Safectory Track Configuration Guide for Cisco (gRPC-Based) Access Points

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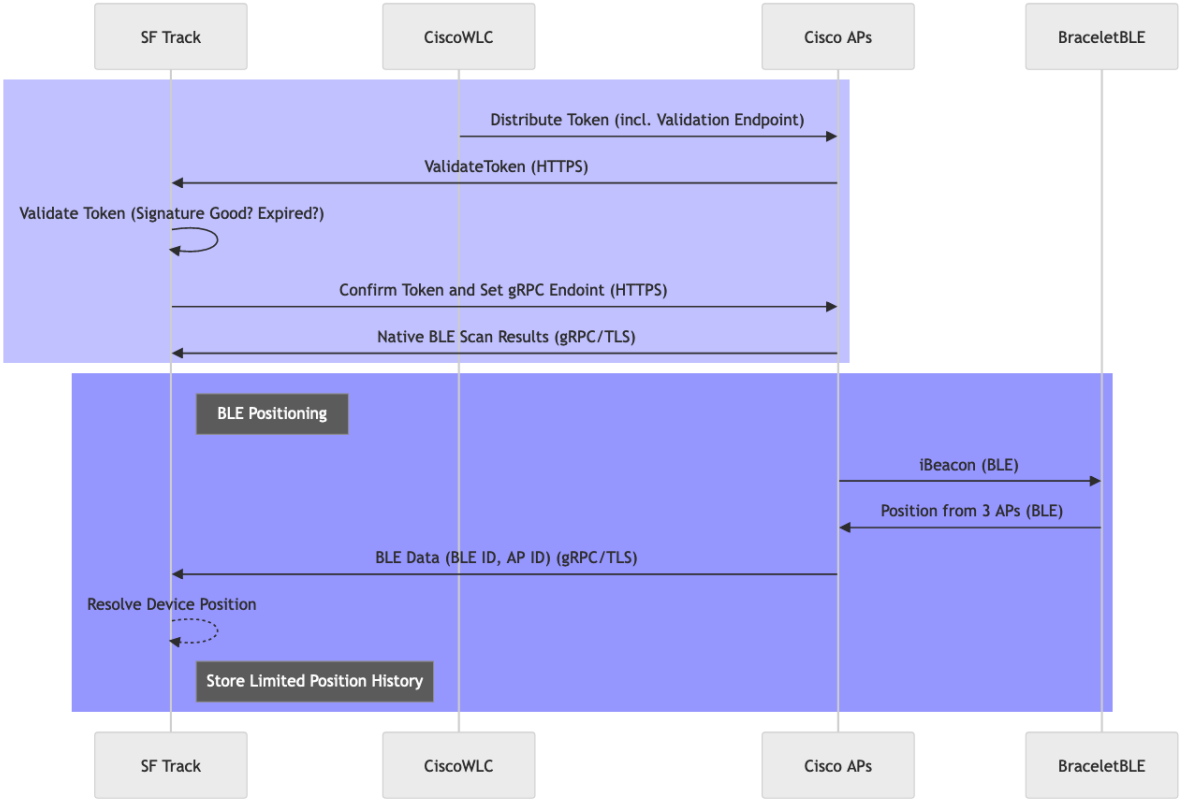
Revision history

Version	Date	Description
0.1	12/2023	Initial version
0.2	04/2024	Revised version

Introduction

safectory´s BLE hardware for tracking assets and tracing contacts.



To set up Cisco access points to be used with safectory products (asset tags, beacons, mobile SDK, Track backend), use the following manual.

Certified Product and Software Summary

- Certified products:
  - all BLE-enabled access points (e.g., Cisco Catalyst 9105AX Series-W / 9115AXI-E / 9115AXE-E (tested))
  - (v)WLCs: Cisco Catalyst 9800 Series Wireless Controller / Cisco Catalyst 9800-CL Wireless Controller

- Certified software:
  - Cisco software versions approved (WLC): Cisco IOS 1.17.3+
  - SF backend versions approved: 1.17.+
  - Minimal gRPC version: 1.11.0

Configuring Clock/NTP Services

Time synchronization is an essential part of managing beacons and tracking asset in your network, so please make sure that all the nodes are synchronized with the same reference server and time.

Configuring Preferred DNS to Reach *.safectory.com

For non-Track-On-Premise (non-ToP) installations only: The controller should have DNS configured and be able to reach `*.safectory.com` server.

Request or Create an Authorized User

- Request or create a Track user with email `mysecret@authkey.safectory.com`
- Set a secret password, (e.g. `mysecret`)
- Make sure the user has a group in Track that can at least access (read/write) beacons and devices.

Part I: HTTPS and gRPC Setup for Track Service

In order to make all communication channel work, the following changes are necessary (all described in the upcoming subsections):

- HTTPS and gRPC certificate creation
- Nginx configuration and firewall adjustments
- Track backend config adjustments
- WLC config adjustments
- Certificate enrollment (WLC)
- Enabling gRPC in AP Join Profile (WLC)
- Enabling BLE radio(s) for scanning and beaconing (WLC)
- Enabling gRPC endpoint(s) in the Track backend

Hint: Once HTTPS connection between the backend and Cisco APs work, in SF Track, devices (+ associated beacons) with the exact same name as your Cisco APs will be automatically created and shown online/green.

safectory

Set Up Certificate + PKCS#8 Key

The following steps describe generation of a self-signed certificate.
If there is already a certificate available, then you may skip to bullet 5 (PKCS#8 generation).

1. Suggestion: Use the same certificate for both HTTPS (→ Nginx config) and gRPC
2. Determine the IP address of the target system (the one the backend is running on)
3. Generate a file named `ssl.conf` with following content; adjust the IP address `xxx.xxx.xxx.xxx` to the one determined in the previous step (the file is assumed to be in the same directory as the other files generated in the next steps):

```
[req]
distinguished_name = req_distinguished_name
req_extensions = v3_req
[req_distinguished_name]
countryName                 = DE
countryName_default         = CA
stateOrProvinceName         = Bayern
stateOrProvinceName_default = Bayern
localityName                = Bamberg
localityName_default        = Bamberg
organizationName            = safectory
organizationName_default    = safectory
commonName                  = xxx.xxx.xxx.xxx
commonName_max              = 64
commonName_default          = xxx.xxx.xxx.xxx

[v3_req]
subjectAltName = @alt_names

[alt_names]
IP.1 = xxx.xxx.xxx.xxx
```

4. Generate basic key file (`server.key`) and certificate (`server.cert`):

```
openssl genrsa -out myca.key 2048
openssl genrsa -out server.key 2048
openssl req -x509 -new -nodes -key myca.key -sha256 -days 365 -out myca.cert
openssl req -out server.csr -key server.key -new -config ssl.conf
openssl x509 -req -in server.csr -CA myca.cert -CAkey myca.key -CAcreateserial -
out server.cert -days 365 -extensions v3_req -extfile ./ssl.conf
```

5. Generate `server.pkcs8` from `server.key` (**without** password)

```
$ openssl pkcs8 -topk8 -inform PEM -outform PEM -nocrypt -in server.key -out
server.pkcs8
```

6. Adjust Nginx config to use newly generated key pair, see next subsection (requires to generate PEM: `openssl x509 -inform PEM -in server.cert > server.cert.pem`)

Set Up Nginx and Firewall (Track On-Premise (ToP) Installation)

1. Nginx: Check config (`streaming` endpoint defined?):
   - Open `/etc/nginx/sites-enabled/001-trac-ssl`
   - If not defined yet, add:

```
location /streaming {
    proxy_pass          http://backend-track/api/streaming;
    proxy_set_header    X-Real-IP       $remote_addr;
    proxy_set_header    X-Forwarded-For $remote_addr;
    proxy_set_header    Host            $host;

}
```

   - Update paths of `ssl_certificate` and `ssl_certificate_key` (to the ones of `server.cert.pem` and `server.key`, respectively)
   - Verify changed config via `nginx -t` (outputs like `syntax is ok` and `test is successful` are expected)
   - When there were no errors, reload or restart Nginx: `systemctl restart nginx`
2. Firewall: Ensure that TCP ports 57501 (gRPC) and 443 (HTTPS) are open

Set Up Track

- [ ] Make sure that `gateway.jwt.secretKey` is set in `/opt/prodtrac/config/credentials.xml`, otherwise generate a new key via `openssl rand 256 | openssl enc -A -base64`
- [ ] Add/adjust those backend config options to/in `/opt/prodtrac/config/custom.xml` (make sure to replace `TRACK_ADDRESS` with the IP address or hostname; `server.{cert,pkcs8}` are the files generated in Set Up Certificate + PKCS#8 Key, whose paths need to be adjusted in the backend config):

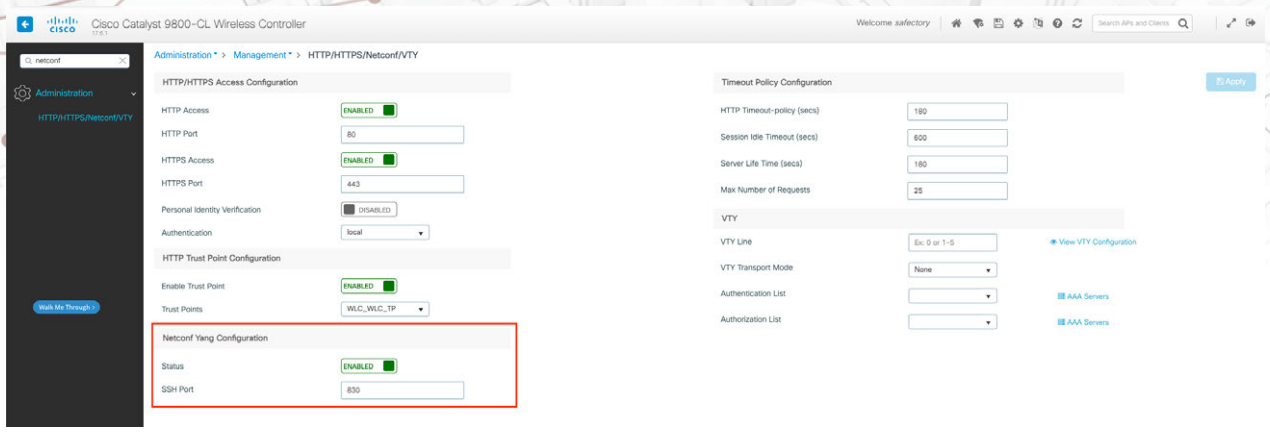
```
<entry key='gateway.jwt.grpcRetryIntervalSec'>120</entry>
<entry key='gateway.grpc.streaming.port'>57501</entry>
<entry key='gateway.grpc.autoAddDevicesAndBeacons.enable'>true</entry>

<entry key='gateway.jwt.tokenValidateEndpoint'>TRACK_ADDRESS:443</entry>
<entry key='gateway.jwt.grpcEndpointInvalid'>TRACK_ADDRESS:9</entry>
<entry key='gateway.grpc.server.cert'>/path/to/server.cert</entry>
<entry key='gateway.grpc.server.key'>/path/to/server.pkcs8</entry>
```

Set Up WLC (and Access Points)

Enable NETCONF via Web UI on WLC

Navigate to **Administration** > **Management** > **HTTP/HTTPS/Netconf/VTY**:

- Enable **Netconf Yang Configuration**
- SSH Port: 830

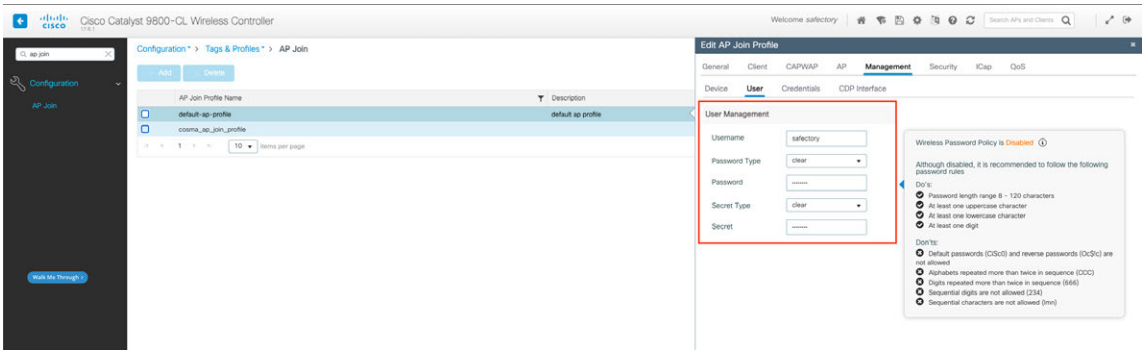


Enable SSH Access via Web UI on WLC and APs

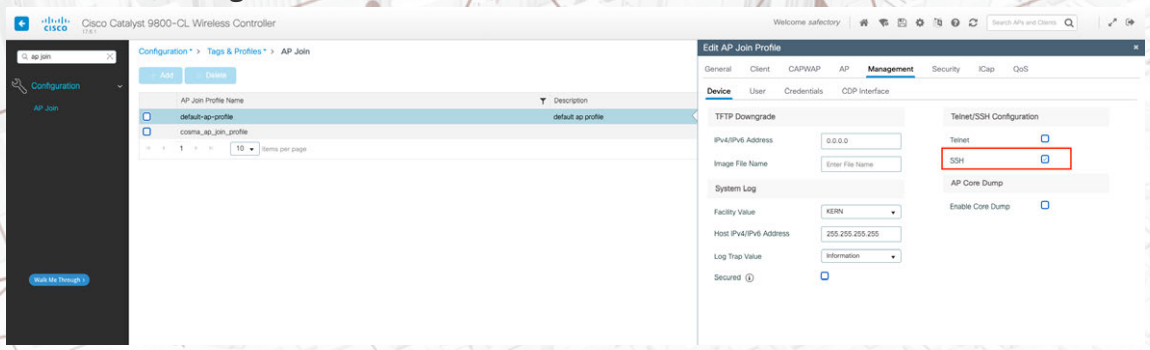
1. Navigate to **Administration** > **Command Line Interface**:
   - Switch to **Configure** mode
   - Paste and execute (**Run Command** button) following commands:

```
aaa new-model
aaa authentication login default local
aaa authorization exec default local
```

2. Navigate to **Configuration** > **Tags & Profiles** > **AP Join** > Select (default) AP profile
   - Add new user (**Management** > **User** tab)



- Enable SSH (**Management** > **Device** tab)



Setting up Cisco YANG Suite (NETCONF Client with Web UI)

The Cisco YANG Suite is a set of tools for interacting with Cisco IOS XE and other network operating systems via NETCONF (and other interfaces) [https://developer.cisco.com/yangsuite/].
For our purpose, it serves to enable features such as BLE scanning or beaconing and to distribute a Java Web Token (JWT), required for successful authentication and communication between access points and the Track service.
The Track service will generate XMLs that are executed as RPCs via YANG Suite.

The following procedures were tested on Ubuntu 20.04.2 LTS.

Install YANG Suite (Debian-based distribution assumed)

Please ensure that you have a machine with direct WLC access, then install the suite as described on following resources:

- https://developer.cisco.com/docs/yangsuite/#!welcome-to-cisco-yang-suite/docker-based-installation
- https://github.com/CiscoDevNet/yangsuite

For the next steps, a successful installation is assumed, which allows you to log in to the YANG Suite web frontend.

Configure YANG Suite

Navigate (left menu bar) to **Setup** > **Device profiles** > Set up new device by

- giving it a name (e.g., `WLC`)
- entering the WLC's IP address (e.g., `172.27.0.121`)
- entering credentials (e.g., `safectory` / `safe4711`)
- selecting **Skip SSH key validation for this device** in device settings
- making sure that the correct type is selected for NETCONF (i.e., `Cisco IOS XE`)
- testing the config and confirming (green) checkmarks for NETCONF and "Ping" when hitting the **Check connectivity** button

Running an RPC via NETCONF / YANG Suite

An XML RPC can be executed by

1. navigating (left menu bar in YANG Suite) to **Protocols** > **NETCONF**
2. selecting a device (e.g., `WLC`)
3. pasting one or more XMLs into the text field on the right and hitting **Run RPC(s)**

Note:

- It is **neither** necessary to select a **YANG Set** nor any **Module(s)** nor a **NETCONF Operation** to successfully execute RPCs (because the XMLs contain all information needed to execute them).
- Loading modules etc. is only required if you want to display the **YANG Tree**, which can be useful to generate custom XML RPCs via YANG Suite (**Build RPC** button)

Adding a Trust Point and Certificate to the (v)WLC (Enrollment)

A trust point and the certificate can be enrolled via CLI.

If you are using two certificates (one for Nginx/HTTPS and one for gRPC), it is required to enroll both certificates as described for one certificate in the following to the (v)WLC.
This is necessary to allow communication with the ToP backend endpoint `/api/streaming/validate` (HTTPS) and to allow gRPC connections from the AP(s) to the gRPC endpoint (see section Set up gRPC Endpoints) that is configured for the respective AP device (e.g., via TrackUI).

1. Connect to the (v)WLC via SSH/CLI
2. Optional: To remove an already existing trust point (`trackca` in the example):

```
WLC#configure t
WLC(config)#no crypto pki trustpoint trackca
% Removing an enrolled trustpoint will destroy all certificates
 received from the related Certificate Authority.

Are you sure you want to do this? [yes/no]: yes
% Be sure to ask the CA administrator to revoke your certificates.
```

3. Prepare new trust point via following commands; the name of the trust point (`trackca` in the example below) can be chosen freely:

```
Enter configuration commands, one per line.  End with CNTL/Z.
WLC#configure t
WLC(config)#crypto pki trustpoint trackca
WLC(ca-trustpoint)#enrollment terminal
WLC(ca-trustpoint)#chain-validation stop
WLC(ca-trustpoint)#revocation-check  none
WLC(ca-trustpoint)#exit
```

4. Add the actual certificate to the trust point; it simply can be pasted after entering the following command on the first line:

```
WLC(config)#crypto pki authenticate trackca

Enter the base 64 encoded CA certificate.
End with a blank line or the word "quit" on a line by itself

-----BEGIN CERTIFICATE-----
MIIDPzCCAiegAwIBAgIULzxZ3O1WImFajJohxbCGsisQgYQwDQYJKoZIhvcNAQEL
BQAwRDELMAkGA1UEBhMCREUxDzANBgNVBAgMBkJheWVybjEQMA4GA1UEBwwHQmFt
YmVyZzESMBAGA1UECgwJU2FmZWN0b3J5MB4XDTIyMDExMjE2MTA0NFoXDTIzMDEx
MjE2MTA0NFowWjELMAkGA1UEBhMCQ0ExDzANBgNVBAgMBkJheWVybjEQMA4GA1UE
BwwHQmFtYmVyZzESMBAGA1UECgwJc2FmZWN0b3J5MRQwEgYDVQQDDAsxNzIuMjcu
MC41NTCCASIwDQYJKoZIhvcNAQEBBQADggEPADCCAQoCggEBAJ/l/Ry6xSW/FgHW
4GIA9cQkuHSURUefvCFKOP9DkLo7tW6Zd+1t5PhixaAfocY5/WiBJ7p61F2DaeTI
e0mG337tG3f2sCGbJiGfFaBuWPb5cfMyW1kv9AeRWRdeSSyusS/VW4oulKTUPqIA
UcG2M5FBeOQ3QDXm/gRvCmbl29nP3EBIriG7V6wxoh+mcrd2rnsd+qXZxUNGutOs
iomtruV2v1R78XXeDCipXq571aC73guB4rRHcDnbAT4JEZmIGUVTCeGND+KGr9c8
9D5yeuxPuTvNO3W8+bpkXMNHL/aNUKbOO6KOwYJz/7YOGKXMKo3SQVovAsuEVqdP
+4Iu1C8CAwEAAaMTMBEwDwYDVR0RBAgwBocECi0AIjANBgkqhkiG9w0BAQsFAAOC
AQEAjOZjtL/Yt4u+rSj/1GG4RUEnkAm9r5W0hvFl5/OJgGeBcwEOk9rtiC0UsYqC
U8+vo391leMy7wC6+DpaHHf/zHnKa35iyg6FrRyjoRas/61WPjoUGAbGW/6wB7Ri
1dO+L2TXvugn6HtvWGyopO6euBemhPVqgLa9fwGYyiGyYFbcQ09y8muiaZ1UoYd1
u8zzPyI+qrqFiCTjtYicRkHpUlLc33pRKZxvAyOmdSrPAHK9sG+V8AtaOQOnEsrI
vpE69eXb2piQReZw863OeGw3z/qg2n7znJEko1/ouvtoG+OrZU1KGFwCtXtvBIF
QsPnyIyBA2/916aW4ugc4AgMiQ==
-----END CERTIFICATE-----

Trustpoint 'trackca' is a subordinate CA and holds a non self signed cert
Trustpoint 'trackca' is a subordinate CA.
but certificate is not a CA certificate.
Manual verification required
Certificate has the following attributes:
       Fingerprint MD5: 4BE72F95 6DF15BA8 A29F8118 A54626A1
      Fingerprint SHA1: 7121A37A D9381935 D43FBA7D BFD27574 3B566D01

% Do you accept this certificate? [yes/no]: yes
Trustpoint CA certificate accepted.
% Certificate successfully imported
```

5. Optional: To verify/view the certificate afterwards:

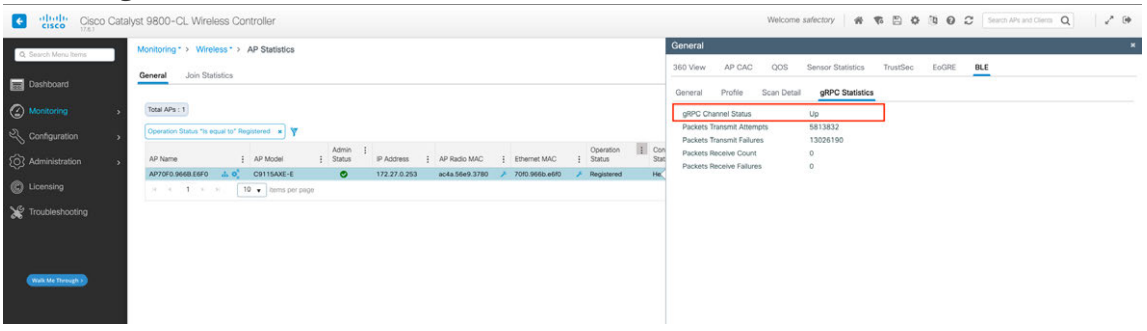
```
WLC#show crypto pki certificates
CA Certificate
  Status: Available
  Certificate Serial Number (hex): 2F3C59DCED5622615A8C9A21C5B086B22B108184
  Certificate Usage: General Purpose
```

```
  Issuer:
    o=Safectory
    l=Bamberg
    st=Bayern
    c=DE
  Subject:
    cn=172.27.0.55
    o=safectory
    l=Bamberg
    st=Bayern
    c=CA
  Validity Date:
    start date: 17:10:44 MST Jan 12 2022
    end   date: 17:10:44 MST Jan 12 2023
  Associated Trustpoints: trackca
...
```

Enable gRPC in AP Join Profile

The following steps need to be done via CLI:

1. Log in via SSH
2. Type `configure terminal`
3. Type `ap profile ap-profile-name` (replace `ap-profile-name` appropriately)
4. Type `cisco-dna grpc`
5. Verify **gRPC Channel Status** is **Up** via web UI
    - Navigate to **Monitoring** > **Wireless** > **AP Statistics**
    - Select an AP
    - Switch to **BLE** tab (on the right-hand side)
    - Switch to **gRPC Statistics** tab



Steps 1–4 are also described in more detail on https://www.cisco.com/c/en/us/td/docs/wireless/controller/9800/17-5/config-guide/b_wl_17_5_cg/m_ble_management_in_the_controller.html.

Notes:

- It may be necessary to create an **AP Join Profile** in the first place, which can be done at **Configuration** > **Tags & Profiles** > **AP Join**.

- Furthermore, it may also be necessary to create a **Site Tag** that needs to be associated with the **AP Join Profile** at **Configuration** > **Tags & Profiles** > **Tags** > select **Site** tab:

Enable BLE Radio (Scanning and Beaconing) and JWT Distribution

The Track backend has a generator at `/api/netconf` to generate NETCONF XML entries for different tasks/settings.
Track also has a function to generate signed JSON Web Tokens (JWTs) that can be used as an authorized user with device-write permissions by requesting `https://<TRACK_ADDRESS>/api/streaming/token/generate`.

1. To enable BLE scanning, get output from Track service and execute via NETCONF as follows:
   - TrackUI: Have at least one (AP) device with attribute `generate_grpc_netconf == true`
   - Get output for NETCONF (for all APs): https://TRACK_ADDRESS/api/netconf?configsEnabled=ble-scan-req&configsEnabled=ble-ibeacon-req&configsEnabled=ble-mgt-admin-req&configsEnabled=ap-dna-global-config
   - Submit NETCONF RPC via YANG suite (w/o `<CONFIGURATION>` start and end tag), see section Running an RPC via NETCONF / YANG Suite
2. To distribute a new token (JWT), get output from Track service and execute via CLI as follows:
   - Generate JWT: https://TRACK_ADDRESS/api/streaming/token/generate → returned value from key `streamAccessKey` needs to be inserted for `$token` in next step (w/o quotes)
   - Distribute JWT via WLC: `configure terminal` + `ap cisco-dna token 0 $token`. Example:

```
WLC#configure t
Enter configuration commands, one per line.  End with CNTL/Z.
WLC(config)# ap cisco-dna token 0
eyJhbGciOiJIUzI1NiJ9.eyJjaWQiOjEwMDAwMDAwMDAwMDAwMDAwLCJ0aWQiOjEwMDAwMCwi
c2Z1aWQiOjEwMDAwMSwiaWF0IjoxNjQyMTU4NjY2LCJlcCI6IjE3Mi4yNy4wLjU1OjQ0MyIsImV4c
CI6MTY3MzY5NDc2Nn0.lLDWKpj_9pW-Z_9SO_pOJ1guMthA3vVEB1VEHQtpFiQ
WLC(config)# exit
WLC#
```

3. WebUI (enabling radio only): https://WLC_ADDRESS/webui/#/wirelessglobal (**Configuration** > **Wireless** > **Wireless Global**)

Set up gRPC Endpoints

To make an AP talk with the ToP backend, it is required to specify the address and port for gRPC connections:

- TrackUI: Add `grpcEndpoint` attribute to generated AP devices via TrackUI (value: `<TRACK_ADDRESS>:57501`)

Part II: Setup Access Point as Location Beacon (iBeacon)

This functionality is given and validated for Cisco IOS XE (17.3.1 + 17.6.1 + 17.9.3).

This step is useful (but optional) if you want to use the integrated AP beacons as location beacon in areas where SF beacons are not mounted (yet).

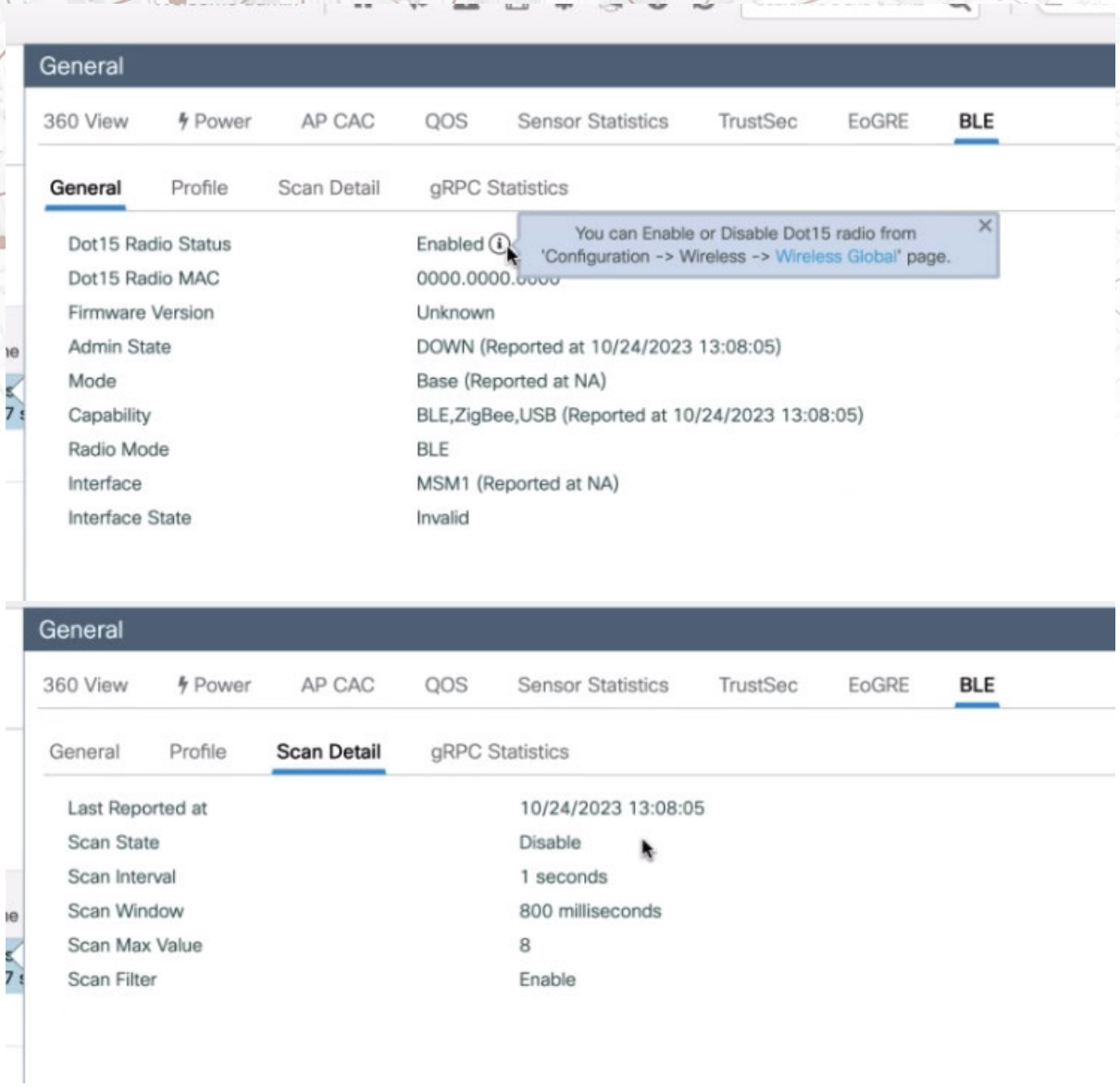
Setting up one or more Cisco access points to transmit iBeacon advertisements is part of section Enable BLE Radio/Scanning and Beaconing.
If you want to adjust the access points' triplets (i.e., UUID, major, and minor), then you need to adjust them in the **Beacon** window in TrackUI, re-generate the XMLs via `/api/netconf` endpoint (see bullet point 2 in the previously referenced section), and then execute the RPCs (e.g., via YANG Suite).

Troubleshooting

The following troubleshooting section may help to solve various error situations.
Note that there is also an official Cisco troubleshooting guide available at https://www.cisco.com/c/en/us/td/docs/wireless/spaces/iot-services-wireless/b_iot_services/m-trb-wlc.html, which contains further hints.

1. When in doubt that the token was accepted by the WLC:
    - Check output of following CLI commands on WLC whether the token was actually set: `show configuration | include token` and `show running-config | include dna`
    - Check output of following CLI command on one of the APs whether they received the `dnas-config` config and if the token was updated (this may also show if there is a problem with the certificate): `enable` (requires to enter SSH password one more time) + `show grpc server log`
2. Bad request (400) when trying to launch YANG Suite
    - Possible solution: When running it locally only, use IP address instead of a hostname for YANG Nginx webserver

3. It 1) is not possible to adjust BLE filtering (function seems to be non-functional) and/or 2) scan state is disabled and BLE radio is enabled but shows an invalid MAC address and unknown firmware version:



Suggestion: Make sure that the admin state is included in the NETCONFIG RPCs with `ble-admin-state-on` (cf. Enable BLE Radio (Scanning and Beaconing) and JWT Distribution, example:

```
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="101">
  <ble-mgt-admin-req xmlns="http://cisco.com/ns/yang/Cisco-IOS-XE-wireless-ble-mgmt-cmd-rpc">
    <state>ble-admin-state-on</state>
    <ap-name>AP70F0.966B.E6F0</ap-name>
  </ble-mgt-admin-req>
</rpc>
```

4. gRPC server (of Track service) does not start up
    - Make sure that permissions and ownerships for certificate and private key are correct

- Make sure that file paths to the certificate and private key are correct (backend config + Nginx)
- Make sure that the key file is passwordless
- Check backend log files for any related error messages (log files of interest: `application.*`, `grpc.*`, `bledataparser.*`)