



UTM
UNIVERSITI TEKNOLOGI MALAYSIA



INSTRUMENTATION & IOT

Prepared by:

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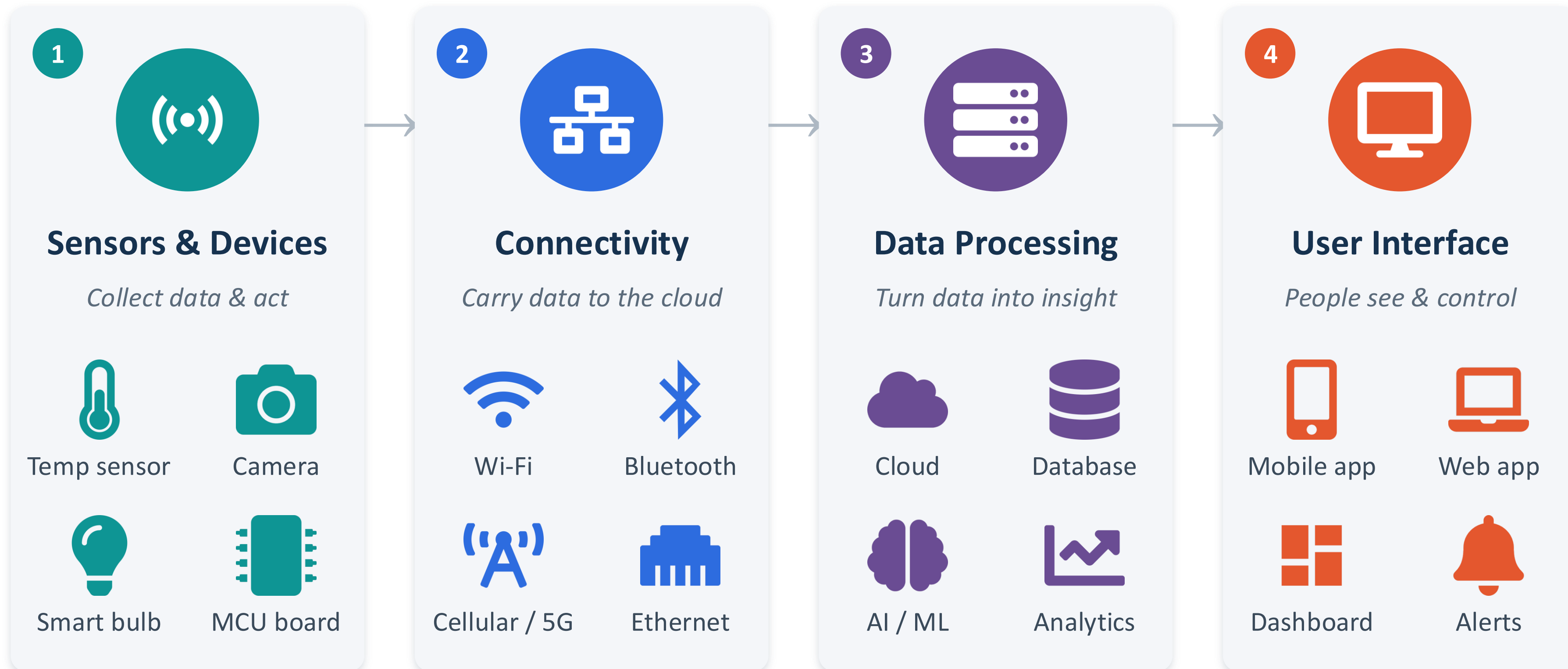
DR. MUHAMMAD ARIFF BIN BAHARUDIN



Brief Intro

THE 4 MAIN COMPONENTS OF IOT

Every complete IoT system integrates these four building blocks — from sensing the world to showing it to people.



IOT COMMUNICATION PROTOCOLS

1 Sensors



2 Connectivity



3 Processing



4 Interface

Communication protocols are the “languages” used inside the Connectivity layer — Component 2.

CATEGORY Application-layer (data / messaging) protocols



MQTT

Message Queuing Telemetry Transport

Publish / Subscribe • TCP

Lightweight pub/sub for constrained, unreliable networks.



HTTP / HTTPS

HyperText Transfer Protocol

Request / Response • TCP

Universal REST — simple and everywhere, but heavier.



CoAP

Constrained Application Protocol

Request / Response • UDP

REST-style for tiny low-power devices; maps to HTTP.



AMQP

Advanced Message Queuing Protocol

Message queue • TCP

Reliable queued messaging with delivery guarantees.



WebSocket

Full-duplex over one TCP socket

Full-duplex • TCP

Persistent two-way channel for real-time dashboards.



DDS

Data Distribution Service

Data bus (pub/sub) • UDP

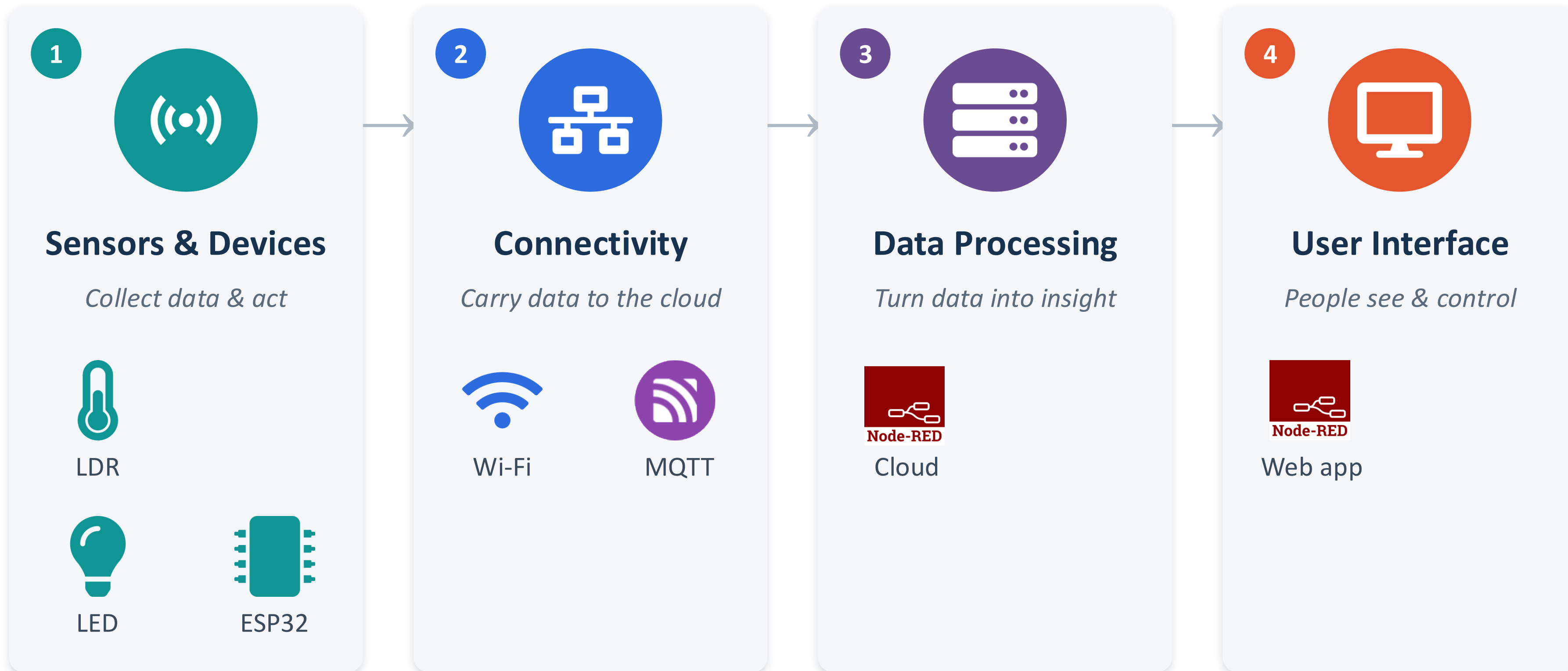
Real-time data bus for industrial, mission-critical IoT.

How it stacks: these run over transport (TCP / UDP), which ride on the link/radio protocols — Wi-Fi, BLE, Zigbee, cellular, LoRaWAN — from the Connectivity component.

Innovating Sustainable Solutions

WALKTHROUGH: IOT LIGHT MONITOR & LED CONTROL

ESP32 + HiveMQ Cloud + Node-RED





MQTT Config

How MQTT Works

Lightweight publish/subscribe messaging for IoT devices

Est. 1999 (IBM & Arcom) • Standardized as ISO/IEC 20922 • Current version: MQTT 5.0 • Runs over TCP/IP

PUBLISHERS



Temperature Sensor

Publishes readings every 5s



Motion Sensor

Publishes on movement detected



Smart Camera

Publishes snapshot events



MQTT BROKER

Routes every message to the right subscribers — filtered by Topic

Example topic:

`home/livingroom/temperature`

SUBSCRIBERS



Mobile App

Subscribes to alerts



Cloud Dashboard

Subscribes to all sensor data



Smart Actuator

Subscribes to control commands

QUALITY OF SERVICE (QoS) — HOW RELIABLY EACH MESSAGE IS DELIVERED



QoS 0 — At most once

Fire-and-forget. Fastest, but a message can be lost.



QoS 1 — At least once

Acknowledged delivery. Guaranteed, but duplicates possible.

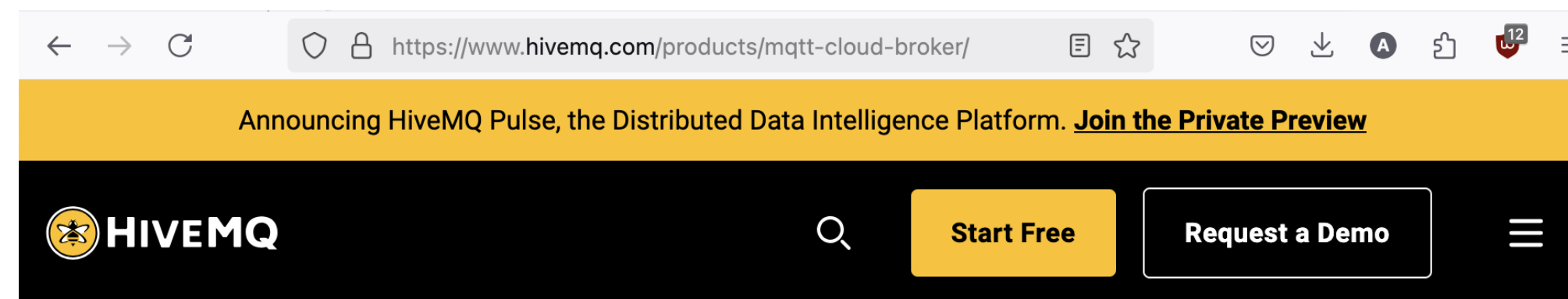


QoS 2 — Exactly once

Four-step handshake. Guaranteed, no duplicates — slowest.

SETTING UP MQTT - HIVEMQ

<https://www.hivemq.com/products/mqtt-cloud-broker/>



Serverless

Free

Get Started

No credit card required

A basic MQTT broker for learning and experimenting with MQTT.

A great place to play

- ✓ Shared MQTT platform
- ✓ 100 connections free
- ✓ 10 GB data traffic per month
- ✓ MQTT 3.1, 3.1.1, 5.0

RECOMMENDED

Starter

Starting from **\$0.34/hour**

+ \$0.80/million messages

15-day trial - no credit card required

Complete MQTT platform for testing and small-scale production.

Everything in Serverless, plus

- ✓ Dedicated MQTT platform
- ✓ Unlimited connections
- ✓ Up to 1MB/s data throughput
- ✓ Client certificate authentication
- ✓ HiveMQ Control Center

Enterprise

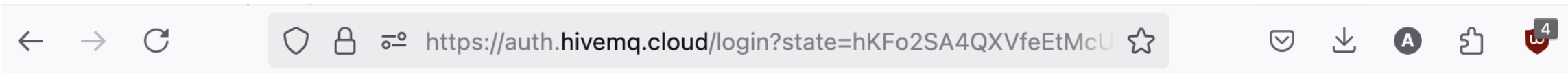
Custom Suite-Based Pricing

Fully customizable MQTT platform for sophisticated workloads.

Fully Customizable Options

- ✓ Unlimited data throughput
- ✓ Exclusive infrastructure
- ✓ Any region
- ✓ Private Link
- ✓ Support for custom

Register free account



Unleash the Potential of IoT with HiveMQ Cloud.

HiveMQ Cloud is a fully-managed service for your IoT messaging needs.

- ✓ Start for Free: Kickstart your IoT journey by connecting up to 100 devices for free.
- ✓ Unrestrained Integration: Boost your use cases with seamless data integration with third-party services.
- ✓ Scalability with Ease: Upgrade as needed. HiveMQ Cloud offers reliability and security, irrespective of scale.
- ✓ Total MQTT Support: Leverage our complete support for the MQTT

Log In Sign Up

 LOG IN WITH GITHUB

 LOG IN WITH GOOGLE

 LOG IN WITH LINKEDIN

or

 yours@example.com

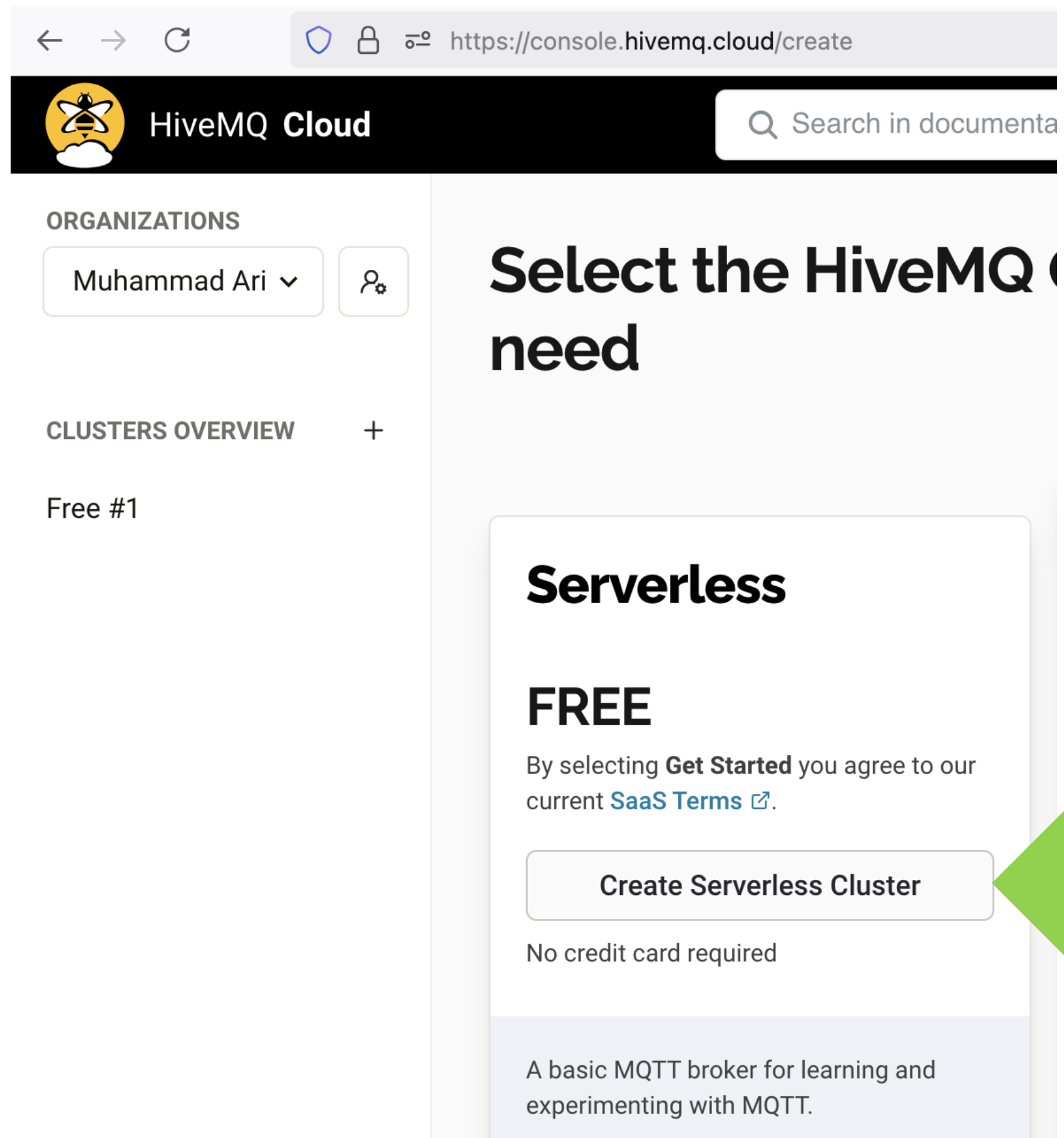
 your password

[Don't remember your password?](#)

Log In >



Use google.

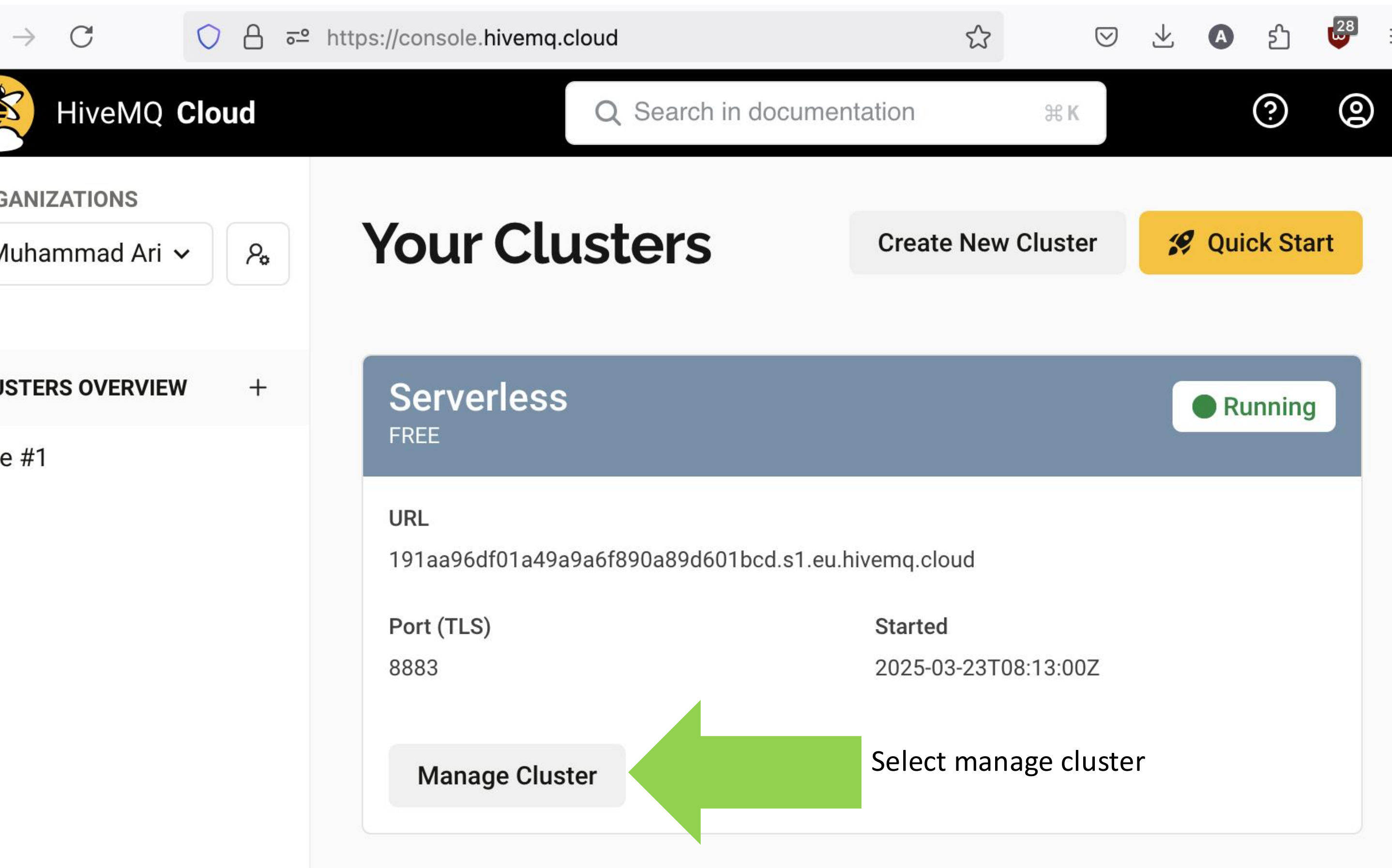


The screenshot shows the HiveMQ Cloud console interface. The browser address bar displays `https://console.hivemq.cloud/create`. The left sidebar contains the following elements:

- ORGANIZATIONS**: A dropdown menu showing 'Muhammad Ari' with a settings icon.
- CLUSTERS OVERVIEW**: A section with a '+' icon and the text 'Free #1'.

The main content area is titled 'Select the HiveMQ cloud you need'. It features a 'Serverless' option, which is highlighted with a green border. Below this, it states 'FREE' and includes a note: 'By selecting **Get Started** you agree to our current [SaaS Terms](#).' A prominent green button labeled 'Create Serverless Cluster' is visible, with a green arrow pointing to it from the right. Below the button, it says 'No credit card required'. At the bottom of the main area, a light blue box contains the text: 'A basic MQTT broker for learning and experimenting with MQTT.'

Create a serverless cluster



The screenshot shows the HiveMQ Cloud console interface. The browser address bar displays `https://console.hivemq.cloud`. The top navigation bar includes the HiveMQ Cloud logo, a search bar for documentation, and user profile icons. The left sidebar shows the 'ORGANIZATIONS' section with a dropdown menu for 'Muhammad Ari' and a '+ CLUSTERS OVERVIEW' button. The main content area is titled 'Your Clusters' and features two buttons: 'Create New Cluster' and 'Quick Start'. A cluster card for 'Serverless' is shown with a 'Running' status. The cluster details include the URL `191aa96df01a49a9a6f890a89d601bcd.s1.eu.hivemq.cloud`, Port (TLS) `8883`, and Started time `2025-03-23T08:13:00Z`. A 'Manage Cluster' button is located at the bottom of the cluster card, with a green arrow pointing to it from the text 'Select manage cluster'.

→ ↺ 🔒 🔓 🔍 `https://console.hivemq.cloud` ☆ 📧 ⬇️ Ⓐ 🗑️ 📧²⁸ ☰

 **HiveMQ Cloud** 🔍 Search in documentation ⌘ K ⓘ 👤

ORGANIZATIONS

Muhammad Ari ▾ ⚙️

CLUSTERS OVERVIEW +

e #1

Your Clusters

Create New Cluster Quick Start

Serverless

FREE

● Running

URL

`191aa96df01a49a9a6f890a89d601bcd.s1.eu.hivemq.cloud`

Port (TLS)

`8883`

Started

`2025-03-23T08:13:00Z`

Manage Cluster

Select manage cluster

SETTING UP MQTT - HIVEMQ

← → ↻ <https://console.hivemq.cloud/clusters/191aa96df01a49a9a6f8> ☆

HiveMQ Cloud ⌘ K ? 👤

ORGANIZATIONS

Muhammad Ari ▾ ⚙️

CLUSTERS OVERVIEW +

Free #1

Free #1

Overview

Connection Details

Comprehensive details and statistics for your cluster

URL

191aa96df01a49a9a6f890a89d601bcd.s1.eu.hivemq.cloud

Port

8883

Websocket Port

8884

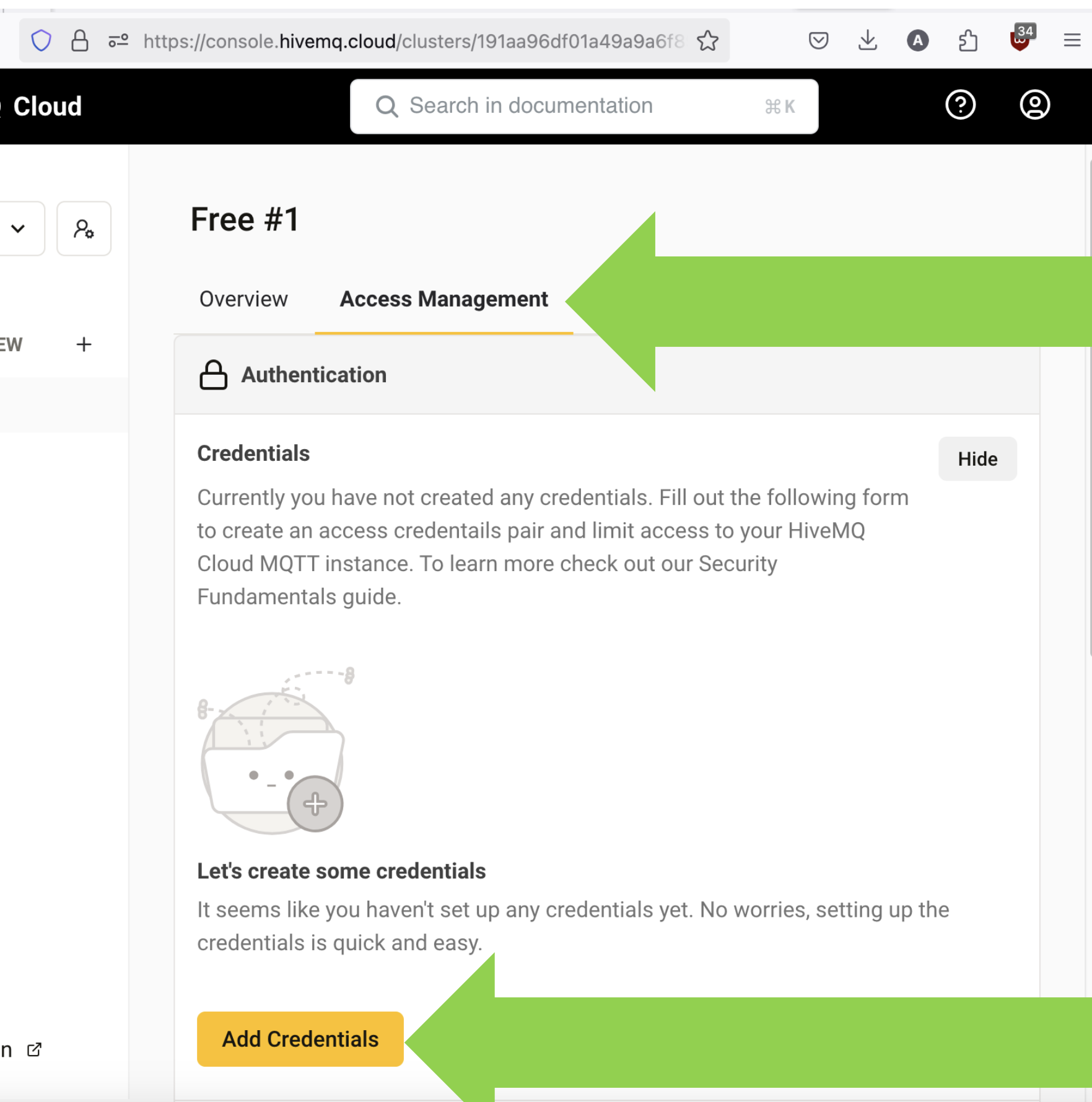
TLS MQTT URL

Overview tab.

This is the url that you will use.

This is the port you will use.

SETTING UP MQTT - HIVEMQ



The screenshot shows the HiveMQ Cloud console interface. The browser address bar displays the URL: `https://console.hivemq.cloud/clusters/191aa96df01a49a9a6f8`. The page header includes a search bar with the text "Search in documentation" and a "K" icon. The main content area is titled "Free #1" and features two tabs: "Overview" and "Access Management". The "Access Management" tab is selected and highlighted with a green arrow. Below the tabs, there is a section titled "Authentication" with a lock icon. Under "Authentication", there is a "Credentials" section with a "Hide" button. The text in the "Credentials" section reads: "Currently you have not created any credentials. Fill out the following form to create an access credentials pair and limit access to your HiveMQ Cloud MQTT instance. To learn more check out our Security Fundamentals guide." Below this text is an illustration of a folder with a plus sign and a minus sign. At the bottom of the "Credentials" section, there is a button labeled "Add Credentials" with a green arrow pointing to it. The text "Add credential." is written next to the button.

Cloud

Search in documentation K

Free #1

Overview Access Management

Authentication

Credentials Hide

Currently you have not created any credentials. Fill out the following form to create an access credentials pair and limit access to your HiveMQ Cloud MQTT instance. To learn more check out our Security Fundamentals guide.

Let's create some credentials

It seems like you haven't set up any credentials yet. No worries, setting up the credentials is quick and easy.

Add Credentials

Add credential.

SETTING UP MQTT - HIVEMQ

https://console.hivemq.cloud/clusters/191aa96df01a49a9... ☆

Search in documentation ⌘ K ?

Free #1

Overview **Access Management** Integrations Web Client • Getting St

Authentication

Credentials Hide

Currently you have not created any credentials. Fill out the following form to create an access credentials pair and limit access to your HiveMQ Cloud MQTT instance. To learn more check out our Security Fundamentals guide.

Username * **Permission ***

AllahMyR4bb

Password * **Confirm Password ***

AllahMyR4bb

Password must contain at least one digit

Save **Cancel**

Set any username you want.

Set any password you want.

https://console.hivemq.cloud/clusters/191aa96df01a49a9... ☆

Search in documentation ⌘ K ?

Free #1

Overview **Access Management** Integrations Web Client • Getting St

Authentication

Credentials Hide

Currently you have not created any credentials. Fill out the following form to create an access credentials pair and limit access to your HiveMQ Cloud MQTT instance. To learn more check out our Security Fundamentals guide.

Username *	Permission *
AllahMyR4bb	Publish and Subscribe
Password *	Confirm Password *
AllahMyR4bb	AllahMyR4bb

Password must contain at least one digit

Select publish and subscribe.

Password must be same.

Save.

Q Cloud

Search in documentation

?

Free #1

OverviewAccess ManagementIntegrationsWeb Client •Getting St

Authentication

Credentials

Active

Hide

Currently you have not created any credentials. Fill out the following form to create an access credentials pair and limit access to your HiveMQ Cloud MQTT instance. To learn more check out our Security Fundamentals guide.

NAME	PERMISSION	ACTIONS
AllahMyR4bb	PUBLISH_SUBSCRIBE	

Add new credential

Client Certificate

This functionality is available in Cloud Starter and higher tier plans.

Allow your clients to prove their identity

Compare plans

Credential created.

https://console.hivemq.cloud/clusters/191aa96df01a49a9

Search in documentation

Free #1

Overview Access Management Integrations **Web Client** Getting St

Please connect to the WebClient in order to subscribe to topics

Connection Settings

Connect to your HiveMQ Cloud Cluster with your credentials. Do not worry you can quickly connect with autogenerated credentials.

Username * **Password ***

AllahMyR4bb AllahMyR4bb

Connect

Username & Password same as we set just now.

Must connect when we want to use.



Node-RED

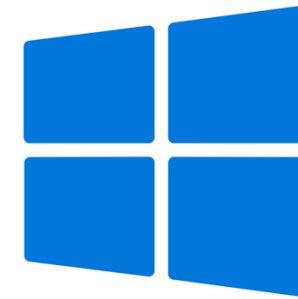
Node-RED Installation Guide

<https://www.influxdata.com/blog/guide-installing-node-red/>

Node-RED RUN



```
sudo node-red
```



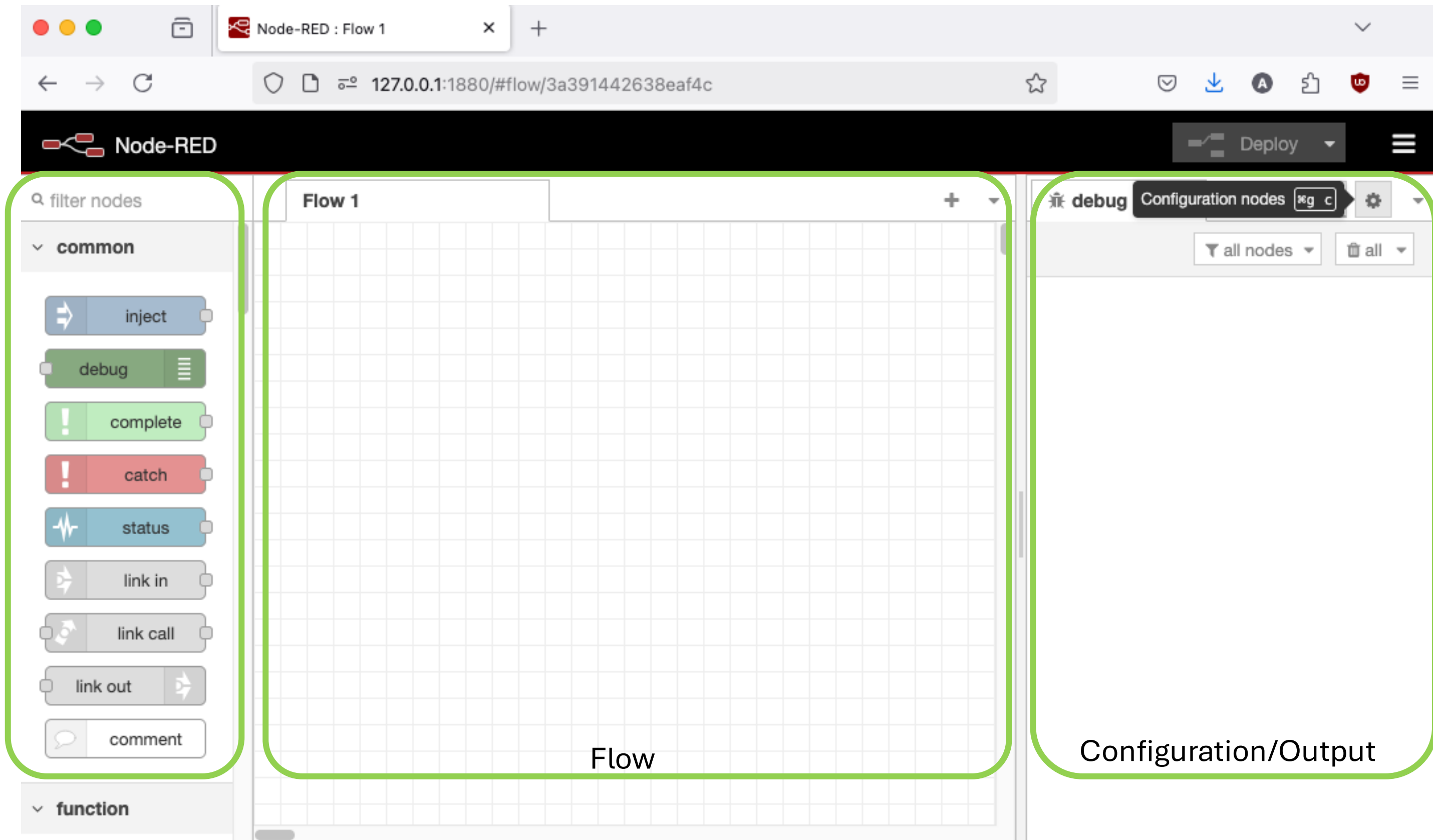
```
node-red
```

Once loaded, copy the IP address given and paste it into the browser.
Usually, the address is as follows:

<http://127.0.0.1:1880/>

Node-RED FLOW INTERFACE

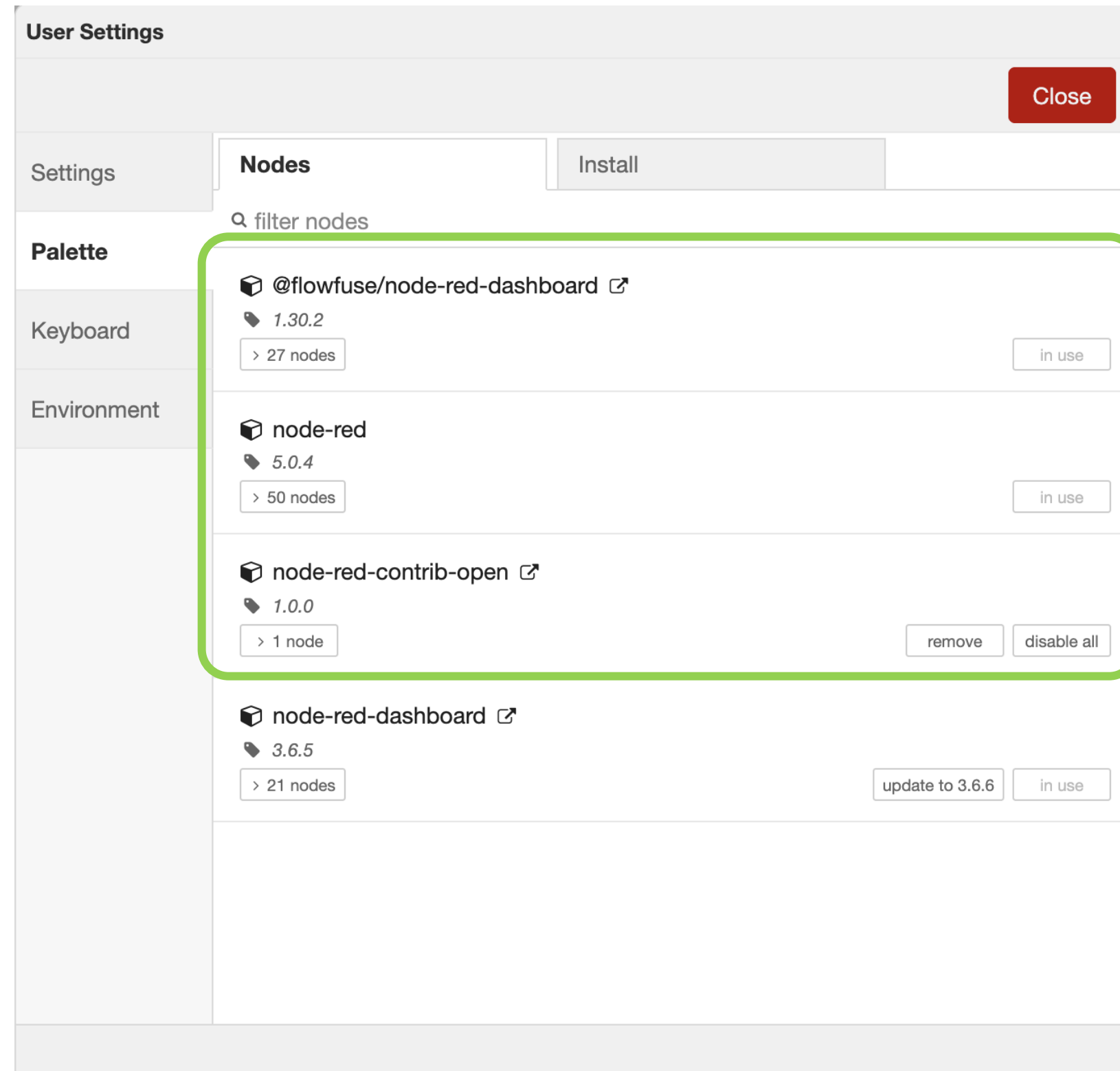
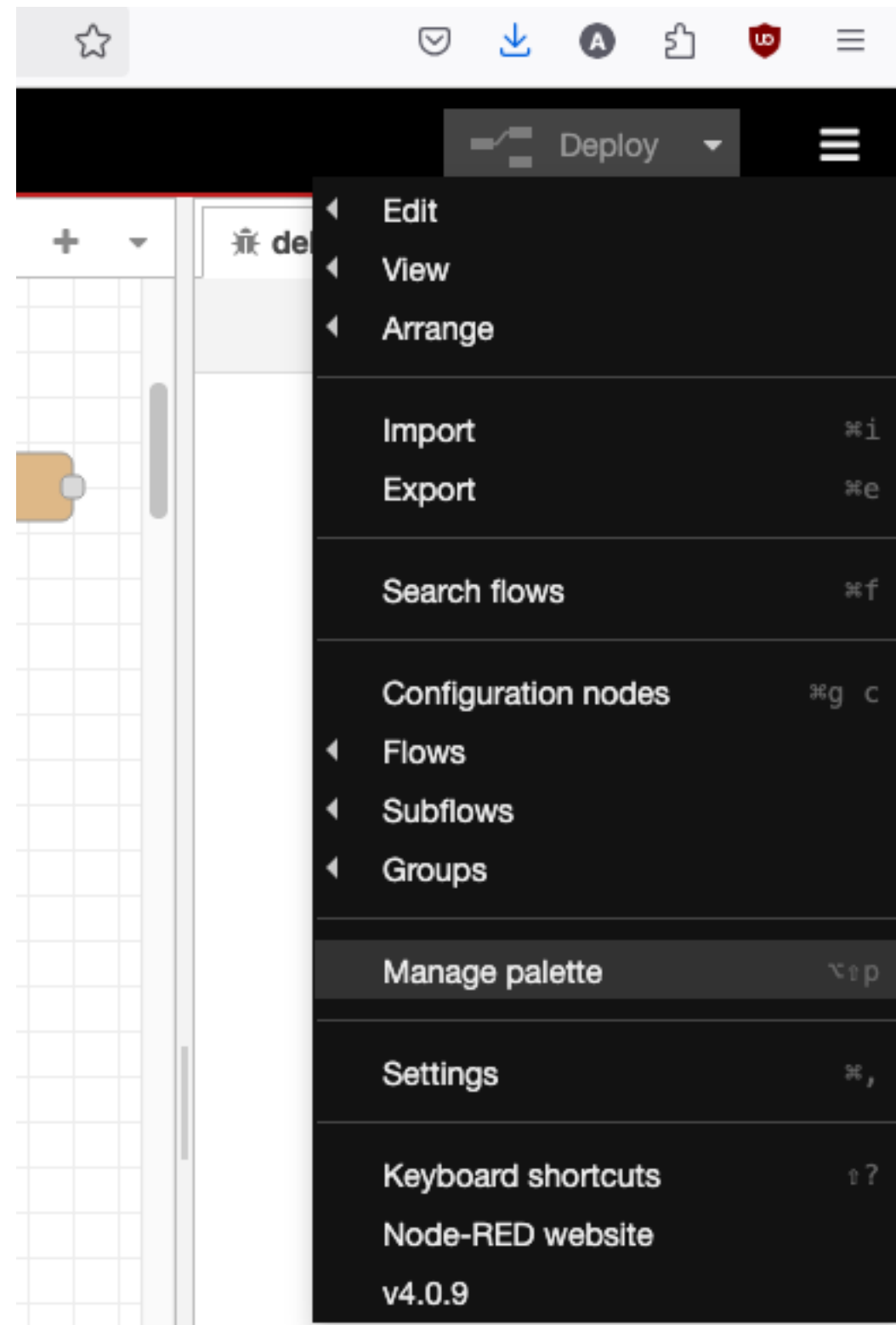
Nodes



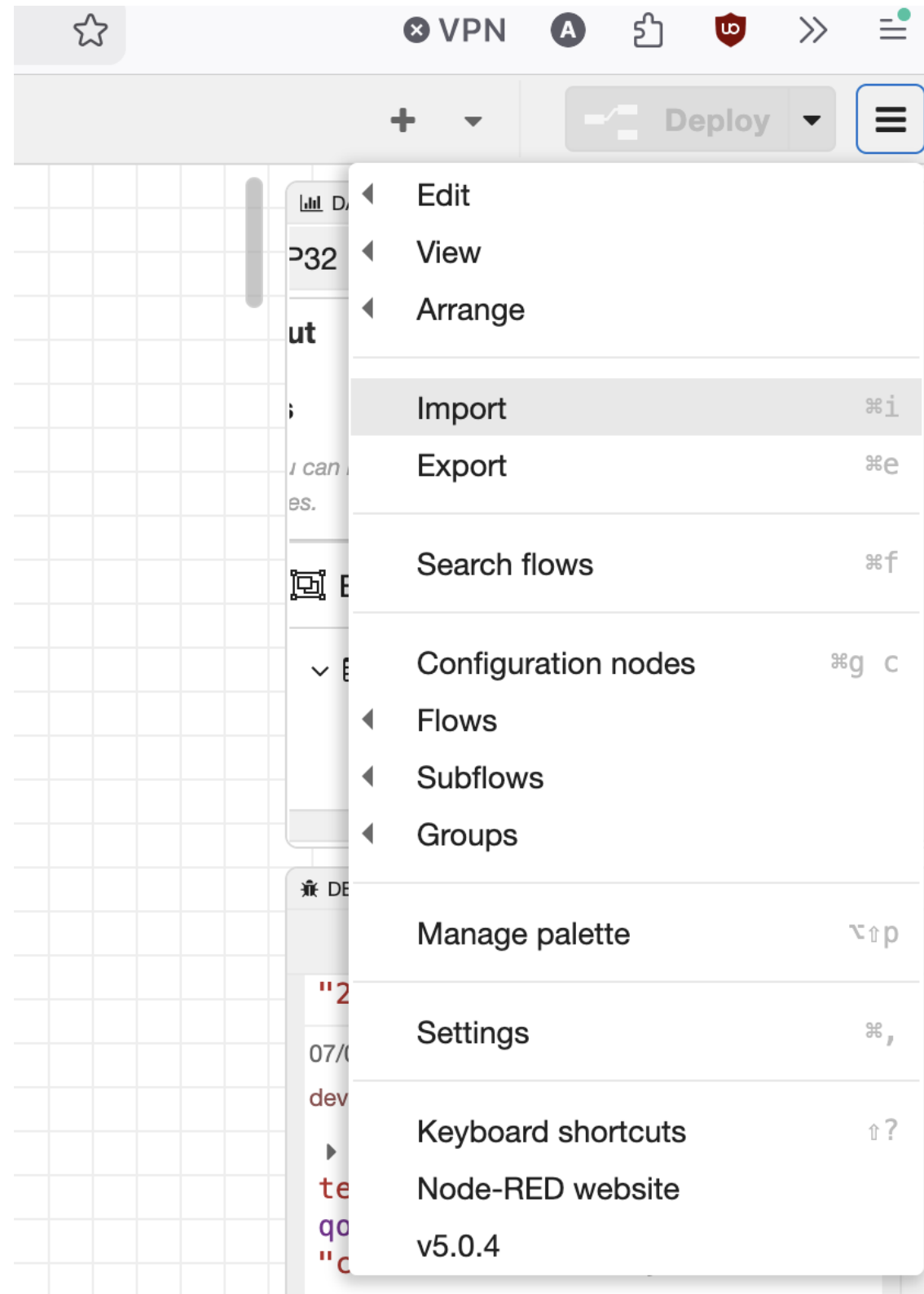
The screenshot displays the Node-RED web interface in a browser window. The browser's address bar shows the URL `127.0.0.1:1880/#flow/3a391442638eaf4c`. The interface is divided into three main sections:

- Nodes:** A sidebar on the left containing a search bar labeled "filter nodes" and two categories of nodes. The "common" category is expanded, showing nodes like "inject", "debug", "complete", "catch", "status", "link in", "link call", "link out", and "comment". The "function" category is partially visible at the bottom.
- Flow:** A central workspace with a grid background, labeled "Flow 1" at the top. It is currently empty.
- Configuration/Output:** A sidebar on the right. It includes a "debug" tab, a "Configuration nodes" dropdown, and filters for "all nodes" and "all".

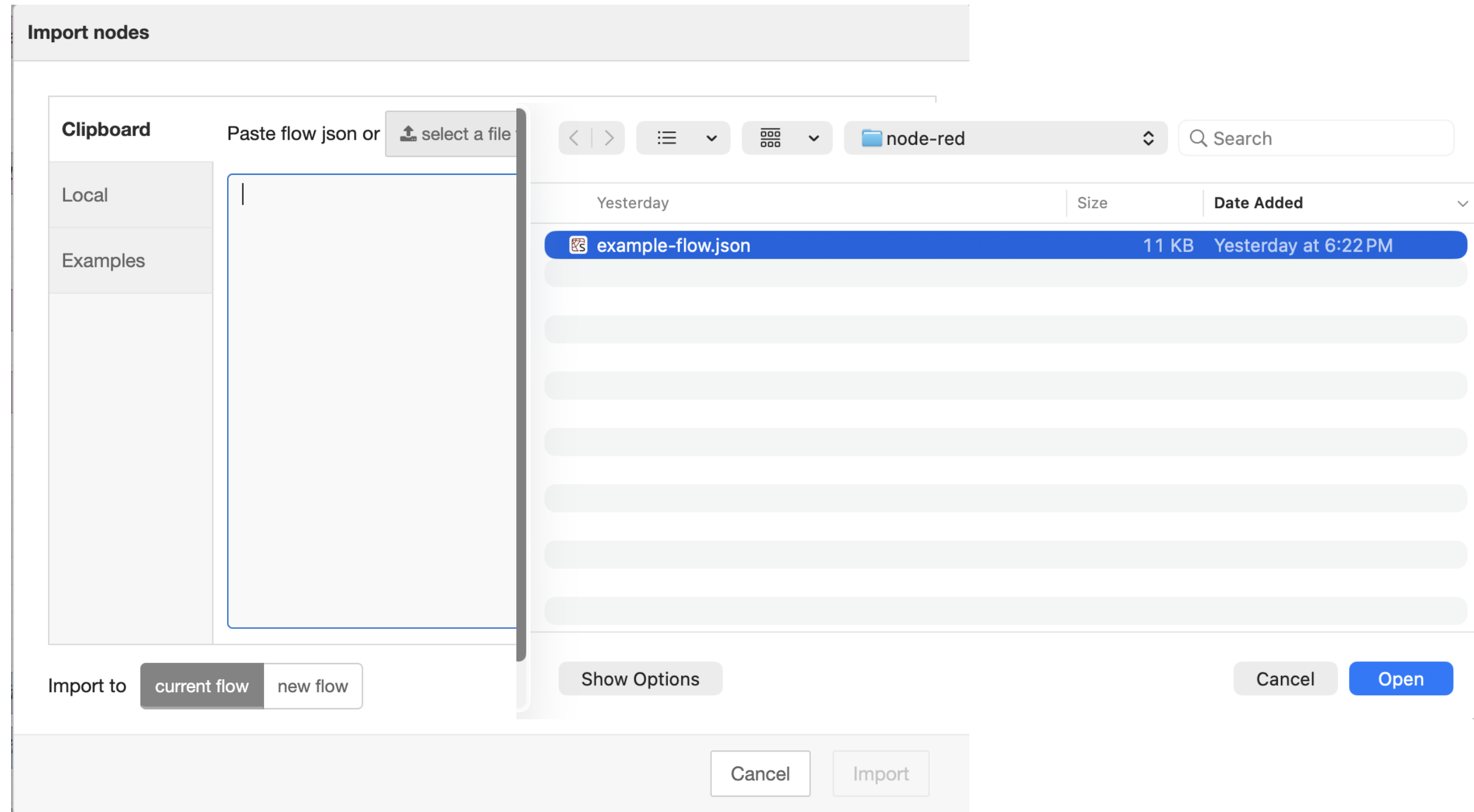
Node-RED FLOW INTERFACE



Node-RED FLOW INTERFACE



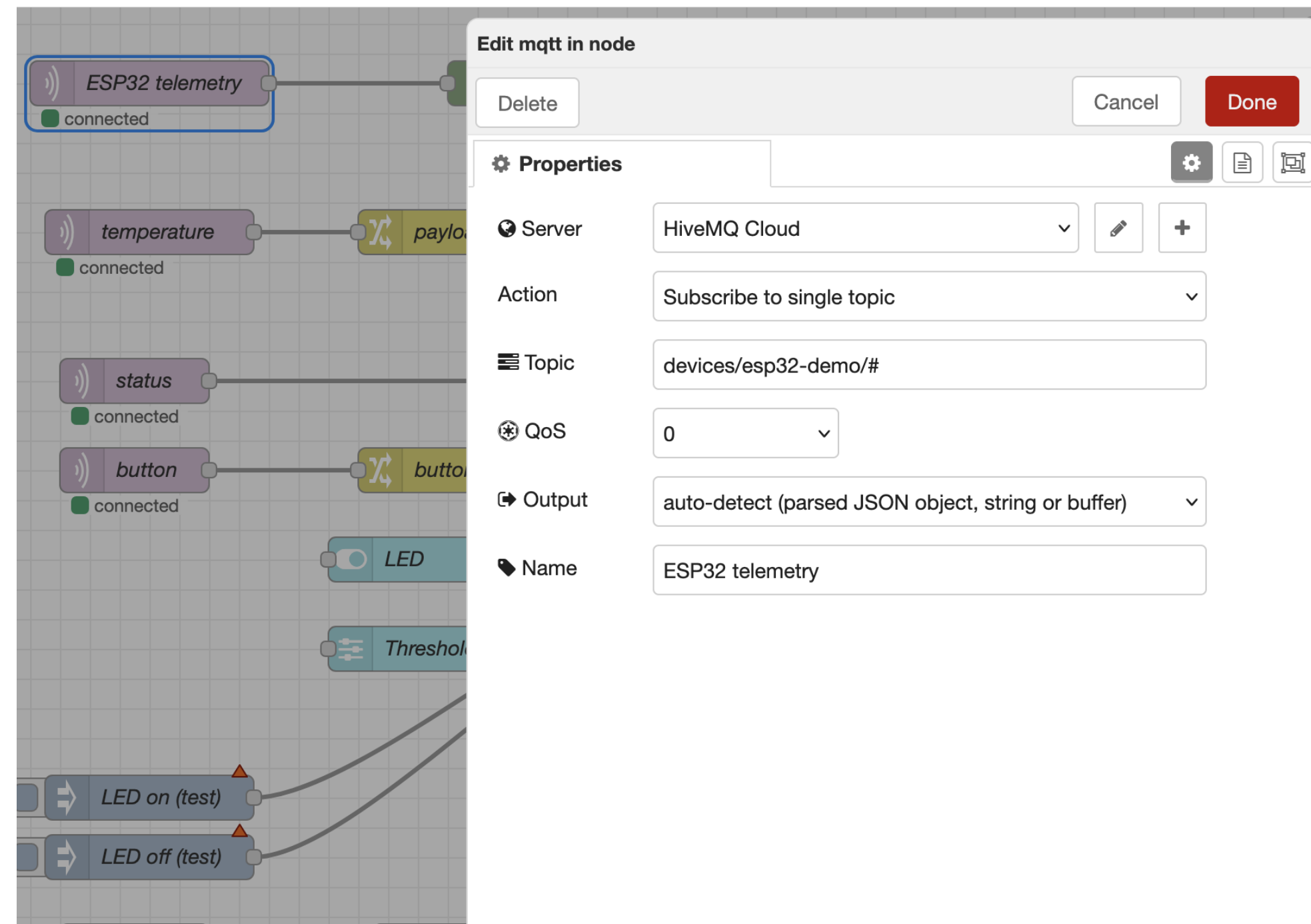
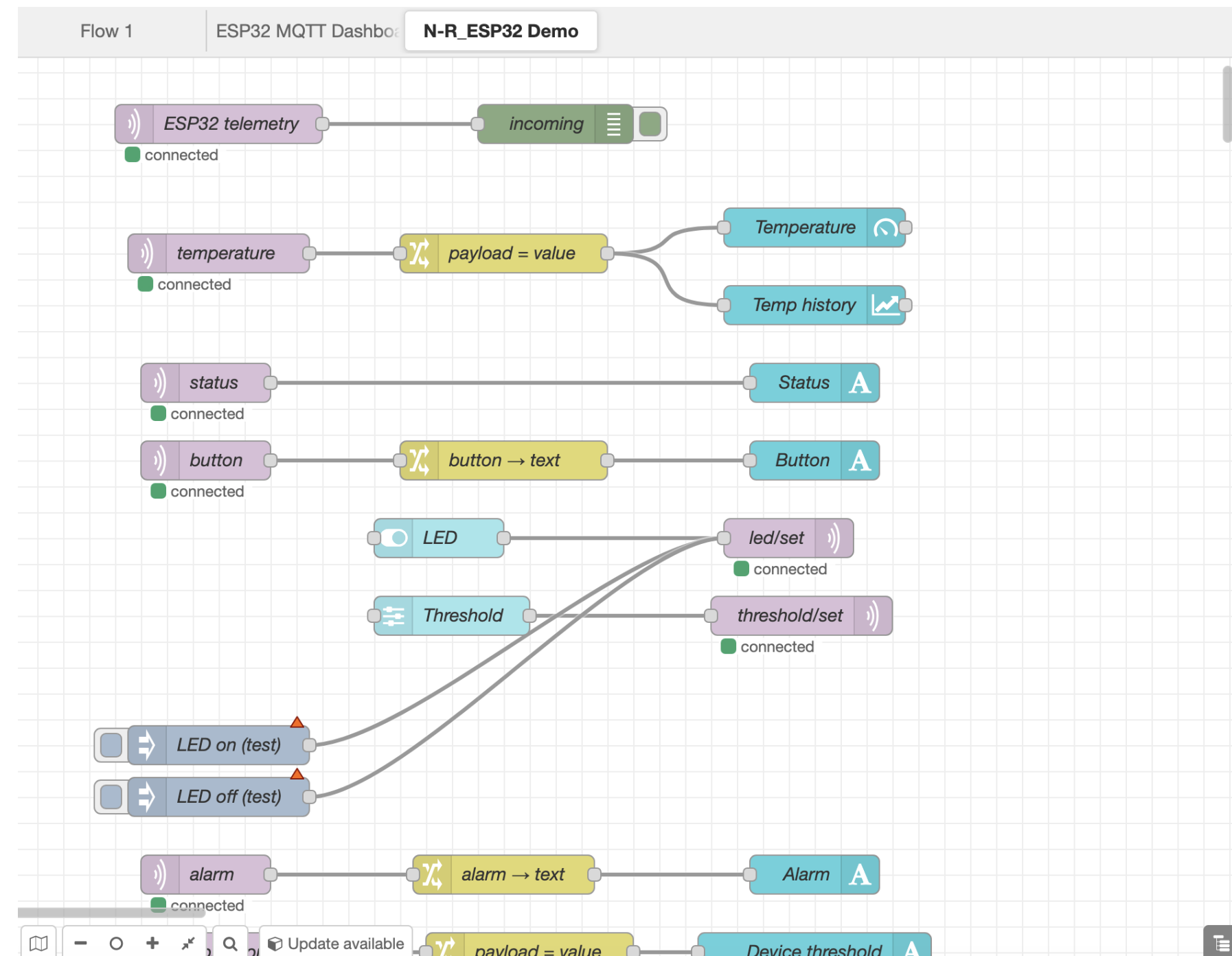
The image shows the Node-RED web interface in a browser. The top bar includes a star icon, a VPN status indicator, and several utility icons. Below this is a toolbar with a plus icon, a dropdown arrow, a 'Deploy' button, and a hamburger menu icon. The main workspace is a grid. On the left, a sidebar contains a list of nodes and a search bar. A context menu is open over the sidebar, displaying the following options: Edit, View, Arrange, Import (highlighted), Export, Search flows, Configuration nodes, Flows, Subflows, Groups, Manage palette, Settings, Keyboard shortcuts, Node-RED website, and v5.0.4.



The image shows the 'Import nodes' dialog in Node-RED. The dialog has a title bar 'Import nodes'. Inside, there's a 'Clipboard' section with a text area for pasting flow JSON. To the right of the text area is a 'select a file' button. Below the text area are 'Local' and 'Examples' tabs. To the right of the clipboard section is a file browser showing a list of files. The file 'example-flow.json' is selected, showing a size of 11 KB and a date added of 'Yesterday at 6:22 PM'. At the bottom of the dialog, there are buttons for 'Import to', 'current flow', 'new flow', 'Show Options', 'Cancel', and 'Open'.

Yesterday	Size	Date Added
example-flow.json	11 KB	Yesterday at 6:22 PM

Node-RED FLOW INTERFACE



Node-RED FLOW INTERFACE

Edit mqtt in node > **Edit mqtt-broker node**

Delete Cancel Update

Properties  

 Name

Connection **Security** **Messages**

 Server Port

☒ Connect automatically

☒ Use TLS  

 Protocol

 Client ID

 Keep Alive 

 Session ☒ Use clean session

Edit mqtt in node > **Edit mqtt-broker node**

Delete Cancel Update

Properties  

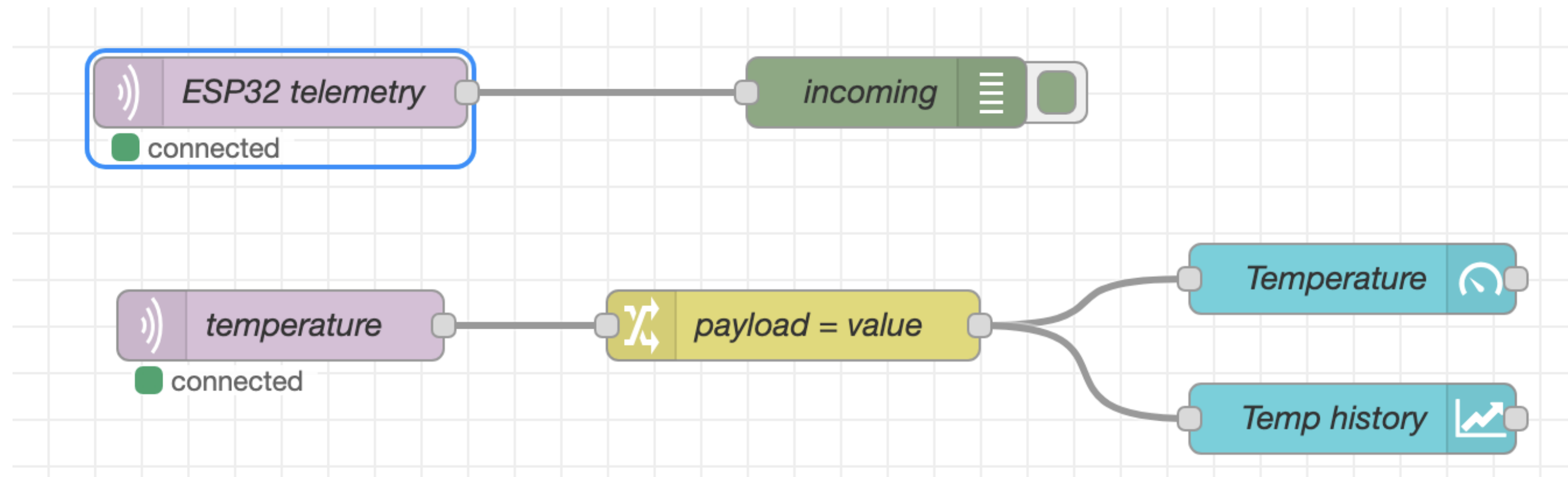
 Name

Connection **Security** **Messages**

 Username

 Password

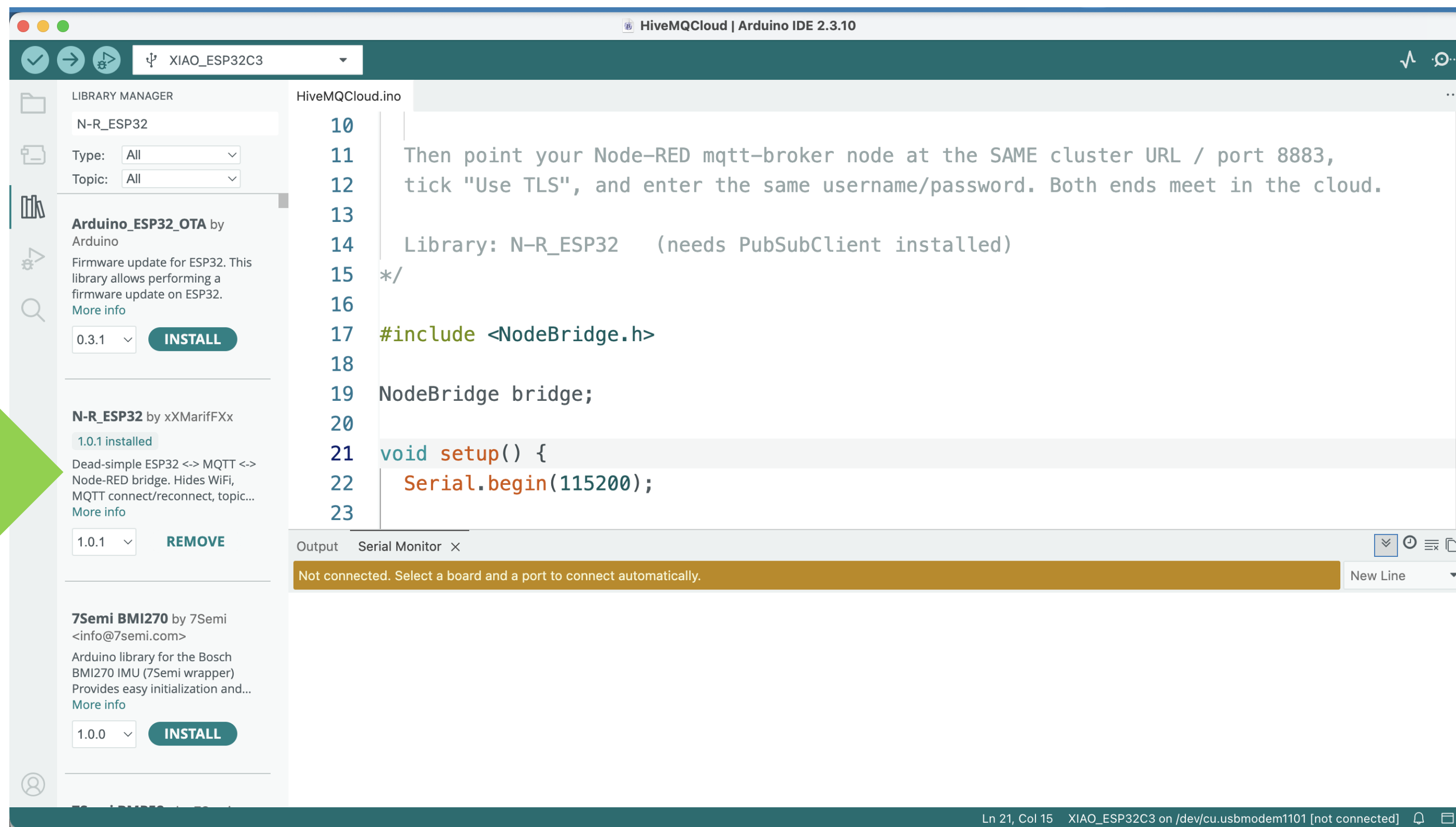
Node-RED FLOW INTERFACE





ESP32

ARDUINO IDE LIBRARY



The screenshot shows the Arduino IDE 2.3.10 interface. The top bar indicates the board is 'XIAO_ESP32C3'. The Library Manager on the left shows the 'N-R_ESP32' library by xXMarifFXx, version 1.0.1, which is already installed. A large green arrow points to this library. The main editor shows the code for 'HiveMQCloud.ino'.

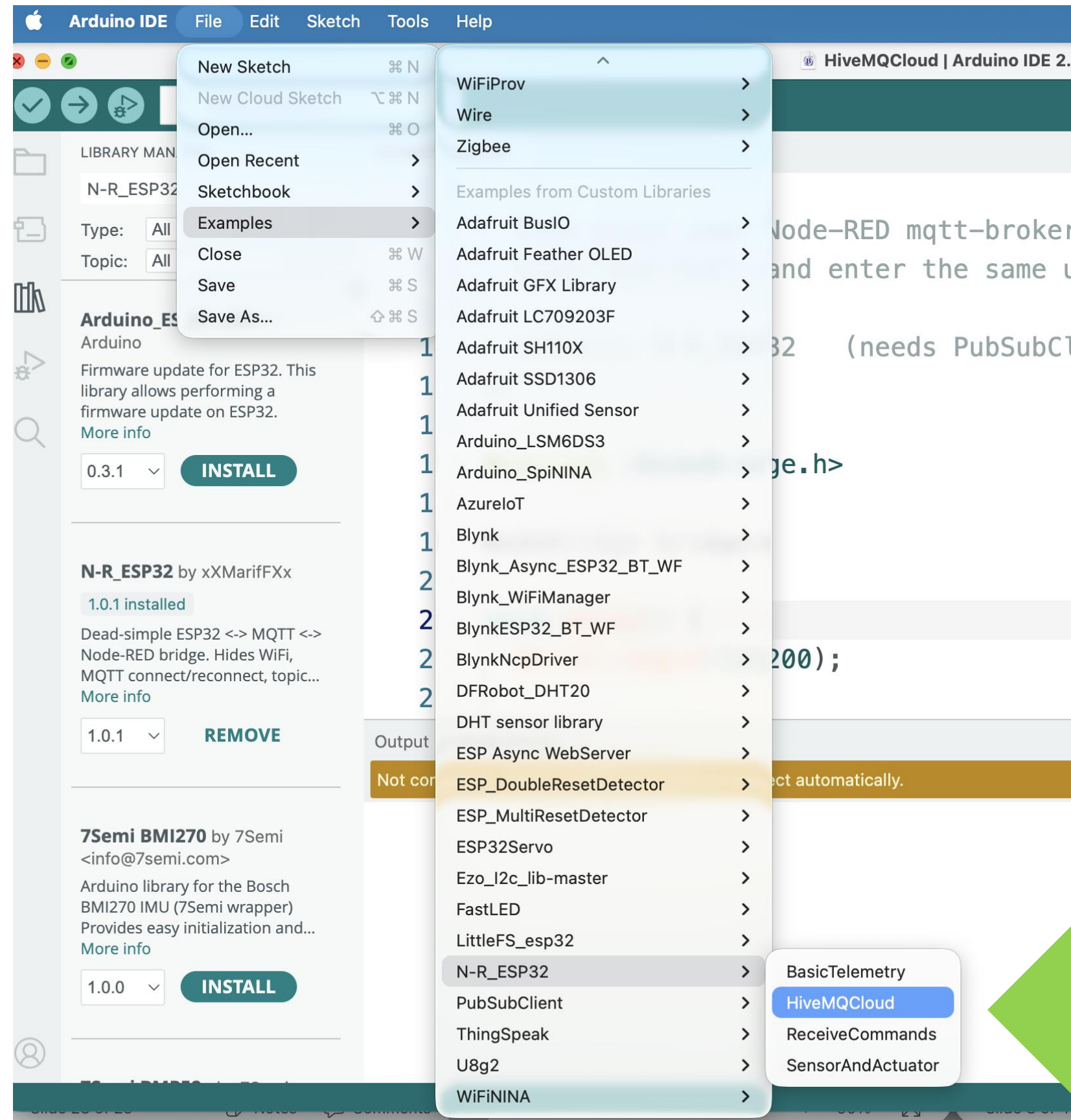
```

10
11 Then point your Node-RED mqtt-broker node at the SAME cluster URL / port 8883,
12 tick "Use TLS", and enter the same username/password. Both ends meet in the cloud.
13
14 Library: N-R_ESP32 (needs PubSubClient installed)
15 */
16
17 #include <NodeBridge.h>
18
19 NodeBridge bridge;
20
21 void setup() {
22     Serial.begin(115200);
23

```

The Serial Monitor at the bottom shows the message: "Not connected. Select a board and a port to connect automatically."

LIBRARY EXAMPLE



HiveMQCloud.ino

```
18
19 NodeBridge bridge;
20
21 void setup() {
22     Serial.begin(115200);
23
24     bridge.wifi("ShadowFox", "asdfghjkl")
25         .broker("191aa96df01a49a9a6f890a89d601bcd.s1.eu.hivemq.cloud") // yo
26         .secure() // TLS on. See note below to
27         .login("AllahMyR4bb", "AllahMyR4bb")
28         .debug(true);
29
30     // Example command coming from Node-RED (devices/esp32-demo/led/set)
31     bridge.on("led", [(Value v) { digitalWrite(2, v.asBool()); }]);
32
33     pinMode(2, OUTPUT);
34     bridge.begin("esp32-mariff");
35 }
```



PRACTICE

Familiarize with the interface and coding and
get your IoT system started

TASK 2

Use available components and build an interesting IoT System.



Thank you

For more info about this report,
send an email to XXXXXXXXXX