



# DMVPN Overview

---



# Module Overview

- ▶ Technology Overview
- ▶ DMVPN Data Plane
- ▶ DMVPN Control Plane



# DMVPN Overview

---

## ▷ Scalable solution for centrally managed VPNs

- ▶ Easy to deploy and manage
- ▶ Hub and Spoke Architecture
  - ▶ On-demand Spoke-Spoke tunnels
- ▶ Dynamic Routing
  - ▶ Pseudo-Broadcast
- ▶ Redundancy
  - ▶ Dual Hub
- ▶ Not secure
  - ▶ IPsec or GETVPN

# DMVPN Data Plane

- ▷ DMVPN uses GRE tunneling
  - ▶ Requires an additional network and addressing
    - ▶ Non-Broadcast Multi Access (NBMA)
      - ▶ Public „underlay”
    - ▶ VPN
      - ▶ Private „overlay”
      - ▶ Needed for routing
  
- ▷ Multipoint GRE (mGRE)
  - ▶ Represents one or more VPN

# DMVPN Control Plane

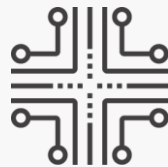
---

## ▷ Next-Hop Resolution Protocol (NHRP)

- ▶ Allows Spokes to join to a DMVPN network/cloud
  - ▶ Registration
- ▶ Provides Spokes with IP address information
  - ▶ VPN to NBMA

## ▷ DMVPN Routing Protocol

- ▶ IGP or BGP



# DMVPN Routing

---



# Module Overview

- ▶ DMVPN Routing Overview
- ▶ DMVPN Routing Protocols



# DMVPN Routing Overview

---

## ▷ Static Routing is not an option for DMVPN

- ▶ IGP or BGP
  - ▶ Adjacencies/peerings are built Spoke-Hub

## ▷ Requirements

- ▶ Split Horizon
  - ▶ Disable unless Summarizing to the default route
- ▶ Next-Hop
  - ▶ Hub vs prefix-originating Spoke

# DMVPN Routing – RIP

- ▶ Distance Vector protocols are preferred
  - ▶ Arbitrary hierarchy
    - ▶ Easy to summarize
  - ▶ No topology data flooding
    - ▶ No distributed (re)calculations
  
- ▶ RIP is not a great choice
  - ▶ Disable Split Horizon with **no ip split-horizon**
  - ▶ Next-Hop behavior cannot be changed

# DMVPN Routing – EIGRP

- ▷ Recommended option for DMVPN
  - ▶ Scalable Distance Vector protocol
  - ▶ Well-suited for Hub & Spoke designs
    - ▶ EIGRP Stub
  - ▶ Disable Split Horizon with **no ip split-horizon eigrp**
    - ▶ Named Mode : **no split-horizon**
  - ▶ Original Next-Hop can be maintained with **no ip next-hop-self eigrp**
    - ▶ Named Mode : **no next-hop-self**

# DMVPN Routing - OSPF

- ▶ Link-State flooding may be problematic in DMVPN
  - ▶ Hub and Spoke tunnel interfaces must be in the same area
    - ▶ May cause a lot of SPF re-runs in large-scale designs
  - ▶ Strict hierarchy limits Summarization/Filtering options
  - ▶ Does not use Split Horizon
  - ▶ OSPF Network Type controls the Next-Hop
    - ▶ Point-to-Multipoint
    - ▶ Broadcast
      - ▶ Requires Hub to be the DR (`ip ospf priority 0` on the Spokes)

# DMVPN Routing - BGP

## ▶ Useful in largest deployments

### ▶ eBGP

- ▶ Automatically modifies the Next-Hop when sending updates
- ▶ May require 32-bit AS numbers
  - ▶ Single AS deployments (Spokes) are feasible but require tweaks

### ▶ iBGP

- ▶ Hub must act as a Route Reflector
  - ▶ Change the Next-Hop with `neighbor next-hop-self all`
- ▶ Uses BGP Dynamic Neighbors



# DMVPN Phase I

---



# Module Overview

## ▶ DMVPN Phase I Concepts



# DMVPN Phase I Overview

## ▷ Legacy Solution

- ▶ Does not support Spoke-Spoke tunnels or Redundancy
- ▶ Simplifies configuration
  - ▶ Single IP subnet
  - ▶ Flexible Spoke addition/removal
- ▶ Uses mGRE but only on the Hub
  - ▶ Spokes use P2P tunnels
- ▶ Next-Hop should point to the Hub

## ▷ NHRP

- ▶ Registration



# Implementing DMVPN Phase I

---



# Module Overview

- ▶ Configuration syntax
- ▶ Hands-on example



# Hub Configuration

---

## ▷ mGRE Tunnel (interface tunnel)

- ▶ ip address
- ▶ tunnel source
- ▶ tunnel mode gre multipoint
- ▶ NHRP Settings
  - ▶ ip nhrp network-id
  - ▶ ip nhrp map multicast dynamic

# Spoke Configuration

## ▷ GRE Tunnel (interface tunnel)

- ▶ ip address
- ▶ tunnel source
- ▶ tunnel destination
- ▶ NHRP Settings
  - ▶ ip nhrp network-id
  - ▶ ip nhrp nhs *hub\_tunnel\_IP*
  - ▶ ip nhrp map *hub\_tunnel\_IP hub\_NBMA\_IP*
  - ▶ ip nhrp map multicast *hub\_NBMA\_IP*

# IPsec Configuration

---

- ▶ Enabled through an IPsec Profile on DMVPN tunnels
  - ▶ `crypto ipsec transform-set`
  - ▶ `crypto ipsec profile`
  - ▶ `tunnel protection ipsec profile`
  
- ▶ IKE Phase I settings and Authentication data are still needed
  - ▶ `crypto isakmp policy`
  - ▶ `crypto isakmp key`



# DMVPN Phase II

---



# Module Overview

- ▶ DMVPN Phase II Concepts



# DMVPN Phase II Overview

---

- ▶ Introduces Spoke-Spoke tunnels and allows for Redundancy
  - ▶ Requires mGRE interfaces on all devices
  - ▶ Next-Hop must point to the Spoke
  
- ▶ NHRP
  - ▶ Registration
  - ▶ Resolution Request
    - ▶ Give me the NBMA of the Next-Hop
  - ▶ Resolution Reply
    - ▶ Here's the NBMA



# Implementing DMVPN Phase II

---



# Module Overview

- ▶ Configuration syntax
- ▶ Hands-on example



# Hub Configuration

---

## ▷ mGRE Tunnel (interface tunnel)

- ▶ ip address
- ▶ tunnel source
- ▶ tunnel mode gre multipoint
- ▶ NHRP Settings
  - ▶ ip nhrp network-id
  - ▶ ip nhrp map multicast dynamic

# Spoke Configuration

## ▷ mGRE Tunnel (interface tunnel)

- ▶ ip address
- ▶ tunnel source
- ▶ tunnel mode gre multipoint
- ▶ NHRP Settings
  - ▶ ip nhrp network-id
  - ▶ ip nhrp nhs *hub\_tunnel\_IP*
  - ▶ ip nhrp map *hub\_tunnel\_IP hub\_NBMA\_IP*
  - ▶ ip nhrp map multicast *hub\_NBMA\_IP*

# IPsec Configuration

---

- ▶ Enabled through an IPsec Profile on DMVPN tunnels
  - ▶ `crypto ipsec transform-set`
  - ▶ `crypto ipsec profile`
  - ▶ `tunnel protection ipsec profile`
  
- ▶ IKE Phase I settings and Authentication data are still needed
  - ▶ `crypto isakmp policy`
  - ▶ `crypto isakmp key`



# DMVPN Phase III

---



# Module Overview

## ▶ DMVPN Phase III Concepts



# DMVPN Phase III Overview

---

- ▷ Allows for effective route Summarization
  - ▶ Next-Hop must point to the Hub
- ▷ Supports multi-tier designs
  
- ▷ NHRP
  - ▶ Registration
  - ▶ Resolution Request
  - ▶ Resolution Reply
  - ▶ Redirect (`ip nhrp redirect`)
    - ▶ NHRP Shortcut (`ip nhrp shortcut`) allows to overwrite CEF



# Implementing DMVPN Phase III

---



# Module Overview

- ▶ Configuration syntax
- ▶ Hands-on example



# Hub Configuration

---

## ▷ mGRE Tunnel (interface tunnel)

- ▶ ip address
- ▶ tunnel source
- ▶ tunnel mode gre multipoint
- ▶ NHRP Settings
  - ▶ ip nhrp network-id
  - ▶ ip nhrp map multicast dynamic
  - ▶ ip nhrp redirect

# Spoke Configuration

## ▷ mGRE Tunnel (interface tunnel)

- ▶ ip address
- ▶ tunnel source
- ▶ tunnel mode gre multipoint
- ▶ NHRP Settings
  - ▶ ip nhrp network-id
  - ▶ ip nhrp nhs *hub\_tunnel\_IP*
  - ▶ ip nhrp map *hub\_tunnel\_IP hub\_NBMA\_IP*
  - ▶ ip nhrp map multicast *hub\_NBMA\_IP*
  - ▶ ip nhrp shortcut

# IPsec Configuration

---

- ▶ Enabled through an IPsec Profile on DMVPN tunnels
  - ▶ `crypto ipsec transform-set`
  - ▶ `crypto ipsec profile`
  - ▶ `tunnel protection ipsec profile`
  
- ▶ IKE Phase I settings and Authentication data are still needed
  - ▶ `crypto isakmp policy`
  - ▶ `crypto isakmp key`



# DMVPN and IPv6

---



# Module Overview

- ▶ DMVPN and IPv6 interoperability
- ▶ IPv6 DMVPN Routing



# DMVPN and IPv6

- ▶ IPv6 is fully supported inside and outside DMVPN cloud
  - ▶ Underlay transport
    - ▶ tunnel mode gre multipoint [ipv6]
  - ▶ VPN traffic
    - ▶ Depends on the tunnel's IP address
      - ▶ IPv6 requires unique link-local addresses
  - ▶ NHRP mappings may need to be IPv4, IPv6 (`ipv6 nhrp`) or mixed
    - ▶ E.g. `ipv6 nhrp map 2001:256::6/128 6.6.6.6`
    - ▶ Link-local addresses will be mapped automatically

# IPv6 DMVPN Routing

---

- ▶ IPv6 routing protocols require v6 routing to be enabled
  - ▶ ipv6 unicast-routing
  - ▶ Remember IPv6 syntax
    - ▶ no ipv6 split-horizon eigrp, ipv6 ospf network broadcast ...
  - ▶ Phase I, II and III concepts don't change



# DMVPN Dual Hub

---



# Module Overview

- ▶ DMVPN Dual Hub Overview
- ▶ Single Cloud vs Dual Cloud DMVPN



# DMVPN Dual Hub Overview

---

- ▶ Using two or more Hubs provides redundancy
  - ▶ The Spokes are required to register with all Hubs
  - ▶ Available as a Single or Dual Cloud(s) solution

# Single Cloud

---

- ▶ One mGRE interface on the Spokes and the Hubs
  - ▶ Hubs are part of the same DMVPN Network (Cloud) and IP subnet
  - ▶ Spokes are configured with NHRP mappings for each Hub
  
- ▶ Offers little routing control
  - ▶ IGP workarounds
    - ▶ AD changes
    - ▶ EIGRP Offset-Lists
  - ▶ Good for Active-Standby deployments

# Single Cloud DMVPN Configuration

## ▷ Hub1

```
int tunnel 10
 ip address 10.0.0.1 255.255.255.0
 ip nhrp network-id 123
 ip nhrp map multicast dynamic
 tunnel source 1.1.1.1
 tunnel mode gre multipoint
```

## Hub2

```
int tunnel 10
 ip address 10.0.0.2 255.255.255.0
 ip nhrp network-id 123
 ip nhrp map multicast dynamic
 tunnel source 2.2.2.2
 tunnel mode gre multipoint
```

# Single Cloud DMVPN Configuration

## ▷ Spoke

```
interface tunnel 10
 ip address 10.0.0.5 255.255.255.0
 ip nhrp network-id 123
 ip nhrp map 10.0.0.1 1.1.1.1
 ip nhrp map 10.0.0.2 2.2.2.2
 ip nhrp map multicast 1.1.1.1
 ip nhrp map multicast 2.2.2.2
 ip nhrp nhs 10.0.0.1
 ip nhrp nhs 10.0.0.2
 tunnel source G0/1
 tunnel mode gre multipoint
```

# Dual Cloud

---

- ▶ Needs two mGRE interfaces on the Spokes, one on the Hubs
  - ▶ Hubs are part of different DMVPN Clouds and IP subnets
    - ▶ Each Spoke interface corresponds to one of the Hubs
  
- ▶ Traffic Engineering can be performed with normal IGP techniques
  - ▶ Delay, cost, etc.
  
- ▶ IPsec protection may need to be shared on the Spokes
  - ▶ tunnel protection ipsec profile shared

# Dual Cloud DMVPN Configuration

## ▶ Hub1

```
int tunnel 10
 ip address 10.1.1.1 255.255.255.0
 ip nhrp network-id 123
 ip nhrp map multicast dynamic
 tunnel source 1.1.1.1
 tunnel mode gre multipoint
 tunnel key 123
```

## Hub2

```
int tunnel 10
 ip address 10.2.2.2 255.255.255.0
 ip nhrp network-id 234
 ip nhrp map multicast dynamic
 tunnel source 2.2.2.2
 tunnel mode gre multipoint
 tunnel key 234
```

# Dual Cloud DMVPN Configuration

## ▷ Spokes

interface tunnel 10

ip address 10.1.1.5 255.255.255.0

ip nhrp network-id 123

ip nhrp map 10.1.1.1 1.1.1.1

ip nhrp map multicast 1.1.1.1

ip nhrp nhs 10.1.1.1

tunnel source G0/1

tunnel mode gre multipoint

tunnel key 123

interface tunnel 20

ip address 10.2.2.5 255.255.255.0

ip nhrp network-id 234

ip nhrp map 10.2.2.2 2.2.2.2

ip nhrp map multicast 2.2.2.2

ip nhrp nhs 10.2.2.2

tunnel source G0/1

tunnel mode gre multipoint

tunnel key 234