy rules. Any routing policy rules that specify neither source IP addresses nor destination IP addresses now apply to both IPv4 and IPv6 packets that match the other rule characteristics.

To allow those rules to continue to apply to only IPv4 packets that match the rule characteristics, you need to modify the rule to specify the value 0.0.0.0/0 for either the source or destination address.



## Things to think about (2 of 2)

- Dynamic routes are maintained for each policy-based route table that is using dynamic routing (DynamicRoutingParms are specified in the route table configuration)
- There is an OMPROUTE performance cost for each table using dynamic routing
- Avoid large numbers of policy-based route tables using dynamic routing
- Avoid duplicate route tables

Each policy-based route table that is configured for dynamic routing adds additional processing to OMPROUTE. The appropriate dynamic routes to be added to each table must be calculated using the network topology learned by OMPROUTE together with the dynamic routing parameters configured for the table. Duplicate route tables should be avoided and this is ensured if IBM Configuration Assistant is used to create your policy agent flat-files. In addition, you should avoid having large numbers of policy-based route tables that use dynamic routing.

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