Installing OpenShift 4.1 Using Libvirt and KVM

Jul 8th, 2019 11:53 am

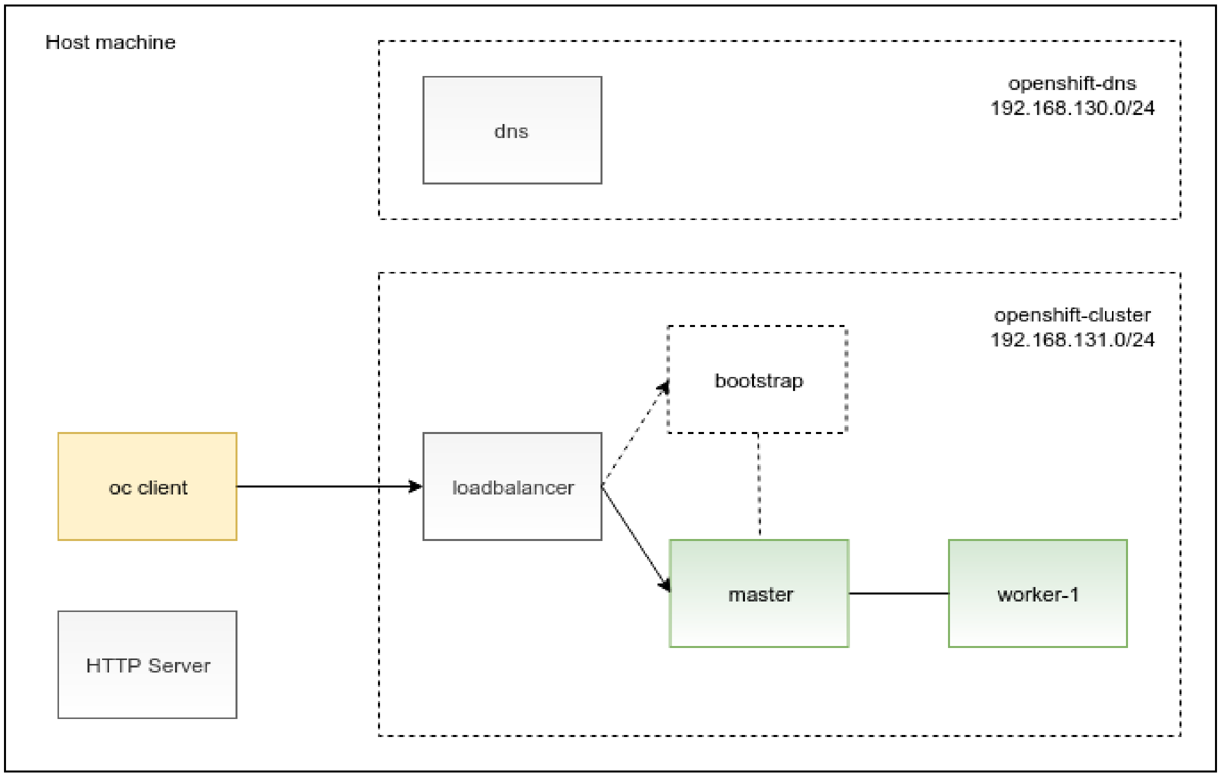
In this blog post, I am going to talk about how I installed OpenShift 4.1 on a Fedora laptop with 16 GB of RAM. If you are interested in deploying your own OpenShift instance whether for evaluation or testing please follow along with me.

OpenShift 4.1 is the first GA release in the OpenShift 4 series. It is a significant leap forward in the evolution of OpenShift mainly due to the incorporation of features developed by the folks at CoreOS. In order to take a closer look at the latest and greatest version of OpenShift, I installed OpenShift 4.1 on my laptop using Libvirt and KVM. How did I accomplish this?

I essentially followed the guide for installing the OpenShift cluster on bare metal and I recommend that you read this guide first. After you make yourself familiar with the bare metal installation process, read on to learn the details on how I made this process work on Libvirt and KVM.

Deployment overview

First, let's take a look at the diagram showing the deployment of the OpenShift cluster on Libvirt/KVM. In addition to the OpenShift cluster nodes, the diagram also depicts supplementary pieces of the user-provisioned infrastructure that you will need to deploy:



In the diagram, you can see that there is an HTTP server and an oc client installed directly on the host machine. The remaining boxes in the diagram are virtual machines. I outlined the purpose of the virtual machines for you in the following table:

VM Name	Operating System	Purpose
dns	RHEL7	Custom Dnsmasq DNS server used by the load balancer, bootstrap node and OpenShift nodes.
loadbalancer	RHEL 7	HAProxy load balancer. Facilitates bootstrapping, balances the load between the master nodes and also between the ingress router pods.
bootstrap	RHCOS	The bootstrap machine. Used one-time to initialize the OpenShift cluster.
master	RHCOS	OpenShift master node.
worker-1	RHCOS	OpenShift worker node.

Note that the virtual machines are deployed across two Libvirt networks: `openshift-dns` and `openshift-cluster`. Using two Libvirt networks allowed me to meet the OpenShift DNS requirements and I will elaborate on this design later on in this post.

After reviewing the big picture, let’s roll up our sleeves and get to work. We are going to deal with the HTTP server first.

Setting up HTTP server

The OpenShift installation process assumes installation on empty virtual machines with no operating system pre-installed. There are two provisioning methods available to choose from. You can either provision OpenShift nodes by booting from an ISO image or you can leverage the PXE boot. I find the PXE boot option to take a bit more effort to configure and hence went with the ISO image method.

Using the ISO image method, you are supposed to boot the virtual machines using the `rhcos-4.1.0-x86_64-installer.iso` CD-ROM image. During the boot from this image, the Red Hat CoreOS installer starts up and provisions an empty virtual machine in two steps:

1. It downloads a disk image `rhcos-4.1.0-x86_64-metal-bios.raw.gz` from a URL you specify and writes it to the virtual machine’s disk.
2. It downloads one of the ignition files (e.g. `bootstrap.ign`, `master.ign`, or `worker.ign`) and installs it on the virtual machine’s file system. This ignition file contains configuration required for the bootstrap of the OpenShift cluster that is triggered on the next reboot.

You are expected to host the aforementioned files on an HTTP server that is reachable from the OpenShift nodes during the provisioning process. To meet this requirement, I installed an Apache HTTP server on my Fedora host machine and copied the disk image and ignition files to the `/var/www/html` directory which is the default `DocumentRoot` directory on a Fedora host.

Addressing OpenShift DNS requirements

OpenShift requires a set of records to be configured in your DNS. In addition to simple A records, you must also configure a wildcard DNS record that points to the load balancer and an SRV DNS record for each of the etcd nodes.

Libvirt allows you to insert custom A and SRV records into DNS. You can specify them using the network descriptor. However, Libvirt doesn't support creating wildcard DNS records. The respective feature request can be found here. It would be great if it would be possible to meet the OpenShift DNS requirements by just configuring the DNS records in the Libvirt's network descriptor. However, as the wildcard DNS records were not supported at the time of this writing, I had to look for an alternative solution. After giving it some thought, I decided to spin up my own DNS server and instructed Libvirt to forward the DNS queries sent by the OpenShift nodes to this server. In order to achieve this, I had to define two networks in Libvirt: `openshift-dns` and `openshift-cluster`.

Let's tackle the `openshift-dns` network first. A single virtual machine is connected to this network. This virtual machine hosts the custom DNS server. Here is the respective network XML descriptor:

```
<network>
  <name>openshift-dns</name>
  <forward mode='nat'>
    <nat>
      <port start='1024' end='65535'/>
    </nat>
  </forward>
  <bridge name='virbr-oshd' stp='on' delay='0'/>
  <mac address='52:54:00:2c:00:00'/>
  <domain name='mycluster.example.com' localOnly='no'/>
  <ip address='192.168.130.1' netmask='255.255.255.0'>
    <dhcp>
      <range start='192.168.130.10' end='192.168.130.254'/>
      <host mac='52:54:00:2c:00:10' name='dns.mycluster.example.com' ip='192.168.130.10'/>
    </dhcp>
  </ip>
</network>
```

As you can see in the descriptor, I prefer to manage virtual machine's MAC addresses and the associated IP addresses and host names by hand. The virtual machine `dns` that hosts my DNS server is connected to the `openshift-dns` network by including these settings in its domain configuration:

```
<domain type='kvm'>
  <name>dns.mycluster.example.com</name>
  ...
    <interface type='network'>
      <mac address='52:54:00:2c:00:10'/>
      <source network='openshift-dns'/>
      <model type='virtio'/>
      <address type='pci' domain='0x0000' bus='0x00' slot='0x03' function='0x0'/>
    </interface>
    ...
</domain>
```

I installed Dnsmasq on this `dns` virtual machine and replaced the content of `/etc/dnsmasq.conf` with my own configuration:

```
local=/mycluster.example.com/
address=/apps.mycluster.example.com/192.168.131.10
srv-host=_etcd-server-ssl._tcp.mycluster.example.com,master.mycluster.example.com,2380,0,10
no-hosts
addn-hosts=/etc/dnsmasq.openshift.addnhosts
conf-dir=/etc/dnsmasq.d,.rpmnew,.rpmsave,.rpmorig
```

The listing of the `/etc/dnsmasq.openshift.addnhosts` file referred to in the above configuration looks as follows:

```
192.168.130.10 dns.mycluster.example.com
192.168.131.10 loadbalancer.mycluster.example.com  api.mycluster.example.com  api-int.mycluster.example.com
192.168.131.11 bootstrap.mycluster.example.com
192.168.131.12 master.mycluster.example.com  etcd-0.mycluster.example.com
192.168.131.13 worker-1.mycluster.example.com
```

This configuration addresses the user-provisioned DNS requirements as specified in the installation guide.

In the next step, we want to make the load balancer machine and OpenShift nodes resolve their DNS queries using our custom DNS server. In order to achieve that, we define a second Libvirt network called `openshift-cluster` and place the load balancer and OpenShift nodes onto this network. The definition of the `openshift-cluster` network looks like this:

```
<network>
  <name>openshift-cluster</name>
  <forward mode='nat'>
    <nat>
      <port start='1024' end='65535'/>
    </nat>
  </forward>
  <bridge name='virbr-osh' stp='on' delay='0'/>
  <mac address='52:54:00:2c:01:00'/>
  <domain name='mycluster.example.com' localOnly='no'/>
  <dns>
    <forwarder addr='192.168.130.10'/>
  </dns>
  <ip address='192.168.131.1' netmask='255.255.255.0'>
    <dhcp>
      <range start='192.168.131.10' end='192.168.131.254'/>
      <host mac='52:54:00:2c:01:10' name='loadbalancer.mycluster.example.com' ip='192.168.131.10'/>
      <host mac='52:54:00:2c:01:11' name='bootstrap.mycluster.example.com' ip='192.168.131.11'/>
      <host mac='52:54:00:2c:01:12' name='master.mycluster.example.com' ip='192.168.131.12'/>
      <host mac='52:54:00:2c:01:13' name='worker-1.mycluster.example.com' ip='192.168.131.13'/>
    </dhcp>
  </ip>
</network>
```

Note the `<forwarder addr='192.168.130.10'/>` setting which allows all DNS requests from the load balancer and OpenShift nodes deployed on this network to be forwarded to our custom DNS server. Remember that the IP address `192.168.130.10` is the address of our custom DNS server that we configured previously.

With the DNS configuration out of the way, let's continue with deploying a load balancer in the next section.

Setting up a load balancer

Installing OpenShift on a user-provisioned infrastructure requires you to provision a load balancer. The details on how the load balancer should be configured can be found in the networking requirements section of the OpenShift installation guide.

The load balancer is used during the bootstrapping process to route the requests to the bootstrap and the master nodes. After the OpenShift installation is complete, the load balancer remains part of the deployment and balances load between the master nodes and also between the ingress router pods.

I created a dedicated virtual machine called `loadbalancer` and installed HAProxy on top of it. The HAProxy configuration is pretty straight forward. Here is the listing of the `/etc/haproxy/haproxy.cfg` file:

```
global
    log         127.0.0.1 local2 info
    chroot      /var/lib/haproxy
    pidfile     /var/run/haproxy.pid
    maxconn     4000
    user        haproxy
    group       haproxy
    daemon

defaults
    timeout connect         5s
    timeout client          30s
    timeout server          30s
    log                     global

frontend kubernetes_api
    bind 0.0.0.0:6443
    default_backend kubernetes_api

backend kubernetes_api
    balance roundrobin
    option ssl-hello-chk
    server bootstrap bootstrap.mycluster.example.com:6443 check
    server master master.mycluster.example.com:6443 check

frontend machine_config
    bind 0.0.0.0:22623
    default_backend machine_config

backend machine_config
    balance roundrobin
    option ssl-hello-chk
    server bootstrap bootstrap.mycluster.example.com:22623 check
    server master master.mycluster.example.com:22623 check

frontend router_https
    bind 0.0.0.0:443
    default_backend router_https

backend router_https
    balance roundrobin
    option ssl-hello-chk
    server worker-1 worker-1.mycluster.example.com:443 check

frontend router_http
    mode http
    option httplog
    bind 0.0.0.0:80
    default_backend router_http

backend router_http
    mode http
    balance roundrobin
    server worker-1 worker-1.mycluster.example.com:80 check
```

With the load balancer in place, we will move on to creating OpenShift virtual machines in the next section.

Creating OpenShift virtual machines

The official installation guide defines minimum machine requirements for installing an OpenShift cluster as follows:

- One bootstrap machine
- Three control plane, or master, machines
- At least two compute, or worker, machines

If you can meet these requirements, you will achieve the smallest *highly available* OpenShift cluster. However, do we really need high availability for our test installation?

Internally, OpenShift uses etcd to store its state. Since etcd is a quorum-based cluster, it requires at least three nodes to achieve high availability. These etcd nodes are installed on OpenShift master machines which is the reason for the minimum requirement of three OpenShift master machines. In our limited environment, we are going to give up on high availability and instead save up two master machines. OpenShift can install with a single master machine just fine if you can accept the fact that the OpenShift control plane won't be highly available.

And what about the requirement of two worker machines? The minimum requirement of two worker machines ensures that there will be at least two OpenShift routers running on the cluster. OpenShift router is an ingress point for external traffic to reach application pods running on OpenShift. Production installations require that at least two routers are installed to avoid a single point of failure. Furthermore, a highly available load balancer is deployed in front of the two routers. In a data center, a hardware load balancer is typically used, in cloud environments like AWS an Elastic Load Balancer can be utilized. As we don’t pursue a highly available deployment, we are going to install an OpenShift cluster with a single worker machine. There will be a single router running on top of this cluster which we hereby accept.

This discussion leads us to the minimum requirements for a *not highly available* OpenShift cluster:

- One bootstrap machine
- One control plane, or master, machine
- One compute, or worker, machine

In regards to the minimum memory requirements for each of the machines, I was able to install OpenShift on virtual machines with the following memory configuration:

Machine	RAM
Bootstrap	4 GB
Control plane	6 GB
Compute	6 GB

Note that the above memory requirements allow you to properly deploy the OpenShift cluster including the monitoring and log collection components. Furthermore, there will be enough capacity left on the worker node for you to run several hello world applications.

This concludes the user-provisioned infrastructure setup. At this point, we have HTTP server, DNS server, load balancer and a set of empty virtual machines in place. Let’s dive into the OpenShift installation in the next section.

Installing OpenShift 4.1

The installation of OpenShift 4 starts with crafting an installation configuration file. You can use the `install-config.yaml` configuration file that I created, just remember to replace the placeholders with your own pull secret and public SSH key:

```
apiVersion: v1
baseDomain: example.com
compute:
- hyperthreading: Enabled
  name: worker
  platform: {}
  replicas: 0
controlPlane:
  hyperthreading: Enabled
  name: master
  platform: {}
  replicas: 1
metadata:
  creationTimestamp: null
  name: mycluster
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  networkType: OpenShiftSDN
  serviceNetwork:
  - 172.30.0.0/16
platform:
  none: {}
pullSecret: '<INSERT_YOUR_PULL_SECRET_HERE>'
sshKey: '<INSERT_YOUR_PUBLIC_SSH_KEY_HERE>'
```

The OpenShift installation is actually driven by the ignition configuration files. You can issue this command to generate ignition configuration files out of your `install-config.yaml` file:

```
./openshift-install create ignition-configs
```

Beware that the above command will remove your handcrafted `install-config.yaml` from the disk. I found this behavior of the `openshift-install` tool rather annoying. In order to not lose my configuration settings, I protect the `install-config.yaml` file from deletion by creating a hard link like this:

```
ln install-config.yaml install-config.yaml.hardlink
```

And after the `install-config.yaml` file is deleted, I can simply recreate it with:

```
ln install-config.yaml.hardlink install-config.yaml
```

Finally, we can use our ignition files to kick off the OpenShift installation process which deploys OpenShift cluster on our fleet of virtual machines. The whole process takes about 30 minutes and consists of several steps:

1. Provision and reboot the bootstrap machine
2. Provision and reboot the master machine
3. Bootstrap the master machine
4. Shut down the bootstrap machine
5. Provision and reboot the worker machine
6. Worker machine joins the OpenShift cluster

Note that after you bootstrap the master machine, you should shut down the bootstrap machine. Only after that, you should boot up the worker machine. On startup, the worker node registers with the master node and forms an OpenShift cluster.

Conclusion

In this blog post, we discussed how to deploy OpenShift 4.1 into the Libvirt/KVM-based virtualized environment. We created and configured a bunch of user-provisioned infrastructure which was a prerequisite for the OpenShift installation. With the user-provisioned infrastructure in place, we followed the OpenShift bare metal deployment guide to create an OpenShift cluster.

I hope that you found this article useful and you have your OpenShift 4.1 cluster running by now. If you have any questions or comments please feel free to add them to the comment section below.

Posted by Ales Nosek Jul 8th, 2019 11:53 am devops

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Dean Peterson • a month ago

Hello Ales, I set up both openshif-dns and openshift-cluster networks. Even with the <forwarder> set in openshift-cluster network descriptor set, it doesn't appear forwarding is working. I added a few entries in the dns server's /etc/hosts file but the loadbalancer is not able to ping those addresses by name (it can by ip). Internet also works on the dns machine, but not on the loadbalancer machine. Any help would be much appreciated. So far your tutorial has gotten me the furthest so thanks for that.

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Ales Nosek Mod → Dean Peterson • 23 days ago

Hello Dean, to troubleshoot the DNS resolution problem you could:
1. Check that DNS resolution works on the DNS server itself, using the host or dig commands.
2. Note that the /etc/dnsmasq.conf that I listed in the arctile contains the no-hosts option which instructs dnsmasq to ignore the /etc/hosts file.
3. Make sure port 53 is open on the firewall on the DNS server.
4. Use tcpdump on the DNS server and loadbalancer to see whether the DNS request reaches the DNS server at all and whether the response arrives at the loadbalancer.

Let me know if this helps or if you have further questions.

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Avinash • 2 months ago

I would grateful to you if you share your notes on production ready open shift and open stack , rather referring provider guides

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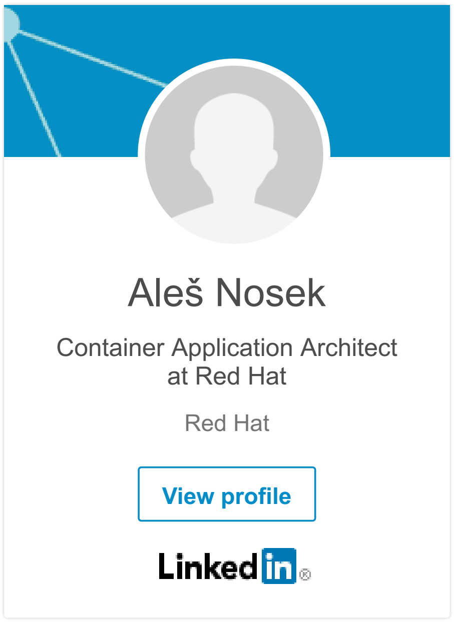
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