EDI: First & Second Assigment

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Abstract

This report will cover and use three main topics:

- SPECviewperf;
- Windows Performance Monitor;
- DNS.

1 SPECviewperf tool and WIndows Performance Monitor Project

To assess the graphics processing units (GPUs) in the three computers used in this study, we employed SPECviewperf, a widely recognized tool in the industry for benchmarking graphic performance. SPECviewperf is a free and open-source application designed to measure graphics performance by running a series of benchmarks, called 'viewsets,' which simulate realistic workloads for professional applications.

SPECviewperf measures the frame rate, or frames per second (FPS), at which your graphics card can render scenes across a wide variety of applications and usage models. Each viewset represents an application or a usage model, and each composite score below is based on a weighted geometric mean of many different scenes and rendering modes.

Additionally, the Windows Performance Monitor was utilized to monitor and analyze the system's performance metrics during the benchmarking process. This tool provides detailed insights into various system components' utilization, including CPU, memory, disk, and network activity, allowing for a comprehensive understanding of system behavior and potential bottlenecks.

To explore a viewset in more detail, including the measured frame rate for each test of which the composite score is comprised, the Windows Performance Monitor offers customizable performance counters and real-time monitoring capabilities, enabling users to delve deeper into system performance analysis.

1.1 Methodology and experimental setup

Installing SPECviewperf is straightforward and typically requires just a few steps. Once installed, we ran benchmarks using a standard selection of viewsets to ensure

consistency in our tests. The viewsets used include 'energy-03,' 'medical-03,' and 'snx-04,' each representing a specific use case that tests different capabilities of the GPU.

energy-03: The energy-03 viewset is based on rendering techniques used by the open-source OpendTect seismic visualization application. Similar to medical imaging such as MRI or CT, geophysical surveys generate image slices through the subsurface that are built into a 3D grid.

medical-03: The medical-03 viewset demonstrates the performance of several medical visualization volume rendering techniques.

snx-04: The snx-04 viewset was created from traces of the graphics workload generated by the NX 8.0 application from Siemens PLM. Model sizes range from 7.15 to 8.45 million vertices.

Moreover, during each test execution on a computer, I kept the Windows Performance Monitor open and observed and monitored step by step the CPU, GPU, and other relevant metrics graphs.

1.2 Experiments & Results

1.2.1 First PC

The first PC under consideration is the workstation, an assembled computer built a few months ago with good components for work/study but not optimized for graphic tasks. Indeed, it does not have a dedicated graphics card but only relies on the GPU integrated within the processor.

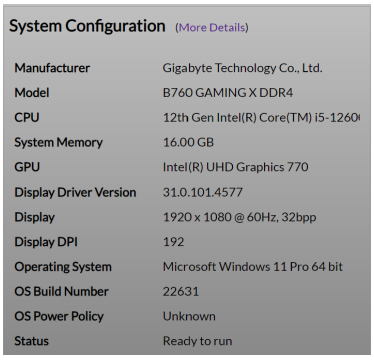


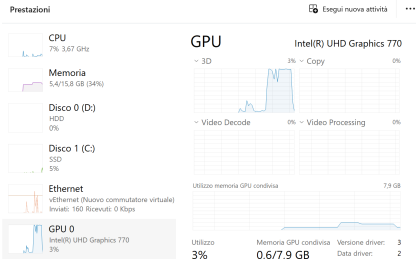
Figure 1

Figure 1 shows the HW & SW specification about PC1. We can observe the CPU, RAM, Display settings, Operating System and that there is no GPU dedicated.

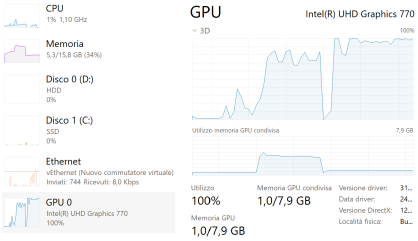
At the outset, as soon as the program launched, the PC began experiencing frequent freezes. The software interfaces were unresponsive to my commands, and the various 3D images displayed on the screen remained stagnant, showing no signs of activity. Commands executed prior were delayed by several minutes. Moreover, attempting drag-and-drop actions on the Windows 10 home screen resulted in somewhat sluggish responses, albeit executing with slight delays.

Furthermore, the 3D images resumed their movement only after a complete image change or after several tens of minutes. Ultimately, upon concluding the benchmark tests, the PC still exhibited some lag within the operating system. However, considering the workload it had just undergone, such delays were understandable.

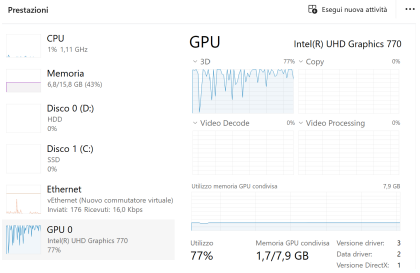
In Figure 2, we can observe the following: in (a), GPU 0 appears to be ”sleeping” because the program has not yet started, but the CPU and memory are engaged in background tasks. In (b), the test begins, and we witness a spike in GPU 0 activity, which immediately reaches 100% load, while memory also shows an increase in workload. In (c), the memory workload remains constant, while the GPU graphs indicate significant activity. Finally, in (d), the graph declines, assuming a different appearance.



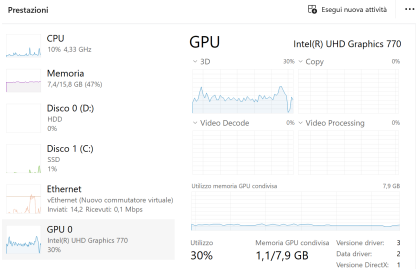
(a) Before starting the test



(b) Just launched the test



(c) During testing



(d) End of the test

Figure 2

The final and overall results in Figure 3 are incomprehensible. We start from 1600 points and drop to less than 10. Unfortunately, being the first time I’ve tested software of this kind, I immediately think of some outliers that may have occurred in the first benchmark. The only reference I can make, which may have caused this error, is that when the program and the OS were frozen, I opened a new task manager using the command combination: Ctrl + Alt + Canc.

Viewset	Composite Score	Window
energy-03	1691.82	1900 x 1060
medical-03	3.14	1900 x 1060
snx-04	6.05	1900 x 1060

Figure 3

Not being satisfied with this outcome, I opted to restart the test from scratch without performing any further operations or executions on the computer.

The result of this last test give to me a correct result, that is show in Figure 4.

Viewset	Composite Score	Window
energy-03	1.29	1900 x 1060
medical-03	3.24	1900 x 1060
snx-04	6.09	1900 x 1060

Figure 4

The results tables (Table 1) below includes the details about each test within a viewset. Viewsets are often comprised of many tests which produce a frame rate. Frame rate is computed as the average Frames Per Second (FPS), or the total number of frames rendered divided by the time in seconds to render those frames. These FPS values are then used to compute the composite score using the weights for each test.

Index	Description	Weight	FPS
1	Blake Ridge volume (1307x95x1300) and horizons	16.67	1.78
2	F3 Netherlands volume (950x450x462) and horizons	16.67	1.72
3	Opunake volume (1949x731x1130)	16.67	0.45
4	Blake ridge volume (with animated clipping plane) and horizons	16.67	2.36
5	F3 Netherlands volume (with animated clipping plane) and horizons	16.66	2.17
6	Opunake volume (with animated clipping plane)	16.66	0.65

Index	Description	Weight	FPS
7	Beating heart, 256x256x32, 1D transfer, slice rendering	10	33.78
8	Beating heart, 256x256x32, 1D transfer, raycasting	10	33.23
9	Beetle, 832x832x494, 1D transfer, slice rendering	10	3.65
10	Beetle, 832x832x494, 1D transfer, raycasting	10	2.18
11	Brain, 232x256x192, 2D transfer, raycasting	10	2.02
12	Brain, 232x256x192, 2D transfer, raycasting, clipping plane	10	5.93
13	Broken arm, 512x512x102, 2D transfer, raycasting	10	2.21
14	Broken arm, 512x512x102, 2D transfer, raycasting, clipping plane	10	3.91
15	Alligator, 737x511x1536, 2D transfer, raycasting	10	0.26
16	Alligator, 737x511x1536, 2D transfer, raycasting, clipping plane	10	0.54

Index	Description	Weight	FPS
17	Powertrain in advanced studio mode	7.5	7.16
18	Powertrain in shaded mode	10	7.01
19	Powertrain in shaded-with-edges mode	20	4.59
20	Powertrain in studio mode	5	3.89
21	Powertrain in wireframe mode	7.5	4.15
22	SUV in advanced studio mode	7.5	11.08
23	SUV in shaded mode	10	10.80
24	SUV in shaded-with-edges mode	20	5.91
25	SUV in studio mode	5	5.84
26	SUV in wireframe mode	7.5	5.11

Table 1: Tables of 'energy-03', 'medical-03', 'snx-04' data.

Looking at the performance data presented in Table 1, we can discern notable variations across different visualization scenarios and models.

For instance, in the case of volumetric data sets like Blake Ridge and F3 Netherlands volumes, the average frame rates range from approximately 1.7 to 2.4 FPS, indicating moderate rendering performance.

Moving to more complex rendering tasks involving anatomical models, such as the brain and heart simulations, the average frame rates exhibit a considerable increase, reaching values between 2 and 34 FPS, depending on the specific rendering technique used.

However, when considering more detailed and intricate models, like the powertrain and SUV simulations, the average frame rates tend to decrease, averaging around 4 to 12 FPS across different visualization modes.

Overall, these findings underscore the diverse performance characteristics of the graphics processing units (GPUs) under varying workload conditions and visualization requirements.

1.2.2 Second PC

The second PC under consideration is my personal computer, which I use daily at university for studying. Furthermore, it is also a brand-new PC.

Figure 5 displaying the technical specifications of PC2.

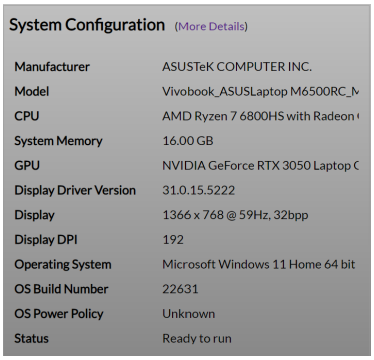
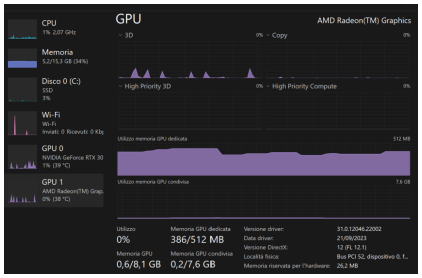


Figure 5

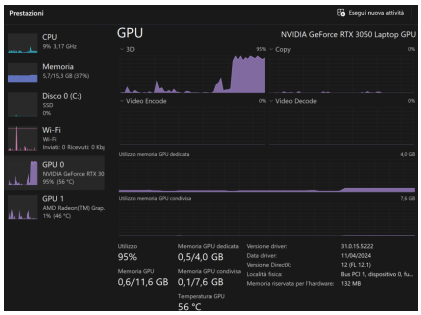
The first observation we can make is that in this test case, we have a different type of PC; the previous one was a workstation, while this one is a laptop. Secondly, the previous PC did not have a dedicated graphics card, while this one does, and it also features a good GPU.

Launching the program with the same benchmarks, I immediately noticed a vast difference. Right from the start, the 3D graphics were very clear, and there was no lag whatsoever. Furthermore, from the outset, the computer entered gaming mode, most likely due to the 3D designs it had to load, both because of the GPU overheating, as we can see in the photos below. After a few minutes, some lag occurred, but much less compared to the test conducted on PC1. The most significant lags were noticed during the change of benchmarks. Another important thing to mention is that the GPU never reached 100% usage, whereas in PC1, it was constantly at 100% .

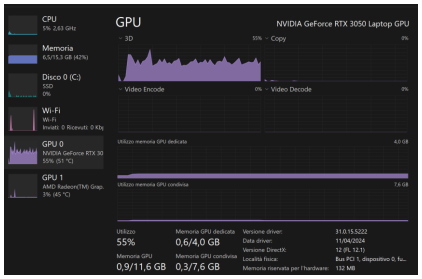
In Figure 6 we can observe: in (a) we can see that, GPU 0 and GPU 1 are ”not working” because the program is not started yet. In addition, in a similar way the memory, it’s working to perform some tasks in the background. in (b) the test start and we can watch a spread in the GPU 0, that is the dedicated one and also the memory undergoes a percentage increase in workload. in (c) the working load of memory and GPU are pretty constant. Finally, in (d) the graph decreases, and as we can see, the temperature decreases as well.



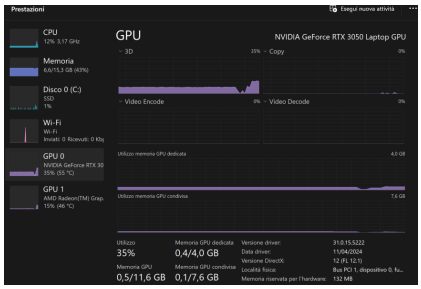
(a) Before starting the test



(b) Just launched the test



(c) During testing



(d) End of the test

Figure 6: four test phases on PC2

To provide a partial result, the test went well since the 3D images were displayed clearly throughout the process, and there were far fewer lag issues.

Figure 7 shows the final score of the tests.

Viewset	Composite Score	Window
energy-03	10.06	1900 x 1060
medical-03	12.12	1900 x 1060
snx-04	10.85	1900 x 1060

Figure 7

To provide a brief comparison between the final results of PC1 and PC2, we can observe that in the former case, we do not exceed six points in the composite score, while in the latter case, we start from a minimum of 10 points.

The tables of results (Table 2) provided below contain comprehensive information regarding each individual test within a viewset. Viewsets typically consist of multiple tests, each generating a frame rate. The frame rate is calculated as the average number of frames rendered per second (FPS), obtained by dividing the total number of frames rendered by the time taken in seconds to render those frames. These FPS values are subsequently utilized to compute the composite score, with each test being assigned specific weights.

Index	Description	Weight	FPS
1	Blake Ridge volume (1307x95x1300) and horizons	16.67	8.28
2	F3 Netherlands volume (950x450x462) and horizons	16.67	14.07
3	Opunake volume (1949x731x1130)	16.67	5.42
4	Blake ridge volume (with animated clipping plane) and horizons	16.67	12.60
5	F3 Netherlands volume (with animated clipping plane) and horizons	16.66	17.90
6	Opunake volume (with animated clipping plane)	16.66	7.30
7	Beating heart, 256x256x32, 1D transfer, slice rendering	10	105.98
8	Beating heart, 256x256x32, 1D transfer, raycasting	10	134.71
9	Beetle, 832x832x494, 1D transfer, slice rendering	10	18.27
10	Beetle, 832x832x494, 1D transfer, raycasting	10	11.10
11	Brain, 232x256x192, 2D transfer, raycasting	10	7.34
12	Brain, 232x256x192, 2D transfer, raycasting, clipping plane	10	25.97
13	Broken arm, 512x512x102, 2D transfer, raycasting	10	9.90
14	Broken arm, 512x512x102, 2D transfer, raycasting, clipping plane	10	17.64
15	Alligator, 737x511x1536, 2D transfer, raycasting	10	0.52
16	Alligator, 737x511x1536, 2D transfer, raycasting, clipping plane	10	1.37
17	Powertrain in advanced studio mode	7.5	75.54
18	Powertrain in shaded mode	10	7.06
19	Powertrain in shaded-with-edges mode	20	6.76
20	Powertrain in studio mode	5	5.85
21	Powertrain in wireframe mode	7.5	6.21
22	SUV in advanced studio mode	7.5	119.89
23	SUV in shaded mode	10	9.05
24	SUV in shaded-with-edges mode	20	8.60
25	SUV in studio mode	5	5.41
26	SUV in wireframe mode	7.5	8

Table 2: Tables of 'energy-03', 'medical-03', 'snx-04' data.

Analyzing the data, in Table 2, obtained from the various tests, we can observe that performance varies significantly depending on different conditions and visualization modes. For instance, concerning the Blake Ridge and F3 Netherlands volumes, the average frame rates are around 11-12 FPS, while for Opunake, they are around 9 FPS.

Moving on to the heart and brain tests, a notable difference is observed: the average

frame rates exceed 100 FPS in the heart tests, with values reaching almost 120 FPS, whereas in the brain tests, they range around 15-20 FPS.

Regarding other tests, such as the broken arm and alligator tests, the average frame rates are rather low, with values oscillating around 1-2 FPS.

Lastly, for the vehicle model tests, we observe a broader range of average frame rates, ranging from 5 to over 60 FPS, depending on the visualization mode.

Overall, these data provide us with an insight into the performance variation based on the context and visualization mode used.

1.2.3 Third PC

The third PC utilized in this experiment belongs to my brother, purchased in 2019. Primarily intended for academic purposes, this laptop serves as a dedicated tool for studying.

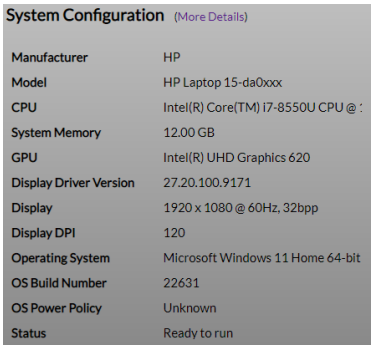


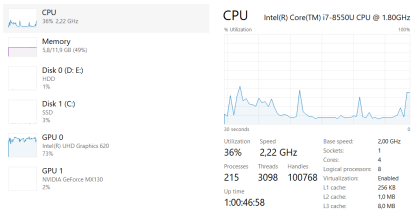
Figure 8

Figure 8 shows the technical specification of the personal computer.

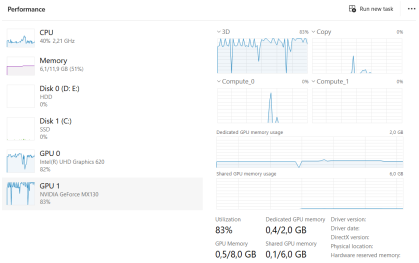
First of all, I can say that even on this PC, the execution of the benchmarks was quite smooth. Let me explain: the images of the three classic benchmarks I selected were displayed fairly well. Occasionally, the frames would freeze for a few seconds, but this did not pose a significant visual problem. These ”lags” were likely due to the age of the PC and the difficulty of handling a heavy graphical workload.

Secondly, by analyzing the screenshots shown in Figure 9, we can say: in (a) we observe that only the integrated graphics card in the CPU (GPU 0) is working, while the other card, the dedicated one, is not working at all. In (b) we see that both cards are working at full capacity (more than 83%) due to the start of the tests, which caused a rapid increase in the 3D graphics workload. In (c) we see something very important: the ”dedicated GPU memory usage” graph is completely saturated, indicating that the workload is being offloaded from the CPU and RAM. Therefore, this helps with faster graphics processing and also improves the overall performance of the computer. Additionally, in the ”shared GPU memory usage” graph, we notice a rapid rise, indicating that the video card is accessing data directly from the RAM without needing to copy or transfer it from other parts of the system. This reduces latency times and improves

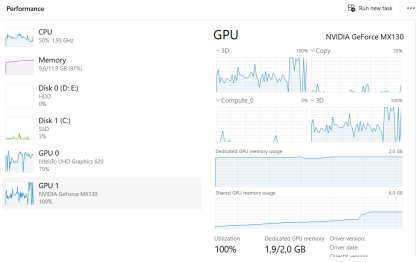
the overall system performance. Finally, in (d) we see that after the tests are finished, the only GPU that continues to work is the one integrated into the CPU.



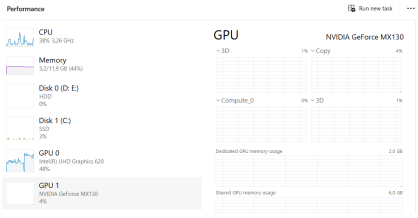
(a) Before starting the test



(b) Just launched the test



(c) During testing



(d) End of the test

Figure 9: four test phases on PC3

In Figure 10, the final scores are shown. We can observe that the results do not exceed 7 points in the composite score. Additionally, we notice here the worst result among all the test results across various PCs, with a score in the ”energy-03” test being less than 1.

Viewset	Composite Score	Window
energy-03	0.55	1900 x 1060
medical-03	2.51	1900 x 1060
snx-04	7.76	1900 x 1060

Figure 10

Index	Description	Weight	FPS
1	Blake Ridge volume (1307x95x1300) and horizons	16.67	3.57
2	F3 Netherlands volume (950x450x462) and horizons	16.67	3.87
3	Opunake volume (1949x731x1130)	16.67	0.01
4	Blake ridge volume (with animated clipping plane) and horizons	16.67	4.77
5	F3 Netherlands volume (with animated clipping plane) and horizons	16.66	4.41
6	Opunake volume (with animated clipping plane)	16.66	0.01

Index	Description	Weight	FPS
1	Beating heart, 256x256x32, 1D transfer, slice rendering	10	18.77
2	Beating heart, 256x256x32, 1D transfer, raycasting	10	35.95
3	Beetle, 832x832x494, 1D transfer, slice rendering	10	2.22
4	Beetle, 832x832x494, 1D transfer, raycasting	10	1.48
5	Brain, 232x256x192, 2D transfer, raycasting	10	2.41
6	Brain, 232x256x192, 2D transfer, raycasting, clipping plane	10	6.76
7	Broken arm, 512x512x102, 2D transfer, raycasting	10	2.31
8	Broken arm, 512x512x102, 2D transfer, raycasting, clipping plane	10	4.15
9	Alligator, 737x511x1536, 2D transfer, raycasting	10	0.12
10	Alligator, 737x511x1536, 2D transfer, raycasting, clipping plane	10	0.25

Index	Description	Weight	FPS
11	Powertrain in advanced studio mode	7.5	22.96
12	Powertrain in shaded mode	10	6.73
13	Powertrain in shaded-with-edges mode	20	5.80
14	Powertrain in studio mode	5	4.84
15	Powertrain in wireframe mode	7.5	4.97
16	SUV in advanced studio mode	7.5	42.82
17	SUV in shaded mode	10	7.08
18	SUV in shaded-with-edges mode	20	6.23
19	SUV in studio mode	5	5.03
20	SUV in wireframe mode	7.5	7.24

Table 3: Tables of 'energy-03', 'medical-03', 'snx-04' data.

In the first group of data, each element is assigned a weight of 16.67 or 16.66, indicating a certain relative importance compared to other data. However, despite the assigned weight, FPS varies, with values starting from 0.01 but not exceeding 5. This variation suggests that rendering performance may be influenced by data complexity or system processing capability.

The second group of data includes various representations of objects such as hearts, beetles, and brains. In this case, each element is assigned a uniform weight of 10. However, FPS varies significantly among the different representations, with values ranging from 1.48 to 35.95.

In the third group, data focuses on different visualization modes of motor and SUV models. Again, there are variations in both weights and FPS among the different visualization modes, indicating that factors such as model complexity and rendering tech-

nique can influence rendering performance.

1.3 Conclusion

In summary, this project began with an analysis of three different types of systems: a recently assembled workstation without a dedicated graphics card, relying solely on the integrated GPU in the processor, a brand-new personal computer, and an older personal computer, both equipped with dedicated GPUs. I conducted the same benchmarks on each of these computers in the same sequence, analyzing them and observing various key components of the computer using the Windows Performance System.

After analyzing the data from each benchmark result, I can conclude that the dedicated graphics card proved to be necessary and highly beneficial for handling 3D graphics workloads. This ensured that the workload was effectively distributed or even assigned to the most suitable GPU for the task, resulting in a significant reduction in lag.

Finally, this project provided me with the opportunity to explore, study, analyze, and test the Specviewperf software, which proved to be an extremely useful tool for evaluating the graphic performance of computer systems. Its ability to conduct a series of standardized benchmarks across a wide range of hardware configurations provided a clear picture of the rendering capabilities of each system, allowing me to make informed decisions regarding system design and performance optimization.

2 Domain Name System Project

This second project is related to the DNS, where I will cover:

- Active experiments;
- Performance experiments.

2.1 Active experiments

The target of the experiment is `apple.com`, and the local name server used in the experiments is: `1.1.1.1`.

2.1.1 Query the DNS to obtain the IP addresses of the Name Servers of a company located outside Europe; how many queries did you execute? What type(s) of queries? How many Name Servers are associated with the company? Do they belong to the same domain? Can you identify the primary Name Server? Why? Who registered the domain? When will it expire

To uncover the Name Servers of `apple.com`, one may initiate a query specifying the type as NS (Name Servers) as follows:

```
dig @1.1.1.1 NS apple.com
```

```
fedelinux@workstation:/mnt/c/Users/feder$ dig @1.1.1.1 NS apple.com

; <<>> DiG 9.18.18-0ubuntu0.22.04.2-Ubuntu <<>> @1.1.1.1 NS apple.com
; (1 server found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 27958
;; flags: qr rd ra; QUERY: 1, ANSWER: 4, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 1232
;; QUESTION SECTION:
;apple.com.                     IN      NS

;; ANSWER SECTION:
apple.com.              33734   IN      NS      a.ns.apple.com.
apple.com.              33734   IN      NS      b.ns.apple.com.
apple.com.              33734   IN      NS      c.ns.apple.com.
apple.com.              33734   IN      NS      d.ns.apple.com.

;; Query time: 10 msec
;; SERVER: 1.1.1.1#53(1.1.1.1) (UDP)
;; WHEN: Sun May 19 14:45:21 CEST 2024
;; MSG SIZE  rcvd: 105
```

Figure 11

In Figure 11, there is the output of a command called `dig`, which is a tool used to execute DNS queries, i.e., to obtain information about domain names and their associated servers. In the command you executed, you specified to query the DNS server with the IP address `1.1.1.1` to find the name servers of the domain `apple.com`.

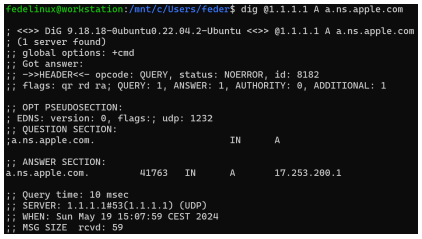
The interesting part of this output is the "ANSWER SECTION". Here, we see that there are four responses. These are the name servers associated with the domain `apple.com`. The name servers are `a.ns.apple.com`, `b.ns.apple.com`,

`c.ns.apple.com`, and `d.ns.apple.com`. These servers are responsible for resolving domain names within the `apple.com` domain.

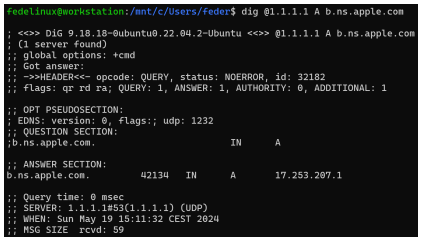
Additionally, we can notice that the time taken to obtain the response is `10` milliseconds, as indicated in the "Query time" section.

To retrieve the IP addresses of the Name Servers, you can send a query of type A to each name server. So,

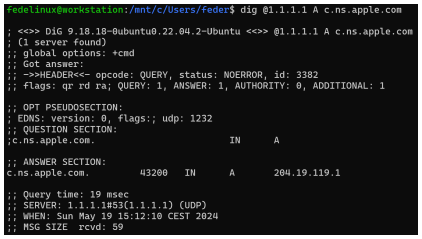
```
dig @1.1.1.1 A @nameserver
```



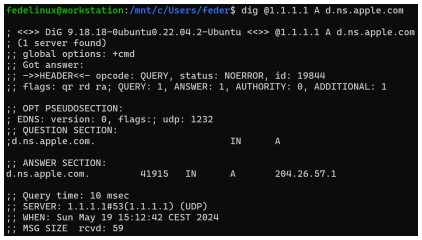
(a) First NS



(b) Second NS



(c) third NS



(d) Fourth NS

Figure 12

In Figure 12, taking as an example the scree (a), in the "ANSWER" section, a response to the query of type A for the name server a.ns.apple.com was received. The returned IP address is 17.253.200.1. The time taken to obtain the response was 10 milliseconds. The "OPT PSEUDOSECTION" section provides additional information on the use of EDNS and the configuration of the UDP protocol. The date and time when the query was made are indicated in the "WHEN" section."

To determine the primary Name Server, the query type is switched to SOA. So, `dig @1.1.1.1 SOA apple.com`

Figure 13

In Figure 13, we can observe lots important information:

- The "ANSWER" section provides the response to the query. In this case, we have a SOA (Start of Authority) record for the domain `apple.com`. This SOA record contains information about the authoritative server for the domain and other parameters related to the management of the domain itself.
- The SOA record specifies the name of the authoritative server as:

  `usmsc2-extxfr-001.dns.apple.com.`, and the email address of the domain administrator as:

  `hostmaster.apple.com.`

  Additionally, various parameters are provided, such as the serial number, refresh time, retry time, expiry time, and minimum TTL.
- The time taken to obtain the response is 29 milliseconds, as indicated in the "Query time" section.
- Finally, the date and time when the query was made are indicated in the "WHEN" section.

To discover who registered the domain and when the domain will expire, it's possible to use the command whois: `whois apple.com`

```
fedelinux@workstation:/mnt/c/Users/feder$ whois apple.com
   Domain Name: APPLE.COM
   Registry Domain ID: 1225976_DOMAIN_COM-VRSN
   Registrar WHOIS Server: whois.comlaude.com
   Registrar URL: http://www.comlaude.com
   Updated Date: 2023-08-28T18:33:11Z
   Creation Date: 1987-02-19T05:00:00Z
   Registry Expiry Date: 2025-02-20T05:00:00Z
   Registrar: Nom-iq Ltd. dba COM LAUDE
   Registrar IANA ID: 470
   Registrar Abuse Contact Email: abuse@comlaude.com
   Registrar Abuse Contact Phone: +442074218250
   Domain Status: clientDeleteProhibited
       ↪ https://icann.org/epp#clientDeleteProhibited
```

```
    Domain Status: clientTransferProhibited
        ↪ https://icann.org/epp#clientTransferProhibited
    Domain Status: clientUpdateProhibited
        ↪ https://icann.org/epp#clientUpdateProhibited
    Domain Status: serverDeleteProhibited
        ↪ https://icann.org/epp#serverDeleteProhibited
    Domain Status: serverTransferProhibited
        ↪ https://icann.org/epp#serverTransferProhibited
    Domain Status: serverUpdateProhibited
        ↪ https://icann.org/epp#serverUpdateProhibited
    Name Server: A.NS.APPLE.COM
    Name Server: B.NS.APPLE.COM
    Name Server: C.NS.APPLE.COM
    Name Server: D.NS.APPLE.COM
    DNSSEC: unsigned
    URL of the ICANN Whois Inaccuracy Complaint Form:
        ↪ https://www.icann.org/wicf/
>>> Last update of whois database: 2024-05-19T13:33:48Z <<<

For more information on Whois status codes, please visit
    ↪ https://icann.org/epp

NOTICE: The expiration date displayed in this record is the date the
registrar's sponsorship of the domain name registration in the
    ↪ registry is
currently set to expire. This date does not necessarily reflect the
    ↪ expiration
date of the domain name registrant's agreement with the sponsoring
registrar.  Users may consult the sponsoring registrar's Whois
    ↪ database to
view the registrar's reported date of expiration for this registration.

TERMS OF USE: You are not authorized to access or query our Whois
database through the use of electronic processes that are high-volume
    ↪ and
automated except as reasonably necessary to register domain names or
modify existing registrations; the Data in VeriSign Global Registry
Services' ("VeriSign") Whois database is provided by VeriSign for
information purposes only, and to assist persons in obtaining
    ↪ information
about or related to a domain name registration record. VeriSign does
    ↪ not
guarantee its accuracy. By submitting a Whois query, you agree to abide
by the following terms of use: You agree that you may use this Data
    ↪ only
for lawful purposes and that under no circumstances will you use this
    ↪ Data
to: (1) allow, enable, or otherwise support the transmission of mass
unsolicited, commercial advertising or solicitations via e-mail,
    ↪ telephone,
or facsimile; or (2) enable high volume, automated, electronic
    ↪ processes
that apply to VeriSign (or its computer systems). The compilation,
repackaging, dissemination or other use of this Data is expressly
prohibited without the prior written consent of VeriSign. You agree
    ↪ not to
use electronic processes that are automated and high-volume to access
```

```
    ↪ or
query the Whois database except as reasonably necessary to register
domain names or modify existing registrations. VeriSign reserves the
    ↪ right
to restrict your access to the Whois database in its sole discretion
    ↪ to ensure
operational stability.  VeriSign may restrict or terminate your access
    ↪ to the
Whois database for failure to abide by these terms of use. VeriSign
reserves the right to modify these terms at any time.

The Registry database contains ONLY .COM, .NET, .EDU domains and
Registrars.
Domain Name: apple.com
Registry Domain ID: 1225976_DOMAIN_COM-VRSN
Registrar WHOIS Server: whois.comlaude.com
Registrar URL: https://www.comlaude.com
Updated Date: 2024-05-03T09:53:59Z
Creation Date: 1987-02-19T05:00:00Z
Registrar Registration Expiration Date: 2025-02-20T00:00:00Z
Registrar: NOM-IQ Ltd dba Com Laude
Registrar IANA ID: 470
Domain Status: clientDeleteProhibited
    ↪ https://www.icann.org/epp#clientDeleteProhibited
Domain Status: clientTransferProhibited
    ↪ https://www.icann.org/epp#clientTransferProhibited
Domain Status: clientUpdateProhibited
    ↪ https://www.icann.org/epp#clientUpdateProhibited
Domain Status: serverDeleteProhibited
    ↪ https://www.icann.org/epp#serverDeleteProhibited
Domain Status: serverTransferProhibited
    ↪ https://www.icann.org/epp#serverTransferProhibited
Domain Status: serverUpdateProhibited
    ↪ https://www.icann.org/epp#serverUpdateProhibited
Registry Registrant ID: REDACTED FOR PRIVACY
Registrant Name: REDACTED FOR PRIVACY
Registrant Organization: Apple Inc.
Registrant Street: REDACTED FOR PRIVACY
Registrant City: REDACTED FOR PRIVACY
Registrant State/Province: CA
Registrant Postal Code: REDACTED FOR PRIVACY
Registrant Country: US
Registrant Phone: REDACTED FOR PRIVACY
Registrant Phone Ext: REDACTED FOR PRIVACY
Registrant Fax: REDACTED FOR PRIVACY
Registrant Fax Ext: REDACTED FOR PRIVACY
Registrant Email: apple.com-Registrant@anonymised.email
Registry Admin ID: REDACTED FOR PRIVACY
Admin Name: REDACTED FOR PRIVACY
Admin Organization: REDACTED FOR PRIVACY
Admin Street: REDACTED FOR PRIVACY
Admin City: REDACTED FOR PRIVACY
Admin State/Province: REDACTED FOR PRIVACY
Admin Postal Code: REDACTED FOR PRIVACY
Admin Country: REDACTED FOR PRIVACY
Admin Phone: REDACTED FOR PRIVACY
Admin Phone Ext: REDACTED FOR PRIVACY
```

```
Admin Fax: REDACTED FOR PRIVACY
Admin Fax Ext: REDACTED FOR PRIVACY
Admin Email: apple.com-Admin@anonymised.email
Registry Tech ID: REDACTED FOR PRIVACY
Tech Name: REDACTED FOR PRIVACY
Tech Organization: REDACTED FOR PRIVACY
Tech Street: REDACTED FOR PRIVACY
Tech City: REDACTED FOR PRIVACY
Tech State/Province: REDACTED FOR PRIVACY
Tech Postal Code: REDACTED FOR PRIVACY
Tech Country: REDACTED FOR PRIVACY
Tech Phone: REDACTED FOR PRIVACY
Tech Phone Ext: REDACTED FOR PRIVACY
Tech Fax: REDACTED FOR PRIVACY
Tech Fax Ext: REDACTED FOR PRIVACY
Tech Email: apple.com-Tech@anonymised.email
Name Server: a.ns.apple.com
Name Server: b.ns.apple.com
Name Server: c.ns.apple.com
Name Server: d.ns.apple.com
DNSSEC: Unsigned Delegation
Registrar Abuse Contact Email: abuse@comlaude.com
Registrar Abuse Contact Phone: +44.2074218250
URL of the ICANN WHOIS Data Problem Reporting System:
    ↪ http://wdprs.internic.net/
>>> Last update of WHOIS database: 2024-05-19T12:40:12Z <<<

For more information on Whois status codes, please visit
    ↪ https://www.icann.org/resources/pages
                                        /epp-status-codes-2014-06-16-en

Please query the RDDS service of the Registrar of Record identified in
    ↪ this
output for information on how to contact the Registrant, Admin, or
    ↪ Tech contact
of the queried domain name.

----------------------------------------------------------------------
Com Laude registers, maintains and renews domain names around the
    ↪ world for
leading intellectual property owners and the law firms that support
    ↪ them.
If you have queries about this domain, you may contact us via our
    ↪ website
at www.comlaude.com.
----------------------------------------------------------------------

The data in the Com Laude Whois database is provided to assist you in
    ↪ obtaining
information about a domain name registration record.  Com Laude makes
    ↪ this
information available "as is," and does not guarantee its accuracy.
By submitting a WHOIS query, you agree that you will use this data
    ↪ only for
lawful purposes and that, under no circumstances will you use this
    ↪ data to:

```

```
(1) allow, enable, or otherwise support the transmission of mass
    ↪ unsolicited,
commercial advertising or solicitations via e-mail (spam), telephone
    ↪ or fax; or
(2) enable high volume, automated, electronic processes that that send
    ↪ queries
or data to Com Laude or the systems of any Registry Operator or
    ↪ ICANN-Accredited
registrar.  The compilation, repackaging, dissemination or other use
    ↪ of this
data is expressly prohibited without the prior written consent of Com
    ↪ Laude.

Com Laude reserves the right to modify these terms at any time. By
    ↪ submitting
this query, you agree to abide by these terms. If you fail to abide by
    ↪ this
policy, we may terminate your access to this WHOIS database.

----------------------------------------------------------------------
Com Laude protects intellectual property in the domain name system.
    ↪ Com Laude
only registers domain names for legitimate rights owners. Should you
    ↪ have any
queries about the legitimacy of this name or our work as a UK based,
    ↪ ICANN
Accredited Registrar, contact us at:
Com Laude, 28 Little Russell Street, London WC1A 2HN, UK.
Com Laude is a business name of Nom IQ Ltd.
----------------------------------------------------------------------
```

In this output we can see many important information but, the most important for us are:

1. **Domain Details:** The domain name is "APPLE.COM", with a registered domain ID and registrar URL.
2. **Key Dates:** The creation date of the domain (1987-02-19) and the most recent update date (2023-08-28) are provided. Additionally, the registry expiration date is indicated (2025-02-20).
3. **Name Servers:** Name servers associated with the domain are listed, such as: "a.ns.apple.com", "b.ns.apple.com", "c.ns.apple.com", "d.ns.apple.com".

2.1.2 Query one of the Name Servers identified in the previous experiment to obtain the IP address of the Name Servers of the domains polimi.it and akamai.com. How many IP addresses did you get? Why?

I choose `17.253.200.1` as the Name Server (`a.ns.apple.com`) to query resulted in no answer being provided.

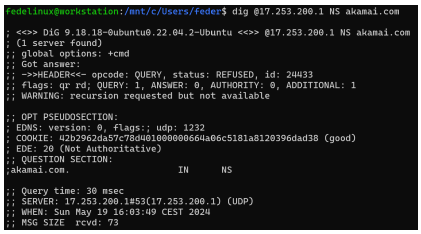


Figure 14

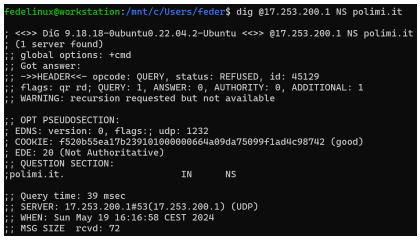


Figure 15

Figure 14 and Figure 15 explains to us that: the DNS server was contacted successfully, but it refused to respond to the query, as indicated by the status 'REFUSED'. This means that the server is not authorized to provide an answer for the requested query.

The flags indicate that the query was received (qr) and that recursion was requested (rd), but recursion is not available on this server (WARNING: recursion requested but not available).

The time taken to get a response was 30 milliseconds. The server used for the query is '17.253.200.1' on UDP port 53. Therefore, the DNS server '17.253.200.1' refused to respond to the request for the NS records for 'akamai.com/polimi.it'. This can happen for various reasons, such as a server configuration that does not allow responses to queries from unauthorized or external clients.

2.2 Performance Experiments

2.2.1 Measure the performance of a Name Server of your choice when processing multiple queries, analyze the obtained results and discuss your main findings and any expected/unexpected behavior. Your discussion should also highlight whether and how the types of query affect the query time. The impact of transport protocols (i.e., UDP, TCP) and of encrypted transmissions (i.e., DoT, DoH) should also be considered in the discussion.

To conduct this experiment, the `dnsping` command was used to estimate the min, avg, and max response times of NS `a.ns.apple.com`. The list of commands used are:

```
dnsping -c 20 -t ANY a.ns.apple.com
dnsping -c 20 -t ANY --tcp a.ns.apple.com
dnsping -c 20 -t ANY --doh a.ns.apple.com
dnsping -c 20 -t ANY --tls a.ns.apple.com
```

I repeated these commands a couple of times each. With the results obtained, I took an average and inserted it into the table below.

Protocol used	min	avg	max
UDP	0.920	1.510	1.696
TCP	1.037	1.782	2.344
DOH	3.702	5.966	7.816
DOT	4.233	5.522	6.500

From the values in the table, we can deduce the following:

- UDP (User Datagram Protocol): This protocol has the lowest minimum response time among the four, with a value of 0.920 milliseconds.
- TCP (Transmission Control Protocol): Although it has a slightly higher minimum response time compared to UDP, the TCP protocol shows higher average and maximum times.
- DOH (DNS-over-HTTPS): This protocol has the highest response times among those listed in the table. Although it offers greater security and privacy compared to other protocols, it may take longer to complete requests.
- DOT (DNS-over-TLS): Although similar to the DOH protocol in providing greater security, it shows generally lower response times compared to DOH. However, the maximum time is higher than UDP and TCP, which may indicate some variation in the DNS server response.

(Switching the query type to A/AAAA/SOA did not result in any notable changes in response time)

2.2.2 Measure the performance of different Name Servers of your choice when processing the same set of queries, analyze the obtained results and discuss your main findings and any expected/unexpected behavior. Your discussion should also highlight whether and how the query time varies with the Name Server and depends on the "distance" of the Name Server.

In this section (Figure 16 and Figure 17), I used various `dnseval` commands to evaluate the performance of the DNS server 172.24.224.1 in responding to different types of DNS queries. Each command executes a set of DNS requests and reports the average response time, minimum time, maximum time, standard deviation, percentage of lost packets, and other relevant information.

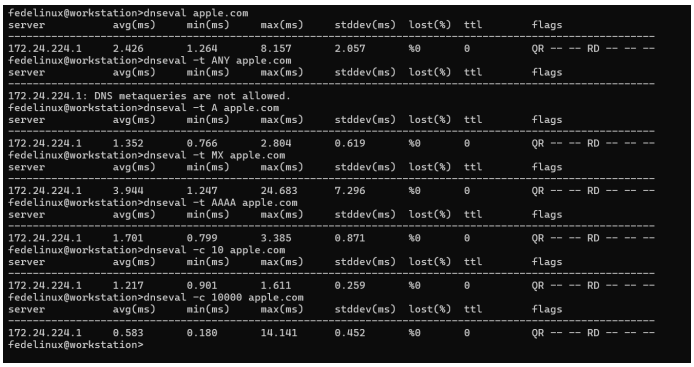


Figure 16

1. **Command**: `dnseval apple.com`
   - **Description**: Executes a default type (A) query to the domain `apple.com`.
   - **Analysis**: This command shows that the average response time is about 2.426 ms with a standard deviation of 2.057 ms. There are no lost packets.
2. **Command**: `dnseval -t ANY apple.com`
   - **Description**: Attempts to execute an ANY type query to the domain `apple.com`.
   - **Analysis**: The DNS server does not allow ANY type queries.
3. **Command**: `dnseval -t A apple.com`
   - **Description**: Executes an A type query to the domain `apple.com`.
   - **Analysis**: The A type query shows an average response time of about 1.352 ms, with a standard deviation of 0.619 ms and no lost packets.
4. **Command**: `dnseval -t MX apple.com`
   - **Description**: Executes an MX type query to the domain `apple.com`.

- **Analysis**: The MX type query has a higher average response time (3.944 ms) and a larger standard deviation (7.296 ms), indicating more variability in response times.

5. **Command**: `dnseval -t AAAA apple.com`
   - **Description**: Executes an AAAA type query to the domain `apple.com`.
   - **Analysis**: The AAAA type query shows an average response time of 1.701 ms with a standard deviation of 0.871 ms.
6. **Command**: `dnseval -c 10 apple.com`
   - **Description**: Executes 10 queries to the domain `apple.com`.
   - **Analysis**: The 10 queries have an average response time of 1.217 ms with a standard deviation of 0.259 ms, indicating good consistency in the responses.
7. **Command**: `dnseval -c 10000 apple.com`
   - **Description**: Executes 10,000 queries to the domain `apple.com`.
   - **Analysis**: Executing 10,000 queries, the average response time drops to 0.583 ms with a standard deviation of 0.452 ms, showing very fast and consistent response times.

Figure 17

1. **Command**: `dnseval -c 10 -tls apple.com`
   - **Description**: Attempts to execute 10 queries over TLS to the domain `apple.com`.
   - **Analysis**: The DNS server does not recognize the resource record type for this query.
2. **Command**: `dnseval -c 10 -tls -t A apple.com`
   - **Description**: Executes 10 queries of type A over TLS to the same domain.

- **Analysis**: The query shows an average response time of 2.297 ms, with a standard deviation of 3.247 ms and no packet loss.

3. **Command**: `dnseval -c 10 -tls -t AAAA apple.com`
   - **Description**: Executes 10 queries of type AAAA over TLS to the domain `apple.com`.
   - **Analysis**: The query shows an average response time of 2.647 ms, with a higher standard deviation of 5.063 ms, indicating more variability in response times.
4. **Command**: `dnseval -c 10 -tls -t MX apple.com`
   - **Description**: Executes 10 queries of type MX over TLS to the domain `apple.com`.
   - **Analysis**: The query shows an average response time of 2.264 ms, with a standard deviation of 3.001 ms, indicating consistent performance.
5. **Command**: `dnseval -c 10 -tls -t ANY apple.com`
   - **Description**: Attempts to execute 10 queries of type ANY over TLS to the domain `apple.com`.
   - **Analysis**: The DNS server does not allow queries of type ANY.

2.3 Conclusion

This laboratory activity was very important and interactive for me because it allowed me to personally test, analyze, and delve into many theoretical concepts studied in class. Furthermore, it was also very interesting to use new commands that I had never seen before and to better understand some that I already knew. All of this was the result of the theoretical concepts previously studied in class regarding DNS. The practical aspects resulting from these activities are essential to ensure that what I have studied does not remain merely an abstract concept.