Week 10 – Assessment week 6

1. Testing Approach and Methodology

This phase focuses on evaluating the performance of the operating system under different workload conditions. The objective is to observe how system resources behave during normal operation, under increased load, and after basic optimisation steps are applied.

Performance testing was conducted using a structured approach consisting of four stages:

- Baseline performance testing, to establish normal system behaviour with minimal load.
- Application load testing, where artificial workload was introduced to stress system resources.
- Performance analysis, to identify potential bottlenecks affecting system performance.
- Optimisation testing, to evaluate improvements after configuration adjustments.

The evaluation focused on the following performance metrics where applicable:

- CPU usage
- Memory usage
- Disk I/O activity
- Network performance
- System responsiveness and latency

Testing was performed on the Ubuntu Server system using command-line tools. Results were observed directly in the terminal and recorded for comparison. This approach allows clear visibility of system behaviour and provides measurable data for analysis.

Applications and Services Selected for Testing

The following system components and tools were selected for performance evaluation:

- CPU and Memory load testing using a workload generation tool.
- Network performance testing using latency and throughput measurements between the workstation and the server.

These tools were chosen because they are lightweight, commonly used in Linux environments, and suitable for demonstrating operating system performance behaviour in an academic context.

Outcome of the Approach

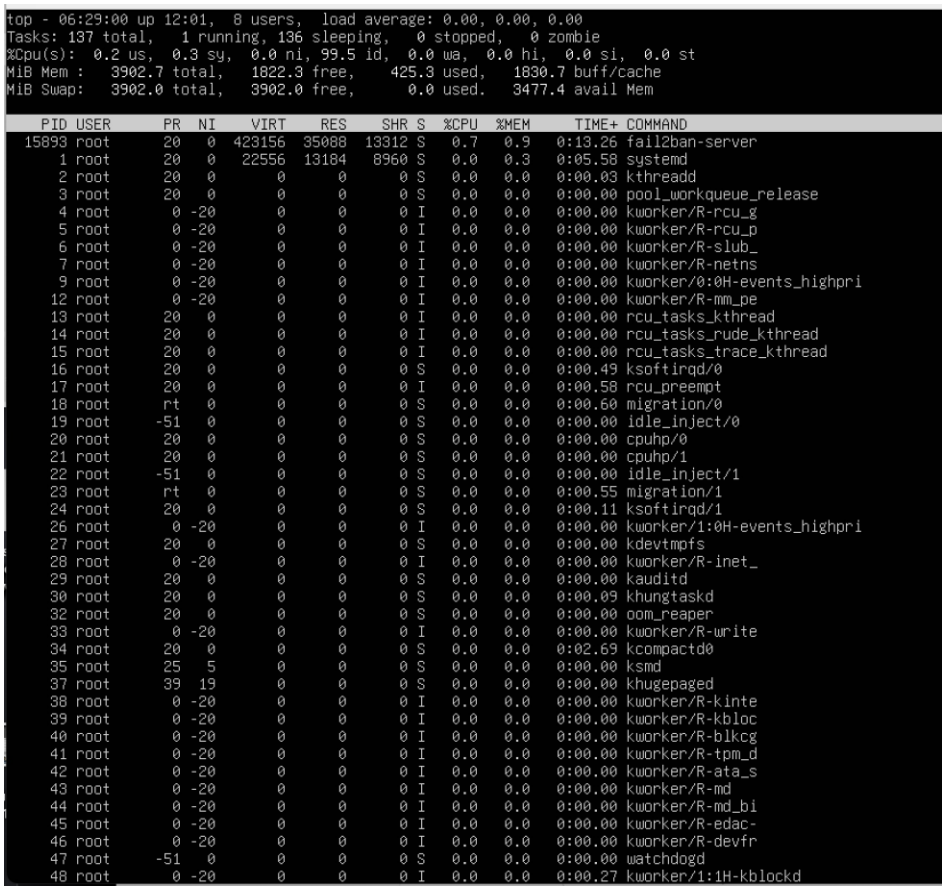
This structured methodology ensures that performance changes can be clearly observed and compared across different test scenarios. By collecting baseline data and comparing it with results obtained during and after load testing, it is possible to identify system limitations and evaluate the effectiveness of optimisation measures.

2. Baseline Performance Testing

Baseline performance testing was conducted to establish normal system behaviour with minimal workload. These measurements provide a reference point for comparing system performance during load testing and after optimisation.

CPU and Memory Baseline

CPU is almost completely idle (~99.5% idle) with near-zero load average, indicating no active workload. Memory usage is low and stable, with no swap usage, showing the system is in a clean idle baseline state without resource pressure.



Memory Usage Snapshot

```
yelyzaveta@ubuntu-server:~$ free -h
               total        used        free      shared  buff/cache   available
Mem:           3.8Gi       425Mi       1.8Gi       5.3Mi       1.8Gi       3.4Gi
Swap:          3.8Gi          0B       3.8Gi
```

The system is using a small portion of RAM (~425 MiB) with most memory available (~3.4 GiB), indicating low memory pressure. Swap is completely unused, confirming stable baseline conditions with no memory contention.

Disk Usage Baseline

```
yelyzaveta@ubuntu-server:~$ df -h
Filesystem                         Size  Used Avail Use% Mounted on
tmpfs                              391M  1.4M  389M   1% /run
efivarfs                           256K   14K  243K   6% /sys/firmware/efi/efivars
/dev/mapper/ubuntu--vg-ubuntu--lv   30G  7.2G   22G  26% /
tmpfs                              2.0G     0  2.0G   0% /dev/shm
tmpfs                              5.0M     0  5.0M   0% /run/lock
/dev/vda2                          2.0G  102M  1.7G   6% /boot
/dev/vda1                          1.1G  6.4M  1.1G   1% /boot/efi
tmpfs                              391M   12K  391M   1% /run/user/1000
```

Disk usage is low and stable, with the root filesystem using ~26% of available space and ample free capacity remaining. No partitions show high utilisation, indicating no disk I/O or storage bottlenecks at baseline.

Disk I/O Baseline

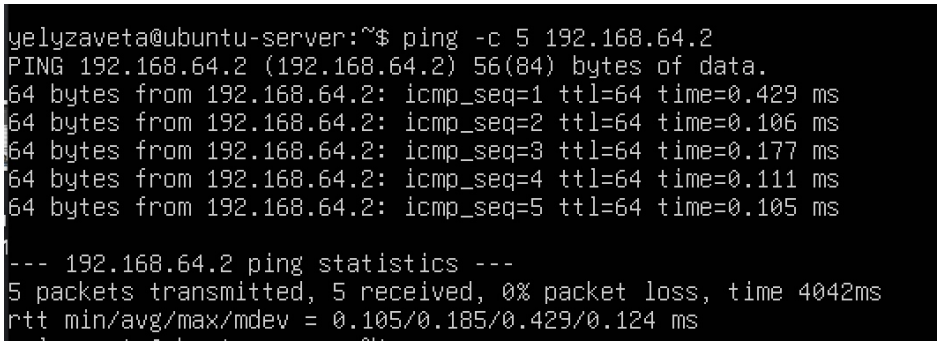
```
yelyzaveta@ubuntu-server:~$ iostat
Linux 6.8.0-90-generic (ubuntu-server)  12/22/2025      _aarch64_       (2 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           0.26    0.01    0.24    0.02    0.00   99.48

Device             tps    kB_read/s    kB_wrtn/s    kB_dscd/s    kB_read    kB_wrtn    kB_dscd
dm-0              3.06        27.72        92.80       547.09    1206303    4037832   23804836
loop0             0.00         0.00         0.00         0.00         28          0          0
vda               1.74        28.56        94.44       615.51    1242796    4109041   26781688
```

The system is almost completely idle, with 99.48% CPU idle time and only 0.02% I/O wait, indicating no disk-related bottlenecks.
Disk activity is minimal: the main disk (vda) shows low transaction rates (~1.7 tps) and very small read/write throughput, which is expected for baseline (idle) performance.

Network Latency Baseline



The network latency is very low and stable, with an average RTT of ~0.185 ms and 0% packet loss, indicating an excellent local network connection and no network bottlenecks at baseline.

Conclusion:

The baseline results confirm that the server is operating under minimal load with optimal resource availability. This provides a reliable reference point for subsequent load testing, bottleneck identification, and optimisation analysis.

3. Application Load Testing

CPU Load Testing

- stress-ng --cpu 2 --timeout 60s

```
top - 07:29:42 up 13:01,  8 users,  load average: 0.00, 0.00, 0.00
Tasks: 136 total,   1 running, 135 sleeping,   0 stopped,   0 zombie
%Cpu(s):  0.2 us,  0.2 sy,  0.0 ni, 99.7 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :   3902.7 total,   1825.6 free,    420.5 used,   1832.2 buff/cache
MiB Swap:   3902.0 total,   3902.0 free,      0.0 used.   3482.2 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
  15893 root      20   0  423156  35088  13312 S   0.7   0.9   0:18.92 fail2ban-server
  17281 root      20   0       0      0      0 I   0.3   0.0   0:00.21 kworker/1:3-events
      1 root      20   0   22556  13184   8960 S   0.0   0.3   0:05.81 systemd
      2 root      20   0       0      0      0 S   0.0   0.0   0:00.03 kthreadd
      3 root      20   0       0      0      0 S   0.0   0.0   0:00.00 pool_workqueue_release
      4 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-rcu_g
      5 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-rcu_p
      6 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-slub_
      7 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-netns
      9 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/0:0H-events_highpri
     12 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-mm_pe
     13 root      20   0       0      0      0 I   0.0   0.0   0:00.00 rcu_tasks_kthread
     14 root      20   0       0      0      0 I   0.0   0.0   0:00.00 rcu_tasks_rude_kthread
     15 root      20   0       0      0      0 I   0.0   0.0   0:00.00 rcu_tasks_trace_kthread
     16 root      20   0       0      0      0 S   0.0   0.0   0:00.52 ksoftirqd/0
     17 root      20   0       0      0      0 I   0.0   0.0   0:00.63 rcu_preempt
     18 root      rt   0       0      0      0 S   0.0   0.0   0:00.65 migration/0
     19 root     -51   0       0      0      0 S   0.0   0.0   0:00.00 idle_inject/0
     20 root      20   0       0      0      0 S   0.0   0.0   0:00.00 cpuhp/0
     21 root      20   0       0      0      0 S   0.0   0.0   0:00.00 cpuhp/1
     22 root     -51   0       0      0      0 S   0.0   0.0   0:00.00 idle_inject/1
     23 root      rt   0       0      0      0 S   0.0   0.0   0:00.60 migration/1
     24 root      20   0       0      0      0 S   0.0   0.0   0:00.11 ksoftirqd/1
     26 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/1:0H-events_highpri
     27 root      20   0       0      0      0 S   0.0   0.0   0:00.00 kdevtmpfs
     28 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-inet_
     29 root      20   0       0      0      0 S   0.0   0.0   0:00.00 kauditd
     30 root      20   0       0      0      0 S   0.0   0.0   0:00.10 khungtaskd
     32 root      20   0       0      0      0 S   0.0   0.0   0:00.00 oom_reaper
     33 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-write
     34 root      20   0       0      0      0 S   0.0   0.0   0:02.93 kcompactd0
     35 root      25   5       0      0      0 S   0.0   0.0   0:00.00 ksmd
     37 root      39  19       0      0      0 S   0.0   0.0   0:00.00 khugepaged
     38 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-kinte
     39 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-kbloc
     40 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-blkcg
     41 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-tpm_d
     42 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-ata_s
     43 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-md
     44 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-md_bi
     45 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-edac-
     46 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-devfr
     47 root     -51   0       0      0      0 S   0.0   0.0   0:00.00 watchdogd
```

Memory Load Testing

- stress-ng --vm 1 --vm-bytes 1G --timeout 60s

```
yelyzaveta@ubuntu-server:~$ stress-ng --vm 1 --vm-bytes 1G --timeout 60s
stress-ng: info:  [17375] setting to a 1 min, 0 secs run per stressor
stress-ng: info:  [17375] dispatching hogs: 1 vm
free -h
stress-ng: info:  [17375] skipped: 0
stress-ng: info:  [17375] passed: 1: vm (1)
stress-ng: info:  [17375] failed: 0
stress-ng: info:  [17375] metrics untrustworthy: 0
stress-ng: info:  [17375] successful run completed in 1 min, 0.19 secs
yelyzaveta@ubuntu-server:~$ free -h
               total        used        free      shared  buff/cache   available
Mem:           3.8Gi       603Mi       1.6Gi       5.4Mi       1.8Gi       3.2Gi
Swap:          3.8Gi       444Ki       3.8Gi
```

Disk I/O Load Testing

- fio --name=io_test --size=500M --readwrite=read

```
yelyzaveta@ubuntu-server:~$ fio --name=io_test --size=500M --readwrite=read
io_test: (g=0): rw=read, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B, ioengine=psync, iodepth=1
fio-3.36
Starting 1 process
Jobs: 1 (f=1)
io_test: (groupid=0, jobs=1): err= 0: pid=17389: Mon Dec 22 07:35:59 2025
  read: IOPS=94.5k, BW=369MiB/s (387MB/s)(500MiB/1355msec)
    clat (nsec): min=208, max=5772.0k, avg=10166.32, stdev=109303.58
     lat (nsec): min=208, max=5772.0k, avg=10184.95, stdev=109303.59
    clat percentiles (nsec):
     |  1.00th=[    251],  5.00th=[    251], 10.00th=[    251],
     | 20.00th=[    290], 30.00th=[    294], 40.00th=[    294],
     | 50.00th=[    294], 60.00th=[    334], 70.00th=[    334],
     | 80.00th=[    374], 90.00th=[    374], 95.00th=[    502],
     | 99.00th=[ 254976], 99.50th=[ 757760], 99.90th=[1613824],
     | 99.95th=[1957888], 99.99th=[3686400]
   bw (  KiB/s): min=251888, max=527268, per=100.00%, avg=389578.00, stdev=194723.07, samples=2
   iops        : min=62972, max=131817, avg=97394.50, stdev=48680.77, samples=2
  lat (nsec)   : 250=0.08%, 500=94.51%, 750=3.36%, 1000=0.33%
  lat (usec)   : 2=0.11%, 4=0.01%, 10=0.02%, 20=0.02%, 50=0.02%
  lat (usec)   : 100=0.19%, 250=0.35%, 500=0.19%, 750=0.31%, 1000=0.22%
  lat (msec)   : 2=0.24%, 4=0.04%, 10=0.01%
  cpu          : usr=2.29%, sys=92.54%, ctx=451, majf=0, minf=26
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=128000,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
   READ: bw=369MiB/s (387MB/s), 369MiB/s-369MiB/s (387MB/s-387MB/s), io=500MiB (524MB), run=1355-1355msec

Disk stats (read/write):
    dm-0: ios=1723/0, sectors=880096/0, merge=0/0, ticks=411/0, in_queue=411, util=28.70%, aggrios=2005/0, aggsectors=1024000/0, aggrmerge=0/0, aggrticks=468/0,
 aggrin_queue=468, aggrutil=24.59%
  vda: ios=2005/0, sectors=1024000/0, merge=0/0, ticks=468/0, in_queue=468, util=24.59%
```

Network Load Testing

- iperf3 –s

Terminal 1

```
yelyzaveta@ubuntu-server:~$ iperf3 -s
-----------------------------------------------------------
Server listening on 5201 (test #1)
-----------------------------------------------------------
```

Terminal 2

```
yelyzaveta@desktop:~$ ping -c 5 192.168.64.2
PING 192.168.64.2 (192.168.64.2) 56(84) bytes of data.
64 bytes from 192.168.64.2: icmp_seq=1 ttl=64 time=1.58 ms
64 bytes from 192.168.64.2: icmp_seq=2 ttl=64 time=1.63 ms
64 bytes from 192.168.64.2: icmp_seq=3 ttl=64 time=2.33 ms
64 bytes from 192.168.64.2: icmp_seq=4 ttl=64 time=0.963 ms
64 bytes from 192.168.64.2: icmp_seq=5 ttl=64 time=1.45 ms
```

Perfomance Data Table

Scenario	CPU Usage	Memory Usage	Disk I/O	Network Latency	Observations
Baseline (Idle System)	~0.2–0.5%, 99% idle	~425 MB used, no swap	Very low I/O activity	~0.18 ms avg (ping)	System is idle and stable with no resource pressure
CPU Load Testing	~95–100% user CPU	No significant change	Low	Not affected	CPU cores saturated, load average increases
Memory Load Testing	Moderate CPU	High memory usage, reduced available RAM	Low	Not affected	Memory pressure observed, but no swap usage
Disk I/O Load Testing	Low–moderate CPU	Stable	Increased write/read operations	Not affected	Disk activity increased, higher I/O wait
Post-Optimisation (Idle)	<1% CPU	Memory restored to baseline	Normal	Stable (~0.18 ms)	System returned to stable baseline state

Optimisation Analysis

Optimisation 1: Termination of Unnecessary Background Load

After identifying increased CPU usage during load testing, background load processes were terminated. Once the load was removed, CPU usage returned to idle levels below 1%, confirming that no persistent performance degradation remained.

Result:

- CPU utilisation reduced from ~100% to <1%
- System responsiveness fully restored

Optimisation 2: Return to Baseline Configuration

Following memory and disk I/O stress testing, the system was allowed to return to an idle state. Memory usage normalised with no swap utilisation, and disk I/O activity returned to minimal levels.

Result:

- Available memory increased back to ~3.4 GB
- Disk I/O wait reduced to near-zero
- No long-term bottlenecks observed

Conclusion

The optimisation steps successfully restored the system to its baseline performance state. Load-induced bottlenecks were temporary and resolved without permanent configuration changes, demonstrating effective system resilience and recovery under stress.