Driving the Future of Connected Cars with MQTT

Introduction

Vehicle connectivity will drive the future of automotive transportation and smart mobility. The next decade will introduce widely varied modes of transportation and related infrastructure communicating as part of a broad, tightly integrated system, which will require vehicles capable of fast, reliable messaging.

What are some examples? Simple functions include remote door, light and engine controls. Others are massive innovations in safety, like automatic communication with roadside assistance or emergency services, obstacle detection and autonomous driving. Whatever the case, implementing this type of user experience requires a communication architecture scalable to millions of devices and vehicles, delivering low–latency data exchange over unreliable networks and providing a nearly instantaneous bidirectional interface with the cloud and other vehicles.

As advanced in-vehicle applications and large-scale automotive mobile networks come together, vehicle-to-everything (V2X) concepts are evolving, with the Internet of Vehicles (IoV) becoming the foundation of intelligent transportation. As the computing capabilities of automobile systems have grown, IoV connectivity has gradually developed to include human, vehicle, roadway, and cloud communication and coordination, with multiple channels of vehicle communication.

Automobile connectivity will continue delivering more benefits to customers, auto manufacturers and other interested groups. Here are some examples of what may be possible in the future:

- Remote predictive and preventive maintenance for owners and automotive service technicians
- Enhanced environmental safety information, including roadway, construction and traffic updates
- Personalized in-cockpit and remote interfaces for connectivity in and outside of the vehicle
- Autonomous, large-scale coordination of vehicle flow through city roadways
- Real-time telematics data for drivers, car owners, insurers, manufacturers, regulators, rideshare providers and so much more

Car manufacturers seek to reliably scale architectures for better connectivity in and out of the vehicle in order to meet these new IoV demands. The good news is all of this can be realized with MQTT, a driving force for IoV. The question is: how will MQTT accomplish that?

Table of Contents

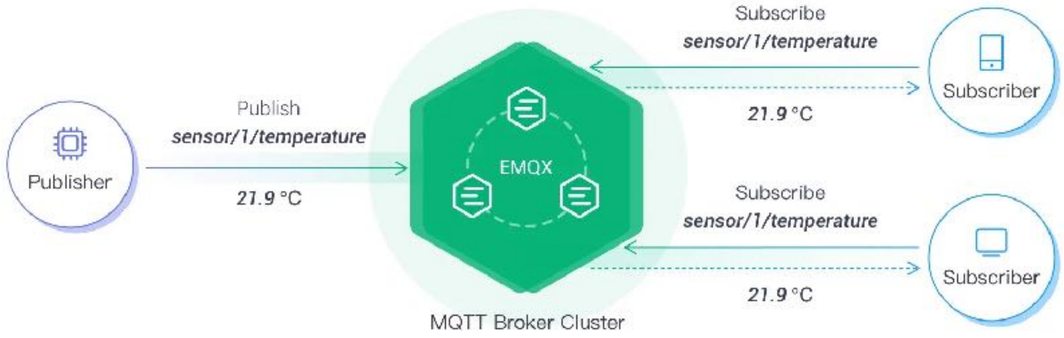
Driving the Future of Connected Cars with MQTT

What is MQTT?

What is MQTT exactly? It's a simple and easy-to-implement messaging protocol ideal for embedded computing environments that have limited computing power or limited network bandwidth. The MQTT communications protocol has become the de facto standard in the field of the Internet of Things (IoT) because it provides a lightweight and very low overhead format for efficient, reliable and secure two-way messaging.

Publish-Subscribe Model

In the MQTT publish-subscribe model, a client can function as a publisher, a subscriber, or both. When a client publishes a message, it sends it to the MQTT server, which then routes the message to all clients subscribed to the given topic. A topic is a UTF-8 encoded string that is the basis for message routing in the MQTT protocol. A slash `/` in the topic string indicates a new level in a topic hierarchy, similar to URL paths. If a client subscribes to a topic, it will receive all the messages that the broker forwards for that topic. In the example below, subscribers will receive messages from the `sensor/1/temperature` topic.



Example of MQTT broker managing messages from publisher and subscribers

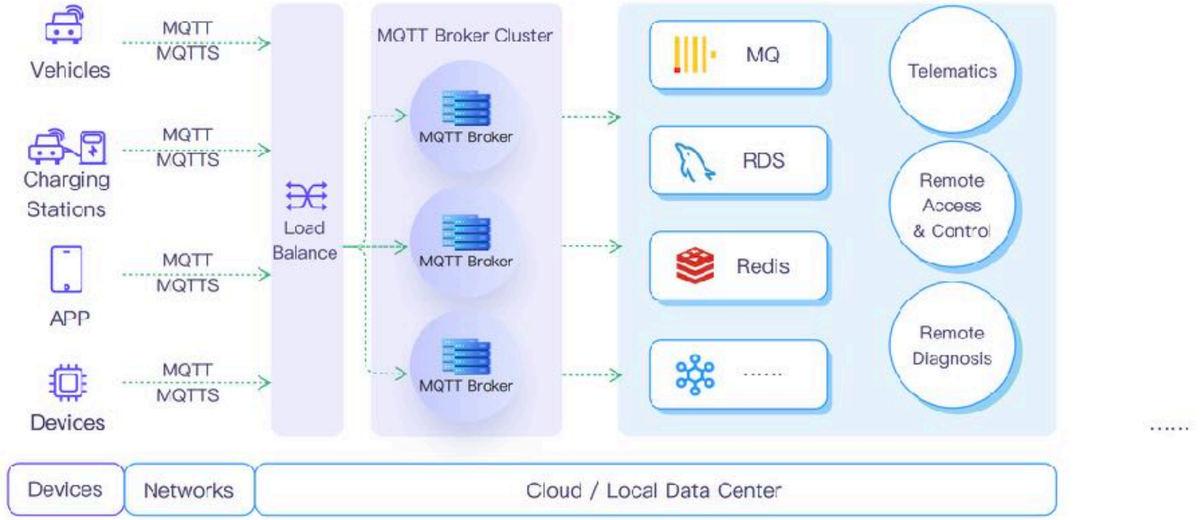
The MQTT server is the go–between for messaging to and from the clients—any device, system, or application that communicates using MQTT. For this reason, the server is often referred to as a message broker. Because all messages go through the MQTT broker, it is critical that the broker be specified appropriately based on requirements for scalability, latency, ease of integration, fault tolerance and recovery.

Technical benefits of MQTT that make it a great solution for connected vehicles

- **Lightweight messaging for fast delivery:** MQTT provides a flexible messaging model that can reduce network traffic for vehicles and mobile networks.
- **Quality of service and reliability control:** MQTT provides various quality of service levels and fault–tolerance mechanisms, helping service providers reduce data loss and stabilize client connections in challenging network environments.

Lightweight Messaging for Fast Delivery

The MQTT protocol itself is inherently lightweight; the message packets are streamlined for faster delivery with less network bandwidth and low edge compute requirements. The MQTT data format is highly efficient and requires fewer data packets than other protocols. Both factors are important in scaling an MQTT IoV architecture for millions of messages. The demands of automotive connectivity can extend beyond what might be termed traditional communications protocols. Standard internet protocols, such as HTTP, can possibly be scaled for IoV; however, synchronous “request/response” messaging requires more transactions and more frequent reconnection than asynchronous approaches like MQTT, increasing latency and data loss.



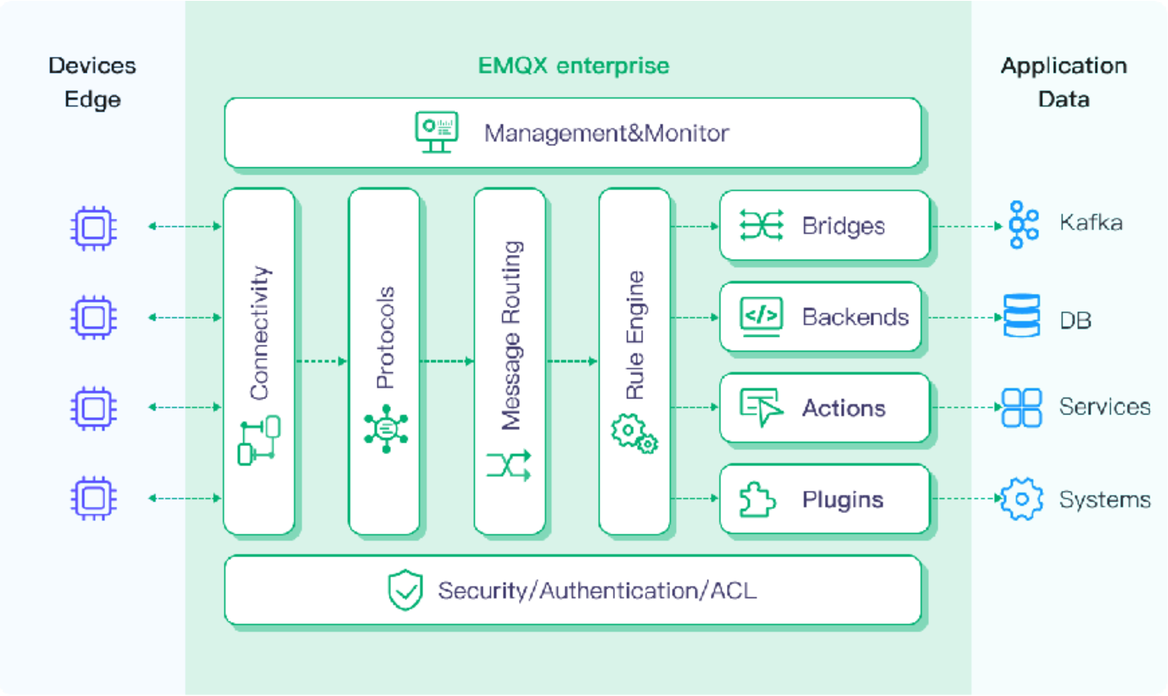
Here is an example of the data that an MQTT broker can process for connected vehicles.

In MQTT’s asynchronous publish/subscribe communication pattern, clients do not contact one another directly; all connections are handled by the MQTT broker and originate from the clients. Clients communicate as needed, publishing or receiving updates on subscribed topics as they enter and leave the network. This model reduces required back–and–forth transactions and makes it very easy to add publishers or subscribers without disrupting the system.

Quality of Service and Reliability

Securely and reliably delivering and receiving messages for a given vehicle clearly is a key requirement for scalable IoV systems. MQTT was designed specifically for reliable messaging under challenging network conditions.

During a loss of service due to network dropout or performance issues, traditional synchronous protocols require the server to reestablish a connection with each affected client, resulting in either lost messages or high latency. MQTT meets this challenge with mechanisms like persistent sessions and quality of service controls, which respectively, instruct the MQTT broker to remember a client's connection details after a disconnection and to store up critical messages for delivery once that client reconnects. Other features of MQTT like Last Will messages and Retained messages provide other options for fault–tolerant delivery.

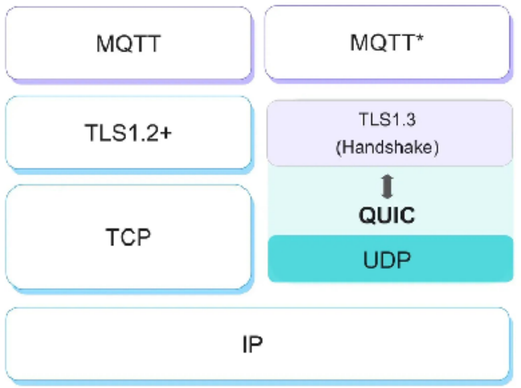


An MQTT broker reliably monitors and delivers IoT data to your back end applications with very low latency

If proper security methods are implemented, connected automobiles using MQTT over public internet are also inherently secure. Client connections support a variety of authentication methods and can be encrypted, typically using the transport layer security (TLS) protocol. Since MQTT connections originate at the client, connected automobiles can also be completely firewalled from outside connection requests. At the broker and broker cluster levels, multiple mechanisms can be implemented to ensure security, including authentication and authorization at the node level and TLS/SSL and datagram transport layer security (DTLS) encryption for cluster node communications. Access control lists (ACLs) determine which clients are allowed to publish or subscribe and on which topics.

Leveraging the next-generation IoT standard: MQTT over QUIC

While on the subject of reliability, the next level of efficient data management is on the horizon. QUIC (Quick UDP Internet Connections, pronounced “quick”) is a new multiplexed message transport designed for mobile internet. Built on top of UDP, QUIC is implemented with less connection overhead, lower message latency, and modern algorithms for dealing with network switching, congestion, data loss, and other common challenges. MQTT over QUIC also benefits from a wide range of improved capabilities such as reduced packet loss and higher stability, reduced overhead and better performance, greater efficiency in reconnection, and a more flexible architecture. QUIC also standardizes efficient end-to-end encryption to make communications more secure by default. Additional features like message prioritization and multi-streaming are in development as



standardization of MQTT over QUIC progresses. As the demand for vehicle data increasingly outstrips available bandwidth, MQTT messaging over QUIC will be a critical part of the Internet of Vehicles.

Scaling your MQTT Network

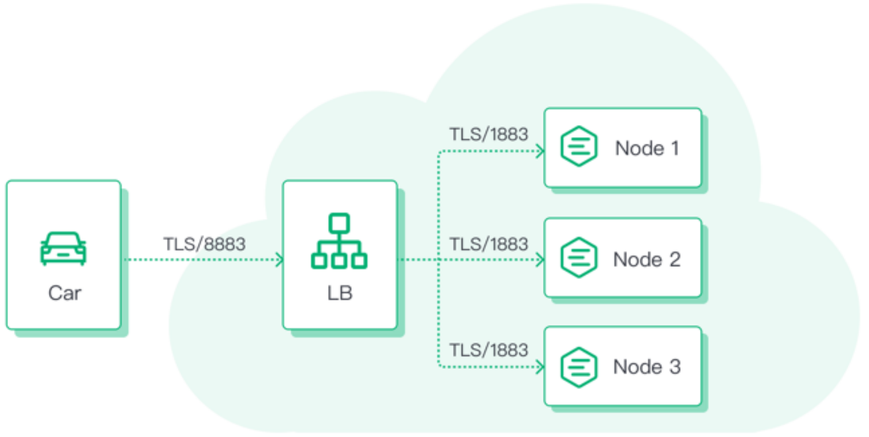
Outside of the MQTT protocol's native features, building a reliable MQTT network that supports millions of connections requires broker clustering and load balancing.

What is broker clustering? Simply arranging multiple MQTT brokers into a single architecture for resilience. In a clustered system, all brokers share information about MQTT topic routing. If a single broker is unavailable, other brokers in the cluster can take over those client connections.

Load balancers help with this by evenly distributing client sessions among clustered brokers, acting as the intermediary between them and the MQTT clients. Clients don't need to select a specific broker in a cluster; they only need to interface with the load balancer.

Load balancers can reconnect persistent sessions and even ensure that clients reconnect with the same broker in the cluster.

This approach provides a high level of efficiency and availability as the number of connections scales into the millions.



Conclusion

Connectivity is the future of automobiles and transportation. A scalable, reliable, and secure system using the MQTT protocol is a clear choice for efficient low–bandwidth data transfer and handling. A communications system built on MQTT provides reliable messaging for the future of connected vehicles. Clustered broker architectures achieve the access capacity for real–world solutions. EMQ is the currently the only MQTT broker that can support MQTT over QUIC. Contact EMQ today to help build a secure, reliable and scalable connected car communication strategy Contact Us.

EMQ

Learn more at: **www.emqx.com**

Contact us at: sales@emqx.io

EMQ Technologies Inc.

305 Vineyard Town Center #140, Morgan Hill, CA 95037

Rapidly deploy connected car services at scale

www.emqx.com Email Twitter YouTube