

Lab 2: Capture and Analyze IoT Device Traffic

Lab Scenario

As a professional ethical hacker or pen tester, you must have sound knowledge to capture and analyze the traffic between IoT devices. Using various tools and techniques, you can capture the valuable data flowing between the IoT devices, analyze it to obtain information on the communication protocol used by the IoT devices, and acquire sensitive information such as credentials, device identification numbers, etc.

Lab Objectives

- Capture and analyze IoT traffic using Wireshark

Overview of IoT and OT Traffic

Many IoT devices such as security cameras host websites for controlling or configuring cameras from remote locations. These websites mostly implement the insecure HTTP protocol instead of the secure HTTPS protocol and are, hence, vulnerable to various attacks. If the cameras use the default factory credentials, an attacker can easily intercept all the traffic flowing between the camera and web applications and further gain access to the camera itself. Attackers can use tools such as Wireshark to intercept such traffic and decrypt the Wi-Fi keys of the target network.

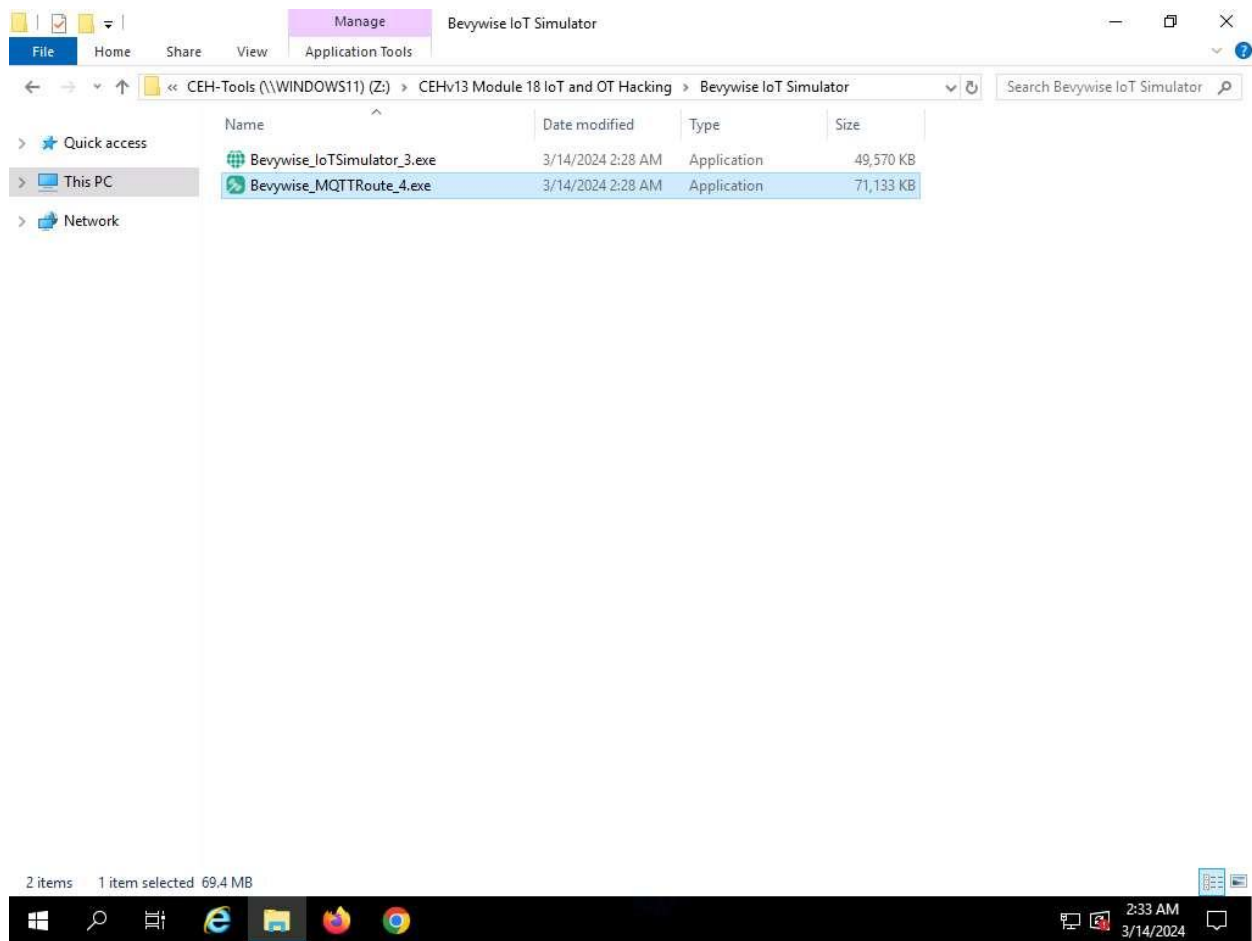
Task 1: Capture and Analyze IoT Traffic using Wireshark

Wireshark is a free and open-source packet analyzer. It facilitates network troubleshooting, analysis, software and communications protocol development, and education. It is used to identify the target OS and sniff/capture the response generated from the target machine to the machine from which a request originates.

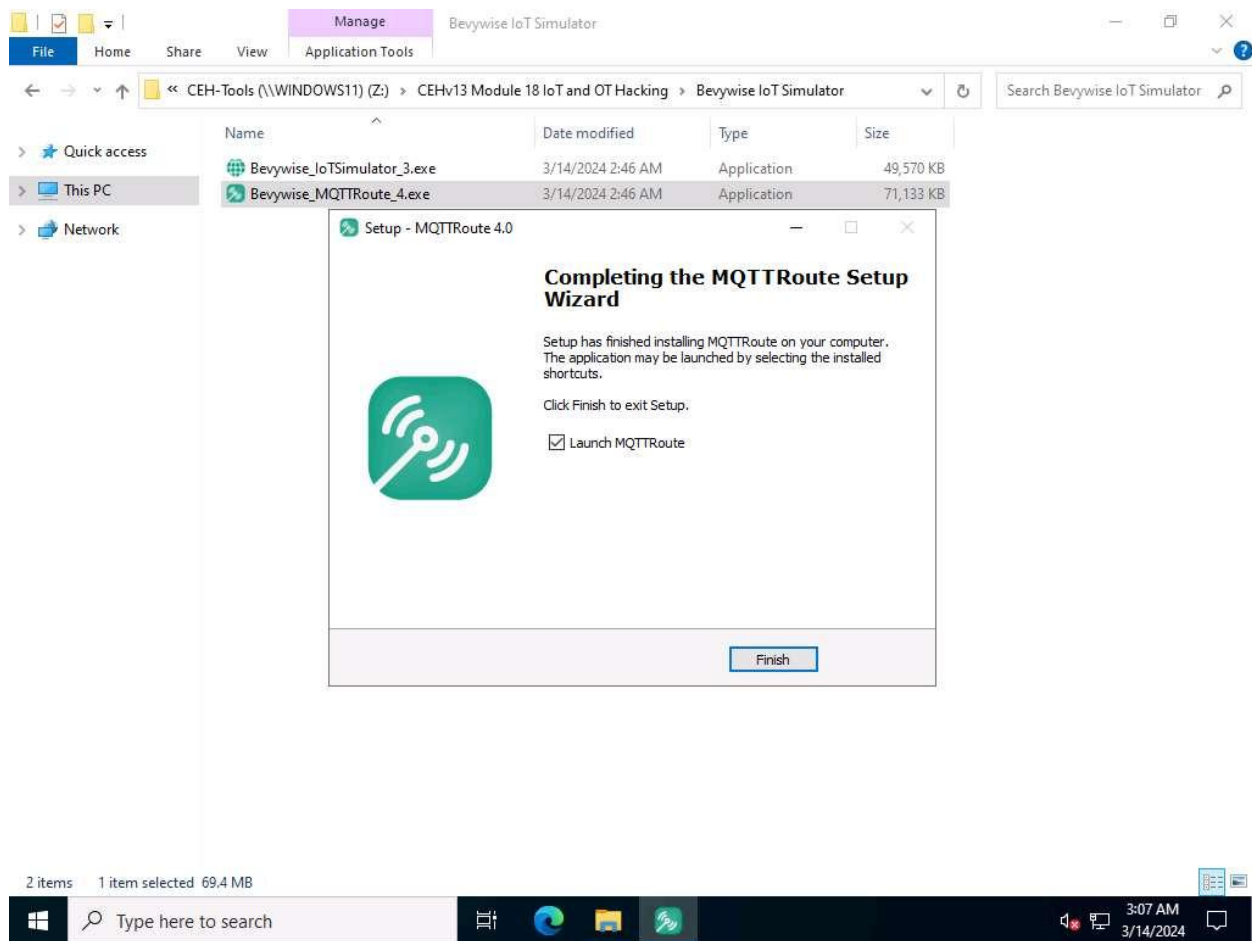
MQTT is a lightweight messaging protocol that uses a publish/subscribe communication pattern. Since the protocol is meant for devices with a low-bandwidth, it is considered ideal for machine-to-machine (M2M) communication or IoT applications. We can create virtual IoT devices over the virtual network using the Bevywise IoT simulator on the client side and communicate these devices to the server using the MQTT Broker web interface. This interface collects data and displays the status and messages of connected devices over the network.

Here, we use Wireshark to capture and analyze traffic between IoT devices.

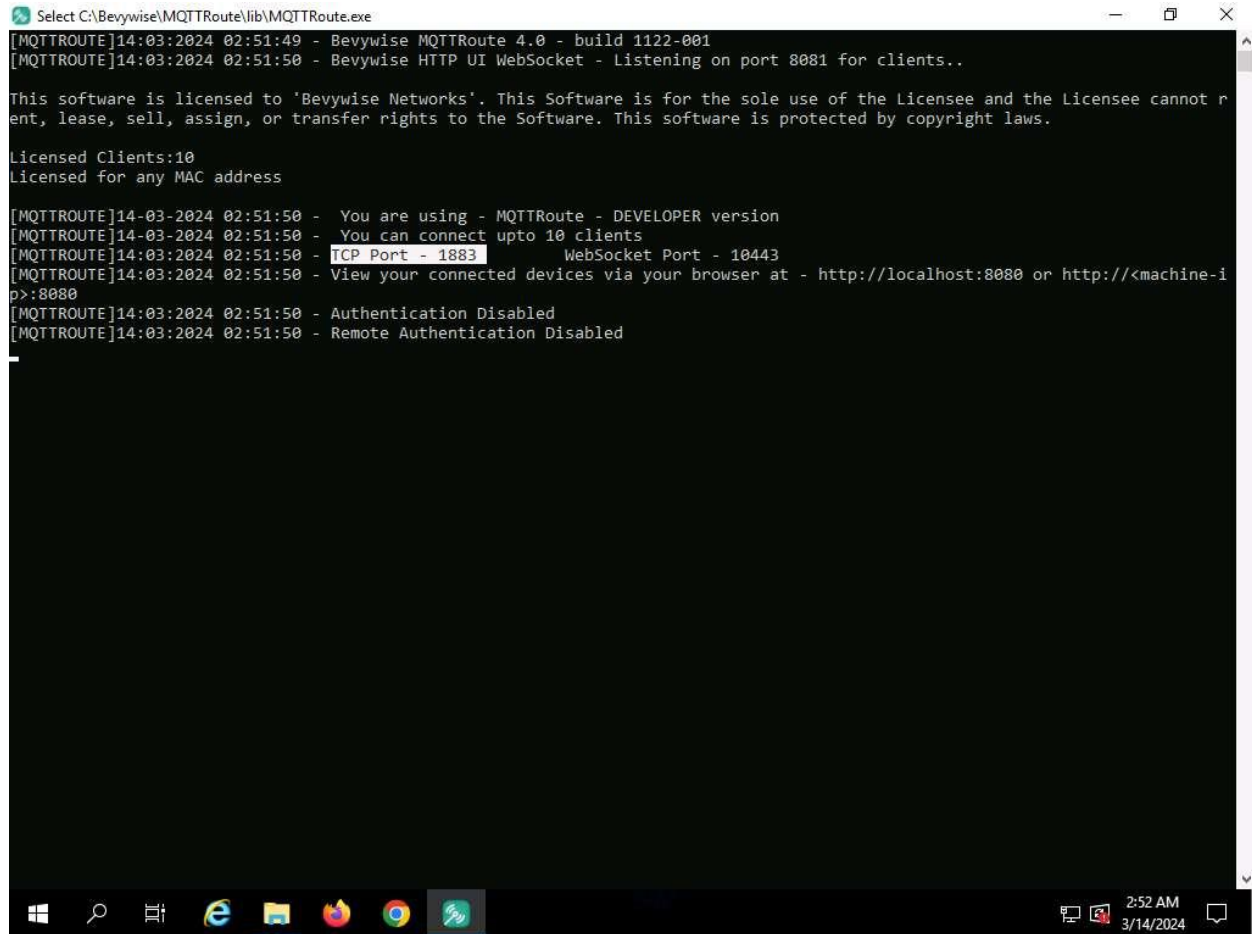
1. To install the **MQTT Broker** on the **Windows Server 2019**, click [Windows Server 2019](#) to launch **Windows Server 2019** machine. Click [Ctrl+Alt+Delete](#) and login with **Administrator/Pa\$\$w0rd**.
2. Navigate to **Z:\CEHv13 Module 18 IoT and OT Hacking\Bevywise IoT Simulator** folder and double-click on the **Bevywise_MQTTRoute_4.exe** file.



3. If **Open File - Security Warning** popup appears, click **Run**.
4. The **Setup - MQTTRoute 4.0** window opens. Select **I accept the agreement** and click on **Next**. Follow the wizard driven steps to install the tool.
5. After the installation completes, click on **Finish**. Ensure that **Launch MQTTRoute** is checked.



6. The MQTTRoute will execute and the command prompt will appear. You can see the **TCP** port using **1883**.



```
Select C:\Bevywise\MQTTRoute\lib\MQTTRoute.exe
[MQTTRoute]14-03-2024 02:51:49 - Bevywise MQTTRoute 4.0 - build 1122-001
[MQTTRoute]14-03-2024 02:51:50 - Bevywise HTTP UI WebSocket - Listening on port 8081 for clients..

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ent, lease, sell, assign, or transfer rights to the Software. This software is protected by copyright laws.

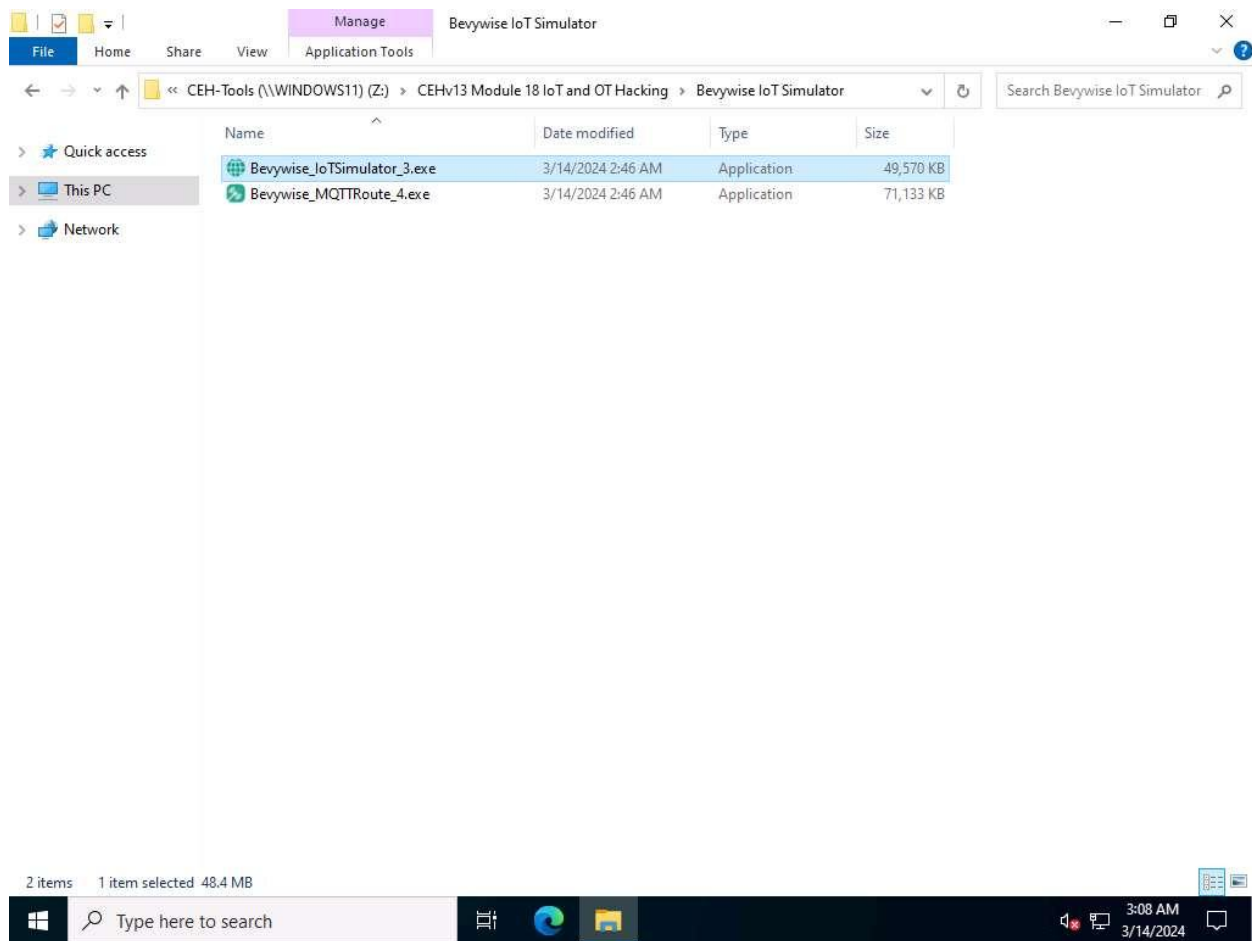
Licensed Clients:10
Licensed for any MAC address

[MQTTRoute]14-03-2024 02:51:50 - You are using - MQTTRoute - DEVELOPER version
[MQTTRoute]14-03-2024 02:51:50 - You can connect upto 10 clients
[MQTTRoute]14-03-2024 02:51:50 - TCP Port - 1883      WebSocket Port - 10443
[MQTTRoute]14-03-2024 02:51:50 - View your connected devices via your browser at - http://localhost:8080 or http://<machine-i
p>:8080
[MQTTRoute]14-03-2024 02:51:50 - Authentication Disabled
[MQTTRoute]14-03-2024 02:51:50 - Remote Authentication Disabled
```

7. We have installed MQTT Broker successfully and leave the Bevywise MQTT **running**.
8. To create IoT devices, we must install the **IoT simulator** on the client machine.
9. Click [Windows Server 2022](#) to switch to **Windows Server 2022** machine.
Click [Ctrl+Alt+Delete](#) and login with **Administrator/Pa\$\$w0rd**.

If the network screen appears, click **Yes**.

10. Navigate to **Z:\CEHv13 Module 18 IoT and OT Hacking\Bevywise IoT Simulator** folder and double-click on the **Bevywise_IoTSimulator_3.exe** file.

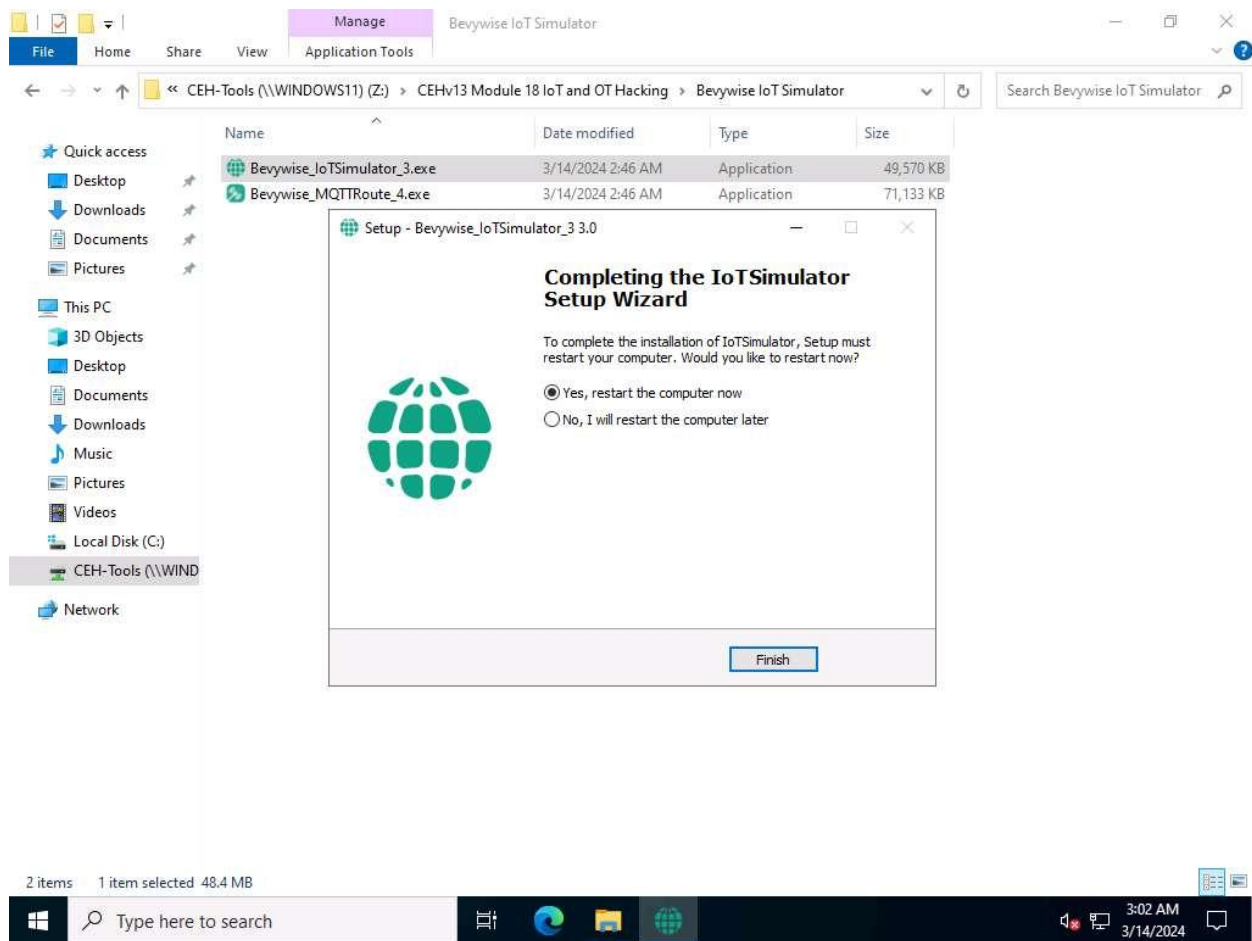


11. If **Open File - Security Warning** popup appears, click **Run..**

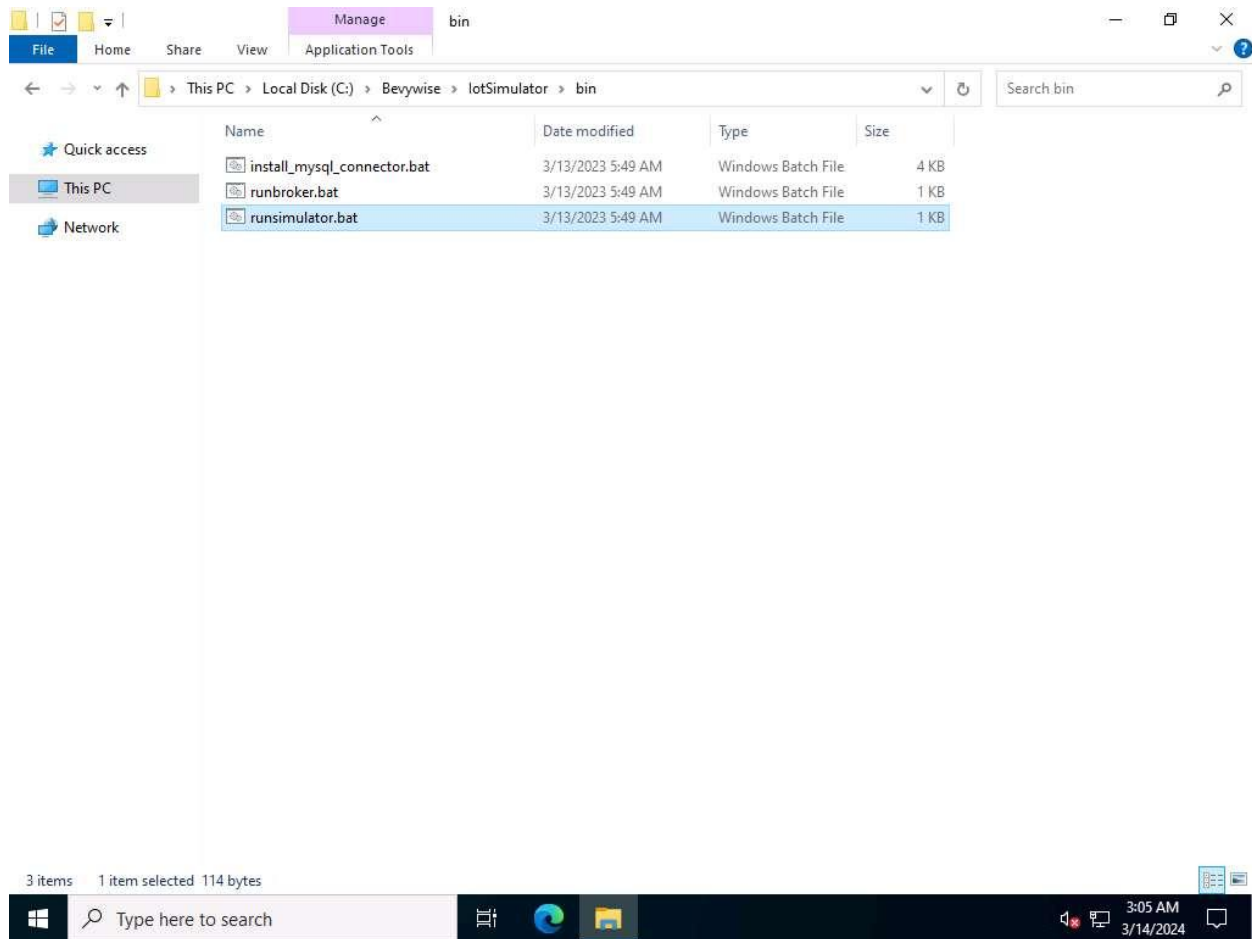
12. The **Setup-IoTSimulator_3 3.0** setup wizard opens. Select **I accept the agreement** and follow the wizard driven steps.

13. To complete the installation, select **Yes, restart the computer now** and click on **Finish** to complete the installation.

If restart computer option does not appear, then continue from **Step#16**.



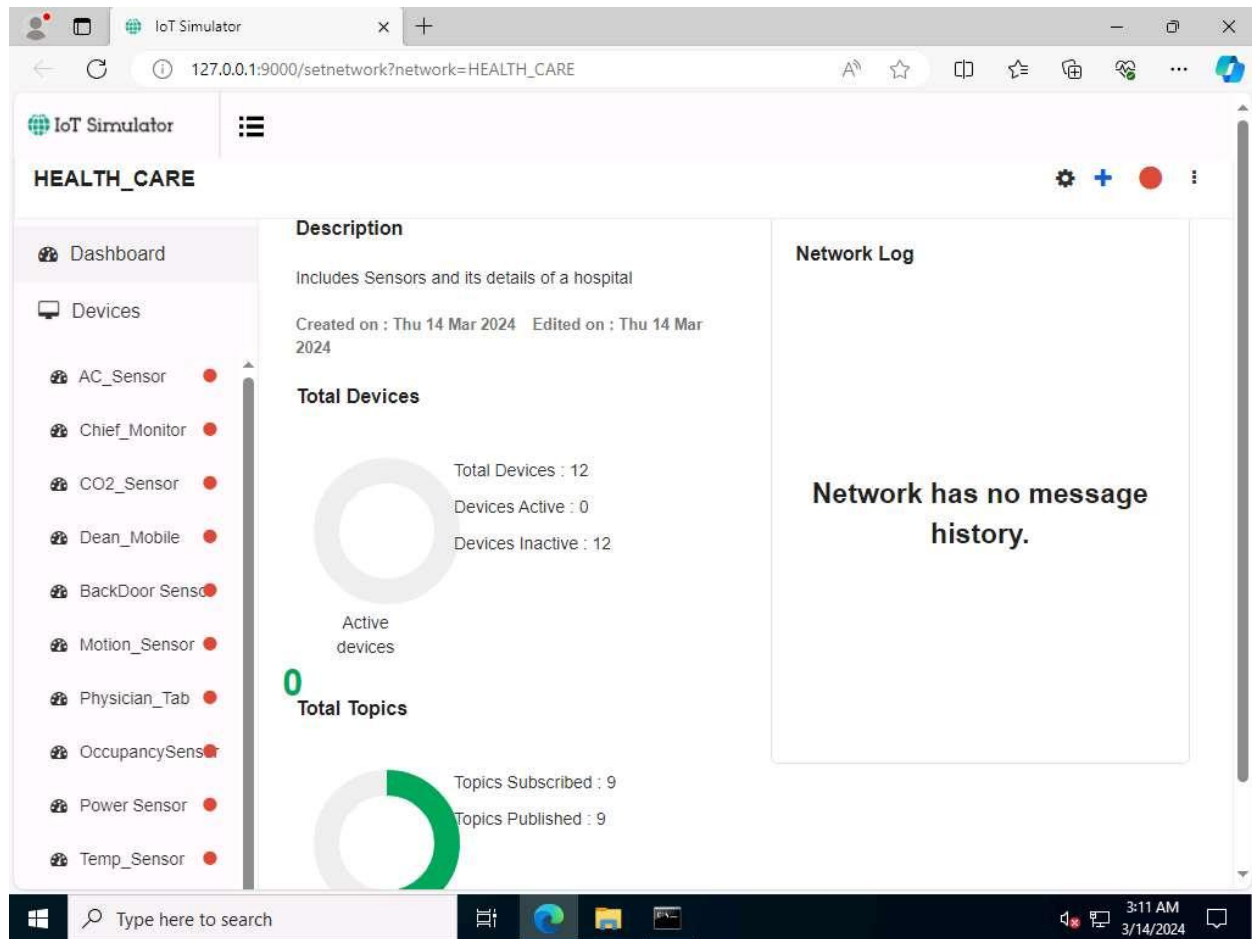
14. After restarting, Bevywise IoT Simulator is installed successfully. To launch the **IoT simulator**, navigate to the **C:\Bevywise\IoT Simulator\bin** directory and double-click on the **runsimulator.bat** file.



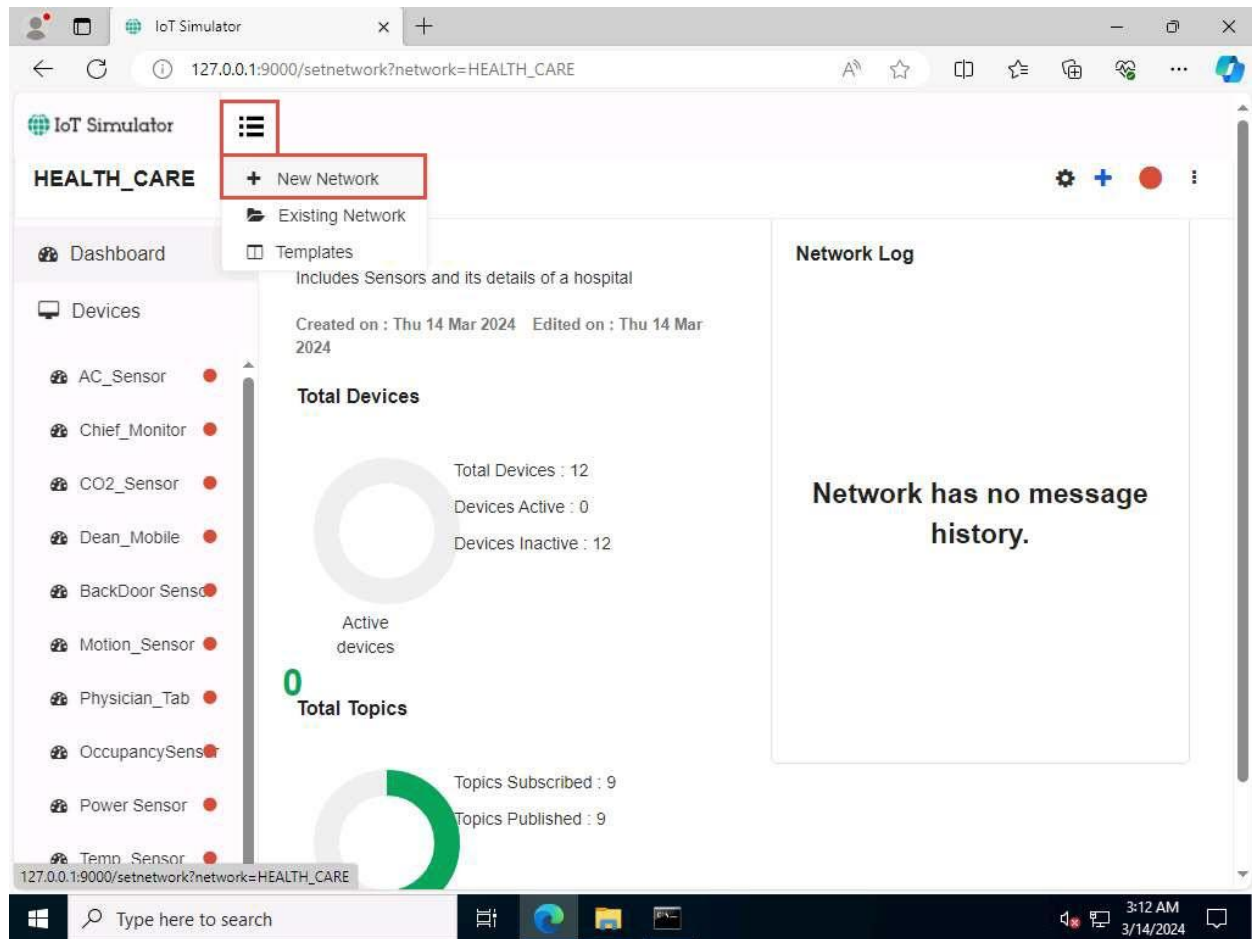
15. Upon double-clicking the **runsimulator.bat** file opens in the command prompt. If **How do you want to open this?** pop-up appears, select **Microsoft Edge** browser and click **OK** to open the URL **http://127.0.0.1:9000/setnetwork?network=HEALTH_CARE**.

If the URL directly opens in Microsoft Edge browser, then continue.

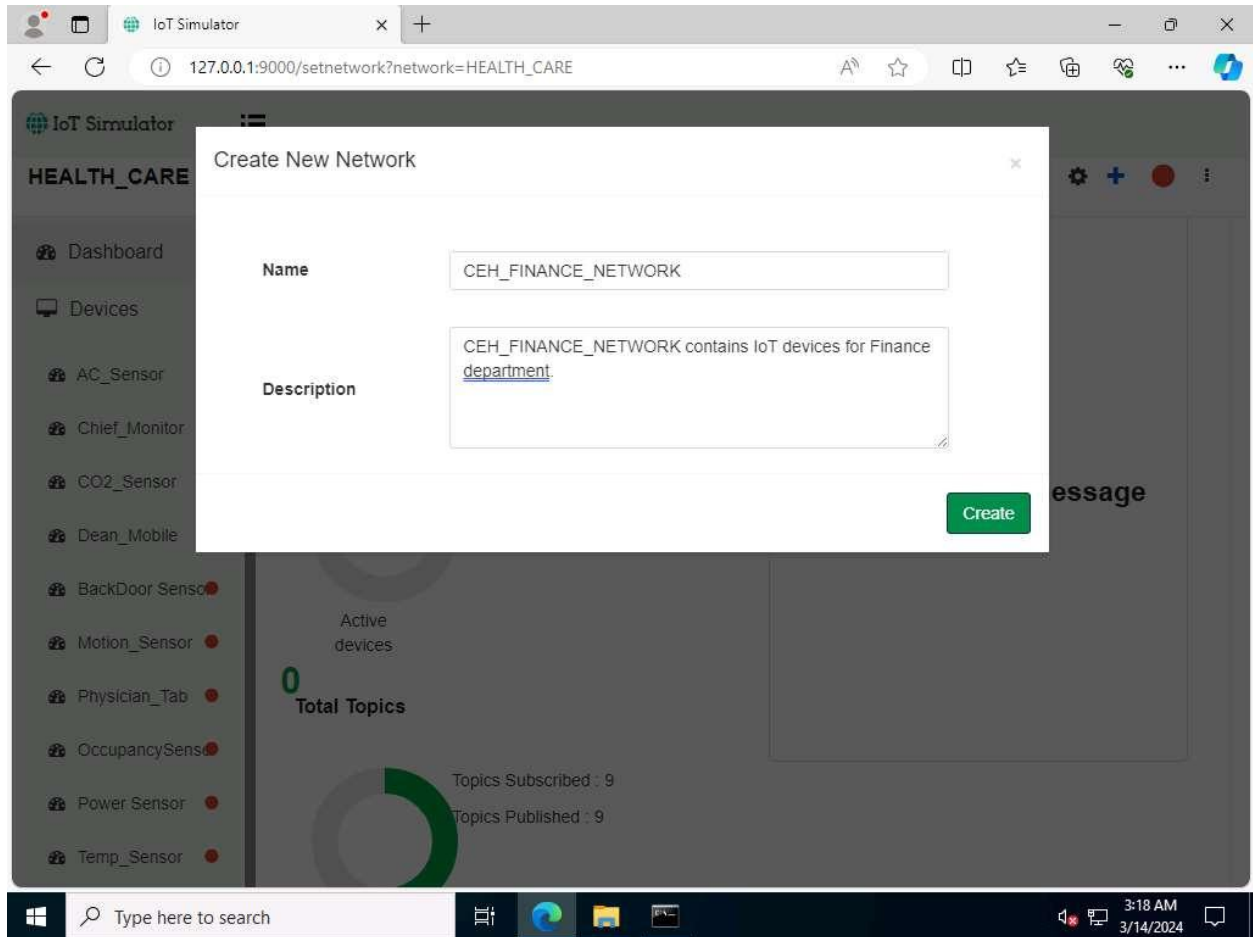
16. The web interface of the IoT Simulator opens in Edge browser. In the IoT Simulator, you can view the default network named **HEALTH_CARE** and several devices.



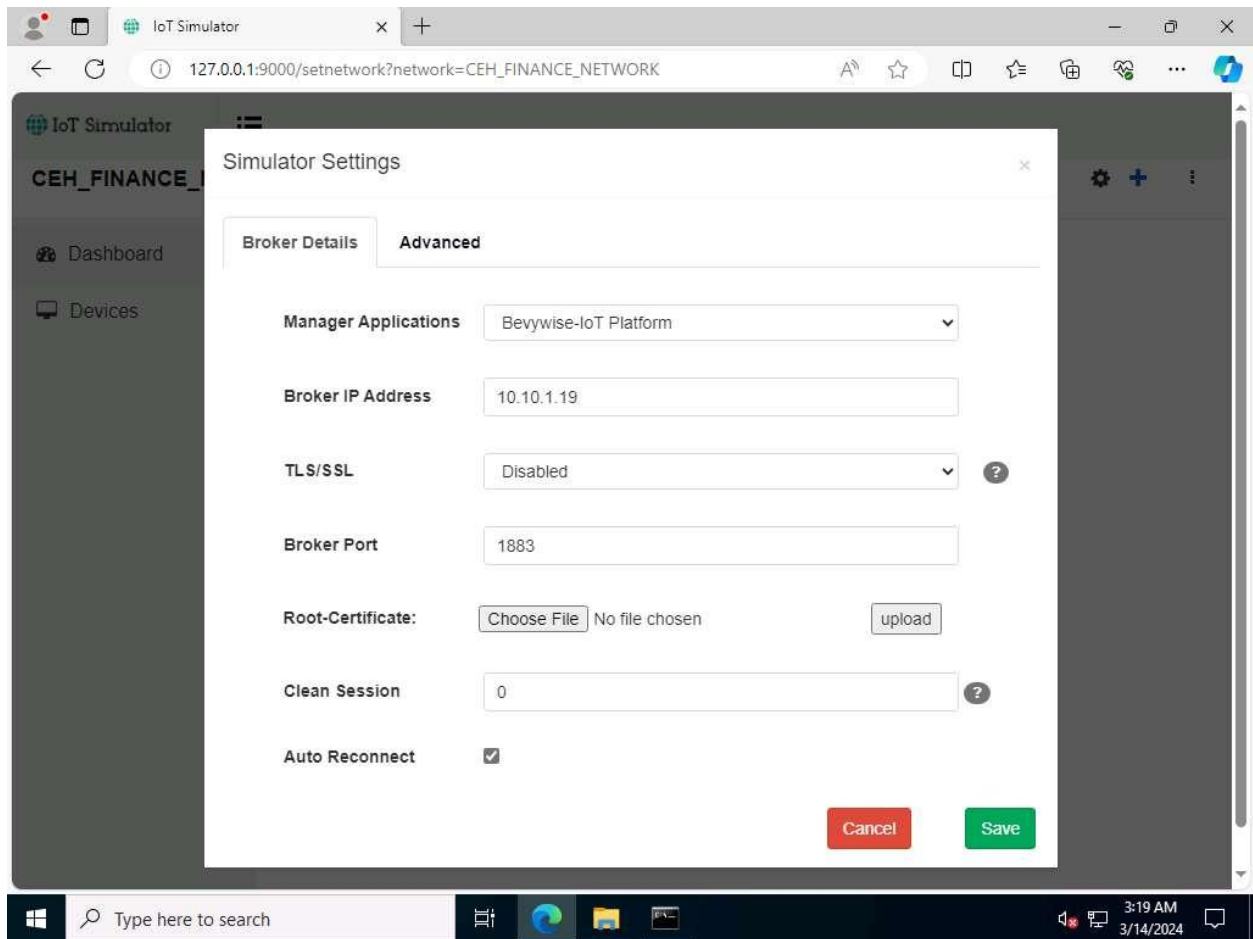
17. Next, we will create a **virtual IoT network** and **virtual IoT devices**. Click on the **menu** icon and select the **+New Network** option.



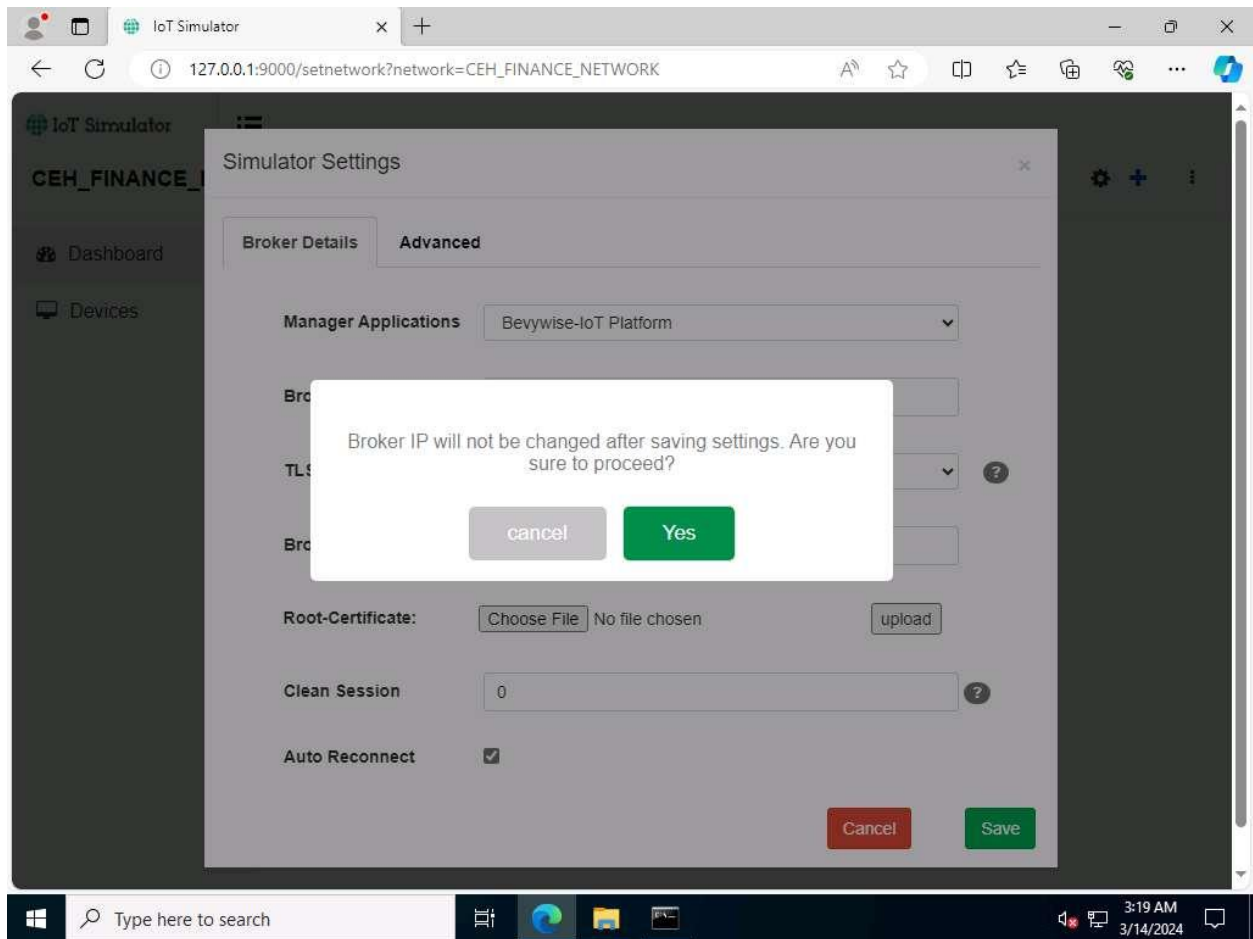
18. The **Create New Network** popup appears. Type any name (here, **CEH_FINANCE_NETWORK**) and description. Click on **Create**.



19. In the next screen, we will setup the **Simulator Settings**. Set the **Broker IP Address** as **10.10.1.19** (the IP address of the **Windows Server 2019**). Since we have installed the Broker on the web server, the created network will interact with the server using MQTT Broker. Do not change default settings and click on **Save**.

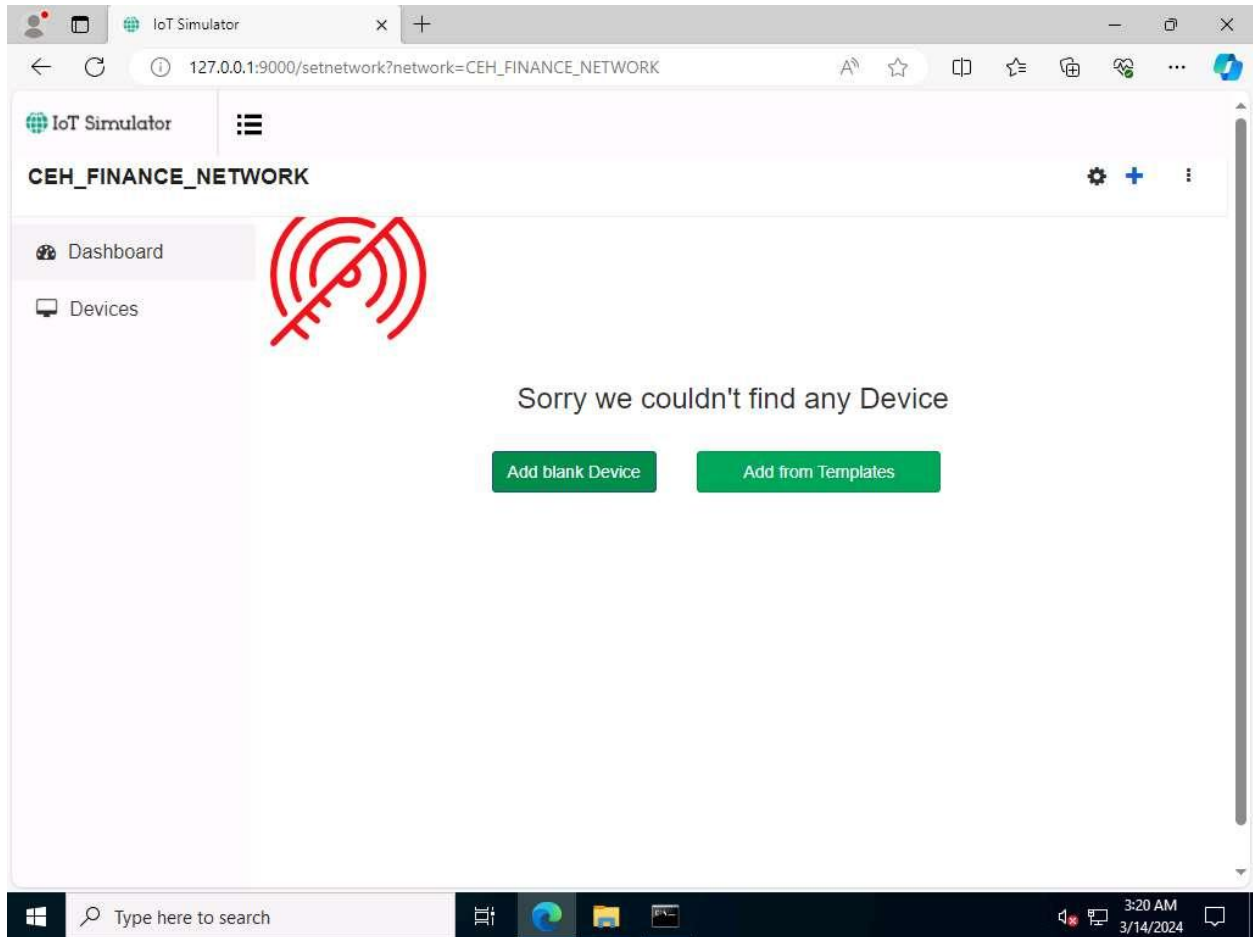


20. To proceed with the network creation, click on **Yes**.

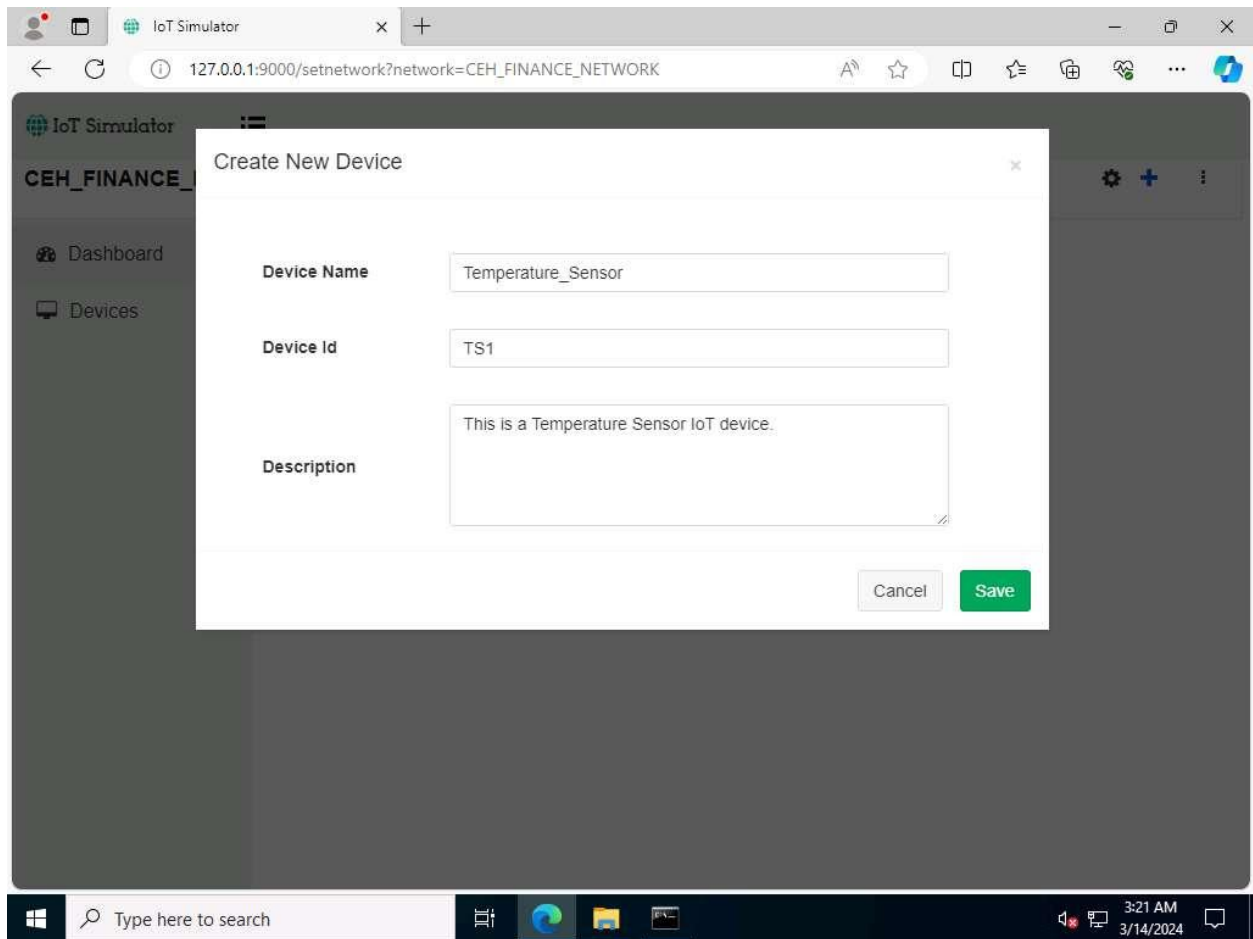


If **Configuration Saved** pop-up appears. Click on **OK** to continue. This step completes the creation of the virtual IoT network.

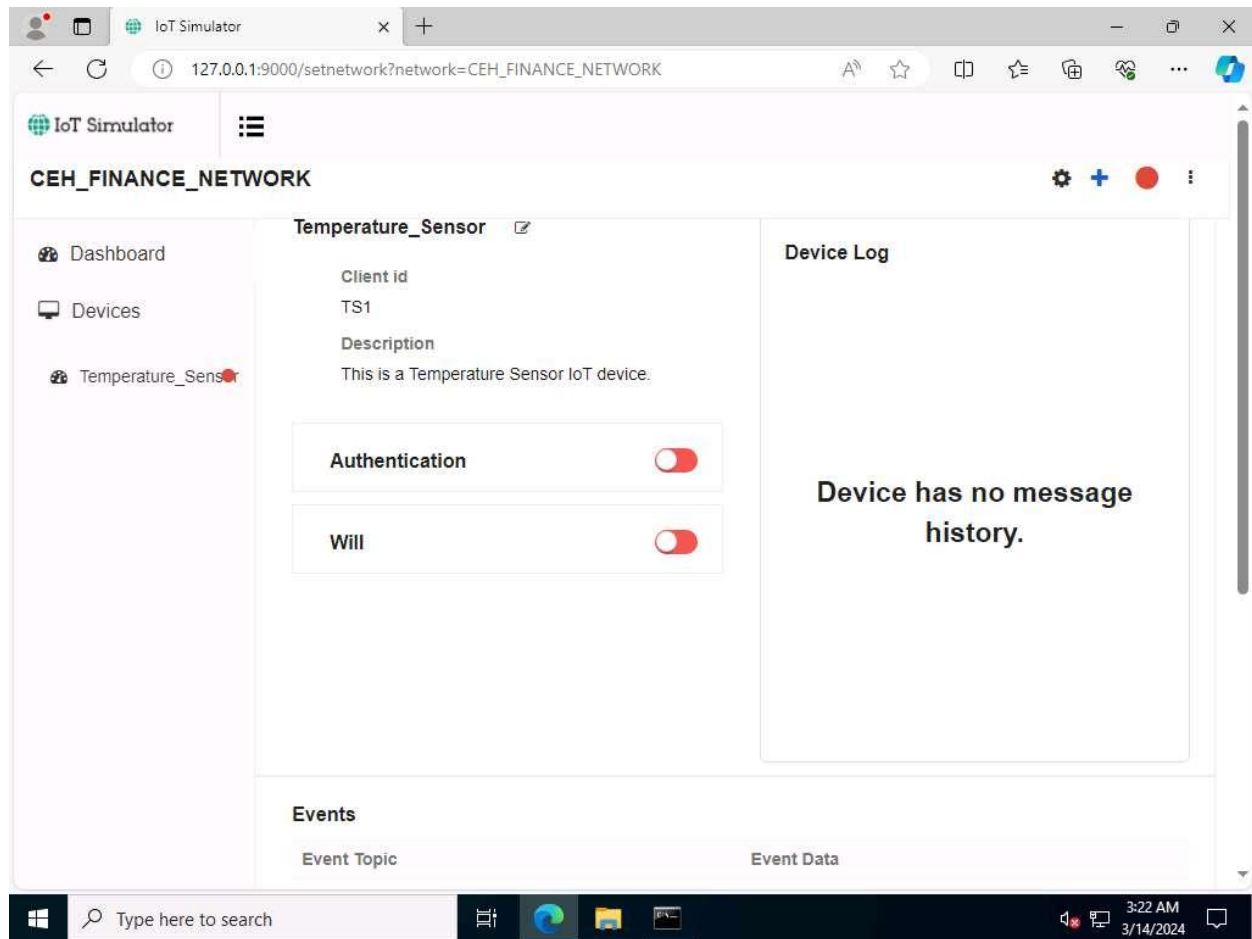
21. To add IoT devices to the created network, click on the **Add blank Device** button.



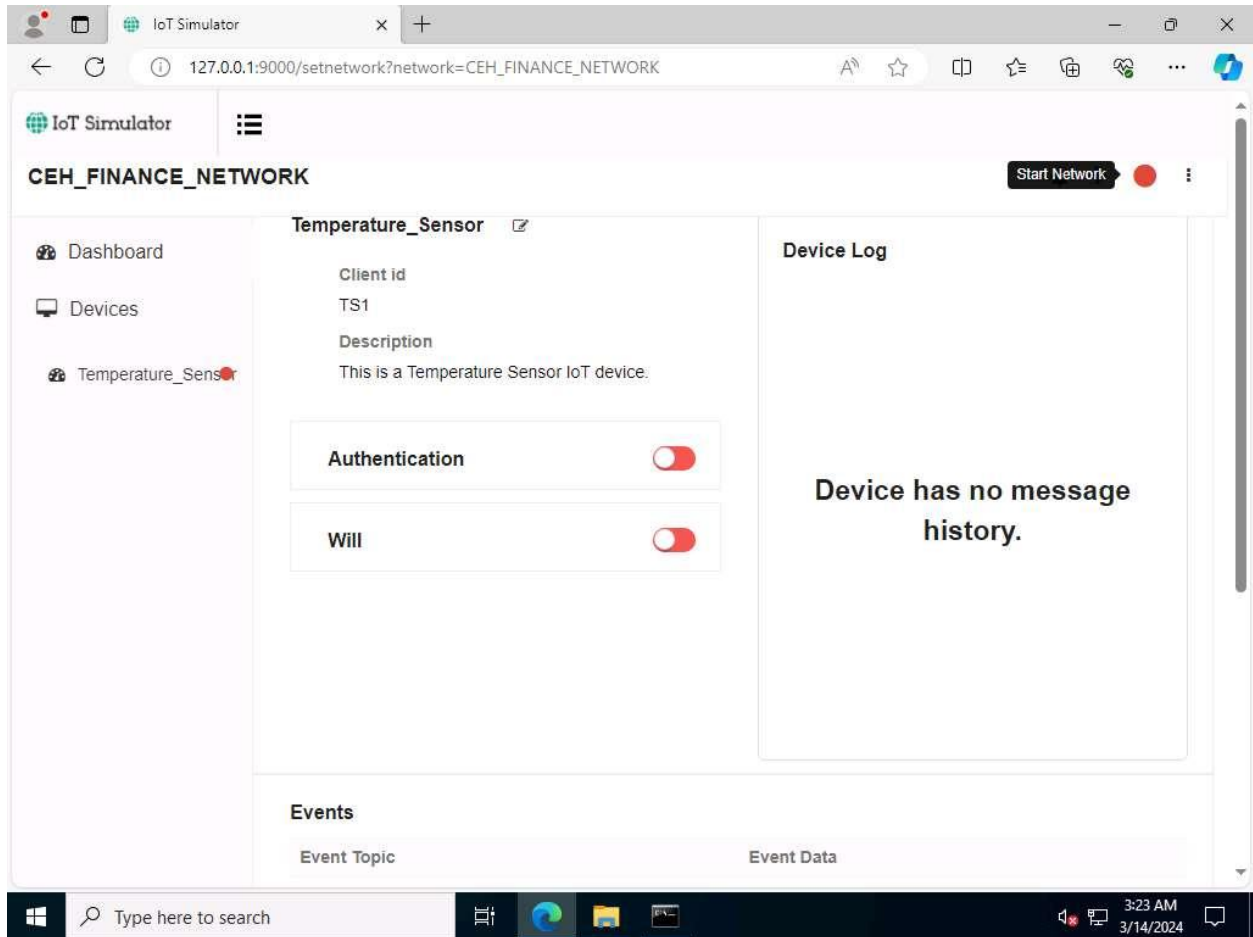
22. The **Create New Device** popup opens. Type the device name (here, we use **Temperature_Sensor**), enter Device Id (here, we use **TS1**), provide a **Description** and click on **Save**.



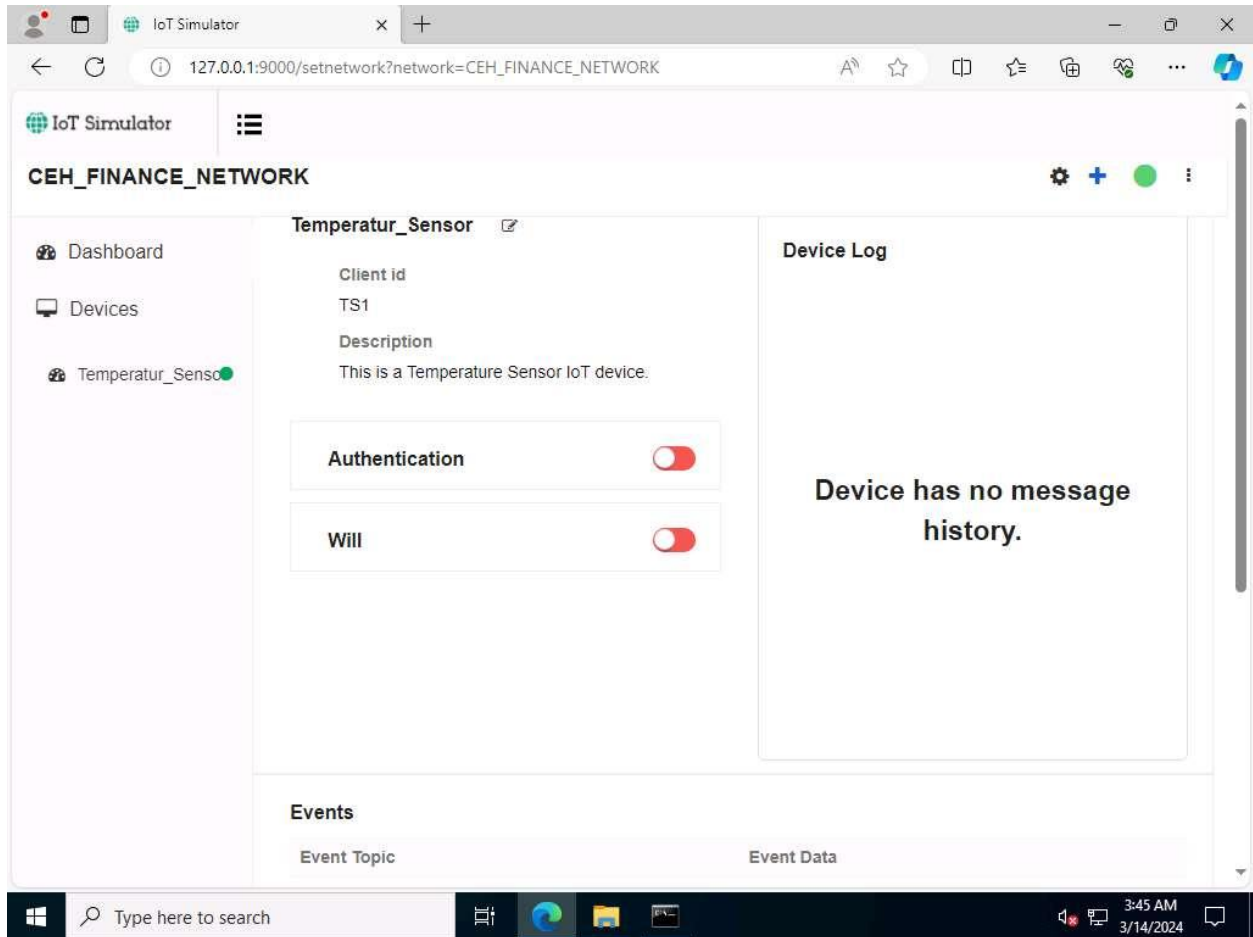
23. The device will be added to the **CEH_FINANCE_NETWORK**.



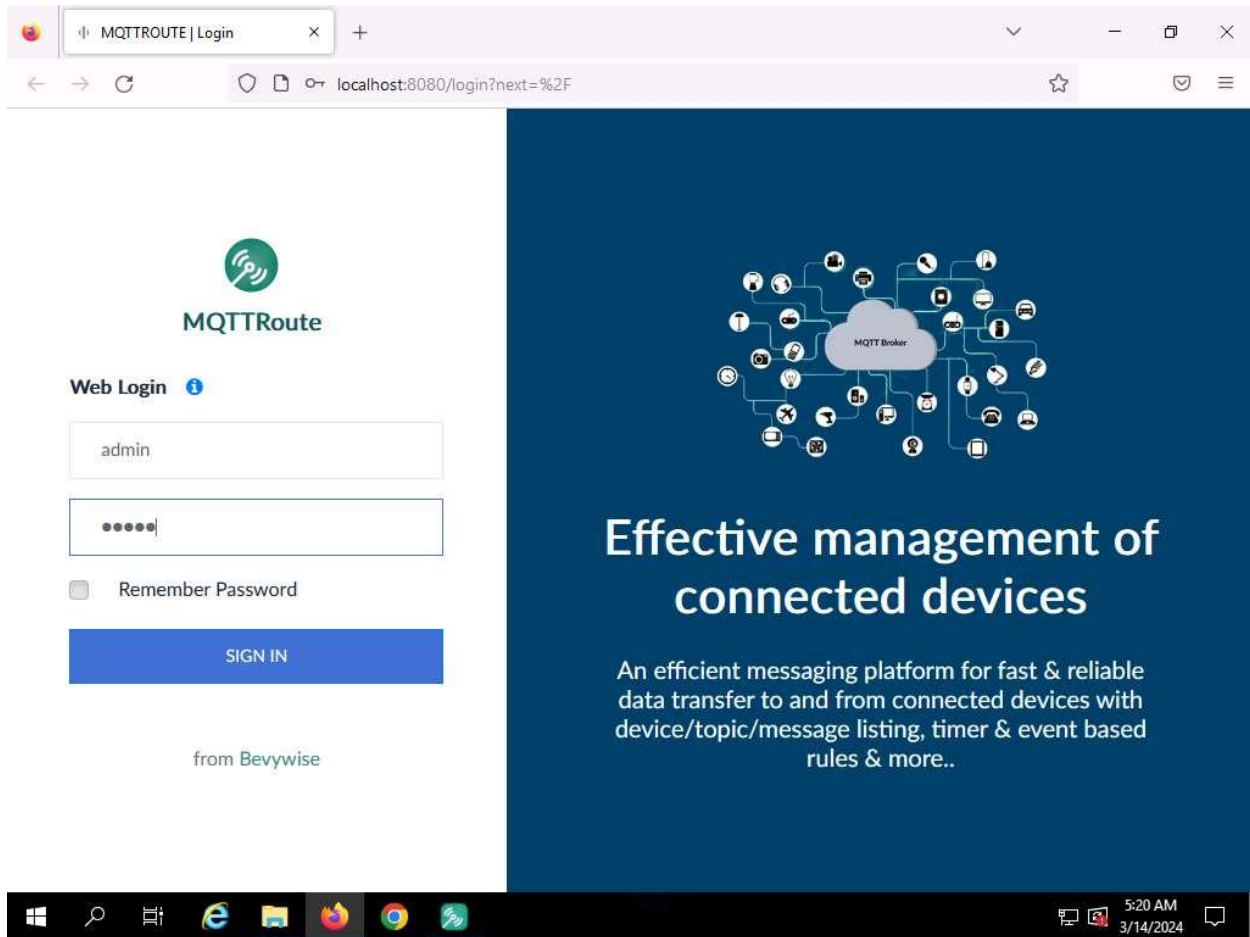
24. To connect the Network and the added devices to the server or Broker, click on the **Start Network** red color circular icon in right corner.



25. When a connection is established between the network and the added devices and the web server or the MQTT Broker, the red button turns into **green**.



26. Next, switch to the [Windows Server 2019](#) machine. Open a web browser, and go to `http://localhost:8080` and login using `admin/admin` (here, we are using **Firefox** Browser).



27. Since the Broker was **left running**, you can see a connection request from machine **10.10.1.22** for the device **TS1** under **Recent Connections** section.

The screenshot shows the MQTTRoute web interface in a browser window. The address bar shows 'localhost:8080'. The interface has a top navigation bar with a plus icon in the top right corner. Below the navigation bar, there are four summary cards: 'Active Devices' (1), 'Total Devices' (1), 'Events' (0), and 'Commands' (0). Below these cards are three main sections: 'Recent Events', 'Recent Device Log', and 'Recent Connections'. The 'Recent Events' and 'Recent Device Log' sections show 'No Data Found'. The 'Recent Connections' section is highlighted with a red border and contains one entry for device 'TS1' with IP '10.10.1.22' and connection time 'Today 05:15:32'. To the right of 'Recent Connections' is a 'Recent Disconnections' section, which also shows 'No Data Found'. The Windows taskbar is visible at the bottom of the screen.

MQTTRoute

localhost:8080

Active Devices
1

Total Devices
1

Events
0

Commands
0

Recent Events

Device Id	Topic	Message	Time
No Data Found			

Recent Device Log

Device Id	IP	Status	Time
No Data Found			

Recent Connections

Device Id	IP	Time
TS1	10.10.1.22	Today 05:15:32

Recent Disconnections

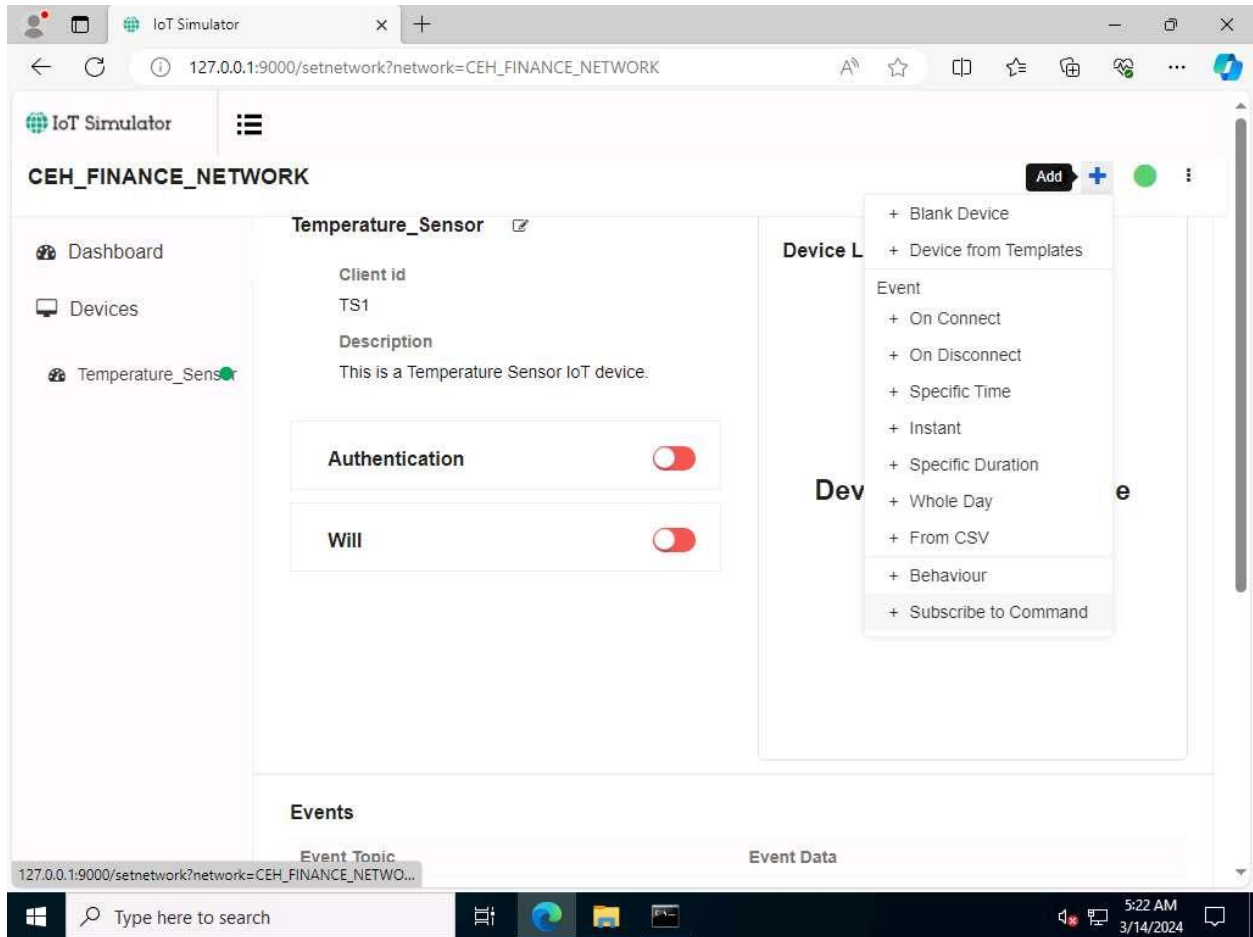
Device Id	IP	Time
No Data Found		

5:21 AM
3/14/2024

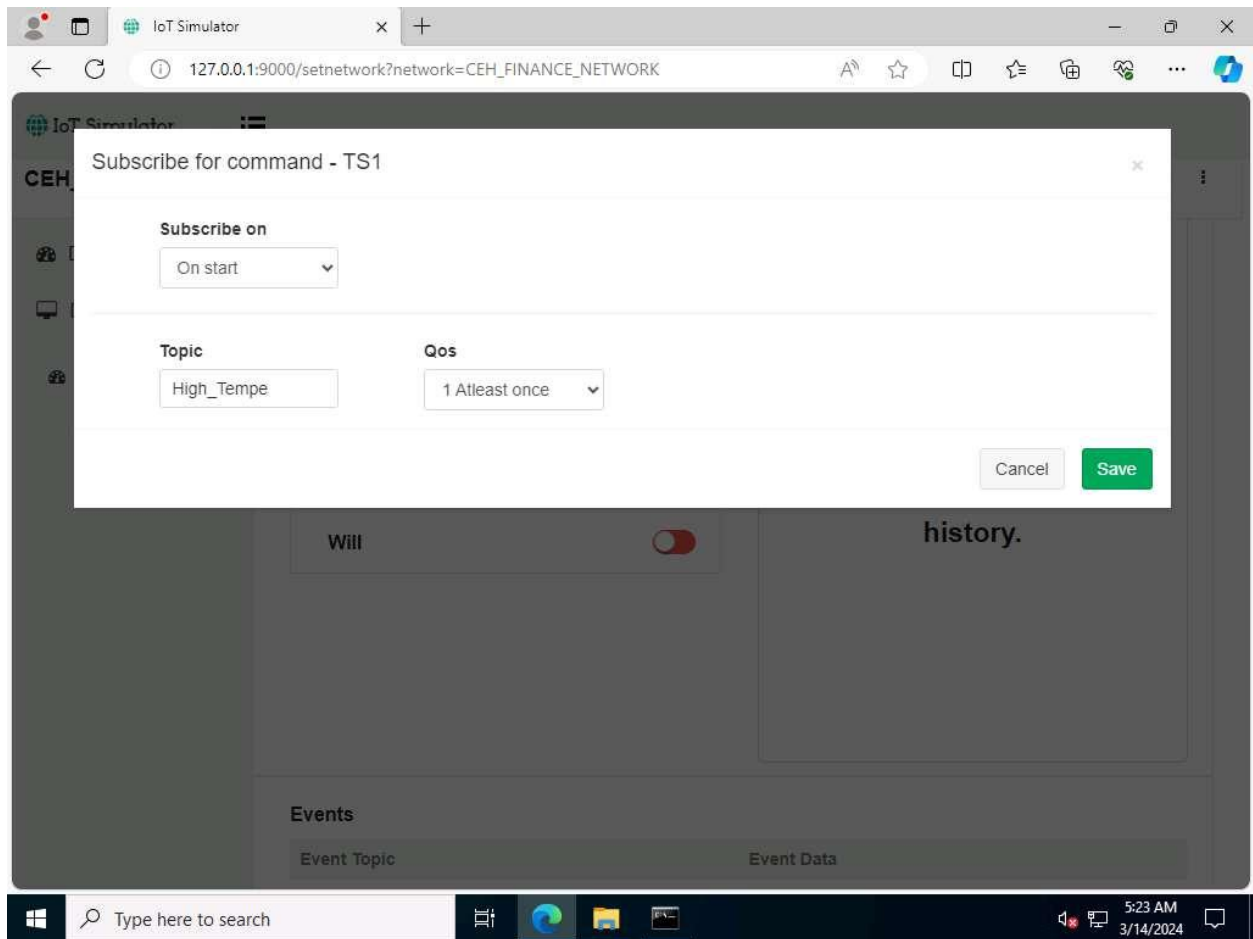
28. Switch back to [Windows Server 2022](#) machine.

29. Next, we will create the **Subscribe command** for the device Temperature_Sensor.

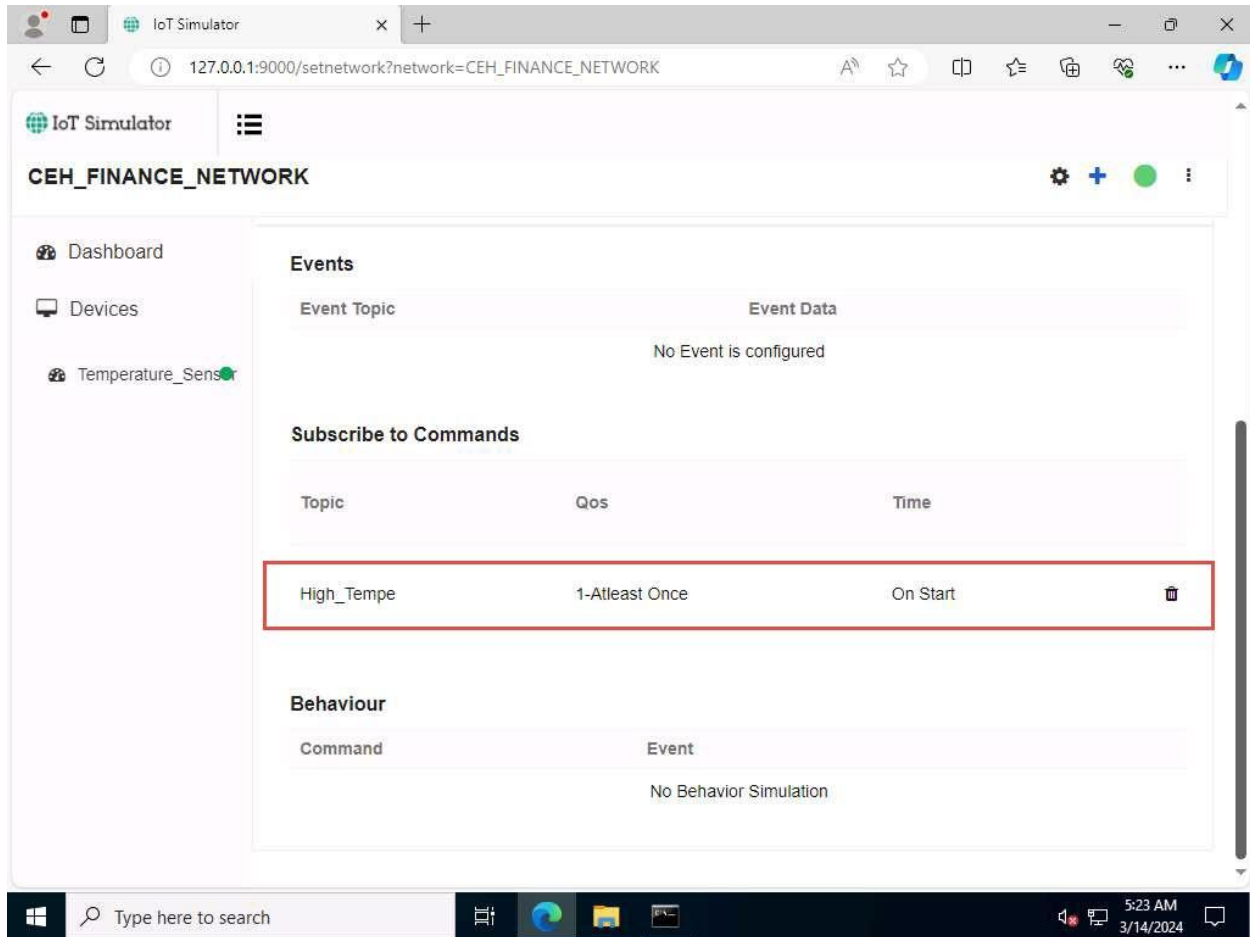
30. Click on the **Plus** icon in **the top right corner** and select the **Subscribe to Command** option.



31. The **Subscribe for command - TS1** popup opens. Select **On start** under the **Subscribe on** tab, type **High_Tempe** under the **Topic** tab, and select **1 Atleast once** below the **Qos** option. Click on **Save**.



32. Scroll down the page, you can see the **Topic** added under the **Subscribe to Commands** section.



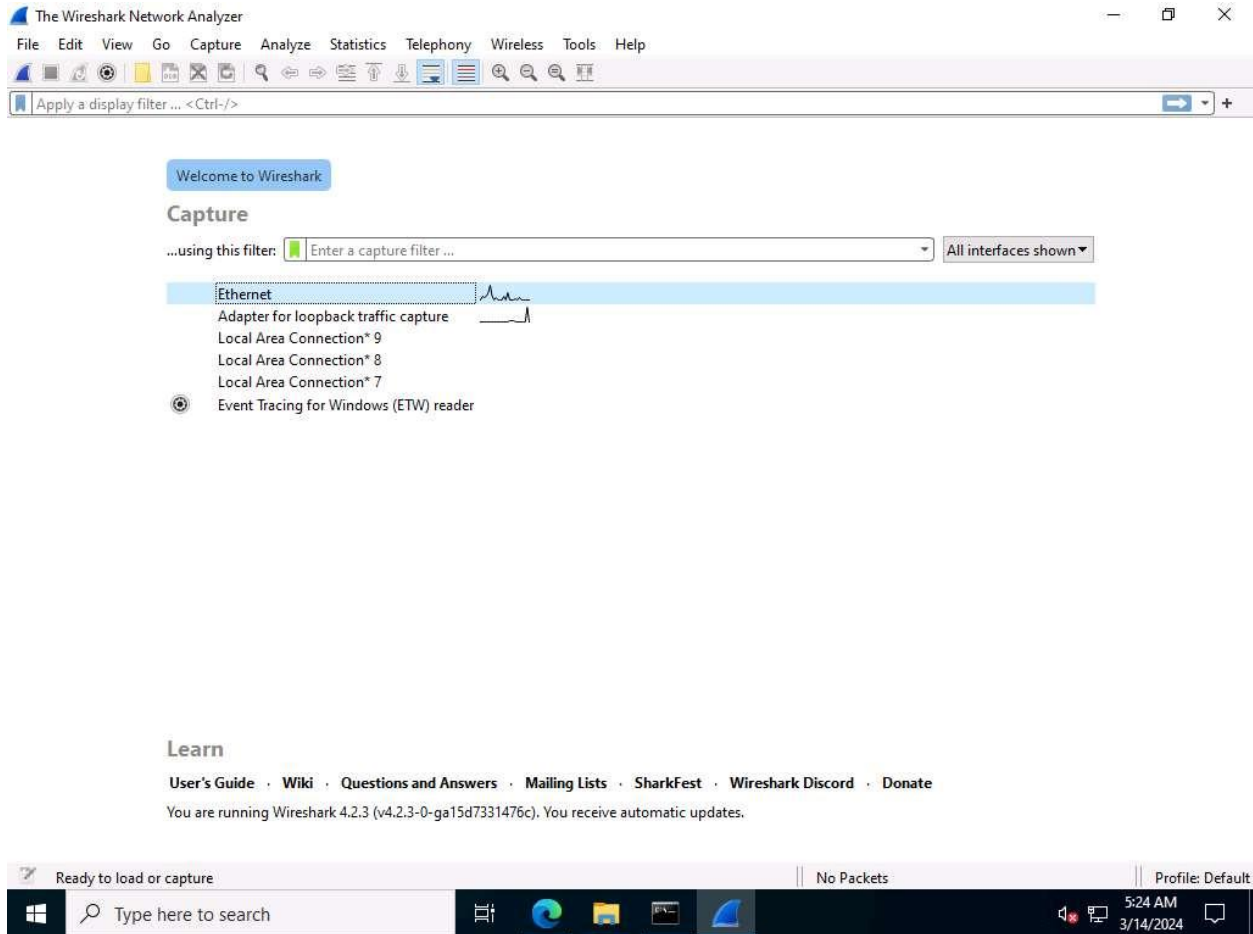
33. Next, we will capture the traffic between the **virtual IoT network** and the **MQTT Broker** to monitor the secure communication.

34. Minimise the Edge browser. Click **Type here to search** field on the **Desktop**, search for **wireshark** in the search bar and select **Wireshark** from the results.

35. The Wireshark Application window appears, select the **Ethernet** as interface.

Make sure you have selected interface which has **10.10.1.22** as the IP address.

If Software update popup appears click on **Skip this version**.



36. Click on the **Start Wireshark** icon to start the capturing packets, leave the Wireshark running.
37. Leave the IoT simulator running and switch to the [Windows Server 2019](#) machine.
38. Navigate to **Devices** menu and click on connected device i.e.**TS1**.

The screenshot shows a web browser window with the MQTTRoute application running on localhost:8080. The 'Devices' tab is selected in the top navigation bar. Below the navigation bar, a table lists devices. The first device, 'TS1', is highlighted with a red box. Below the table, the 'Send Command' section is active, showing a 'Topic' dropdown set to 'High_Tempe' and a 'Message' text area. A 'Submit' button is located at the bottom right of the 'Send Command' section. The Windows taskbar is visible at the bottom of the screen.

Device Name	Device Id	Status	Will Topic	Will Qos	Will Message	Time
TS1	TS1	Active				Today 22:02:28

Events **Commands** **Subscribe Topics** **Send Command**

Topic

High_Tempe

Message

Submit

39. Now, we will send the command to **TS1** using the **High_Tempe** topic.

40. In **Send Command** section, select **Topic** as **High_Tempe**, type **Alert for High Temperature** in **Message** field and click on the **Submit** button.

MQTTRoute

localhost:8080/#page-single-device

Beyywise Dashboard Devices Topics Rules Device Log

Device Name	Device Id	Status	Will Topic	Will Qos	Will Message	Time
TS1	TS1	Active				Today 22:02:28

Events Commands Subscribe Topics Send Command

Topic

High_Tempe

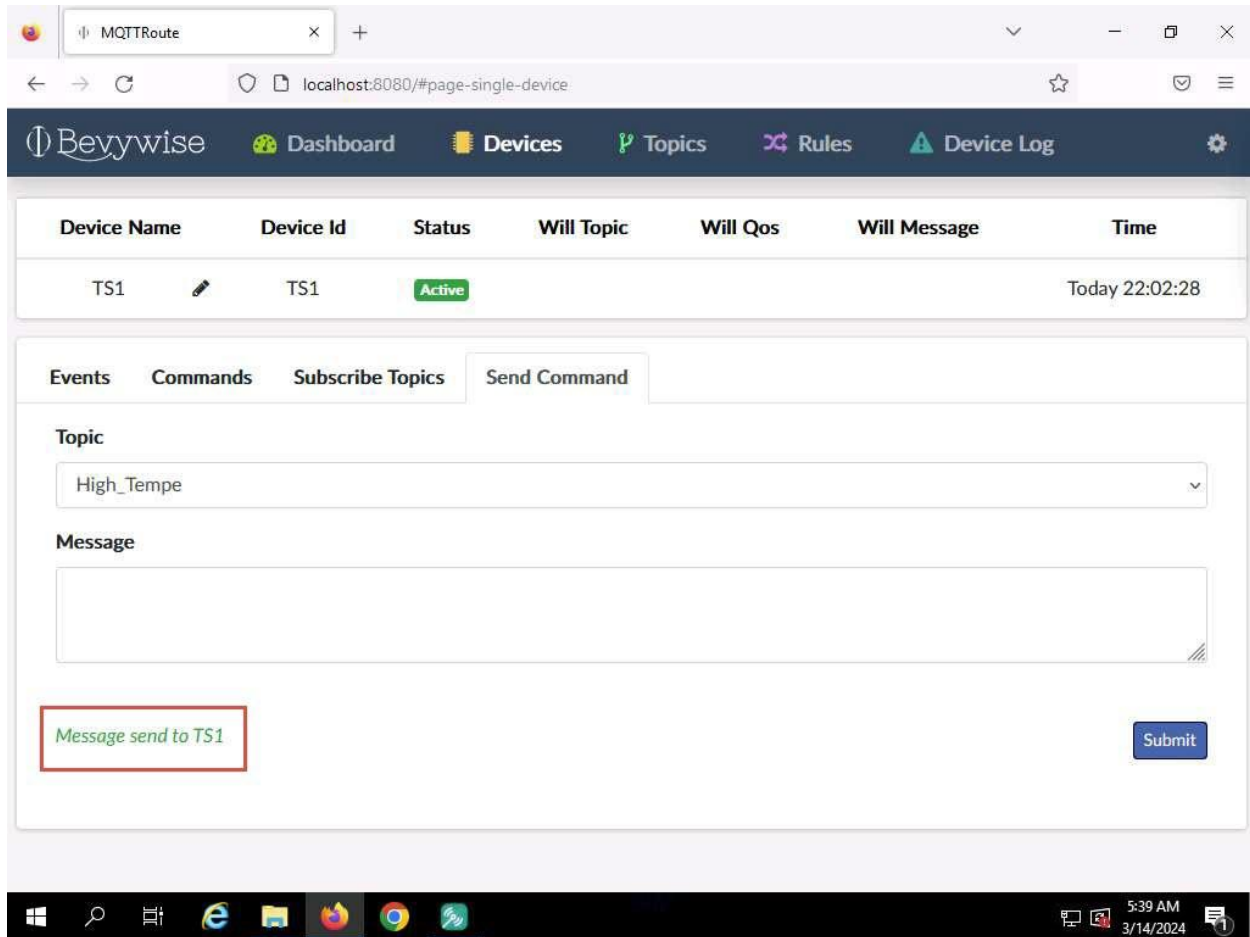
Message

Alert for High Temperature.

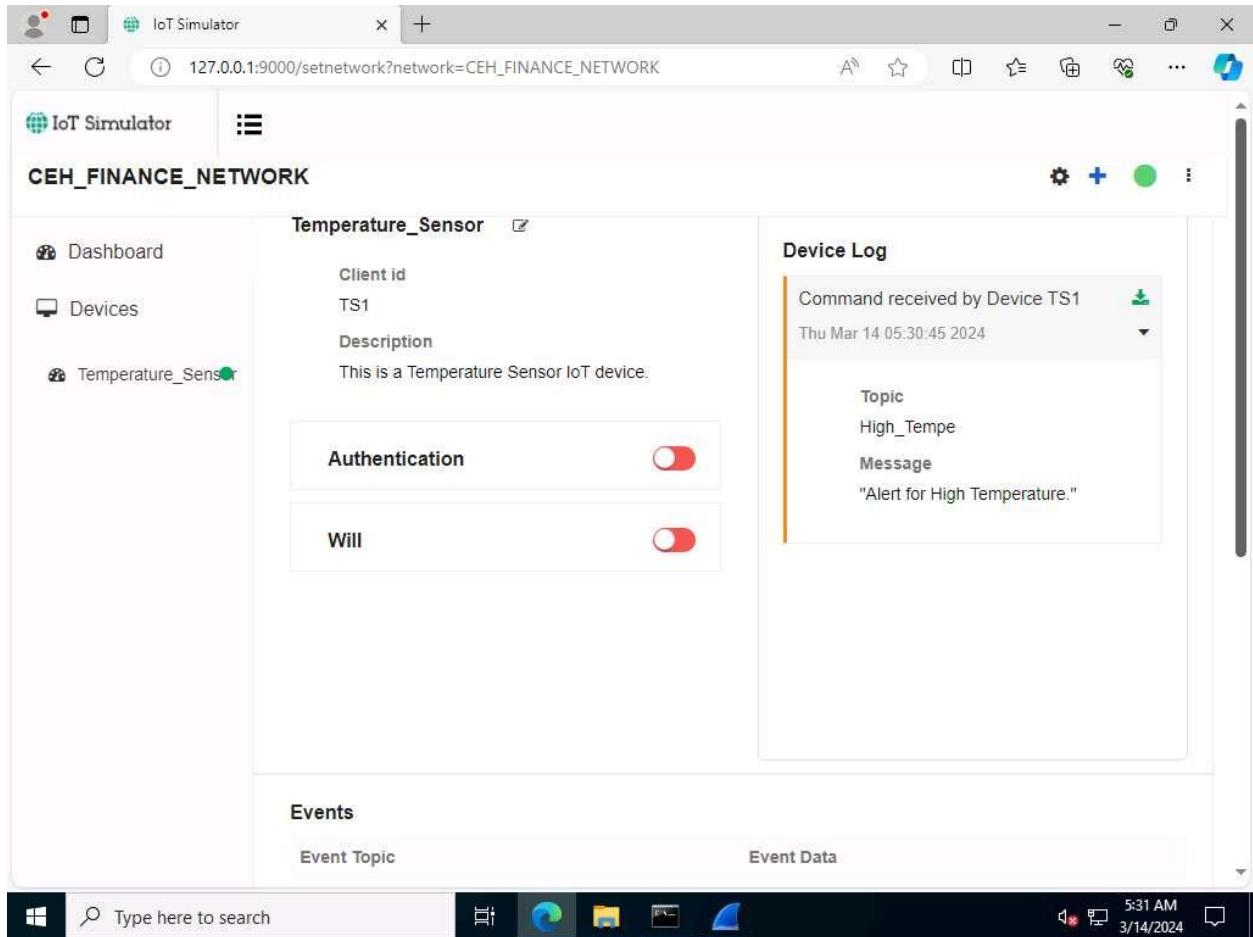
Submit

5:30 AM 3/14/2024

41. **Message sent to TS1** appears under **Message** box which indicates that the message was successfully sent to TS1.



42. The message has been sent to the device using this topic.
43. Next, switch to [Windows Server 2022](#) machine.
44. We have left the IoT simulator running in the web browser. To see the alert message, maximise the Edge browser and expand the arrow under the connected **Temperature_Sensor, Device Log** section.
45. You can see the alert message "**Alert for High Temperature**"



46. To verify the communication, we have executed **Wireshark** application, switch to the Wireshark traffic capturing window.

47. Type **mqtt** under the **filter** field and press **Enter**. To display only the MQTT protocol packets.

The screenshot shows a Wireshark capture of MQTT traffic on the interface \Device\NPF_{6FB...}. The packet list displays a series of MQTT messages between 10.10.1.22 and 10.10.1.19. The selected packet (No. 97) is a Publish Message (id=2) [High_Tempe]. The packet details pane shows the following layers:

- Ethernet II, Src: Microsoft_01:80:02 (00:15:5d:01:80:02), Dst: MS-NLB-PhysServer-21_5d:35:38:46 (08:00:2b:01:5d:35:38:46)
- Internet Protocol Version 4, Src: 10.10.1.22, Dst: 10.10.1.19
- Transmission Control Protocol, Src Port: 53217, Dst Port: 1883, Seq: 1, Ack: 1, Len: 2
- MQ Telemetry Transport Protocol, Ping Request

The packet bytes pane shows the raw data for the selected packet:

```

0000  02 15 5d 35 38 46 00 15 5d 01 80 02
0010  00 2a ce 6b 40 00 80 06 00 00 0a 0a
0020  01 13 cf e1 07 5b 94 b6 ea f7 f6 2a
0030  04 02 16 59 00 00 c0 00
  
```

48. Select any **Publish Message** packet from the **Packet List** pane. In the **Packet Details** pane at the middle of the window, expand the **Transmission Control Protocol**, **MQ Telemetry Transport Protocol**, and **Header Flags** nodes.
49. Under the **MQ Telemetry Transport Protocol** nodes, you can observe details such as **Msg Len**, **Topic Length**, **Topic**, and **Message**.
50. Publish Message can be used to obtain the message sent by the MQTT client to the broker.

The screenshot shows a Wireshark capture of MQTT traffic on the 'mqtt' interface. The packet list on the left shows a sequence of ping requests and responses, followed by a 'Publish Message (id=2) [High_Tempe]' packet at frame 679. The packet details pane on the right shows the structure of this message:

- Frame 679: 97 bytes on wire (776 bits), 97 bytes captured (776 bits) on interface \Device\NPF_{6F...}
- Ethernet II, Src: MS-NLB-PhysServer-21_5d:35:38:46 (02:15:5d:35:38:46), Dst: Microsoft_01:80:02 (08:00:02:01:80:02)
- Internet Protocol Version 4, Src: 10.10.1.19, Dst: 10.10.1.22
- Transmission Control Protocol, Src Port: 1883, Dst Port: 53217, Seq: 13, Ack: 13, Len: 43
- MQ Telemetry Transport Protocol, Publish Message**
 - [Expert Info (Note/Protocol): Unknown version (missing the CONNECT packet?)]
 - Header Flags: 0x32, Message Type: Publish Message, QoS Level: At least once delivery (Acknowledged)
 - Msg Len: 41
 - Topic Length: 10
 - Topic: High_Tempe
 - Message Identifier: 2
 - Message: 416c65727420666f7220486967682054656d706572617475726552e

The packet bytes pane on the right shows the raw data of the message, with the topic 'High_Tempe' and message identifier '2' visible in the first few bytes.

Note: After establishing a successful connection with the MQTT broker, the MQTT client can publish messages. The headers in the Publish Message packet are given below:

- Header Flags: Contains information regarding the MQTT control packet type.
- DUP flag: If the DUP flag is 0, it indicates the first attempt at sending this PUBLISH packet; if the flag is 1, it indicates a possible re-attempt at sending the message.
- QoS: Determines the assurance level of a message.
- Retain Flag: If the retain flag is set to 1, the server must store the message and its QoS, so it can cater to future subscriptions matching the topic.
- Topic Name: Contains a UTF-8 string that can also include forward slashes when it needs to be hierarchically structured.
- Message: Contains the actual data to be transmitted.
- Payload: Contains the message that is being published.

51. Select any **Publish Release** packet from the **Packet List** pane. In the **Packet Details** pane at the middle of the window, expand the **Transmission Control Protocol**, **MQ Telemetry Transport Protocol**, and **Header Flags** nodes.

52. Under the **MQ Telemetry Transport Protocol** nodes, you can observe details such as **Msg Len**, **Message Type**, **Message Identifier**.

The screenshot shows a Wireshark capture of MQTT traffic. The packet list on the left shows a sequence of MQTT packets. The selected packet (No. 683) is a Publish Release (id=2) from 10.10.1.19 to 10.10.1.22. The packet details pane on the right shows the structure of the MQTT message, including the Header, Topic, and Payload. The packet bytes pane on the far right shows the raw data in hexadecimal and ASCII.

No.	Time	Source	Destination	Protocol	Length	Info
530	243.698216	10.10.1.19	10.10.1.22	MQTT	56	Ping Response
603	301.751903	10.10.1.22	10.10.1.19	MQTT	56	Ping Request
604	301.753327	10.10.1.19	10.10.1.22	MQTT	56	Ping Response
679	343.062962	10.10.1.19	10.10.1.22	MQTT	97	Publish Message (id=2) [High_Tempe]
680	343.063563	10.10.1.22	10.10.1.19	MQTT	58	Publish Ack (id=2)
682	343.086632	10.10.1.22	10.10.1.19	MQTT	58	Publish Received (id=2)
683	343.087487	10.10.1.19	10.10.1.22	MQTT	58	Publish Release (id=2)
684	343.087528	10.10.1.22	10.10.1.19	MQTT	58	Publish Complete (id=2)
694	358.892109	10.10.1.22	10.10.1.19	MQTT	56	Ping Request
695	358.892654	10.10.1.19	10.10.1.22	MQTT	56	Ping Response
809	417.030668	10.10.1.22	10.10.1.19	MQTT	56	Ping Request

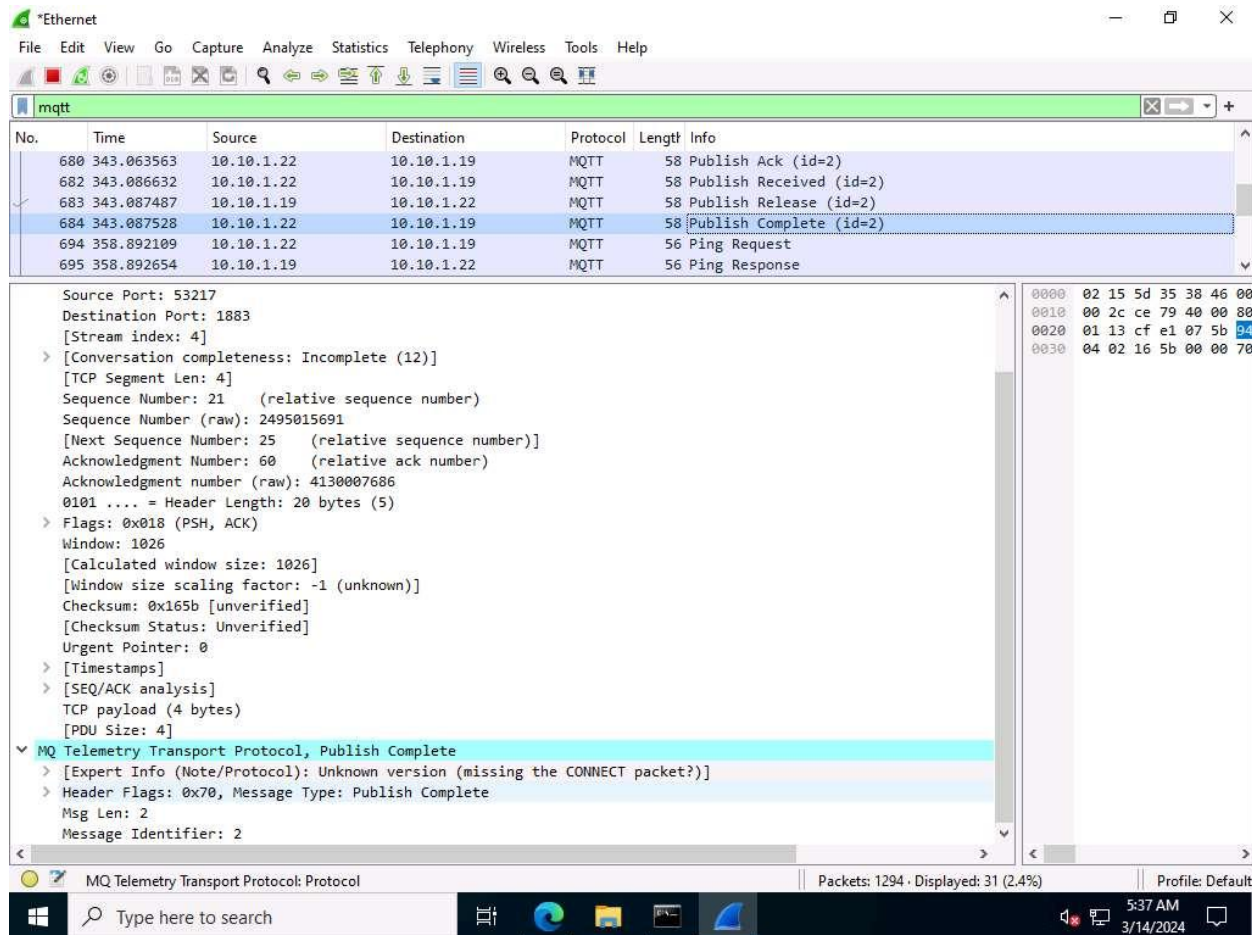
Sequence Number: 56 (relative sequence number)
Sequence Number (raw): 4130007682
[Next Sequence Number: 60 (relative sequence number)]
Acknowledgment Number: 21 (relative ack number)
Acknowledgment number (raw): 2495015691
0101 = Header Length: 20 bytes (5)
> Flags: 0x018 (PSH, ACK)
Window: 8212
[Calculated window size: 8212]
[Window size scaling factor: -1 (unknown)]
Checksum: 0xdfc6 [unverified]
[Checksum Status: Unverified]
Urgent Pointer: 0
> [Timestamps]
> [SEQ/ACK analysis]
TCP payload (4 bytes)
[PDU Size: 4]
MQ Telemetry Transport Protocol, Publish Release
> [Expert Info (Note/Protocol): Unknown version (missing the CONNECT packet?)]
> Header Flags: 0x62, Message Type: Publish Release
Msg Len: 2
Message Identifier: 2

0000 00 15 5d 01 80 02 02 15 5d 35 38 46
0010 00 2c e6 97 40 00 80 06 fd f5 0a 0a
0020 01 16 07 5b cf e1 f6 2a ea 82 94 b6
0030 20 14 df c6 00 00 62 02 00 02

Note: A Publish Release (PUBREL) packet is the response to a Publish Received (PUBREC) packet.

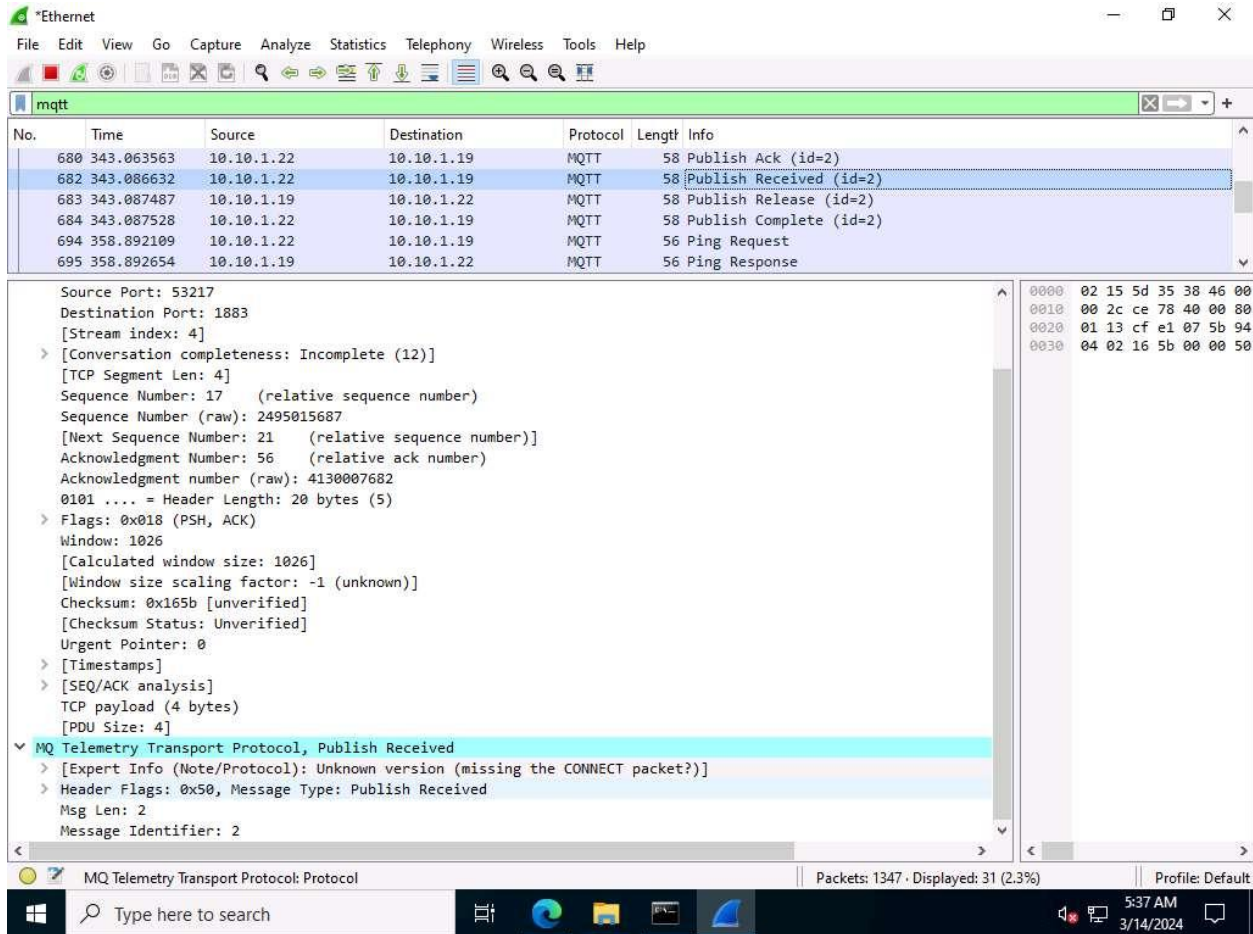
53. Now, scroll down, look for the **Publish Complete** packet from the **Packet List** pane, and click on it. In the **Packet Details** pane at the middle of the window, expand the **Transmission Control Protocol**, **MQ Telemetry Transport Protocol**, and **Header Flags** nodes.

54. Under the **MQ Telemetry Transport Protocol** nodes, you can observe details such as **Msg Len** and **Message Identifier**.



Note: The Publish Complete (PUBCOMP) packet is the response to a Publish Release (PUBREL) packet.

55. Now, scroll down, look for the **Publish Received** packet from the **Packet List** pane, and click on it. In the **Packet Details** pane at the middle of the window, expand the **Transmission Control Protocol**, **MQ Telemetry Transport Protocol**, and **Header Flags** nodes.
56. Under the **MQ Telemetry Transport Protocol** nodes, you can observe details such as **Message Type**, **Msg Len** and **Message Identifier**.



57. Similarly you can select **Ping Request**, **Ping Response** and **Publish Ack** packets and observe the details.

58. This concludes the demonstration of capturing and analyzing MQTT protocol packets. Here, we analyzed different processes involved in the communication between an MQTT client and an MQTT broker using Wireshark. Understanding these metrics as well as the workflow can help you in quickly identifying the MQTT-related issues.

59. Close all open windows and document all the acquired information.

Question 18.2.1.1

Use Wireshark and Bevywise MQTT Route and Bevywise IoT Simulator to capture and analyze traffic between IoT devices. What is the default TCP port used by Bevywise MQTT Route to establish connection with Bevywise IoT Simulator?

Question 18.2.1.2

Use Wireshark and Bevywise MQTT Route and Bevywise IoT Simulator to capture and analyze traffic between IoT devices. What is the default WebSocket port used by Bevywise MQTT IoT Simulator to establish connection with Bevywise MQTT Route?