Socket Programming Project 1 - Introduction to Network Programming

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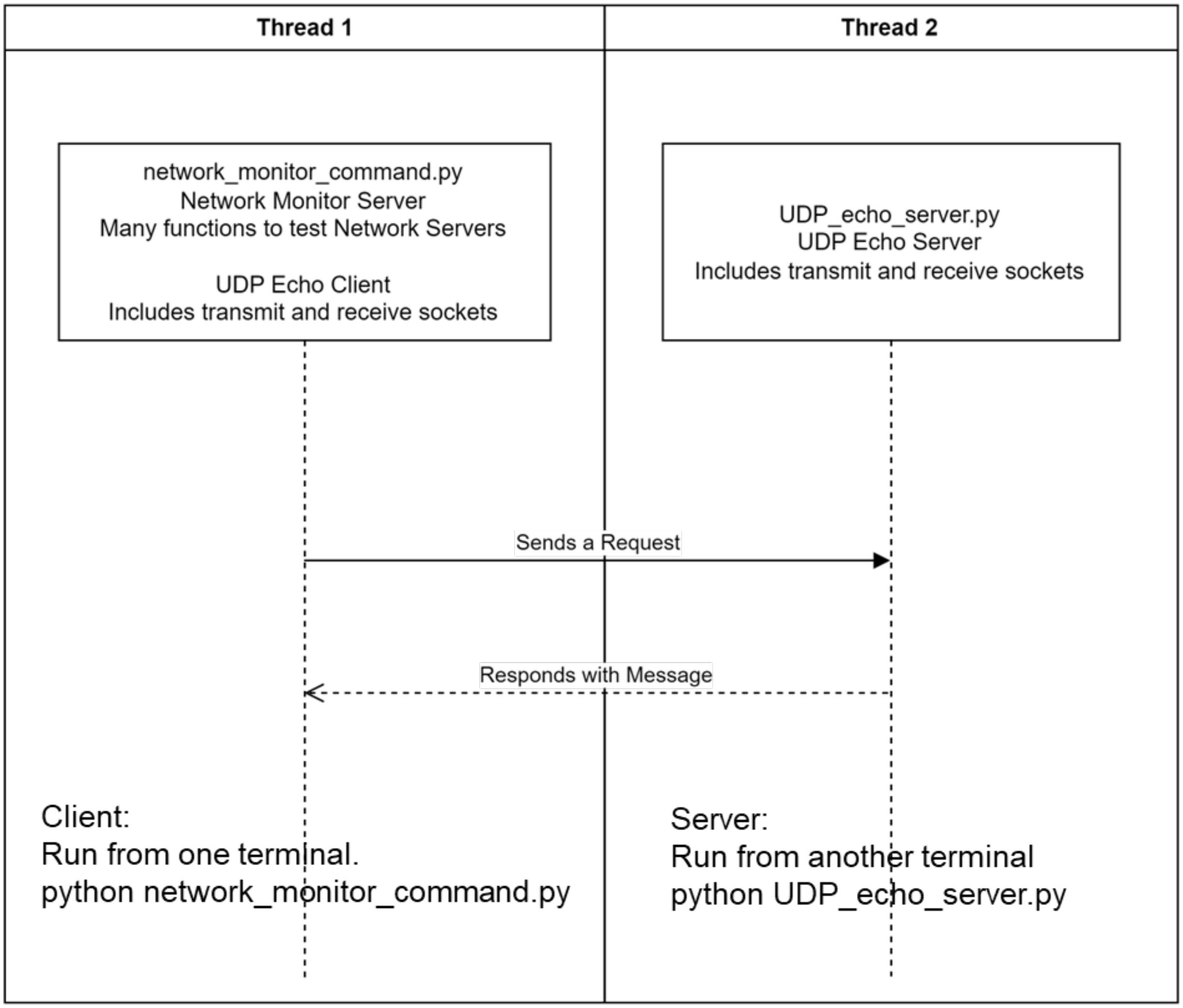
App 1 Network Monitor

1. Network Monitoring Application

How to run Network Monitoring Server and UDP Echo Server

Figure 1 UML Block Diagram of Client - Server Processes and How to Run Apps


Thread 1
Thread 2
network_monitor_command.py
Network Monitor Server
Many functions to test Network Servers
UDP Echo Client
Includes transmit and receive sockets
UDP_echo_server.py
UDP Echo Server
Includes transmit and receive sockets
Sends a Request
Responds with Message
Client:
Run from one terminal.
python network_monitor_command.py
Server:
Run from another terminal
python UDP_echo_server.py

See README.pdf or README.docx file in Sock-Programming_Project_1 directory. The UDP Echo Server will always be on. The Network Monitoring Server will send request messages to the UDP Echo Server to check that it is still working.

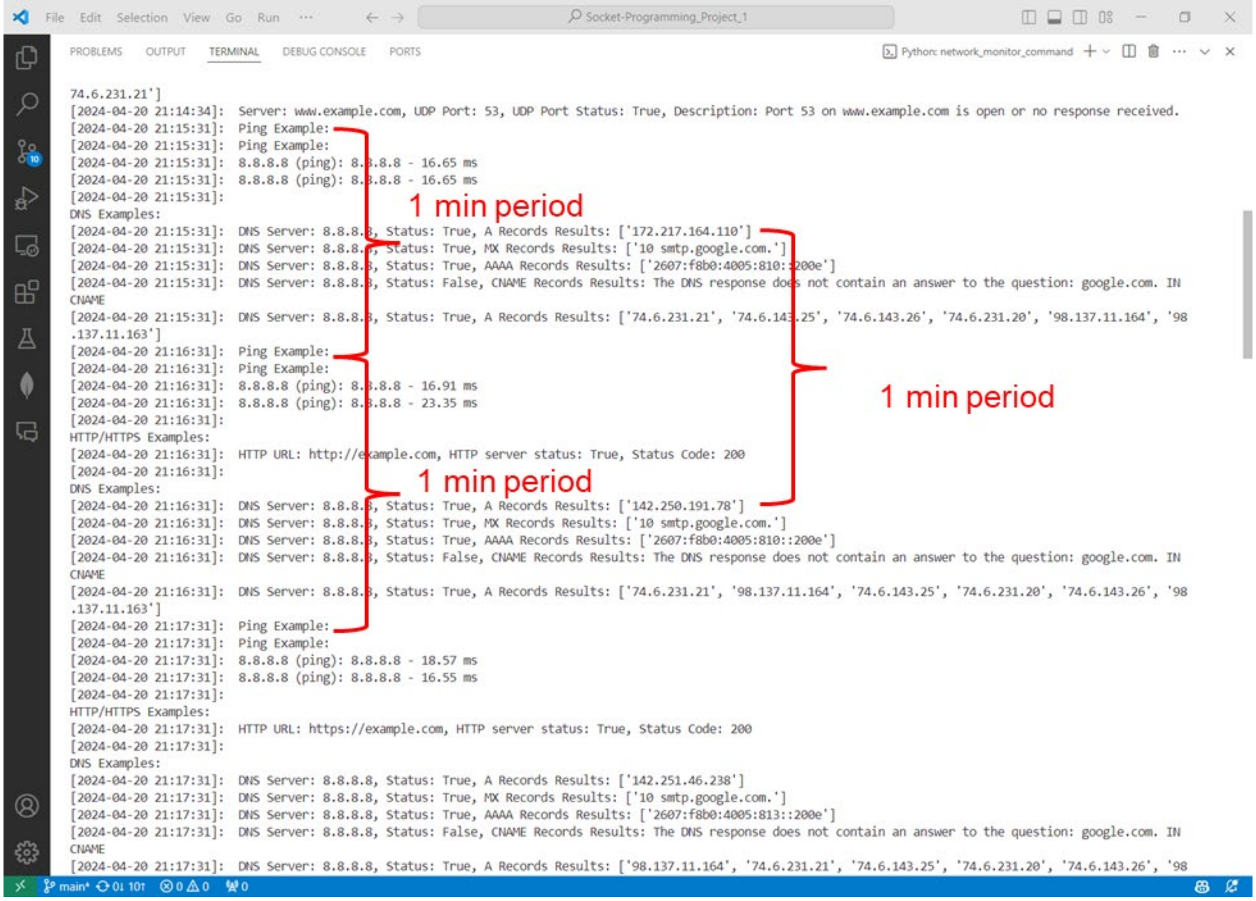
The commands to run the apps in their own terminal are

```
python network_monitor_command.py
```

python UDP_echo_server.py

1. Create an application that uses the configuration information in Requirement 2 to automatically check the status of servers and services.

Figure 2 Output of Network Monitoring Server. One Minute Timing Intervals for Servers and Services



```
74.6.231.21']
[2024-04-20 21:14:34]:  Server: www.example.com, UDP Port: 53, UDP Port Status: True, Description: Port 53 on www.example.com is open or no response received.
[2024-04-20 21:15:31]:  Ping Example:
[2024-04-20 21:15:31]:  Ping Example:
[2024-04-20 21:15:31]:  8.8.8.8 (ping): 8.8.8.8 - 16.65 ms
[2024-04-20 21:15:31]:  8.8.8.8 (ping): 8.8.8.8 - 16.65 ms
[2024-04-20 21:15:31]:
DNS Examples:
[2024-04-20 21:15:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['172.217.164.110']
[2024-04-20 21:15:31]:  DNS Server: 8.8.8.8, Status: True, MX Records Results: ['10 smtp.google.com.']
[2024-04-20 21:15:31]:  DNS Server: 8.8.8.8, Status: True, AAAA Records Results: ['2607:f8b0:4005:810::200e']
[2024-04-20 21:15:31]:  DNS Server: 8.8.8.8, Status: False, CNAME Records Results: The DNS response does not contain an answer to the question: google.com. IN
CNAME
[2024-04-20 21:15:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['74.6.231.21', '74.6.143.25', '74.6.143.26', '74.6.231.20', '98.137.11.164', '98
.137.11.163']
[2024-04-20 21:16:31]:  Ping Example:
[2024-04-20 21:16:31]:  Ping Example:
[2024-04-20 21:16:31]:  8.8.8.8 (ping): 8.8.8.8 - 16.91 ms
[2024-04-20 21:16:31]:  8.8.8.8 (ping): 8.8.8.8 - 23.35 ms
[2024-04-20 21:16:31]:
HTTP/HTTPS Examples:
[2024-04-20 21:16:31]:  HTTP URL: http://example.com, HTTP server status: True, Status Code: 200
[2024-04-20 21:16:31]:
DNS Examples:
[2024-04-20 21:16:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.250.191.78']
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[2024-04-20 21:16:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['74.6.231.21', '98.137.11.164', '74.6.143.25', '74.6.231.20', '74.6.143.26', '98
.137.11.163']
[2024-04-20 21:17:31]:  Ping Example:
[2024-04-20 21:17:31]:  Ping Example:
[2024-04-20 21:17:31]:  8.8.8.8 (ping): 8.8.8.8 - 18.57 ms
[2024-04-20 21:17:31]:  8.8.8.8 (ping): 8.8.8.8 - 16.55 ms
[2024-04-20 21:17:31]:
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[2024-04-20 21:17:31]:  HTTP URL: https://example.com, HTTP server status: True, Status Code: 200
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DNS Examples:
[2024-04-20 21:17:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.251.46.238']
[2024-04-20 21:17:31]:  DNS Server: 8.8.8.8, Status: True, MX Records Results: ['10 smtp.google.com.']
[2024-04-20 21:17:31]:  DNS Server: 8.8.8.8, Status: True, AAAA Records Results: ['2607:f8b0:4005:813::200e']
[2024-04-20 21:17:31]:  DNS Server: 8.8.8.8, Status: False, CNAME Records Results: The DNS response does not contain an answer to the question: google.com. IN
CNAME
[2024-04-20 21:17:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['98.137.11.164', '74.6.231.21', '74.6.143.25', '74.6.231.20', '74.6.143.26', '98
```
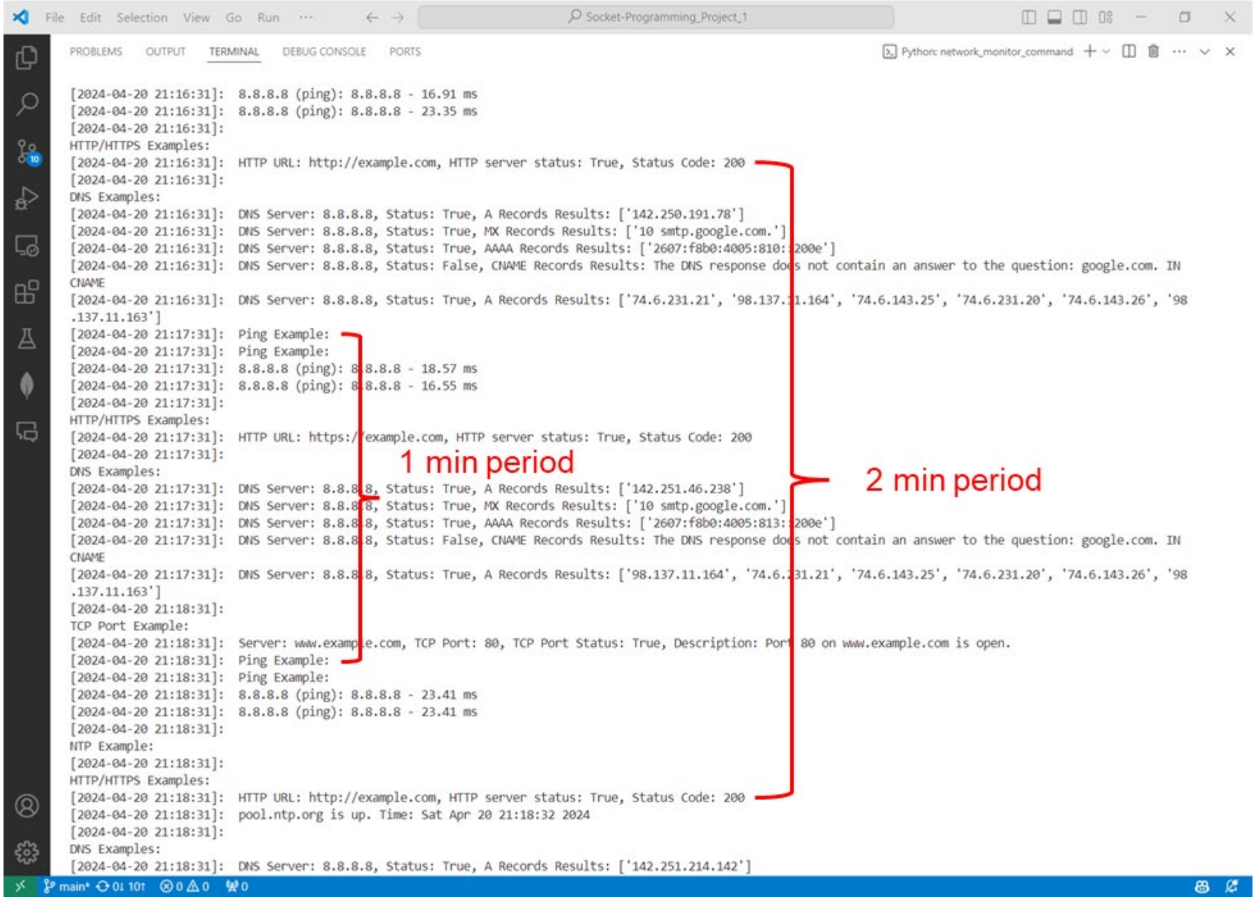

Figure 3 Output of Network Monitoring Server. One and Two Minute Timing Intervals for Servers and Services



```
[2024-04-20 21:16:31]:  8.8.8.8 (ping): 8.8.8.8 - 16.91 ms
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[2024-04-20 21:17:31]:  8.8.8.8 (ping): 8.8.8.8 - 18.57 ms
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[2024-04-20 21:18:31]:  Server: www.example.com, TCP Port: 80, TCP Port Status: True, Description: Port 80 on www.example.com is open.
[2024-04-20 21:18:31]:  Ping Example:
[2024-04-20 21:18:31]:  Ping Example:
[2024-04-20 21:18:31]:  8.8.8.8 (ping): 8.8.8.8 - 23.41 ms
[2024-04-20 21:18:31]:  8.8.8.8 (ping): 8.8.8.8 - 23.41 ms
[2024-04-20 21:18:31]:
NTP Example:
[2024-04-20 21:18:31]:
HTTP/HTTPS Examples:
[2024-04-20 21:18:31]:  HTTP URL: http://example.com, HTTP server status: True, Status Code: 200
[2024-04-20 21:18:31]:  pool.ntp.org is up. Time: Sat Apr 20 21:18:32 2024
[2024-04-20 21:18:31]:
DNS Examples:
[2024-04-20 21:18:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.251.214.142']
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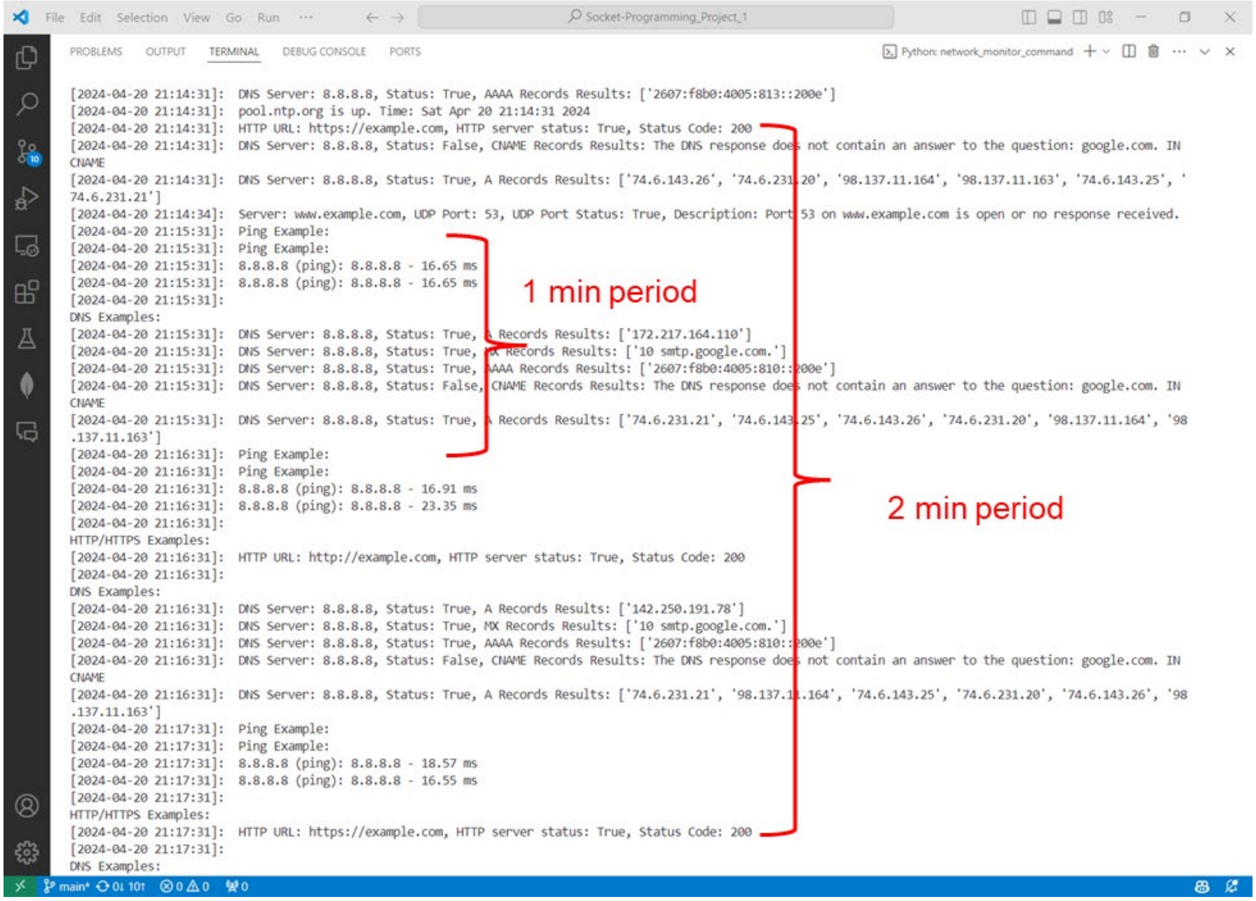

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[2024-04-20 21:16:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.250.191.78']
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.137.11.163']
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[2024-04-20 21:17:31]:
HTTP/HTTPS Examples:
[2024-04-20 21:17:31]:  HTTP URL: https://example.com, HTTP server status: True, Status Code: 200
[2024-04-20 21:17:31]:
DNS Examples:
```
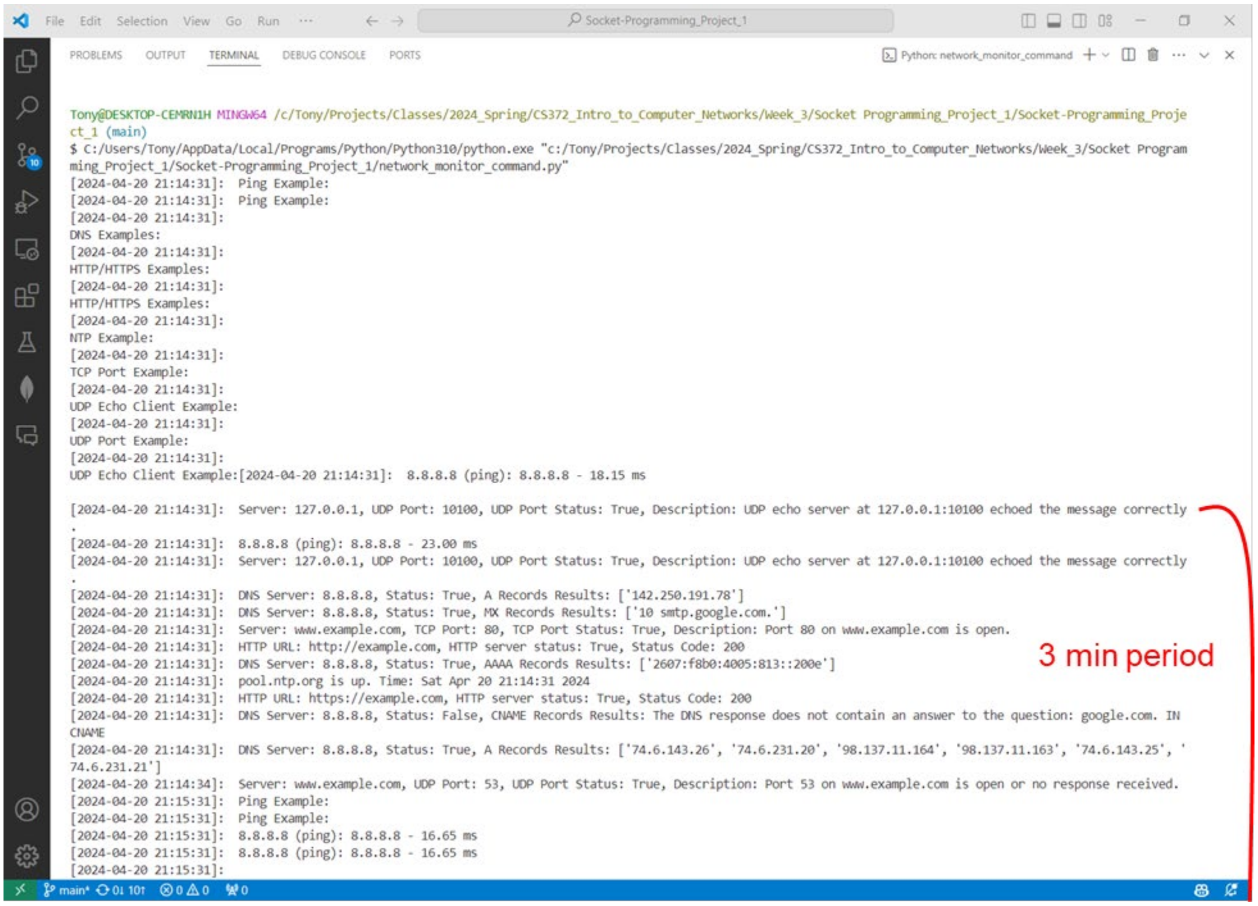

Figure 5 Output of Network Monitoring Server. Three Minute Timing Intervals for Servers and Services



```
Tony@DESKTOP-CEMRN1H MINGW64 /c/Tony/Projects/Classes/2024_Spring/CS372_Intro_to_Computer_Networks/Week_3/Socket Programming_Project_1/Socket-Programming_Proje
ct_1 (main)
$ C:/Users/Tony/AppData/Local/Programs/Python/Python310/python.exe "c:/Tony/Projects/Classes/2024_Spring/CS372_Intro_to_Computer_Networks/Week_3/Socket Program
ming_Project_1/Socket-Programming_Project_1/network_monitor_command.py"
[2024-04-20 21:14:31]:  Ping Example:
[2024-04-20 21:14:31]:  Ping Example:
[2024-04-20 21:14:31]:
DNS Examples:
[2024-04-20 21:14:31]:
HTTP/HTTPS Examples:
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[2024-04-20 21:14:31]:
NTP Example:
[2024-04-20 21:14:31]:
TCP Port Example:
[2024-04-20 21:14:31]:
UDP Echo Client Example:
[2024-04-20 21:14:31]:
UDP Port Example:
[2024-04-20 21:14:31]:
UDP Echo Client Example:[2024-04-20 21:14:31]:  8.8.8.8 (ping): 8.8.8.8 - 18.15 ms

[2024-04-20 21:14:31]:  Server: 127.0.0.1, UDP Port: 10100, UDP Port Status: True, Description: UDP echo server at 127.0.0.1:10100 echoed the message correctly
.
[2024-04-20 21:14:31]:  8.8.8.8 (ping): 8.8.8.8 - 23.00 ms
[2024-04-20 21:14:31]:  Server: 127.0.0.1, UDP Port: 10100, UDP Port Status: True, Description: UDP echo server at 127.0.0.1:10100 echoed the message correctly
.
[2024-04-20 21:14:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.250.191.78']
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[2024-04-20 21:14:31]:  DNS Server: 8.8.8.8, Status: False, CNAME Records Results: The DNS response does not contain an answer to the question: google.com. IN
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[2024-04-20 21:14:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['74.6.143.26', '74.6.231.20', '98.137.11.164', '98.137.11.163', '74.6.143.25', '
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[2024-04-20 21:14:34]:  Server: www.example.com, UDP Port: 53, UDP Port Status: True, Description: Port 53 on www.example.com is open or no response received.
[2024-04-20 21:15:31]:  Ping Example:
[2024-04-20 21:15:31]:  Ping Example:
[2024-04-20 21:15:31]:  8.8.8.8 (ping): 8.8.8.8 - 16.65 ms
[2024-04-20 21:15:31]:  8.8.8.8 (ping): 8.8.8.8 - 16.65 ms
[2024-04-20 21:15:31]:
```
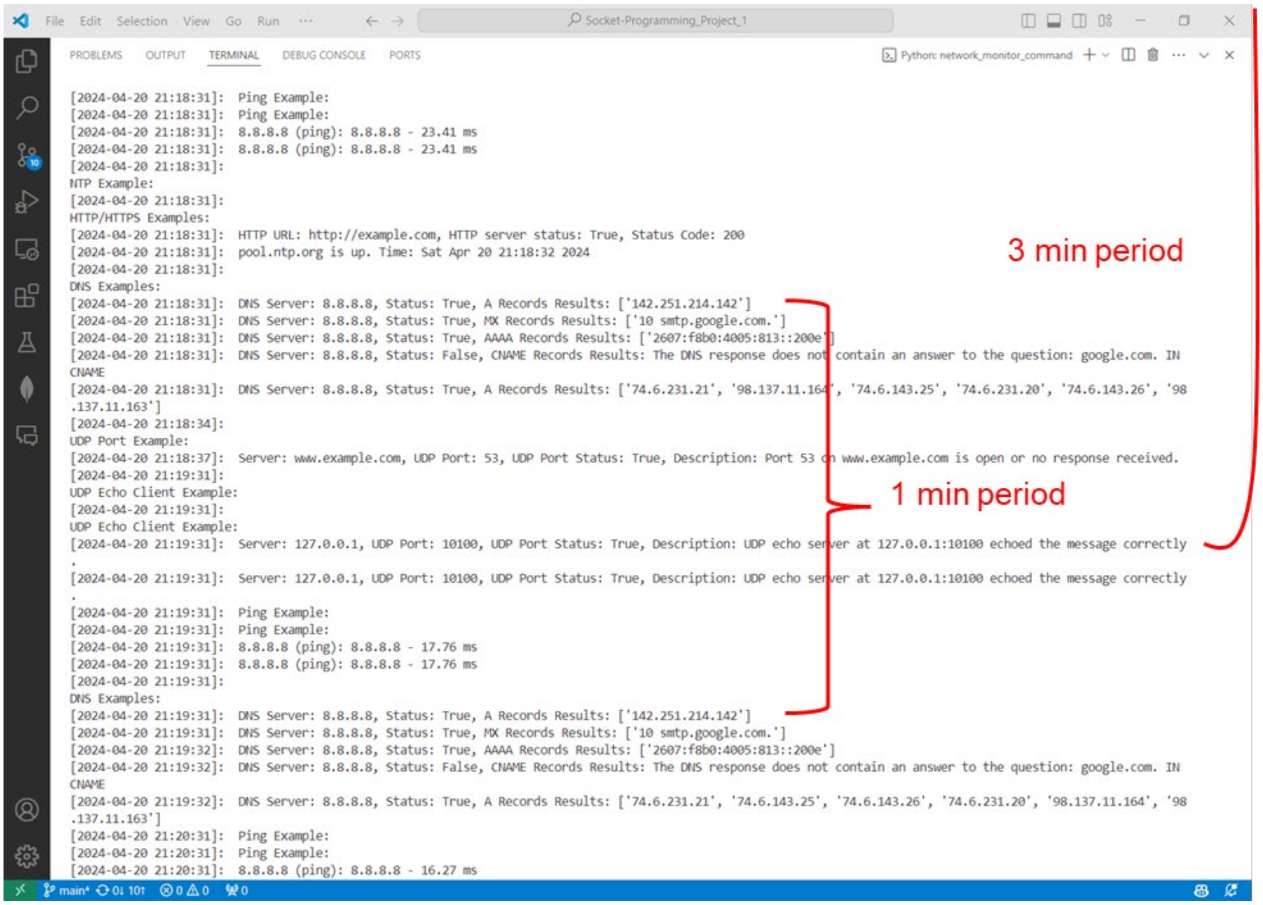

Figure 6 Output of Network Monitoring Server. Three Minute Timing Intervals for Servers and Services



```
[2024-04-20 21:18:31]:  Ping Example:
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[2024-04-20 21:18:31]:  8.8.8.8 (ping): 8.8.8.8 - 23.41 ms
[2024-04-20 21:18:31]:  8.8.8.8 (ping): 8.8.8.8 - 23.41 ms
[2024-04-20 21:18:31]:
NTP Example:
[2024-04-20 21:18:31]:
HTTP/HTTPS Examples:
[2024-04-20 21:18:31]:  HTTP URL: http://example.com, HTTP server status: True, Status Code: 200
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[2024-04-20 21:18:31]:
DNS Examples:
[2024-04-20 21:18:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.251.214.142']
[2024-04-20 21:18:31]:  DNS Server: 8.8.8.8, Status: True, MX Records Results: ['10 smtp.google.com.']
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[2024-04-20 21:18:31]:  DNS Server: 8.8.8.8, Status: False, CNAME Records Results: The DNS response does not contain an answer to the question: google.com. IN
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[2024-04-20 21:18:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['74.6.231.21', '98.137.11.164', '74.6.143.25', '74.6.231.20', '74.6.143.26', '98
.137.11.163']
[2024-04-20 21:18:34]:
UDP Port Example:
[2024-04-20 21:18:37]:  Server: www.example.com, UDP Port: 53, UDP Port Status: True, Description: Port 53 on www.example.com is open or no response received.
[2024-04-20 21:19:31]:
UDP Echo Client Example:
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[2024-04-20 21:19:31]:  Ping Example:
[2024-04-20 21:19:31]:  Ping Example:
[2024-04-20 21:19:31]:  8.8.8.8 (ping): 8.8.8.8 - 17.76 ms
[2024-04-20 21:19:31]:  8.8.8.8 (ping): 8.8.8.8 - 17.76 ms
[2024-04-20 21:19:31]:
DNS Examples:
[2024-04-20 21:19:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.251.214.142']
[2024-04-20 21:19:31]:  DNS Server: 8.8.8.8, Status: True, MX Records Results: ['10 smtp.google.com.']
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[2024-04-20 21:19:32]:  DNS Server: 8.8.8.8, Status: False, CNAME Records Results: The DNS response does not contain an answer to the question: google.com. IN
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[2024-04-20 21:20:31]:  Ping Example:
[2024-04-20 21:20:31]:  Ping Example:
[2024-04-20 21:20:31]:  8.8.8.8 (ping): 8.8.8.8 - 16.27 ms
```
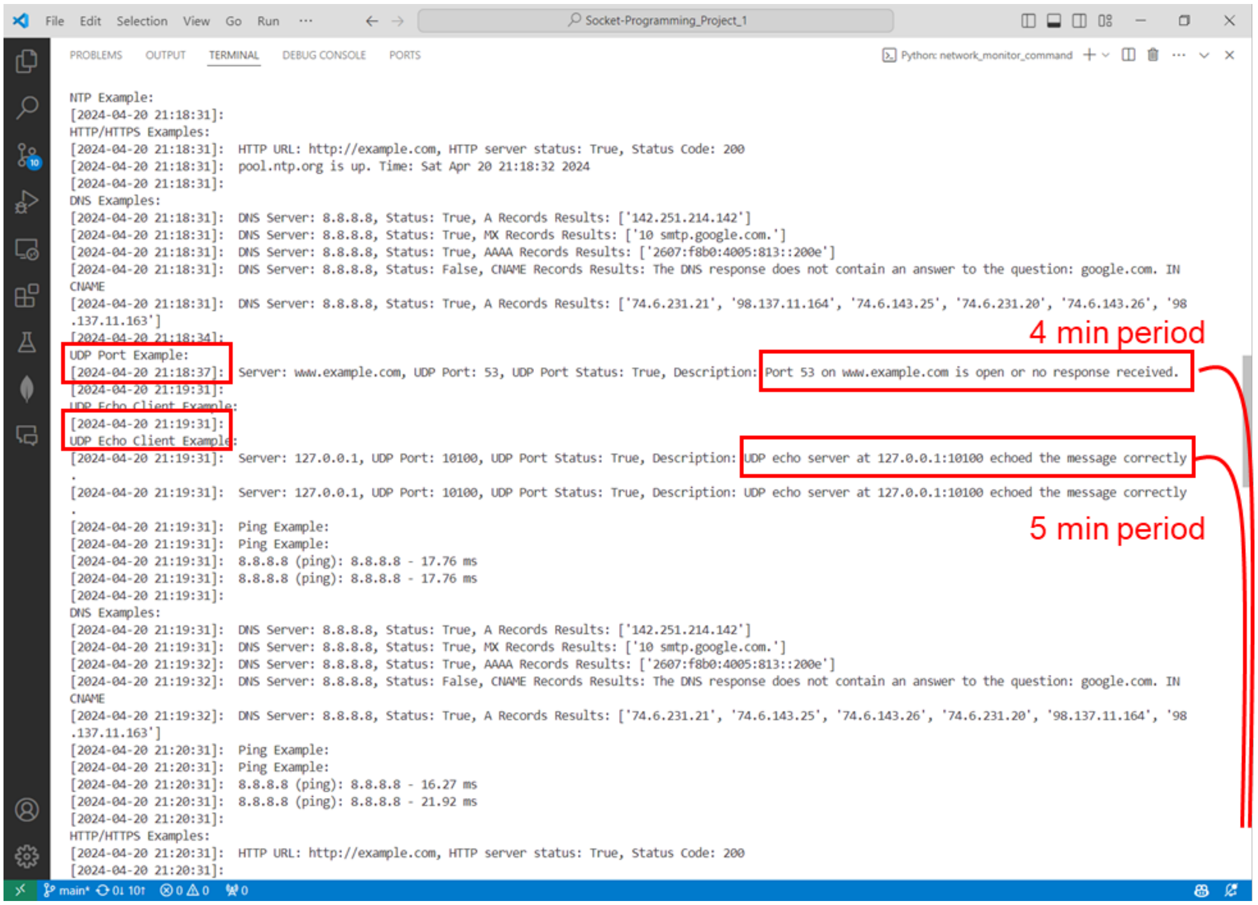
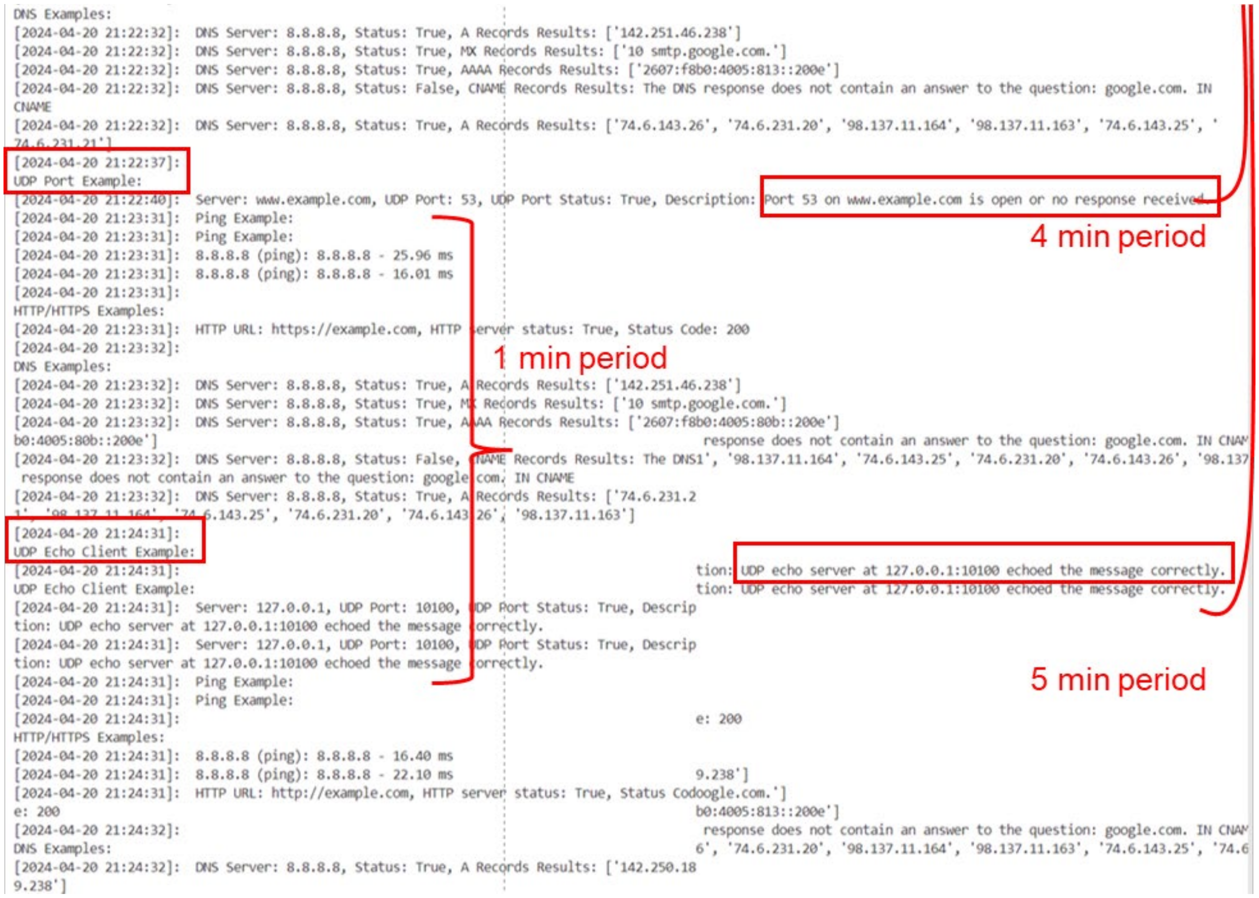

Figure 7 Output of Network Monitoring Server. 4 and 5 Minute Timing Intervals for UDP Echo Client and Server



```
NTP Example:
[2024-04-20 21:18:31]:
HTTP/HTTPS Examples:
[2024-04-20 21:18:31]:  HTTP URL: http://example.com, HTTP server status: True, Status Code: 200
[2024-04-20 21:18:31]:  pool.ntp.org is up. Time: Sat Apr 20 21:18:32 2024
[2024-04-20 21:18:31]:
DNS Examples:
[2024-04-20 21:18:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.251.214.142']
[2024-04-20 21:18:31]:  DNS Server: 8.8.8.8, Status: True, MX Records Results: ['10 smtp.google.com.']
[2024-04-20 21:18:31]:  DNS Server: 8.8.8.8, Status: True, AAAA Records Results: ['2607:f8b0:4005:813::200e']
[2024-04-20 21:18:31]:  DNS Server: 8.8.8.8, Status: False, CNAME Records Results: The DNS response does not contain an answer to the question: google.com. IN
CNAME
[2024-04-20 21:18:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['74.6.231.21', '98.137.11.164', '74.6.143.25', '74.6.231.20', '74.6.143.26', '98
.137.11.163']
[2024-04-20 21:18:34]:
UDP Port Example:
[2024-04-20 21:18:37]:  Server: www.example.com, UDP Port: 53, UDP Port Status: True, Description: Port 53 on www.example.com is open or no response received.
[2024-04-20 21:19:31]:
UDP Echo Client Example:
[2024-04-20 21:19:31]:
UDP Echo Client Example:
[2024-04-20 21:19:31]:  Server: 127.0.0.1, UDP Port: 10100, UDP Port Status: True, Description: UDP echo server at 127.0.0.1:10100 echoed the message correctly
.
[2024-04-20 21:19:31]:  Server: 127.0.0.1, UDP Port: 10100, UDP Port Status: True, Description: UDP echo server at 127.0.0.1:10100 echoed the message correctly
.
[2024-04-20 21:19:31]:  Ping Example:
[2024-04-20 21:19:31]:  Ping Example:
[2024-04-20 21:19:31]:  8.8.8.8 (ping): 8.8.8.8 - 17.76 ms
[2024-04-20 21:19:31]:  8.8.8.8 (ping): 8.8.8.8 - 17.76 ms
[2024-04-20 21:19:31]:
DNS Examples:
[2024-04-20 21:19:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.251.214.142']
[2024-04-20 21:19:31]:  DNS Server: 8.8.8.8, Status: True, MX Records Results: ['10 smtp.google.com.']
[2024-04-20 21:19:32]:  DNS Server: 8.8.8.8, Status: True, AAAA Records Results: ['2607:f8b0:4005:813::200e']
[2024-04-20 21:19:32]:  DNS Server: 8.8.8.8, Status: False, CNAME Records Results: The DNS response does not contain an answer to the question: google.com. IN
CNAME
[2024-04-20 21:19:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['74.6.231.21', '74.6.143.25', '74.6.143.26', '74.6.231.20', '98.137.11.164', '98
.137.11.163']
[2024-04-20 21:20:31]:  Ping Example:
[2024-04-20 21:20:31]:  Ping Example:
[2024-04-20 21:20:31]:  8.8.8.8 (ping): 8.8.8.8 - 16.27 ms
[2024-04-20 21:20:31]:  8.8.8.8 (ping): 8.8.8.8 - 21.92 ms
[2024-04-20 21:20:31]:
HTTP/HTTPS Examples:
[2024-04-20 21:20:31]:  HTTP URL: http://example.com, HTTP server status: True, Status Code: 200
[2024-04-20 21:20:31]:
```

Figure 8 Output of Network Monitoring Server. 4 and 5 Minute Timing Intervals for UDP Port of www.example.com



```
DNS Examples:
[2024-04-20 21:22:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.251.46.238']
[2024-04-20 21:22:32]:  DNS Server: 8.8.8.8, Status: True, MX Records Results: ['10 smtp.google.com.']
[2024-04-20 21:22:32]:  DNS Server: 8.8.8.8, Status: True, AAAA Records Results: ['2607:f8b0:4005:813::200e']
[2024-04-20 21:22:32]:  DNS Server: 8.8.8.8, Status: False, CNAME Records Results: The DNS response does not contain an answer to the question: google.com. IN
CNAME
[2024-04-20 21:22:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['74.6.143.26', '74.6.231.20', '98.137.11.164', '98.137.11.163', '74.6.143.25', '
74.6.231.21']
[2024-04-20 21:22:37]:
UDP Port Example:
[2024-04-20 21:22:40]:  Server: www.example.com, UDP Port: 53, UDP Port Status: True, Description: Port 53 on www.example.com is open or no response received.
[2024-04-20 21:23:31]:  Ping Example:
[2024-04-20 21:23:31]:  Ping Example:
[2024-04-20 21:23:31]:  8.8.8.8 (ping): 8.8.8.8 - 25.96 ms
[2024-04-20 21:23:31]:  8.8.8.8 (ping): 8.8.8.8 - 16.01 ms
[2024-04-20 21:23:31]:
HTTP/HTTPS Examples:
[2024-04-20 21:23:31]:  HTTP URL: https://example.com, HTTP server status: True, Status Code: 200
[2024-04-20 21:23:32]:
DNS Examples:
[2024-04-20 21:23:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.251.46.238']
[2024-04-20 21:23:32]:  DNS Server: 8.8.8.8, Status: True, MX Records Results: ['10 smtp.google.com.']
[2024-04-20 21:23:32]:  DNS Server: 8.8.8.8, Status: True, AAAA Records Results: ['2607:f8b0:4005:80b::200e']
b0:4005:80b::200e']                                                    response does not contain an answer to the question: google.com. IN CNAM
[2024-04-20 21:23:32]:  DNS Server: 8.8.8.8, Status: False, CNAME Records Results: The DNS1', '98.137.11.164', '74.6.143.25', '74.6.231.20', '74.6.143.26', '98.137
 response does not contain an answer to the question: google.com. IN CNAME
[2024-04-20 21:23:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['74.6.231.2
1', '98.137.11.164', '74.6.143.25', '74.6.231.20', '74.6.143.26', '98.137.11.163']
[2024-04-20 21:24:31]:
UDP Echo Client Example:
[2024-04-20 21:24:31]:                                                tion: UDP echo server at 127.0.0.1:10100 echoed the message correctly.
UDP Echo Client Example:                                              tion: UDP echo server at 127.0.0.1:10100 echoed the message correctly.
[2024-04-20 21:24:31]:  Server: 127.0.0.1, UDP Port: 10100, UDP Port Status: True, Descrip
tion: UDP echo server at 127.0.0.1:10100 echoed the message correctly.
[2024-04-20 21:24:31]:  Server: 127.0.0.1, UDP Port: 10100, UDP Port Status: True, Descrip
tion: UDP echo server at 127.0.0.1:10100 echoed the message correctly.
[2024-04-20 21:24:31]:  Ping Example:
[2024-04-20 21:24:31]:  Ping Example:
[2024-04-20 21:24:31]:                                                e: 200
HTTP/HTTPS Examples:
[2024-04-20 21:24:31]:  8.8.8.8 (ping): 8.8.8.8 - 16.40 ms
[2024-04-20 21:24:31]:  8.8.8.8 (ping): 8.8.8.8 - 22.10 ms              9.238']
[2024-04-20 21:24:31]:  HTTP URL: http://example.com, HTTP server status: True, Status Codoogle.com.']
e: 200                                                                b0:4005:813::200e']
[2024-04-20 21:24:32]:                                                 response does not contain an answer to the question: google.com. IN CNAM
DNS Examples:                                                         6', '74.6.231.20', '98.137.11.164', '98.137.11.163', '74.6.143.25', '74.6
[2024-04-20 21:24:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.250.18
9.238']
```

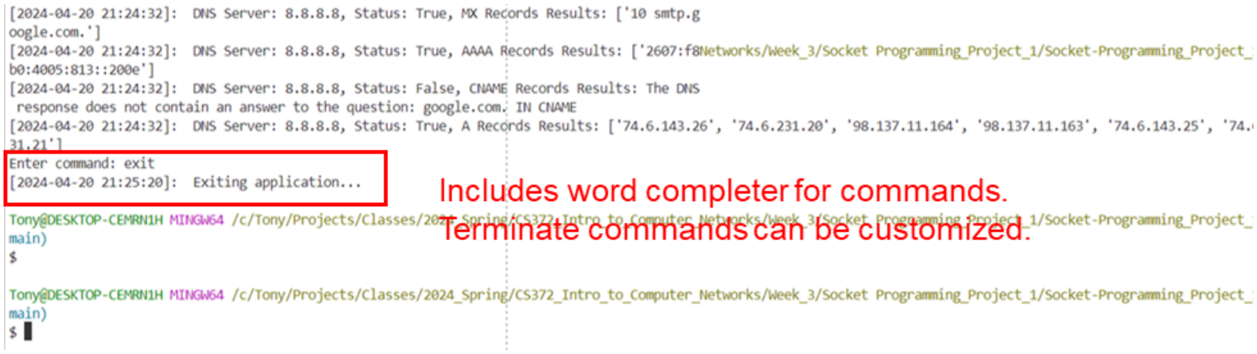
4 min period

1 min period

5 min period

2. Application should run continuously using a loop until it is terminated by the user (i.e. this is not a one time check).

Figure 9 Output of Network Monitoring Server. User Configurable Exit Command and Word Completion Capable



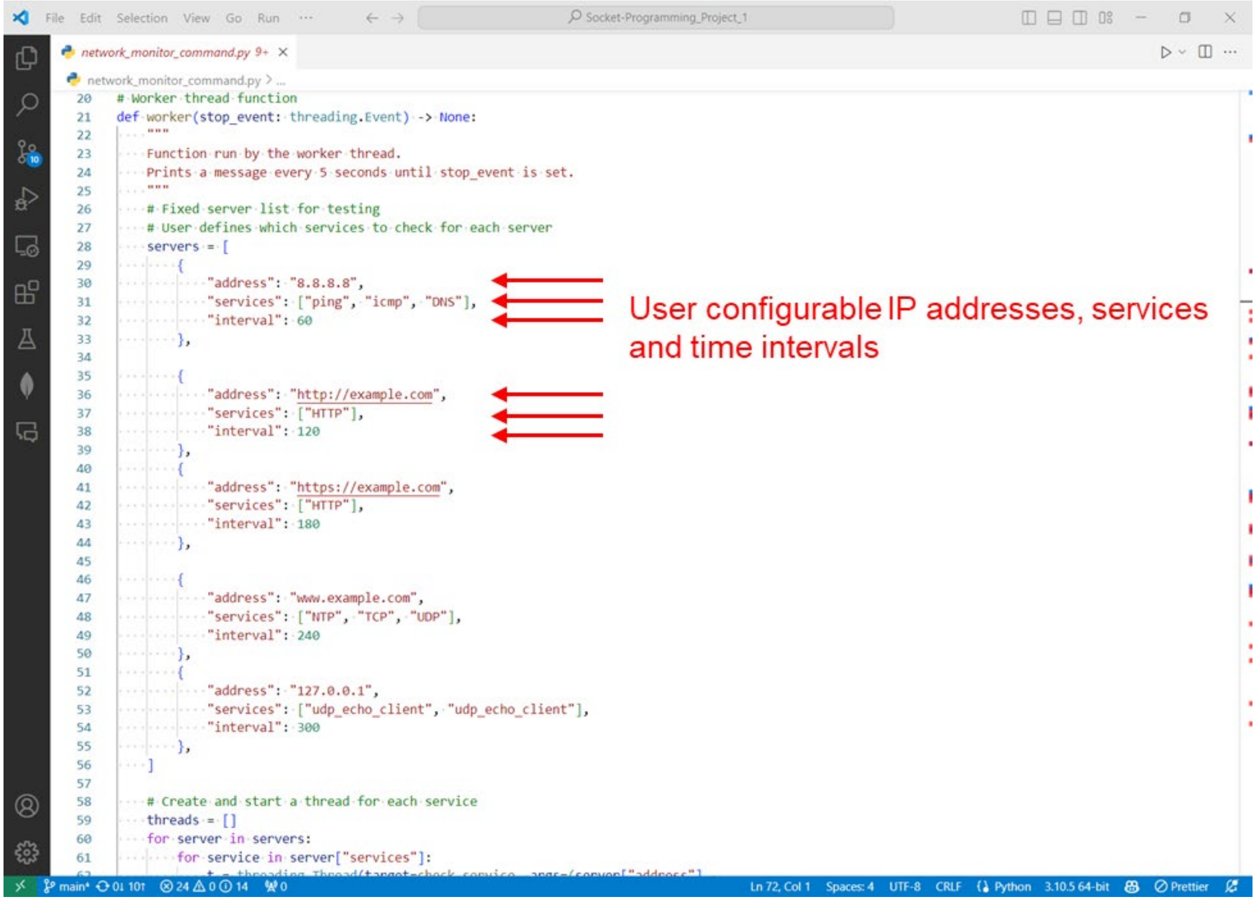
```
[2024-04-20 21:24:32]:  DNS Server: 8.8.8.8, Status: True, MX Records Results: ['10 smtp.g
oogle.com.']
[2024-04-20 21:24:32]:  DNS Server: 8.8.8.8, Status: True, AAAA Records Results: ['2607:f8Networks/Week_3/Socket Programming_Project_1/Socket-Programming_Project_
b0:4005:813::200e']
[2024-04-20 21:24:32]:  DNS Server: 8.8.8.8, Status: False, CNAME Records Results: The DNS
 response does not contain an answer to the question: google.com. IN CNAME
[2024-04-20 21:24:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['74.6.143.26', '74.6.231.20', '98.137.11.164', '98.137.11.163', '74.6.143.25', '74.6.2
31.21']
Enter command: exit
[2024-04-20 21:25:20]:  Exiting application...

Tony@DESKTOP-CEMRN1H MINGW64 /c/Tony/Projects/Classes/2024_Spring/CS372_Intro_to_Computer_Networks/Week_3/Socket Programming_Project_1/Socket-Programming_Project_
main)
$

Tony@DESKTOP-CEMRN1H MINGW64 /c/Tony/Projects/Classes/2024_Spring/CS372_Intro_to_Computer_Networks/Week_3/Socket Programming_Project_1/Socket-Programming_Project_
main)
$ █
```

Includes word completer for commands.
Terminate commands can be customized.

2. User-Defined Monitoring Configuration

1. Configure a list of servers (IP addresses or domain names) and services they want to monitor (HTTP, HTTPS, ICMP, DNS, NTP, TCP, UDP).

Figure 10 User Configurable List of Servers, Parameters and Services to Use

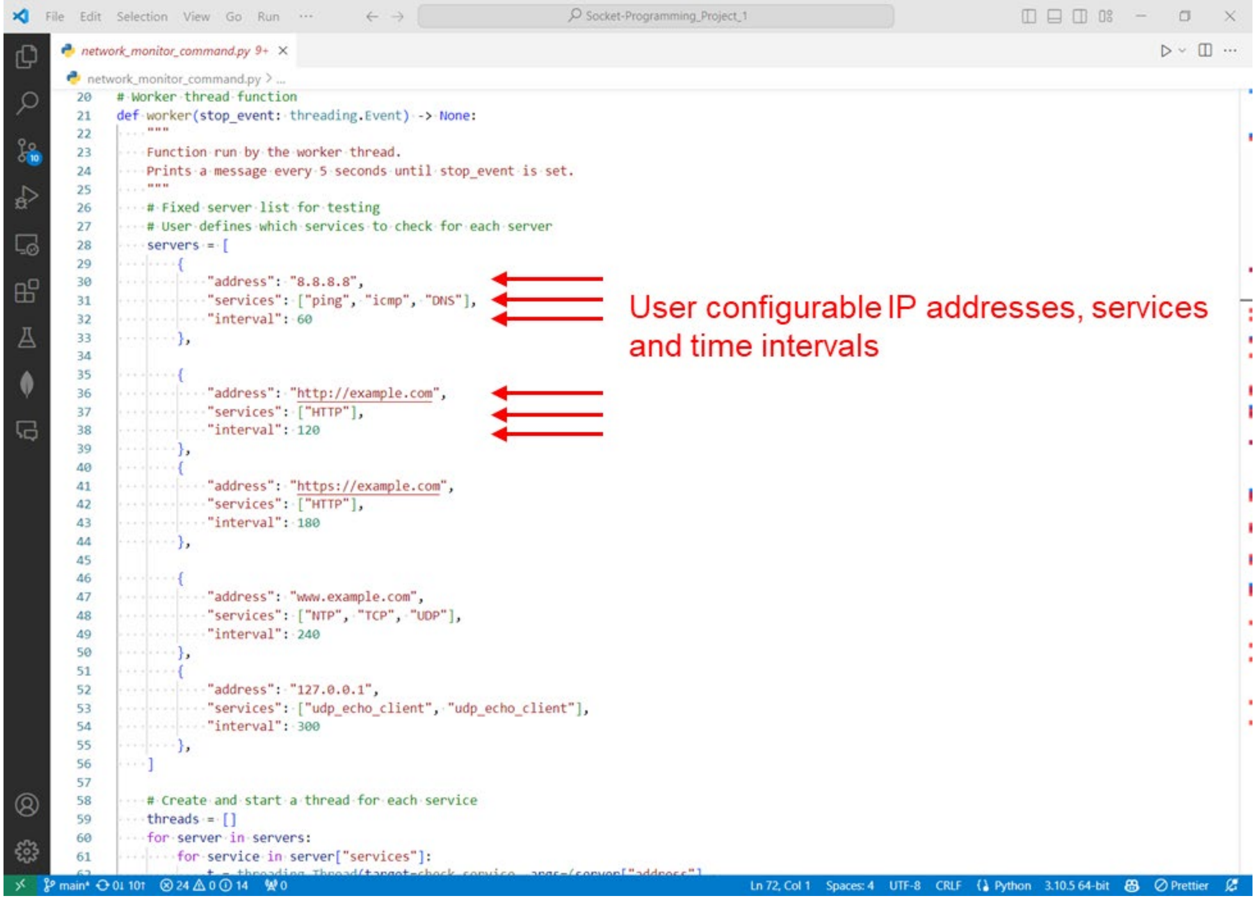

File
Edit
Selection
View
Go
Run
Socket-Programming_Project_1
network_monitor_command.py 9+
network_monitor_command.py > ...
main* 0↓ 10↑ ⊗ 24 ⚠ 0 ⓘ 14 0
Ln 72, Col 1
Spaces: 4
UTF-8
CRLF
{} Python
3.10.5 64-bit
Prettier

```python
# Worker thread function
def worker(stop_event: threading.Event) -> None:
    """
    Function run by the worker thread.
    Prints a message every 5 seconds until stop_event is set.
    """
    # Fixed server list for testing
    # User defines which services to check for each server
    servers = [
        {
            "address": "8.8.8.8",
            "services": ["ping", "icmp", "DNS"],
            "interval": 60
        },

        {
            "address": "http://example.com",
            "services": ["HTTP"],
            "interval": 120
        },
        {
            "address": "https://example.com",
            "services": ["HTTP"],
            "interval": 180
        },

        {
            "address": "www.example.com",
            "services": ["NTP", "TCP", "UDP"],
            "interval": 240
        },
        {
            "address": "127.0.0.1",
            "services": ["udp_echo_client", "udp_echo_client"],
            "interval": 300
        },
    ]

    # Create and start a thread for each service
    threads = []
    for server in servers:
        for service in server["services"]:
            t = threading.Thread(target=check_service, args=(server["address"],
```

User configurable IP addresses, services and time intervals

2. Setting parameters for each service check, such as URL for HTTP/HTTPS, server address for DNS/NTP, port numbers for TCP/UDP, etc.

Figure 11 User Configurable List of Servers, Parameters and Services to Use


File Edit Selection View Go Run ···
Socket-Programming_Project_1
network_monitor_command.py 9+
network_monitor_command.py > ...
main* 0↓ 10↑ ⊗ 24 ⚠ 0 ⓘ 14 0
Ln 72, Col 1 Spaces: 4 UTF-8 CRLF Python 3.10.5 64-bit Prettier

```python
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def worker(stop_event: threading.Event) -> None:
    """
    Function run by the worker thread.
    Prints a message every 5 seconds until stop_event is set.
    """
    # Fixed server list for testing
    # User defines which services to check for each server
    servers = [
        {
            "address": "8.8.8.8",
            "services": ["ping", "icmp", "DNS"],
            "interval": 60
        },

        {
            "address": "http://example.com",
            "services": ["HTTP"],
            "interval": 120
        },
        {
            "address": "https://example.com",
            "services": ["HTTP"],
            "interval": 180
        },

        {
            "address": "www.example.com",
            "services": ["NTP", "TCP", "UDP"],
            "interval": 240
        },
        {
            "address": "127.0.0.1",
            "services": ["udp_echo_client", "udp_echo_client"],
            "interval": 300
        },
    ]

    # Create and start a thread for each service
    threads = []
    for server in servers:
        for service in server["services"]:
```
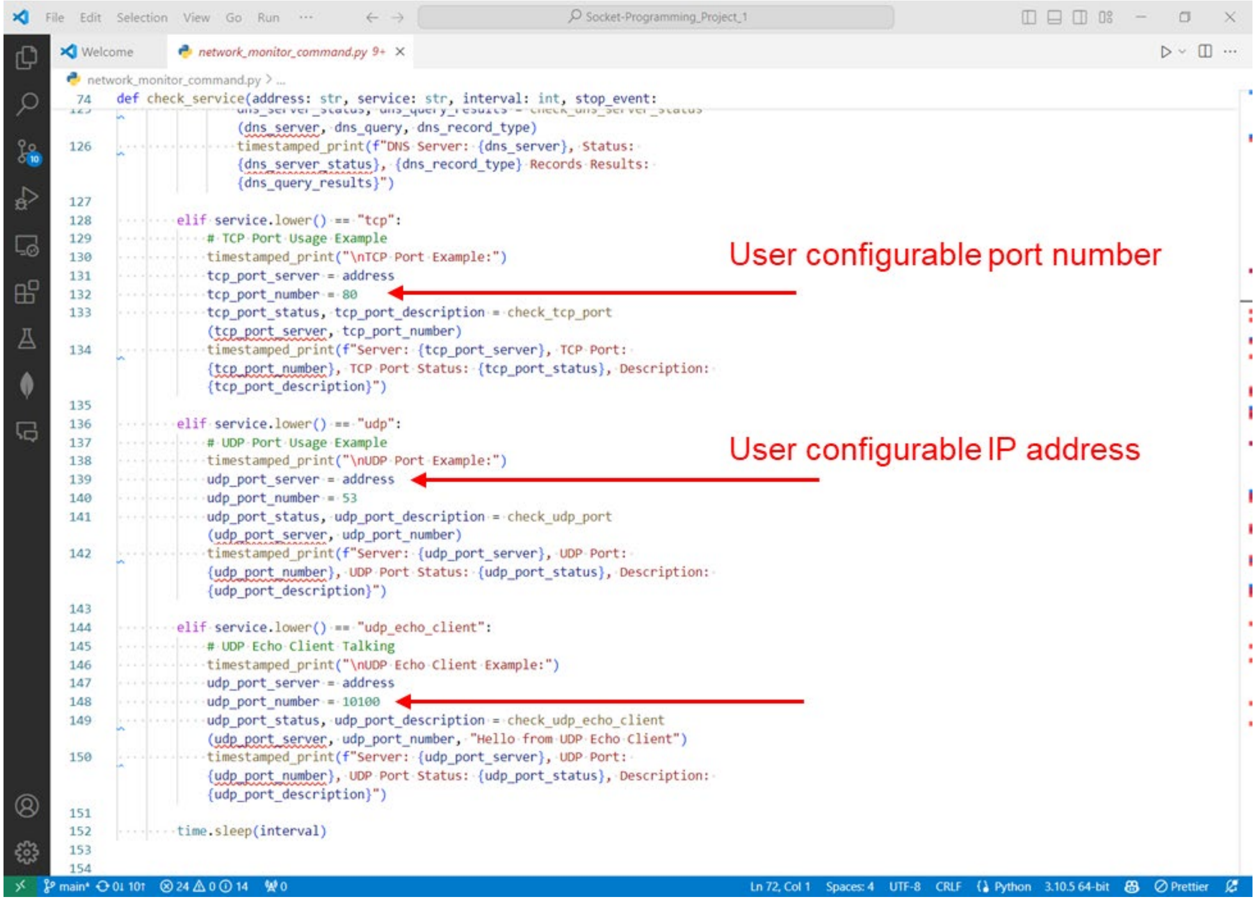

User configurable IP addresses, services and time intervals

Figure 12 User Configurable List of Servers, Parameters and Services to Use



File Edit Selection View Go Run ···
Socket-Programming_Project_1
Welcome
network_monitor_command.py 9+
network_monitor_command.py > ...
main* 0↓ 10↑ ⊗ 24 ⚠ 0 ⓘ 14 0
Ln 72, Col 1 Spaces: 4 UTF-8 CRLF {} Python 3.10.5 64-bit Prettier

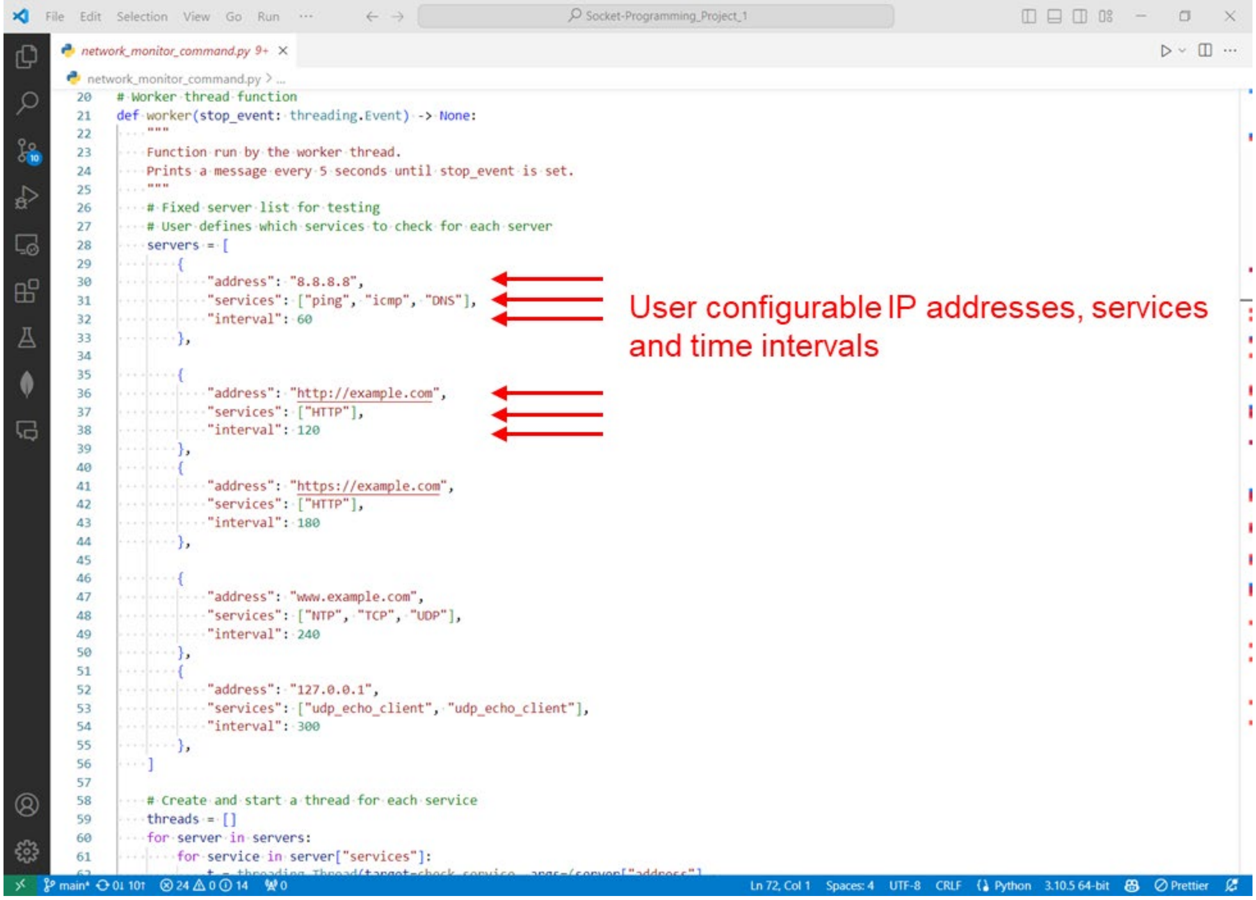
```python
def check_service(address: str, service: str, interval: int, stop_event:
            dns_server_status, dns_query_results = check_dns_server_status
            (dns_server, dns_query, dns_record_type)
            timestamped_print(f"DNS Server: {dns_server}, Status:
            {dns_server_status}, {dns_record_type} Records Results:
            {dns_query_results}")

        elif service.lower() == "tcp":
            # TCP Port Usage Example
            timestamped_print("\nTCP Port Example:")
            tcp_port_server = address
            tcp_port_number = 80
            tcp_port_status, tcp_port_description = check_tcp_port
            (tcp_port_server, tcp_port_number)
            timestamped_print(f"Server: {tcp_port_server}, TCP Port:
            {tcp_port_number}, TCP Port Status: {tcp_port_status}, Description:
            {tcp_port_description}")

        elif service.lower() == "udp":
            # UDP Port Usage Example
            timestamped_print("\nUDP Port Example:")
            udp_port_server = address
            udp_port_number = 53
            udp_port_status, udp_port_description = check_udp_port
            (udp_port_server, udp_port_number)
            timestamped_print(f"Server: {udp_port_server}, UDP Port:
            {udp_port_number}, UDP Port Status: {udp_port_status}, Description:
            {udp_port_description}")

        elif service.lower() == "udp_echo_client":
            # UDP Echo Client Talking
            timestamped_print("\nUDP Echo Client Example:")
            udp_port_server = address
            udp_port_number = 10100
            udp_port_status, udp_port_description = check_udp_echo_client
            (udp_port_server, udp_port_number, "Hello from UDP Echo Client")
            timestamped_print(f"Server: {udp_port_server}, UDP Port:
            {udp_port_number}, UDP Port Status: {udp_port_status}, Description:
            {udp_port_description}")

        time.sleep(interval)
```

User configurable port number

User configurable IP address

3. Set the frequency or interval of checks for each service.

Figure 13 User Configurable Time Intervals



File Edit Selection View Go Run ···
Socket-Programming_Project_1
network_monitor_command.py 9+
network_monitor_command.py > ...
main* 0↓ 10↑ ⊗ 24 ⚠ 0 ⓘ 14 0
Ln 72, Col 1 Spaces: 4 UTF-8 CRLF {} Python 3.10.5 64-bit Prettier

```python
# Worker thread function
def worker(stop_event: threading.Event) -> None:
    """
    Function run by the worker thread.
    Prints a message every 5 seconds until stop_event is set.
    """
    # Fixed server list for testing
    # User defines which services to check for each server
    servers = [
        {
            "address": "8.8.8.8",
            "services": ["ping", "icmp", "DNS"],
            "interval": 60
        },

        {
            "address": "http://example.com",
            "services": ["HTTP"],
            "interval": 120
        },
        {
            "address": "https://example.com",
            "services": ["HTTP"],
            "interval": 180
        },

        {
            "address": "www.example.com",
            "services": ["NTP", "TCP", "UDP"],
            "interval": 240
        },
        {
            "address": "127.0.0.1",
            "services": ["udp_echo_client", "udp_echo_client"],
            "interval": 300
        },
    ]

    # Create and start a thread for each service
    threads = []
    for server in servers:
        for service in server["services"]:
            t = threading.Thread(target=check_service, args=(server["address"]
```

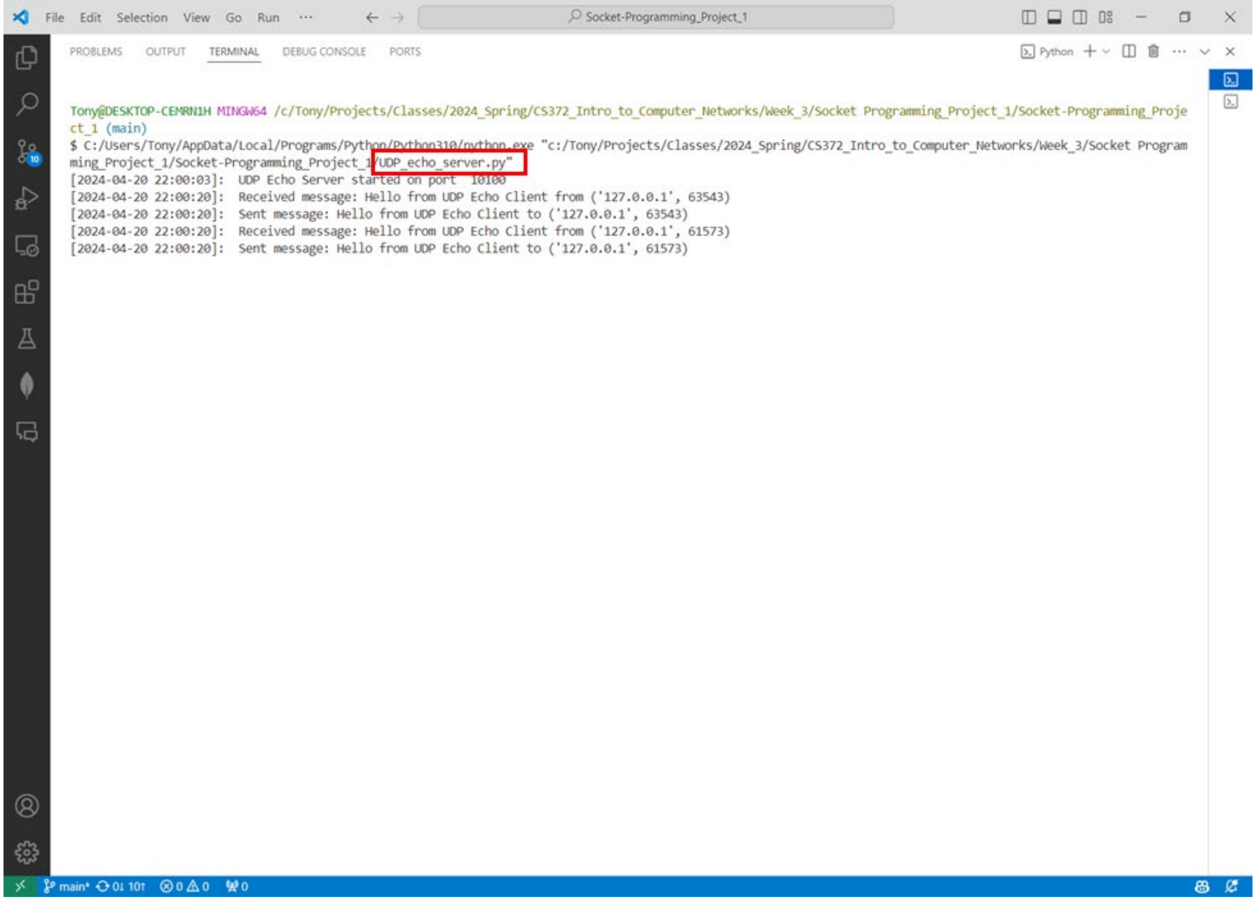
User configurable IP addresses, services and time intervals

App 2 Eco Server

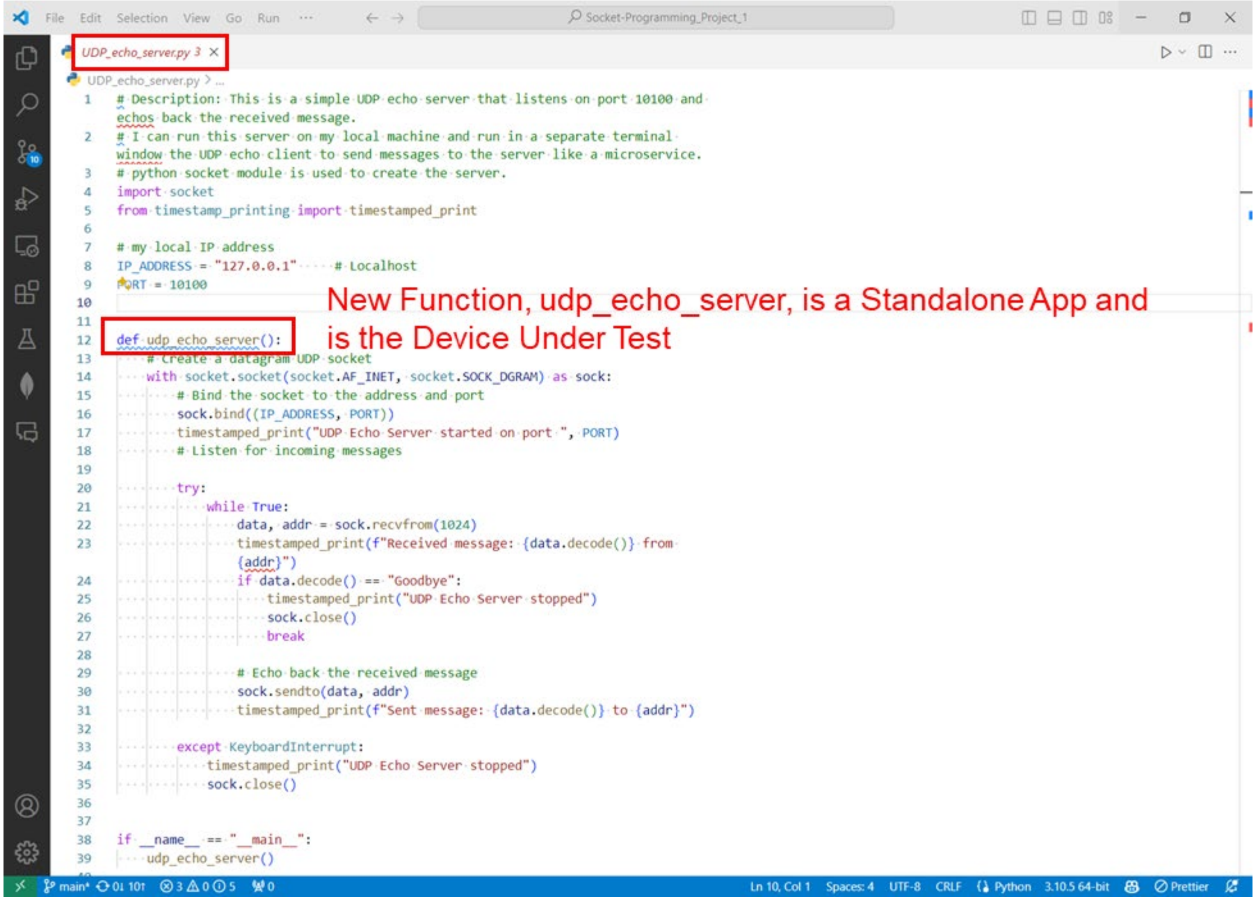
1. Echo Server Implementation

1. Using the Socket Programming Exploration - Fundamentals of Network Programming as a resource, create and test an echo server.

Figure 14 Echo Server is Running in Its Own Process and Always On



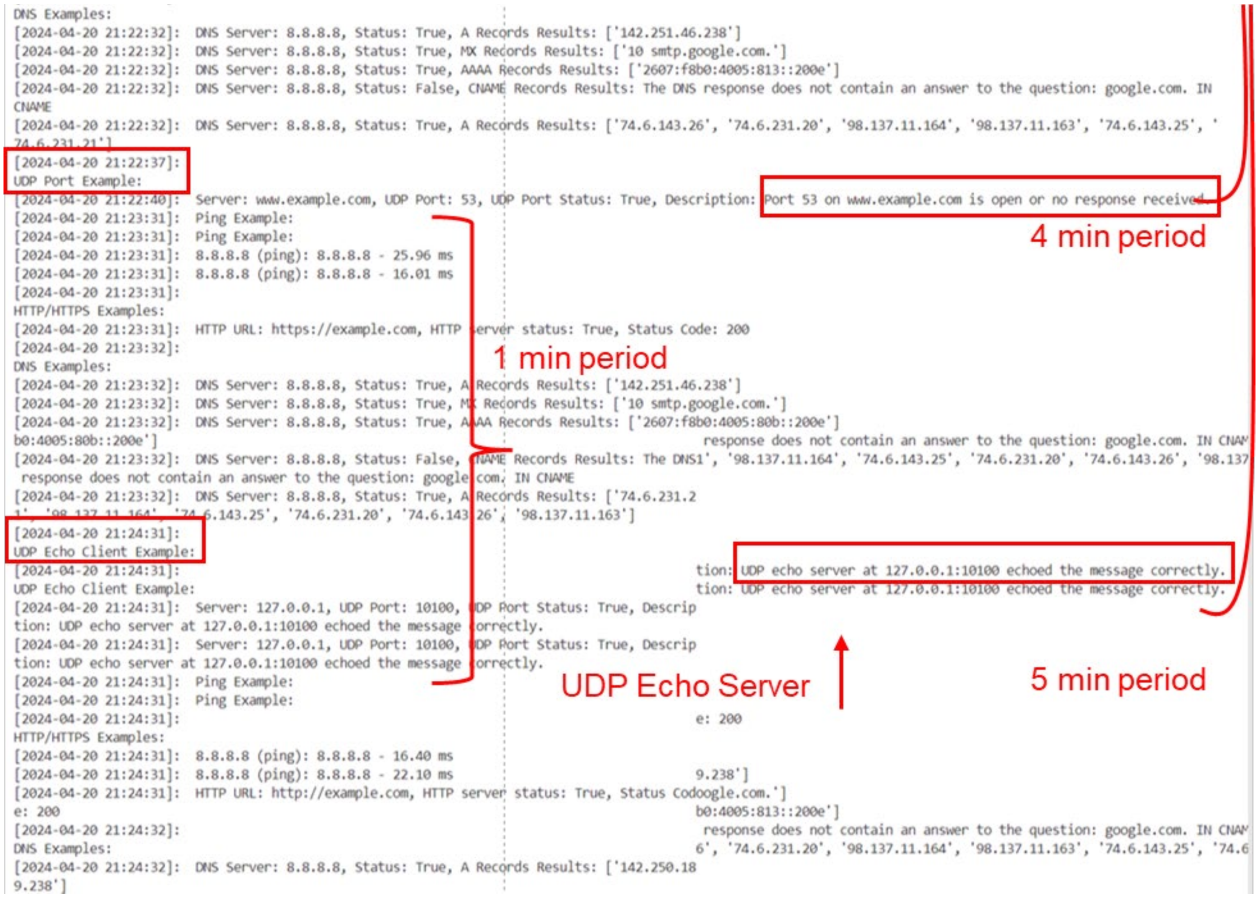
```
Tony@DESKTOP-CEMRN1H MINGW64 /c/Tony/Projects/Classes/2024_Spring/CS372_Intro_to_Computer_Networks/Week_3/Socket Programming_Project_1/Socket-Programming_Proje
ct_1 (main)
$ C:/Users/Tony/AppData/Local/Programs/Python/Python310/python.exe "c:/Tony/Projects/Classes/2024_Spring/CS372_Intro_to_Computer_Networks/Week_3/Socket Program
ming_Project_1/Socket-Programming_Project_1/UDP_echo_server.py"
[2024-04-20 22:00:03]:  UDP Echo Server started on port  10100
[2024-04-20 22:00:20]:  Received message: Hello from UDP Echo Client from ('127.0.0.1', 63543)
[2024-04-20 22:00:20]:  Sent message: Hello from UDP Echo Client to ('127.0.0.1', 63543)
[2024-04-20 22:00:20]:  Received message: Hello from UDP Echo Client from ('127.0.0.1', 61573)
[2024-04-20 22:00:20]:  Sent message: Hello from UDP Echo Client to ('127.0.0.1', 61573)
```


File Edit Selection View Go Run ···
Socket-Programming_Project_1
UDP_echo_server.py 3
UDP_echo_server.py > ...
main* 0↓ 10↑ ⊗ 3 ⚠ 0 ⓘ 5 0
Ln 10, Col 1 Spaces: 4 UTF-8 CRLF Python 3.10.5 64-bit Prettier

New Function, udp_echo_server, is a Standalone App and is the Device Under Test

```python
# Description: This is a simple UDP echo server that listens on port 10100 and echos back the received message.
# I can run this server on my local machine and run in a separate terminal window the UDP echo client to send messages to the server like a microservice.
# python socket module is used to create the server.
import socket
from timestamp_printing import timestamped_print

# my local IP address
IP_ADDRESS = "127.0.0.1"     # Localhost
PORT = 10100


def udp_echo_server():
    # Create a datagram UDP socket
    with socket.socket(socket.AF_INET, socket.SOCK_DGRAM) as sock:
        # Bind the socket to the address and port
        sock.bind((IP_ADDRESS, PORT))
        timestamped_print("UDP Echo Server started on port ", PORT)
        # Listen for incoming messages

        try:
            while True:
                data, addr = sock.recvfrom(1024)
                timestamped_print(f"Received message: {data.decode()} from {addr}")
                if data.decode() == "Goodbye":
                    timestamped_print("UDP Echo Server stopped")
                    sock.close()
                    break

                # Echo back the received message
                sock.sendto(data, addr)
                timestamped_print(f"Sent message: {data.decode()} to {addr}")

        except KeyboardInterrupt:
            timestamped_print("UDP Echo Server stopped")
            sock.close()


if __name__ == "__main__":
    udp_echo_server()
```

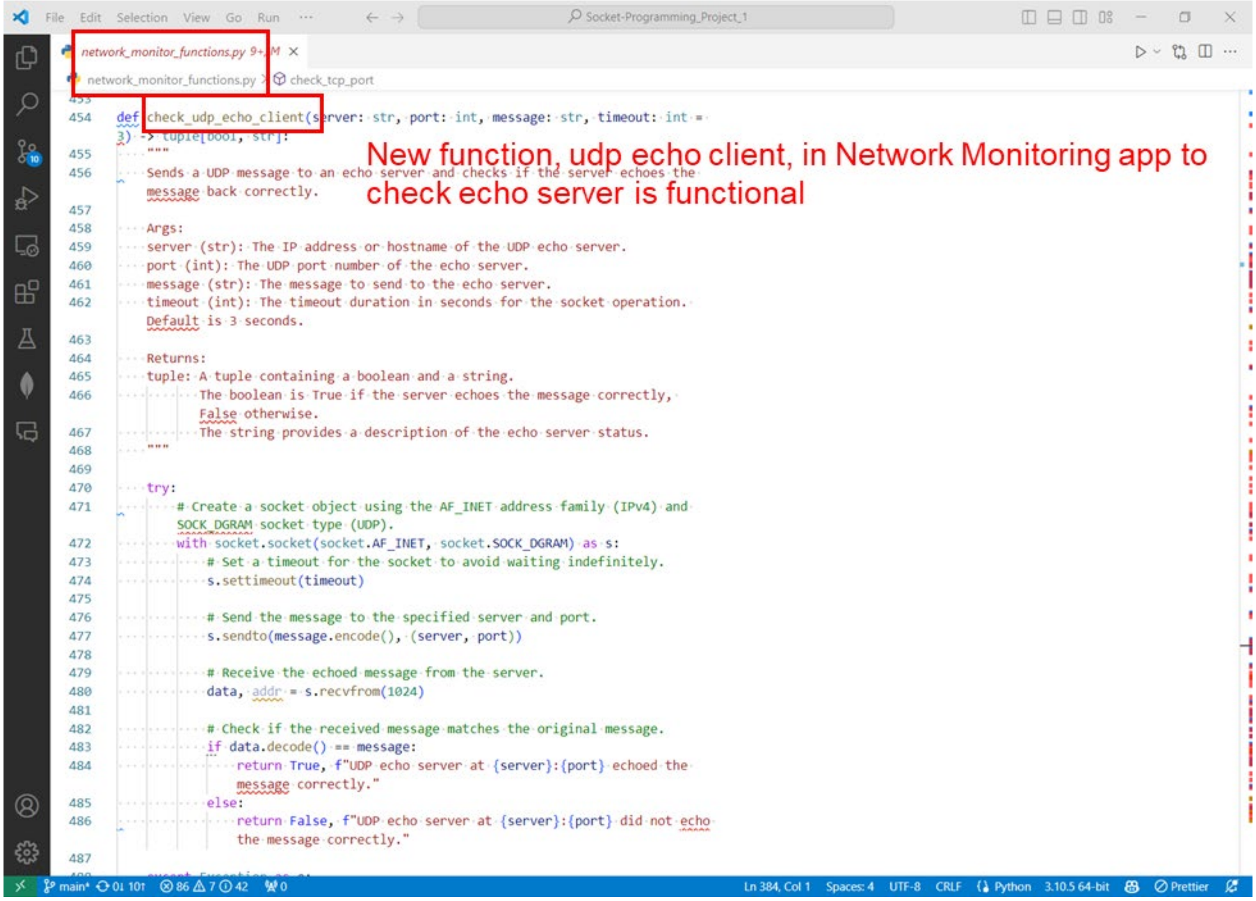
Figure 15 UDP Echo Server Output of Network Monitoring Server. The UDP Echo Server is Responding to a Request



```
DNS Examples:
[2024-04-20 21:22:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.251.46.238']
[2024-04-20 21:22:32]:  DNS Server: 8.8.8.8, Status: True, MX Records Results: ['10 smtp.google.com.']
[2024-04-20 21:22:32]:  DNS Server: 8.8.8.8, Status: True, AAAA Records Results: ['2607:f8b0:4005:813::200e']
[2024-04-20 21:22:32]:  DNS Server: 8.8.8.8, Status: False, CNAME Records Results: The DNS response does not contain an answer to the question: google.com. IN
CNAME
[2024-04-20 21:22:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['74.6.143.26', '74.6.231.20', '98.137.11.164', '98.137.11.163', '74.6.143.25', '
74.6.231.21']
[2024-04-20 21:22:37]:
UDP Port Example:
[2024-04-20 21:22:40]:  Server: www.example.com, UDP Port: 53, UDP Port Status: True, Description: Port 53 on www.example.com is open or no response received
[2024-04-20 21:23:31]:  Ping Example:
[2024-04-20 21:23:31]:  Ping Example:
[2024-04-20 21:23:31]:  8.8.8.8 (ping): 8.8.8.8 - 25.96 ms
[2024-04-20 21:23:31]:  8.8.8.8 (ping): 8.8.8.8 - 16.01 ms
[2024-04-20 21:23:31]:
HTTP/HTTPS Examples:
[2024-04-20 21:23:31]:  HTTP URL: https://example.com, HTTP server status: True, Status Code: 200
[2024-04-20 21:23:32]:
DNS Examples:
[2024-04-20 21:23:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.251.46.238']
[2024-04-20 21:23:32]:  DNS Server: 8.8.8.8, Status: True, MX Records Results: ['10 smtp.google.com.']
[2024-04-20 21:23:32]:  DNS Server: 8.8.8.8, Status: True, AAAA Records Results: ['2607:f8b0:4005:80b::200e']
b0:4005:80b::200e']                                                        response does not contain an answer to the question: google.com. IN CNAM
[2024-04-20 21:23:32]:  DNS Server: 8.8.8.8, Status: False, CNAME Records Results: The DNS1', '98.137.11.164', '74.6.143.25', '74.6.231.20', '74.6.143.26', '98.137
 response does not contain an answer to the question: google.com. IN CNAME
[2024-04-20 21:23:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['74.6.231.2
1', '98.137.11.164', '74.6.143.25', '74.6.231.20', '74.6.143.26', '98.137.11.163']
[2024-04-20 21:24:31]:
UDP Echo Client Example:
[2024-04-20 21:24:31]:                                                    tion: UDP echo server at 127.0.0.1:10100 echoed the message correctly.
UDP Echo Client Example:                                                   tion: UDP echo server at 127.0.0.1:10100 echoed the message correctly.
[2024-04-20 21:24:31]:  Server: 127.0.0.1, UDP Port: 10100, UDP Port Status: True, Descrip
tion: UDP echo server at 127.0.0.1:10100 echoed the message correctly.
[2024-04-20 21:24:31]:  Server: 127.0.0.1, UDP Port: 10100, UDP Port Status: True, Descrip
tion: UDP echo server at 127.0.0.1:10100 echoed the message correctly.
[2024-04-20 21:24:31]:  Ping Example:
[2024-04-20 21:24:31]:  Ping Example:
[2024-04-20 21:24:31]:                                                    e: 200
HTTP/HTTPS Examples:
[2024-04-20 21:24:31]:  8.8.8.8 (ping): 8.8.8.8 - 16.40 ms
[2024-04-20 21:24:31]:  8.8.8.8 (ping): 8.8.8.8 - 22.10 ms                9.238']
[2024-04-20 21:24:31]:  HTTP URL: http://example.com, HTTP server status: True, Status Codoogle.com.']
e: 200                                                                    b0:4005:813::200e']
[2024-04-20 21:24:32]:                                                     response does not contain an answer to the question: google.com. IN CNAM
DNS Examples:                                                             6', '74.6.231.20', '98.137.11.164', '98.137.11.163', '74.6.143.25', '74.6
[2024-04-20 21:24:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.250.18
9.238']
```

2. Create a new function in the Network Monitoring application, similar to the existing service based check functions, that can check if the echo server is functional (use what you learn from the echo client implementation requirement to build this function).

Figure 16 UDP Echo Client in Network Monitoring Server to Test UDP Echo Server


File Edit Selection View Go Run ···
Socket-Programming_Project_1
network_monitor_functions.py 9+, M
network_monitor_functions.py > check_tcp_port
main* 0↓ 10↑ ⊗ 86 ⚠ 7 ⓘ 42 0
Ln 384, Col 1 Spaces: 4 UTF-8 CRLF Python 3.10.5 64-bit Prettier

New function, udp echo client, in Network Monitoring app to check echo server is functional

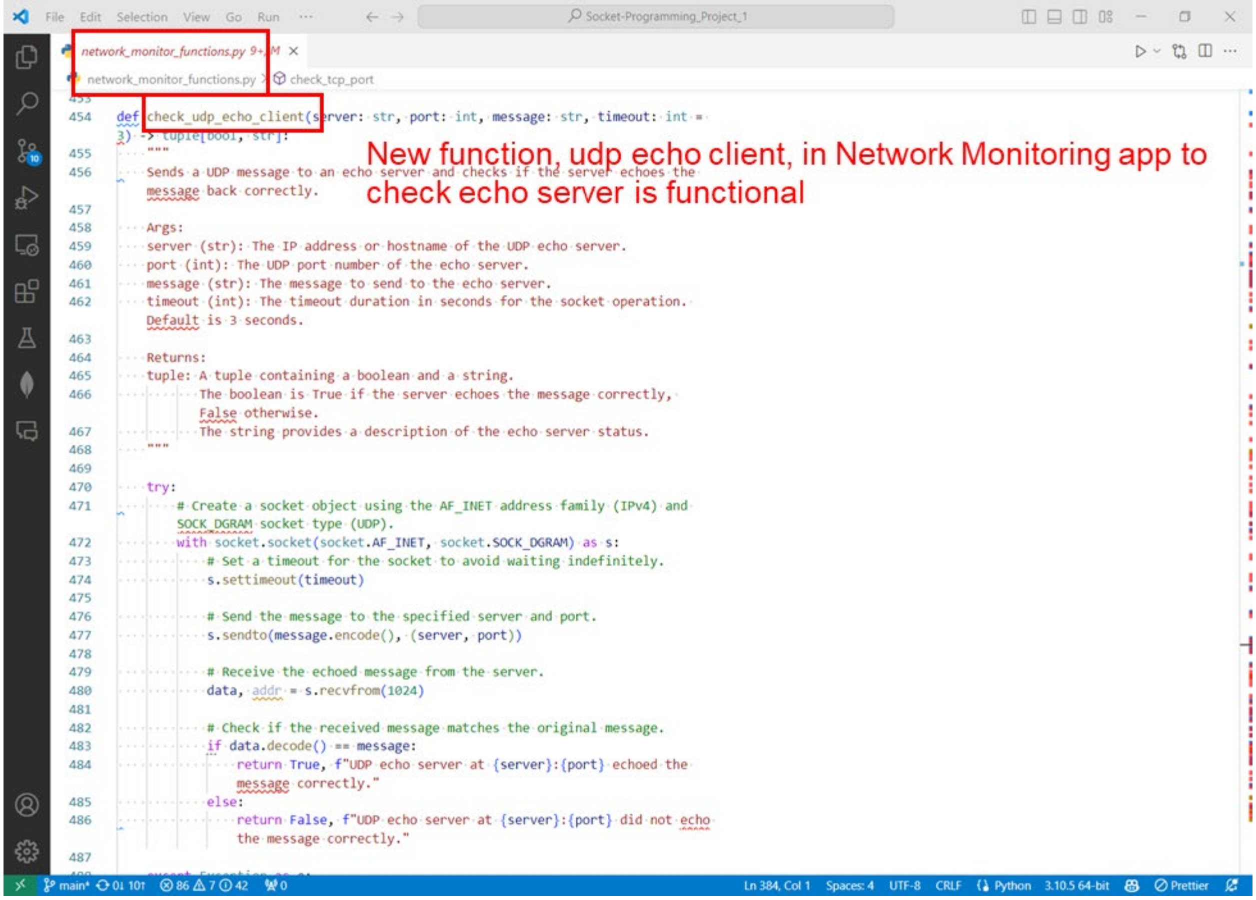
```
def check_udp_echo_client(server: str, port: int, message: str, timeout: int =
3) -> tuple[bool, str]:
    """
    Sends a UDP message to an echo server and checks if the server echoes the
    message back correctly.

    Args:
    server (str): The IP address or hostname of the UDP echo server.
    port (int): The UDP port number of the echo server.
    message (str): The message to send to the echo server.
    timeout (int): The timeout duration in seconds for the socket operation.
    Default is 3 seconds.

    Returns:
    tuple: A tuple containing a boolean and a string.
           The boolean is True if the server echoes the message correctly,
           False otherwise.
           The string provides a description of the echo server status.
    """

    try:
        # Create a socket object using the AF_INET address family (IPv4) and
        SOCK_DGRAM socket type (UDP).
        with socket.socket(socket.AF_INET, socket.SOCK_DGRAM) as s:
            # Set a timeout for the socket to avoid waiting indefinitely.
            s.settimeout(timeout)

            # Send the message to the specified server and port.
            s.sendto(message.encode(), (server, port))

            # Receive the echoed message from the server.
            data, addr = s.recvfrom(1024)

            # Check if the received message matches the original message.
            if data.decode() == message:
                return True, f"UDP echo server at {server}:{port} echoed the
                message correctly."
            else:
                return False, f"UDP echo server at {server}:{port} did not echo
                the message correctly."

```

App 3 Eco Client

1. Echo Client Implementation

1. Using the Exploration page, create and test an echo client to work with your echo server.

Figure 17 UDP Echo Client in Network Monitoring Server to Check UDP Echo Server is Still Working



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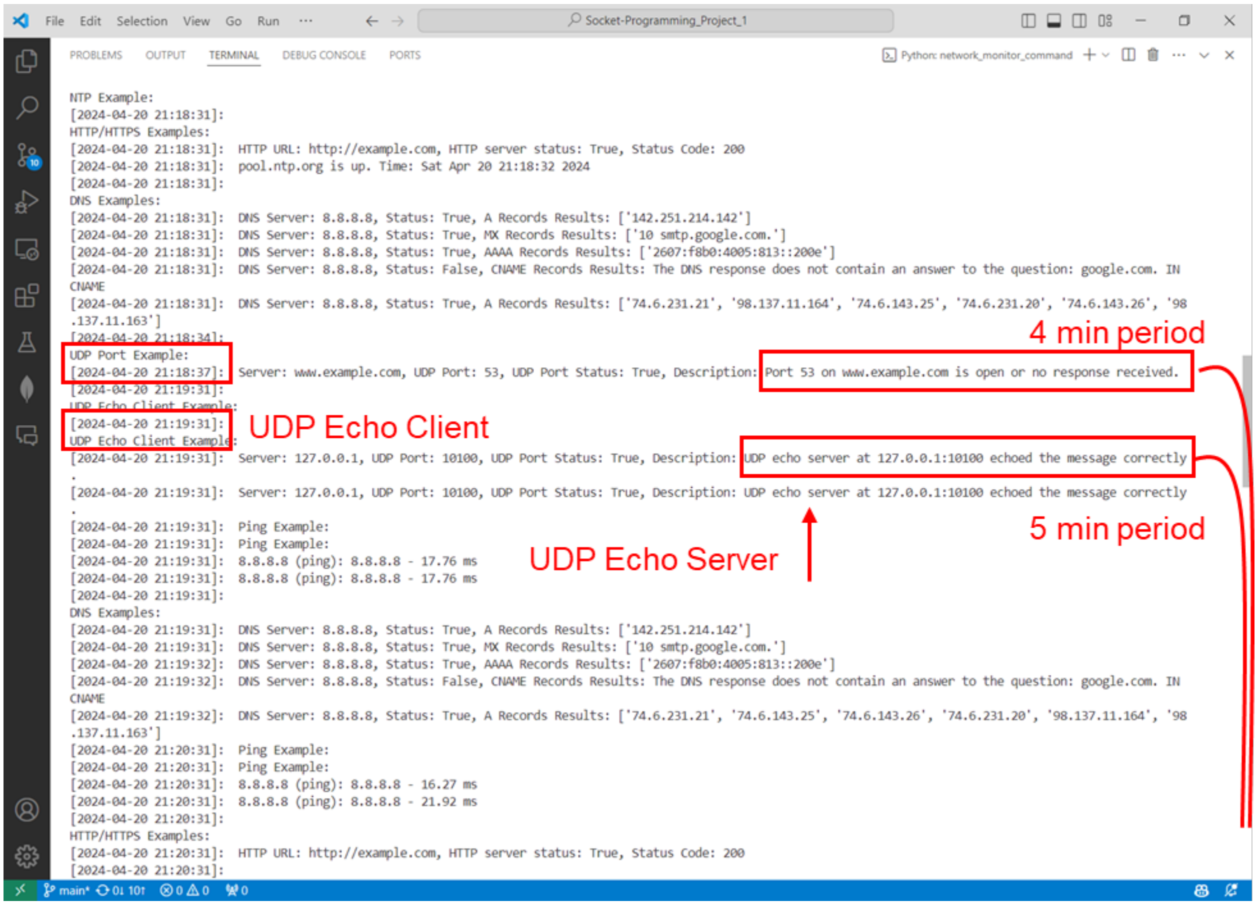
Go
Run
Socket-Programming_Project_1
network_monitor_functions.py 9+, M
network_monitor_functions.py > check_tcp_port
main* 0↓ 10↑ ⊗ 86 ⚠ 7 ⓘ 42 0
Ln 384, Col 1
Spaces: 4
UTF-8
CRLF
Python
3.10.5 64-bit
Prettier

New function, udp echo client, in Network Monitoring app to check echo server is functional

```python
def check_udp_echo_client(server: str, port: int, message: str, timeout: int = 3) -> tuple[bool, str]:
    """
    Sends a UDP message to an echo server and checks if the server echoes the message back correctly.

    Args:
    server (str): The IP address or hostname of the UDP echo server.
    port (int): The UDP port number of the echo server.
    message (str): The message to send to the echo server.
    timeout (int): The timeout duration in seconds for the socket operation. Default is 3 seconds.

    Returns:
    tuple: A tuple containing a boolean and a string.
           The boolean is True if the server echoes the message correctly, False otherwise.
           The string provides a description of the echo server status.
    """

    try:
        # Create a socket object using the AF_INET address family (IPv4) and SOCK_DGRAM socket type (UDP).
        with socket.socket(socket.AF_INET, socket.SOCK_DGRAM) as s:
            # Set a timeout for the socket to avoid waiting indefinitely.
            s.settimeout(timeout)

            # Send the message to the specified server and port.
            s.sendto(message.encode(), (server, port))

            # Receive the echoed message from the server.
            data, addr = s.recvfrom(1024)

            # Check if the received message matches the original message.
            if data.decode() == message:
                return True, f"UDP echo server at {server}:{port} echoed the message correctly."
            else:
                return False, f"UDP echo server at {server}:{port} did not echo the message correctly."
```

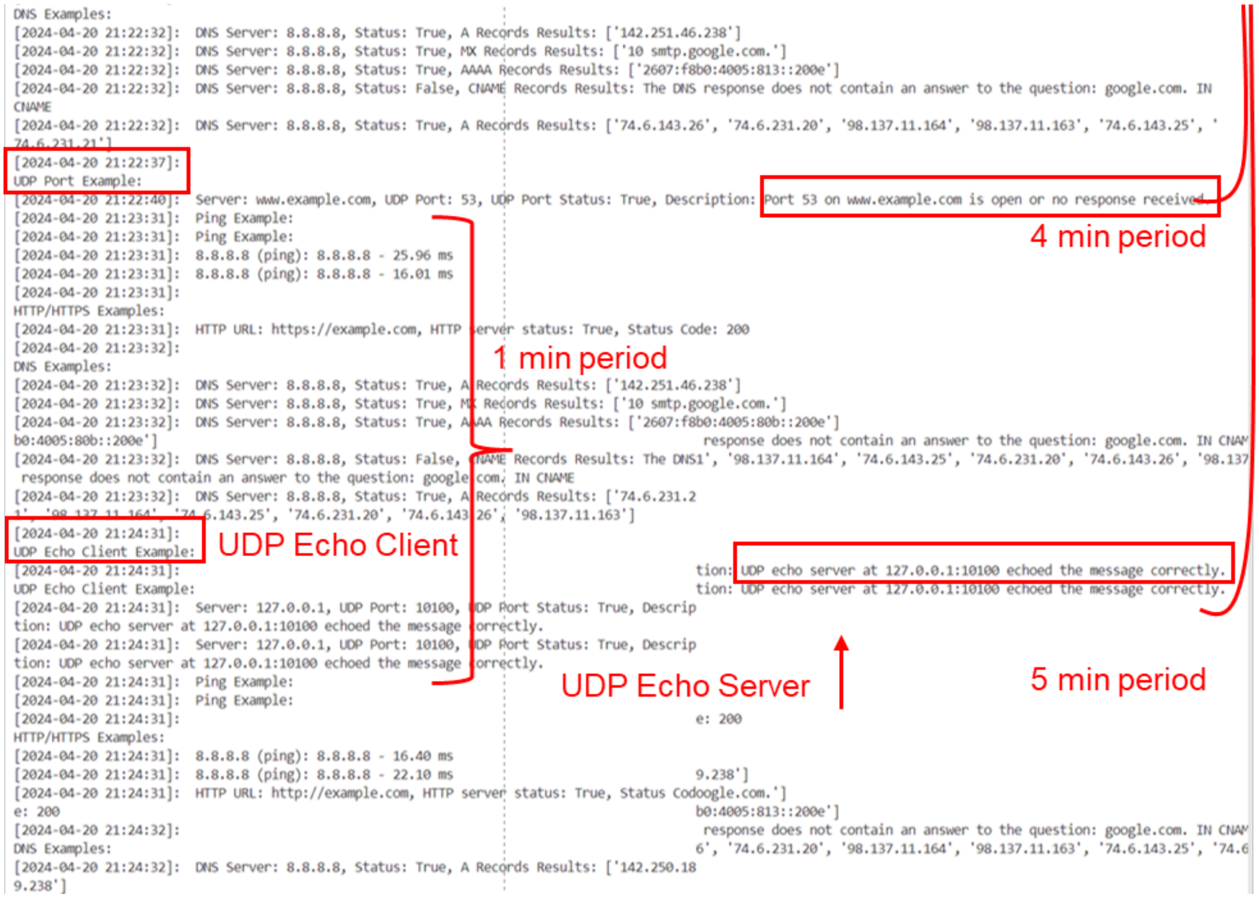
Figure 18 Output of Network Monitoring Server with UDP Echo Client Working



File Edit Selection View Go Run ···
Socket-Programming_Project_1
PROBLEMS OUTPUT TERMINAL DEBUG CONSOLE PORTS
Python: network_monitor_command
4 min period
UDP Echo Client
5 min period
UDP Echo Server
main* 0↓ 10↑ ⊗0 ⚠0 0

```
NTP Example:
[2024-04-20 21:18:31]:
HTTP/HTTPS Examples:
[2024-04-20 21:18:31]:  HTTP URL: http://example.com, HTTP server status: True, Status Code: 200
[2024-04-20 21:18:31]:  pool.ntp.org is up. Time: Sat Apr 20 21:18:32 2024
[2024-04-20 21:18:31]:
DNS Examples:
[2024-04-20 21:18:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.251.214.142']
[2024-04-20 21:18:31]:  DNS Server: 8.8.8.8, Status: True, MX Records Results: ['10 smtp.google.com.']
[2024-04-20 21:18:31]:  DNS Server: 8.8.8.8, Status: True, AAAA Records Results: ['2607:f8b0:4005:813::200e']
[2024-04-20 21:18:31]:  DNS Server: 8.8.8.8, Status: False, CNAME Records Results: The DNS response does not contain an answer to the question: google.com. IN
CNAME
[2024-04-20 21:18:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['74.6.231.21', '98.137.11.164', '74.6.143.25', '74.6.231.20', '74.6.143.26', '98
.137.11.163']
[2024-04-20 21:18:34]:
UDP Port Example:
[2024-04-20 21:18:37]:  Server: www.example.com, UDP Port: 53, UDP Port Status: True, Description: Port 53 on www.example.com is open or no response received.
[2024-04-20 21:19:31]:
UDP Echo Client Example:
[2024-04-20 21:19:31]:
UDP Echo Client Example:
[2024-04-20 21:19:31]:  Server: 127.0.0.1, UDP Port: 10100, UDP Port Status: True, Description: UDP echo server at 127.0.0.1:10100 echoed the message correctly
.
[2024-04-20 21:19:31]:  Server: 127.0.0.1, UDP Port: 10100, UDP Port Status: True, Description: UDP echo server at 127.0.0.1:10100 echoed the message correctly
.
[2024-04-20 21:19:31]:  Ping Example:
[2024-04-20 21:19:31]:  Ping Example:
[2024-04-20 21:19:31]:  8.8.8.8 (ping): 8.8.8.8 - 17.76 ms
[2024-04-20 21:19:31]:  8.8.8.8 (ping): 8.8.8.8 - 17.76 ms
[2024-04-20 21:19:31]:
DNS Examples:
[2024-04-20 21:19:31]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.251.214.142']
[2024-04-20 21:19:31]:  DNS Server: 8.8.8.8, Status: True, MX Records Results: ['10 smtp.google.com.']
[2024-04-20 21:19:32]:  DNS Server: 8.8.8.8, Status: True, AAAA Records Results: ['2607:f8b0:4005:813::200e']
[2024-04-20 21:19:32]:  DNS Server: 8.8.8.8, Status: False, CNAME Records Results: The DNS response does not contain an answer to the question: google.com. IN
CNAME
[2024-04-20 21:19:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['74.6.231.21', '74.6.143.25', '74.6.143.26', '74.6.231.20', '98.137.11.164', '98
.137.11.163']
[2024-04-20 21:20:31]:  Ping Example:
[2024-04-20 21:20:31]:  Ping Example:
[2024-04-20 21:20:31]:  8.8.8.8 (ping): 8.8.8.8 - 16.27 ms
[2024-04-20 21:20:31]:  8.8.8.8 (ping): 8.8.8.8 - 21.92 ms
[2024-04-20 21:20:31]:
HTTP/HTTPS Examples:
[2024-04-20 21:20:31]:  HTTP URL: http://example.com, HTTP server status: True, Status Code: 200
[2024-04-20 21:20:31]:
```

Figure 19 Output of Network Monitoring Server with UDP Echo Client Working



```
DNS Examples:
[2024-04-20 21:22:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.251.46.238']
[2024-04-20 21:22:32]:  DNS Server: 8.8.8.8, Status: True, MX Records Results: ['10 smtp.google.com.']
[2024-04-20 21:22:32]:  DNS Server: 8.8.8.8, Status: True, AAAA Records Results: ['2607:f8b0:4005:813::200e']
[2024-04-20 21:22:32]:  DNS Server: 8.8.8.8, Status: False, CNAME Records Results: The DNS response does not contain an answer to the question: google.com. IN
CNAME
[2024-04-20 21:22:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['74.6.143.26', '74.6.231.20', '98.137.11.164', '98.137.11.163', '74.6.143.25', '
74.6.231.21']
[2024-04-20 21:22:37]:
UDP Port Example:
[2024-04-20 21:22:40]:  Server: www.example.com, UDP Port: 53, UDP Port Status: True, Description: Port 53 on www.example.com is open or no response received.
[2024-04-20 21:23:31]:  Ping Example:
[2024-04-20 21:23:31]:  Ping Example:
[2024-04-20 21:23:31]:  8.8.8.8 (ping): 8.8.8.8 - 25.96 ms
[2024-04-20 21:23:31]:  8.8.8.8 (ping): 8.8.8.8 - 16.01 ms
[2024-04-20 21:23:31]:
HTTP/HTTPS Examples:
[2024-04-20 21:23:31]:  HTTP URL: https://example.com, HTTP server status: True, Status Code: 200
[2024-04-20 21:23:32]:
DNS Examples:
[2024-04-20 21:23:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.251.46.238']
[2024-04-20 21:23:32]:  DNS Server: 8.8.8.8, Status: True, MX Records Results: ['10 smtp.google.com.']
[2024-04-20 21:23:32]:  DNS Server: 8.8.8.8, Status: True, AAAA Records Results: ['2607:f8b0:4005:80b::200e']
b0:4005:80b::200e']                                                                 response does not contain an answer to the question: google.com. IN CNAM
[2024-04-20 21:23:32]:  DNS Server: 8.8.8.8, Status: False, CNAME Records Results: The DNS1', '98.137.11.164', '74.6.143.25', '74.6.231.20', '74.6.143.26', '98.137
 response does not contain an answer to the question: google.com. IN CNAME
[2024-04-20 21:23:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['74.6.231.2
1', '98.137.11.164', '74.6.143.25', '74.6.231.20', '74.6.143.26', '98.137.11.163']
[2024-04-20 21:24:31]:
UDP Echo Client Example:
[2024-04-20 21:24:31]:                                                             tion: UDP echo server at 127.0.0.1:10100 echoed the message correctly.
UDP Echo Client Example:                                                           tion: UDP echo server at 127.0.0.1:10100 echoed the message correctly.
[2024-04-20 21:24:31]:  Server: 127.0.0.1, UDP Port: 10100, UDP Port Status: True, Descrip
tion: UDP echo server at 127.0.0.1:10100 echoed the message correctly.
[2024-04-20 21:24:31]:  Server: 127.0.0.1, UDP Port: 10100, UDP Port Status: True, Descrip
tion: UDP echo server at 127.0.0.1:10100 echoed the message correctly.
[2024-04-20 21:24:31]:  Ping Example:
[2024-04-20 21:24:31]:  Ping Example:
[2024-04-20 21:24:31]:                                                             e: 200
HTTP/HTTPS Examples:
[2024-04-20 21:24:31]:  8.8.8.8 (ping): 8.8.8.8 - 16.40 ms
[2024-04-20 21:24:31]:  8.8.8.8 (ping): 8.8.8.8 - 22.10 ms                         9.238']
[2024-04-20 21:24:31]:  HTTP URL: http://example.com, HTTP server status: True, Status Codoogle.com.']
e: 200                                                                             b0:4005:813::200e']
[2024-04-20 21:24:32]:                                                              response does not contain an answer to the question: google.com. IN CNAM
DNS Examples:                                                                      6', '74.6.231.20', '98.137.11.164', '98.137.11.163', '74.6.143.25', '74.6
[2024-04-20 21:24:32]:  DNS Server: 8.8.8.8, Status: True, A Records Results: ['142.250.18
9.238']
```