Google Global Cache

Installation Guide

Dell R430 / R440 / R730xd / R740xd / R740xd2
HPE Apollo 4200

March 2019

Contents

Installation Process Overview

This document describes the installation and commissioning process for a Google Global Cache (GGC) node. Please follow these instructions if you are an ISP planning and then deploying GGC in your network.

The installation process has several steps:

1. Hardware installation

2. Network installation

3. IP addressing

4. Software installation

5. BGP configuration

Google may provide a networking device to connect GGC machines to. In some cases it will be managed by the ISP, in others by Google. In this Installation Guide, all references to **Google Router** mean a networking device both provided **and** managed by Google.

Steps **2** and **5** above have two variants, depending on whether the GGC node is connected to a **Google Router** or an **ISP Managed Switch**.

You only need to follow the section applicable to the GGC node type you're installing.

Hardware Installation

Follow these instructions to correctly rack mount the GGC machines. Some details vary depending on the type of GGC hardware provided. Consult the appendices for further information.

You may rack mount the GGC machines as soon as you receive them.

2.1 You will need

- Help to lift the machines into position

- Rack mount installation kit and vendor specific instructions (shipped with machines)

- Phillips (crosshead) screwdriver

- T-15 and T-25 Torx screwdrivers

- Rack space, as listed in Appendix D

- Power feeds and cables, as listed in Appendix E

- Network and power cabling, as listed in Appendix A and B

2.2 Procedure

1. *HPE Apollo 4200 only*: Remove shipping screws on either side of the chassis, according to the vendor instructions

   NOTE: Failure to remove shipping screws will prevent opening of chassis, and future maintenance of mid-chassis mounted disks

2. Install provided rails and mounting hardware in your rack

3. Install the machines in the rack, according to the vendor instructions

   ⚠️ GGC equipment is very heavy. Please follow appropriate health and safety procedures, to prevent injury to yourself and your colleagues, and to avoid damage to GGC equipment or your facility

   NOTE: For Dell R740xd2 machines; to prevent possible injury ensure that the thumbscrews located on the front left and right control panels are fastened during racking, to ensure that the machine does not slide out of the rack when pulling the front drive bay.

4. Connect power, *but do not turn the system on yet*

5. Verify that both Power Supply Units (PSUs) show green indicator lights

   ❓ For redundancy and performance reasons, both PSUs must be used. It is strongly recommended that you connect each power supply to independent power feeds. If a second feed is not available, both PSUs can be connected to the same feed

Network Installation (Google Router)

Follow the instructions in this section if Google is providing and managing a GGC router to which GGC machines are connected.

Connect the GGC machines and the router to your network as soon as you receive them. Please do this even if you are not ready to install GGC software or start GGC traffic.

The GGC Router comes preconfigured with uplink interface, LACP and IP addressing as shown in the ISP portal *(https://isp.google.com/assets/)*.

3.1 You will need

Equipment supplied by Google:

- GGC router

- Rack mount hardware

- Machine to router connectivity components, as listed in Appendix A, including some or all of:
    - SFPs

    - Direct-attach QSFP cables

    - RJ45 ethernet cables

- Uplink connectivity SFPs or QSFPs, as required for number of uplinks

Equipment supplied by ISP:

- Machine to router connectivity components, specifically multimode fibers, as listed in Appendix A

- Uplink connectivity components, including SFPs or QSFPs, single or multimode fibers, as required for number of uplinks

3.2 Procedure

3.2.1 Install and connect the router

Details of cabling and network interfaces to be used vary, depending on GGC hardware type, the number of machines in the node, and the type and number of uplinks in use. Full details are shown in Appendix A.

1. Install the router in the rack

2. Install SFPs and cabling as described in Appendix A

3. Power on the router

3.2.2 Configure your network

For each uplink bundle, configure LACP on your device as follows:

- Passive mode

- Layer 2 mode

- Load balanced on source/destination layer 3 information

If you are using a single, non bundled uplink, do not enable LACP.

3.2.3 Verify connectivity

- Check uplink physical status (link lights) on GGC router, and on your device

- Verify GGC router light levels (Tx and Rx) at your device

- Verify GGC router LACP status at your device

Network Installation (ISP Managed Switch)

Follow the instructions in this section if you will be providing all network connectivity for the GGC machines.

You may connect the GGC machines to your network as soon as you receive them, even if you are not ready to commence GGC software installation, or to start GGC traffic.

4.1 You will need

Equipment supplied by Google:

- SFPs for machine to switch or router links

Equipment supplied by ISP:

- Switch or router

- SFPs for uplinks

- Cabling, as described in Appendix B

You will also need:

- Administrative access to your Ethernet switch

- Switch port numbers facing the GGC machines

4.2 Procedure

Install SFPs and cabling, as described in Appendix B.

Configure your switch with the following settings:

- Maximum port speed (i.e. 10Gbps for 10Gbps links, 1Gbps for 1Gbps links, etc.)

- Full duplex

- Auto-negotiation enabled

- Flow control enabled

- Spanning tree, either:
    - disabled on GGC machine facing ports

    - *or*, set to Portfast (Cisco IOS), Edge port (JUNOS), or equivalent

- All GGC machines in a single, dedicated layer 2 broadcast domain (VLAN)

For GGC machines using a single interface (see Appendix B), Link Aggregation Control Protocol (LACP) should be *disabled*.

For GGC machines using multiple interfaces (see Appendix B), LACP should be *enabled*, and configured as follows:

- Passive mode

- Layer 2 mode

- Load balanced on source/destination layer 3 information

- Standalone mode (aggregated link should remain up, even if a physical port is down)

- All interfaces for a machine connected to the same switch

- Separate LACP bundle for each machine

You may connect different GGC machines in the same node to different switches, but it is not required. If you decide to use multiple switches, the VLAN used by the GGC machines must span all switches involved.

Sample switch configurations are provided in Appendix C. Please refer to your switch vendor's documentation for specific configuration commands.

IP Addressing

GGC nodes require a dedicated layer 3 subnet. Nodes may be dual-stacked (preferred), or IPv4 only, or IPv6 only.

For each IP protocol version supported by the GGC node, machines have the following addresses assigned:

- static maintenance IP address

- multiple VIPs to serve traffic to users

- BGP VIP (on one machine at any time)

Maintenance **IPs** are configured statically. **VIPs** are managed automatically to ensure they move to other machines during failures and machine maintenances. This is to minimize disruption of traffic to the users and to ensure the BGP sessions with GGC nodes to not remain down for extended periods of time.

5.1 IP addressing requirements for GGC nodes

GGC nodes require a specific size of public IP subnet to be allocated to them, according to the table below.

IP subnet size requirements for GGC nodes

Number of machines in the node	IPv4 subnet size	IPv6 subnet size
2 - 6	/27	/64
6 - 8	/27 or /26 (recommended)	/64
more than 8	/26	/64

5.1.1 IPv4 addressing scheme

IPv4 addresses are assigned within the GGC allocated subnet as follows:

1. The 1st usable address in the subnet must be used for the subnet gateway

2. If required, the 2nd and 3rd addresses may be assigned to an ISP managed switch (e.g. for HSRP or GLBP)

3. The 4th and following IP addresses in the subnet are reserved for GGC machines (management IPs and VIPs)

4. Check the node information in the ISP Portal *(https://isp.google.com/assets/)* for the BGP peering IP address

5.1.2 IPv6 addressing scheme

IPv6 addresses are assigned within the GGC subnet as follows:

1. The ::1 address in the subnet is used as a statically addressed subnet gateway. If your device is configured to send Router Advertisements, the GGC machines will use this in preference to the static gateway

2. If required, the ::2 and ::3 addresses may be be assigned to an ISP managed switch (e.g. for HSRP or GLBP)

3. The ::4 and following IP addresses in the subnet are reserved for GGC machines (management IPs and VIPs)

4. Check the node information in the ISP Portal *(https://isp.google.com/assets/)* for the BGP peering IP address

5.2 IP addressing requirements for Google Routers

GGC nodes that are behind Google Routers have additional subnet requirements due to interconnects needed to connect them to your network.

- We support up to 4 interconnects per Google Router

- Each interconnect may be configured with either IPv4, IPv6 or both address types

Subnet sizes required for each interconnect type are as follows:

- a /31 IPv4 subnet is required for interconnects with standard configuration

- a /29 IPv4 subnet (or larger) is required for interconnects where redundancy protocol (HSRP, VRRP, etc.) is used at the ISP's side

- a /127 IPv6 subnet is required for interconnects

It is up to the ISP to decide which IP from the interconnect allocated subnet is configured at either side of the interconnect. Google doesn't have any guidelines or preferences.

5.3 IPv6 enablement

5.3.1 New node

IPv6 can be enabled prior to installation by including the **IPv6 subnet** and **IPv6 Router for BGP Sessions** when you supply the technical information required for node activation in the ISP Portal *(https://isp.google.com/assets/)* asset pages.

Google *strongly* recommends you enable IPv6 for new nodes, even if you do not yet have significant IPv6 user traffic, provided that IPv6 is globally reachable. Please note that connectivity issues will delay turn up.

5.3.2 Existing node

For a node already serving IPv4 traffic, IPv6 can be enabled through the ISP Portal *(https://isp.google.com/assets/)* asset pages by following the below steps:

1. In the 'Configuration' tab check select 'Update Configuration' at the bottom.

2. Select 'Enabled' for IPv6 and supply the IPv6 subnet.

3. click 'Update' to save the changes.

You will receive an email when configuration changes have been completed.

> **?** If you are enabling IPv6 support for a GGC node that is connected to a Google Router you will need to provide the IPv6 subnet for the interconnect that is configured with a BGP session over it. Please contact ggc@google.com to verify these prerequisites are in place.

Software Installation

This section describes the steps to install the GGC software on the machine. After completing this step the installer will automatically signal to Google to begin the next steps in the turnup process or to return this machine into a serving state, in case of a reinstallation.

This is an overview of the installation steps:

1. Download the USB image

2. Create the USB boot sticks

3. Boot each machine from a USB stick

4. Enter the network configuration and wait for the installer to complete

5. Reboot the machine

It is possible to install a GGC machine without Internet connectivity. In such cases, the machine will repeatedly try contacting GGC management systems until it succeeds.

6.1 You will need

- A monitor and keyboard

- IP information provided to Google in the ISP Portal *(https://isp.google.com/assets/)*

- Labels to mark the IP address on each machine

- A USB stick with a capacity of at least 1 GB. One USB stick per machine is provided

- Access to a computer with appropriate permissions to:
    - download and save the install image file

    - download, save and run the tools required to create a bootable USB stick

- GGC machines mounted in a rack and powered up

- GGC machines connected to the network with Internet connectivity (preferred but not required, as mentioned above).

    Please remember to advertise the prefix allocated to the GGC node to your upstream networks.

6.2 Procedure

6.2.1 Download the install image

Download a copy of the latest GGC setup image *(https://dl.google.com/ggc/install/ggc-setup-latest.img)*.

The latest version of the setup image is the only supported version. We may have to ask you to reinstall the machine if you use an older installer version.

6.2.2 Prepare the USB stick(s)

You will need a USB removable media device. This can be a USB stick shipped with the GGC servers. You may also provide any other USB stick or a portable USB drive, with enough capacity to store the GGC setup image.

The USB boot sticks need to be created on a computer on which you have the permissions mentioned above. You can create multiple boot sticks, to install machines in parallel or you can make one USB stick, and reuse it for multiple machine installations.

For details on how to write the install image to the USB stick, on various operating systems, see the ISP Help Center *(https://support.google.com/interconnect?p=usb)*

6.2.3 GGC software installation

The installation needs to be repeated on each machine in the GGC node.

1. Connect a monitor and a keyboard to the machine

2. Insert the prepared setup USB stick in any USB port (front or back). Using the front USB port may prevent easily connecting a keyboard in the future, or from closing the rack doors.

3. Power off the machine, if it's currently running

4. Power on the machine, by pressing the front power switch

5. Allow some time for the machine to boot from the USB stick

> **?** If you have installed this machine before, it might not boot from the USB stick automatically. If that happens, please follow the steps at Booting the machine from the USB stick.

A screen similar to the following should appear:
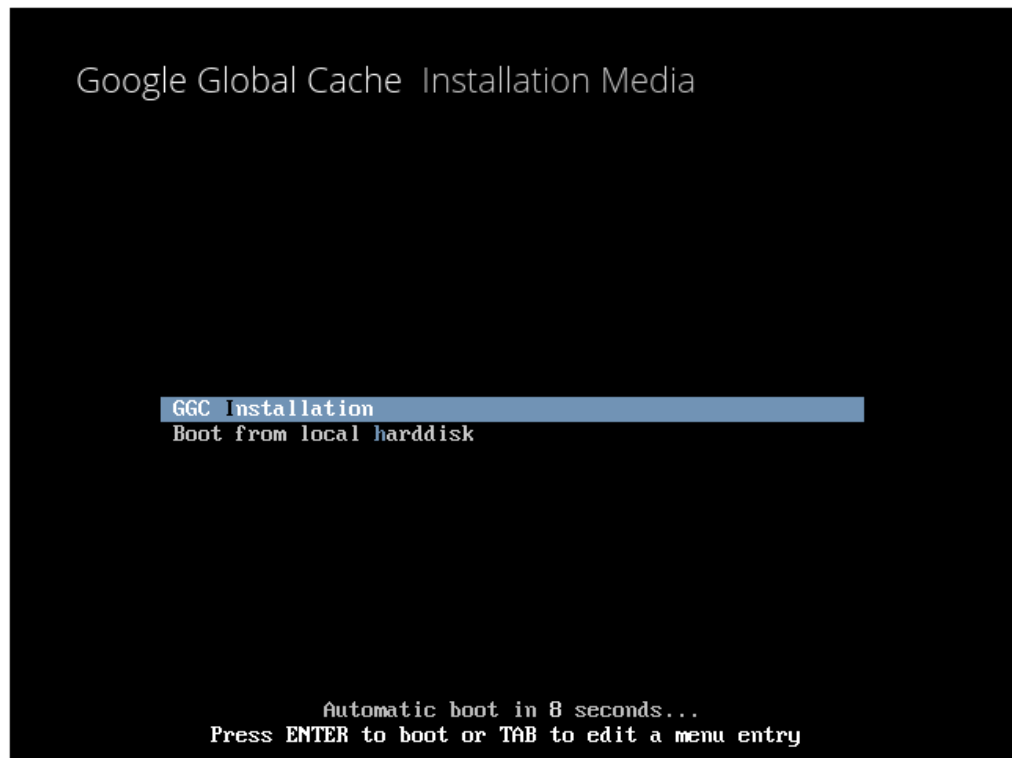
Installer Start Screen

6. Press `ENTER` or wait for 10 seconds for the 'Boot Menu' to disappear. The machine will boot up and start the installation program.

   The installer will examine the hardware. Some modifications applied by the installer may require the machine to reboot.

   If that happens, please make sure the machine boots from the USB stick again. The installation program will then resume automatically.

7. The installer will detect which network interface has a link. In this example, it is the first 10GE interface. It will ask if you wish to configure it, as shown in the following screen. Press `ENTER` to proceed:

```
Starting GGC installer.

Link has been detected on 10Ge NICs.
Do you want to configure these NICs? [Y]: █
```

NIC Detection

8. Answer the questions that appear on the screen. The configuration should match the information provided to Google in the ISP Portal *(https://isp.google.com/assets/)*:

   NOTE: If you have used this USB stick to install any GGC machines before, answers to questions below will already be pre-populated with previously used values. Please verify they are correct before pressing `ENTER`.

   - Enable LACP: select 'Y' if the machine has multiple interfaces connected, or 'N' if it has only a single interface connected

   - Enter GGC node subnet in CIDR format (x.x.x.x/nn or x:x:x:x::/64).

   - Enter the machine number (1 for the first machine, 2 for the second, and so on)

   - Confirm the configuration when prompted

```
Starting GGC installer.

Link has been detected on 10Ge NIC.
Do you want to configure this NIC? [Y]: y
Enable LACP [N]: n
Node IP subnet (x.x.x.x/nn or x:x:x:x::/64) []: 172.21.115.0/26
Machine number in this node [1]: 3

Network configuration:
 LACP is disabled
 Node IP subnet: 172.21.115.0/26
 Machine number in the node: 3
 Machine IP address: 172.21.115.6
 Default gateway: 172.21.115.1
Is this correct? [Y]: █
```

IP Information

9. The installer will validate IP information and connectivity and then begin software installation onto local hard drive. This step will take a couple of minutes. Please be patient and allow it to finish.

10. When the installation process has completed successfully, you will be asked to press `ENTER` to reboot the machine:

```
Pinging 172.21.115.1.
Pinging 8.8.8.8.
Pinging www.google.com.

Network test: successful

Gathering system information...

System Id: OEM-R 720xd
Service tag: J21P022

Configuring RAID...
Partitioning disks...
Creating file system...
Installing system...
Configuring boot loader...
Registering machine...
Configuring BIOS general settings...
Configuring BIOS boot settings...
Writing BIOS settings...

Installation complete.

Press ENTER to finish the installation. The machine will then reboot.
```

Successful installation

If any warnings or error messages are shown on the screen, please do not reboot the machine and see GGC software installation failures.

11. Remove the USB stick from the machine and press `ENTER` to reboot.

12. When the machine reboots after a successful installation, it will boot from disk. The machine is now ready for remote management. The monitor will show the Machine Health Screen:

```
Host: install                              Hardware: Hardware model
   IP: 172.16.113.58                    Service tag: 1234567
                                        Uptime: 26 days 2:11 hours

Disk status                  Network interface status
All disks are healthy        LACP state          : disabled

                             NIC Speed      Details
Power supply status          Gb1 10Gbps     UP
Both power supplies are healthy  Gb2 -          DOWN
                             Gb3 -          DOWN
                             Gb4 -          DOWN
Fan status
All fans are healthy
                             Network connectivity
                             172.16.113.254              OK
Memory status                8.8.8.8                     OK
Detected: 31 GB              8.8.4.4                     OK




Wait 04:58 for an automatic refresh          Press h for help
```

Booted from disk

13. Label each machine with the name and IP address assigned to it

> ❓ If the installation did not go as described above, please follow the steps in the next section GGC software installation failures.

6.3 GGC software installation failures

Occasionally GGC software installation may fail. This is usually due to either:

- Hardware issues, which prevent the machine from booting, or preventing the install image being written to disk or

- Network issues, which prevent the machine from connecting to GGC management systems.

First, check machine hardware status by attaching a monitor, and viewing the Machine Health Screen (https://support.google.com/interconnect/answer/9028258?hl=en&ref_topic=7658879). Further information on the available in the ISP Help Center.

When network connectivity cannot be established, please check the cables, switch and router configuration, and the IP information entered during installation. Check IP connectivity to the GGC machines from the GGC switch, from elsewhere in your network, and using external Looking Glass utilities.

If you're installing a brand new machine for the first time and the setup process reports an error *before* network connectivity is available, please always make sure you let ggc@google.com know what its service tag is when reporting the problem.

If the setup process reports an error *after* network connectivity is established, it will automatically upload logs to Google for investigation. If this happens, please leave the machine running with the USB stick inserted, so we can gather additional diagnostics, if required.

No transparent proxies, NAT devices or filters may be placed in the path of communications between the GGC Node and the Internet, subject to the explicit exceptions in the GGC Agreement. Any filtering of traffic to or from GGC machines is likely to block remote management of machines. This will delay turnup.

In other cases, please contact the GGC Operations team: ggc@google.com. Please always include the GGC node name in communications with us.

NOTE: Photos of the fault including those of the installer and Machine Health Screen will often be very useful.

6.4 Booting the machine from the USB stick

6.4.1 Dell hardware

During POST, a menu will appear on the screen, similar to the following:

Dell POST screen

- Press `F11` to enter the Boot Manager

- Select the 'BIOS Boot Menu'
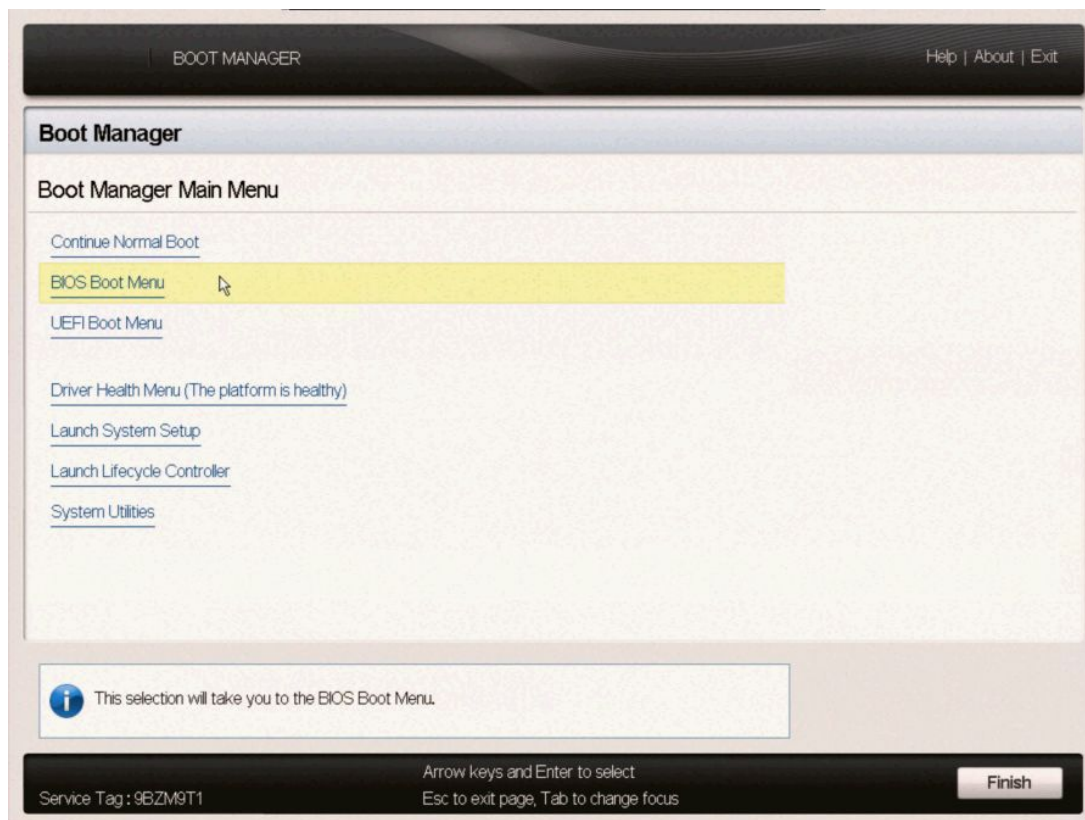
Boot manager

- From the list of bootable devices, select 'Hard disk C:' and then the USB stick, as shown in the following screen:
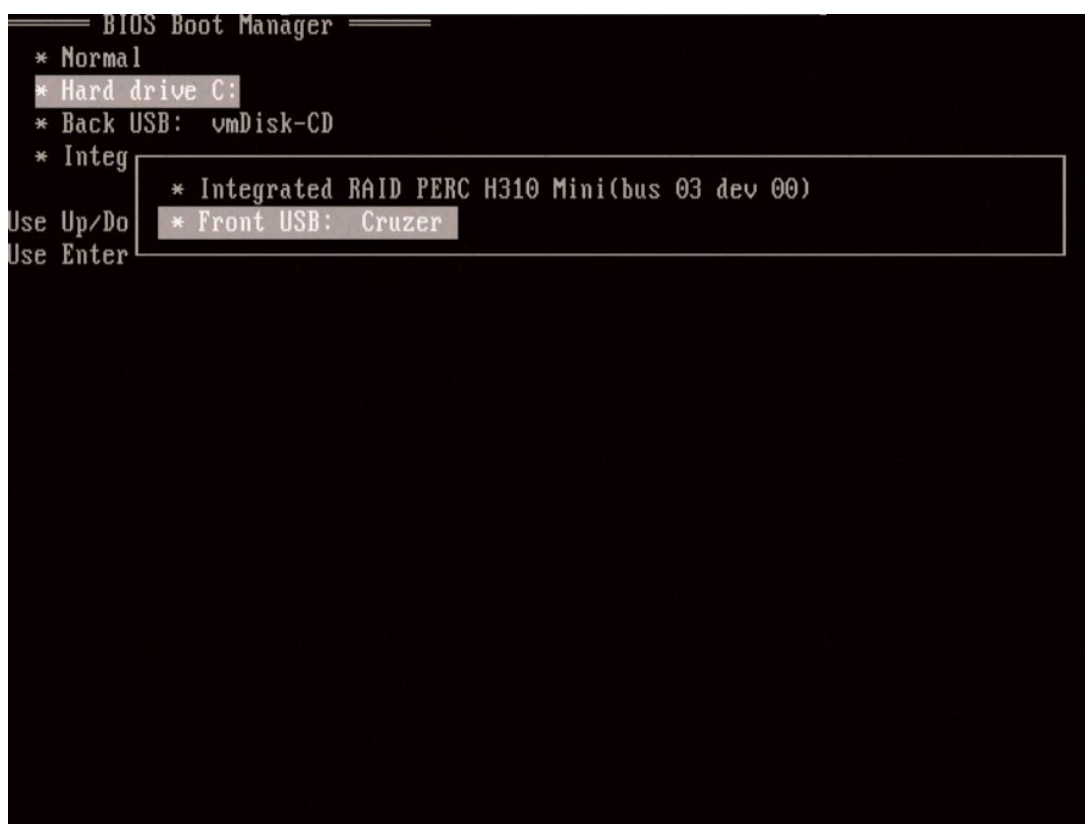
Boot from USB stick

6.4.2 HPE hardware

During POST, a menu will appear on the screen, similar to the following:
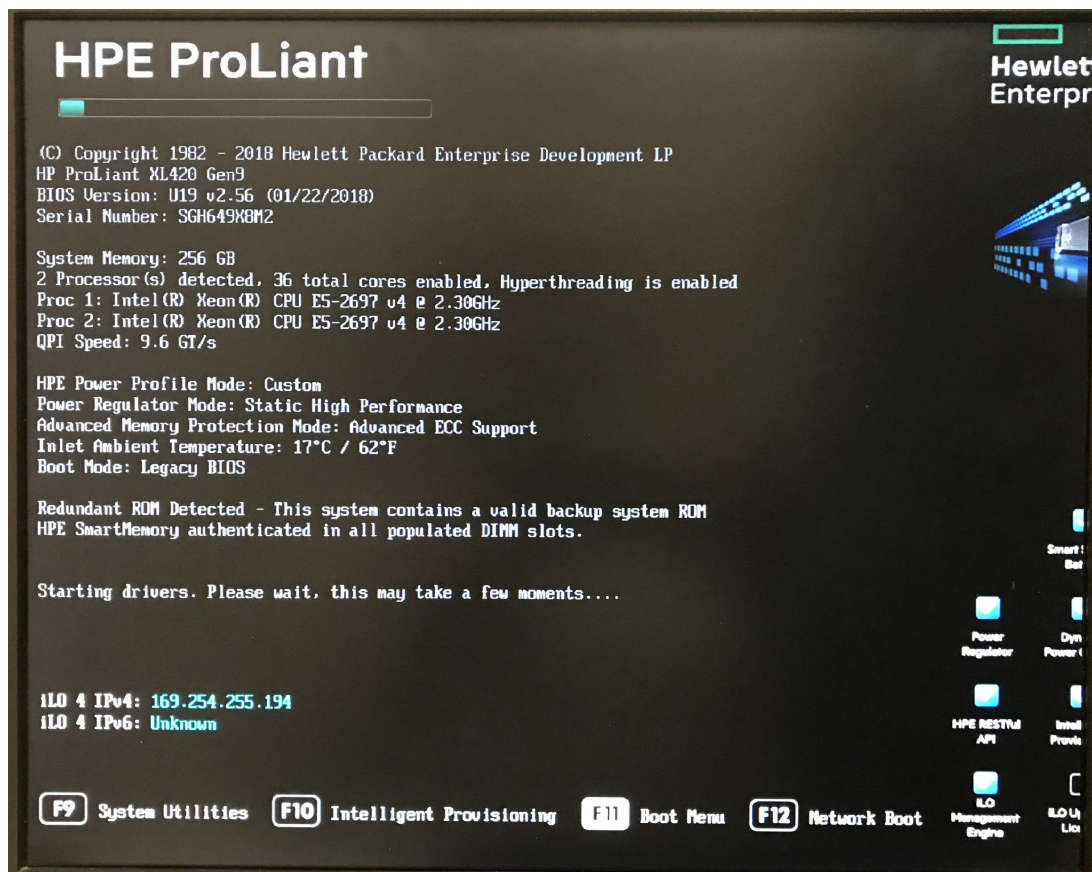
HPE POST screen

- Press `F11` to enter the Boot Menu

- Select 'Legacy BIOS One-Time Boot Menu' and select 'ENTER'
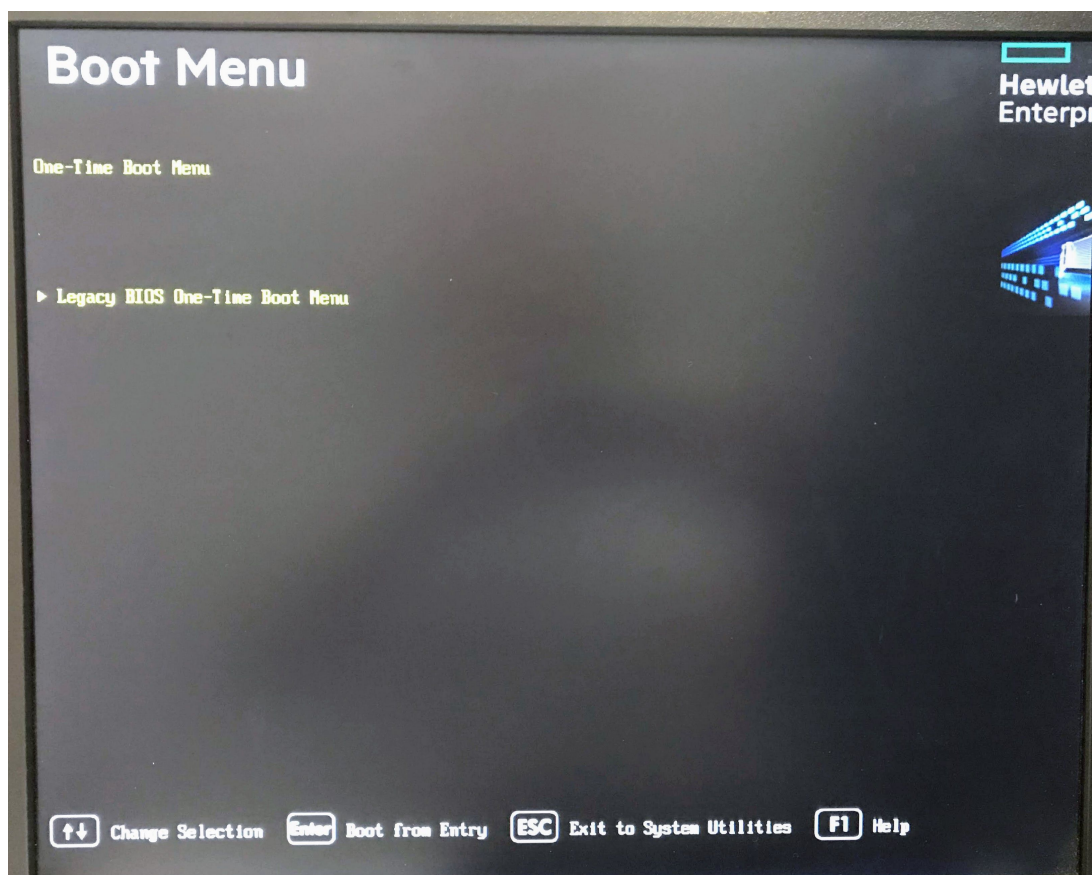
Legacy One-Time Boot

- Choose 'One Time Boot to USB DriveKey'


```
Please Choose one of the Following Default Boot Override Options:
    1) One Time Boot to CD-ROM
    2) One Time Boot to USB DriveKey
    3) One Time Boot to HDD
    4) One Time Boot to Network (1st NIC in IPL)
    5) One Time Boot to UEFI Boot Menu (after system reset)
    6) One Time Boot to UEFI Shell (after system reset)
    7) One Time Boot to Intelligent Provisioning (after system reset)
    8) Enter the System Utilities menu (after system reset)
    0) Exit Boot Override Menu and Continue Default Boot Process

 This option allows the user to choose a specific boot override
 option for this boot only. This will not modify your normal boot
 order settings.
```

Boot from USB DriveKey

BGP Configuration (Google Router)

In this scenario you will establish BGP sessions with the Google provided router. One session per each interconnect and IP protocol version is required.

7.1 You will need

- administrative access to your BGP peer router, or route server

- for BGP configuration details, please contact ggc@google.com

7.2 Procedure

You may configure your BGP router at any time. The session will not come up until Google completes the next steps of the installation - this is expected. Please note, establishing a BGP session with a Google Router and advertising prefixes will not cause traffic to flow. We will contact you to arrange a date and time to start traffic.

We recommend at least one BGP session between your BGP peer(s) and the Google provided router.

We will contact you if we have problems establishing the BGP session, or when we detect problems with the prefixes advertised.

> ⚠️ Please do not disable BGP sessions if you're planning to perform work that may adversely affect GGC nodes. Instead, please schedule a maintenance for it in the ISP Portal (https://isp.google.com/assets/).

BGP Configuration (ISP Managed Switch)

In this scenario you will establish a BGP session directly with the GGC node.

8.1 You will need

- administrative access to your BGP peer router, or route server

- general BGP instructions from https://support.google.com/interconnect?p=bgp

- BGP configuration details for this node from ISP Portal *(https://isp.google.com/assets/)*

8.2 Procedure

You may configure your BGP router at any time. The session will not come up until Google completes the next steps of the installation - this is expected. Please note, establishing a BGP session with a new GGC node and advertising prefixes will not cause traffic to flow. We will contact you to arrange a date and time to start traffic.

The BGP session established with GGC node is not used for traditional routing purposes. This is important and has two implications:

- only a single BGP session (for IPv4 and IPv6 each) with a GGC node is supported and necessary

- there is no need to monitor the session or to notify us if it is down

We will contact you if we have problems establishing the BGP session, or when we detect problems with the prefixes advertised.

⚠️ Disabling the BGP session will not stop the node from serving traffic. Our systems will continue to use the most recently received BGP feed when the session isn't established.

If your intention is to perform work that may adversely affect GGC nodes, please schedule a maintenance for it in the ISP Portal *(https://isp.google.com/assets/)* instead.

Appendix A - Cabling Requirements (Google Router)

9.1 Dell R730xd (Cisco NCS 5001)

Each machine requires:

- 2 x 10G SR SFPs; one for the machine, the other for the router

- 1 x 1G copper SFP

- 1 x multi-mode fiber

- 1 x copper Cat5e cable

- LACP disabled in GGC installer

You will also need:

- Additional SFPs for uplink(s) to your network

- Fiber of correct type for uplink(s)

Procedure:

- Insert 10G SFPs into machine network interface "Port 1", as shown below

- Insert SFPs into GGC router:
  - machine facing 10G SFPs, starting from interface #0
  - machine facing 1G SFPs, starting from interface #14
  - uplink SFPs, starting from interface #30
  - or uplink QSFPs, starting from interface #1/0

- Connect machines to switch with fiber, as shown
  - First machine 10G interface "Port 1" to router interface #0
  - Second machine 10G interface "Port 1" to router interface #1
  - and so on…
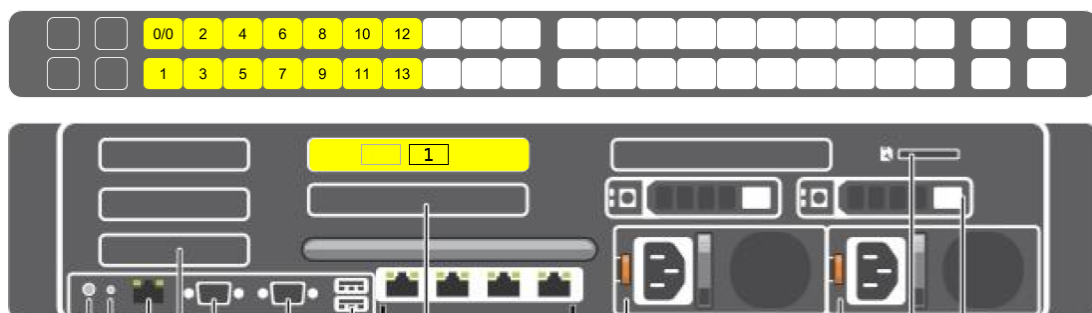
R730 Cabling (Google)

- Connect machines to switch with Cat5e cabling:
  - First machine RJ45 interface #3 to router interface #14
  - Second machine RJ45 interface #3 to router interface #15
  - and so on…

R730 Cabling (out-of-band)

- Connect uplinks from GGC router to your router

R730 Cabling (uplinks)

- Verify uplink Tx and Rx light levels from your router

9.2 Dell R740xd (Cisco NCS 5001, up to 12 machines)

Each machine requires:

- 4 x 10G SR SFPs; 2 for the machine, the other 2 for the switch

- 2 x multi-mode fiber

- LACP enabled in GGC installer

You will also need:

- Additional 10G SFPs or 100G QSFPs for uplink to your network

- Fiber of correct type for uplinks

Procedure:

- Insert uplink SFPs into GGC router:
    - if 10G SFPs are used, insert up to 16 10G SFPs into GGC router, starting from interface #24
    - if 100G QSFPs are used, insert up to 2 100G QSFPs into GGC router, starting from interface #1/0

R740 10G Uplinks (Google)

- Insert machine facing 10G SFPs into GGC router, starting from interface #0

- Insert 10G SFPs into machine network interfaces #1 and #2

- Connect machines to switch, as follows:
    - First machine interface #1 to router interface #0
    - First machine interface #2 to router interface #1
    - Second machine interface #1 to router interface #2
    - Second machine interface #2 to router interface #3
    - and so on…

R740 2x10G Cabling

9.3 Dell R740xd (Cisco NCS 5001, more than 12 machines)

Each machine requires:

- 4 x 10G SR SFPs; 2 for the machine, the other 2 for the router

- 2 x multi-mode fiber

- LACP enabled in GGC installer

You will also need:

- Additional 100G QSFPs for uplink to your network
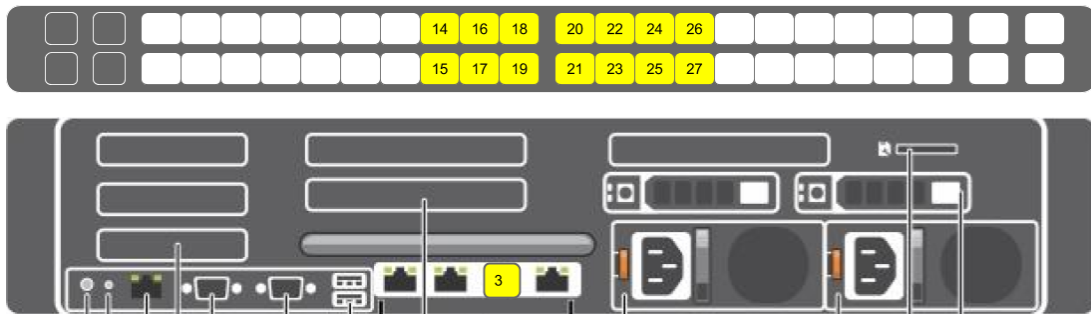
- Fiber of correct type for uplinks

Procedure:

- Insert uplink SFPs into GGC router:
  - insert up to 2 100G QSFPs into GGC router, starting from interface #1/0
  - 10G uplinks are not supported

R740 100G Uplinks (Google)

- Insert machine facing 10G SFPs into GGC router, starting from interface #0

- Insert 10G SFPs into machine network interfaces #1 and #2

- Connect machines to switch, as follows:
  - First machine interface #1 to router interface #0
  - First machine interface #2 to router interface #1
  - Second machine interface #1 to router interface #2
  - Second machine interface #2 to router interface #3
  - and so on…

R740 2x10G Cabling

9.4 Dell R740xd2 (Cisco NCS 5011)

Each machine requires:

- 1 x 40G QSFP direct-attach cable

You will also need:

- Additional 100G QSFPs for uplink to your network

- Fiber of correct type for uplinks

Procedure:

- Connect machines to switch with direct-attach cable, as shown:
  - First machine 40G interface (#1 in the diagram) to GGC router interface #0
  - Second machine 40G interface (#1 in the diagram) to GGC router interface #1
  - and so on…

R740xd2 Cabling

- Insert 100G QSFPs used for uplinks into GGC router, starting from interface #24

R740xd2 Uplinks

- Connect uplinks from GGC router to your router

- Verify uplink Tx and Rx light levels from your router

9.5 HPE Apollo 4200 (Cisco NCS 5001, up to 8 machines)

Each machine requires:

- 4 x 10G SR SFPs; 2 for the machine, the other 2 for the router

- 1 x 1G copper SFP (router end)

- 2 x multi-mode fibers

- 1 x copper Cat5e cable

- LACP enabled in GGC installer

You will also need:

- Additional SFPs or QSFPs for uplink to your network

- Fiber of correct type for uplinks

Procedure:

- Insert SFPs into GGC router:
    - machine facing 10G SFPs, starting from interface #0
    - machine facing 1G SFPs, starting from interface #16
    - uplink SFPs, starting from interface #24
    - or QSFPs, starting from interface #1/0

- Insert 10G SFPs into machine network interfaces #1 and #2, as shown

- Connect machines to switch with fiber, as shown:
    - First machine 10G interfaces #1, #2 to router interface #0, #1
    - Second machine 10G interfaces #1, #2 to router interfaces #2, #3
    - and so on…

HPE Apollo 4200 Cabling

- Connect machines to switch with Cat5e cabling, as shown:
    - First machine RJ45 interface #1 to router interface #16
    - Second machine RJ45 interface #1 to router interface #17
    - and so on…

HPE Apollo 4200 Cabling (out-of-band)

- Connect uplinks from GGC router to your router

- Verify uplink Tx and Rx light levels from your router

9.6 HPE Apollo 4200 (Cisco NCS 5001, more than 8 machines)
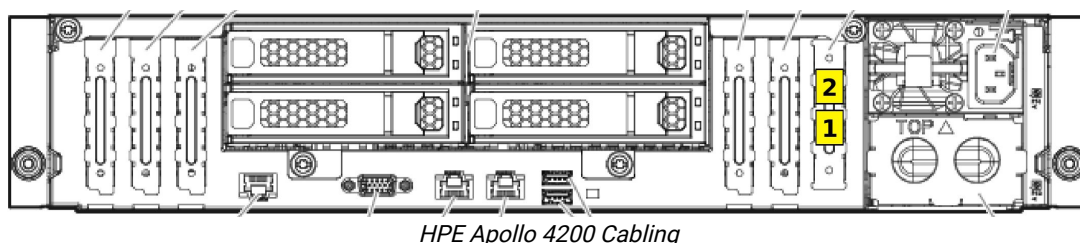
Each machine requires:

- 2 x 10G SR SFPs; 2 for the machine, the other 2 for the router

- 1 x 1G copper SFP (router end)

- 2 x multi-mode fibers

- 1 x copper Cat5e cable
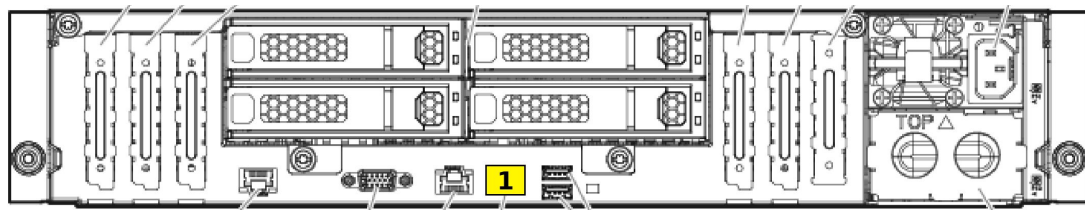
- LACP enabled in GGC installer

You will also need:

- Additional 100G QSFPs for uplink to your network (10G SFP uplinks are not supported)

- Fiber of correct type for uplinks

Procedure:

- Insert SFPs into GGC router:
    - machine facing 10G SFPs, starting from interface #0
    - machine facing 1G SFPs, starting from interface #24
    - uplink QSFPs, starting from interface #1/0

- Insert 10G SFPs into machine network interfaces #1 and #2, as shown

- Connect machines to switch with fiber, as shown:
    - First machine 10G interfaces #1, #2 to router interface #0, #1
    - Second machine 10G interfaces #1, #2 to router interfaces #2, #3
    - and so on…

HPE Apollo 4200 Cabling

- Connect machines to switch with Cat5e cabling:
    - First machine RJ45 interface #1 to router interface #24
    - Second machine RJ45 interface #1 to router interface #25
    - and so on…

HPE Apollo 4200 Cabling (out-of-band)

- Connect uplinks from GGC router to your router

HPE Apollo 4200 Cabling (uplinks)

- Verify uplink Tx and Rx light levels from your router

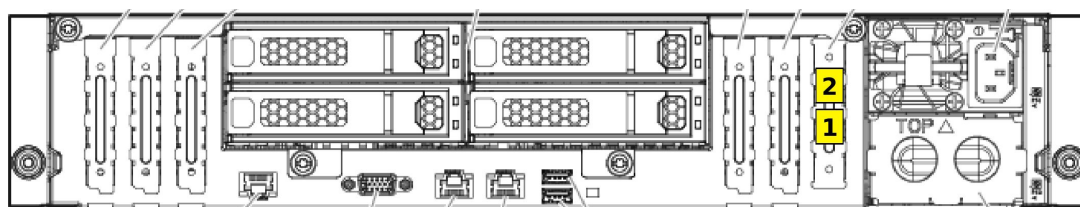# 9.7 HPE Apollo 4200 (Cisco NCS 5011)

Each machine requires:

- 1 x QSFP direct-attach cable

- LACP disabled in GGC installer

You will also need:

- Additional 100G QSFPs for uplink to your network

- Fiber of correct type for uplinks

Procedure:

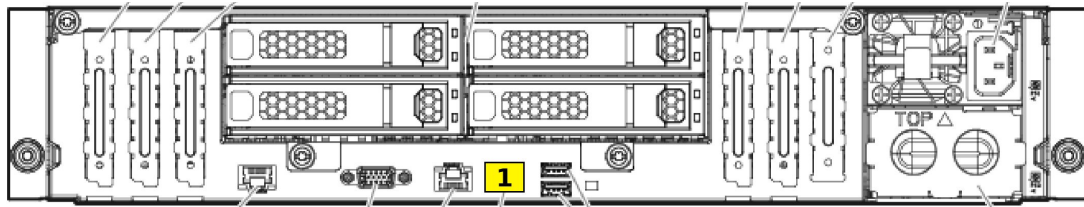- Insert 100G QSFPs into GGC router, starting from interface #24

- Connect machines to switch with direct-attach cable, as shown:
    - First machine 40G interface (#2 in the diagram) to GGC router interface #0

    - Second machine 40G interface (#2 in the diagram) to GGC router interface #1

    - and so on…
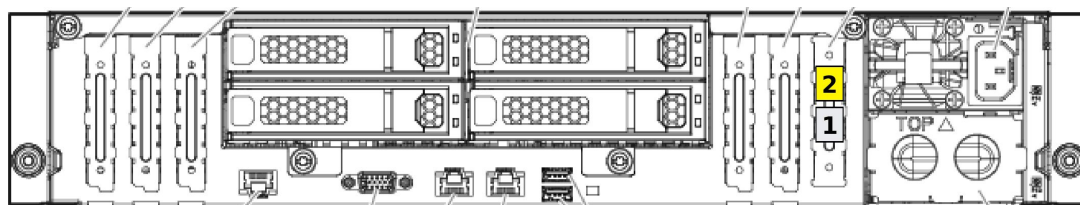
HPE Apollo 4200 Cabling (40G)

- Connect uplinks from GGC router to your router

- Verify uplink Tx and Rx light levels from your router

Appendix B - Cabling Requirements (ISP Managed Switch)

10.1 Dell R430

Each machine requires:

- 2 x copper Cat5e or Cat6 cables

- LACP enabled in GGC installer

Procedure:

- Connect machine RJ45 network interfaces #1 and #2, as shown, to your switch

R430 Cabling

10.2 Dell R440

Each machine requires:

- 2 x copper Cat5e or Cat6 cables

- LACP enabled in GGC installer

Procedure:

- Connect machine RJ45 network interfaces #1 and #2, as shown, to your switch

R440 Cabling

10.3 Dell R730xd

Each machine requires:

- 2 x 10G SFPs (SR or LR); one for the machine, the other for the switch

- 1 x multi-mode or single-mode fiber, to match SFP type

- LACP disabled in GGC installer

Procedure:

- Insert SFPs into machine network interface #1, as shown

- Insert SFPs into your switch

- Connect machines to switch

- Verify Tx and Rx light levels from your switch

R730 Cabling (ISP)

10.4 Dell R740xd 2x10G

Each machine requires:

- 4 x 10G SFPs (SR or LR); 2 for the machine, the other 2 for the router

- 2 x multi-mode or single-mode fiber, to match SFP type

- LACP enabled in GGC installer

Procedure:

- Insert two SFPs into machine network interfaces #1 and #2, as shown

- Insert SFPs into your switch

- Connect machines to switch

- Verify Tx and Rx light levels from your switch

- On your switch add two ports facing each machine into separate LACP bundle
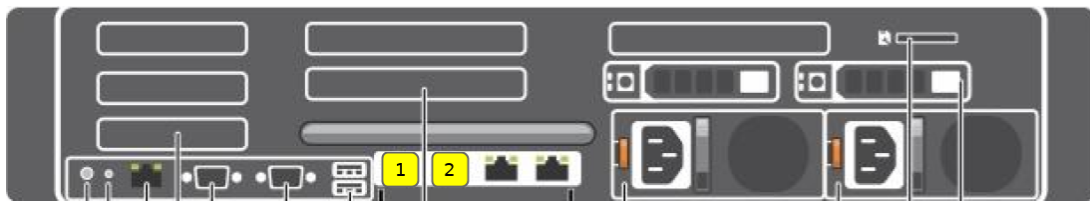

R740 2x10G Cabling

10.5 Dell R740xd 1x10G

Each machine requires:

- 2 x 10G SFPs (SR or LR); one for the machine, the other for the switch

- 1 x multi-mode or single-mode fiber, to match SFP type

- LACP disabled in GGC installer

Procedure:

- Insert SFP into machine network interface #1, as shown

- Insert SFP into your switch

- Connect machines to switch

- Verify Tx and Rx light levels from your switch

R740 1x10G Cabling

Appendix C - Configuration Examples (ISP Managed Switch)

The following examples are for illustrative purposes only. Your configuration may vary. Please contact your switch vendor for detailed configuration support for your specific equipment.

11.1 Cisco switch interface configuration (LACP disabled)

You should replace interface descriptions `mynode-abc101` with the name of the GGC node, and the machine number.

```
!
  interface TenGigabitEthernet1/1
    description mynode-abc101
    switchport mode access
    flowcontrol send off
    spanning-tree portfast
  !
  interface TenGigabitEthernet1/2
    description mynode-abc102
    switchport mode access
    flowcontrol send off
    spanning-tree portfast
  !
  interface TenGigabitEthernet1/3
    description mynode-abc103
    switchport mode access
    flowcontrol send off
    spanning-tree portfast
  !
  interface TenGigabitEthernet1/4
    description mynode-abc104
    switchport mode access
    flowcontrol send off
    spanning-tree portfast
  !
  end
```

11.2 Cisco switch interface configuration (LACP enabled)

You should replace interface descriptions `mynode-abc101-Gb1` with the name of the GGC node, the machine number, and machine interface name.

```
!
  interface GigabitEthernet1/1
    description mynode-abc101-Gb1
    switchport mode access
    flowcontrol send off
    channel-protocol lacp
    channel-group 1 mode passive
    spanning-tree portfast
  !
  interface GigabitEthernet1/2
    description mynode-abc101-Gb2
    switchport mode access
    flowcontrol send off
    channel-protocol lacp
    channel-group 1 mode passive
    spanning-tree portfast
  !
  interface Port-channel1
    description mynode-abc101
    switchport
    switchport mode access
    no port-channel standalone-disable
    spanning-tree portfast
  !
  interface GigabitEthernet1/3
    description mynode-abc102-Gb1
    switchport mode access
    flowcontrol send off
    channel-protocol lacp
    channel-group 2 mode passive
    spanning-tree portfast
  !
  interface GigabitEthernet1/4
    description mynode-abc102-Gb2
    switchport mode access
    flowcontrol send off
    channel-protocol lacp
    channel-group 2 mode passive
    spanning-tree portfast
  !
  interface Port-channel2
    description mynode-abc102
    switchport
    switchport mode access
    no port-channel standalone-disable
    spanning-tree portfast
  end
```

11.3 Juniper switch interface configuration (LACP disabled)

You should replace interface descriptions `mynode-abc101` with the name of the GGC node, and the machine number.

```
set interfaces xe-0/0/1 description mynode-abc101-Xe1
  set interfaces xe-0/0/1 unit 0 family ethernet-switching port-mode access
  set interfaces xe-0/0/2 description mynode-abc101-Xe1
  set interfaces xe-0/0/2 unit 0 family ethernet-switching port-mode access
  set interfaces xe-0/0/3 description mynode-abc101-Xe1
  set interfaces xe-0/0/3 unit 0 family ethernet-switching port-mode access
  set interfaces xe-0/0/4 description mynode-abc101-Xe1
  set interfaces xe-0/0/4 unit 0 family ethernet-switching port-mode access
  # The above may be "interface-mode" access
  set interfaces xe-0/0/1 unit 0 family ethernet-switching vlan members vlan10
  set interfaces xe-0/0/1 ether-options no-flow-control
  set protocols stp interface xe-0/0/1 edge
  set interfaces xe-0/0/2 unit 0 family ethernet-switching vlan members vlan10
  set interfaces xe-0/0/2 ether-options no-flow-control
  set protocols stp interface xe-0/0/2 edge
  set interfaces xe-0/0/3 unit 0 family ethernet-switching vlan members vlan10
  set interfaces xe-0/0/3 ether-options no-flow-control
  set protocols stp interface xe-0/0/3 edge
  set interfaces xe-0/0/4 unit 0 family ethernet-switching vlan members vlan10
  set interfaces xe-0/0/4 ether-options no-flow-control
  set protocols stp interface xe-0/0/4 edge
```

11.4 Juniper switch interface configuration (LACP enabled)

You should replace interface descriptions `mynode-abc101-Xe1` with the name of the GGC node, the machine number, and interface name on your switch.

```
set interfaces ge-0/0/1 description GGChost1-Gb1
  set interfaces ge-0/0/1 ether-options 802.3ad lacp force-up
  set interfaces ge-0/0/1 ether-options 802.3ad ae0
  set interfaces ge-0/0/2 description GGChost1-Gb2
  set interfaces ge-0/0/2 ether-options 802.3ad lacp force-up
  set interfaces ge-0/0/2 ether-options 802.3ad ae0
  set interfaces ge-0/0/3 description GGChost2-Gb1
  set interfaces ge-0/0/3 ether-options 802.3ad lacp force-up
  set interfaces ge-0/0/3 ether-options 802.3ad ae1
  set interfaces ge-0/0/4 description GGChost2-Gb2
  set interfaces ge-0/0/4 ether-options 802.3ad lacp force-up
  set interfaces ge-0/0/4 ether-options 802.3ad ae1
  set interfaces ae0 description GGChost1
  set interfaces ae0 aggregated-ether-options no-flow-control
  set interfaces ae0 aggregated-ether-options lacp passive
  set interfaces ae0 unit 0 family ethernet-switching port-mode access
  set interfaces ae0 unit 0 family ethernet-switching vlan members vlan10
  set interfaces ae1 description GGChost2
  set interfaces ae1 aggregated-ether-options no-flow-control
  set interfaces ae1 aggregated-ether-options lacp passive
  set interfaces ae1 unit 1 family ethernet-switching port-mode access
  set interfaces ae1 unit 1 family ethernet-switching vlan members vlan10
  # Use "stp" or "rstp" depending on the spanning-tree protocol in use
  set protocols stp interface ae0 edge
  set protocols stp interface ae1 edge
```

11.5 Cisco BGP configuration (prefix list based route filtering)

```
neighbor <IP address of GGC> remote-as 11344
  neighbor <IP address of GGC> transport connection-mode passive
  neighbor <IP address of GGC> prefix-list deny-any in
  neighbor <IP address of GGC> prefix-list GGC-OUT out

  ip prefix-list deny-any deny 0.0.0.0/0 le 32

  ip prefix-list GGC-OUT permit <x.y.z/24>
  ip prefix-list GGC-OUT permit <a.b.c/24>
```

11.6 Cisco BGP configuration (AS-PATH based route filtering)

```
neighbor <IP address of GGC> remote-as 11344
  neighbor <IP address of GGC> transport connection-mode passive
  neighbor <IP address of GGC> filter-list 1 in
  neighbor <IP address of GGC> filter-list 2 out

  ip as-path access-list 1 deny .*

  ip as-path access-list 2 permit _100_
  ip as-path access-list 2 permit _200$
  ip as-path access-list 2 permit ^300$
```

11.7 Juniper BGP configuration (prefix based policy)

```
neighbor <IP address of GGC> {
    description "GGC";
    import no-routes;
    export export-filter;
    peer-as 11344;
    passive;
  }

  policy-statement no-routes {
    term default {
      then reject;
    }
  }
```

11.8 Juniper BGP configuration (AS-PATH based policy)

```
neighbor <IP address of GGC> {
    description "GGC";
    import no-routes;
    export export-filter;
    peer-as 11344;
    passive;
}
policy-statement no-routes {
    term default {
        then reject;
    }
}
policy-statement export-filter {
    term allow-routes {
        from {
            from as-path-group GGC;
        }
        then accept;
    }
}
as-path-group GGC {
    as-path AS-PATH-NAME-1 "^100.*";
    as-path AS-PATH-NAME-2 "^200.*";
}
```

Appendix D - Physical Requirements

Physical Dimensions

Hardware	Height	Width	Depth	Weight
Dell R430xd	1U	19" rack mount	607mm (24")	19.9kg (44lb)
Dell R440	1U	19" rack mount	693mm (27")	17.5kg (38.6lb)
Dell R730xd	2U	19" rack mount	684mm (27")	32.5kg (72lb)
Dell R740xd	2U	19" rack mount	715mm (28")	33.1kg (73lb)
Dell R740xd2	2U	19" rack mount	811mm (32")	43.2 kg (95.24 lb)
HPE Apollo 4200	2U	19" rack mount	813mm (32")	35kg (77lb)
Cisco NCS 5001	1U	19" rack mount	490mm (19")	9.3kg (20.5lb)
Cisco NCS 5011	1U	19" rack mount	572mm (22.5")	10kg (22.2lb)

Required operating temperature is 10°C to 35°C (50°F to 95°F), at up to 80% **non-condensing** humidity. Exhaust temperatures of up to 50°C (122°F) may be observed; this is normal.

See vendor documentation for further environmental and mechanical specifications.

Appendix E - Power Requirements

Each machine requires dual power feeds. Machines will be shipped with either 110V/240V PSUs, or 50V DC power PSUs.

Google provides only some power cord types. If your facility requires other types of power cords and they're not listed in the table below, you will need to provide them.

Per-machine power requirements and power cords provided by Google

Hardware	Nominal Power[1]	Peak Power	AC Power Cords	DC Power Cords
Dell R430xd	250W	270W	C13/C14	None
Dell R440	166W	307W[2]	C13/C14	None
Dell R730xd	350W	450W	C13/C14	None
Dell R740xd	357W	780W[3]	C13/C14	None
Dell R740xd2	617W	1018W[4]	C13/C14	None
HPE Apollo 4200	372W	633W	C13/C14	None
Cisco NCS 5001	200W	275W	C13/C14	CAB-48DC-40A-8AWG
Cisco NCS 5011	228W	508W	C13/C14	CAB-48DC-40A-8AWG

Google does not provide DC power cords for machines; please have your electrician connect machines to DC power.

See Appendix F for further electrical specifications.

Appendix F - Vendor Hardware Documentation

If you have further questions related to hardware delivered by Google and cannot find answers in this document, please consult the appropriate resource listed below.

Vendor hardware documentation

Hardware	Link
Dell PowerEdge (all)	General Resources *(https://qrl.dell.com/Product/Category/1)*
Dell R430xd	Owner's Manual *(http://topics-cdn.dell.com/pdf/poweredge-r430_owner's%20manual_en-us.pdf)*
Dell R440	Owner's Manual *(http://topics-cdn.dell.com/pdf/poweredge-r440_owner's%20manual_en-us.pdf)*
Dell R730xd	Owner's Manual *(http://topics-cdn.dell.com/pdf/poweredge-r730_Owner's%20Manual_en-us.pdf)*
Dell R740xd	Owner's Manual *(http://topics-cdn.dell.com/pdf/poweredge-r740_Owner's%20Manual_en-us.pdf)*
Dell R740xd2	Owner's Manual *(https://topics-cdn.dell.com/pdf/poweredge-r740xd2_owners-manual_en-us.pdf)*
HPE Apollo 4200	Owner's Manual *(http://h20566.www2.hpe.com/hpsc/doc/public/display?sp4ts.oid=8261831&docLocale=en_US&docId=emr_na-c04718413)* Quick Specs *(https://www.hpe.com/h20195/v2/GetPDF.aspx/c04616497.pdf)*
Cisco NCS 5000 series	Hardware Installation Guide *(https://www.cisco.com/c/en/us/td/docs/iosxr/ncs5000/hardware-install/b-ncs5000-hardware-installation-guide/b-ncs5000-hardware-installation-guide_chapter_01.html#id_16803)*

1. Nominal power during regular operation.↵

2. Dell estimated maximum potential instantaneous power draw of the product under maximum usage conditions. Should only be used for sizing the circuit breaker. Peak power values for other platforms were sourced in-house by running synthetic stress test.↵

3. Dell estimated maximum potential instantaneous power draw of the product under maximum usage conditions. Should only be used for sizing the circuit breaker. Peak power values for other platforms were sourced in-house by running synthetic stress test.↵

4. Dell estimated maximum potential instantaneous power draw of the product under maximum usage conditions. Should only be used for sizing the circuit breaker. Peak power values for other platforms were sourced in-house by running synthetic stress test.↵