IPv4/IPv6 Tunnels over IPv6

bintec-Dm 809-I

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bintec-Dm 719-I IP Tunnel

bintec-Dm 805-I IPv6 Addressing

bintec-Dm 810-I IPv6 over IPv4 Tunnel

Chapter 1 Introduction

1.1 Requirements

This manual describes the configuration the router needs to establish IPv6 tunneling. Specifically it will describe two types of tunnels: IPv4 over IPv6 and IPv6 over IPv6. The aim of this manual is to establish tunnels between the IPv4/IPv6 domain networks through IPv6 domain networks. To do this, IPv4/IPv6 packets are encapsulated in IPv6 packets.

In this section we are going to describe the need for IPv4/IPv6 over IPv6 tunnels. For further information on these tunnels, we recommend reading RFC2473.

IPv4 over IPv6 tunneling emerged due to the need to maintain compatibility between the new IPv6 infrastructures and the large number of IPv4 hosts and routers currently deployed. This is a transition mechanism needed to ensure interoperability between the new IPv6 networks with the available IPv4 infrastructures. This allows both protocols to co-exist without the immediate need to upgrade the IPv4 infrastructure to the new IPv6 protocol.

Figure 1 shows this need, where in order to send a packet from an IPv4 network to a destination located in another IPv4 network it needs to pass through the IPv6 infrastructure.

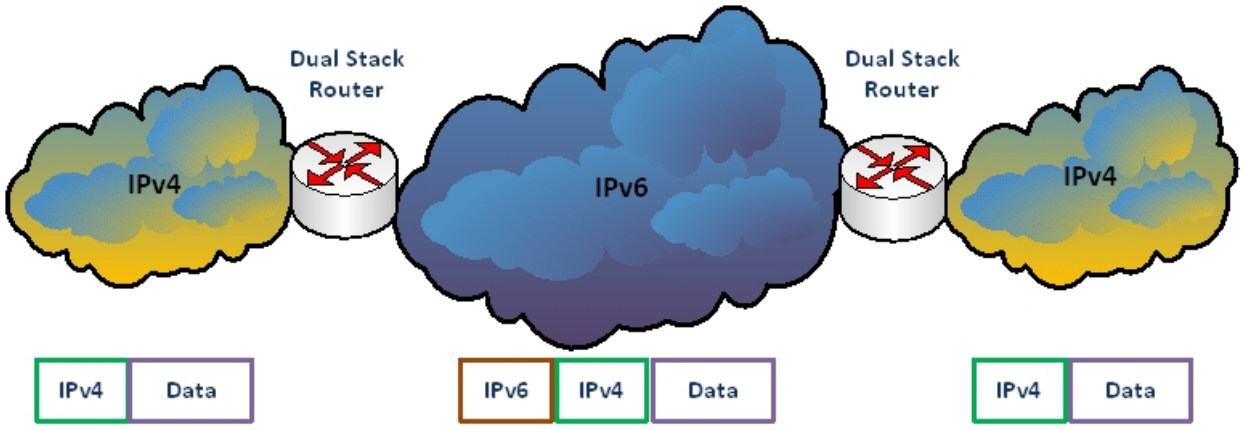

Fig. 1: Establishing IPv4 over IPv6 tunnel between the Dual Stack routers.

IPv6 over IPv6 tunneling arose out of the need to encapsulate IPv6 packets in new IPv6 packets. Figure 2 shows an example of this necessity; where two private networks using ULA *(Unique Local Address* RFC 4193) IPv6 addresses need to send packets through the IPv6 global network. A ULA address is an IPv6 address with prefix fc00::/7, which can only be used in private IPv6 networks. Therefore, ULA addresses cannot be used for routing in the IPv6 Internet global network as they require IPv6 over IPv6 tunneling at both ends.

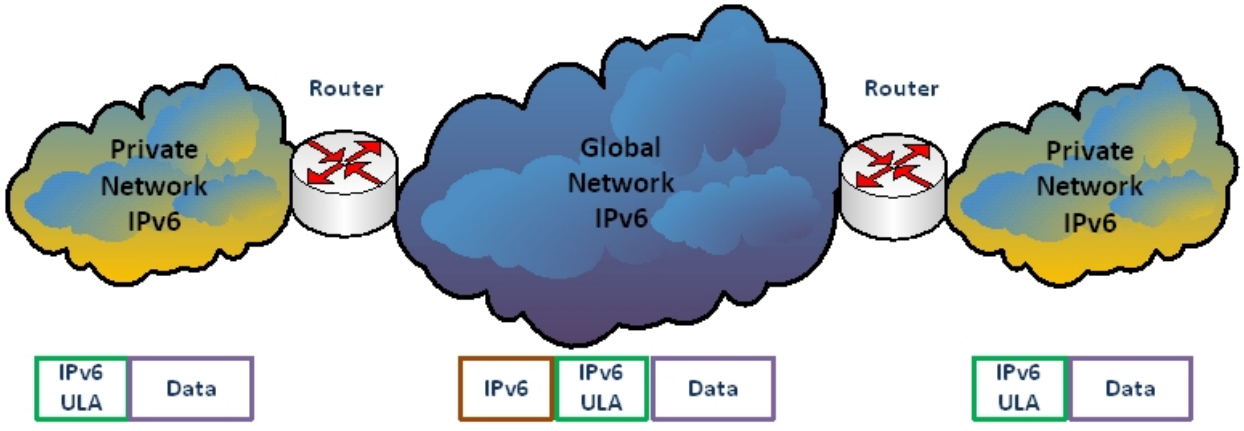

Fig. 2: Establishing an IPv6 over IPv6 tunnel between two routers.

1.2 Tunneling over IPv6: Format

1.2.1 IPv4 over IPv6 tunnel

In IPv4 over IPv6 tunneling, the IPv4 packets are encapsulated in IPv6 packets so the IPv4 packet is contained in the IPv6 data. This kind of encapsulation must be executed by a *Dual Stack* (DS) device located on the border between the IPv6 network and the IPv4 infrastructure. A DS device can support both protocols: IPv4 and IPv6.

Figure 3 shows the format of the IPv4 packet encapsulated in an IPv6 packet. This is made up of the IPv6 header, followed by the IPv6 extension headers, the IPv4 header and the data (both in the IPv6 packet's data field). The value of the type of IPv6 header protocol assigned in RFC 4213 for this type of encapsulation is 0x0800. The source and destination IPv6 addresses are those from the *Dual Stack* routers where the tunnel is established.

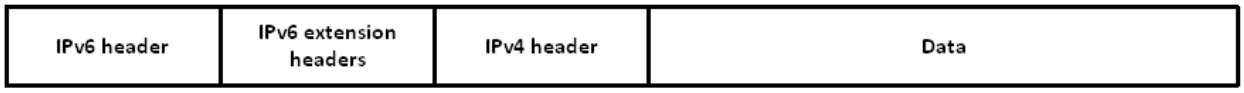

Fig. 3: IPv4 packet encapsulated in an IPv6 packet

You need to bear in mind that by using IPv4 over IPv6 tunneling, you reduce the MTU (*Maximum Transmission Unit*) for an interface by a number of bytes equal to the length of the IPv6 header and the IPv6 extension headers.

1.2.2 IPv6 over IPv6 tunneling

In IPv6 over IPv6 tunneling, the IPv6 packets are encapsulated in IPv6 packets. Consequently, the encapsulation procedure is similar to that of IPv4 over IPv6. The value of the type of IPv6 header protocol assigned in RFC 4213 for this type of encapsulation is 0x86DD.

Chapter 2 Configuration

2.1 Configuring IPv4 over IPv6 tunnels

In order to configure an IPv4 over IPv6 tunnel, you first need to create an IP tunnel interface; consequently you need to enter **"add device tnip <tunnel identifier>"** in the global configuration menu:

Example:

```
Config>add device tnip 1
Added TNIP interface tnip1
Config>
```

To subsequently access the configuration, simply enter **"network tnipX"**, where **X** represents the tunnel identifier:

```
Config>network tnip1

-- IP Tunnel Net Configuration --
tnip1 config>
```

In this manual we are only going to detail the commands available for the tnip interfaces which are implied in the above described tunnel. The rest of the commands available for a tnip interface can be found in manual bintec-Dm719-I IP Tunnel and bintec-Dm810-I IPv6 over IPv4 Tunnel.

The basic commands used to configure the IPv6 over IPv4 tunnels are as follows:

2.1.1 MODE

Permits you to select the encapsulation mode. For a tunnel over IPv6, the mode must be '**ipv6**'.

Syntax:

```
tnip1 config>mode ?
  gre       Generic Routing Encapsulation Protocol
  ipv6      IPv4 or IPv6 over IPv6 tunnel
  ipv6ip    IPv6 over IPv4 tunnel
tnip1 config>
```

Example:

```
tnip1 config>mode ipv6
tnip1 config>
```

2.1.2 SOURCE

Allows you to configure the IPv6 source address for the IPv4 over IPv6 tunnel. The IPv6 address must coincide with one of the interfaces configured in the router (Ethernet, PPP, Loopback, etc.).

The IPv6 address configured as destination in the device that is at the other end of the tunnel must also coincide. If the IPv6 address configured as source does not match the one configured as destination at the other end of the router, then a link can never exist.

The tunnel source can be an IPv6 address or an interface name. In the case of IPv4 addresses, the device will respond with an error message:

Syntax:

```
tnip1 config>source ?
  <a.b.c.d>      Tunnel source address
  <a::b>         Ipv6 address
  <interface>    Tunnel source interface
tnip1 config>
```

Example1:

```
tnip1 config>source 2001:db8:0:1::1
tnip1 config>
```

Example2:

```
tnip1 config>source ethernet0/0
tnip1 config>
```

Example3:

```
tnip1 config>source 10.10.10.10
CLI Error: Cannot assign assign ipv4 address to an ipv6 tunnel
CLI Error: Command error
tnip1 config>
```

When the tunnel source is an interface, an IPv6 address must be configured and active. When the source interface has several IPv6 addresses, the tunnel source is chosen based on the tunnel's destination address.

Command history:

Release	Modification
11.01.04	As of version 11.01.04, an interface can be configured as source on IPv6 tunnels.

2.1.3 DESTINATION

Configures the IPv6 destination address for the IPv4 over IPv6 tunnel. This must coincide with the IPv6 address configured as source for the tunnel in the router at the other end. If the IPv6 destination address for the tunnel does not coincide with that configured as source at the other end, the packets sent to said router are dropped for not pertaining to the tunnel.

A route towards the IPv6 destination address must exist otherwise the packets in the tunnel cannot be routed.

Syntax:

```
tnip1 config>destination ?
  <a.b.c.d>    Ipv4 format
  <a::b>       Ipv6 address
tnip1 config>
```

Example:

```
tnip1 config>destination 2001:db8:0:2::1
tnip1 config>
```

2.1.4 ENABLE

Enables the tunnel interface. By default the tunnel is inactive.

Syntax:

```
tnip1 config>enable ?
  <cr>
tnip1 config>
```

Example:

```
tnip1 config>enable
tnip1 config>
```

2.1.5 LIST

Displays the configuration for the IPv4 over IPv6 tunnel.

Example:

```
tnip1 config>list
Tunnel mode: ipv4 or ipv6 over ipv6 (enabled)
Tunnel source 2001:db8:0:1::1, destination 2001:db8:0:2::1
QoS preclassify: disabled
Keepalive disabled
NHRP type of service: 0
tnip1 config>
```

Tunnel mode:	indicates the type of encapsulation and the state (enabled/disabled).
Tunnel source / destination:	tunnel source / destination IPv6 addresses
QoS preclassify:	indicates if the BRS pre-classification is enabled.
Keepalive:	displays the “keepalive” maintenance configuration.
NHRP type of service:	displays the type of service selected for the NHRP packets.

2.2 Configuring IPv6 over IPv6 tunnels

The basic steps to follow to configure an IPv6 over IPv6 tunnel are similar to those described for configuring an IPv4 over IPv6 tunnel, except that you need to add a new step:

2.2.1 IPV6 ENABLE

Enable the IPv6 protocol in the interface. By default this protocol is disabled in the interface. This command is explained in manual bintec-Dm805-I IPv6 Addressing.

Syntax:

```
tnip1 config>ipv6 enable
```

Example:

```
tnip1 config>ipv6 enable
tnip1 config>
```

Another way of enabling IPv6 in the interface is by configuring an IPv6 address in the interface using the ‘ **ipv6 address**’ command. This is also detailed in manual bintec-Dm805-I IPv6 Addressing.

Chapter 3 Monitoring

3.1 Monitoring tunnels over IPv6

Tunnel monitoring is explained in manuals bintec-Dm719-I IP Tunnel and bintec-Dm810-I IPv6 over IPv4 Tunnel. These show two examples for tnip interface monitoring both for IPv4 and for IPv6 respectively.

```
Router1 *monitor
Console Operator
Router1 +protocol ip
-- IP protocol monitor --
Router1 IP+interface-addresses
Interface IP Addresses:
-----------------------
ethernet0/1        192.168.212.200/23
tnip1              192.0.0.1/29

Special IP Addresses:
---------------------
internal-address    0.0.0.0
management-address  0.0.0.0
router-id           0.0.0.0
global-address      192.168.212.200
Router1 IP+
Router1 +protocol ipv6

-- IPv6 protocol monitor --

Router1 IPv6+list interface tnip1

Interface tnip1:
----------------------------
IPv6 is Enabled
Link-local address is:  fe80::2a0:26ff:fe28:3918 [PERM]

Global unicast address(es):
  fdfe:dcba:9876::1/48 cfg [PERM/UP]

Joined group address(es):
  ff02::1:ff28:3918
  ff02::1:ff00:1
  ff02::1

MTU is 1572 bytes
ICMP error messages limited to one every 1000 milliseconds
ICMP redirects are enabled
ICMP unreachables are sent
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds
There is no default router

IPv6 Prefix Advertisements tnip1
Codes: A - Address, P - Prefix-Advertisement, N - Not advertised,
       [L] - On-link, [A] - Autonomous

A  fdfe:dcba:9876::/48  [LA]  Valid lifetime: 2592000, preferred lifetime: 604800
Router1 IPv6+
```

Events relative to the IPv4/IPv6 over IPv6 tunnels can be found in the “TNIP” subsystem.

Chapter 4 Configuring Tunnels over IPv6: Example

4.1 Configuring an IPv4 over IPv6 tunnel

4.1.1 Steps to follow at each end of the tunnel

- Create the **tnip** interface using the **add device tnip <tunnel-id>** configuration command (this configuration command is global).
- Configure the IPv6 address in the interface through which the packets are going to exit the tunnel.
- Configure the tunnel's encapsulation mode as IPv4/IPv6 over IPv6 through the **mode ipv6** command.
- Configure the tunnel source using the **source** command and the tunnel source IPv6 address, or the name of the source interface.
- Configure the tunnel destination using the **destination** command and the tunnel destination IPv6 address. Add the necessary IP route in order to reach said destination.
- Enable the IPv4 protocol in the tunnel, adding an IPv4 address (or adding the **ip address unnumbered** command).
- Enable the tunnel using the **enable** command.
- Add the IPv4 routes for those networks that must be accessible through the tunnel by setting the tunnel interface as next hop whenever necessary.
- Save and restart.

4.1.2 Example

Configure an IPv4 over IPv6 tunnel between two routers, so networks IPv4 192.168.1.0/24 and 192.168.2.0/24 can communicate and to which their Loopback interfaces pertain respectively; as shown in Figure 4.

Fig. 4: IPv4 over IPv6 tunnel.

4.1.2.1 Configuring Router1

Add the IP tunnel interface and the Loopback interface:

```
*P 4
Config>set hostname Router1
Router1 Config>add device tnip 1
Router1 Config>add device loopback 1
Router1 Config>
```

Configure the IPv6 address for the tunnel output interface:

```
Router1 Config>network ethernet0/0

-- Ethernet Interface User Configuration -
Router1 ethernet0/0 config>ipv6 address 2001:db8:0:1::1/32
Router1 ethernet0/0 config>exit
Router1 Config>
```

Configure the IPv4 address in the Loopback1 interface:

```
Router1 Config>network loopback1

-- Loopback interface configuration --
Router1 loopback1 config>ip address 192.168.1.1 255.255.255.0
```

```
Router1 Config>
```

Subsequently configure the IPv4 over IPv6 tunnel:

```
Router1 Config>network tnip1

-- IP Tunnel Net Configuration
Router1 tnip1 config>mode ipv6
Router1 tnip1 config>source 2001:db8:0:1::1
Router1 tnip1 config>destination 2001:db8:0:2::1
Router1 tnip1 config>ip address unnumbered loopback1
Router1 tnip1 config>enable
Router1 tnip1 config>exit
Router1 Config>
```

Add the necessary IPv4 route:

```
Router1 Config>protocol ip

-- Internet protocol user configuration --
Router1 IP config>route 192.168.2.0 255.255.255.0 tnip1
Router1 IP config>exit
Router1 Config>
```

Once you've carried out all these configuration steps, you need to save the configuration and restart the device.

The final configuration will look like this:

```
Router1 Config$show config
;
   set hostname Router1
   add device tnip 1
   add device loopback 1
;
   network ethernet0/0
; -- Ethernet Interface User Configuration --
      ipv6 address 2001:db8:0:1::1/32
   exit
;
;
   network tnip1
; -- IP Tunnel Net Configuration --
      ip address unnumbered loopback1
;
      enable
      mode ipv6
      source 2001:db8:0:1::1
      destination 2001:db8:0:2::1
   exit
;
;
   network loopback1
; -- Loopback interface configuration --
      ip address 192.168.1.1 255.255.255.0
;
   exit
;
;
   protocol ip
; -- Internet protocol user configuration --
      route 192.168.2.0 255.255.255.0 tnip1
;
   exit
;
;
   dump-command-errors
   end
Router1 Config$
```

4.1.2.2 Configuring Router2

Add the IP tunnel interface and the Loopback interface:

```
*P 4
Config>set hostname Router2
Router2 Config>add device tnip 1
Router2 Config>add device loopback 1
Router2 Config>
```

Configure the IPv6 address for the tunnel output interface:

```
Router2 Config>network ethernet0/0

-- Ethernet Interface User Configuration -
Router2 ethernet0/0 config>ipv6 address 2001:db8:0:2::1/32
Router2 ethernet0/0 config>exit
Router2 Config>
```

Configure the IPv4 address in the Loopback1 interface:

```
Router2 Config>network loopback1

-- Loopback interface configuration --
Router2 loopback1 config>ip address 192.168.2.1 255.255.255.0
Router2 Config>
```

Subsequently configure the IPv4 over IPv6 tunnel:

```
Router2 Config>network tnip1

-- IP Tunnel Net Configuration
Router2 tnip1 config>mode ipv6
Router2 tnip1 config>source 2001:db8:0:2::1
Router2 tnip1 config>destination 2001:db8:0:1::1
Router2 tnip1 config>ip address unnumbered loopback1
Router2 tnip1 config>enable
Router2 tnip1 config>exit
Router2 Config>
```

Add the necessary IPv4 route:

```
Router2 Config>protocol ip

-- Internet protocol user configuration --
Router2 IP config>route 192.168.1.0 255.255.255.0 tnip1
Router2 IP config>exit
Router2 Config>
```

Once you've carried out all these configuration steps, you need to save the configuration and restart the device.

The final configuration will look like this:

```
Router2 Config$show config
;
   set hostname Router2
   add device tnip 1
   add device loopback 1
;
   network ethernet0/0
; -- Ethernet Interface User Configuration --
      ipv6 address 2001:db8:0:2::1/32
   exit
;
;
   network tnip1
; -- IP Tunnel Net Configuration --
      ip address unnumbered loopback1
;
      enable
      mode ipv6
```

```
      source 2001:db8:0:2::1
      destination 2001:db8:0:1::1
   exit
;
;
   network loopback1
; -- Loopback interface configuration --
      ip address 192.168.2.1 255.255.255.0
;
   exit
;
;
   protocol ip
; -- Internet protocol user configuration --
      route 192.168.1.0 255.255.255.0 tnip1
;
   exit
;
Router2 Config$
```

4.2 IPv6 over IPv6 tunnel

4.2.1 Steps to follow at each end of the tunnel

- Create the **tnip** interface using the **add device tnip <tunnel-id>** configuration command (this configuration command is global).
- Configure the IPv6 address in the interface through which the packets are going to exit the tunnel.
- Configure the tunnel's encapsulation mode as IPv4/IPv6 over IPv6 through the **mode ipv6** command.
- Configure the tunnel source using the **source** command and the tunnel source IPv6 address, or the name of the source interface.
- Configure the tunnel destination using the **destination** command and the tunnel destination IPv6 address. Add the necessary IP route in order to reach said destination.
- Enable the IPv6 protocol in the interface through the **ipv6 enable** command.
- Enable the tunnel using the **enable** command.
- Add the IPv6 routes for those networks that must be accessible through the tunnel by setting the tunnel interface as next hop whenever necessary.
- Save and restart.

4.2.2 Example

Configure an IPv4 over IPv6 tunnel between two routers, so networks IPv6 fdfe:dcba:9876::/48 and fdfe:dcba:9875::/48 can communicate, and to which their Loopback interfaces pertain respectively; as shown in Figure 5.

Fig. 5: IPv6 over IPv6 tunnel.

4.2.2.1 Configuring Router1

Add the IP tunnel interface and the Loopback interface:

```
*P 4
Config>set hostname Router1
Router1 Config>add device tnip 1
```

```
Router1 Config>add device loopback 1
Router1 Config>
```

Configure the IPv6 address for the tunnel output interface:

```
Router1 Config>network ethernet0/0

-- Ethernet Interface User Configuration –
Router1 ethernet0/0 config>ipv6 address 2001:db8:0:1::1/32
Router1 ethernet0/0 config>exit
Router1 Config>
```

Configure the IPv6 address in the Loopback1 interface:

```
Router1 Config>network loopback1

-- Loopback interface configuration --
Router1 loopback1 config>ipv6 address fdfe:dcba:9876::1/48
Router1 loopback1 config>exit
Router1 Config>
```

Subsequently configure the IPv6 over IPv6 tunnel:

```
Router1 Config>network tnip1

-- IP Tunnel Net Configuration
Router1 tnip1 config>mode ipv6
Router1 tnip1 config>source 2001:db8:0:1::1
Router1 tnip1 config>destination 2001:db8:0:2::1
Router1 tnip1 config>ipv6 enable
Router1 tnip1 config>enable
Router1 tnip1 config>exit
Router1 Config>
```

Add the necessary IPv6 route:

```
Router1 Config>protocol ipv6

-- IPv6 user configuration --
Router1 IPv6 config>route fdfe:dcba:9875::/48 interface tnip1
Router1 IPv6 config>exit
Router1 Config>
```

Once you've carried out all these configuration steps, you need to save the configuration and restart the device.

The final configuration will look like this:

```
Router1 Config$show config
;
   set hostname Router1
   add device tnip 1
   add device loopback 1
;
   network ethernet0/0
; -- Ethernet Interface User Configuration --
      ipv6 address 2001:db8:0:1::1/32
   exit
;
;
   network tnip1
; -- IP Tunnel Net Configuration --
      enable
      ipv6 enable
      mode ipv6
      source 2001:db8:0:1::1
      destination 2001:db8:0:2::1
   exit
;
   network loopback1
; -- Loopback interface configuration --
      ipv6 address fdfe:dcba:9876::1/48
```

```
   exit
;
   protocol ipv6
; -- IPv6 user configuration --
      route fdfe:dcba:9875::/48 interface tnip1
   exit
;
Router1 Config$
```

4.2.2.2 Configuring Router2

Add the IP tunnel interface and the Loopback interface:

```
*P 4
Config>set hostname Router2
Router2 Config>add device tnip 1
Router2 Config>add device loopback 1
Router2 Config>
```

Configure the IPv6 address for the tunnel output interface:

```
Router2 Config>network ethernet0/0

-- Ethernet Interface User Configuration -
Router2 ethernet0/0 config>ipv6 address 2001:db8:0:2::1/32
Router2 ethernet0/0 config>exit
Router2 Config>
```

Configure the IPv6 address in the Loopback1 interface:

```
Router2 Config>network loopback1

-- Loopback interface configuration --
Router2 loopback1 config>ipv6 address fdfe:dcba:9875::1/48
Router2 loopback1 config>exit
Router2 Config>
```

Subsequently configure the IPv6 over IPv6 tunnel:

```
Router2 Config>network tnip1

-- IP Tunnel Net Configuration
Router2 tnip1 config>mode ipv6
Router2 tnip1 config>source 2001:db8:0:2::1
Router2 tnip1 config>destination 2001:db8:0:1::1
Router2 tnip1 config>ipv6 enable
Router2 tnip1 config>enable
Router2 tnip1 config>exit
Router2 Config>
```

Add the necessary IPv6 route:

```
Router2 Config>protocol ipv6

-- IPv6 user configuration --
Router2 IPv6 config>route fdfe:dcba:9876::/48 interface tnip1
Router2 IPv6 config>exit
Router2 Config>
```

Once you've carried out all these configuration steps, you need to save the configuration and restart the device.

The final configuration will look like this:

```
Router2 Config$show config
;
   set hostname Router2
   add device tnip 1
   add device loopback 1
;
   network ethernet0/0
; -- Ethernet Interface User Configuration --
```

```
      ipv6 address 2001:db8:0:2::1/32
   exit
;
;
   network tnip1
; -- IP Tunnel Net Configuration --
      enable
      ipv6 enable
      mode ipv6
      source 2001:db8:0:2::1
      destination 2001:db8:0:1::1
   exit
;
   network loopback1
; -- Loopback interface configuration --
      ipv6 address fdfe:dcba:9875::1/48
   exit
;
   protocol ipv6
; -- IPv6 user configuration --
      route fdfe:dcba:9876::/48 interface tnip1
   exit
;
Router2 Config$
```