CN: Assignment 2

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  - Task: DNS Query Resolution
    - ***Setup***
    - **A. Simulate the below given topology in Mininet and demonstrate successful connectivity among all nodes. (20 Points)**
    - **B. In the simulated topology, use the default host resolver to resolve the URLs specified in each host's respective PCAP file, and record for each host the average lookup latency, average throughput, number of successfully resolved queries, and number of failed resolutions. (10 Points)**
    - **C. Modify the DNS configuration of all Mininet hosts to use your custom resolver as the primary DNS server instead of the default system resolver. Show all the steps along with relevant screenshots. (10 Points)**
    - **D. Repeat DNS resolution for the given PCAPs as done in part B, this time using your custom DNS resolver (10.0.0.5). Compare the results with those obtained in part B. Additionally, log the following in the custom DNS resolver:**
      - Plots for H1 (first 10 URLs)
    - **F. Implement caching within your custom DNS resolver. Store recently resolved domain-to-IP mappings and serve repeated queries directly from cache without contacting external servers. Record the average lookup latency, average throughput, number of successfully resolved queries, % of queries resolved from cache and number of failed resolutions. (2.5 Points)**

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Github Repository Link: Reckadon/mininet-assignment

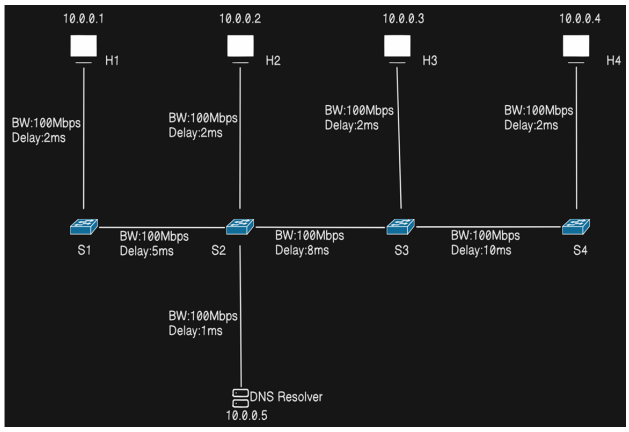
Task: DNS Query Resolution

Setup

To Setup the assignment, we have used the **Mininet-VM** on Oracle VirtualBox. The setup was done by following instructions from this page. Then, we SSHed into the VM from our host system to write code and run commands.
Remember to run the following command to bring up Internet connection in the VM.

```
sudo dhclient eth1
```

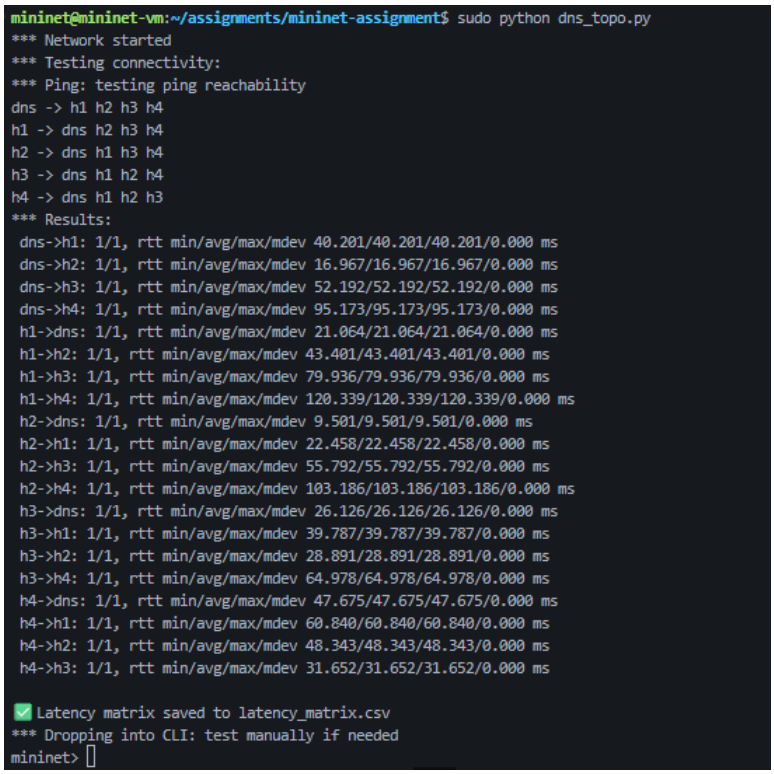
A. Simulate the below given topology in Mininet and demonstrate successful connectivity among all nodes. (20 Points)



The following script (`dns_topo.py`) was used to create and check the connections for the given topology.

```
from mininet.topo import Topo
from mininet.net import Mininet
from mininet.node import OVSController
from mininet.link import TCLink
from mininet.cli import CLI
import csv

class DNSTopo(Topo):
    def build(self):
```

```
        # Hosts
        h1 = self.addHost('h1', ip='10.0.0.1/24')
        h2 = self.addHost('h2', ip='10.0.0.2/24')
        h3 = self.addHost('h3', ip='10.0.0.3/24')
        h4 = self.addHost('h4', ip='10.0.0.4/24')
        dns = self.addHost('dns', ip='10.0.0.5/24')

        # Switches
        s1 = self.addSwitch('s1')
        s2 = self.addSwitch('s2')
        s3 = self.addSwitch('s3')
        s4 = self.addSwitch('s4')

        # Host-Switch links
        self.addLink(h1, s1, bw=100, delay='2ms')
        self.addLink(h2, s2, bw=100, delay='2ms')
        self.addLink(h3, s3, bw=100, delay='2ms')
        self.addLink(h4, s4, bw=100, delay='2ms')

        # Switch-Switch links (core network)
        self.addLink(s1, s2, bw=100, delay='5ms')
        self.addLink(s2, s3, bw=100, delay='8ms')
        self.addLink(s3, s4, bw=100, delay='10ms')

        # DNS resolver link
        self.addLink(s2, dns, bw=100, delay='1ms')

def log_latencies(net):
    """Ping all host pairs and save results to CSV."""
    hosts = net.hosts
    csv_file = "latency_matrix.csv"

    with open(csv_file, 'w', newline='') as f:
        writer = csv.writer(f)
        # Header row
        header = ["Source/Destination"] + [h.name for h in hosts]
        writer.writerow(header)

        for src in hosts:
            row = [src.name]
            for dst in hosts:
                if src == dst:
                    row.append("-")  # no self-latency
                    continue
                # Ping once and extract average latency
                latency = src.cmd(f'ping -c 1 {dst.IP()} | tail -1 | cut -d"/" -f5').strip()
                row.append(latency if latency else "timeout")
            writer.writerow(row)

    print(f"\n✅ Latency matrix saved to {csv_file}")

if __name__ == '__main__':
    net = Mininet(topo=DNSTopo(), controller=OVSController, link=TCLink)
    # nat = net.addNAT(name='nat0', connect='s2', ip='10.0.0.254/24').configDefault()
    net.start()
    print("*** Network started")
    print("*** Testing connectivity:")
    net.pingFull()
    log_latencies(net)
    print("*** Dropping into CLI: test manually if needed")
    CLI(net)
    net.stop()
```



This uses `pingFull` to display all the connection metrics as well. By running it with `sudo` we get:

We also get access to the mininet CLI from here, which can be used to check individual connections and run scripts on specific hosts. You can type `exit` to close the topology and CLI.

The latency matrix is as follows:

Source/Destination	dns	h1	h2	h3	h4
dns	—	17.653	6.992	23.770	46.273
h1	17.848	—	20.470	38.208	62.031
h2	7.590	19.783	—	29.870	48.204
h3	24.067	36.649	26.144	—	29.150
h4	46.017	56.523	50.763	30.902	—

To run commands from a specific node of the network, we can use the following syntax:

```
<node to execute command from> <command>
```

example:

```
h1 ping -c 2 dns
```

This pings the DNS node from H1 node for 2 packets.

B. In the simulated topology, use the default host resolver to resolve the URLs specified in each host's respective PCAP file, and record for each host the average lookup latency, average throughput, number of successfully resolved queries, and number of failed resolutions. (10 Points)

We first extracted the DNS queries from the respective PCAP files (stored in /pcap) to get the URLs to be resolved, using the command:

```
tshark -r pcap/PCAP_3_H3.pcap -Y "dns && udp.port == 53" -T fields -e dns.qry.name > pcap/h3_domains.txt
```

Breakdown of the command:

Part	Description

Part	Description
tshark	Command-line version of Wireshark used for analyzing packet capture (PCAP) files.
-r pcap/PCAP_3_H3.pcap	Reads packets from the specified PCAP file corresponding to Host H3.
-Y "dns && udp.port == 53"	Display filter ensuring that only DNS packets (port 53) are processed, filtering out non-DNS traffic like LLMNR or mDNS.
-T fields	Specifies that only selected fields (not full packet details) should be printed.
-e dns.qry.name	Extracts the domain name field from each DNS query packet.
> pcap/h3_domains.txt	Redirects the extracted domain names into a text file for further processing.

This was repeated for all the pcap files, to get `h1_domains.txt`, `h2_domains.txt`, `h3_domains.txt` and `h4_domains.txt`.

Then, we used this script (`reolve_default.py`) to resolve the URLs using socket's `gethostbyname()`. The VM must be connected to the Internet through the Host, by using a NAT Adapter. We set the nameserver to Google's DNS (`8.8.8.8`) using `h1 python -c "open('/etc/resolv.conf','w').write('nameserver 8.8.8.8\n')"`.

> We used Google DNS since we couldnt figure out a way to connect to the VM's default host resolver. The Mininet VM used systemd-resolved with a local stub (127.0.0.53) and upstream DNS (10.0.2.3). However, since 10.0.2.3 is part of the VM's internal NAT network and unreachable from the Mininet virtual network (10.0.0.0/24), it could not be used directly by the Mininet hosts. Instead, a public DNS (8.8.8.8) was configured in each Mininet host's /etc/resolv.conf to ensure external DNS resolution via the NAT gateway.

The script can be run on each host as such:

```
h1 python resolve_default.py H1
```

where you can replace h1/H1 with h2/H2, h3/H3 and h4/H4 respectively.

The detailed records for each Host can be found in `results/H1_default_results.csv`, `results/H2_default_results.csv`, `results/H3_default_results.csv` and `results/H4_default_results.csv` respectively. The summary of all the records can be found in `results/default_summmary.csv`. Also given below is the summary:

Host	Total Queries	Success	Failed	Avg Latency (ms)	Throughput (qps)
H1	100	71	29	166.42	6.01
H2	100	68	32	110.20	9.07
H3	100	72	28	131.48	7.6
H4	100	73	27	120.46	8.3

It should be noted that the latencies and throughput depend on that particular instants system performance (memory usage etc), since the VM's performace is impacted heavily sometimes.

C. Modify the DNS configuration of all Mininet hosts to use your custom resolver as the primary DNS server instead of the default system resolver. Show all the steps along with relevant screenshots. (10 Points)

To modify the DNS configuration of all hosts from `h1 → default system resolver → external DNS servers` to `h1 → 10.0.0.5 (custom resolver) → external servers (Google/Root/etc.)`:

1. Start the topology:

```
sudo python dns_topo.py
```

2. Inside the mininet CLI, we can verify the nodes and their IP addresses using: `<node> ifconfig`.
3. We start running the custom DNS resolver we built in the previous assignment, using

```
dns python custom_dns.py &
```

(The '&' runs it in the background. To check, you can run `dns ps`)

4. Now, we will configure the hosts to use our custom DNS server:

```
h1 python -c "open('/etc/resolv.conf','w').write('nameserver 10.0.0.5\n')"
```

This will set the nameserver to `10.0.0.5`, which all hosts can now use.

We can check for the changes using `cat` command to open the file.

```
mininet> h4 python -c "open('/etc/resolv.conf','w').write('nameserver 10.0.0.5\n')"
mininet> h1 cat /etc/resolv.conf
nameserver 10.0.0.5
```

D. Repeat DNS resolution for the given PCAPs as done in part B, this time using your custom DNS resolver (10.0.0.5). Compare the results with those obtained in part B. Additionally, log the following in the custom DNS resolver:

- **Timestamp**
- **Domain name queried**
- **Resolution mode**
- **DNS server IP contacted**
- **Step of resolution (Root / TLD / Authoritative / Cache (if caching implemented))**
- **Response or referral received**
- **Round-trip time to that server**
- **Total time to resolution**
- **Cache status (HIT / MISS) (if caching implemented)**

For PCAP_1_H1, present graphical plots for the first 10 URLs, showing the total number of DNS servers visited and latency per query.

The Pure Iterative DNS Resolver can be found in `custom_dns.py`

To let the Mininet nodes access the internet: Enable IP forwarding on the VM

```
sudo sysctl -w net.ipv4.ip_forward=1
```

And, uncomment the line `nat = net.addNAT(name='nat0', connect='s2', ip='10.0.0.254/24').configDefault()` in `dns_topo.py`. This connects nat0 to the Mininet topology (via s2) and to the VM's external interface (eth1), providing Internet access.

To test DNS resolution:

```
h1 dig example.com
```

The resolver logs can be found in `results_custom` folder in `steps` and `summary` log files. (`H1_steps.csv`, `H1_summary.csv`, etc.)

resolver_detailed_steps.csv

```
timestamp,domain,resolution_mode,dns_server_ip,step,response_type,rtt_ms,total_time_ms,cache_status
2025-10-28 09:11:35,tuhafhaberler.com,iterative,198.41.0.4,ROOT,REFERRAL,172.14,-,N/A
2025-10-28 09:11:35,tuhafhaberler.com,iterative,192.41.162.30,TLD/AUTHORITATIVE,REFERRAL,161.69,-,N/A
2025-10-28 09:11:35,tuhafhaberler.com,iterative,192.48.79.30,TLD/AUTHORITATIVE,REFERRAL,155.67,-,N/A
2025-10-28 09:11:35,tuhafhaberler.com,iterative,192.54.112.30,TLD/AUTHORITATIVE,NO_RESPONSE,timeout,-,N/A
2025-10-28 09:11:35,tuhafhaberler.com,iterative,192.31.80.30,TLD/AUTHORITATIVE,NO_RESPONSE,timeout,-,N/A
2025-10-28 09:11:35,tuhafhaberler.com,iterative,192.33.14.30,TLD/AUTHORITATIVE,REFERRAL,270.17,-,N/A
2025-10-28 09:11:35,tuhafhaberler.com,iterative,192.35.51.30,TLD/AUTHORITATIVE,REFERRAL,169.46,-,N/A
2025-10-28 09:11:35,tuhafhaberler.com,iterative,170.247.170.2,ROOT,REFERRAL,268.79,-,N/A
2025-10-28 09:11:35,tuhafhaberler.com,iterative,192.5.6.30,TLD/AUTHORITATIVE,REFERRAL,49.93,-,N/A
2025-10-28 09:11:35,tuhafhaberler.com,iterative,192.26.92.30,TLD/AUTHORITATIVE,REFERRAL,173.21,-,N/A
```

We can also have some random/leaky DNS queries from internal applications, as shown below:

resolver_summary.csv

```
timestamp,client,domain,result_ip,total_time_ms
2025-10-28 08:39:48,10.0.0.1,example.com,23.192.228.80,1228.38
2025-10-28 08:40:17,10.0.0.254,default.exp-tas.com,FAIL,21374.71
2025-10-28 08:40:39,10.0.0.254,westus-0.in.applicationinsights.azure.com,FAIL,21856.45
```

Now, you can use the following command to resolve the URLs form the PCAPs (Repeat Part B):

```
h1 python resolve_custom.py H1
```

where you can replace h1/H1 with h2/H2, h3/H3 and h4/H4 respectively.

Then, you can see the logs live in the `csv` files mentioned above.

resolver_detailed_steps.csv

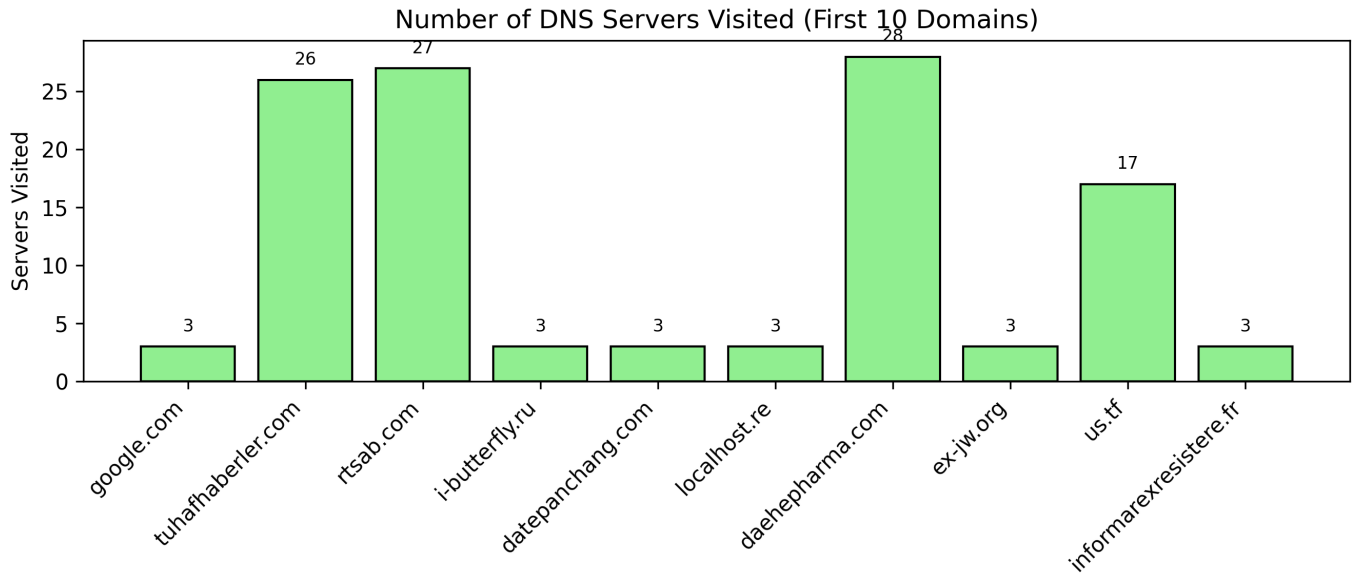
```
2025-10-28 10:10:17,probigbets.com,iterative,192.43.172.30,TLD/AUTHORITATIVE,REFERRAL,171.28,-,N/A
2025-10-28 10:10:17,probigbets.com,iterative,199.7.91.13,ROOT,REFERRAL,44.79,-,N/A
2025-10-28 10:10:17,probigbets.com,iterative,192.203.230.10,ROOT,REFERRAL,45.04,-,N/A
2025-10-28 10:10:17,probigbets.com,iterative,192.5.5.241,ROOT,NO_RESPONSE,timeout,-,N/A
2025-10-28 10:10:17,probigbets.com,iterative,192.112.36.4,ROOT,REFERRAL,162.09,-,N/A
2025-10-28 10:10:17,probigbets.com,iterative,198.97.190.53,ROOT,REFERRAL,297.16,-,N/A
2025-10-28 10:10:17,probigbets.com,iterative,192.36.148.17,ROOT,REFERRAL,31.51,-,N/A
2025-10-28 10:10:17,probigbets.com,iterative,192.58.128.30,ROOT,NO_RESPONSE,timeout,-,N/A
2025-10-28 10:10:17,probigbets.com,iterative,193.0.14.129,ROOT,REFERRAL,53.06,-,N/A
2025-10-28 10:10:17,probigbets.com,iterative,199.7.83.42,ROOT,NO_RESPONSE,timeout,-,N/A
2025-10-28 10:10:17,probigbets.com,iterative,202.12.27.33,ROOT,REFERRAL,173.31,-,N/A
2025-10-28 10:10:39,bikesandtransit.com,iterative,198.41.0.4,ROOT,REFERRAL,154.28,-,N/A
2025-10-28 10:10:39,bikesandtransit.com,iterative,192.41.162.30,TLD/AUTHORITATIVE,REFERRAL,152.45,-,N/A
2025-10-28 10:10:39,bikesandtransit.com,iterative,198.181.116.9,TLD/AUTHORITATIVE,ANSWER,43.86,351.24,N/A
2025-10-28 10:10:39,aqvr.com,iterative,198.41.0.4,ROOT,REFERRAL,165.45,-,N/A
2025-10-28 10:10:39,aqvr.com,iterative,192.41.162.30,TLD/AUTHORITATIVE,REFERRAL,150.78,-,N/A
2025-10-28 10:10:39,aqvr.com,iterative,89.117.23.47,TLD/AUTHORITATIVE,ANSWER,294.89,611.66,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,198.41.0.4,ROOT,REFERRAL,168.57,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,193.232.128.6,TLD/AUTHORITATIVE,REFERRAL,218.01,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,194.190.124.17,TLD/AUTHORITATIVE,REFERRAL,272.21,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,193.232.156.17,TLD/AUTHORITATIVE,REFERRAL,309.24,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,194.85.252.62,TLD/AUTHORITATIVE,REFERRAL,219.47,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,193.232.142.17,TLD/AUTHORITATIVE,REFERRAL,185.06,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,170.247.170.2,ROOT,REFERRAL,266.84,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,192.33.4.12,ROOT,REFERRAL,97.71,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,199.7.91.13,ROOT,REFERRAL,42.59,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,192.203.230.10,ROOT,REFERRAL,53.48,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,192.5.5.241,ROOT,NO_RESPONSE,timeout,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,192.112.36.4,ROOT,REFERRAL,148.43,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,198.97.190.53,ROOT,REFERRAL,297.88,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,192.36.148.17,ROOT,REFERRAL,36.53,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,192.58.128.30,ROOT,NO_RESPONSE,timeout,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,193.0.14.129,ROOT,REFERRAL,75.63,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,199.7.83.42,ROOT,NO_RESPONSE,timeout,-,N/A
2025-10-28 10:10:40,niceinternetmoney.ru,iterative,202.12.27.33,ROOT,REFERRAL,169.70,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,198.41.0.4,ROOT,REFERRAL,157.61,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.41.162.30,TLD/AUTHORITATIVE,REFERRAL,151.41,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.48.79.30,TLD/AUTHORITATIVE,REFERRAL,147.92,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.54.112.30,TLD/AUTHORITATIVE,NO_RESPONSE,timeout,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.31.80.30,TLD/AUTHORITATIVE,NO_RESPONSE,timeout,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.33.14.30,TLD/AUTHORITATIVE,REFERRAL,272.96,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.35.51.30,TLD/AUTHORITATIVE,REFERRAL,175.31,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,170.247.170.2,ROOT,REFERRAL,268.77,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.5.6.30,TLD/AUTHORITATIVE,REFERRAL,136.26,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.26.92.30,TLD/AUTHORITATIVE,REFERRAL,173.24,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.12.94.30,TLD/AUTHORITATIVE,REFERRAL,175.82,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.42.93.30,TLD/AUTHORITATIVE,NO_RESPONSE,timeout,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.33.4.12,ROOT,REFERRAL,87.82,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.55.83.30,TLD/AUTHORITATIVE,REFERRAL,149.10,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.52.178.30,TLD/AUTHORITATIVE,REFERRAL,168.35,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.43.172.30,TLD/AUTHORITATIVE,REFERRAL,174.89,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,199.7.91.13,ROOT,REFERRAL,42.48,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.203.230.10,ROOT,REFERRAL,47.35,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.5.5.241,ROOT,NO_RESPONSE,timeout,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.112.36.4,ROOT,REFERRAL,152.33,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,198.97.190.53,ROOT,REFERRAL,317.84,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.36.148.17,ROOT,REFERRAL,47.82,-,N/A
2025-10-28 10:10:51,chonvn.com,iterative,192.58.128.30,ROOT,NO_RESPONSE,timeout,-,N/A
```

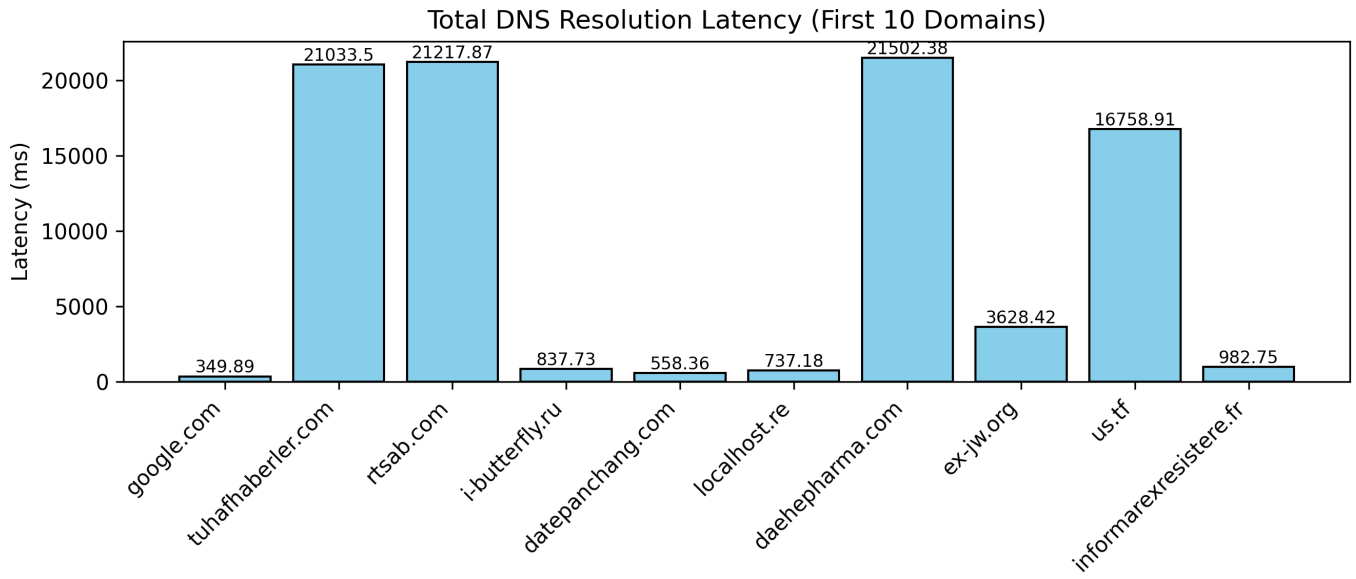
resolver_summary.csv

```
2025-10-28 10:05:24,10.0.0.1,ex-jw.org,185.230.63.107,3628.42
2025-10-28 10:05:28,10.0.0.1,us.tf,FAIL,16758.91
2025-10-28 10:05:45,10.0.0.1,informarexresistere.fr,178.32.143.165,982.75
2025-10-28 10:05:46,10.0.0.1,running-sigi.de,FAIL,11481.85
2025-10-28 10:05:57,10.0.0.1,buynowfromusa.com,35.223.118.1,442.46
2025-10-28 10:05:58,10.0.0.1,pbprofile.com,FAIL,23950.77
2025-10-28 10:06:22,10.0.0.1,fini.net,198.57.192.137,602.66
2025-10-28 10:06:22,10.0.0.1,globalpoliticalspectrum.com,FAIL,21056.41
2025-10-28 10:06:43,10.0.0.1,41latitude.com,FAIL,21196.87
2025-10-28 10:07:04,10.0.0.1,zzxu.cn,FAIL,15935.90
2025-10-28 10:07:20,10.0.0.1,energybulbs.co.uk,23.227.38.32,1002.38
2025-10-28 10:07:21,10.0.0.1,o-ov.com,FAIL,24339.12
2025-10-28 10:07:46,10.0.0.1,lozo.com,107.21.144.47,352.33
2025-10-28 10:07:46,10.0.0.1,tottenhamhk.com,FAIL,21075.97
2025-10-28 10:08:07,10.0.0.1,newstetic.com,172.67.131.89,348.12
2025-10-28 10:08:08,10.0.0.1,triggerfish.se,162.159.135.42,520.60
2025-10-28 10:08:08,10.0.0.1,reprosystems.ru,172.67.167.102,943.13
2025-10-28 10:08:09,10.0.0.1,interfloracentral.co.uk,217.69.32.44,994.56
2025-10-28 10:08:10,10.0.0.1,afairjudgement.com,172.67.178.132,354.11
2025-10-28 10:08:10,10.0.0.1,owlcreek.com,205.178.189.129,360.78
2025-10-28 10:08:11,10.0.0.1,radioterminal.ru,188.225.40.161,575.96
2025-10-28 10:08:11,10.0.0.1,junio.com,209.196.144.25,636.57
2025-10-28 10:08:12,10.0.0.1,ditrblog.com,FAIL,21098.57
2025-10-28 10:08:33,10.0.0.1,alchemedialtd.com,68.66.224.29,346.28
2025-10-28 10:08:33,10.0.0.1,portclydegeneralstore.com,198.185.159.144,496.40
2025-10-28 10:08:34,10.0.0.1,alenpuaca.com,67.205.28.253,614.07
2025-10-28 10:08:34,10.0.0.1,dj-producer-j-mbargo.com,FAIL,21103.39
2025-10-28 10:08:56,10.0.0.1,iag-inc.com,103.224.182.253,10155.68
2025-10-28 10:09:06,10.0.0.1,advertos.ru,45.92.176.75,1360.55
2025-10-28 10:09:07,10.0.0.1,kh.ua,195.69.185.211,421.50
2025-10-28 10:09:08,10.0.0.1,kennethehartman.com,192.0.78.25,392.64
2025-10-28 10:09:08,10.0.0.1,hemcolubricants.com,194.9.94.85,1010.26
2025-10-28 10:09:09,10.0.0.1,forpsi.net,85.255.6.237,496.67
2025-10-28 10:09:09,10.0.0.1,memeblender.com,104.21.7.158,396.94
2025-10-28 10:09:10,10.0.0.1,somode.com,FAIL,21151.60
2025-10-28 10:09:31,10.0.0.1,gamemob.com,3.33.130.190,491.90
2025-10-28 10:09:31,10.0.0.1,monsterhomesecuritystore.com,FAIL,21300.61
2025-10-28 10:09:53,10.0.0.1,door2games.com,160.153.0.43,877.21
2025-10-28 10:09:54,10.0.0.1,ondemandappliancerepair.com,74.208.236.102,617.81
2025-10-28 10:09:54,10.0.0.1,gensee.com,211.150.89.25,633.95
2025-10-28 10:09:55,10.0.0.1,caricsports.com,104.21.51.12,447.28
2025-10-28 10:09:55,10.0.0.1,auqzzx.com,FAIL,21248.38
2025-10-28 10:10:17,10.0.0.1,toaskfuture.com,119.18.54.195,365.80
2025-10-28 10:10:17,10.0.0.1,cetsi.fr,91.151.64.24,505.34
2025-10-28 10:10:17,10.0.0.1,probigbets.com,FAIL,21119.44
2025-10-28 10:10:39,10.0.0.1,bikesandtransit.com,192.0.78.25,351.24
2025-10-28 10:10:39,10.0.0.1,aqvr.com,89.117.19.57,611.66
2025-10-28 10:10:40,10.0.0.1,niceinternetmoney.ru,FAIL,11574.82
2025-10-28 10:10:51,10.0.0.1,chonvn.com,FAIL,21147.91
2025-10-28 10:11:12,10.0.0.1,eugenbotnar.com,FAIL,21328.91
2025-10-28 10:11:34,10.0.0.1,phi-pe.com,FAIL,21422.88
```

Plots for H1 (first 10 URLs)

Pure Iterative Server





F. Implement caching within your custom DNS resolver. Store recently resolved domain-to-IP mappings and serve repeated queries directly from cache without contacting external servers. Record the average lookup latency, average throughput, number of successfully resolved queries, % of queries resolved from cache and number of failed resolutions. (2.5 Points)

The DNS Resolver with Caching can be found in `custom_dns_cache.py`

You can see the detailed logs and overall metrics, for Custom DNS Resolver with Cache, in the folder `results_custom_cache`.

Steps with Cache Status

resolver_detailed_steps.csv

```
timestamp,domain,resolution_mode,dns_server_ip,step,response_type,rtt_ms,total_time_ms,cache_status
2025-10-28 11:02:14,tuhafhaberler.com,iterative,198.41.0.4,ROOT,REFERRAL,174.09,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.41.162.30,TLD/AUTH,REFERRAL,157.00,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.48.79.30,TLD/AUTH,REFERRAL,177.10,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.54.112.30,TLD/AUTH,NO_RESPONSE,timeout,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.31.80.30,TLD/AUTH,NO_RESPONSE,timeout,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.33.14.30,TLD/AUTH,REFERRAL,279.16,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.35.51.30,TLD/AUTH,REFERRAL,174.64,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,170.247.170.2,ROOT,REFERRAL,276.28,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.5.6.30,TLD/AUTH,REFERRAL,146.81,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.26.92.30,TLD/AUTH,REFERRAL,181.59,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.12.94.30,TLD/AUTH,REFERRAL,177.66,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.42.93.30,TLD/AUTH,NO_RESPONSE,timeout,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.33.4.12,ROOT,REFERRAL,93.50,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.55.83.30,TLD/AUTH,REFERRAL,175.07,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.52.178.30,TLD/AUTH,REFERRAL,153.75,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.43.172.30,TLD/AUTH,REFERRAL,177.96,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,199.7.91.13,ROOT,REFERRAL,57.25,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.203.230.10,ROOT,REFERRAL,57.90,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.5.5.241,ROOT,NO_RESPONSE,timeout,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.112.36.4,ROOT,REFERRAL,168.52,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,198.97.190.53,ROOT,REFERRAL,311.99,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.36.148.17,ROOT,REFERRAL,47.45,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,192.58.128.30,ROOT,NO_RESPONSE,timeout,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,193.0.14.129,ROOT,REFERRAL,63.53,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,199.7.83.42,ROOT,NO_RESPONSE,timeout,-,MISS
2025-10-28 11:02:14,tuhafhaberler.com,iterative,202.12.27.33,ROOT,REFERRAL,173.42,-,MISS
2025-10-28 11:02:35,rtsab.com,iterative,198.41.0.4,ROOT,REFERRAL,166.35,-,MISS
```