CN: Assignment 2

Team Details:

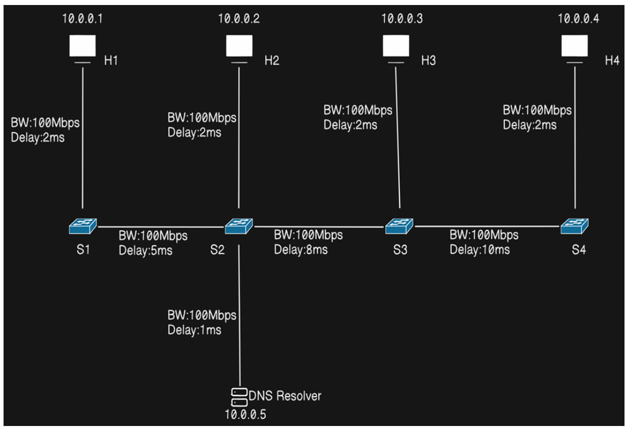
Name	Roll Number
Romit Mohane	23110279
Bhavya Parmar	-

Task: DNS Query Resolution

Setup

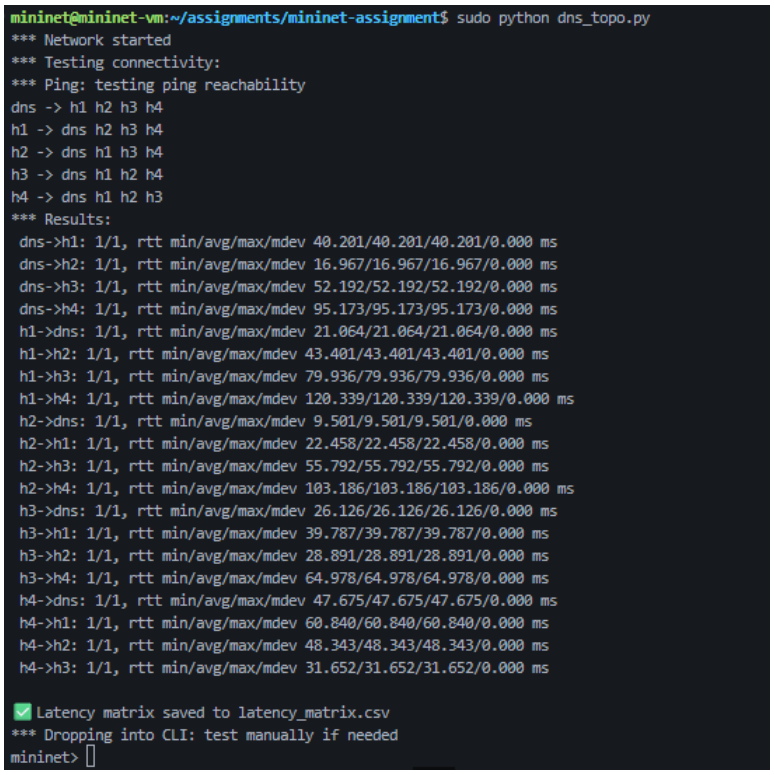
To Setup the assignment, we have used the **Mininet-VM** on Oracle VirtualBox. The setup was done by following instructions from this page. Then, we SSHed into the VM from our host system to write code and run commands.

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.

```python
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)
    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()
```



```
mininet@mininet-vm:~/assignments/mininet-assignment$ sudo python dns_topo.py
*** Network started
*** Testing connectivity:
*** Ping: testing ping reachability
dns -> h1 h2 h3 h4
h1 -> dns h2 h3 h4
h2 -> dns h1 h3 h4
h3 -> dns h1 h2 h4
h4 -> dns h1 h2 h3
*** Results:
 dns->h1: 1/1, rtt min/avg/max/mdev 40.201/40.201/40.201/0.000 ms
 dns->h2: 1/1, rtt min/avg/max/mdev 16.967/16.967/16.967/0.000 ms
 dns->h3: 1/1, rtt min/avg/max/mdev 52.192/52.192/52.192/0.000 ms
 dns->h4: 1/1, rtt min/avg/max/mdev 95.173/95.173/95.173/0.000 ms
 h1->dns: 1/1, rtt min/avg/max/mdev 21.064/21.064/21.064/0.000 ms
 h1->h2: 1/1, rtt min/avg/max/mdev 43.401/43.401/43.401/0.000 ms
 h1->h3: 1/1, rtt min/avg/max/mdev 79.936/79.936/79.936/0.000 ms
 h1->h4: 1/1, rtt min/avg/max/mdev 120.339/120.339/120.339/0.000 ms
 h2->dns: 1/1, rtt min/avg/max/mdev 9.501/9.501/9.501/0.000 ms
 h2->h1: 1/1, rtt min/avg/max/mdev 22.458/22.458/22.458/0.000 ms
 h2->h3: 1/1, rtt min/avg/max/mdev 55.792/55.792/55.792/0.000 ms
 h2->h4: 1/1, rtt min/avg/max/mdev 103.186/103.186/103.186/0.000 ms
 h3->dns: 1/1, rtt min/avg/max/mdev 26.126/26.126/26.126/0.000 ms
 h3->h1: 1/1, rtt min/avg/max/mdev 39.787/39.787/39.787/0.000 ms
 h3->h2: 1/1, rtt min/avg/max/mdev 28.891/28.891/28.891/0.000 ms
 h3->h4: 1/1, rtt min/avg/max/mdev 64.978/64.978/64.978/0.000 ms
 h4->dns: 1/1, rtt min/avg/max/mdev 47.675/47.675/47.675/0.000 ms
 h4->h1: 1/1, rtt min/avg/max/mdev 60.840/60.840/60.840/0.000 ms
 h4->h2: 1/1, rtt min/avg/max/mdev 48.343/48.343/48.343/0.000 ms
 h4->h3: 1/1, rtt min/avg/max/mdev 31.652/31.652/31.652/0.000 ms

✅ Latency matrix saved to latency_matrix.csv
*** Dropping into CLI: test manually if needed
mininet> 
```

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_1_H1.pcap -Y "dns.qry.name" -T fields -e dns.qry.name > h1_domains.txt
```

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 sockets. The VM must be connected to the Internet through the Host, by using a NAT Adapter.

```
import socket
import time
import csv

def resolve_domains(host_name, domain_file):
    results = []
    total_time = 0
    success = 0
    fail = 0

    with open(domain_file, 'r') as f:
        domains = [line.strip() for line in f if line.strip()]

    start_all = time.time()

    for domain in domains:
        start = time.time()
        try:
            socket.gethostbyname(domain)
            latency = (time.time() - start) * 1000  # ms
            results.append((domain, "SUCCESS", round(latency, 2)))
            success += 1
        except Exception:
            latency = (time.time() - start) * 1000
            results.append((domain, "FAIL", round(latency, 2)))
            fail += 1
        total_time += latency

    total_queries = len(domains)
    avg_latency = total_time / total_queries if total_queries else 0
    throughput = total_queries / (time.time() - start_all)

    # Save per-domain results
    csv_file = f"results/{host_name}_default_results.csv"
    with open(csv_file, 'w', newline='') as f:
        writer = csv.writer(f)
        writer.writerow(["Domain", "Status", "Latency (ms)"])
        writer.writerows(results)

    # Summary
    print(f"\n--- {host_name} ---")
    print(f"Queries: {total_queries}")
    print(f"Success: {success}")
    print(f"Failed: {fail}")
    print(f"Average latency: {avg_latency:.2f} ms")
    print(f"Throughput: {throughput:.2f} queries/sec")

    return {
        "host": host_name,
        "queries": total_queries,
        "success": success,
        "fail": fail,
        "avg_latency": avg_latency,
        "throughput": throughput
    }

if __name__ == "__main__":
    import os
    os.makedirs("results", exist_ok=True)

    hosts = {
        "H1": "pcap/h1_domains.txt",
        "H2": "pcap/h2_domains.txt",
        "H3": "pcap/h3_domains.txt",
        "H4": "pcap/h4_domains.txt"
    }

    summary = []
    for host, file in hosts.items():
        summary.append(resolve_domains(host, file))

    # Write overall summary
    with open("results/default_summary.csv", 'w', newline='') as f:
        writer = csv.writer(f)
        writer.writerow(["Host", "Total Queries", "Success", "Failed", "Avg Latency (ms)", "Throughput (qps)"])
        for row in summary:
            writer.writerow(row.values())
```

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	162	71	91	22.542311821454838	44.34783126295888
H2	162	66	96	4.336991427857199	230.22739502956463
H3	162	72	90	6.3273376888699	157.88486403903687
H4	162	73	89	1.626307581677849	612.7997344896502