

16.4 Labs

Exercise 16.1: High Availability Steps

Overview

In this lab we will add two more control planes to our cluster, change taints and deploy an application to a particular node, and test that we can access it from outside the cluster. The nodes will handle various infrastructure services and the **etcd** database and should be sized accordingly.

The steps are presented in two ways. First the general steps for those interested in more of a challenge. Following that will be the detailed steps found in previous labs.

You will need three more nodes. One to act as a load balancer, the other two will act as cp nodes for quorum. Log into each and use the **ip** command to fill in the table with the IP addresses of the primary interface of each node. If using **GCE** nodes it would be `ens4`, yours may be different. You may need to install software such an editor on the nodes.

Proxy Node	
Second Control Plane	
Third Control Plane	

As the prompts may look similar you may want to change the terminal color or other characteristics to make it easier to keep them distinct. You can also change the prompt using something like: **PS1="ha-proxy\$ "**, which may help to keep the terminals distinct.

High level steps:

1. Deploy a load balancer configured to pass through traffic on your new proxy node. HAProxy is easy to deploy using online documentation. Start with forwarding traffic of the cp alias to just the working cp.
2. Install the Kubernetes software on the second and third cp nodes.
3. Use **kubeadm join** on the second cp, adding it to the cluster as another control plane using the node name.

4. Join the third cp as another control plane to the cluster using the node name.
5. Update the proxy to use all three cps backend IPs.
6. Temporarily shut down the first cp and monitor traffic.

Exercise 16.2: Detailed Steps

Deploy a Load Balancer

While there are many options, both software and hardware, we will be using an open source tool **HAProxy** to configure a load balancer.

1. Deploy HAProxy. Log into the proxy node. Update the repos then install a the HAProxy software. Answer yes, should you the installation ask if you will allow services to restart.

```
student@ha-proxy:~$ sudo apt-get update ; sudo apt-get install -y haproxy vim
```

```
<output_omitted>
```

2. Edit the configuration file and add sections for the front-end and back-end servers. We will comment out the second and third cp node until we are sure the proxy is forwarding traffic to the known working cp.

```
student@ha-proxy:~$ sudo vim /etc/haproxy/haproxy.cfg
```

```
....
defaults
    log global                #<-- Edit these three lines, starting around line 23
    option tcplog
    mode tcp
....
    errorfile 503 /etc/haproxy/errors/503.http
```

```
errorfile 504 /etc/haproxy/errors/504.http

frontend proxynode                                #<-- Add the following lines to bottom of file
    bind *:80
    bind *:6443
    stats uri /proxystats
    default_backend k8sServers

backend k8sServers
    balance roundrobin
    server cp 10.128.0.24:6443 check #<-- Edit these with your IP addresses, port, and hostname
#   server secondcp 10.128.0.30:6443 check #<-- Comment out until ready
#   server thirdcp 10.128.0.66:6443 check #<-- Comment out until ready
listen stats
    bind :9999
    mode http
    stats enable
    stats hide-version
    stats uri /stats
```

3. Restart the haproxy service and check the status. You should see the frontend and backend proxies report being started.

```
student@ha-proxy:~$ sudo systemctl restart haproxy.service
student@ha-proxy:~$ sudo systemctl status haproxy.service
```

```
<output_omitted>
Aug 08 18:43:08 ha-proxy systemd[1]: Starting HAProxy Load Balancer...
Aug 08 18:43:08 ha-proxy systemd[1]: Started HAProxy Load Balancer.
Aug 08 18:43:08 ha-proxy haproxy-systemd-wrapper[13602]: haproxy-systemd-wrapper:
Aug 08 18:43:08 ha-proxy haproxy[13603]: Proxy proxynode started.
Aug 08 18:43:08 ha-proxy haproxy[13603]: Proxy proxynode started.
Aug 08 18:43:08 ha-proxy haproxy[13603]: Proxy k8sServers started.
Aug 08 18:43:08 ha-proxy haproxy[13603]: Proxy k8sServers started.
```

4. **On the cp** Edit the `/etc/hosts` file and comment out the old and add a new `k8scp` alias to the IP address of the proxy server.

```
student@cp:~$ sudo vim /etc/hosts
```

```
10.128.0.64 k8scp      #<-- Add alias to proxy IP
#10.128.0.24 k8scp    #<-- Comment out the old alias, in case its needed
127.0.0.1 localhost
....
```

5. Use a local browser to navigate to the public IP of your proxy server. The `http://34.69.XX.YY:9999/stats` is an example your IP address would be different. Leave the browser up and refresh as you run following steps. You can find your public ip using **curl**. Your IP will be different than the one shown below.

```
ha-proxy$ curl ifconfig.io
```

```
34.69.73.159
```

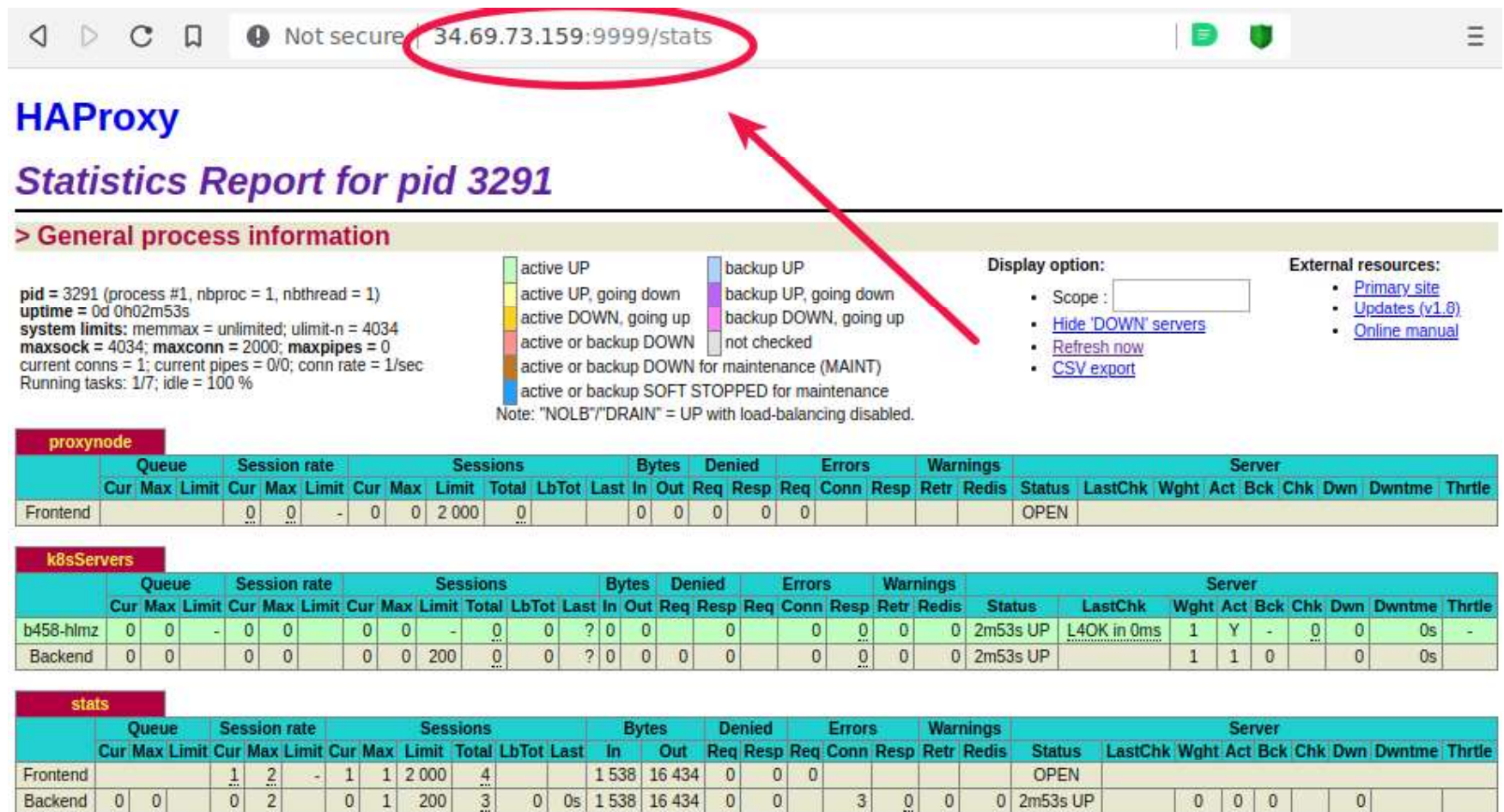


Figure 16.1: Initial HAProxy Status

6. Check the node status from the cp node then check the proxy statistics. You should see the byte traffic counter increase.

```
student@cp:~$ kubectl get nodes
```

NAME	STATUS	ROLES	AGE	VERSION
cp	Ready	control-plane	2d6h	v1.28.1
worker	Ready	<none>	2d3h	v1.28.1

Install Software

We will add two more control planes with stacked **etcd** databases for cluster quorum. You may want to open up two more PuTTY or SSH sessions and color code the terminals to keep track of the nodes.

Initialize the second cp before adding the third cp

1. Configure and install the kubernetes software on the **second cp**. Use the same steps as when we first set up the cluster, earlier in the course. You may want to copy and paste from earlier commands in your **history** to make these steps easier. **All the steps up to but not including `kubeadm init` or `kubeadm join`** A script `k8sWorker.sh` has been included in the course tarball to make this process go faster, if you would like. View and edit the script to be the correct version before running it.
2. Install the software on the **third cp** using the same commands.

Join Control Plane Nodes

1. Edit the `/etc/hosts` file **ON ALL NODES** to ensure the alias of `k8scp` is set on each node to the proxy IP address. Your IP address may be different.

```
student@cp:~$ sudo vim /etc/hosts
```

```
10.128.0.64 k8scp
#10.128.0.24 k8scp
127.0.0.1 localhost
....
```

2. On the **first cp** create the tokens and hashes necessary to join the cluster. These commands may be in your **history** and easier to copy and paste.
3. Create a new token.

```
student@cp:~$ sudo kubeadm token create
```

```
jasg79.fdh4p279l320cz1g
```

4. Create a new SSL hash.

```
student@cp:~$ openssl x509 -pubkey \  
-in /etc/kubernetes/pki/ca.crt | openssl rsa \  
-pubin -outform der 2>/dev/null | openssl dgst \  
-sha256 -hex | sed 's/^.* //'
```

```
f62bf97d4fba6876e4c3ff645df3fca969c06169dee3865aab9d0bca8ec9f8cd
```

5. Create a new cp certificate to join as a cp instead of as a worker.

```
student@cp:~$ sudo kubeadm init phase upload-certs --upload-certs
```

```
[upload-certs] Storing the certificates in Secret "kubeadm-certs" in the "kube-system" Namespace  
[upload-certs] Using certificate key:  
5610b6f73593049acddee6b59994360aa4441be0c0d9277c76705d129ba18d65
```

6. On the **second cp** use the previous output to build a **kubeadm join** command. Please be aware that multi-line copy and paste from Windows and some MacOS has paste issues. If you get unexpected output copy one line at a time.

```
student@$secondcp:~$ sudo kubeadm join k8scp:6443 \  
--token jasg79.fdh4p279l320cz1g \  
--discovery-token-ca-cert-hash sha256:f62bf97d4fba6876e4c3ff645df3fca969c06169dee3865aab9d0bca8ec9f8cd \  
--control-plane --certificate-key \  
5610b6f73593049acddee6b59994360aa4441be0c0d9277c76705d129ba18d65
```

```
[preflight] Running pre-flight checks  
[WARNING IsDockerSystemdCheck]: detected "cgroupfs" as the Docker cgroup driver. The recommended  
↪ driver \  
is "systemd". Please follow the guide at https://kubernetes.io/docs/setup/cri/  
<output_omitted>
```

7. Return to the first cp node and check to see if the node has been added and is listed as a cp.

```
student@cp:~$ kubectl get nodes
```

NAME	STATUS	ROLES	AGE	VERSION
cp	Ready	control-plane	2d6h	v1.28.1
secondcp	Ready	control-plane	10m	v1.28.1
worker	Ready	<none>	2d3h	v1.28.1

8. Copy and paste the **kubeadm join** command to the third cp. Then check that the third cp has been added.

```
student@cp:~$ kubectl get nodes
```

NAME	STATUS	ROLES	AGE	VERSION
cp	Ready	control-plane	2d6h	v1.28.1
secondcp	Ready	control-plane	13m	v1.28.1
thirdcp	Ready	control-plane	3m	v1.28.1
worker	Ready	<none>	2d3h	v1.28.1

9. Copy over the configuration file as suggested in the output at the end of the join command. Do this on both newly added cp nodes.

```
student@secondcp:~$ mkdir -p $HOME/.kube
student@secondcp:~$ sudo cp -i /etc/kubernetes/admin.conf $HOME/.kube/config
student@secondcp:~$ sudo chown $(id -u):$(id -g) $HOME/.kube/config
```

10. On the **Proxy node**. Edit the proxy to include all three cp nodes then restart the proxy.

```
student@ha-proxy:~$ sudo vim /etc/haproxy/haproxy.cfg
```

```
....
backend k8sServers
    balance roundrobin
    server cp          10.128.0.24:6443 check
```



```
server secondcp 10.128.0.30:6443 check #<-- Edit/Uncomment these lines
server thirdcp 10.128.0.66:6443 check #<--
....
```

```
student@ha-proxy:~$ sudo systemctl restart haproxy.service
```

- View the proxy statistics. When it refreshes you should see three new back-ends. As you check the status of the nodes using **kubectrl get nodes** you should see the byte count increase on each node indicating each is handling some of the requests.

proxynode

	Queue			Session rate			Sessions						Bytes		Denied		
	Cur	Max	Limit	Cur	Max	Limit	Cur	Max	Limit	Total	LbTot	Last	In	Out	Req	Resp	
Frontend				0	5	-	4	6	262 121	34			57 679	333 984	0	0	

k8s Servers

	Queue			Session rate			Sessions						Bytes		Denied		
	Cur	Max	Limit	Cur	Max	Limit	Cur	Max	Limit	Total	LbTot	Last	In	Out	Req	Resp	
cp	0	0	-	0	2		2	3	-	12	12	2s	19 280	89 042	0		
secondcp	0	0	-	0	2		1	2	-	11	11	3s	19 147	115 928	0		
thirdcp	0	0	-	0	2		1	2	-	11	11	3s	19 252	129 014	0		
Backend	0	0		0	5		4	5	26 213	34	34	2s	57 679	333 984	0	0	

stats

	Queue			Session rate			Sessions						Bytes		Denied		
	Cur	Max	Limit	Cur	Max	Limit	Cur	Max	Limit	Total	LbTot	Last	In	Out	Req	Resp	
Frontend				0	3	-	1	4	262 121	11			4 916	119 887	0	0	3
Backend	0	0		0	1		0	1	26 213	7	0	0s	4 916	119 887	0	0	

Figure 16.2: Multiple HAProxy Status

12. View the logs of the newest **etcd** pod. Leave it running, using the **-f** option in one terminal while running the following commands in a different terminal. As you have copied over the cluster admin file you can run **kubectl** on any cp.

```
student@cp:~$ kubectl -n kube-system get pods |grep etcd
```

```
etcd-cp          1/1      Running   0          2d12h
etcd-secondcp    1/1      Running   0          22m
etcd-thirdcp     1/1      Running   0          18m
```

```
student@cp:~$ kubectl -n kube-system logs -f etcd-thirdcp
```

```
....
2023-08-09 01:58:03.768858 I | mvcc: store.index: compact 300473
2023-08-09 01:58:03.770773 I | mvcc: finished scheduled compaction at 300473 (took 1.286565ms)
2023-08-09 02:03:03.766253 I | mvcc: store.index: compact 301003
2023-08-09 02:03:03.767582 I | mvcc: finished scheduled compaction at 301003 (took 995.775µs)
2023-08-09 02:08:03.785807 I | mvcc: store.index: compact 301533
2023-08-09 02:08:03.787058 I | mvcc: finished scheduled compaction at 301533 (took 913.185µs)
```

13. Log into one of the **etcd** pods and check the cluster status, using the IP address of each server and port 2379. Your IP addresses may be different. Exit back to the node when done.

```
student@cp:~$ kubectl -n kube-system exec -it etcd-cp -- /bin/sh
```



etcd pod

```
/ # ETCDCTL_API=3 etcdctl -w table \
--endpoints 10.128.0.66:2379,10.128.0.24:2379,10.128.0.30:2379 \
--cacert /etc/kubernetes/pki/etcd/ca.crt \
--cert /etc/kubernetes/pki/etcd/server.crt \
--key /etc/kubernetes/pki/etcd/server.key \
endpoint status
```



```

+-----+-----+-----+-----+-----+-----+
|  ENDPOINT  |      ID      | VERSION | DB SIZE | IS LEADER | RAFT TERM | RAFT
↳ INDEX |
+-----+-----+-----+-----+-----+-----+
| 10.128.0.66:2379 | 2331065cd4fb02ff | 3.5.7 | 24 MB | true | 11 |
↳ 392573 |
| 10.128.0.24:2379 | d2620a7d27a9b449 | 3.5.7 | 24 MB | false | 11 |
↳ 392573 |
| 10.128.0.30:2379 | ef44cc541c5f37c7 | 3.5.7 | 24 MB | false | 11 |
↳ 392573 |
+-----+-----+-----+-----+-----+-----+

```

Test Failover

Now that the cluster is running and has chosen a leader we will shut down containerd, which will stop all containers on that node. This will emulate an entire node failure. We will then view the change in leadership and logs of the events.

1. Shut down the service on the node which shows IS LEADER set to true.

```
student@cp:~$ sudo systemctl stop containerd.service
```

If you chose cri-o as the container engine then the cri-o service and common processes are distinct. It may be easier to reboot the node and refresh the HAProxy web page until it shows the node is down. It may take a while for the node to finish the boot process. The second and third cp should work the entire time.

```
student@cp:~$ sudo reboot
```

2. You will probably note the **logs** command exited when the service shut down. Run the same command and, among other output, you'll find errors similar to the following. Note the messages about losing the leader and electing a new one, with an eventual message that a peer has become inactive.

```
student@cp:~$ kubectl -n kube-system logs -f etcd-thirdcp
```

```
....
2023-08-09 02:11:39.569827 I | raft: 2331065cd4fb02ff [term: 9] received a MsgVote message with
↳ higher \
                                term from ef44cc541c5f37c7 [term: 10]
2023-08-09 02:11:39.570130 I | raft: 2331065cd4fb02ff became follower at term 10
2023-08-09 02:11:39.570148 I | raft: 2331065cd4fb02ff [logterm: 9, index: 355240, vote: 0] cast
↳ MsgVote \
                                for ef44cc541c5f37c7 [logterm: 9, index: 355240] at term 10
2023-08-09 02:11:39.570155 I | raft: raft.node: 2331065cd4fb02ff lost leader d2620a7d27a9b449 at
↳ term 10
2023-08-09 02:11:39.572242 I | raft: raft.node: 2331065cd4fb02ff elected leader ef44cc541c5f37c7
↳ at \
                                term 10
2023-08-09 02:11:39.682319 W | rafthttp: lost the TCP streaming connection with peer
↳ d2620a7d27a9b449 \
                                (stream Message reader)
2023-08-09 02:11:39.682635 W | rafthttp: lost the TCP streaming connection with peer
↳ d2620a7d27a9b449 \
                                (stream MsgApp v2 reader)
2023-08-09 02:11:39.706068 E | rafthttp: failed to dial d2620a7d27a9b449 on stream MsgApp v2 \
                                (peer d2620a7d27a9b449 failed to find local node 2331065cd4fb02ff)
2023-08-09 02:11:39.706328 I | rafthttp: peer d2620a7d27a9b449 became inactive (message send to
↳ peer failed)
....
```

3. View the proxy statistics. The proxy should show the first cp as down, but the other cp nodes remain up.

k8sServers																								
	Queue			Session rate			Sessions						Bytes		Denied		Errors			Warnings		Status	LastChk	Wgt
	Cur	Max	Limit	Cur	Max	Limit	Cur	Max	Limit	Total	LbTot	Last	In	Out	Req	Resp	Req	Conn	Resp	Retr	Redis			
cp	0	0	-	0	2	2	3	-	23	23	1m50s	40 091	518 686	0	0	0	0	0	0	0	0	2s DOWN	* L4TOUT in 2001ms	1
secondcp	0	0	-	0	2	1	2	-	23	23	1m50s	48 861	302 977	0	0	0	0	0	0	0	0	41m18s UP	L4OK in 0ms	1
thirdcp	0	0	-	0	2	1	2	-	22	22	1m54s	38 446	257 768	0	0	0	0	0	0	0	0	41m18s UP	L4OK in 0ms	1
Backend	0	0		0	5	4	7	26 213	68	68	1m50s	127 398	1 079 431	0	0	0	0	0	0	0	0	41m18s UP		2

stats																								
	Queue			Session rate			Sessions						Bytes		Denied		Errors			Warnings		Status	LastChk	Wght
	Cur	Max	Limit	Cur	Max	Limit	Cur	Max	Limit	Total	LbTot	Last	In	Out	Req	Resp	Req	Conn	Resp	Retr	Redis			
Frontend				0	3	-	1	4	262 121	24			11 228	282 167	0	0	8					OPEN		
Backend	0	0		0	1		0	1	26 213	15	0	0s	11 228	282 167	0	0		15	0	0	0	41m18s UP		0

Figure 16.3: HAProxy Down Status

- View the status using **etcdctl** from within one of the running **etcd** pods. You should get an error for the endpoint you shut down and a new leader of the cluster.

```
student@secondcp:~$ kubectl -n kube-system exec -it etcd-secondcp -- /bin/sh
```



etcd pod

```
/ # ETCDCTL_API=3 etcdctl -w table \
--endpoints 10.128.0.66:2379,10.128.0.24:2379,10.128.0.30:2379 \
--cacert /etc/kubernetes/pki/etcd/ca.crt \
--cert /etc/kubernetes/pki/etcd/server.crt \
--key /etc/kubernetes/pki/etcd/server.key \
endpoint status
```



```
Failed to get the status of endpoint 10.128.0.66:2379 (context deadline exceeded)
```

ENDPOINT	ID	VERSION	DB SIZE	IS LEADER	RAFT TERM	RAFT INDEX
10.128.0.24:2379	d2620a7d27a9b449	3.5.7	24 MB	true	12	395729
10.128.0.30:2379	ef44cc541c5f37c7	3.5.7	24 MB	false	12	395729

5. Turn the containerd service back on. You should see the peer become active and establish a connection.

```
student@cp:~$ sudo systemctl start containerd.service
```

```
student@cp:~$ kubectl -n kube-system logs -f etcd-thirdcp
```

```
....
2023-08-09 02:45:11.337669 I | rafthttp: peer d2620a7d27a9b449 became active
2023-08-09 02:45:11.337710 I | rafthttp: established a TCP streaming connection with peer\
d2620a7d27a9b449 (stream MsgApp v2 reader)
....
```

6. View the **etcd** cluster status again. Experiment with how long it takes for the **etcd** cluster to notice failure and choose a new leader with the time you have left.