Assignment 3

COMP6331 – COMPUTER NETWORKS
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Question 1

The three channels were subscribed using matching QoS and the data capture with Wireshark for each of them are shown below. Filter was applied to show the traffic between 3310exp.hopto.org (broker) and the client.

Slow Counter q0

The command used to subscribe to the first counter, Q0, is:

Acknowledge:

We can see that the MQTT is using the TCP to communicate with the broker. First of the MQTT commands is a Connect command which is sent from the client to the broker. The first four bits of the header flag, 0001, show this in the figure above. The next four bits, 0000, show that the Duplicate (DUP) is not set, Quality of Service (QoS) is set at 00 which is Fire and Forget, and the Retain flag is not set also.

Connect Acknowledge:

The second of the command is sent from the broker to the client and is a Connect Acknowledge. The return code is 0 which means the broker has authorized and the username and password provided in the Connect command before were valid.

Subscribe Request:

```
176 3.368980738
                          52.65.194.50
                                                      192.168.111.4
                                                                                                 71 Subscribe Ack
   177 3.412824409
                          192.168.111.4
                                                      52.65.194.50
                                                                                  TCP
                                                                                                66 36990 → 1883 [ACK] Seq=72 Ack=10
   178 3.532057670
                          52.65.194.50
                                                      192.168.111.4
                                                                                 MQTT
                                                                                                88 Publish Message
                                                                                                66 36990 →
                                                                                                               1883 [ACK] Sen=72 Ack=32
   179 3 532094064
                          192 168 111 A
                                                      52 65 194 50
                                                                                 TCP
Frame 175: 88 bytes on wire (704 bits), 88 bytes captured (704 bits) on interface 0
Ethernet II, Src: Dell_27:fa:db (14:b3:1f:27:fa:db), Dst: IntelCor_d9:b1:72 (00:15:17:d9:b1:72) Internet Protocol Version 4, Src: 192.168.111.4, Dst: 52.65.194.50 Transmission Control Protocol, Src Port: 36990, Dst Port: 1883, Seq: 50, Ack: 5, Len: 22
MQ Telemetry Transport Protocol, Subscribe Request

▼ Header Flags: 0x82 (Subscribe Request)
                                                 ibe Request (8)
        .... 0... = DUP Flag: Not set
       .... .01. = QoS Level: At least once delivery (Acknowledged deliver) (1) .... ...0 = Retain: Not set
    Msg Len: 20
    Message Identifier: 1
    Topic Length: 15
    Topic: counter/slow/q0
    Requested QoS: At most once delivery (Fire and Forget) (0)
```

When the client receives the Connect Acknowledge command it sends a Subscribe Request as the third command. The QoS level is set at 01 to make sure the request is delivered at least once to the broker. The topic requested can also be seen as 'counter/slow/q0'.

Subscribe Ack:

```
177 3.412824409
                      192.168.111.4
                                             52.65.194.50
                                                                    TCP
                                                                                66 36990 → 1883 [ACK] Seq=72 Ack
                                                                               88 Publish Message
                                                                   MOTT
   178 3.532057670
                      52.65.194.50
                                             192.168.111.4
                      192 168 111 4
                                                                               66 36990 → 1883 [ACK] Sen=72 Ack
   179 3 532094064
                                             52 65 194 50
                                                                    TCP
Frame 176: 71 bytes on wire (568 bits), 71 bytes captured (568 bits) on interface 0
Ethernet II, Src: IntelCor_d9:b1:72 (00:15:17:d9:b1:72), Dst: Dell_27:fa:db (14:b3:1f:27:fa:db)
Internet Protocol Version 4, Src: 52.65.194.50, Dst: 192.168.111.4
Transmission Control Protocol, Src Port: 1883, Dst Port: 36990, Seq: 5, Ack: 72, Len: 5
MQ Telemetry Transport Protocol, Subscribe Ack
 ▼ Header Flags: 0x90 (Subscribe Ack)
      .... 0... = DUP Flag: Not set
      .... .00. = QoS Level: At most once delivery (Fire and Forget) (0)
       .... Not set
   Msg Len: 3
   Message Identifier: 1
   Granted QoS: At most once delivery (Fire and Forget) (0)
```

The server replies with the Subscriber Acknowledge request that has a length of 71.

Publish:

```
88 Publish Message
66 36990 → 1883 [ACK] Seq=76 Ack=234 Win=29312
        271 13.186171039
                                  192.168.111.4
                                                                   52.65.194.50
       272 13.186334943 192.168.111.4
                                                                   52.65.194.50
                                                                                                   MQTT
                                                                                                                     68 Disconnect Req
                                                                                                                    66 36990 - 1883 [FIN, ACK] Seq=78 Ack=234 Win=
66 1883 - 36990 [FIN, ACK] Seq=234 Ack=79 Win=
66 36990 - 1883 [ACK] Seq=79 Ack=235 Win=29312
        273 13.186367221
                                  192.168.111.4
                                                                   52.65.194.50
                                                                                                    TCP
        274 13.271822760 52.65.194.50
                                                                   192.168.111.4
                                                                                                    TCP
        275 13.271867077 192.168.111.4
                                                                   52.65.194.50
Frame 270: 88 bytes on wire (704 bits), 88 bytes captured (704 bits) on interface 0
Fethernet II, Src: IntelCor_d9:b1:72 (00:15:17:d9:b1:72), Dst: Dell_27:fa:db (14:b3:1f:27:fa:db)
Internet Protocol Version 4, Src: 52.65.194.50, Dst: 192.168.111.4
Transmission Control Protocol, Src Port: 1883, Dst Port: 36990, Seq: 212, Ack: 76, Len: 22
        Header Flags: 0x30 (Publish Message)
            0011 .... = Message Type: Publish Message (3)
            .... 0... = DUP Flag: Not set
            .... .00. = QoS Level: At most once delivery (Fire and Forget) (0)
        .... 0 = Retain: Not set
Msg Len: 20
        Topic Length: 15
        Topic: counter/slow/q0
        Message: 315
```

After the client has subscribed to the topic 'counter/slow/q0', each time the key-value pair at the broker is updated, a publish message is sent to all the subscribing client. The figure above shows one of such messages.

Disconnect:

In the end, when the client wants to disconnect with the broker, it sends a disconnect message. After this, the connection is terminated. The figure below shows the disconnect message.

```
68 Disconnect Req
66 36990 → 1883 [FIN, ACK]
66 1883 → 36990 [FIN, ACK]
   273 13.186367221 192.168.111.4
274 13.271822760 52.65.194.50
                                                         52.65.194.50
                                                                                      TCP
                                                                                      TCP
                                                         192.168.111.4
    275 13.271867077 192.168.111.4
                                                         52.65.194.50
                                                                                                      66 36990 → 1883 [ACK] Seq=79
Frame 272: 68 bytes on wire (544 bits), 68 bytes captured (544 bits) on interface 0 Ethernet II, Src: Dell_27:fa:db (14:b3:1f:27:fa:db), Dst: IntelCor_d9:b1:72 (00:15:17:d9:b1:72)
Internet Protocol Version 4, Src: 192.168.111.4, Dst: 52.65.194.50
Transmission Control Protocol, Src Port: 36990, Dst Port: 1883, Seq: 76, Ack: 234, Len: 2
  Header Flags: 0xe0 (Disconnect Req)
        1110 .... = Message Type: Disconnect Req (14)
        .... 0... = DUP Flag: Not set
        .... .00. = QoS Level: At most once delivery (Fire and Forget) (0)
        .... Not set
    Msg Len: 0
```

Slow Counter q1

The slow counter uses QoS 1 and we will subscribe to it using this QoS. We will only however compare the differences in the MQTT messages send and received to save space as much of the handshake messages sent and received are similar to counter q0. The figure below shows all the MQTT and TCP messages sent and received between the client and the broker.

	ip.addr == 52.65.194.	50			Expression +				
No.	Time	Source	Destination		Length Info				
Г	8 0.426831445	192.168.111.4	52.65.194.50	TCP	74 37690 → 1883 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=4011549462				
	9 0.442574629	52.65.194.50	192.168.111.4	TCP	74 1883 - 37690 [SYN, ACK] Seq=0 Ack=1 Win=26847 Len=0 MSS=1460 SACK_PERM=1 TSval=				
	10 0.442630728 11 0.442770640	192.168.111.4 192.168.111.4	52.65.194.50 52.65.194.50	TCP MQTT	66 37690 → 1883 [ACK] Seq=1 Ack=1 Win=29312 Len=0 TSval=4011549478 TSecr=48563762 115 Connect Command				
	12 0.523510061	52.65.194.50	192.168.111.4	TCP	66 1883 → 37690 [ACK] Seq=1 Ack=50 Win=26880 Len=0 TSval=48563783 TSecr=4011549478				
	13 0.523944647	52.65.194.50	192.168.111.4	MOTT	70 Connect Ack				
		192.168.111.4	52.65.194.50	TCP	66 37690 → 1883 [ACK] Seq=50 Ack=5 Win=29312 Len=0 TSval=4011549559 TSecr=48563783				
	15 0.524132878		52.65.194.50	MQTT	88 Subscribe Request				
	16 0.685811372		192.168.111.4	TCP	66 1883 → 37690 [ACK] Seq=5 Ack=72 Win=26880 Len=0 TSval=48563823 TSecr=4011549560				
	17 0.771415275 18 0.811935169	52.65.194.50 192.168.111.4	192.168.111.4 52.65.194.50	MQTT TCP	71 Subscribe Ack 66 37690 → 1883 [ACK] Seq=72 Ack=10 Win=29312 Len=0 TSval=4011549807 TSecr=48563845				
	21 1.178019289		192.168.111.4	MOTT	90 Publish Message				
	22 1.178051964		52.65.194.50	TČP	66 37690 → 1883 [ACK] Seg=72 Ack=34 Win=29312 Len=0 TSval=4011550213 TSecr=48563946				
	23 1.178222822	192.168.111.4	52.65.194.50	MQTT	70 Publish Ack				
	24 1.262565434	52.65.194.50	192.168.111.4	TCP	66 1883 - 37690 [ACK] Seq=34 Ack=76 Win=26880 Len=0 TSval=48563967 TSecr=4011550214				
	26 2.246117703	52.65.194.50	192.168.111.4	MQTT	90 Publish Message				
	27 2.246236823 28 2.326522138	192.168.111.4 52.65.194.50	52.65.194.50 192.168.111.4	MQTT TCP	70 Publish Ack 66 1883 → 37690 [ACK] Seq=58 Ack=80 Win=26880 Len=0 TSval=48564233 TSecr=4011551282				
	29 3.394503921	52.65.194.50	192.168.111.4	MOTT	90 Publish Message				
	30 3.394663166	192.168.111.4	52.65.194.50	MOTT	70 Publish Ack				
	31 3.474878049		192.168.111.4	TCP	66 1883 - 37690 [ACK] Seq=82 Ack=84 Win=26880 Len=0 TSval=48564520 TSecr=4011552430				
	45 4.377897639		192.168.111.4	MQTT	90 Publish Message				
		192.168.111.4	52.65.194.50	MQTT	70 Publish Ack				
	47 4.378137348 48 4.457927220	192.168.111.4 52.65.194.50	52.65.194.50 192.168.111.4	MQTT TCP	68 Disconnect Req 66 1883 → 37690 [ACK] Seg=106 Ack=88 Win=26880 Len=0 TSval=48564766 TSecr=40115534				
	49 4.457960251		192.168.111.4	TCP	66 1883 - 37690 [FIN, ACK] Seq=106 Ack=91 Win=26880 Len=0 TSval=48564766 TSecr=401				
L	50 4.457981550	192.168.111.4	52.65.194.50	TCP	66 37690 → 1883 [ACK] Seq=91 Ack=107 Win=29312 Len=0 TSval=4011553493 TSecr=485647				
. 0	F 45: 00 bit-		00 5-5	04 5455					
			88 bytes captured (7		b1:72 (00:15:17:d9:b1:72)				
			168.111.4, Dst: 52.65		51.72 (00.10.17.40.01.72)				
			t: 37690, Dst Port: 1		50, Ack: 5, Len: 22				
	▼ MQ Telemetry Transport Protocol, Subscribe Request								
	Header Flags: 0x82 (Subscribe Request)								
	1000 = Message Type: Subscribe Request (8) 0 = DUP Flag: Not set								
	01. = QoS Level: At least once delivery (Acknowledged deliver) (1)0 = Retain: Not set Msg Len: 20 Message Identifier: 1								
	Topic Length: 15								
Topic: counter/slow/q1 Requested QoS: At least once delivery (Acknowledged deliver) (1)									
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The client sends a Connect command to the broker and is replied a Connect Ack command. After that a Subscribe Request is sent with the QoS flag set to 01 as shown in the figure above which is at least once delivery.

Publish and Publish Acknowledge:

lsa Len

Message Identifier: 1

```
66 37690 → 1883 [ACK] Seq=72
      22 1.178051964
                       192.168.111.4
                                            52.65.194.50
                                                                  TCP
                       192.168.111.4
     23 1.178222822
                                            52.65.194.50
                                                                  MQTT
                                                                             70 Publish Ack
     24 1.262565434
                       52.65.194.50
                                            192.168.111.4
                                                                  TČP
                                                                             66 1883 → 37690 [ACK] Seq=34
                                                                             90 Publish Message
     26 2.246117703
                       52.65.194.50
                                            192.168.111.4
                                                                  MOTT
     27 2.246236823
                       192.168.111.4
                                            52.65.194.50
                                                                 MQTT
                                                                             70 Publish Ack
     28 2.326522138
                       52.65.194.50
                                            192.168.111.4
                                                                  TČP
                                                                             66 1883 → 37690 [ACK] Seq=58
                                                                             90 Publish Message
     29 3.394503921
                       52.65.194.50
                                            192.168.111.4
                                                                  MQTT
     30 3.394663166
                       192.168.111.4
                                            52.65.194.50
                                                                 MOTT
                                                                             70 Publish Ack
  Frame 21: 90 bytes on wire (720 bits), 90 bytes captured (720 bits) on interface 0
 Ethernet II, Src: IntelCor_d9:b1:72 (00:15:17:d9:b1:72), Dst: Dell_27:fa:db (14:b3:1f:27:fa:db)
 Internet Protocol Version 4, Src: 52.65.194.50, Dst: 192.168.111.4
  Transmission Control Protocol, Src Port: 1883, Dst Port: 37690, Seq: 10, Ack: 72, Len: 24
▼ MQ Telemetry Transport Protocol, Publish Message
     Header Flags: 0x32 (Publish Message)
        0011 .... = Message Type: Publish Message (3)
        .... 0... = DUP Flag: Not set
        .... .01. = QoS Level: At least once delivery (Acknowledged deliver) (1)
        .... ...0 = Řetain: Not set
     Topic Length: 15
     Topic: counter/slow/q1
     Message Identifier: 1
     Message: 268
                                                                            70 Publish
     24 1.262565434
                      52.65.194.50
                                            192.168.111.4
                                                                 TCP
                                                                            66 1883 → 37690 [ACK] Seq=34
                                                                            90 Publish Message
     26 2.246117703
                      52.65.194.50
                                            192.168.111.4
                                                                 MOTT
     27 2.246236823
                      192.168.111.4
                                            52.65.194.50
                                                                 MOTT
                                                                            70 Publish Ack
                      52.65.194.50
                                                                 TČP
                                                                            66 1883 → 37690 [ACK] Seq=58
     28 2.326522138
                                            192.168.111.4
     29 3.394503921
                                            192.168.111.4
                                                                 MQTT
                      52.65.194.50
                                                                            90 Publish Message
     30 3.394663166
                      192.168.111.4
                                            52.65.194.50
                                                                 MOTT
                                                                            70 Publish Ack
Frame 23: 70 bytes on wire (560 bits), 70 bytes captured (560 bits) on interface 0
Ethernet II, Src: Dell_27:fa:db (14:b3:1f:27:fa:db), Dst: IntelCor_d9:b1:72 (00:15:17:d9:b1:72)
▶ Internet Protocol Version 4, Src: 192.168.111.4, Dst: 52.65.194.50
 Transmission Control Protocol, Src Port: 37690, Dst Port: 1883, Seq: 72, Ack: 34, Len: 4
 MQ Telemetry Transport Protocol, Publish Ack
     Header Flags: 0x40 (Publish Ack)
        0100 .... = Message Type: Publish Ack (4)
        .... 0... = DUP Flag: Not set
        .... .00. = QoS Level: At most once delivery (Fire and Forget) (0)
        .... Not set
```

After the subscription is successful, a Publish message is sent by the broker to the client. We can see from the figure above that the QoS flag is set to 01 which ensures that the client receives the message at least once. For this reason, every Publish message from the broker to the client is followed by a Publish Acknowledge message. Also, each Publish message has a message identifier which is replied in the Publish Ack to tell broker that the message has been received. In the end the client and broker disconnect as q0.

Slow Counter q2

The slow counter q2 uses QoS 2 which is 'Exactly Once'. The figure below shows the MQTT messages sent and received between the client and the broker. Again, we will discuss the differences in MQTT messages with respect to QoS.

15.4.2920807 192.108.111.4 52.65.194.59 170 74 39256 - 1883 [SYN] Seq=0 Ack=19 Winz-2928 Lene B SSC-1408 SAKK PEPM=1 Toval-4013987365 126.4 38080528 32 56.5 194.59 192.108.111.4 TCP 74 38256 - 1883 [SYN] Seq=0 Ack=19 Winz-2932 Lene B TSVal-4013987355 TSecr=49173235 154.39189834 192.108.111.4 TCP 76 65 1883 - 37956 [AKK] Seq=2 Ack=19 Winz-2932 Lene B TSVal-401398755 TSecr=49173235 154.39189834 192.108.111.4 TCP 76 65 1883 - 37956 [AKK] Seq=2 Ack=50 Winz-29312 Lene B TSVal-4013987754 TSecr=49173257 155 4.39664922 52.65.194.59 192.108.111.4 WQTT 76 65 1893 - 37956 [AKK] Seq=2 Ack=50 Winz-29312 Lene B TSVal-4013987744 TSecr=49173257 156 4.3966492 192.108.111.4 S2.65.194.59 WQTT 78 65 195 - 1883 [AKK] Seq=2 Ack=50 Winz-29312 Lene B TSVal-4013987744 TSecr=49173257 150 4.69792013 52 55.5194.59 WQTT 78 150 4.79792013 52 55.5194.59 WQTT 79 150 4.79792013 52 5										
153 4.399946396 192.168.111.4 52.65.194.59 TCP 66 37955 - 1883 [ACK] Seq=1 Ack=1 Win-29312 Len=0 TSval=4013987355 TSecr=40173255 TSecr=4013987356 TSecr=4013987357 TSecr=4013987356 TSecr=4013987357 TSecr=4013987357 TSecr=4013987357 TSecr=4013987357 TSecr=4013987356 TSecr=4013987357 TSecr=4013987	_ 151 4.250200477	192.168.111.4	52.65.194.50	TCP	74 37956 → 1883 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=4013987305					
154 4.391898834 192 168.111.4 5 2.65.194.50 192.168.111.4 TCP 61 883 - 37956 [ACK] Seq-1 Ack=50 Min=26880 Len=0 TSval=49173257 TSecr=491398736 156 4.386642825 5 2.65.194.50 192.168.111.4 NOTT 70 Connect Ack 37956 - 1883 [ACK] Seq-50 Ack=5 Min=29312 Len=0 TSval=4913987441 TSecr=49173257 158 4.386612141 192.168.111.4 5 2.65.194.50 MOJT 70 Connect Ack 6 37956 - 1883 [ACK] Seq-50 Ack=5 Min=29312 Len=0 TSval=4013987441 TSecr=49173257 158 4.386612141 192.168.111.4 5 2.65.194.50 MOJT 70 PSP 100 P										
156 4.385848789 52.66.194.59 192.168.111.4 MQTT 70 66 1883 - 37956 [ACK] Seq-34 Ack-59 MIn-26889 Lene9 TSVal-49173257 TSecr-4913987356 157 4.386668492 192.168.111.4 52.65.194.50 TCP 66 37956 - 1883 [ACK] Seq-59 Ack-5 MIn-29312 Lene9 TSVal-491398741 TSecr-49173257 158 4.396668492 192.168.111.4 52.65.194.50 TCP 65 37956 - 1883 [ACK] Seq-59 Ack-5 MIn-29312 Lene9 TSVal-491398741 TSecr-49173277 161 4.71965822 52.65.194.50 192.168.111.4 DZ 102.168.111.4 DZ 102.168.11										
156 4.386668492 52.66.194.59 192.168.111.4 52.65.194.50 TCP 63 37956 - 1883 [ACK] Seq=50 Ack=5 Win=29312 Len=0 TSval=401398741 TSecr=49173257 1594.368681241 192.168.111.4 52.65.194.50 MQTT 78 88 subscribe Request 169 4.56702941 52.65.194.50 192.168.111.4 52.65.194.50 TCP 66 37956 - 1883 [ACK] Seq=72 Ack=10 Win=29312 Len=0 TSval=401398752 TSecr=49173277 1614.716660232 5.65.194.50 192.168.111.4 52.65.194.50 TCP 66 37956 - 1883 [ACK] Seq=72 Ack=10 Win=29312 Len=0 TSval=401398752 TSecr=49173277 1614.71660523 5.65.194.50 192.168.111.4 52.65.194.50 TCP 66 37956 - 1883 [ACK] Seq=72 Ack=40 Win=29312 Len=0 TSval=401398765 TSecr=49173277 1614.71660523 52.65.194.50 192.168.111.4 52.65.194.50 TCP 66 37956 - 1883 [ACK] Seq=72 Ack=40 Win=29312 Len=0 TSval=4013987765 TSecr=4013987765 TSecr=40		192.168.111.4	52.65.194.50							
157 4.38668492 192.168.111.4 52.65.194.50 MQTT 88 Subscribe Ack 637956 - 1883 [ACK] Seq=59 Ack=5 Win=29312 Len=0 TSval=4013987441 TSecr=49173257 158 4.38668492 192.168.111.4 52.65.194.50 MQTT 74 Subscribe Ack 637956 - 1883 [ACK] Seq=72 Ack=10 Win=29312 Len=0 TSval=4013987522 TSecr=49173277 161.47.10650232 52.65.194.50 192.168.111.4 Sp. 65.194.50 MQTT 99 Publish Message 162 4.710650533 192.168.111.4 Sp. 65.194.50 MQTT 99 Publish Ressage 163 4.71065078 192.168.111.4 Sp. 65.194.50 MQTT 79 Publish Complete 164 4.71065078 192.168.111.4 Sp. 65.194.50 MQTT 79 Publish Complete 164 4.7707078 192.168.111.4 Sp. 65.194.50 MQTT 79 Publish Complete 165 4.87707078 192.168.111.4 Sp. 65.194.50 MQTT 79 Publish Ressage 179 5.093542691 Jp. 168.111.4 Sp. 65.194.50 MQTT 79 Publish Ressage 179 5.093542691 Jp. 168.111.4 Sp. 65.194.50 MQTT 79 Publish Ressage 188 5.773825799 Sp. 65.194.50 192.168.111.4 Sp. 65.194.50 MQTT 79 Publish Ressage 188 5.773825799 Sp. 65.194.50 192.168.111.4 Sp. 65.194.50 MQTT 79 Publish Ressage 188 5.773825799 Sp. 65.194.50 192.168.111.4 Sp. 65.194.50 MQTT 79 Publish Received 188 5.773825799 Sp. 65.194.50 192.168.111.4 Sp. 65.194.50 MQTT 79 Publish Ressage 188 5.774209900 192.168.111.4 Sp. 65.194.50 MQTT 79 Publish Received 188 5.774209900 192.168.111.4 Sp. 65.194.50 MQTT 79 Publish Received 188 5.49487845 Sp. 65.5194.50 MQTT 79 Publish Received 188 5.49487845 Sp. 65.5194.50 MQTT 79 Publish Received 188 6.492391399 Sp. 65.5194.50 MQTT 79 Publish Ressage 192.168.111.4 Sp. 65.194.50 MQTT 79 Publish Ressage 192.168.111.4 Sp. 65.194.50 MQTT 79 Publish Ressage 192.168.111.4 Sp. 65.194.50 MQTT 79 Publish Received 192.168.111.4 Sp. 65.194.50 MQTT 79 Publish Ressage 192.168.111.4 Sp. 65.194.50 MQTT 79 Publish Res			192.168.111.4							
158 4.386811241 192.168.111.4 52.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.111.4 192.65.194.59 192.168.192.198.192	156 4.386642825	52.65.194.50	192.168.111.4	MQTT	70 Connect Ack					
169 4.487929431 52.65.194.59 192.168.111.4 52.65.194.59 TCP 66 37956 - 1883 [ACK] Seq=72 Ack=10 Win=29312 Len=0 TSval=401398752 TSecr=49173277 161 4.710655523 [92.168.111.4 52.65.194.59 TCP 66 37956 - 1883 [ACK] Seq=72 Ack=10 Win=29312 Len=0 TSval=4013987765 TSecr=49173378 162 4.710695583 [92.168.111.4 52.65.194.59 MQTT 79 Publish Resoage 779 Publish Resoage 163 4.710823771 192.168.111.4 52.65.194.59 MQTT 79 Publish Resoage 165 4.876956146 52.65.194.59 192.168.111.4 MQTT 79 Publish Resoage 179 Publish Resoage 179 Publish Resoage 179 Publish Resoage 178 5.08338955 [5.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=38 Ack=80 Win=26880 Len=0 TSval=4917379 TSecr=4013987932 178 5.08338955 [5.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=38 Ack=80 Win=26880 Len=0 TSval=49173400 TSecr=4013987932 178 5.08338955 [5.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSval=49173400 TSecr=4013987932 179 5.083542891 192.168.111.4 52.65.194.59 MQTT 79 Publish Resoage 181.5 T74977722 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSval=49173604 TSecr=4013988748 1815.774977722 52.65.194.59 192.168.111.4 Span 19	157 4.386668492	192.168.111.4	52.65.194.50	TCP	66 37956 → 1883 [ACK] Seq=50 Ack=5 Win=29312 Len=0 TSval=4013987441 TSecr=49173257					
160 4.597498193 192.168.111.4 52.65.194.59 192.168.111.4 MQTT 197.10852932 52.65.194.59 192.168.111.4 52.65.194.59 TCP 66 37956 - 1883 [ACK] Seq=72 Ack=34 Win=29312 Len=0 TSval=4913987522 TSecr=49173277 1614 4.17108592531 192.168.111.4 52.65.194.59 TQP publish Resease 164 4.876387402 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=34 Ack=76 Win=26880 Len=0 TSval=49173379 TSecr=4913987765 165 4.876956146 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=34 Ack=76 Win=26880 Len=0 TSval=49173379 TSecr=4913987765 167 4.957964558 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=38 Ack=80 Win=26880 Len=0 TSval=49173409 TSecr=4913987932 179 5.693349655 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=38 Ack=80 Win=26880 Len=0 TSval=49173409 TSecr=4913987932 179 5.69345965 192.168.111.4 52.65.194.59 MQTT 79 Publish Reseave 188 5.773825798 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSval=49173604 TSecr=4913988748 183 5.940407845 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSval=49173604 TSecr=4913988748 183 5.940407845 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSval=49173604 TSecr=4913988829 185 6.757588773 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSval=49173645 TSecr=4913988829 185 6.757588773 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=4913988829 189 6.842584578 192.168.111.4 52.65.194.59 MQTT 79 Publish Reseave 199 7.99898967 192.168.111.4 52.65.194.59 MQTT 79 Publish Reseave 199 7.9989897 191 7.998989137 75.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=491398987 199 7.998989137 75.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=4917497 TSecr=491399897 191 7.998989137 75.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=128 Ack=128 Win=26880 Len=0 TSval=49174157 TSecr=4913	158 4.386811241	192.168.111.4	52.65.194.50	MQTT	88 Subscribe Request					
161 4.710655232 52.65.194.59 192.168.111.4 50.65.194.59 TCP 66 37956 183 [ACK] Seq=72 Ack=34 Win=29312 Len=0 TSval=4013987765 TSecr=49173338 163 4.710823771 192.168.111.4 52.65.194.59 MQTT 70 Publish Received 66 183 7.37956 [ACK] Seq=34 Ack=76 Win=26889 Len=0 TSval=49173379 TSecr=4913987765 165 4.876956146 52.65.194.59 192.168.111.4 TCP 66 1833 - 37956 [ACK] Seq=34 Ack=76 Win=26889 Len=0 TSval=49173400 TSecr=401398795765 167 4.957954588 52.65.194.59 192.168.111.4 TCP 66 1833 - 37956 [ACK] Seq=38 Ack=80 Win=26889 Len=0 TSval=49173400 TSecr=4013987932 178 5.693389655 52.65.194.59 192.168.111.4 MQTT 70 Publish Resage 179 5.693542691 192.168.111.4 TCP 181 52.65.194.59 MQTT 70 Publish Resage 181 5.774077722 52.65.194.59 192.168.111.4 TCP 66 1833 - 37956 [ACK] Seq=62 Ack=84 Win=26889 Len=0 TSval=49173400 TSecr=401398748 181 5.774077722 52.65.194.59 192.168.111.4 MQTT 70 Publish Reclare 182 5.74409960 192.168.111.4 S2.65.194.59 MQTT 70 Publish Reclare 182 5.944097845 52.65.194.59 192.168.111.4 MQTT 70 Publish Reclare 183 5.94967845 52.65.194.59 192.168.111.4 MQTT 70 Publish Reclare 193 52.65.194.59 192.168.111.4 MQTT 70 Publish Reclare 193 7.9956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=4013989812 193 7.997596965 52.65.194.59 192.168.111.4 MQTT 70 Publish Reclare 193 7.99659605 52.65.194.59	159 4.467029431	52.65.194.50	192.168.111.4	MOTT	71 Subscribe Ack					
162 4.7169895583 192.168.111.4 52.65.194.59 MQTT 70 Publish Received 164 4.87687402 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=72 Ack=84 Win=29812 Len=0 TSval=49173379 TSecr=4913987765 165 4.876956146 52.65.194.59 192.168.111.4 MQTT 70 Publish Release 166 4.877079678 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=34 Ack=76 Win=26880 Len=0 TSval=49173379 TSecr=4913987765 167 4.957954558 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=38 Ack=80 Win=26880 Len=0 TSval=49173400 TSecr=4913987932 179 5.693542081 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=80 Win=26880 Len=0 TSval=49173400 TSecr=4913987932 179 5.693542081 192.168.111.4 MQTT 70 Publish Received 180 5.773825789 52.65.194.50 192.168.111.4 MQTT 70 Publish Received 181 5.774077722 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSval=49173604 TSecr=401398748 181 5.774077722 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSval=49173604 TSecr=4013988748 181 5.774077722 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSval=49173645 TSecr=4013988829 183 5.94407845 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSval=49173645 TSecr=4013988829 186 6.757713190 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=4013989812 186 6.75768773 192 7.096891377 52.65.194.50 192.168.111.4 MQTT 70 Publish Received 192.168.111.4 MQTT 70 Publish Received 193 6.842548789 192.168.111.4 MQTT 70 Publish Received 193 7.96755085 193.50 192.168.111.4 MQTT 70 Publish Received 193 7.96755085 193.50 192.168.111.4 MQTT 70 Publish Received 193 7.96755085 193.50 193 193 193 193 193 193 193 193 193 193	160 4.507498103	192.168.111.4	52.65.194.50	TCP	66 37956 → 1883 [ACK] Seq=72 Ack=10 Win=29312 Len=0 TSval=4013987522 TSecr=49173277					
163 4.716823771 192.168.111.4 52.65.194.59 MQTT 70 Publish Received 154 4.876837640 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq-34 Ack=76 Win=26880 Len=0 TSval=49173379 TSccr=4013987765 165 4.876956146 52.65.194.59 192.168.111.4 MQTT 70 Publish Complete 167 4.957954558 52.65.194.59 192.168.111.4 MQTT 70 Publish Complete 179 5.69354951 192.168.111.4 Sp. 2.65.194.59 MQTT 70 Publish Complete 189 5.773825798 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq-38 Ack=80 Win=26880 Len=0 TSval=49173400 TSccr=401398748 189 5.7748077722 52.65.194.59 MQTT 70 Publish Received 181 5.7748077722 52.65.194.59 192.168.111.4 MQTT 70 Publish Complete 181 5.774807869 192.168.111.4 MQTT 70 Publish Complete 182 5.774289960 192.168.111.4 MQTT 70 Publish Complete 183 5.940407845 52.65.194.59 192.168.111.4 MQTT 70 Publish Complete 183 5.940407845 52.65.194.59 192.168.111.4 MQTT 70 Publish Complete 183 6.757713198 192.168.111.4 Sp. 2.65.194.59 MQTT 70 Publish Complete 186 6.757713198 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq-66 Ack=88 Win=26880 Len=0 TSval=49173645 TSccr=4013988829 187 6.842151052 52.65.194.59 192.168.111.4 MQTT 70 Publish Received 187 6.842151052 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq-90 Ack=92 Win=26880 Len=0 TSval=49173871 TSccr=4013989812 189 6.842548758 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq-90 Ack=92 Win=26880 Len=0 TSval=49173871 TSccr=4013989812 190 7.066891377 52.65.194.59 192.168.111.4 MQTT 70 Publish Received 190 7.066891377 52.65.194.59 192.168.111.4 MQTT 70 Publish Received 190 7.066891375 52.65.	161 4.710650232	52.65.194.50	192.168.111.4	MOTT	90 Publish Message					
164 4.876387402 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=34 Ack=76 Win=26880 Len=0 TSval=4917379 TSecr=4013987765 165 4.87769768 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=38 Ack=80 Win=26880 Len=0 TSval=49173400 TSecr=4013987932 178 5.693349655 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=38 Ack=80 Win=26880 Len=0 TSval=49173400 TSecr=4013987932 179 5.693542591 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSval=49173604 TSecr=4013987932 180 5.773825798 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSval=49173604 TSecr=401398783 181 5.774207972 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSval=49173604 TSecr=401398848 181 5.774209960 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSval=49173645 TSecr=401398848 182 5.774209960 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSval=49173645 TSecr=4013988829 185 6.757568773 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=69 Ack=92 Win=26880 Len=0 TSval=49173645 TSecr=4013988829 182 6.842581758 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=99 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=401398987 191.796893137 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=99 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=401398987 191.796893137 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=18 Ack=100 Win=26880 Len=0 TSval=4917317 TSecr=401399897 191.796893137 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=18 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013999.191.796893137 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=18 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013999.191.796893137 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=18 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013999.191.796893157 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=18 Ack=100 Win=26880 Len=0 TSval=4013991128 TSecr=198 8.073251419 192.168.111.4 TCP 66	162 4.710695583	192.168.111.4	52.65.194.50	TČP	66 37956 → 1883 [ACK] Seg=72 Ack=34 Win=29312 Len=0 TSval=4013987765 TSecr=49173338					
166 4.876956146 52.65.194.59 192.168.111.4 NQTT 70 Publish Replase 167 4.967954558 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=38 Ack=80 Win=26880 Len=0 TSval=49173400 TSecr=4013987932 178 5.693389655 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSval=49173400 TSecr=4013987932 178 5.693542691 192.168.111.4 Sp. 194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSval=49173604 TSecr=401398748 180 5.7742077722 52.65.194.59 192.168.111.4 MQTT 70 Publish Received 182 5.774209760 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSval=49173604 TSecr=4013988748 181 5.774077722 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSval=49173645 TSecr=4013988829 185 6.757568773 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSval=49173645 TSecr=4013988829 186 6.757713198 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=401398812 189 6.842548758 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=4013989812 199 7.096891377 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=4013989812 199 7.096891377 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173911 TSecr=401398987 191 7.996891377 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=90 Win=26880 Len=0 TSval=49173911 TSecr=4013990897 191 7.996891377 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=18 Ack=100 Win=26880 Len=0 TSval=49173911 TSecr=401399897 191 7.996891377 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=18 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013999897 191 7.996891377 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=18 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013999897 191 7.996891377 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=18 Ack=100 Win=26880 Len=0 TSv	163 4.710823771	192.168.111.4	52.65.194.50	MOTT	70 Publish Received					
166 4.876956146 52.65.194.59 192.168.111.4 NQTT 70 Publish Replase 167 4.967954558 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=38 Ack=80 Win=26880 Len=0 TSval=49173400 TSecr=4013987932 178 5.693389655 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSval=49173400 TSecr=4013987932 178 5.693542691 192.168.111.4 Sp. 194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSval=49173604 TSecr=401398748 180 5.7742077722 52.65.194.59 192.168.111.4 MQTT 70 Publish Received 182 5.774209760 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSval=49173604 TSecr=4013988748 181 5.774077722 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSval=49173645 TSecr=4013988829 185 6.757568773 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSval=49173645 TSecr=4013988829 186 6.757713198 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=401398812 189 6.842548758 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=4013989812 199 7.096891377 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=4013989812 199 7.096891377 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173911 TSecr=401398987 191 7.996891377 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=90 Win=26880 Len=0 TSval=49173911 TSecr=4013990897 191 7.996891377 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=18 Ack=100 Win=26880 Len=0 TSval=49173911 TSecr=401399897 191 7.996891377 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=18 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013999897 191 7.996891377 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=18 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013999897 191 7.996891377 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=18 Ack=100 Win=26880 Len=0 TSv	164 4.876387402	52.65.194.50	192.168.111.4	TČP	66 1883 → 37956 [ACK] Seg=34 Ack=76 Win=26880 Len=0 TSval=49173379 TSecr=4013987765					
166 4.877679578 192.168.111.4 52.65.194.50 MQTT 70 Publish Complete 167 4.957954558 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=38 Ack=80 Win=26880 Len=0 TSVal=49173604 TSecr=4013987932 178 5.693389655 52.65.194.50 192.168.111.4 MQTT 70 Publish Rescape 180 5.773825798 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSVal=49173604 TSecr=401398748 181 5.774677722 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSVal=49173604 TSecr=4013988748 181 5.774209960 192.168.111.4 52.65.194.50 MQTT 70 Publish Release 182 5.774209960 192.168.111.4 52.65.194.50 MQTT 70 Publish Release 183 5.940407645 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSVal=49173645 TSecr=401398829 185 6.7577588773 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=68 Ack=88 Win=26880 Len=0 TSVal=49173645 TSecr=401398829 186 6.757713198 192.168.111.4 52.65.194.50 MQTT 70 Publish Received 187 6.842151952 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSVal=49173871 TSecr=4013989812 189 6.842548758 192.168.111.4 52.65.194.50 MQTT 70 Publish Release 190 7.096891377 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSVal=49173911 TSecr=401398987 191 7.99689137 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=90 Win=26880 Len=0 TSVal=49173911 TSecr=401398987 191 7.99689137 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=90 Win=26880 Len=0 TSVal=49174157 TSecr=4013998.1				MOTT						
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178 5.693342861 192.168.111.4 MQTT 99 Publish Message 179 5.693542861 192.168.111.4 52.65.194.50 MQTT 79 Publish Received 180 5.773825798 52.65.194.50 192.168.111.4 MQTT 76 Publish Received 181 5.774269960 192.168.111.4 52.65.194.50 192.168.111.4 MQTT 76 Publish Received 182 5.774269960 192.168.111.4 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSval=49173645 TSecr=401398848 183 5.946407845 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSval=49173645 TSecr=401398829 185 6.757568173 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSval=49173645 TSecr=401398829 186 6.757713198 192.168.111.4 52.65.194.50 MQTT 76 Publish Received 187 6.842151052 52.65.194.50 192.168.111.4 MQTT 76 Publish Received 188 6.842391393 52.65.194.50 192.168.111.4 MQTT 76 Publish Received 189 6.842584758 192.168.111.4 52.65.194.50 MQTT 76 Publish Received 189 6.842584758 192.168.111.4 MQTT 76 Publish Received 190 7.004489643 52.65.194.50 192.168.111.4 MQTT 76 Publish Received 191 7.990898053 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=94 Ack=96 Win=26880 Len=0 TSval=49173911 TSecr=401398987 191 7.990769605 192.168.111.4 MQTT 76 Publish Received 192 7.990769605 192.168.111.4 MQTT 76 Publish Received 193 7.987522182 52.65.194.50 192.168.111.4 MQTT 76 Publish Received 194 8.073251438 192.168.111.4 52.65.194.50 MQTT 76 Publish Received 195 8.073251438 192.168.111.4 52.65.194.50 MQTT 76 Publish Received 196 8.073251438 192.168.111.4 52.65.194.50 MQTT 76 Publish Received 197 8.07365787 52.65.194.50 192.168.111.4 TCP 76 1883 - 37956 [ACK] Seq=118 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990 195 8.073057878 52.65.194.50 MQTT 76 Publish Received 197 8.07365787 52.65.194.50 192.168.111.4 TCP 76 1883 - 37956 [ACK] Seq=118 Ack=100 Win=26880 Len=0 TSval=49174197 TSecr=4013991.194.194.194.194.194.194.194.194.194.										
179 5.693842691 192.168.111.4 52.65.194.59 MQTT 70 Publish Received 1815.77489759 52.65.194.59 192.168.111.4 MQTT 70 Publish Release 182.5.77420996 192.168.111.4 170 Publish Release 183.5.940407845 52.65.194.59 192.168.111.4 MQTT 70 Publish Release 183.5.940407845 52.65.194.59 192.168.111.4 MQTT 70 Publish Release 183.5.940407845 52.65.194.59 192.168.111.4 MQTT 70 Publish Received 183.5.940407845 52.65.194.59 192.168.111.4 MQTT 70 Publish Received 183.6.757568773 52.65.194.59 192.168.111.4 MQTT 70 Publish Received 183.6.42591399 52.65.194.59 192.168.111.4 MQTT 70 Publish Received 183.6.42391399 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=401398812 183.6.842391399 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=4013989812 199.7.904489643 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=94 Ack=96 Win=26880 Len=0 TSval=49173911 TSecr=401398987 199.7.997659065 192.168.111.4 S2.65.194.59 MQTT 70 Publish Received 193.7.987522182 52.65.194.59 192.168.111.4 MQTT 90 Publish Message 193.7.987522182 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=94 Ack=96 Win=26880 Len=0 TSval=49174157 TSecr=401398987 193.7.987522182 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=18 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990 195.8.673950787 52.65.194.59 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=118 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990 196.8.67351439 192.168.111.4 52.65.194.59 MQTT 66 1883 - 37956 [ACK] Seq=122 Ack=102 Win=26880 Len=0 TSval=49174157 TSecr=4013990 196.8.67351439 192.168.111.4 52.65.194.59 MQTT 66 1883 - 37956 [ACK] Seq=122 Ack=102 Win=26880 Len=0 TSval=49174157 TSecr=4013991 196.8.67351439 192.168.111.4 52.65.194.59 MQTT 66 1883 - 37956 [ACK] Seq=122 Ack=102 Win=26880 Len=0 TSval=49174157 TSecr=4013991 196.8.67351439 192.168.111.4 52.65.194.59 MQTT 66 1883 - 37956 [ACK] Seq=122 Ack=102 Win=26880 Len=0 TSval=49174159 TSecr=4013991 196.8.										
189 5.773825798 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=62 Ack=84 Win=26880 Len=0 TSval=49173604 TSecr=4013988748 1815.774077272 52.65.194.50 192.168.111.4 MQTT 70 Publish Release 182 5.774209960 192.168.111.4 52.65.194.50 MQTT 70 Publish Complete 183 5.94467845 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSval=49173645 TSecr=401398829 185 6.757568773 52.65.194.50 192.168.111.4 MQTT 70 Publish Ressage 186 6.757713198 192.168.111.4 52.65.194.50 MQTT 70 Publish Received 61 883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=4013989812 189 6.842549159 52.65.194.50 192.168.111.4 MQTT 70 Publish Release 71 Publish Releas										
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182 5.774209960 192.168.111.4 52.65.194.50 MQTT 70 Publish Complete 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSval=49173645 TSecr=401398829 185 6.757568773 52.65.194.50 192.168.111.4 MQTT 70 Publish Message 186 6.757713198 192.168.111.4 52.65.194.50 MQTT 76 Publish Received 187 6.842151052 52.65.194.50 192.168.111.4 MQTT 76 Publish Received 188 6.842391939 52.65.194.50 192.168.111.4 MQTT 76 Publish Release 78 189 6.842391939 52.65.194.50 192.168.111.4 MQTT 76 Publish Release 78 189 6.842584758 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=4013989812 189 6.842584758 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=94 Ack=96 Win=26880 Len=0 TSval=49173911 TSecr=401398987 191 7.906891377 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=94 Ack=96 Win=26880 Len=0 TSval=49173911 TSecr=401398987 191 7.90769065 192.168.111.4 52.65.194.50 MQTT 70 Publish Received 193 7.997522182 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=118 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990 195 8.073050787 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=118 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990 195 8.073050787 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=118 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990 196 8.073251438 192.168.111.4 52.65.194.50 MQTT 60 1883 FIN, ACK] Seq=102 Ack=122 Win=26880 Len=0 TSval=49174197 TSecr=4013991 197 8.073251491 192.168.111.4 52.65.194.50 MQTT 60 1883 FIN, ACK] Seq=102 Ack=122 Win=26880 Len=0 TSval=49174197 TSecr=4013991 198 8.1542542911 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=122 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=122 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=122 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 379										
183 5.940407845 5.265.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=66 Ack=88 Win=26880 Len=0 TSval=49173645 TSecr=4013988829 186 6.757588773 52.65.194.50 192.168.111.4 MQTT 70 Publish Received 187 6.842548758 192.168.111.4 52.65.194.50 MQTT 70 Publish Release 189 6.842548758 192.168.111.4 52.65.194.50 MQTT 70 Publish Release 199.108.481494 52.65.194.50 MQTT 70 Publish Complete 6 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=4013989812 199.7004489843 52.65.194.50 MQTT 70 Publish Complete 6 1883 - 37956 [ACK] Seq=94 Ack=96 Win=26880 Len=0 TSval=4917391 TSecr=4013989819 199.7004489843 52.65.194.50 MQTT 70 Publish Received 199.7.907695065 192.168.111.4 MQTT 90 Publish Received 193.7.907695065 192.168.111.4 MQTT 90 Publish Received 193.7.907695065 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=94 Ack=96 Win=26880 Len=0 TSval=4917391 TSecr=401398987 195.807305678 52.65.194.50 MQTT 90 Publish Received 195.807305678 52.65.194.50 MQTT 90 Publish Received 195.807305678 52.65.194.50 MQTT 90 Publish Received 196.807305678 52.65.194.50 MQTT 90 Publish Received 196.807305678 52.65.194.50 MQTT 90 Publish Received 197.807305678 52.65.194.50 MQTT 90 Publish Received 198.807305678 52.65.194.50 MQTT 90 Publish Received 198.80730578 52.65.194.50 MQTT 90 Publish Received 198.80730578 52.65.194.50 MQTT 90 Publish Received 198.80730578 52.65.1										
185 6.757713198 192.168.111.4 52.65.194.50 MQTT 70 Publish Message 187 6.842151052 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=4013989812 189 6.84239139 52.65.194.50 192.168.111.4 MQTT 70 Publish Release 7 Publish Release 8 Publish Release 9 Publish Release 9 Publish Release 9 Publish Release 9 Publish Release 197 Burgish 8 Publish Release 197 Burgish 8 Publish Release 198 Burgish 8 Publish 8 Publish Release 198 Burgish 8 Publish										
186 6.757713198 192.168.111.4 52.65.194.50 MOTT 70 Publish Received 61883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=4013989812 188 6.83239139 52.65.194.50 192.168.111.4 MOTT 70 Publish Release 199 7.004489445 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=94 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=4013989812 199 7.004489445 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=94 Ack=96 Win=26880 Len=0 TSval=49173911 TSecr=401398987 191 7.99650965 192.168.111.4 DQTT 99 Publish Message 193 7.987552182 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=18 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990_195 8.073050787 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=18 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990_195 8.073050787 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=118 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990_196 8.073251438 192.168.111.4 52.65.194.50 MOTT 68 Disconnect Req 197 8.07325149 192.168.111.4 52.65.194.50 MOTT 68 Disconnect Req 198 8.154242911 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=122 Win=29812 Len=0 TSval=4913991128 TSecr=40.199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=122 Win=26880 Len=0 TSval=49174199 TSecr=40.199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=122 Ack=103 Win=26880 Len=0 TSval=49174199 TSecr=40.199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=103 Win=26880 Len=0 TSval=49174199 TSecr=40.199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=103 Win=26880 Len=0 TSval=49174199 TSecr=40.199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=103 Win=26880 Len=0 TSval=49174199 TSecr=40.199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=103 Ack=123 Win=26880 Len=0 TSval=49174199 TSecr=40.199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=103 Ack=123 Win=26880 Len=0 TSval=49174199 TSe										
187 6.842151052 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=90 Ack=92 Win=26880 Len=0 TSval=49173871 TSecr=4013989812 189 6.842594393 52.65.194.50 192.168.111.4 TCP 67 Publish Release 189 6.842548758 192.168.111.4 52.65.194.50 MQTT 70 Publish Complete 199 7.004489643 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=94 Ack=96 Win=26880 Len=0 TSval=4917391 TSecr=401398987 191 7.996891377 52.65.194.50 192.168.111.4 MQTT 70 Publish Ressage 192 7.997050065 192.168.111.4 52.65.194.50 MQTT 70 Publish Received 193 7.997552128 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=118 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990 195 8.073950787 52.65.194.50 192.168.111.4 MQTT 70 Publish Release 196 8.073215438 192.168.111.4 52.65.194.50 MQTT 70 Publish Release 197 8.073254199 192.168.111.4 52.65.194.50 MQTT 70 Publish Release 198 8.154242911 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=122 Win=29312 Len=0 TSval=49174197 TSecr=4013991 199 8.154275957 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=122 Win=29312 Len=0 TSval=49174199 TSecr=4013991 199 8.154275957 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.154275957 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [FIN, ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.154275957 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [FIN, ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.154275957 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [FIN, ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.154275957 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [FIN, ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.154275957 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [FIN, ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.154275957 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=102 Win=2688										
188 6.842939139 52.65.194.50 192.168.111.4 MQTT 70 Publish Release 190 7.094489643 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=94 Ack=96 Win=26880 Len=0 TSval=49173911 TSecr=401398987 191 7.996891377 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=94 Ack=96 Win=26880 Len=0 TSval=49173911 TSecr=401398987 192 7.997650065 192.168.111.4 52.65.194.50 MQTT 70 Publish Reseave 193 7.98752182 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=118 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990 195 8.073525187 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=118 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990 196 8.073251438 192.168.111.4 52.65.194.50 MQTT 68 Disconnect Req 197 8.07325149 192.168.111.4 52.65.194.50 MQTT 68 Disconnect Req 198 8.154242911 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=122 Win=29312 Len=0 TSval=49174199 TSecr=4013991. 199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991. 199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991. 199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991. 199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [FIN, ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991. 199 Secr=4013991. 1										
189 6.842548758 192.168.111.4 52.65.194.50 MQTT 76 Publish Complete 66 1883 → 37956 [ACK] Seq=94 Ack=96 Win=26880 Len=0 TSval=49173911 TSecr=401398987 1917.996891377 52.65.194.50 192.168.111.4 MQTT 79 Publish Message 192 7.997950965 192.168.111.4 52.65.194.50 MQTT 76 Publish Message 193 7.99752182 52.65.194.50 192.168.111.4 MQTT 78 Publish Message 195 8.073956978 52.65.194.50 192.168.111.4 MQTT 79 Publish Received 61 183 → 37956 [ACK] Seq=118 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990 195 8.073956787 52.65.194.50 192.168.111.4 MQTT 79 Publish Release 196 8.073215438 192.168.111.4 52.65.194.50 MQTT 70 Publish Release 197 8.073251419 192.168.111.4 52.65.194.50 MQTT 79 Publish Release 198 8.152422911 52.65.194.50 192.168.111.4 TCP 66 183 → 37956 [ACK] Seq=102 Ack=122 Win=29312 Len=0 TSval=491399128 TSecr= 199 8.152472597 52.65.194.50 192.168.111.4 TCP 66 1883 → 37956 [ACK] Seq=102 Ack=122 Win=26880 Len=0 TSval=491399128 TSecr= 199 8.152472917 52.65.194.50 192.168.111.4 TCP 66 183 → 37956 [ACK] Seq=102 Ack=122 Win=26880 Len=0 TSval=491399128 TSecr= 199 8.152472917 52.65.194.50 192.168.111.4 TCP 66 1883 → 37956 [ACK] Seq=102 Ack=122 Win=26880 Len=0 TSval=491399129 TSecr=4013991 199 8.152472912 192.168.111.4 52.65.194.50 TCP 66 37956 → 1883 [ACK] Seq=102 Ack=122 Win=26880 Len=0 TSval=491399129 TSecr=4013991 199 8.15247294124 192.168.111.4 52.65.194.50 TCP 66 37956 → 1883 [ACK] Seq=102 Ack=123 Win=26880 Len=0 TSval=491399129 TSecr=49174 199 8.15247294124 192.168.111.4 52.65.194.50 TCP 66 37956 → 1883 [ACK] Seq=103 Ack=123 Win=29312 Len=0 TSval=491399129 TSecr=49174 199 Tenment Protocol Version 4, Src: 52.65.194.50, Dst: 192.168.111.4 TCP 61 1883 192 188.111.4 TCP 61 1883 192 188.111.4 TCP 61 1883 192 188.										
190 7.004489643 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=94 Ack=96 Win=26880 Len=0 TSval=49173911 TSecr=4013989897 192 7.997050065 192.168.111.4 52.65.194.50 MQTT 70 Publish Received 193 7.98752182 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=118 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990 195 8.07352182 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=118 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990 196 8.0735215438 192.168.111.4 52.65.194.50 MQTT 68 Disconnect Req 197 8.073521649 192.168.111.4 52.65.194.50 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=122 Win=29312 Len=0 TSval=49174197 TSecr=4013991 198 8.154242911 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [FIN, ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.154275597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [FIN, ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.154275597 52.65.194.50 TCP 66 1883 - 37956 [FIN, ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.154275597 52.65.194.50 TCP 66 1883 - 37956 [FIN, ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.1542759172 PScr=4013991 199 8.15427591 PSccr=4013991 199 8.15427691 PSccr=4013991										
191 7, 906891377 52,65,194.50 192,168.111.4 MQTT 90 Publish Message 192 7,907050065 192.168.111.4 52,65.194.50 MQTT 70 Publish Received 193 7,98752182 52,65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=118 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990 195 8.073050787 52,65.194.50 192.168.111.4 MQTT 70 Publish Release 196 8.073215438 192.168.111.4 52,65.194.50 MQTT 70 Publish Release 197 8.073251419 192.168.111.4 52,65.194.50 TCP 66 37956 - 1883 [FIN, ACK] Seq=102 Ack=122 Win=29312 Len=0 TSval=4913991128 TSecr=197 8.073251419 192.168.111.4 52,65.194.50 TCP 66 1883 - 37956 [ACK] Seq=122 Ack=102 Win=26880 Len=0 TSval=4913991128 TSecr=198 8.154276597 52,65.194.50 192.168.111.4 TCP 66 1883 - 37956 [FIN, ACK] Seq=122 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.154276597 52,65.194.50 192.168.111.4 TCP 66 1883 - 37956 [FIN, ACK] Seq=122 Ack=103 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.154276597 52,65.194.50 TCP 66 37956 - 1883 [ACK] Seq=103 Ack=123 Win=29312 Len=0 TSval=49174199 TSecr=4013991 199 8.154274124 192.168.111.4 52,65.194.50 TCP 66 37956 - 1883 [ACK] Seq=103 Ack=123 Win=29312 Len=0 TSval=4913991209 TSecr=49174 199 TSecr=4013991 1										
192 7, 997650965 192,168.111.4 52.65.194.50 MQTT 70 Publish Received 66 1883 - 37956 [ACK] Seq=118 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990 195 8.073050787 52.65.194.50 192.168.111.4 MQTT 70 Publish Release 196 8.073251438 192.168.111.4 52.65.194.50 MQTT 80 Disconnect Req 197 8.073251419 192.168.111.4 52.65.194.50 MQTT 80 Disconnect Req 198 8.154242911 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=122 Win=29312 Len=0 TSval=49174199 TSecr=4013991 199 8.154242911 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [FIN, ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.15427597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=122 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.15427597 52.65.194.50 TCP 66 37956 - 1883 [ACK] Seq=103 Ack=123 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.15427597 52.65.194.50 TCP 66 1883 - 37956 [FIN, ACK] Seq=122 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991 199 8.15427597 52.65.194.50 TCP 66 1883 - 37956 [FIN, ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=4913991 199 Secr=4013991										
193 7.987522182 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=118 Ack=100 Win=26880 Len=0 TSval=49174157 TSecr=4013990_195 8.073050787 52.65.194.50 192.168.111.4 MQTT 68 Disconnect Req 196 8.073215438 192.168.111.4 52.65.194.50 MQTT 68 Disconnect Req 197 8.073251419 192.168.111.4 52.65.194.50 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=122 Win=29312 Len=0 TSval=4913991128 TSecr=. 198 8.154242911 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991. 199 8.154276597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991. 199 8.154276597 52.65.194.50 192.168.111.4 TCP 66 1883 - 37956 [ACK] Seq=102 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991. 199 8.154276597 52.65.194.50 TCP 66 37956 - 1883 [ACK] Seq=103 Ack=103 Win=26880 Len=0 TSval=49174199 TSecr=40. 199 8.154276597 52.65.194.50 TCP 66 37956 - 1883 [ACK] Seq=103 Ack=103 Win=26880 Len=0 TSval=49174199 TSecr=40. 199 8.154276597 52.65.194.50 TCP 66 37956 - 1883 [ACK] Seq=103 Ack=103 Win=26880 Len=0 TSval=4913991. 199 8.154276597 52.65.194.50 TCP 66 37956 - 1883 [ACK] Seq=103 Ack=103 Win=26880 Len=0 TSval=4913991. 199 8.154276597 52.65.194.50 TCP 66 37956 - 1883 [ACK] Seq=103 Ack=103 Win=26880 Len=0 TSval=4913991. 199 TSecr=40. 199 TS										
195 8.073950787 52.65.194.50 192.168.111.4 MQTT 70 Publish Release 196 8.073251343 192.168.111.4 52.65.194.50 MQTT 68 Disconnect Req 197 8.073251419 192.168.111.4 52.65.194.50 TCP 66 37956 − 1883 [FIN, ACK] Seq=102 Ack=122 Win=29312 Len=0 TSval=4913991128 TSecr=. 198 8.154242911 52.65.194.50 192.168.111.4 TCP 66 1883 − 37956 [FIN, ACK] Seq=102 Ack=122 Win=26880 Len=0 TSval=49174199 TSecr=4013991. 199 8.154275957 52.65.194.50 192.168.111.4 TCP 66 1883 − 37956 [FIN, ACK] Seq=122 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991. □ 200 8.154294124 192.168.111.4 52.65.194.50 TCP 66 37956 − 1883 [ACK] Seq=103 Ack=123 Win=26880 Len=0 TSval=49174199 TSecr=49174 □ Frame 159: 71 bytes on wire (568 bits), 71 bytes captured (568 bits) on interface 0 □ Ethernet II, Src: IntelCor_d9:b1:72 (00:15:17:d9:b1:72), Dst: Dell_27:fa:db (14:b3:1f:27:fa:db) □ Internet Protocol Version 4, Src: 52.65.194.50, Dst: 192.168.111.4 □ Transmission Control Protocol, Src Port: 1883, Dst Port: 37956, Seq: 5, Ack: 72, Len: 5 □ WQ Telemetry Transport Protocol, Subscribe Ack □ Header Flags: 0x90 (Subscribe Ack) □ 1001 = Message Type: Subscribe Ack (9)										
196 8.073215438 192_168.111.4 52.65.194.50 MOTT 68 Disconnect Req 197 8.0732514919 192_168.111.4 52.65.194.50 TCP 66 37956 - 1883 [FIN, ACK] Seq=102 Ack=122 Win=29312 Len=0 TSval=4913991128 TSecr= 198 8.154242911 52.65.194.50 192_168.111.4 TCP 66 1883 - 37956 [ACK] Seq=122 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=4013991. 199 8.154275597 52.65.194.50 192_168.111.4 TCP 66 1883 - 37956 [FIN, ACK] Seq=122 Ack=102 Win=26880 Len=0 TSval=49174199 TSecr=40. 200 8.154294124 192_168.111.4 52.65.194.50 TCP 66 37956 - 1883 [ACK] Seq=103 Ack=103 Win=26880 Len=0 TSval=49174199 TSecr=40. ▶ Frame 159: 71 bytes on wire (568 bits), 71 bytes captured (568 bits) on interface 0 ▶ Ethernet II, Src: IntelCor_d9:b1:72 (00:15:17:d9:b1:72), Dst: Dell_27:fa:db (14:b3:1f:27:fa:db) Internet Protocol Version 4, Src: 52.65.194.50, Dst: 192_168.111.4 ▶ Transmission Control Protocol, Subscribe Ack ▼ MQ Telemetry Transport Protocol, Subscribe Ack (9)										
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▼ Header Flags: 9x90 (Subscribe Ack) 1001 = Message Type: Subscribe Ack (9)										
1001 = Message Type: Subscribe Ack (9)										
00. = QoS Level: At most once delivery (Fire and Forget) (0)										
0 = Retain: Not set										
Msq Len: 3										
Message Identifier: 1			(Assured Delivery) (2)						
Message Identifier: 1	Granted QoS: Exactly once delivery (Assured Delivery) (2)									

The Connect command follows with the usual Connect Acknowledge command. It can be seen that QoS 2 is granted to the client in the Subscriber Ack.

Publish:

Each of the Publish Message sent from the broker is replied with Publish Received message by the client. The broker then sends a Publish Release command and the client replies with the Publish Complete command ensuring that the message is received exactly once. Each of the messages have the Message Identifier.

Summary:

For QoS 0, the message duplication bit carries no significance. The broker pushes out the message as soon as it receives. The message from the broker received do not necessarily have to be in order therefore. It will be used where the data will not severely effect if it is lost. For example, if a temperature sensor is sending the data at a very fast rate, a few packets lost will not make a significant difference.

For QoS 1, The broker ensures that the client receives the message at least once and if the client does not receive, the message is sent again with the duplicate bit set. The message is deleted after the receiver processes it and sends an acknowledgement to the sender who then deletes it.

In QoS 2, the message is delivered exactly once, and this is the safest mode of transfer. Two pairs of transmission between the sender and receiver are used for this. In the first, sender sends the message to the receiver telling it that it has stored the message. Once the receiver replies with an acknowledgement a PUBREL is sent by the sender that tells the receiver that it can complete processing the message. When the client sends the acknowledgement of the PUBREL, sender deletes the message.

Question 2(a)

The following statistics for different QoS was collected from one run of the code:

QoS: 0

- 1. Rate of messages received: 3485
- 2. Rate of messages lost: 0
- 3. Rate of duplicated messages: 0
- 4. Rate of out-of-order messages: 0

QoS: 1

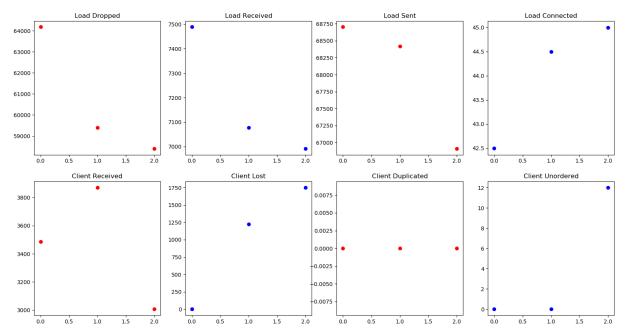
- 1. Rate of messages received: 3870
- 2. Rate of messages lost: 1226
- 3. Rate of duplicated messages: 0
- 4. Rate of out-of-order messages: 0

QoS: 2

- 1. Rate of messages received: 3007
- 2. Rate of messages lost: 1751
- 3. Rate of duplicated messages: 0
- 4. Rate of out-of-order messages: 12

Question 2(b)

The following figure shows how broker and client perform for different QoS for one session the client is connected to the broker. The first row shows the messages dropped, received, sent and number of active client on the broker in one minute from left to right. The second row shows messages received, lost, duplicated and unordered in one minute that the client experiences.



We can see that the dropped messages and the received messages on the broker are correlated. This is expected as the broker will lose more messages if the publishers want to send more data. If they send less data, the broker is less likely to lose messages. Another correlation we can expect is between number of clients connected to the broker and the rate of message loss by the client. As the number of active clients subscribed increase, we would expect the client to lose more messages. This is proven in the figure above as the number of clients increase from QoS 0 to 2, more messages are lost by the client.

Question 4

Results were compared across loss/dupe/out-of-order for the timestamp 152696xxxx for similar time comparison. The table below summarizes the values for each of the messages

Sr. No	Loss QoS (1)	Dupe	Out-of-order
1	88	24	4.15
2	47	20	1.39
3	0	12	1.77
4	59	2.38	6
5	14	24.82	1.6
6	68	15.4	8.38
7	40	2.66	1
8	35	0	10

9	39	13.64	11.59
10	36	13	1.9

There is similarity between the different rates although some extreme values can be seen as well.

No correlation in performance is seen from the different use of language.

Question 5

- a. In the broader end-to-end environment, there is a limit to which the network's performance could be extended. A CPU is one element in an MQTT network and performs processing tasks such as updating the key-value pairs when a message is received from the publishers and retrieving when subscribers need it. If processing is slow then there will be delays in subscribers receiving information and publishers would have to wait. Memory especially heap memory is another element which allows for quick update of key-value pairs of MQTT. Heap memory is dynamic and provides for quick access to key-value pairs. Amount of memory is directly proportional to different number of topics that need updating. If new topics are added, heap memory will be consumed faster. This is especially important if the messages sent to the broker have the 'retain' flag set. Lastly, type of network defines how quickly messages are transferred between the broker and subscribers and clients. A fast connection over a fiber optic would update and deliver the messages fast. If the network is slow, then it may be the case that the values received by subscribers may not be most recent. Also, fewer messages will be dropped with a more reliable mode of transfer.
- b. Different QoS can have different effects on the performance of the broader MQTT network. The 0 QoS which is 'fire and forget' will increase performance in a certain way. With this QoS, the broker does not have to ensure that the client receives the message or not and thus other clients' message will be sent more frequently. Fewer memory will be consumed as well as the broker does not have to keep an account of who has received what message as it does not send puback messages. Over a less reliable network though, clients may have a high chance that they are not receiving message and they have no way of telling the broker. QoS 1 which is 'At least once' would use more of the computing resources but it means that clients will receive message at least once. More memory would be required thus as the broker needs to keep track if the message has been received by the client. QoS 2 which is 'Exactly once' is the safest but will reduce the performance of the network the most. It involves a four-way handshake, thus using even more computing resources. Messages sent and received by the broker need to be tracked more so needs more memory resources as well. However, like other QoS it does not improve or deteriorate the effect of network type on the performance.
- c. We can see from the diagram that the number of messages received decrease as QoS level increase. This Is because, lost messages are sent again until the broker is sure that we have received it. Also, as QoS levels increase, more acknowledge messages are exchanged between the client and the broker.