TELE6510

Professor Herrero

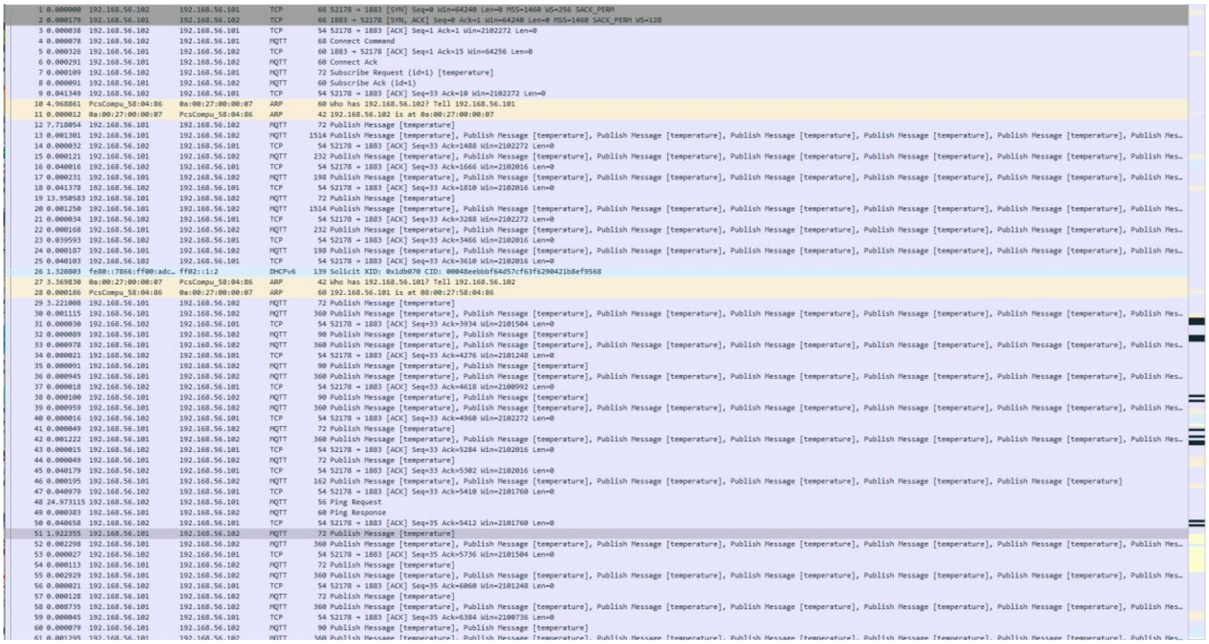
Wenyi Cai

Dec 12, 2022

Project

MQTT

1.

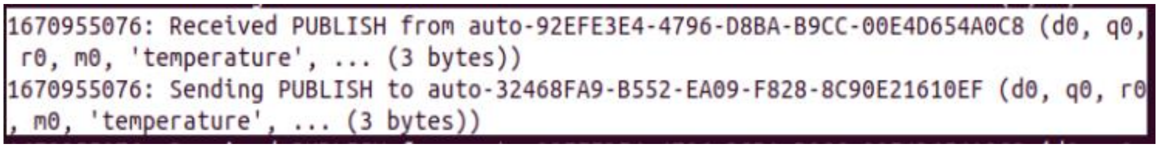


```
 1 0.000000  192.168.56.102     192.168.56.101     TCP      66 52178 → 1883 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM
 2 0.000179  192.168.56.101     192.168.56.102     TCP      66 1883 → 52178 [SYN, ACK] Seq=0 Ack=1 Win=64240 Len=0 MSS=1460 SACK_PERM WS=128
 3 0.000038  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=1 Ack=1 Win=2102272 Len=0
 4 0.000078  192.168.56.102     192.168.56.101     MQTT     68 Connect Command
 5 0.000326  192.168.56.101     192.168.56.102     TCP      60 1883 → 52178 [ACK] Seq=1 Ack=15 Win=64256 Len=0
 6 0.000291  192.168.56.101     192.168.56.102     MQTT     60 Connect Ack
 7 0.000109  192.168.56.102     192.168.56.101     MQTT     72 Subscribe Request (id=1) [temperature]
 8 0.000091  192.168.56.101     192.168.56.102     MQTT     60 Subscribe Ack (id=1)
 9 0.041349  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=33 Ack=10 Win=2102272 Len=0
10 4.968861  PcsCompu_58:04:86  0a:00:27:00:00:07  ARP      60 Who has 192.168.56.102? Tell 192.168.56.101
11 0.000012  0a:00:27:00:00:07  PcsCompu_58:04:86  ARP      42 192.168.56.102 is at 0a:00:27:00:00:07
12 7.718054  192.168.56.101     192.168.56.102     MQTT     72 Publish Message [temperature]
13 0.001301  192.168.56.101     192.168.56.102     MQTT   1514 Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Mes…
14 0.000032  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=33 Ack=1488 Win=2102272 Len=0
15 0.000121  192.168.56.101     192.168.56.102     MQTT    232 Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Mes…
16 0.040016  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=33 Ack=1666 Win=2102016 Len=0
17 0.000231  192.168.56.101     192.168.56.102     MQTT    198 Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Mes…
18 0.041378  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=33 Ack=1810 Win=2102016 Len=0
19 13.950583 192.168.56.101     192.168.56.102     MQTT     72 Publish Message [temperature]
20 0.001250  192.168.56.101     192.168.56.102     MQTT   1514 Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Mes…
21 0.000034  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=33 Ack=3288 Win=2102272 Len=0
22 0.000168  192.168.56.101     192.168.56.102     MQTT    232 Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Mes…
23 0.039593  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=33 Ack=3466 Win=2102016 Len=0
24 0.000187  192.168.56.101     192.168.56.102     MQTT    198 Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Mes…
25 0.040103  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=33 Ack=3610 Win=2102016 Len=0
26 1.320803  fe80::7866:ff00:adc… ff02::1:2        DHCPv6  139 Solicit XID: 0x1db070 CID: 00048eebbbf64d57cf63f6290421b8ef9568
27 3.369830  0a:00:27:00:00:07  PcsCompu_58:04:86  ARP      42 Who has 192.168.56.101? Tell 192.168.56.102
28 0.000186  PcsCompu_58:04:86  0a:00:27:00:00:07  ARP      60 192.168.56.101 is at 08:00:27:58:04:86
29 3.221008  192.168.56.101     192.168.56.102     MQTT     72 Publish Message [temperature]
30 0.001115  192.168.56.101     192.168.56.102     MQTT    360 Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Mes…
31 0.000030  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=33 Ack=3934 Win=2101504 Len=0
32 0.000089  192.168.56.101     192.168.56.102     MQTT     90 Publish Message [temperature], Publish Message [temperature]
33 0.000978  192.168.56.101     192.168.56.102     MQTT    360 Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Mes…
34 0.000021  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=33 Ack=4276 Win=2101248 Len=0
35 0.000091  192.168.56.101     192.168.56.102     MQTT     90 Publish Message [temperature], Publish Message [temperature]
36 0.000945  192.168.56.101     192.168.56.102     MQTT    360 Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Mes…
37 0.000018  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=33 Ack=4618 Win=2100992 Len=0
38 0.000100  192.168.56.101     192.168.56.102     MQTT     90 Publish Message [temperature], Publish Message [temperature]
39 0.000959  192.168.56.101     192.168.56.102     MQTT    360 Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Mes…
40 0.000016  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=33 Ack=4960 Win=2102272 Len=0
41 0.000049  192.168.56.101     192.168.56.102     MQTT     72 Publish Message [temperature]
42 0.001222  192.168.56.101     192.168.56.102     MQTT    360 Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Mes…
43 0.000015  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=33 Ack=5284 Win=2102016 Len=0
44 0.000049  192.168.56.101     192.168.56.102     MQTT     72 Publish Message [temperature]
45 0.040179  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=33 Ack=5302 Win=2102016 Len=0
46 0.000195  192.168.56.101     192.168.56.102     MQTT    162 Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature]
47 0.040979  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=33 Ack=5410 Win=2101760 Len=0
48 24.973115 192.168.56.102     192.168.56.101     MQTT     56 Ping Request
49 0.000383  192.168.56.101     192.168.56.102     MQTT     60 Ping Response
50 0.040658  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=35 Ack=5412 Win=2101760 Len=0
51 1.922355  192.168.56.101     192.168.56.102     MQTT     72 Publish Message [temperature]
52 0.002298  192.168.56.101     192.168.56.102     MQTT    360 Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Mes…
53 0.000027  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=35 Ack=5736 Win=2101504 Len=0
54 0.000113  192.168.56.101     192.168.56.102     MQTT     72 Publish Message [temperature]
55 0.002929  192.168.56.101     192.168.56.102     MQTT    360 Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Mes…
56 0.000021  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=35 Ack=6060 Win=2101248 Len=0
57 0.000128  192.168.56.101     192.168.56.102     MQTT     72 Publish Message [temperature]
58 0.008735  192.168.56.101     192.168.56.102     MQTT    360 Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Mes…
59 0.000045  192.168.56.102     192.168.56.101     TCP      54 52178 → 1883 [ACK] Seq=35 Ack=6384 Win=2100736 Len=0
60 0.000079  192.168.56.101     192.168.56.102     MQTT     90 Publish Message [temperature], Publish Message [temperature]
61 0.001295  192.168.56.101     192.168.56.102     MQTT    360 Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Message [temperature], Publish Mes…
```

2.

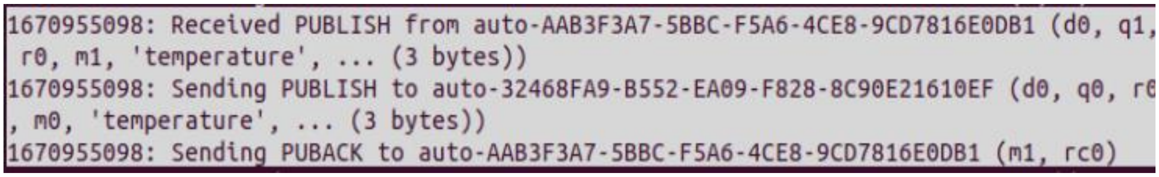
MQTT Packet Loss vs.Latency			
Package Loss	QOS 0	QoS 1	QoS 2
0%	0.041378s	0.040103s	0.040979s
2%	0.041493s	0.041035s	0.041192s
4%	0.040201s	0.040508s	0.040260s
8%	0.040419s	0.040107s	0.039922s

3.



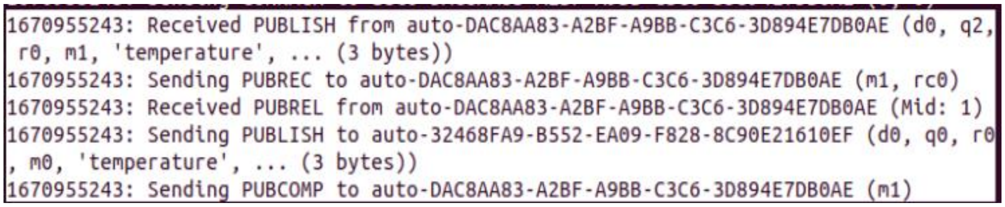
```
1670955076: Received PUBLISH from auto-92EFE3E4-4796-D8BA-B9CC-00E4D654A0C8 (d0, q0,
 r0, m0, 'temperature', ... (3 bytes))
1670955076: Sending PUBLISH to auto-32468FA9-B552-EA09-F828-8C90E21610EF (d0, q0, r0
, m0, 'temperature', ... (3 bytes))
```

At QoS 0, broker displays only two messages: “sending PUBLISH to xxxx (d0,q0,r0,m0, ‘temperature’, …..(3Bytes))” and “Received PUBLISH from xxxx(d0,q0,r0,m0, ‘temperature’, …..(3Bytes))”. These messages contain publisher’s name, debug message (d0), QoS level(q) , retained message(r), message payload to send(m), topic(temperature), and so on. All the data is 3 bytes.



```
1670955098: Received PUBLISH from auto-AAB3F3A7-5BBC-F5A6-4CE8-9CD7816E0DB1 (d0, q1,
 r0, m1, 'temperature', ... (3 bytes))
1670955098: Sending PUBLISH to auto-32468FA9-B552-EA09-F828-8C90E21610EF (d0, q0, r0
, m0, 'temperature', ... (3 bytes))
1670955098: Sending PUBACK to auto-AAB3F3A7-5BBC-F5A6-4CE8-9CD7816E0DB1 (m1, rc0)
```

At QoS 1, broker displays an additional message “sending PUBACK to xxxx (m1, rc0)”. Since QoS 1 requires the broke to guarantee the message is send exactly one time, the brock should send back an acknowledgement to confirm. The m stands for message/packet number, and rc stands for recovery. Rc0 means no recovery needed.



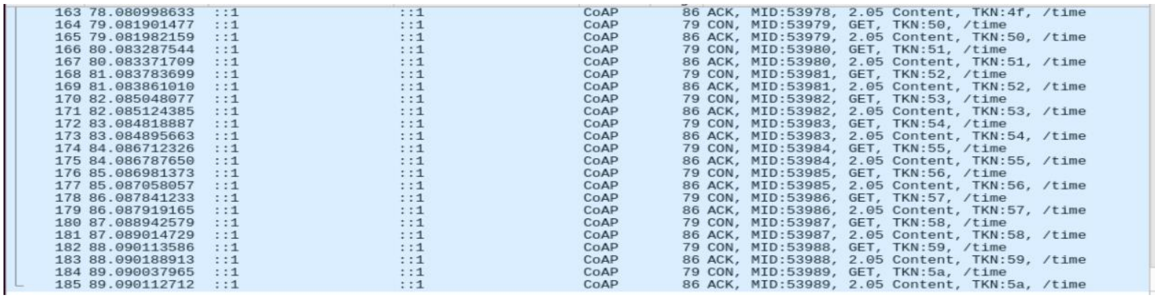
```
1670955243: Received PUBLISH from auto-DAC8AA83-A2BF-A9BB-C3C6-3D894E7DB0AE (d0, q2,
 r0, m1, 'temperature', ... (3 bytes))
1670955243: Sending PUBREC to auto-DAC8AA83-A2BF-A9BB-C3C6-3D894E7DB0AE (m1, rc0)
1670955243: Received PUBREL from auto-DAC8AA83-A2BF-A9BB-C3C6-3D894E7DB0AE (Mid: 1)
1670955243: Sending PUBLISH to auto-32468FA9-B552-EA09-F828-8C90E21610EF (d0, q0, r0
, m0, 'temperature', ... (3 bytes))
1670955243: Sending PUBCOMP to auto-DAC8AA83-A2BF-A9BB-C3C6-3D894E7DB0AE (m1)
```

At QoS 2, broker display two additional message to guarantee the device will send message at most once. After receiving the PUBLISH message like QoS0, the broke will soon send back an acknowledgement- PUBREC to confirm the message number and recovery. Next, the broker will receive another acknowledgement PUBREL as reply to confirm the message id. Once the id confirmed, the broker will soon send PUBLISH and PUBCOMP to display message and confirmed publish completion.

4. According to the capture from Wireshark, a single message contains 72 bytes. Therefore, the transmission rate will be: $DTR = \frac{72*8*100}{0.04} = 1.44Mbps$
5. Theoretically, with the increasing of QoS level, the latency will be increasing. It happens because in QoS 0, message will be send at most one time. There is no confirmation needed. However, when the QoS level reach to 1 and 2, broker needs to send acknowledgement message to confirm the readout is send exactly one time or at most one time.

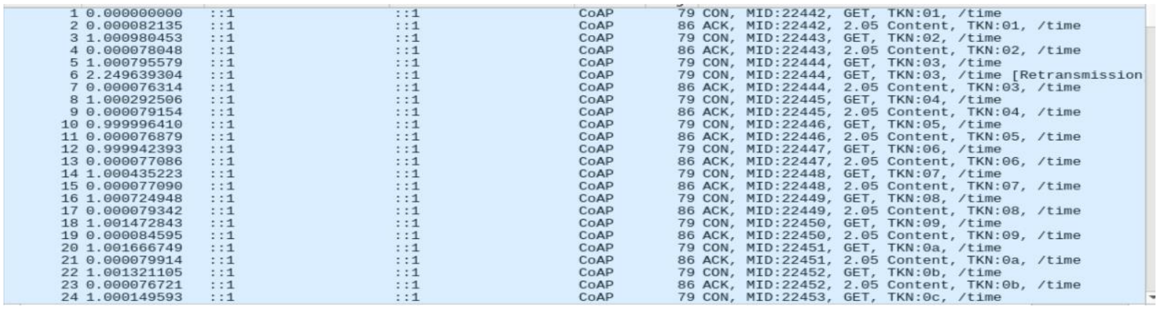
CoAP

1. Confirmable screenshot:



```
    163 78.080998633  ::1                 ::1                 CoAP       86 ACK, MID:53978, 2.05 Content, TKN:4f, /time
    164 79.081901477  ::1                 ::1                 CoAP       79 CON, MID:53979, GET, TKN:50, /time
    165 79.081982159  ::1                 ::1                 CoAP       86 ACK, MID:53979, 2.05 Content, TKN:50, /time
    166 80.083287544  ::1                 ::1                 CoAP       79 CON, MID:53980, GET, TKN:51, /time
    167 80.083371709  ::1                 ::1                 CoAP       86 ACK, MID:53980, 2.05 Content, TKN:51, /time
    168 81.083783699  ::1                 ::1                 CoAP       79 CON, MID:53981, GET, TKN:52, /time
    169 81.083861010  ::1                 ::1                 CoAP       86 ACK, MID:53981, 2.05 Content, TKN:52, /time
    170 82.085048077  ::1                 ::1                 CoAP       79 CON, MID:53982, GET, TKN:53, /time
    171 82.085124385  ::1                 ::1                 CoAP       86 ACK, MID:53982, 2.05 Content, TKN:53, /time
    172 83.084818887  ::1                 ::1                 CoAP       79 CON, MID:53983, GET, TKN:54, /time
    173 83.084895663  ::1                 ::1                 CoAP       86 ACK, MID:53983, 2.05 Content, TKN:54, /time
    174 84.086712326  ::1                 ::1                 CoAP       79 CON, MID:53984, GET, TKN:55, /time
    175 84.086787650  ::1                 ::1                 CoAP       86 ACK, MID:53984, 2.05 Content, TKN:55, /time
    176 85.086981373  ::1                 ::1                 CoAP       79 CON, MID:53985, GET, TKN:56, /time
    177 85.087058057  ::1                 ::1                 CoAP       86 ACK, MID:53985, 2.05 Content, TKN:56, /time
    178 86.087841233  ::1                 ::1                 CoAP       79 CON, MID:53986, GET, TKN:57, /time
    179 86.087919165  ::1                 ::1                 CoAP       86 ACK, MID:53986, 2.05 Content, TKN:57, /time
    180 87.088942579  ::1                 ::1                 CoAP       79 CON, MID:53987, GET, TKN:58, /time
    181 87.089014729  ::1                 ::1                 CoAP       86 ACK, MID:53987, 2.05 Content, TKN:58, /time
    182 88.090113586  ::1                 ::1                 CoAP       79 CON, MID:53988, GET, TKN:59, /time
    183 88.090188913  ::1                 ::1                 CoAP       86 ACK, MID:53988, 2.05 Content, TKN:59, /time
    184 89.090037965  ::1                 ::1                 CoAP       79 CON, MID:53989, GET, TKN:5a, /time
    185 89.090112712  ::1                 ::1                 CoAP       86 ACK, MID:53989, 2.05 Content, TKN:5a, /time
```

Non-confirmable screenshot:

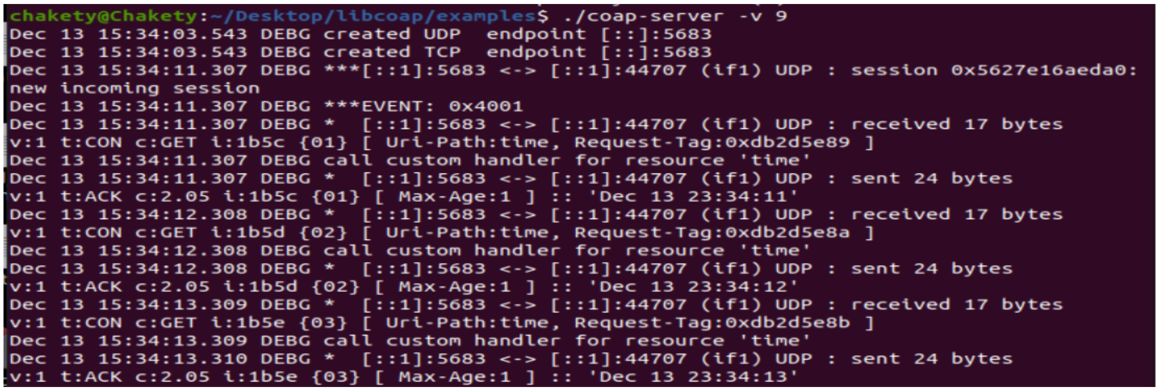


```
      1 0.000000000   ::1                 ::1                 CoAP       79 CON, MID:22442, GET, TKN:01, /time
      2 0.000082135   ::1                 ::1                 CoAP       86 ACK, MID:22442, 2.05 Content, TKN:01, /time
      3 1.000980453   ::1                 ::1                 CoAP       79 CON, MID:22443, GET, TKN:02, /time
      4 0.000078048   ::1                 ::1                 CoAP       86 ACK, MID:22443, 2.05 Content, TKN:02, /time
      5 1.000795579   ::1                 ::1                 CoAP       79 CON, MID:22444, GET, TKN:03, /time
      6 2.249639304   ::1                 ::1                 CoAP       79 CON, MID:22444, GET, TKN:03, /time [Retransmission
      7 0.000076314   ::1                 ::1                 CoAP       86 ACK, MID:22444, 2.05 Content, TKN:03, /time
      8 1.000292506   ::1                 ::1                 CoAP       79 CON, MID:22445, GET, TKN:04, /time
      9 0.000079154   ::1                 ::1                 CoAP       86 ACK, MID:22445, 2.05 Content, TKN:04, /time
     10 0.999996410   ::1                 ::1                 CoAP       79 CON, MID:22446, GET, TKN:05, /time
     11 0.000076879   ::1                 ::1                 CoAP       86 ACK, MID:22446, 2.05 Content, TKN:05, /time
     12 0.999942393   ::1                 ::1                 CoAP       79 CON, MID:22447, GET, TKN:06, /time
     13 0.000077086   ::1                 ::1                 CoAP       86 ACK, MID:22447, 2.05 Content, TKN:06, /time
     14 1.000435223   ::1                 ::1                 CoAP       79 CON, MID:22448, GET, TKN:07, /time
     15 0.000077090   ::1                 ::1                 CoAP       86 ACK, MID:22448, 2.05 Content, TKN:07, /time
     16 1.000724948   ::1                 ::1                 CoAP       79 CON, MID:22449, GET, TKN:08, /time
     17 0.000079342   ::1                 ::1                 CoAP       86 ACK, MID:22449, 2.05 Content, TKN:08, /time
     18 1.001472843   ::1                 ::1                 CoAP       79 CON, MID:22450, GET, TKN:09, /time
     19 0.000084595   ::1                 ::1                 CoAP       86 ACK, MID:22450, 2.05 Content, TKN:09, /time
     20 1.001666749   ::1                 ::1                 CoAP       79 CON, MID:22451, GET, TKN:0a, /time
     21 0.000079914   ::1                 ::1                 CoAP       86 ACK, MID:22451, 2.05 Content, TKN:0a, /time
     22 1.001321105   ::1                 ::1                 CoAP       79 CON, MID:22452, GET, TKN:0b, /time
     23 0.000076721   ::1                 ::1                 CoAP       86 ACK, MID:22452, 2.05 Content, TKN:0b, /time
     24 1.000149593   ::1                 ::1                 CoAP       79 CON, MID:22453, GET, TKN:0c, /time
```

2.

CoAP Packet Loss vs.Latency		
Package Loss	comfirmable	non-comfirmable
0%	0.000083705s	0.000076148s
2%	0.000080928s	0.000076617s
4%	0.000077474s	0.000078029s
8%	0.000075279s	0.000074986s

3.



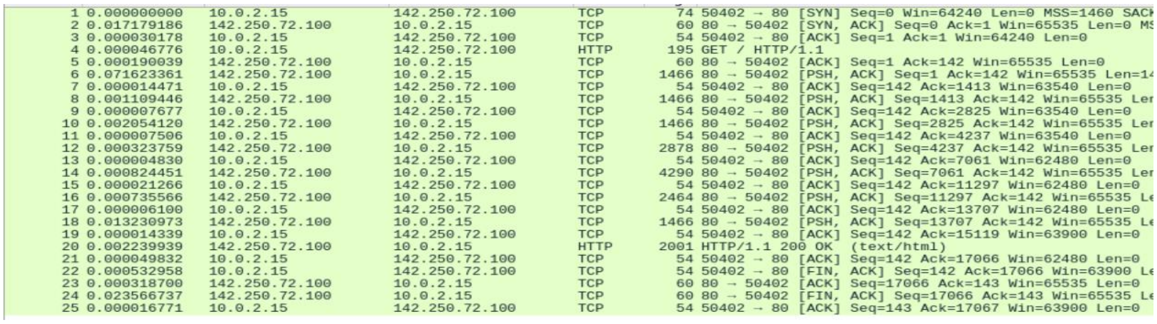
```
chakety@Chakety:~/Desktop/libcoap/examples$ ./coap-server -v 9
Dec 13 15:34:03.543 DEBG created UDP  endpoint [::]:5683
Dec 13 15:34:03.543 DEBG created TCP  endpoint [::]:5683
Dec 13 15:34:11.307 DEBG ***[::1]:5683 <-> [::1]:44707 (if1) UDP : session 0x5627e16aeda0:
new incoming session
Dec 13 15:34:11.307 DEBG ***EVENT: 0x4001
Dec 13 15:34:11.307 DEBG *  [::1]:5683 <-> [::1]:44707 (if1) UDP : received 17 bytes
v:1 t:CON c:GET i:1b5c {01} [ Uri-Path:time, Request-Tag:0xdb2d5e89 ]
Dec 13 15:34:11.307 DEBG call custom handler for resource 'time'
Dec 13 15:34:11.307 DEBG *  [::1]:5683 <-> [::1]:44707 (if1) UDP : sent 24 bytes
v:1 t:ACK c:2.05 i:1b5c {01} [ Max-Age:1 ] :: 'Dec 13 23:34:11'
Dec 13 15:34:12.308 DEBG *  [::1]:5683 <-> [::1]:44707 (if1) UDP : received 17 bytes
v:1 t:CON c:GET i:1b5d {02} [ Uri-Path:time, Request-Tag:0xdb2d5e8a ]
Dec 13 15:34:12.308 DEBG call custom handler for resource 'time'
Dec 13 15:34:12.308 DEBG *  [::1]:5683 <-> [::1]:44707 (if1) UDP : sent 24 bytes
v:1 t:ACK c:2.05 i:1b5d {02} [ Max-Age:1 ] :: 'Dec 13 23:34:12'
Dec 13 15:34:13.309 DEBG *  [::1]:5683 <-> [::1]:44707 (if1) UDP : received 17 bytes
v:1 t:CON c:GET i:1b5e {03} [ Uri-Path:time, Request-Tag:0xdb2d5e8b ]
Dec 13 15:34:13.309 DEBG call custom handler for resource 'time'
Dec 13 15:34:13.310 DEBG *  [::1]:5683 <-> [::1]:44707 (if1) UDP : sent 24 bytes
v:1 t:ACK c:2.05 i:1b5e {03} [ Max-Age:1 ] :: 'Dec 13 23:34:13'
```

When the communication channel set up, the client will send a CON to the sever includes methods, uri-path, request, tag, and UDP protocols. Once the server confirmed the message, it will soon send back the ACK message which includes Max-Age, port number and UDP protocols.

4. $DTR_{client} = \frac{79*8*100}{0.000083705} = 755.03Mbps$ $DTR_{server} = \frac{86*8*100}{0.00083705} = 812.93Mbps$

HTTP

1.

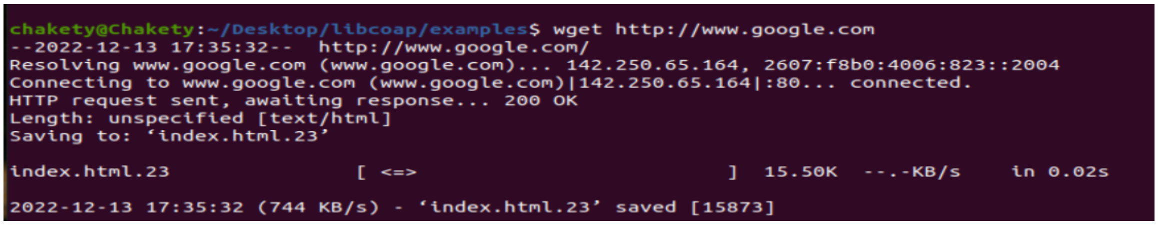


```
 1 0.000000000  10.0.2.15       142.250.72.100  TCP    74 50402 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 SACK
 2 0.017179186  142.250.72.100  10.0.2.15       TCP    60 80 → 50402 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MS
 3 0.000030178  10.0.2.15       142.250.72.100  TCP    54 50402 → 80 [ACK] Seq=1 Ack=1 Win=64240 Len=0
 4 0.000046776  10.0.2.15       142.250.72.100  HTTP  195 GET / HTTP/1.1
 5 0.000190039  142.250.72.100  10.0.2.15       TCP    60 80 → 50402 [ACK] Seq=1 Ack=142 Win=65535 Len=0
 6 0.071623361  142.250.72.100  10.0.2.15       TCP  1466 80 → 50402 [PSH, ACK] Seq=1 Ack=142 Win=65535 Len=14
 7 0.000014471  10.0.2.15       142.250.72.100  TCP    54 50402 → 80 [ACK] Seq=142 Ack=1413 Win=63540 Len=0
 8 0.001109446  142.250.72.100  10.0.2.15       TCP  1466 80 → 50402 [PSH, ACK] Seq=1413 Ack=142 Win=65535 Len
 9 0.000007677  10.0.2.15       142.250.72.100  TCP    54 50402 → 80 [ACK] Seq=142 Ack=2825 Win=63540 Len=0
10 0.002054120  142.250.72.100  10.0.2.15       TCP  1466 80 → 50402 [PSH, ACK] Seq=2825 Ack=142 Win=65535 Len
11 0.000007506  10.0.2.15       142.250.72.100  TCP    54 50402 → 80 [ACK] Seq=142 Ack=4237 Win=63540 Len=0
12 0.000323759  142.250.72.100  10.0.2.15       TCP  2878 80 → 50402 [PSH, ACK] Seq=4237 Ack=142 Win=65535 Len
13 0.000004830  10.0.2.15       142.250.72.100  TCP    54 50402 → 80 [ACK] Seq=142 Ack=7061 Win=62480 Len=0
14 0.000824451  142.250.72.100  10.0.2.15       TCP  4290 80 → 50402 [PSH, ACK] Seq=7061 Ack=142 Win=65535 Len
15 0.000021266  10.0.2.15       142.250.72.100  TCP    54 50402 → 80 [ACK] Seq=142 Ack=11297 Win=62480 Len=0
16 0.000735566  142.250.72.100  10.0.2.15       TCP  2464 80 → 50402 [PSH, ACK] Seq=11297 Ack=142 Win=65535 Le
17 0.000006100  10.0.2.15       142.250.72.100  TCP    54 50402 → 80 [ACK] Seq=142 Ack=13707 Win=62480 Len=0
18 0.013230973  142.250.72.100  10.0.2.15       TCP  1466 80 → 50402 [PSH, ACK] Seq=13707 Ack=142 Win=65535 Le
19 0.000014339  10.0.2.15       142.250.72.100  TCP    54 50402 → 80 [ACK] Seq=142 Ack=15119 Win=63900 Len=0
20 0.002239939  142.250.72.100  10.0.2.15       HTTP 2001 HTTP/1.1 200 OK  (text/html)
21 0.000049832  10.0.2.15       142.250.72.100  TCP    54 50402 → 80 [ACK] Seq=142 Ack=17066 Win=62480 Len=0
22 0.000532958  10.0.2.15       142.250.72.100  TCP    54 50402 → 80 [FIN, ACK] Seq=142 Ack=17066 Win=63900 Le
23 0.000318700  142.250.72.100  10.0.2.15       TCP    60 80 → 50402 [ACK] Seq=17066 Ack=143 Win=65535 Len=0
24 0.023566737  142.250.72.100  10.0.2.15       TCP    60 80 → 50402 [FIN, ACK] Seq=17066 Ack=143 Win=65535 Le
25 0.000016771  10.0.2.15       142.250.72.100  TCP    54 50402 → 80 [ACK] Seq=143 Ack=17067 Win=63900 Len=0
```

2.

HTTP Packet Loss vs.Latency	
Package Loss	Latency
0%	0.000015092s
2%	0.000016771s
4%	0.000013940s
8%	0.000015120s

3.



```
chakety@Chakety:~/Desktop/libcoap/examples$ wget http://www.google.com
--2022-12-13 17:35:32--  http://www.google.com/
Resolving www.google.com (www.google.com)... 142.250.65.164, 2607:f8b0:4006:823::2004
Connecting to www.google.com (www.google.com)|142.250.65.164|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: unspecified [text/html]
Saving to: ‘index.html.23’

index.html.23               [ <=>                             ]  15.50K  --.-KB/s    in 0.02s

2022-12-13 17:35:32 (744 KB/s) - ‘index.html.23’ saved [15873]
```

When the client send request to the server, it will resolving the IP address, and try to connect it. The HTTP will sent a request and waiting for the response, if it receive a response with 200, it means ok to access. Next, the client to be notified the webpage length and where to save it. With a short time of downloading, it will be saved automatically.

4.

Protocol	MQTT	CoAP	HTTP
Properties	Publish-subscribe model	Request-Response Model	Request-Response Model
	Using TCP protocol	Using UDP protocl	Using TCP protocol
	QoS	comfirmable non-comfirmable	/
	contains multiple topics	One to One	One to One
	Data Centric	Document centric.	Document centric.

5. $DTR = 744\ Kbs$