**netkit lab**

load balancer – web switch

<table>
<thead>
<tr>
<th><strong>Version</strong></th>
<th>1.1</th>
</tr>
</thead>
<tbody>
<tr>
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<td><strong>Web</strong></td>
<td><a href="http://www.netkit.org/">http://www.netkit.org/</a></td>
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<tr>
<td><strong>Description</strong></td>
<td>A lab showing the operation of a web switch based on iptables</td>
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lab description

- servers
  - offer a simple HTML default page
  - each physical server hosts a different page, so that they can be easily distinguished

- web switches
  - each web switch implements a different policy for directing requests to the servers
    - **ws_round-robin**: sends request $i$ to server $((i-1) \mod 3)+1$
    - **ws_random**: sends each request to a random server
    - **ws_ip**: directs requests to servers based on the client’s IP address

- clients
  - host a simple web browser ([links](#))
lab description – servers

- each server has a different IP address in the subnet 100.0.0.0/24
- no special configuration, just a simple HTML default page in /var/www/index.html
lab description – web switches

- each web switch has two interfaces
  - one facing the internal network, with an IP address in the same subnet as the servers
  - one facing the external network, exposing a single virtual IP address (VIP) to the clients
- clients only see VIPs of the web switches: they do not know how many servers are in the farm
lab description – web switches

- web switches are implemented using the Linux firewall iptables
- round robin

```
iptables --table nat --append PREROUTING --destination 10.0.0.1 --match statistic --mode nth --every 3 --jump DNAT --to-destination 100.0.0.1
iptables --table nat --append PREROUTING --destination 10.0.0.1 --match statistic --mode nth --every 2 --jump DNAT --to-destination 100.0.0.2
iptables --table nat --append PREROUTING --destination 10.0.0.1 --jump DNAT --to-destination 100.0.0.3
iptables --table nat --append POSTROUTING --source 10.0.0.0/24 --destination 100.0.0.0/24 --jump MASQUERADE
```
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```

traffic redirection is implemented via NAT rules
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iptables --table nat --append POSTROUTING --source 10.0.0.0/24 --destination 100.0.0.0/24 --jump MASQUERADE
```

...to web server 100.0.0.1 (actually, the packet’s destination IP is rewritten)
lab description – web switches

- web switches are implemented using the Linux firewall iptables
  - round robin

```bash
iptables --table nat --append PREROUTING --destination 10.0.0.1 --match statistic --mode nth --every 3 --jump DNAT --to-destination 100.0.0.1
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iptables --table nat --append PREROUTING --destination 10.0.0.1 --jump DNAT --to-destination 100.0.0.3
iptables --table nat --append POSTROUTING --source 10.0.0.0/24 --destination 100.0.0.0/24 --jump MASQUERADE
```

with this rule servers see traffic as if it came from the web switches themselves, and so HTTP replies can properly be sent back
lab description – web switches

- web switches are implemented using the Linux firewall iptables
- round robin

```bash
iptables --table nat --append PREROUTING --destination 10.0.0.1 --match statistic --mode nth --every 3 --jump DNAT --to-destination 100.0.0.1
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iptables --table nat --append PREROUTING --destination 10.0.0.1 --jump DNAT --to-destination 100.0.0.3
iptables --table nat --append POSTROUTING --source 10.0.0.0/24 --destination 100.0.0.0/24 --jump MASQUERADE
```
lab description – web switches

- web switches are implemented using the Linux firewall iptables
- random

```
iptables --table nat --append PREROUTING --destination 10.0.0.2 --match statistic --mode random --probability 0.33 -- 
  jump DNAT --to-destination 100.0.0.1
iptables --table nat --append PREROUTING --destination 10.0.0.2 --match statistic --mode random --probability 0.5 -- 
  jump DNAT --to-destination 100.0.0.2
iptables --table nat --append PREROUTING --destination 10.0.0.2 --jump DNAT --to-destination 100.0.0.3
iptables --table nat --append POSTROUTING --source 10.0.0.0/24 --destination 100.0.0.0/24 --jump MASQUERADE
```

similar to the round robin case, but the rule applies with a certain probability
lab description – web switches

- web switches are implemented using the Linux firewall iptables
- ip-based

```
iptables --table nat --append PREROUTING --destination 10.0.0.3 --source 10.0.0.10 --jump DNAT --to-destination 100.0.0.1
iptables --table nat --append PREROUTING --destination 10.0.0.3 --source 10.0.0.11 --jump DNAT --to-destination 100.0.0.2
iptables --table nat --append POSTROUTING --source 10.0.0.0/24 --destination 100.0.0.0/24 --jump MASQUERADE
```

the server is deterministically chosen based on the client’s (source) address
experiments

- to experiment load balancing, pick one of the clients, start `links`, and direct it to one of the VIPs exposed by web switches:
  
  ```
  client1:~# links http://10.0.0.1/
  client1:~# links http://10.0.0.1/
  client1:~# links http://10.0.0.1/
  client1:~# links http://10.0.0.1/
  ```

  to experiment round robin balancing

  ```
  client1:~# links http://10.0.0.2/
  client1:~# links http://10.0.0.2/
  client1:~# links http://10.0.0.2/
  client1:~# links http://10.0.0.2/
  ```

  to experiment random balancing

  ```
  client1:~# links http://10.0.0.3/
  client1:~# links http://10.0.0.3/
  client1:~# links http://10.0.0.3/
  client1:~# links http://10.0.0.3/
  ```

  to experiment per-client-ip balancing
experiments

- once you have accessed one of the VIPs, you get a page stating which is the physical server that has served it
- load balancing can be checked by reloading the page (\texttt{ctrl+R}), but...

\textit{OOPS!}
experiments

- once you have accessed one of the VIPs, you get a page stating which is the physical server that has served it

- load balancing can be checked by reloading the page (`ctrl+R`), but...
  - ...by default all HTTP requests use the same connection (HTTP 1.1)!
  - since iptables tracks TCP connections, all HTTP requests within the same connection are directed to the same physical server
  - to really appreciate load balancing you need to close the connection and establish a new one
  - `ctrl+S`, then `ctrl+R`
more experiments

- each client has a handy script that
  - sends 100 HTTP requests (each on a different connection) to a user-specified IP
  - reports the number of pages that have been served by each physical server

```
client2:~# ./count_server_replies.sh 10.0.0.2
37 replies received from server 1
32 replies received from server 2
31 replies received from server 3
```
more experiments

- after booting, each web switch automatically displays statistics about the number of times that iptables rules have matched
- check the **pkts** field in chain **PREROUTING**

```
ws_ip

Every 2.0s: iptables

Chain PREROUTING (policy ACCEPT 0 packets, 0 bytes)
  pkts bytes target     prot opt in     out     source           pkts bytes target     prot opt in     out     source       ...
         9  540 DNAT       all  -- *     10.0.0.10  10.0.0.3       to:100.0.0.1
        13  780 DNAT       all  -- *     10.0.0.11  10.0.0.3       to:100.0.0.2

Chain POSTROUTING (policy ACCEPT 1 packets, 60 bytes)
  pkts bytes target     prot opt in     out     source           destination
         22 1320 MASQUERADE all  -- *     10.0.0.0/24  100.0.0.0/24

Chain OUTPUT (policy ACCEPT 1 packets, 60 bytes)
  pkts bytes target     prot opt in     out     source           destination
```