Deploy Router Using Bootz

With the Bootz process, you can securely and seamlessly provision network devices accurately within minutes and without any manual intervention.

Table 1: Feature History Table

Feature	Release Information	Feature Description
Provisioning Using Bootz Process	Release 7.11.1	This feature allows devices in the network to establish a secure connection with the remote Bootz server and authenticate information using a three-step validation process. This process involves validating the network device, the Bootz server, and the onboarding information thereby mitigating security risks and preventing malicious actions during remote provisioning.

Unlike the Secure ZTP process, which relies on vendor-specific definitions for bootstrapping a device, the Bootz process offers a specification that outlines data elements in a vendor-agnostic manner. It also details the necessary operations at turn-up time, integrating them into the boot process.

Also, the bootstrap request in the Bootz process includes the unique identifier or serial number for each node as opposed to the Secure ZTP process where the bootstrap request does not include serial numbers. The Bootz server returns the signed onboarding information with ownership voucher and owner certificate for the requested serial number of the device.

Supported Bootz Versions

This table provides the Bootz versions supported in each release. The Bootz Bootstrap server must be compatible with the respective Bootz version.

Table 2: Bootz Versions

Release	Version with File Path
Release 7.11.1	`openconfig/bootz v0.1.0`

Components used in the Bootz Process

These components are part of the Bootz process.

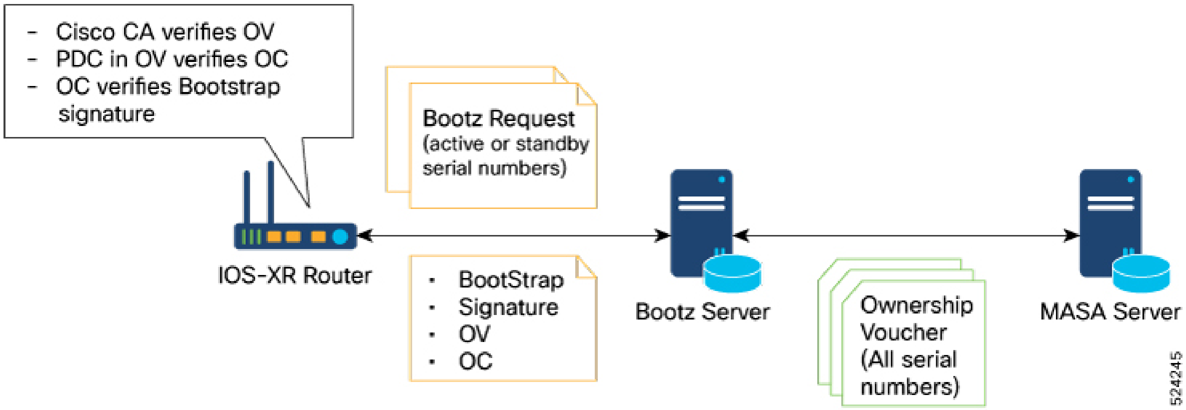
- **Onboarding Device (Router):** A router is a Cisco device that you want to provision and connect to your network. Bootz is supported only on platforms that have *Hardware TAM*[1] support.
- **DHCP Server:** The DHCP server provides the URL where the Bootz process can access the bootstrapping information.
- **MASA Server:** You can generate and store the ownership voucher in the MASA server. The MASA server sends the ownership voucher to the Bootz server so that the Bootz process validates the device and establishes device ownership.
- **Bootz Bootstrap Server:** A Bootz Bootstrap server is any gRPC server used as a Bootz bootstrapping data source. For example, Google Proto. The Bootz Bootstrap server is complaint with Openconfig Bootz standards.

Note Bootz only supports a single name-server. As a result, when the DHCP server has more than one server address configured, Bootz fails to apply the server configuration.

The Bootz server contains these artifacts:

- **Cisco IOS XR software images:** You can download Cisco images, SMU, and patches from the Cisco Support & Downloads page.
- **Bootstrapping Data:** It is a collection of data that you have created and uploaded to the Bootz server. The router obtains this data from the Bootz server during the provisioning process.

[1] A secure storage device that stores the customer certificates and Cisco's internal secure data like trust anchors, SUDI certificates, secure flags, and other security information.


- Cisco CA verifies OV
- PDC in OV verifies OC
- OC verifies Bootstrap signature
Bootz Request (active or standby serial numbers)
IOS-XR Router
• BootStrap
• Signature
• OV
• OC
Bootz Server
Ownership Voucher (All serial numbers)
MASA Server
524245

Onboard Devices Using Bootz Workflow

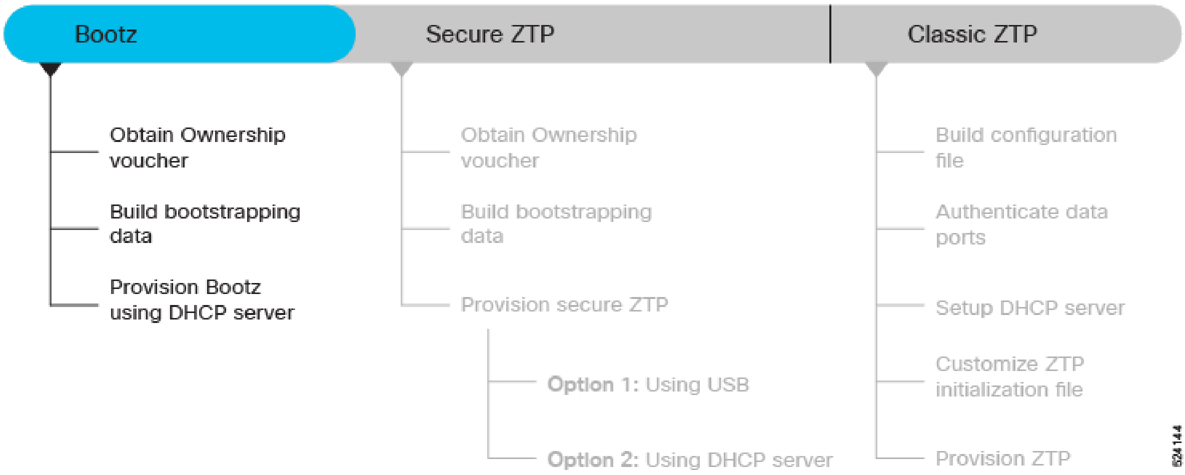
The Cisco IOS XR software supports Bootz provisioning capabilities. The Bootz process uses the Google Remote Procedure Call (gRPC) protocol for fetching information from a remote server.

The Bootz workflow performs these validations to onboard the remote devices securely.

1. **Router Validation**: The Bootz server authenticates the router before providing the bootstrapping data.
2. **Server Validation**: The router in turn validates the Bootz server and ensures that the onboarding is performed for the correct network. Once it is validated, the Bootz server sends the bootstrapping data (for example, a YANG data model) or artifact to the router.
3. **Artifact Validation**: The router validates the bootstrapping data or artifacts received from the Bootz server.

This figure provides the Bootz workflow and the processes involved in the workflow. The sections that follow describe these processes in detail.

Figure 1: Bootz Workflow



Obtain Ownership Voucher

The ownership voucher is used to identify the owner of the device by verifying the owner certificate stored in the device.

How to obtain Ownership Voucher

These steps help you obtain the ownership voucher from Cisco:

1. Contact Cisco Support.
2. Provide these information in your request to Cisco.
    - **Pinned Domain certificate (PDC):** PDC is an X.509 v3 certificate structure that uses Distinguished Encoding Rules (DER). The router uses this certificate to trust a public key infrastructure for verifying a domain certificate supplied to the router separately in the bootstrapping data. This certificate could be an end-entity certificate, including a self signed entity.
    - Purchase order details with the serial numbers of the routers.

    Sample Request:

    ```
    {
       "expires-on": "2016-10-21T19:31:42Z",
       "assertion": "verified",
       "serial-number": "JADA123456789",
       "idevid-issuer": "base64encodedvalue==",
       "pinned-domain-cert": "base64endvalue==",
       "last-renewal-date": "2017-10-07T19:31:42Z"
    }
    ```

3. Cisco generates the ownership voucher in .vcj format (Example: DCA213140YX.vcj) and sends the voucher in response to your request.

Build Bootstrapping Data

Steps to build the bootstrapping data:

1. Create and upload the bootstrapping data to the gRPC server or Bootz bootstrap server.
2. The router sends a bootstrap request with these artifacts to the Bootz server.
    - Serial number of the control card or line card
    - Software image to download and install
    - Bootloader Password for the device
    - Certificate used to validate the bootstrap server
    - Bootstrap server configuration information such as server credentials, path information, authentication information, and certificates

    For the request message format, see the Bootstrap Request Message.

3. The Bootz server returns the listed bootstrapping data in its response to the router. The router receives these data during the provisioning process.

    - **Signed Bootstrap Response:** Each bootstrap response contains the onboarding information for:

      For the response message format, see the Bootstrap Response Message for a single card.

    - **Owner Certificate:** The owner certificate is installed on the router with your organization's public key. The router uses this public key in the owner certificate to verify the signature in the signed bootstrap response artifact.

    - **Ownership Voucher:** The ownership voucher is used to identify the device owner by verifying the owner certificate stored in the device. Cisco generates and supplies the ownership voucher in response to your request containing the PDC and device serial numbers. For more information, see Obtain Ownership Voucher.

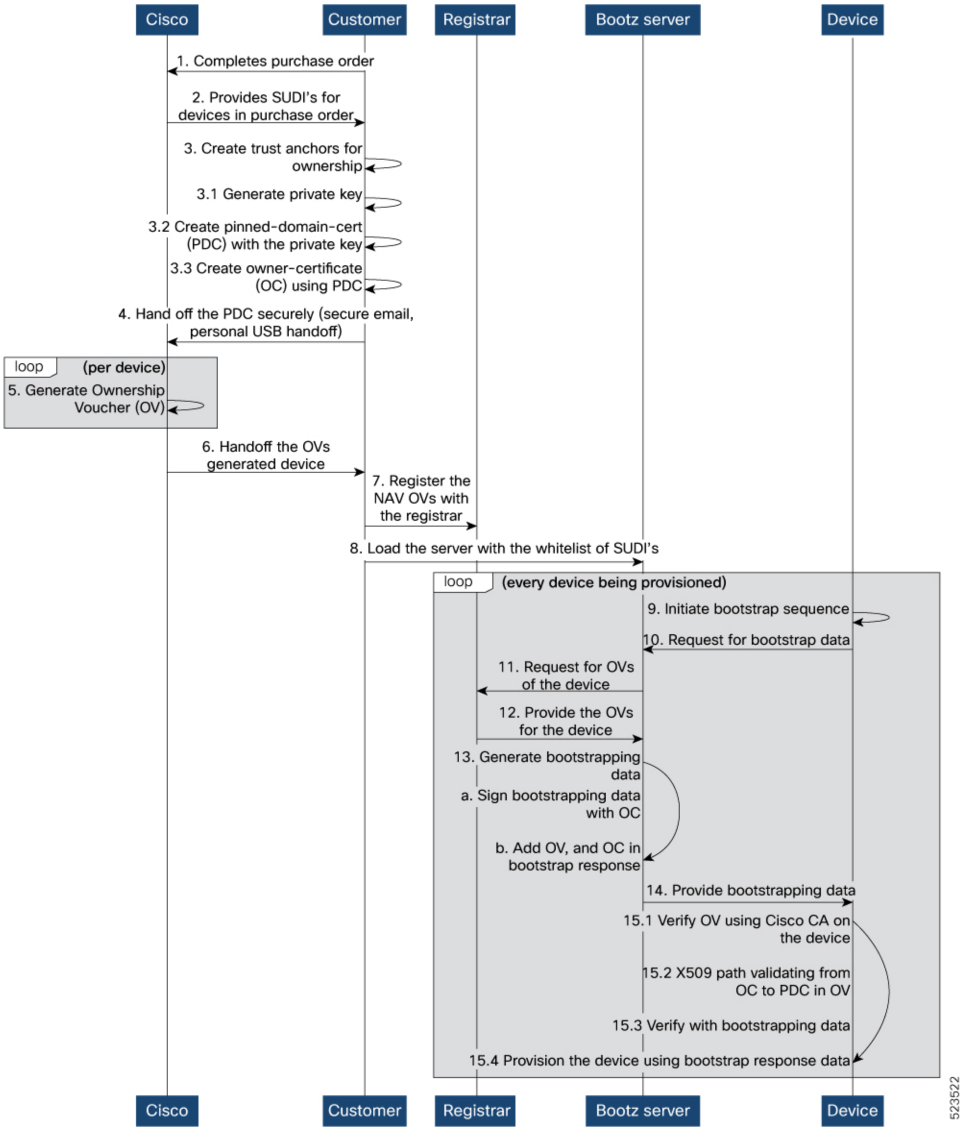
4. When the router obtains the onboarding information from the Bootz server, the router reports the bootstrapping progress to the Bootz server using the API calls.

Provision Bootz Using DHCP Server

When you boot the device, the Bootz process initiates automatically on a device without prior configuration. During the process, the router receives the details of the configuration file from the DHCP server.

This figure illustrates the end-to-end sequence of the Bootz process:

Figure 2: End-to-end sequence of the Bootz process


Cisco
Customer
Registrar
Bootz server
Device
1. Completes purchase order
2. Provides SUDI's for devices in purchase order
3. Create trust anchors for ownership
3.1 Generate private key
3.2 Create pinned-domain-cert (PDC) with the private key
3.3 Create owner-certificate (OC) using PDC
4. Hand off the PDC securely (secure email, personal USB handoff)
loop
(per device)
5. Generate Ownership Voucher (OV)
6. Handoff the OVs generated device
7. Register the NAV OVs with the registrar
8. Load the server with the whitelist of SUDI's
loop
(every device being provisioned)
9. Initiate bootstrap sequence
10. Request for bootstrap data
11. Request for OVs of the device
12. Provide the OVs for the device
13. Generate bootstrapping data
a. Sign bootstrapping data with OC
b. Add OV, and OC in bootstrap response
14. Provide bootstrapping data
15.1 Verify OV using Cisco CA on the device
15.2 X509 path validating from OC to PDC in OV
15.3 Verify with bootstrapping data
15.4 Provision the device using bootstrap response data
Cisco
Customer
Registrar
Bootz server
Device
523522

Before you begin

As part of the initial setup for secure ZTP, the network administrator:

- Ensures to enable secure ZTP on the router using the **ztp secure-mode enable** command and reload the router.
- Contacts Cisco Support and follows the steps in Obtain Ownership Voucher to obtain a voucher from Cisco.

Procedure

Step 1 Upload the listed bootstrapping data to the Bootz server. Refer to your vendor documentation as the upload procedure may vary from server to server.

- Cisco IOS XR software images

  Note Download Cisco images, SMU, and patches from the Cisco Support & Downloads page.

- Serial numbers of the routers to be onboarded
- Owner certificates
- Pinned Domain Certificate (PDC)
- Ownership vouchers

Step 2 Set up the DHCP server to provide the redirect URL to the router:

Before triggering the secure ZTP process, configure the DHCP server so that it provides the location of the IOS-XR image to the router. For information about how to configure the DHCP server, see your DHCP server documentation.

Configure these parameters in the DHCP server:

- `option-code`: Use one of these DHCP SZTP redirect option parameters in the `option-code` setting.
  - OPTION_V4_SZTP_REDIRECT (143): DHCP v4 code for IPv4.
  - OPTION_V6_SZTP_REDIRECT (136): DHCP v6 code for IPv6.
- `option-length`: Provide the option length in octets.
- `bootstrap-servers`: A list of servers. The onboarding device contact these servers for the bootstrapping data.

  ```
  "bootz://<ip-address-or-hostname>[:<port>]<endpoint>"
  ```

Example: `option dhcp6.bootstrap-servers code 136 = text;`

Step 3 Power on the router.

This procedure provides the high-level workflow of the Bootz process:

a. When you boot the device with an IOS-XR image, the secure ZTP process verifies if the secure ZTP mode (`secure-ztp mode`) is enabled. If not enabled, the device boots normally.

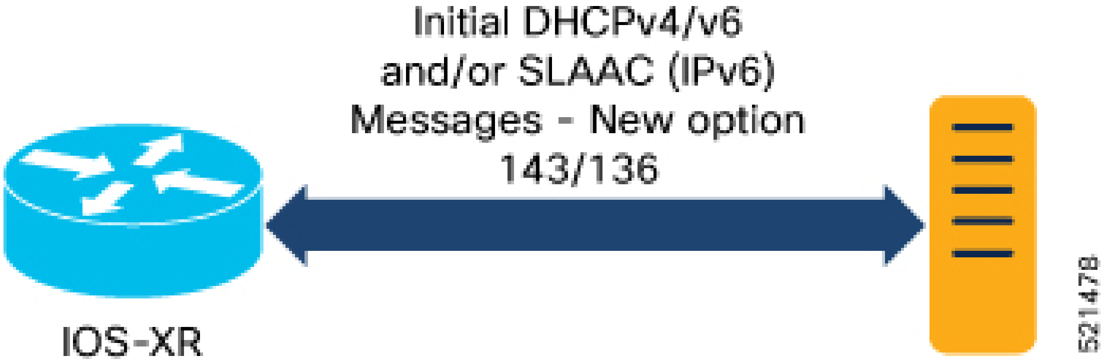
Note When `secure-ztp mode` is enabled, the ZTP process accepts only the `secure-redirect-URL` and ignores the presence of the boot file name option from the DHCP response.

b. **DHCP discovery**:

1. The router initiates a DHCP request to the DHCP server.
2. The DHCP server responds with a DHCPv4 143 address option (for IPv4 addressing) or a DHCPv6 136 option (for IPv6 addressing).

Note URLs to access bootstrap servers for further configuration are listed in options 136 and 143.

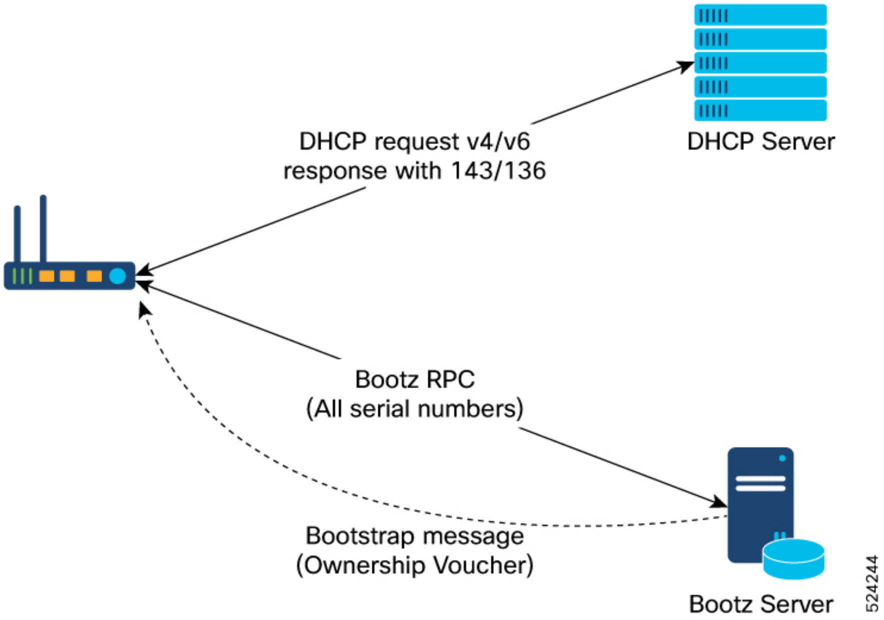
Figure 3: DHCP discovery


Initial DHCPv4/v6 and/or SLAAC (IPv6) Messages - New option 143/136
IOS-XR
521478

c. **Router and Bootz server validation**:

1. After receiving the URL from the DHCP server, the router initiates a gRPC connection to the Bootz server. The Bootz server IP address is obtained from the DHCP response.
2. The Bootz server authenticates the router before it provides the bootstrapping data.
3. After the Bootz server authenticates the router or the onboarding device, the router validates the Bootz server to ensure that the onboarding is performed for the correct network.

   After validating the Bootz server, the router sends the serial number for each control card or line card and other artifacts in its bootstrap request.
4. After its validation, the Bootz server sends the required artifacts along with the bootstrap response data to the router or the onboarding device.



d. **Ownership Voucher verification**:

The router receives the bootstrap response data that contains owner certificate, ownership voucher for each serial number, and the details of the image upgrade, if any.

Bootstrap response data includes the following:

- Image path
- Image version
- Trust anchor
- Boot configuration
- GNSI artifacts

These artifacts come from the Bootz server as a bootstrap response gRPC message. The router verifies the ownership voucher by validating its signature to one of its preconfigured trust anchors and downloads the image. When the router obtains the onboarding information, it reports the bootstrapping progress to the Bootz server.

e. **Artifact Validation**:

The router validates the artifacts received from the Bootz server as follows:

1. The device extracts the `pinned-domain-cert` node, an X.509 certificate from the ownership voucher to verify the owner certificate.
2. The device authenticates the owner certificate by performing the X.509 certificate path verification process on the trusted certificate.
3. Finally, the device verifies whether the artifact is signed by the validated owner certificate.

f. **Provision the device**:

1. The device first processes the boot image information.
2. Executes the script and then onboards the artifacts received from the Bootz server.

g. After the onboarding process is completed, the network device is operational.