

Design Document for ICMP Pinger Lab and Raw Sockets

Luke Pepin, CSE 3300, Tuesday November 12, 2024

Description

Overall Program Design: The program is a Ping application using ICMP to send request and reply messages to a specified host. The application estimates the round-trip time (RTT) for each packet by comparing the sending time and receiving time. It consists of functions for sending and receiving ICMP packets, calculating checksums, and handling timeouts. The main components interact through raw sockets to facilitate low-level network communication, ensuring accurate timing and packet handling.

How It Works: The program begins by creating a raw socket and constructing an ICMP echo request packet with a checksum and a timestamp. This packet is sent to the target host, and the program waits for an echo reply. Upon receiving a reply, the program extracts the timestamp from the packet, calculates the RTT, and prints the result. This process repeats at one-second intervals, providing continuous feedback on the network latency.

Detailed Explanation of Code Between #Fill in Start and #Fill in End:

- **Extracting and Printing Packet Information :**
 - Extracts the ICMP header from the packet.
 - Unpacks the header using `struct.unpack("bbHHh", ICMPheader)` to get type, code, checksum, ID, and sequence number.
- **Verifying the Packet :**
 - Checks if the ICMP type is 0 (echo reply) and if the received ID matches the sent packet ID.
 - If valid, extracts the time data from the packet.
- **Checksum Calculation :**
 - Reconstructs the ICMP header with a zeroed checksum field and combines it with the time data.
 - Calculates the checksum and converts it to network byte order using `htons(calculatedChecksum & 0xffff)`.
 - Compares the calculated checksum with the received checksum.
- **Calculating RTT :**
 - If checksums match, extracts the sending time from the time data.
 - Calculates RTT by subtracting the sending time from the receiving time and converts it to milliseconds.
 - Returns the RTT.

Tradeoffs

The main tradeoff in this design is balancing simplicity and functionality. By focusing on key features like RTT measurement and basic error handling, the program is easy to understand and use. However, this simplicity might affect its accuracy and robustness in more complex network environments.

Extensions

Possible extensions to the program include:

- Adding support for more ICMP message types.
- Implementing better error handling.

- Enhancing the user interface to show detailed statistics like packet loss rate and RTT standard deviation.
- Adding command-line options to specify the number of pings and the TTL value.

Test Cases

As described in the programming assignment document, the following test cases were conducted with their respective screenshots below: Sending packets to localhost, Sending packets to different continents (North America, Asia, Europe, South America), Incorrect IP, and Data loss.

Screenshots

1. Sending packets to localhost (127.0.0.1)

*Due to localhost often `Time.time()` is not precise enough to measure the extremely fast time 0.0ms

```

ICMP.py x lukepin_PA2.md 7
PA2 > ICMP.py > ...
154 def ping(host, timeout=1):
158     print("Pinging " + dest + " using Python:")
159     print("")
160     # Send ping requests to a server separated by approximately one second
161     while 1 :
162         delay = doOnePing(dest, timeout)
163         print(delay)
164         print("_____")
165         time.sleep(1)# one second
166     return delay
167
168 ping('127.0.0.1', 10)
169
PROBLEMS 7 OUTPUT DEBUG CONSOLE TERMINAL PORTS SEARCH ERROR
powershell - PA2 + v
KeyboardInterrupt
PS C:\Users\Luke Pepin\OneDrive\Documents\Academics\PA2> python .\ICMP.py
Ping 127.0.0.1 using Python:

Packet received from: ('127.0.0.1', 0)
Raw packet data: b'E\x00\x00$\xb7\xac\x00\x00\x00\x01\x00\x00\x7f\x00\x00\x01\x7f\x00\x00\x01\x00\x00\x1f\x00(\x01\x00\xa7j>n\xef'
ICMP Header - Type: 0, Code: 0, Checksum: 61471, ID: 10288, Sequence: 1
Time data extracted from packet: b'\xa7j>n\xef\xcc\xd9A'
Combined header and data for checksum: b'\x00\x00\x0000(\x01\x00\xa7j>n\xef\xcc\xd9A'
Calculated checksum: 61471, Received checksum: 61471
Round-trip time (RTT) ms:
0.4487037658691406

Packet received from: ('127.0.0.1', 0)
Raw packet data: b'E\x00\x00$\xb7\xbf\x00\x00\x00\x01\x00\x00\x7f\x00\x00\x01\x7f\x00\x00\x01\x00\x00\xab\xc50(\x01\x00\xdb\x94~n\x'
ICMP Header - Type: 0, Code: 0, Checksum: 50603, ID: 10288, Sequence: 1
Time data extracted from packet: b'\xdb\x94~n\xef\xcc\xd9A'
Combined header and data for checksum: b'\x00\x00\x0000(\x01\x00\xdb\x94~n\xef\xcc\xd9A'
Calculated checksum: 50603, Received checksum: 50603
Round-trip time (RTT) ms:
0.0

Packet received from: ('127.0.0.1', 0)
Raw packet data: b'E\x00\x00$\xb7\xc1\x00\x00\x00\x01\x00\x00\x7f\x00\x00\x01\x7f\x00\x00\x01\x00\x00\x17\x910(\x01\x00/\xc9\xben\x'
ICMP Header - Type: 0, Code: 0, Checksum: 37143, ID: 10288, Sequence: 1
Time data extracted from packet: b' /\xc9\xben\xef\xcc\xd9A'
Combined header and data for checksum: b'\x00\x00\x0000(\x01\x00/\xc9\xben\xef\xcc\xd9A'
Calculated checksum: 37143, Received checksum: 37143
Round-trip time (RTT) ms:
0.0

```

2. Sending packets to different continents:

1. North America (8.8.8.8)


```

ICMP.py x lukepepin_PA2.md 7
PA2 > ICMP.py > ...
154 def ping(host, timeout=1):
155     # timeout=1 means: If one second goes by without a reply from the server,
156     # the client assumes that either the client's ping or the server's pong is lost
157     dest = gethostbyname(host)
158     print("Pinging " + dest + " using Python:")
159     print("")
160     # Send ping requests to a server separated by approximately one second
161     while 1 :
162         delay = doOnePing(dest, timeout)
163         print(delay)
164         print("_____")
165         time.sleep(1)# one second
166     return delay
167
168 ping('1.1.1.1', 5)
169

```

PROBLEMS 7 OUTPUT DEBUG CONSOLE TERMINAL PORTS SEARCH ERROR powershell - PA2 + v

```

PS C:\Users\Luke Pepin\OneDrive\Documents\Academics> cd .\PA2\
PS C:\Users\Luke Pepin\OneDrive\Documents\Academics\PA2> python .\ICMP.py
Pinging 1.1.1.1 using Python:

Packet received from: ('1.1.1.1', 0)
Raw packet data: b'E\x00\x00\xba\xde@\x002\x01\xca7\x01\x01\x01\x01\xc0\xa8\x01\x19\x00\x00v\xfc\xf8\x18\x01\x00R;t\xa0\xef\xcc\xd9'
ICMP Header - Type: 0, Code: 0, Checksum: 64630, ID: 6392, Sequence: 1
Time data extracted from packet: b'R;t\xa0\xef\xcc\xd9A'
Combined header and data for checksum: b'\x00\x00\x00\x00\xf8\x18\x01\x00R;t\xa0\xef\xcc\xd9A'
Calculated checksum: 64630, Received checksum: 64630
Round-trip time (RTT) ms:
23.8950252532959

-----
Packet received from: ('1.1.1.1', 0)
Raw packet data: b'E\x00\x00\xbb\xde@\x002\x01\xc97\x01\x01\x01\x01\xc0\xa8\x01\x19\x00\x00\x3eK\xf8\x18\x01\x00\xf9\xeb\xb5\xa0\xef'
ICMP Header - Type: 0, Code: 0, Checksum: 19342, ID: 6392, Sequence: 1
Time data extracted from packet: b'\xf9\xeb\xb5\xa0\xef\xcc\xd9A'
Combined header and data for checksum: b'\x00\x00\x00\x00\xf8\x18\x01\x00\xf9\xeb\xb5\xa0\xef\xcc\xd9A'
Calculated checksum: 19342, Received checksum: 19342
Round-trip time (RTT) ms:
23.547649383544922

-----
Packet received from: ('1.1.1.1', 0)
Raw packet data: b'E\x00\x00\xbc\xde@\x002\x01\xc87\x01\x01\x01\x01\xc0\xa8\x01\x19\x00\x00\xd1\x94\xf8\x18\x01\x00t\xa2\xf7\xa0\xef'
ICMP Header - Type: 0, Code: 0, Checksum: 38097, ID: 6392, Sequence: 1
Time data extracted from packet: b't\xa2\xf7\xa0\xef\xcc\xd9A'
Combined header and data for checksum: b'\x00\x00\x00\x00\xf8\x18\x01\x00t\xa2\xf7\xa0\xef\xcc\xd9A'
Calculated checksum: 38097, Received checksum: 38097
Round-trip time (RTT) ms:
21.726608276367188

```

3. Europe (93.184.216.34)

```

PA2 > ICMP.py > ...
154 def ping(host, timeout=1):
158     print("Pinging " + dest + " using Python:")
159     print("")
160     # Send ping requests to a server separated by approximately one second
161     while 1 :
162         delay = doOnePing(dest, timeout)
163         print(delay)
164         print("_____")
165         time.sleep(1)# one second
166     return delay
167
168 ping('93.184.216.34', 10)
169

```

PROBLEMS 7 OUTPUT DEBUG CONSOLE **TERMINAL** PORTS SEARCH ERROR powershell - PA2 + v

OSError: [WinError 10049] The requested address is not valid in its context
 PS C:\Users\Luke Pepin\OneDrive\Documents\Academics\PA2> python .\ICMP.py
 Pinging 93.184.216.34 using Python:

Packet received from: ('93.184.216.34', 0)
 Raw packet data: b'E\x00\x00\$-\xd8@\x002\x01\x13e]\xb8\xd8"\xc0\xa8\x01\x19\x00\x00c\xd7\x0cQ\x01\x00\xcf\xb3\xf6\x14\xef\xcc\xd9A'
 ICMP Header - Type: 0, Code: 0, Checksum: 55139, ID: 20748, Sequence: 1
 Time data extracted from packet: b'\xcF\xb3\xf6\x14\xef\xcc\xd9A'
 Combined header and data for checksum: b'\x00\x00\x00\x00\x0cQ\x01\x00\xcf\xb3\xf6\x14\xef\xcc\xd9A'
 Calculated checksum: 55139, Received checksum: 55139
 Round-trip time (RTT) ms:
 24.025678634643555

Packet received from: ('93.184.216.34', 0)
 Raw packet data: b'E\x00\x00\$L\xd8@\x002\x01\x12e]\xb8\xd8"\xc0\xa8\x01\x19\x00\x004+\x0cQ\x01\x00\xbd_8\x15\xef\xcc\xd9A'
 ICMP Header - Type: 0, Code: 0, Checksum: 11060, ID: 20748, Sequence: 1
 Time data extracted from packet: b'\xbd_8\x15\xef\xcc\xd9A'
 Combined header and data for checksum: b'\x00\x00\x00\x00\x0cQ\x01\x00\xbd_8\x15\xef\xcc\xd9A'
 Calculated checksum: 11060, Received checksum: 11060
 Round-trip time (RTT) ms:
 21.036863327026367

Packet received from: ('93.184.216.34', 0)
 Raw packet data: b'E\x00\x00\$L\xd8@\x002\x01\x04e]\xb8\xd8"\xc0\xa8\x01\x19\x00\x00\xf3\xa2\x0cQ\x01\x00\xbc\xe7y\x15\xef\xcc\xd9A'
 ICMP Header - Type: 0, Code: 0, Checksum: 41715, ID: 20748, Sequence: 1
 Time data extracted from packet: b'\xbc\xe7y\x15\xef\xcc\xd9A'
 Combined header and data for checksum: b'\x00\x00\x00\x00\x0cQ\x01\x00\xbc\xe7y\x15\xef\xcc\xd9A'
 Calculated checksum: 41715, Received checksum: 41715
 Round-trip time (RTT) ms:
 20.001649856567383

4. South America (200.160.2.3)

```

ICMP.py x lukepepin_PA2.md 7
PA2 > ICMP.py > ...
154 def ping(host, timeout=1):
158     print("Pinging " + dest + " using Python:")
159     print("")
160     # Send ping requests to a server separated by approximately one second
161     while 1 :
162         delay = doOnePing(dest, timeout)
163         print(delay)
164         print("_____")
165         time.sleep(1)# one second
166     return delay
167
168 ping('200.160.2.3', 10)
169
PROBLEMS 7 OUTPUT DEBUG CONSOLE TERMINAL PORTS SEARCH ERROR powershell - PA2 + v
KeyboardInterrupt
PS C:\Users\Luke Pepin\OneDrive\Documents\Academics\PA2> python .\ICMP.py
Pinging 200.160.2.3 using Python:

Packet received from: ('200.160.2.3', 0)
Raw packet data: b'E\x00\x00$\x9f\xd0@\x00\xec\x01b\x9b\xc8\xa0\x02\x03\xc0\xa8\x01\x19\x00\x00k\xaa\x8c1\x01\x00a\xf4\xdc \xef\xcc'
ICMP Header - Type: 0, Code: 0, Checksum: 43627, ID: 12684, Sequence: 1
Time data extracted from packet: b'a\xf4\xdc \xef\xcc\xd9A'
Combined header and data for checksum: b'\x00\x00\x00\x00\x8c1\x01\x00a\xf4\xdc \xef\xcc\xd9A'
Calculated checksum: 43627, Received checksum: 43627
Round-trip time (RTT) ms:
136.99769973754883

-----
Packet received from: ('200.160.2.3', 0)
Raw packet data: b'E\x00\x00$\xab\xd0@\x00\xec\x01V\x9b\xc8\xa0\x02\x03\xc0\xa8\x01\x19\x00\x00n\xb8\x8c1\x01\x00\x15\xe6%\xef\xcc'
ICMP Header - Type: 0, Code: 0, Checksum: 47214, ID: 12684, Sequence: 1
Time data extracted from packet: b'\x15\xe6%\xef\xcc\xd9A'
Combined header and data for checksum: b'\x00\x00\x00\x00\x8c1\x01\x00\x15\xe6%\xef\xcc\xd9A'
Calculated checksum: 47214, Received checksum: 47214
Round-trip time (RTT) ms:
134.99999046325684

-----
Packet received from: ('200.160.2.3', 0)
Raw packet data: b'E\x00\x00$\xac\xd0@\x00\xec\x01U\x9b\xc8\xa0\x02\x03\xc0\xa8\x01\x19\x00\x00b9\xd7\x8c1\x01\x00\x81\xc6n!\xef\xcc'
ICMP Header - Type: 0, Code: 0, Checksum: 55225, ID: 12684, Sequence: 1
Time data extracted from packet: b'\x81\xc6n!\xef\xcc\xd9A'
Combined header and data for checksum: b'\x00\x00\x00\x00\x8c1\x01\x00\x81\xc6n!\xef\xcc\xd9A'
Calculated checksum: 55225, Received checksum: 55225
Round-trip time (RTT) ms:
134.96875762939453

```

3. Incorrect IP (0.0.0.0)

```

PA2 > ICMP.py > ...
154 def ping(host, timeout=1):
155     # timeout=1 means: If one second goes by without a reply from the server,
156     # the client assumes that either the client's ping or the server's pong is lost
157     dest = gethostbyname(host)
158     print("Pinging " + dest + " using Python:")
159     print("")
160     # Send ping requests to a server separated by approximately one second
161     while 1:
162         delay = doOnePing(dest, timeout)
163         print(delay)
164         print("_____")
165         time.sleep(1)# one second
166     return delay
167
168 ping('0.0.0.0', 10)
169

```

PROBLEMS 9 OUTPUT DEBUG CONSOLE TERMINAL PORTS SEARCH ERROR powershell - PA2 + v

```

Pinging 0.0.0.0 using Python:
PS C:\Users\Luke Pepin\OneDrive\Documents\Academics\PA2> python .\ICMP.py
Pinging 0.0.0.0 using Python:

Traceback (most recent call last):
  File "C:\Users\Luke Pepin\OneDrive\Documents\Academics\PA2\ICMP.py", line 168, in <module>
    ping('0.0.0.0', 10)
  File "C:\Users\Luke Pepin\OneDrive\Documents\Academics\PA2\ICMP.py", line 162, in ping
    delay = doOnePing(dest, timeout)

Traceback (most recent call last):
  File "C:\Users\Luke Pepin\OneDrive\Documents\Academics\PA2\ICMP.py", line 168, in <module>
    ping('0.0.0.0', 10)
  File "C:\Users\Luke Pepin\OneDrive\Documents\Academics\PA2\ICMP.py", line 162, in ping
    delay = doOnePing(dest, timeout)

Traceback (most recent call last):
  File "C:\Users\Luke Pepin\OneDrive\Documents\Academics\PA2\ICMP.py", line 168, in <module>
    ping('0.0.0.0', 10)
  File "C:\Users\Luke Pepin\OneDrive\Documents\Academics\PA2\ICMP.py", line 162, in ping
    delay = doOnePing(dest, timeout)
  File "C:\Users\Luke Pepin\OneDrive\Documents\Academics\PA2\ICMP.py", line 168, in <module>
    ping('0.0.0.0', 10)
  File "C:\Users\Luke Pepin\OneDrive\Documents\Academics\PA2\ICMP.py", line 162, in ping
    delay = doOnePing(dest, timeout)
  File "C:\Users\Luke Pepin\OneDrive\Documents\Academics\PA2\ICMP.py", line 162, in ping
    delay = doOnePing(dest, timeout)
  File "C:\Users\Luke Pepin\OneDrive\Documents\Academics\PA2\ICMP.py", line 148, in doOnePing
  File "C:\Users\Luke Pepin\OneDrive\Documents\Academics\PA2\ICMP.py", line 148, in doOnePing
    sendOnePing(mySocket, destAddr, myID)
    sendOnePing(mySocket, destAddr, myID)

```

4. Data Loss (127.0.0.1 + Disconnect During Program)

