CCIE Enterprise Infrastructure Foundation

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About the Author

Narbik Kocharians, CCIE No. 12410 (Routing and Switching, Service Provider, and Security) is a triple CCIE with more than 46 years of experience in this industry. He has designed, implemented, and supported numerous small, mid-size, and large enterprise networks.

Narbik is the president of Micronics Networking and Training, Inc. (www.Micronics Training.com), where almost all Cisco-authorized and custom courses are conducted, including CCIE-DC, CCIE-SP, CCIE-Enterprise Infrastructure, CCDE, ACI, and many more.

About the Technical Reviewers

Sarah Anand has been affiliated with different networking technologies, including Cisco-specific implementations, for 7 years, with a focus on routing/switching and service provider technologies. Currently she works as a technical writer and editor, training network engineers in vendor-specific and industry-standard technologies. She has a degree in computer science and enjoys spending free time exploring passions in web design and search engine optimization.

Dante McNeil has 10 years of IT networking experience in the nonprofit, enterprise, K–12, and higher education spaces, with a focus on advanced networking implementations and Cisco technologies. He also spends time writing and creating network training content for networking engineers. He holds a bachelor of science degree in computing information sciences from Jacksonville University. In his spare time, he enjoys roller coasters, video games, and road trips.

Dedications

I would like to dedicate this book to my beautiful wife, Janet, my children and their spouses, Chris and Nona (aka Siroon Achik), Patrick and Diana (aka Bestelik Jan), Alexandra (aka Achiko) and Sevak, and Daniel (aka Chompolik), as well as our first grandson, Matthew (aka Jigar), whom I LOVE so much, he brightens my day every morning!

I would like to acknowledge with gratitude the support, sacrifice, and love of my family for making this book possible. I thank God for the health and wisdom that He has instilled in me, my lovely family, my first grandson Mathew, and my father, who was my best friend.

Acknowledgments

A very special thanks to James and Eleanor. I remember brainstorming with James for hours about this book, and eventually he came up with the ultimate solution. I would like to thank Eleanor for having a tremendous amount of patience and professionalism.

I would also like to thank my tech editors, Sarah Anand and Dante McNeil, two gifted network engineers with a tremendous amount of knowledge. God willing, I will be working with these two champions for a long time to come. They are not CCIEs yet, but their knowledge is on par with the best CCIEs out there.

Contents at a Glance

Contents

Command Syntax Conventions

The conventions used to present command syntax in this book are the same conventions used in the IOS Command Reference. The Command Reference describes these conventions as follows:

- **Boldface** indicates commands and keywords that are entered literally as shown. In actual configuration examples and output (not general command syntax), boldface indicates commands that are manually input by the user (such as a **show** command).
- *Italic* indicates arguments for which you supply actual values.
- Vertical bars (|) separate alternative, mutually exclusive elements.
- Square brackets ([ ]) indicate an optional element.
- Braces ({ }) indicate a required choice.
- Braces within brackets ([{ }]) indicate a required choice within an optional element.

Introduction

Enterprise networking has undergone many small changes over the years, building from simple shared bus LANs to intricate routing and switching architectures and wireless communications. Behind all of this is a need to ensure high reliability, agility, and speed. Through the decades, many different networking technologies, from physical connections to software protocols, have been created to assist enterprise networks in reaching those goals. For seasoned networking veterans, working with the various protocols and architectures is second nature. However, those who are just starting to build their careers and trying to study more advanced areas of network engineering may be overwhelmed by the multitude of routing protocols, Layer 2 features, and new buzzwords like "software-defined."

This book is written as a foundation guide for the most common enterprise networking concepts that are required for a network engineer looking to move forward to more advanced aspects of networking. It combines aspects of theory instruction with practical application. Topics such as LAN switching, IP routing, and overlay networking technologies such as DMVPN are explained as foundational topics, including examples. Each chapter also functions as a lab manual with a task-oriented structure. Lab scenarios are presented as either configuration objectives, troubleshooting scenarios, or design scenarios. Each lab scenario includes full solutions and explanations. For beginner to intermediate readers, the solutions can be read while solving the tasks. Advanced readers can challenge their knowledge and skills by solving tasks first and then comparing their solutions to the ones provided in this book.

This book is not meant to be an exhaustive study of all the included technologies. It is meant to provide enough information on all topics to allow you to speak intelligently about each technology and even implement some of the configurations, if necessary, in your own environment. It takes topics from Cisco's CCIE Enterprise Infrastructure certification blueprint but includes some legacy topics, where necessary, to facilitate understanding.

Who This Book Is For

Although the title of this book is *CCIE Enterprise Infrastructure Foundation*, the target audience is not limited to just those seeking expert-level certification. Any person looking to learn a little bit more about these foundational technologies will find this book very accessible.

This book breaks down complicated topics and provides examples to maximize understanding. It does, however, assume some basic networking knowledge. The following types of readers will get the most out of this book:

- Those who have completed CCNA certification and are part of the way through their preparation for CCNP Enterprise certification
- Those who have completed CCNP Enterprise certification and are pursuing CCIE Enterprise Infrastructure certification

- Those who are currently working in an environment that is implementing specific technologies covered in this book
- Those who are migrating from another vendor to a Cisco environment and need to understand Cisco configurations for common networking protocols

How This Book Is Organized

This book is divided into the 11 chapters described here. Every chapter can stand alone and can be used as a reference for the technologies it covers.

Chapter 1: Switching

Chapter 1 introduces Layer 2 concepts such as preventing loops with Spanning Tree Protocol, segmenting with VLANs, extending VLANs between switches through trunking, and bonding multiple Ethernet links together to increase bandwidth between network nodes. It covers topics such as Spanning Tree Protocol, RSTP, MSTP, VTP and VTP pruning, 802.1Q and ISL trunking, and LACP and PAgP.

Chapter 2: IP Prefix Lists

Chapter 2 introduces a common route filtering mechanism known as a prefix list. It explains why prefix lists were invented and why they are used over access lists for route filtering. This chapter shows how to write prefix lists and apply them in various routing protocols for filtering routes.

Chapter 3: RIPv2

Chapter 3 introduces Routing Information Protocol (RIP). RIP may not be included on the exam, but it is a perfect example of a simple distance vector routing protocol that follows all the standard distance vector designs. It focuses on the simplicity of RIP configuration, advanced RIP filtering scenarios, and RIP configuration challenges.

Chapter 4: EIGRP

Chapter 4 focuses on Cisco's improvement on its own version of Interior Gateway Routing Protocol (IGRP), Enhanced Interior Gateway Routing Protocol (EIGRP). It introduces EIGRP as a distance vector protocol that forms neighbor relationships and keeps a topology table like some other protocols. EIGRP is considered an advanced distance vector protocol that uses more than simple hop counts to learn loop-free paths through a network. This chapter covers EIGRP configuration topics such as EIGRP classic and address family configuration, EIGRP stub routing, and EIGRP with BFD.

Chapter 5: OSPF

Chapter 5 introduces the Open Shortest Path First (OSPF) routing protocol. It begins with an analysis of how OSPF builds its link-state database (LSDB) with various link-state advertisements (LSA) and uses that information to calculate loop-free routed paths through a network. This chapter also details multiarea OSPF design, filtering, and virtual links. It includes a detailed walkthrough on OSPF's best-path determination to help you understand OSPF's path selection process.

Chapter 6: BGP

Chapter 6 introduces Border Gateway Protocol (BGP), the protocol that routes the Internet. It explains BGP operation between autonomous systems (external BGP, or eBGP) and within a single autonomous system (internal BGP, or iBGP). Topics covered include BGP session establishment, route reflectors and confederations, aggregation, and filtering. This chapter includes a detailed walkthrough of the BGP best-path determination process.

Chapter 7: DMVPN

Chapter 7 focuses on Cisco's original SD-WAN technology, known as Dynamic Multipoint VPN (DMVPN). It explains DMVPN from the ground up, introducing concepts such as overlay and underlay networking, the link between DMVPN and NHRP, DMVPN routing using common routing protocols, and different DMVPN designs. It covers DMVPN Phase 1 through Phase 3 configurations, NHRP shortcut switching enhancements, hub-and-spoke networking designs, and (m)GRE tunnels.

Chapter 8: MPLS and L3VPNs

Chapter 8 introduces Multiprotocol Label Switching (MPLS) and the suite of services MPLS can provide. This chapter begins with an introduction to MPLS labels and Label Distribution Protocol (LDP). It also introduces the most common MPLS service, MPLS Layer 3 VPN (L3VPN). Topics covered include CE and PE routers, MPLS core configuration, LDP session establishment, BGP route targets and route distinguishers, and exchange of IGP routes between two sites connected by an MPLS L3VPN.

Chapter 9: IPv6

Chapter 9 introduces Internet Protocol Version 6 (IPv6), which is the successor to IPv4 due to its massive address space. It also details IPv6 address types, assignment, and configuration. Topics covered include IPv6 NDP, IPv6 SLAAC, DMVPN for IPv6, OSPF for IPv6 (OSPFv3), EIGRP for IPv6, and BGP for IPv6.

Chapter 10: SD-WAN

Chapter 10 introduces Cisco's new SD-WAN platform, which is based on its acquisition of Viptela. This chapter details basic SD-WAN components, such as vSmart, vManage, and vBond, as well as the setup and configuration required to join vEdge routers to an SD-WAN solution. Topics covered include onboarding WAN edge devices, unicast routing, segmentation, vManage device templates, ZTP, and application-aware policies.

Chapter 11: SD-Access

Chapter 11 introduces Cisco's SD-Access solution for creating scalable, automated, and resilient enterprise fabric. This chapter covers configuration of the SD-Access policy engine as well as SDA design and implementation. Topics covered include Cisco ISE, pxGrid, XMPP, SDA hierarchy global IP pools, DNAC, and LAN automation.

Before Starting the First Chapter

Bookmark the Companion Website

The companion website contains the config files, topology diagrams, CLI output, and explanations for the labs in this book. These elements are essential and a fundamental part of your learning experience. To use this book effectively, you need to have them. Use the config files, reference the topology diagrams, and work through the labs while checking your work against the CLI output on the companion website. At the end of each lab, read through the explanations for further insight.

To access the book's companion website, simply follow these steps:

1. Go to www.ciscopress.com/register.
2. Enter the print book **ISBN: 9780137374243.**
3. Answer the security question to validate you purchase.
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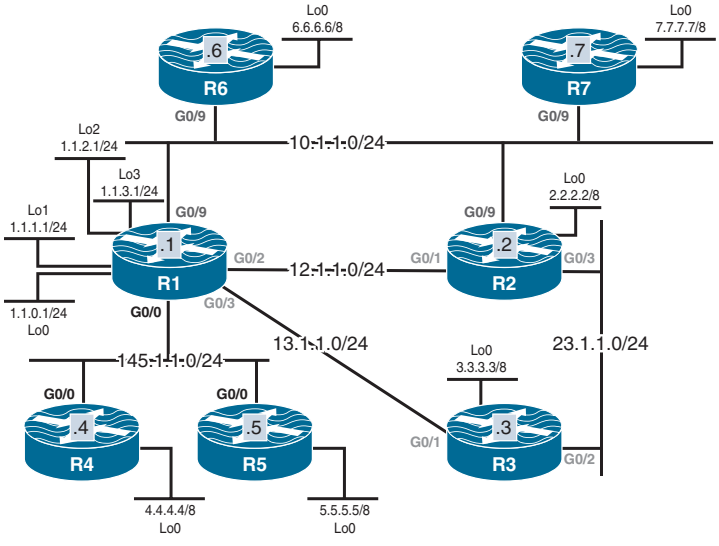
Chapter 4

EIGRP

Lab 1: EIGRP Named Mode



This lab should be conducted on the Enterprise POD.

Lab Setup:

If you are using EVE-NG, and you have imported the EVE-NG topology from the EVE-NG-Topology folder, ignore the following tasks and use Lab 1-EIGRP Named Mode in the EIGRP folder in EVE-NG.

To copy and paste the initial configurations, go to the Initial-config folder → EIGRP folder → Lab-1.

Task 1

Configure EIGRP on R1, R2, and R3 based on the following policy:

Router	Interface	AS Number
R1	G0/9	200
	G0/0	100
	G0/2	100
	G0/3	100
	Loopback0–Loopback3	100
R2	G0/9	200
	G0/1	100
	G0/3	100
	Loopback0	100
R3	G0/1	100
	G0/2	100
	Loopback0	100

- R1 should be configured to use unicast to establish an EIGRP neighbor adjacency with R2.
- R1 should use multicast to establish an EIGRP neighbor adjacency with R3.
- R1, R2, and R3 should use an EIGRP named mode configuration to accomplish this task.

Task 2

Configure R4 and R5 in EIGRP AS 100. You must use named mode to accomplish this task.

Task 3

Configure R1, R4, and R5 to use unicast to establish their EIGRP neighbor adjacency.

Task 4

Configure R6 in EIGRP AS 200. This router should run EIGRP AS 200 on its G0/9 and Loopback0 interfaces. You should use an EIGRP named mode configuration to accomplish this task.

Task 5

Configure OSPF Area 0 on R6's G0/9 and R7's G0/9 and Loopback0 interfaces. The router ID of these routers should be configured as 0.0.0.*x*, where *x* is the router number.

Task 6

Configure R6 to redistribute OSPF into EIGRP such that R1 and R2 go directly to R7 to reach the 7.0.0.0/8 network.

Task 7

Configure the hello interval of all routers in AS 200 to be twice the default hello interval.

Task 8

Configure R4 such that in the worst-case scenario, it uses 10% of the bandwidth for its EIGRP updates. This policy should apply to the existing and future interfaces.

Task 9

Configure R1 to summarize its loopback interfaces and advertise a single summary in the EIGRP AS 100 routing domain.

Task 10

Configure R1 to limit the number of received prefixes from R5 to 10. R1 should be configured to receive a warning message once 50% of this threshold is reached and a warning message for every additional route that exceeds the threshold. You should configure Lo1–Lo10 on R5 by copying and pasting the initial configuration, called **EIGRP-Lab-1-Task10**.

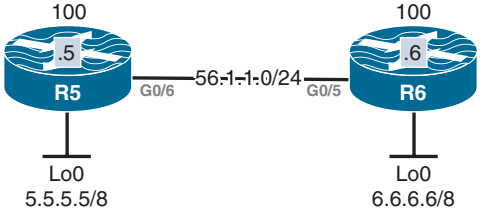
Task 11

Configure R1 to limit the number of prefixes received from R4 to five. R1 should be configured to tear down the adjacency if R4 exceeds the specified threshold. Copy and paste the **EIGRP-Lab-1-Task11** initial configuration on R4.

Task 12

Erase the startup configuration and reload the routers before proceeding to the next lab.

Lab 2: EIGRP and Bidirectional Forwarding Detection (BFD)



Task 1

Configure the routers based on the previous diagram. *Do not* configure any routing protocol.

Task 2

Configure EIGRP AS 100 on all directly connected interfaces of these two routers and ensure reachability. R5 should be configured using EIGRP classical mode, and R6 should use the EIGRP named mode configuration style.

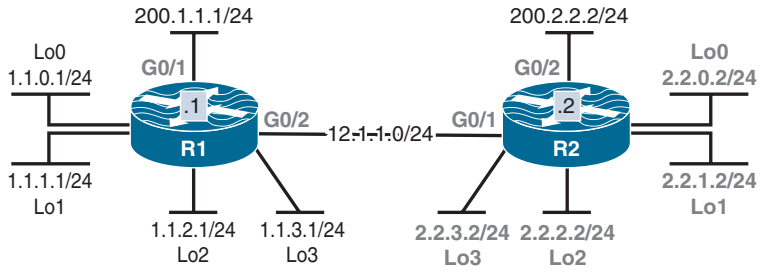
Task 3

Configure and test BFD on these two routers.

Task 4

Erase the startup configuration of these two routers and reload the devices before proceeding to the next lab.

Lab 3: EIGRP Stub



Lab Setup:

If you are using EVE-NG, and you have imported the EVE-NG topology from the EVE-NG-Topology folder, ignore the following tasks and use Lab 3-EIGRP Stub in the EIGRP folder in EVE-NG.

To copy and paste the initial configurations, go to the Initial-config folder → EIGRP folder → Lab-3.

Task 1

Configure EIGRP AS 100 on the G0/2 and G0/1 interfaces of R1 and R2, respectively, as well as on all loopback interfaces of these two routers. On R1 configure EIGRP using the classic mode, and on R2 configure EIGRP in named mode to accomplish this task. *Do not* run EIGRP on the G0/1 interface of R1 or the G0/2 interface of R2.

Task 2

Configure R1 and R2 to summarize their loopback interfaces in EIGRP.

Task 3

Configure the following static routes on R1 and R2 and redistribute them into EIGRP:

- On R1: 11.0.0.0/8 via G0/1
- On R2: 22.0.0.0/8 via G0/2

Task 4

Advertise the G0/1 interface of R1 and the G0/2 interface of R2 into RIPv2 and disable auto-summarization. You should redistribute RIPv2 into EIGRP and use any metric for the redistributed routes.

Task 5

Configure EIGRP stub routing on R1 by using the command **eigrp stub connected**. Test this option and verify the routes in the routing tables of both routers.

Task 6

Remove the **eigrp stub connected** option configured in the previous task and reconfigure EIGRP stub routing on R1 by using the **eigrp stub summary** command. Test this option and verify the routes in the routing tables of both routers.

Task 7

Remove the **eigrp stub summary** option configured in the previous task and reconfigure EIGRP stub routing on R1 by using the command **eigrp stub static**. Test this option and verify the routes in the routing tables of both routers.

Task 8

Remove the **eigrp stub static** option configured in the previous task and reconfigure EIGRP stub routing on R1 by using the command **eigrp stub redistributed**. Test this option and verify the routes in the routing tables of both routers.

Task 9

Remove the **eigrp stub redistributed** option configured in the previous task and reconfigure EIGRP stub routing on R1 by using the command **eigrp stub receive-only**. Test this option and verify the routes in the routing tables of both routers.

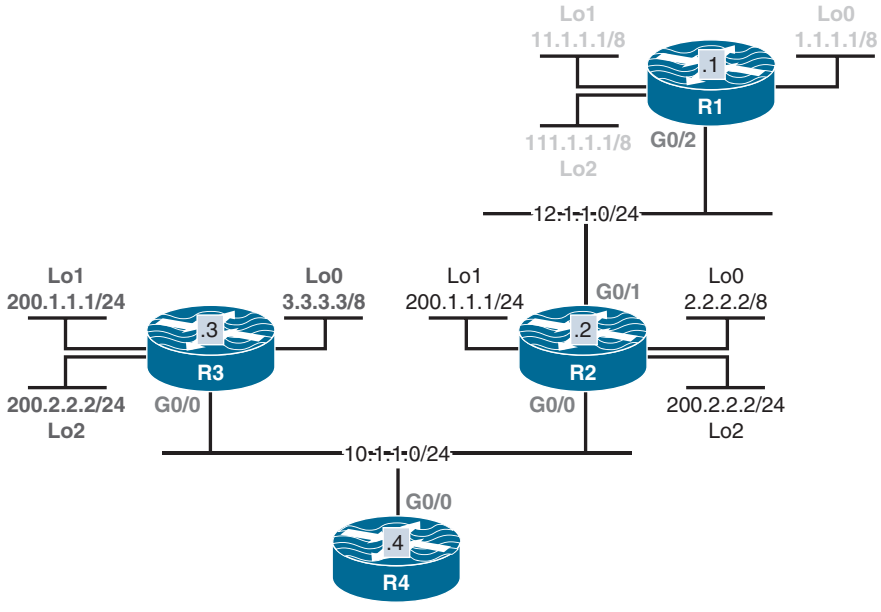
Task 10

Remove the **eigrp stub receive-only** option configured in the previous task and reconfigure EIGRP stub routing on R1 by using the command **eigrp stub**. Test this option and verify the routes in the routing tables of both routers.

Task 11

Erase the startup configuration and reload the routers before proceeding to the next lab.

Lab 4: EIGRP Filtering



Lab Setup:

If you are using EVE-NG, and you have imported the EVE-NG topology from the EVE-NG-Topology folder, ignore the following tasks and use Lab 4-EIGRP Filtering in the EIGRP folder in EVE-NG.

To copy and paste the initial configurations, go to the Initial-config folder → EIGRP folder → Lab-4.

Task 1

Configure EIGRP 100 on all routers and advertise their directly connected links into EIGRP.

Task 2

Configure R4 such that it filters existing (1.0.0.0/8, 11.0.0.0/8, and 111.0.0.0/8) and future networks behind R1. *Do not* use **distribute-list**, **access-list**, **prefix-list**, or **route-map** to accomplish this task.

Task 3

Configure R4 such that it uses R2 as its only connection to network 200.1.1.0 /24. You should use an access list to accomplish this task.

Task 4

Configure R4 such that it takes R3 to reach network 200.2.2.0 /24. R4 should *only* use R2 as the next hop to reach network 200.2.2.0/24 when R3 is down. You should use a standard access list to accomplish this task.

Task 5

Filter network 2.0.0.0/8 on R4. *Do not* use **distribute-list** or **route-map** to accomplish this task.

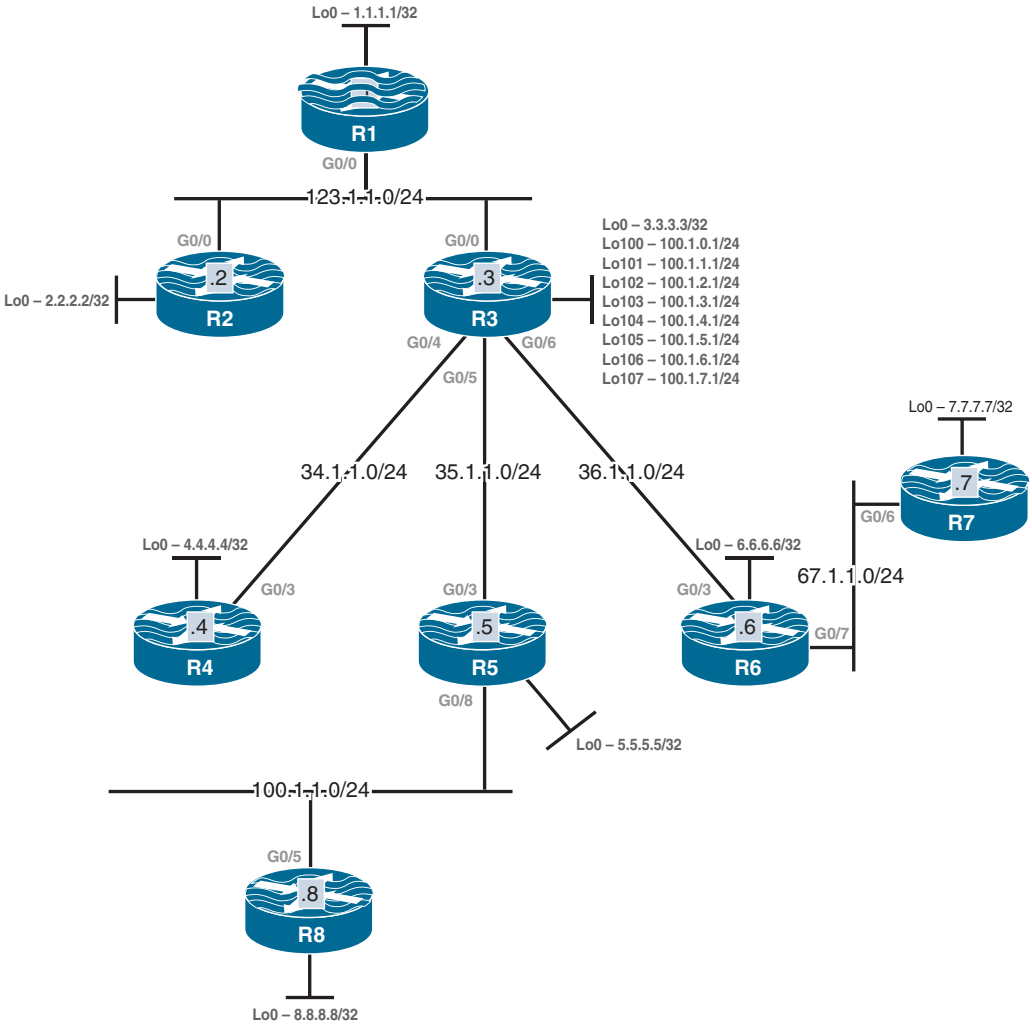
Task 6

Configure R4 to filter network 3.0.0.0/8.

Task 7

Erase the startup configuration and reload the routers before proceeding to the next task.

Lab 5: Advanced EIGRP Lab



Lab Setup:

If you are using EVE-NG, and you have imported the EVE-NG topology from the EVE-NG-Topology folder, ignore the following tasks and use Lab 5-Advanced EIGRP Lab in the EIGRP folder in EVE-NG.

To copy and paste the initial configurations, go to the Initial-config folder → EIGRP folder → Lab-5.

Task 1

Configure the G0/0 interfaces of R1, R2, and R3 in EIGRP AS 100. These routers should be configured to advertise their Lo0 interfaces in this AS, using the following policy:

- These routers should be configured to reach each other's loopback interface/s by going through R1.
- *Do not* use Policy-based Routing (PBR) or configure another AS to accomplish this task.

Task 2

Configure R3's G0/4, G0/5, and G0/6 in AS 300. Configure R4's, R5's, and R6's G0/3 and loopback 0 interfaces in this AS.

Configure R3 to summarize its Lo100–Lo107.

The summary route should be advertised to R4, R5, and R6 based on the following policy:

- R4 should receive the summary *only*.
- R5 should receive the summary plus network 100.1.3.0 /24.
- R6 should receive the summary plus all the specific routes.
- Configure the minimum number of **ip summary-address** commands possible to accomplish this task.

Task 3

Configure EIGRP 300 on R4's Lo134 and Lo135 and advertise a single summary in AS 300.

Task 4

Configure the G0/7 and Lo0 interfaces of R6 and the G0/6 and loopback 0 interfaces on R7 for EIGRP in AS 67.

R7 should be configured to advertise its Lo130, such that the command **show ip route eigrp 67** on R6 produces the following output:

```
D EX  130.3.0.0/16 [170/130816] via 67.1.1.7, 00:00:16,
GigabitEthernet0/7
```

R7 should use **redistribute static** to accomplish this task. *Do not* configure a static route to accomplish this task.

Task 5

Configure the routers in AS 67 such that they log neighbor warning messages and repeat the warning messages every 10 minutes. You should disable logging of neighbor changes for this AS.

Task 6

Configure the routers in AS 67 such that a dead neighbor is detected within 3 seconds.

Task 7

Routers in AS 100 should be configured to use **Bandwidth** and *not* **Bandwidth + DLY** when calculating their composite metric.

Task 8

Configure R2 such that EIGRP *never* uses more than 25% of its G0/0 link's bandwidth.

Task 9

Configure the G0/8 interface of R5 and the G0/5 and the Lo0 interfaces of R8 in AS 500.

Task 10

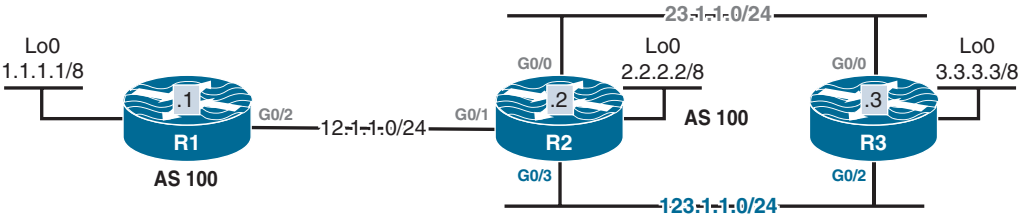
Configure R5 to inject a default route in AS 500 based on the following policy:

- R5 should be configured to inject a default route plus networks 4.0.0.0/8 and 6.0.0.0/8 from AS 300.

Task 11

Erase the startup configuration and reload the routers before proceeding to the next task.

Lab 6: EIGRP Authentication



Lab Setup:

If you are using EVE-NG, and you have imported the EVE-NG topology from the EVE-NG-Topology folder, ignore the following tasks and use Lab 6-EIGRP Authentication in the EIGRP folder in EVE-NG.

To copy and paste the initial configurations, go to the Initial-config folder → EIGRP folder → Lab-6.

Task 1

Configure EIGRP based on the previous diagram. If this configuration is successful, these routers should be able to see and have reachability to all routes. You should use named mode configuration style when configuring R2 and R3 and classic EIGRP configuration style when configuring R1 to accomplish this task.

Task 2

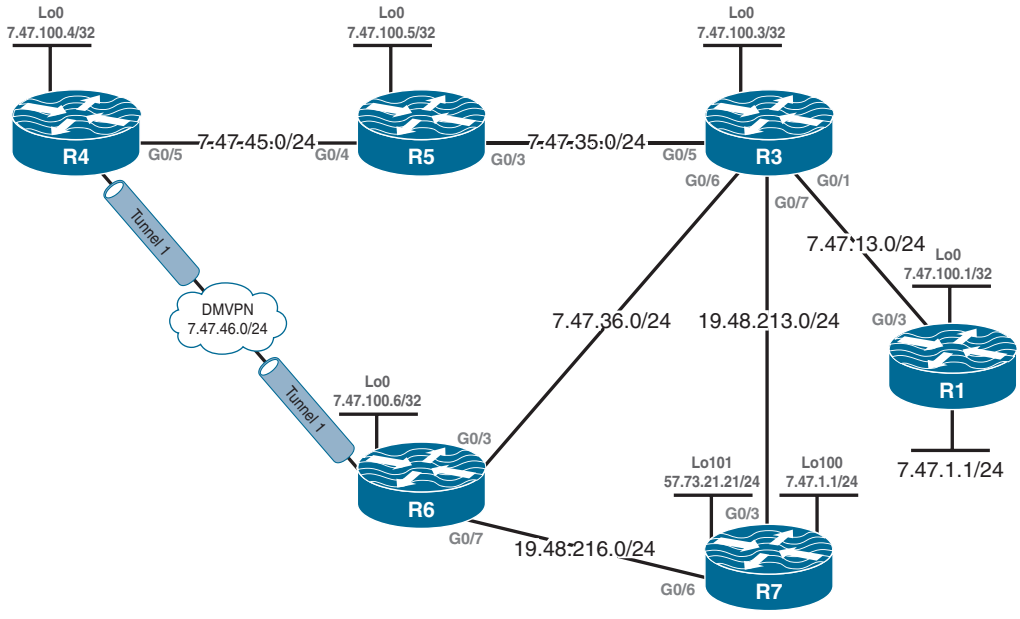
Configure R2 to authenticate all existing and future directly connected interfaces using the strongest authentication method available. Use the minimum number of commands and CCIE as the password to accomplish this task.

- R2 should authenticate R1 using MD5 and Cisco as the password.
- In the future, R3 may have other neighbors that won't need authentication.

Task 3

Erase the startup configuration and reload the routers before proceeding to the next lab.

Lab 7: EIGRP Challenge Lab



Lab Setup:

If you are using EVE-NG, and you have imported the EVE-NG topology from the EVE-NG-Topology folder, ignore the following tasks and use Lab 7-EIGRP Challenge Lab in the EIGRP folder in EVE-NG.

To copy and paste the initial configurations, go to the Initial-config folder → EIGRP folder → Lab-7.

NOTE *Do not* access R7 at all. You should *only* fix the problem identified in the ticket.

Ticket 1

R1 can't reach R3's Lo0. You must configure R1 to fix the problem.

Ticket 2

R6 does *not* have a stable EIGRP adjacency with R4. *Do not* use an EIGRP command to fix this ticket.

Ticket 3

When R3's G0/1, G0/7, and G0/6 are down, R3 can't reach R4's Lo0. *Do not* remove any commands to fix this ticket.

Ticket 4

R1's Lo0 should always have reachability to R4's Lo0 and G0/5 interfaces, but it does not. You should fix this problem without configuring R1 or R4. You should *not* remove any commands to resolve this ticket.

Ticket 5

R3 is configured to use multiple paths to R4's Lo0. However, it's using only one of the paths.

Ticket 6

R6 can't reach R7's Lo101.

Ticket 7

R3 should establish a EIGRP adjacency with R8 over its G0/8 interface. You should make configuration changes on R3 only.

Ticket 8

Erase the startup configuration and reload the devices before proceeding to the next lab.

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