Spectral assignment load testing:

I – Identification of failure points.

a) Hardware failures.

- Given the nature of the single computer, single solution, single network of every scenario – we can say that any hardware failure will result in a total loss of the service. Any form of high availability would require profound changes in the current infrastructure.

This issue can be easily mitigated as the application is extremely easy and quick to deploy. In case of a service failure I would recommand creating a new machine or virtual machine, redeploy the desired scenario and alter DNS or IP routing to point to the new machine.

The old machine should be kept aside for further analysis.

b) Resources starvation

- The application is very light on both CPU and memory. The impact of the service on the machine should be minimal even if said machine is small. Under normal use no resources starvation should occur. In all scenario the service is able to withstand a few hundreds connections per second even on a raspberry pi 3.

- If the amount of connections per second is way over a few hundred per second either stop stress testing the service or seriously evaluate whether someone is trying to perform a DoS attack.

- Using httpperf on an entry level machine you should be able to accept over a thousand connection per second.

c) Information leaks and surface of attack

- No information revealed by the server should be considered sensible.

- Scenario 0 does use Python 3 as an HTTP server and may allow a unauthorized third party attacker to get a memory dump of the entire instance of the Python 3 VM running the service. This is only a potentiality as no such attack exist today to the best of my knowledge.

- Scenario 1 uses NGINX which is generally regarded as a fairly secure HTTP server. In a production environment the installed version of NGINX should be tracked for CVE.

- Scenario 2 uses Minikube – it provides a wide array of potential exploits and should never be deployed on a production system. Since they are no sensible information provided by the service, I would strongly suggest to deploy scenario 2 only on a dedicated machine inside a LAN segment that only contains similarly innocuous systems.

II – Performances

Scenario 1 has the best performances by far, for quite obvious reasons – NGINX being used for the purpose of serving static pages is extremely efficient.

Scenario 0 and 2 should be considered more proof of feasibility than actual deployments. Though they can be useful under specific conditions, they should be avoided if possible.

The docker image created for Scenario 2 can be used for deployment on a more robust and HA capable Kubernetes cluster.

Note that even though it would be slightly harder to maintain, a group of NGINX server installed on bare metal and proxied either behind a capable router or an HaProxy configured as a load balancer would still be more efficient.

Kubernetes network overhead is very noticeable for such simple cases.

Here follow the logs for HTTPPerf launched on every scenario for 100 1,000 and 10,000 connections

It results that Scenario 0 can handle about 1,900 conns/s – Scenario 1 about 10,000 cons/s and Scenario 2 about 5600 conns/sec on an Ryzen 3000G with fast SSD.

The test were launched locally, so in normal case it is very probable that all scenarios would be bottlenecked by the network interface if there is only one exposed Ethernet connection.

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PYTHON (scenario 0)


====================== 100 conns ========================

root@Happiness:/home/kha# httperf --server localhost --port 9080 --uri / --num-conns 100

httperf --client=0/1 --server=localhost --port=9080 --uri=/ --send-buffer=4096 --recv-
buffer=16384 --num-conns=100 --num-calls=1

httperf: warning: open file limit > FD_SETSIZE; limiting max. # of open files to
FD_SETSIZE

Maximum connect burst length: 1


Total: connections 100 requests 100 replies 100 test-duration 0.063 s


Connection rate: 1595.5 conn/s (0.6 ms/conn, <=1 concurrent connections)

Connection time [ms]: min 0.3 avg 0.6 max 7.3 median 0.5 stddev 0.8
```

```
Connection time [ms]: connect 0.1
Connection length [replies/conn]: 1.000

Request rate: 1595.5 req/s (0.6 ms/req)
Request size [B]: 62.0

Reply rate [replies/s]: min 0.0 avg 0.0 max 0.0 stddev 0.0 (0 samples)
Reply time [ms]: response 0.5 transfer 0.0
Reply size [B]: header 186.0 content 545.0 footer 0.0 (total 731.0)
Reply status: 1xx=0 2xx=100 3xx=0 4xx=0 5xx=0

CPU time [s]: user 0.00 system 0.06 (user 6.4% system 91.8% total 98.2%)
Net I/O: 1235.6 KB/s (10.1*10^6 bps)

Errors: total 0 client-timo 0 socket-timo 0 connrefused 0 connreset 0
Errors: fd-unavail 0 addrunavail 0 ftab-full 0 other 0

================== 1,000 conns ========================



root@Happiness:/home/kha# httperf --server localhost --port 9080 --uri / --num-conns 1000
httperf --client=0/1 --server=localhost --port=9080 --uri=/ --send-buffer=4096 --recv-
buffer=16384 --num-conns=1000 --num-calls=1
httperf: warning: open file limit > FD_SETSIZE; limiting max. # of open files to
FD_SETSIZE
Maximum connect burst length: 1

Total: connections 1000 requests 1000 replies 1000 test-duration 0.517 s

Connection rate: 1932.7 conn/s (0.5 ms/conn, <=1 concurrent connections)
Connection time [ms]: min 0.3 avg 0.5 max 4.5 median 0.5 stddev 0.3
Connection time [ms]: connect 0.1
Connection length [replies/conn]: 1.000

Request rate: 1932.7 req/s (0.5 ms/req)
Request size [B]: 62.0

Reply rate [replies/s]: min 0.0 avg 0.0 max 0.0 stddev 0.0 (0 samples)
Reply time [ms]: response 0.4 transfer 0.0
Reply size [B]: header 186.0 content 545.0 footer 0.0 (total 731.0)
```

```
Reply status: 1xx=0 2xx=1000 3xx=0 4xx=0 5xx=0

CPU time [s]: user 0.07 system 0.45 (user 13.1% system 86.7% total 99.8%)
Net I/O: 1496.7 KB/s (12.3*10^6 bps)

Errors: total 0 client-timo 0 socket-timo 0 connrefused 0 connreset 0
Errors: fd-unavail 0 addrunavail 0 ftab-full 0 other 0

============== 10 000 conns ============================



root@Happiness:/home/kha# httperf --server localhost --port 9080 --uri / --num-conns
10000
httperf --client=0/1 --server=localhost --port=9080 --uri=/ --send-buffer=4096 --recv-
buffer=16384 --num-conns=10000 --num-calls=1
httperf: warning: open file limit > FD_SETSIZE; limiting max. # of open files to
FD_SETSIZE
Maximum connect burst length: 1

Total: connections 10000 requests 10000 replies 10000 test-duration 5.262 s

Connection rate: 1900.5 conn/s (0.5 ms/conn, <=1 concurrent connections)
Connection time [ms]: min 0.3 avg 0.5 max 16.4 median 0.5 stddev 0.4
Connection time [ms]: connect 0.1
Connection length [replies/conn]: 1.000

Request rate: 1900.5 req/s (0.5 ms/req)
Request size [B]: 62.0

Reply rate [replies/s]: min 1910.3 avg 1910.3 max 1910.3 stddev 0.0 (1 samples)
Reply time [ms]: response 0.4 transfer 0.0
Reply size [B]: header 186.0 content 545.0 footer 0.0 (total 731.0)
Reply status: 1xx=0 2xx=10000 3xx=0 4xx=0 5xx=0

CPU time [s]: user 0.53 system 4.72 (user 10.1% system 89.7% total 99.8%)
Net I/O: 1471.8 KB/s (12.1*10^6 bps)

Errors: total 0 client-timo 0 socket-timo 0 connrefused 0 connreset 0
Errors: fd-unavail 0 addrunavail 0 ftab-full 0 other 0
```

NGINX (scenario 1)

======================== 100 conns ======================

root@Happiness:/home/kha# httperf --server localhost --port 80 --uri / --num-conns 100

httperf --client=0/1 --server=localhost --port=80 --uri=/ --send-buffer=4096 --recv-buffer=16384 --num-conns=100 --num-calls=1

httperf: warning: open file limit > FD_SETSIZE; limiting max. # of open files to FD_SETSIZE

Maximum connect burst length: 1

Total: connections 100 requests 100 replies 100 test-duration 0.014 s

Connection rate: 7159.2 conn/s (0.1 ms/conn, <=1 concurrent connections)

Connection time [ms]: min 0.1 avg 0.1 max 0.3 median 0.5 stddev 0.0

Connection time [ms]: connect 0.1

Connection length [replies/conn]: 1.000

Request rate: 7159.2 req/s (0.1 ms/req)

Request size [B]: 62.0

Reply rate [replies/s]: min 0.0 avg 0.0 max 0.0 stddev 0.0 (0 samples)

Reply time [ms]: response 0.1 transfer 0.0

Reply size [B]: header 247.0 content 545.0 footer 0.0 (total 792.0)

Reply status: 1xx=0 2xx=100 3xx=0 4xx=0 5xx=0

CPU time [s]: user 0.00 system 0.01 (user 10.5% system 88.2% total 98.7%)

Net I/O: 5970.7 KB/s (48.9*10^6 bps)

Errors: total 0 client-timo 0 socket-timo 0 connrefused 0 connreset 0

Errors: fd-unavail 0 addrunavail 0 ftab-full 0 other 0

================== 1,000 conns ========================

root@Happiness:/home/kha# httperf --server localhost --port 80 --uri / --num-conns 1000

httperf --client=0/1 --server=localhost --port=80 --uri=/ --send-buffer=4096 --recv-buffer=16384 --num-conns=1000 --num-calls=1

httperf: warning: open file limit > FD_SETSIZE; limiting max. # of open files to FD_SETSIZE

Maximum connect burst length: 1

```
Total: connections 1000 requests 1000 replies 1000 test-duration 0.103 s

Connection rate: 9746.2 conn/s (0.1 ms/conn, <=1 concurrent connections)
Connection time [ms]: min 0.1 avg 0.1 max 3.2 median 0.5 stddev 0.1
Connection time [ms]: connect 0.0
Connection length [replies/conn]: 1.000

Request rate: 9746.2 req/s (0.1 ms/req)
Request size [B]: 62.0

Reply rate [replies/s]: min 0.0 avg 0.0 max 0.0 stddev 0.0 (0 samples)
Reply time [ms]: response 0.1 transfer 0.0
Reply size [B]: header 247.0 content 545.0 footer 0.0 (total 792.0)
Reply status: 1xx=0 2xx=1000 3xx=0 4xx=0 5xx=0

CPU time [s]: user 0.00 system 0.10 (user 1.5% system 98.1% total 99.5%)
Net I/O: 8128.2 KB/s (66.6*10^6 bps)

Errors: total 0 client-timo 0 socket-timo 0 connrefused 0 connreset 0
Errors: fd-unavail 0 addrunavail 0 ftab-full 0 other 0

================ 10,000 conns ============================

root@Happiness:/home/kha# httperf --server localhost --port 80 --uri / --num-conns 10000
httperf --client=0/1 --server=localhost --port=80 --uri=/ --send-buffer=4096 --recv-
buffer=16384 --num-conns=10000 --num-calls=1
httperf: warning: open file limit > FD_SETSIZE; limiting max. # of open files to
FD_SETSIZE
Maximum connect burst length: 1

Total: connections 10000 requests 10000 replies 10000 test-duration 0.954 s

Connection rate: 10478.3 conn/s (0.1 ms/conn, <=1 concurrent connections)
Connection time [ms]: min 0.0 avg 0.1 max 8.4 median 0.5 stddev 0.1
Connection time [ms]: connect 0.0
Connection length [replies/conn]: 1.000

Request rate: 10478.3 req/s (0.1 ms/req)
Request size [B]: 62.0
```

Reply rate [replies/s]: min 0.0 avg 0.0 max 0.0 stddev 0.0 (0 samples)

Reply time [ms]: response 0.1 transfer 0.0

Reply size [B]: header 247.0 content 545.0 footer 0.0 (total 792.0)

Reply status: 1xx=0 2xx=10000 3xx=0 4xx=0 5xx=0

CPU time [s]: user 0.08 system 0.87 (user 7.9% system 91.0% total 98.9%)

Net I/O: 8738.7 KB/s (71.6*10^6 bps)

Errors: total 0 client-timo 0 socket-timo 0 connrefused 0 connreset 0

Errors: fd-unavail 0 addrunavail 0 ftab-full 0 other 0

Minikube (Scenario 2)

================== 100 conns ============================

root@Happiness:/home/kha# httperf --server 192.168.49.2 --port 32080 --uri / --num-conns 100

httperf --client=0/1 --server=192.168.49.2 --port=32080 --uri=/ --send-buffer=4096 --recv-buffer=16384 --num-conns=100 --num-calls=1

httperf: warning: open file limit > FD_SETSIZE; limiting max. # of open files to FD_SETSIZE

Maximum connect burst length: 1

Total: connections 100 requests 100 replies 100 test-duration 0.021 s

Connection rate: 4747.9 conn/s (0.2 ms/conn, <=1 concurrent connections)

Connection time [ms]: min 0.1 avg 0.2 max 0.6 median 0.5 stddev 0.1

Connection time [ms]: connect 0.1

Connection length [replies/conn]: 1.000

Request rate: 4747.9 req/s (0.2 ms/req)

Request size [B]: 65.0

Reply rate [replies/s]: min 0.0 avg 0.0 max 0.0 stddev 0.0 (0 samples)

Reply time [ms]: response 0.1 transfer 0.0

Reply size [B]: header 238.0 content 545.0 footer 0.0 (total 783.0)

Reply status: 1xx=0 2xx=100 3xx=0 4xx=0 5xx=0

```
CPU time [s]: user 0.00 system 0.02 (user 0.0% system 97.9% total 97.9%)
Net I/O: 3931.9 KB/s (32.2*10^6 bps)

Errors: total 0 client-timo 0 socket-timo 0 connrefused 0 connreset 0
Errors: fd-unavail 0 addrunavail 0 ftab-full 0 other 0

============ 1,000 conns ==============================

root@Happiness:/home/kha# httperf --server 192.168.49.2 --port 32080 --uri / --num-conns
1000
httperf --client=0/1 --server=192.168.49.2 --port=32080 --uri=/ --send-buffer=4096 --
recv-buffer=16384 --num-conns=1000 --num-calls=1
httperf: warning: open file limit > FD_SETSIZE; limiting max. # of open files to
FD_SETSIZE
Maximum connect burst length: 1

Total: connections 1000 requests 1000 replies 1000 test-duration 0.180 s

Connection rate: 5570.0 conn/s (0.2 ms/conn, <=1 concurrent connections)
Connection time [ms]: min 0.1 avg 0.2 max 1.5 median 0.5 stddev 0.1
Connection time [ms]: connect 0.1
Connection length [replies/conn]: 1.000

Request rate: 5570.0 req/s (0.2 ms/req)
Request size [B]: 65.0

Reply rate [replies/s]: min 0.0 avg 0.0 max 0.0 stddev 0.0 (0 samples)
Reply time [ms]: response 0.1 transfer 0.0
Reply size [B]: header 238.0 content 545.0 footer 0.0 (total 783.0)
Reply status: 1xx=0 2xx=1000 3xx=0 4xx=0 5xx=0

CPU time [s]: user 0.02 system 0.16 (user 8.8% system 90.6% total 99.3%)
Net I/O: 4612.7 KB/s (37.8*10^6 bps)

Errors: total 0 client-timo 0 socket-timo 0 connrefused 0 connreset 0
Errors: fd-unavail 0 addrunavail 0 ftab-full 0 other 0

============ 10,000 conns ============================
```

```
root@Happiness:/home/kha# httperf --server 192.168.49.2 --port 32080 --uri / --num-conns 1000
httperf --client=0/1 --server=192.168.49.2 --port=32080 --uri=/ --send-buffer=4096 --recv-buffer=16384 --num-conns=1000 --num-calls=1
httperf: warning: open file limit > FD_SETSIZE; limiting max. # of open files to FD_SETSIZE
Maximum connect burst length: 1

Total: connections 1000 requests 1000 replies 1000 test-duration 0.180 s

Connection rate: 5570.0 conn/s (0.2 ms/conn, <=1 concurrent connections)
Connection time [ms]: min 0.1 avg 0.2 max 1.5 median 0.5 stddev 0.1
Connection time [ms]: connect 0.1
Connection length [replies/conn]: 1.000

Request rate: 5570.0 req/s (0.2 ms/req)
Request size [B]: 65.0

Reply rate [replies/s]: min 0.0 avg 0.0 max 0.0 stddev 0.0 (0 samples)
Reply time [ms]: response 0.1 transfer 0.0
Reply size [B]: header 238.0 content 545.0 footer 0.0 (total 783.0)
Reply status: 1xx=0 2xx=1000 3xx=0 4xx=0 5xx=0

CPU time [s]: user 0.02 system 0.16 (user 8.8% system 90.6% total 99.3%)
Net I/O: 4612.7 KB/s (37.8*10^6 bps)

Errors: total 0 client-timo 0 socket-timo 0 connrefused 0 connreset 0
Errors: fd-unavail 0 addrunavail 0 ftab-full 0 other 0
```