Workshop

Building Containerlab with cEOS-lab

How to build a lab environment with Containerlab and cEOS-lab

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CONTAINERlab

Credits and References

> Credits to Roman Dodin and other cLab contributors for making the world a better place!

This repository is based on many awesome open source repositories and some free/commercial Github features:

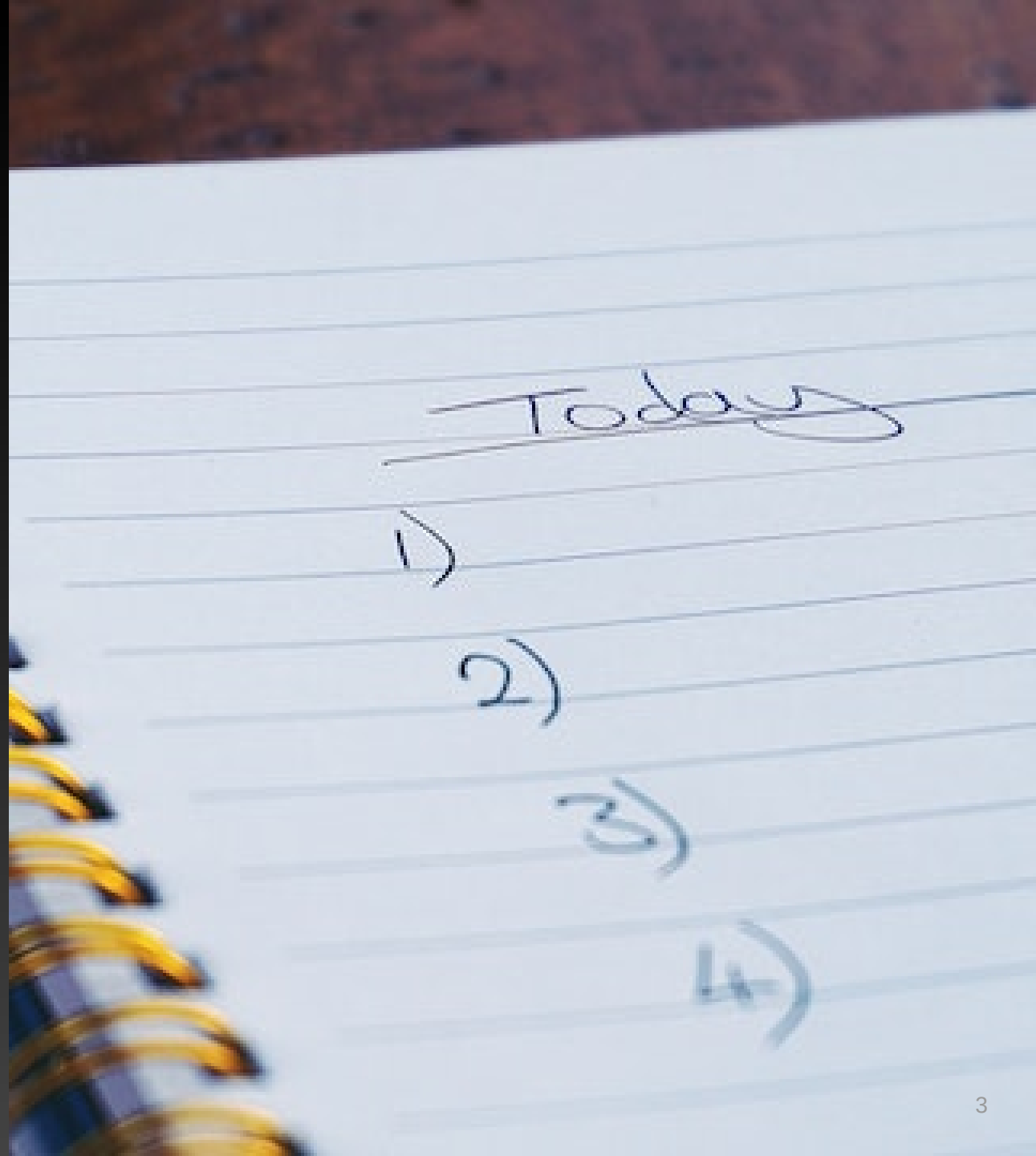
- Containerlab
- VS Code
- DevContainers
- Marp
- Excalidraw VS Code Plugin
- Github Actions
- Github Pages
- Github Codespaces
- Carbon
- And many more...

All photos are taken from Pexels and Unsplash. Excellent free stock photos resources. It's not possible to reference every author individually, but their work is highly appreciated.

Agenda

- Setup Docker on the host
- Install Containerlab and import cEOS-lab image
- Clone this repository and deploy the lab
- Inspect and destroy the lab
- Deploy the lab with a custom startup config
- Make a packet capture
- cLab in a Container
- Possible caveats

> This workshop is a step-by-step guide explaining how to build a lab environment with Containerlab and Arista cEOS-lab. It is focusing on essential and cEOS-lab specific features. Please check Containerlab documentation for details.



Prerequisites

- This workshop requires:
  - Ubuntu LTS 22.04 or later
  - 8 GB RAM and 4 vCPUs
- Only x86 architecture is supported. It is technically possible to run Container lab on ARM, but there are no network images available for ARM as of Aug 2023.
- You can use Github Codespaces or VSCode devcontainer for this workshop. The detailed procedure is described in the appendix.
- The appendix also provides instructions for creating a KVM VM with Ubuntu Cloud Image.
- There is also Vagrant file available in this repository. Use it at your own risk.

Setup Docker on the Host

> Check if Docker is already installed. In this case you can skip the steps below.

1. Install Docker on the host. The detailed instructions are available here. You can used one-liner script for that.
2. Add your user to the `docker` group.
3. Logout and login again to apply the changes.
4. Check the Docker version and run `hello-world` container to test functionality.

```
# install Docker
sudo curl -fsSL https://get.docker.com | sh
# add user to the docker group
sudo usermod -aG docker ${USER}
# test docker
docker --version
docker run hello-world
```

Setup Git (Optional)

- Git must be pre-installed. Otherwise you are in a wrong place. Escape! 👾 🚀
- Setup your name and email address:

```
git config --global user.name "<first-and-2nd-name>"
git config --global user.email "<your-email>"
```

- Check the current configuration:

```
git config --list
```

Clone this Repository

```
$ cd ${HOME}
$ git clone https://github.com/arista-netdevops-community/building-containerlab-with-ceos.git
Cloning into 'building-containerlab-with-ceos'...
remote: Enumerating objects: 198, done.
remote: Counting objects: 100% (198/198), done.
remote: Compressing objects: 100% (120/120), done.
remote: Total 198 (delta 109), reused 152 (delta 66), pack-reused 0
Receiving objects: 100% (198/198), 1.31 MiB | 6.59 MiB/s, done.
Resolving deltas: 100% (109/109), done.
$ ls | grep ceos
building-containerlab-with-ceos
$ cd building-containerlab-with-ceos
```

Download cEOS-lab Image

1. Login to Arista Software Download portal. You need to have an account to download the image.
2. Select `EOS > Active Releases > 4.30 > EOS-4.30.2F > cEOS-lab`.
3. Download `cEOS-lab-4.30.2F.tar.xz` image.
4. Upload the image to your lab VM. For example, you can use SFTP to transfer the image:

```
sftp ${REMOTE_USER}@${UBUNTU_VM_IP}:/home/${REMOTE_USER}/${IMAGE_DIR} <<< $'put cEOS-lab-4.30.2F.tar*'
# for example:
# sftp user@10.10.10.11:/home/user/images <<< $'put cEOS-lab-4.30.2F.tar*'
```

> NOTE: if you are using Vagrant, add the image to `.gitignored` directory. It will be automatically copied to the VM.
> If Github Codespace is used and token is set, the image will be pulled from arista.com automatically.

Import cEOS-lab Image

1. Go to the directory with the uploaded image and import the image:

```
docker import cEOS-lab-4.30.2F.tar.xz ceos-lab:4.30.2F
```

> NOTE: you can also import the image with the tag latest to allow quick "upgrade" of those lab where specific version is not required: `docker tag ceos-lab:4.30.2F ceos-lab:latest`

2. Confirm that the image was imported successfully:

```
$ docker image ls
REPOSITORY    TAG       IMAGE ID       CREATED          SIZE
ceos-lab      4.30.2F   21b540a4a343   45 minutes ago   1.95GB
ceos-lab      latest    21b540a4a343   45 minutes ago   1.95GB
hello-world   latest    b038788ddb22   3 months ago     9.14kB
```

Install Containerlab

- It's just a one-liner:

```
bash -c "$(curl -sL https://get.containerlab.dev)"
```

- Refer to the Containerlab quick start documentation for the details.

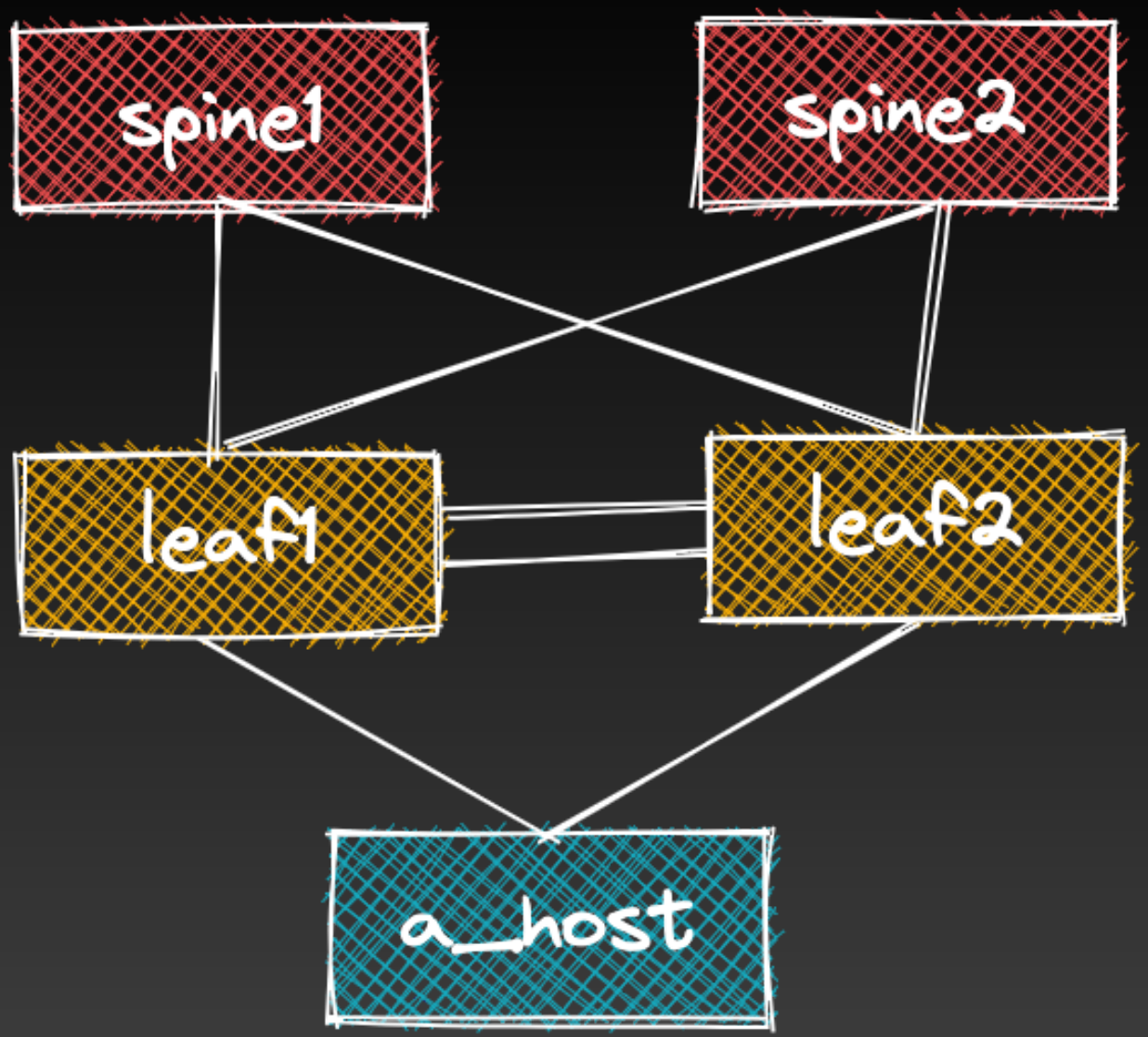
Deploy The Lab

- Inspect `default_cfg.clab.yml` and deploy the lab:

```
sudo containerlab deploy --debug --topo default_cfg.clab.yml
```

- This command will deploy Containerlab with the default EOS configuration provided by Containerlab. The `--debug` flag is optional, but provides additional information while Containerlab is starting.

> NOTE: If there is a single `.clab.yml` file in the current directory, it is possible to use `sudo containerlab deploy` command without specifying the topology file. As we have multiple files in the directory, we must specify the topology explicitly.



Inspect the Lab

Once the lab is ready, you'll see a table with the list of deployed containers, their host names and management IPs:

```
+---+----------------------+--------------+-----------------+------+---------+--------------------+--------------+
| # |         Name         | Container ID |      Image      | Kind |  State  |    IPv4 Address    | IPv6 Address |
+---+----------------------+--------------+-----------------+------+---------+--------------------+--------------+
| 1 | clab-ceos-lab-a_host | 421665f3e67f | ceos-lab:latest | ceos | running | 192.168.123.100/24 | N/A          |
| 2 | clab-ceos-lab-leaf1  | a7f7c80aa90f | ceos-lab:latest | ceos | running | 192.168.123.21/24  | N/A          |
| 3 | clab-ceos-lab-leaf2  | 142ab91f0ceb | ceos-lab:latest | ceos | running | 192.168.123.22/24  | N/A          |
| 4 | clab-ceos-lab-spine1 | 22464060dcf8 | ceos-lab:latest | ceos | running | 192.168.123.11/24  | N/A          |
| 5 | clab-ceos-lab-spine2 | 3f53d1de7add | ceos-lab:latest | ceos | running | 192.168.123.12/24  | N/A          |
+---+----------------------+--------------+-----------------+------+---------+--------------------+--------------+
```

> You can call the table again any time with `sudo clab inspect -t default_cfg.clab.yml`.

Containerlab creates corresponding entries in the `/etc/hosts` file as well:

```
$ cat /etc/hosts | grep -i clab-
###### CLAB-ceos-lab-START ######
192.168.123.22  clab-ceos-lab-leaf2
192.168.123.11  clab-ceos-lab-spine1
192.168.123.12  clab-ceos-lab-spine2
192.168.123.100 clab-ceos-lab-a_host
192.168.123.21  clab-ceos-lab-leaf1
###### CLAB-ceos-lab-END ######
```

You can also list containers using docker command:

```
$ docker container ls
CONTAINER ID   IMAGE             COMMAND                  CREATED         STATUS         PORTS     NAMES
22464060dcf8   ceos-lab:latest   "bash -c '/mnt/flash…"   5 minutes ago   Up 5 minutes             clab-ceos-lab-spine1
3f53d1de7add   ceos-lab:latest   "bash -c '/mnt/flash…"   5 minutes ago   Up 5 minutes             clab-ceos-lab-spine2
a7f7c80aa90f   ceos-lab:latest   "bash -c '/mnt/flash…"   5 minutes ago   Up 5 minutes             clab-ceos-lab-leaf1
421665f3e67f   ceos-lab:latest   "bash -c '/mnt/flash…"   5 minutes ago   Up 5 minutes             clab-ceos-lab-a_host
142ab91f0ceb   ceos-lab:latest   "bash -c '/mnt/flash…"   5 minutes ago   Up 5 minutes             clab-ceos-lab-leaf2
```

Access cEOS-lab CLI

There are few options to access cEOS-lab CLI:

- SSH to the container. For ex.:

```
# the default login is `admin` and password is `admin`
ssh admin@clab-ceos-lab-leaf1
```

- Connect to the "console" using Docker command. For ex.: `docker exec -it clab-ceos-lab-leaf1 Cli`

> NOTE: `docker exec -it clab-ceos-lab-leaf1 bash` allows to connect directly to the switch shell.

Execute few command to confirm that cEOS-lab is functioning:

- `show version`
- `show lldp neighbors`
- `show running-config`

Destroy the Lab

- Destroy the lab with `sudo containerlab destroy -t default_cfg.clab.yml`
- This will stop all containers, but will keep the files created by clab for the next run. For example, startup-configs.
- Check the flash content for leaf1 and inspect it's startup config:

```
$ ls clab-ceos-lab/leaf1/flash/
AsuFastPktTransmit.log  SsuRestore.log        aboot  fastpkttx.backup  kickstart-config  schedule        system_mac_address
Fossil                  SsuRestoreLegacy.log  debug  if-wait.sh        persist           startup-config
$ cat clab-ceos-lab/leaf1/flash/startup-config
```

- To remove these files and have a clean environment on the next run, use `--cleanup` flag:

```
sudo containerlab destroy -t default_cfg.clab.yml --cleanup
```

Deploy the Lab with Custom Startup Config

- Deploy the lab with the custom configuration:

```
sudo containerlab deploy -t custom_cfg.clab.yml --reconfigure
```

> NOTE: `--reconfigure` is required if `--cleanup` flag was not specified in the previous step. Otherwise custom configs will be ignored and startup configs in `clab-ambassadors_clab/` will be used instead.

- Custom startup configs are located in the `init-configs` directory and assigned to every node using `startup-config:` key in the `custom_cfg.clab.yml`. This allows creating pre-configured labs. In this case pre-configured MLAG between leaf switches and basic BGP underlay configuration. Host should be able to ping loopbacks of all leaf and spine switches. Connect to the host and run following commands to confirm that:

```
$ ssh admin@clab-ceos-lab-a_host
Password:
a_host>en
a_host#bash for i in {1..4}; do ping -c 4 10.${i}.${i}.${i}; done
```

Additional Checks

Execute following commands on leaf1 to confirm that it is functioning as expected:

- `show interfaces status`
- `show ip bgp summary`
- `show mlag`
- `show port-channel dense`

> NOTE: `ambassadors_custom_cfg.clab.yml` has custom interface mapping defined in `interface_mapping.json` and assigned to cEOS-lab containers as bind mount. This helps to change default Management0 interface to Management1 as on physical switches.

```
{
    "ManagementIntf": {
        "eth0": "Management1"
    },
    "EthernetIntf": {
        "eth1_1": "Ethernet1/1",
        "eth2_1": "Ethernet2/1",
        "eth3_1": "Ethernet3/1",
        "eth4_1": "Ethernet4/1",
        "eth10_1": "Ethernet10/1"
    }
}
```

```
leaf1#sh ip bgp summary
BGP summary information for VRF default
Router identifier 10.3.3.3, local AS number 65001
Neighbor Status Codes: m - Under maintenance
  Description              Neighbor     V AS           MsgRcvd   MsgSent  InQ OutQ  Up/Down State   PfxRcd PfxAcc
  spine1_Ethernet1/1       10.0.0.0     4 65000             35        35    0    0 00:23:49 Estab   3      3
  spine2_Ethernet1/1       10.0.0.4     4 65000             34        37    0    0 00:23:49 Estab   3      3
  leaf2                    10.255.251.1 4 65001             37        38    0    0 00:23:49 Estab   8      8
```

Make Packet Capture

- Every container has it's own Linux namespace. To list all interfaces for leaf1, execute following command:

```
sudo ip netns exec clab-ceos-lab-leaf1 ip link
```

- Run following command and wait a few minutes to capture a BGP packets:

```
sudo ip netns exec clab-ceos-lab-leaf1 tcpdump -nni eth1_1 port 179 -vvv
```

- For additional details about packet capture check cLab documentation.

```
$ sudo ip netns exec clab-ceos-lab-leaf1 tcpdump -nni eth1_1 port 179 -vvv
tcpdump: listening on eth1_1, link-type EN10MB (Ethernet), snapshot length 262144 bytes

^C07:49:45.039605 IP (tos 0xc0, ttl 1, id 12506, offset 0, flags [DF], proto TCP (6), length 71)
    10.0.0.0.44357 > 10.0.0.1.179: Flags [P.], cksum 0xdbc5 (correct), seq 1756697861:1756697880, ack 3369297165, win 501, options [nop,nop,TS val 4288989697 ecr 2402340456], length 19: BGP
        Keepalive Message (4), length: 19
07:49:45.039649 IP (tos 0xc0, ttl 1, id 11530, offset 0, flags [DF], proto TCP (6), length 52)
    10.0.0.1.179 > 10.0.0.0.44357: Flags [.], cksum 0x6ac1 (correct), seq 1, ack 19, win 509, options [nop,nop,TS val 2402370431 ecr 4288989697], length 0
07:50:10.925048 IP (tos 0xc0, ttl 1, id 11531, offset 0, flags [DF], proto TCP (6), length 71)
    10.0.0.1.179 > 10.0.0.0.44357: Flags [P.], cksum 0x0175 (correct), seq 1:20, ack 19, win 509, options [nop,nop,TS val 2402396317 ecr 4288989697], length 19: BGP
        Keepalive Message (4), length: 19
07:50:10.925102 IP (tos 0xc0, ttl 1, id 12507, offset 0, flags [DF], proto TCP (6), length 52)
    10.0.0.0.44357 > 10.0.0.1.179: Flags [.], cksum 0xa079 (correct), seq 19, ack 20, win 501, options [nop,nop,TS val 4289015583 ecr 2402396317], length 0
```

Containerlab in a Container

- Destroy the lab with cleanup flag: `sudo containerlab destroy -t custom_cfg.clab.yml --cleanup`
- It is possible to run the containerlab on the host without installing it by simply running it in a container. This is helpful on MacBooks (the only way to run cLab) and advanced use cases (like this workshop).
- Start Containerlab by using this command:

```
docker run --rm -it --privileged \
  --network host \
  -v /var/run/docker.sock:/var/run/docker.sock \
  -v /etc/hosts:/etc/hosts \
  --pid="host" \
  -w $(pwd) \
  -v $(pwd):$(pwd) \
  ghcr.io/srl-labs/clab bash
```

- This will start the container in the interactive mode. Once in the container prompt, execute following command to start the lab:

```
containerlab deploy -t custom_cfg.clab.yml --reconfigure
```

- Destroy the lab with `containerlab destroy -t custom_cfg.clab.yml --cleanup` when ready and exit the container.

Containerlab in a Container (Non-Interactive)

- Running cLab container in non-interactive mode is helpful to create shortcuts, etc.
- You can test it now or skip this step.
- Check the documentation for additional details.

```
# deploy the lab
docker run --rm --privileged \
  --network host \
  -v /var/run/docker.sock:/var/run/docker.sock \
  -v /etc/hosts:/etc/hosts \
  --pid="host" \
  -w $(pwd) \
  -v $(pwd):$(pwd) \
  ghcr.io/srl-labs/clab containerlab deploy -t custom_cfg.clab.yml --reconfigure


# destroy the lab
docker run --rm --privileged \
  --network host \
  -v /var/run/docker.sock:/var/run/docker.sock \
  -v /etc/hosts:/etc/hosts \
  --pid="host" \
  -w $(pwd) \
  -v $(pwd):$(pwd) \
  ghcr.io/srl-labs/clab containerlab destroy -t custom_cfg.clab.yml --cleanup
```

Crafting Your Own Container

- It is easy to craft your own container with Containerlab installed.
- Check the following Dockerfile for the details.
- Possible reasons to create your own container:
  - Produce a consistent environment that is easy to share.
  - Pre-install additional tools. (Ansible, docker-in-docker, etc.)
  - Add aliases, etc.

Ansible with Containerlab

- When containerlab starts it automatically creates Ansible inventory that can be used to automate certain tasks in the lab.
- Start the lab and inspect the inventory file: `cat clab-ceos-lab/ansible-inventory.yml`
- Check if ansible is already installed: `ansible --version`
- Install Ansible if it's not present. Use Dockerfile as a reference:

```
pip3 install "ansible-core>=2.13.1,<2.14.0"
ansible-galaxy collection install ansible.netcommon
ansible-galaxy collection install arista.eos
# install community.general to support callback plugins in ansible.cfg, etc.
ansible-galaxy collection install community.general
```

- Inspect `ansible.cfg` and make sure that it is matching your environment.
- Run the playbook: `ansible-playbook playbooks/check_the_lab.yml`
- The playbook will execute number of show commands on all switches in the lab and print output on the screen.

Possible Caveats

> WARNING: If you are planning to deploy a high scale lab, test it on a non-production host that you can access and recover any time. Incorrectly deployed Containerlab at scale can bring your host down due to high CPU utilization on start.

- It's always good to add `--max-workers` and `--timeout` flags to your containerlab deploy command.
- Use recent cEOS-lab version. 4.29 or higher is strongly recommended!
- cLab is creating a lot as root. That can cause permission issues. For example, make sure that all cLab files are gitignored:

```
# ignore clab files
clab-*
*.bak
```

Additional Scale Caveats

- In the past Ubuntu used to have low `fs.inotify.max_user_instances` limit. On top, older cEOS-lab versions were decreasing this system limit to 1256. This was causing issues with high scale labs.
- On a modern system and any cEOS-lab later than 4.28 this system is high enough. 62800 is the default. Increasing this limit on a modern host with high memory is not causing any issues. Feel free to play with this parameter if required:

```
# set system limit
sudo sysctl -w fs.inotify.max_user_instances=62800
# create 99-zceos.conf
sudo sh -c 'echo "fs.inotify.max_user_instances = 62800" > /etc/sysctl.d/99-zceos.conf'
# check the limit
sudo sysctl -a  | grep -i inotify
```

```
topology:
kinds:
  ceos:
    # mount custom 99-zceos.conf to cEOS-lab containers
    binds:
      - /etc/sysctl.d/99-zceos.conf:/etc/sysctl.d/99-zceos.conf:ro
```

- Generally you don't have to touch that. But be aware and check in case of issues.

Q&A