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SoD-MQTT: A SDN-Based Real-Time Distributed MQTT Broker

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Outline

I. SDN-based MQTT Broker

II. State-of-the-art solutions

III. SoD-MQTT Architecture

IV. Proposed Mechanisms for SoD-MQTT Management

V. Evaluation

VI. Conclusions

I.1 The Internet of Things: A challenging environment

An ever-increasing number of devices

- sensors/actuators, traffic lights, vehicles, drones

For numerous use cases requiring efficient communication systems

- Transport, agriculture, health, smart cities, etc.

Many of them using the same protocol at application layer level

- MQTT (Message Queue Telemetry Transport)
- Agriculture, health, smart cities, etc.sed on an asynchronous Publish-Subscribe (Pub/Sub) pattern

That today needs to scale up to manage millions of devices simultaneously

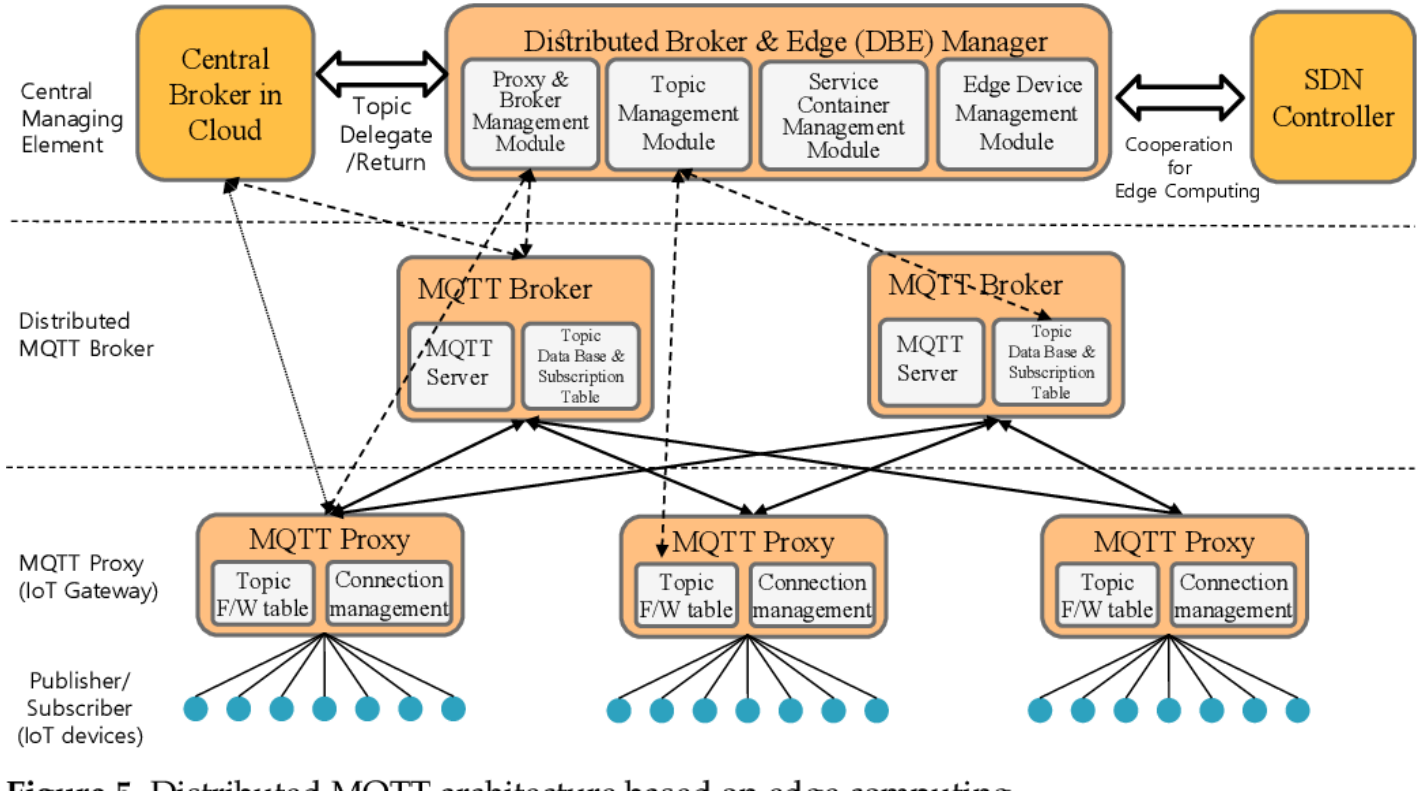
- MQTT broker distribution (multiple brokers belonging to the same cluster distributed on different physical machines) can be a solution

How can we ensure efficient communication between these brokers and guarantee the effectiveness of this approach?

I.1 SDN as a solution

Software Defined Networking (SDN) enabling both scalability and flexibility is presented as a solution in numerous papers

Example of architecture combining SDN and distributed MQTT



Source: https://www.semanticscholar.org/paper/Optimal-Distributed-MQTT-Broker-and-Services-for-Fawwaz-Chung/8337337740681b034f180866f5ab3ffb51719371

I.3 Current challenges

SDN could make MQTT architecture more complex

- How to efficiently integrate SDN within existing MQTT architecture?

SDN could induce latency in mobile environments

- How do you ensure that your SDN solution is high-performance?

SDN must be an end-to-end solution

- How can end-users be integrated into SDN-MQTT architecture?

II.1 State-of-the-art – Existing Work

Two types of existing solutions

1. Studies focusing on MQTT broker scalability

   - Aim to allow the management of a larger number of IoT devices and to enable the implementation of more context-aware services

   - Limitation : Do not take into account the idea of interconnecting the different MQTT brokers and can therefore only provide local services

2. Studies aiming to ensure the MQTT cluster consistency

   - Aim establish communications between distributed MQTT brokers

   - Limitations : consider multi-tier architectures or architectures based on the use of root broke and do not take into account integration into the existing MQTT architecture

II.2 State-of-the-art – Positioning

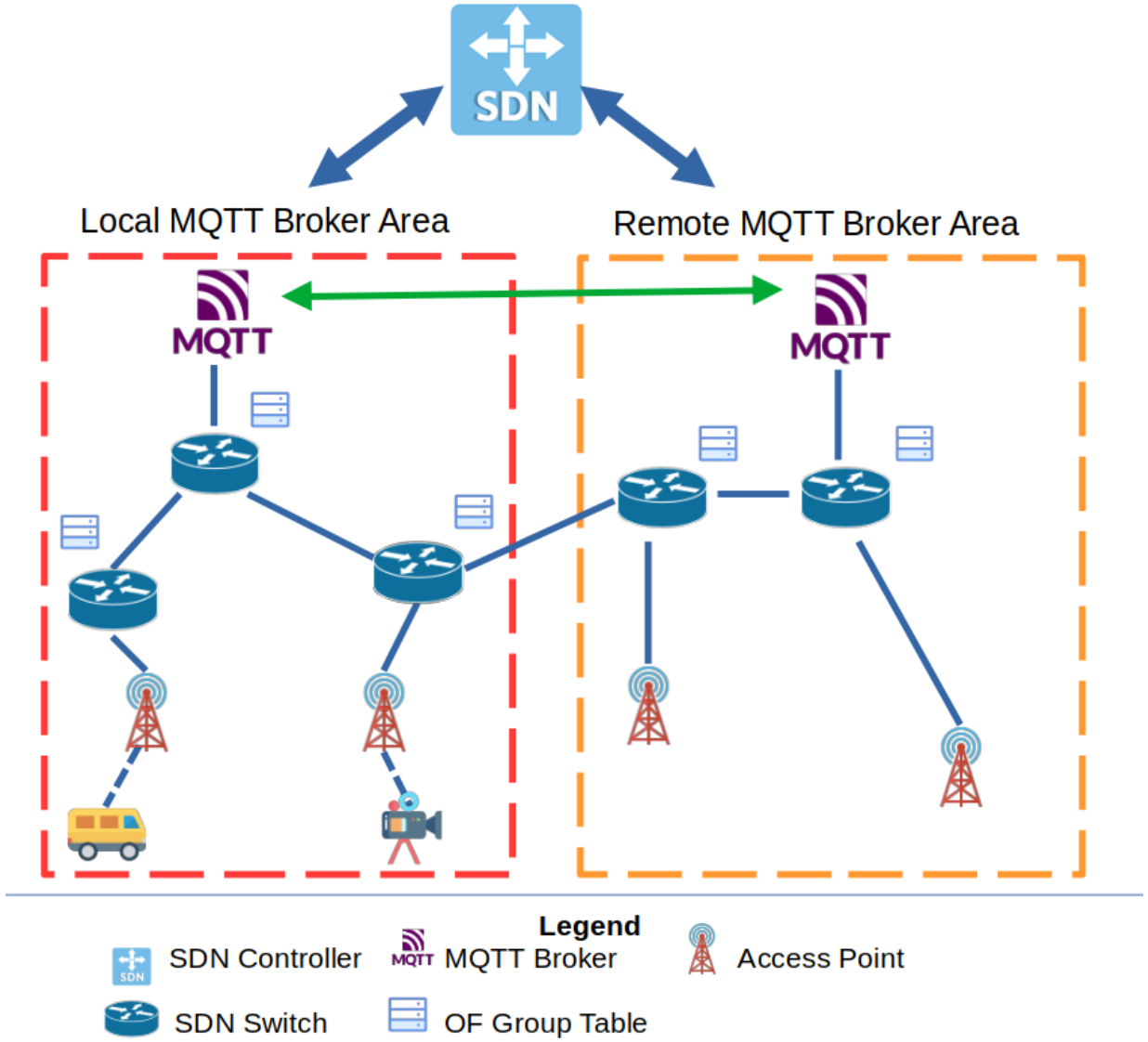
To deal with existing limitations

- The solutions proposed so far have not been designed to be interoperable with the existing MQTT architectures
- The solutions implemented for the interconnection of brokers are based on sequential dissemination to the different brokers, relying on the definition of root brokers (= Latency)
- The management of subscribers has not been considered in the existing works

We aim to propose

- A Scalable architecture
  - integrable in current MQTT architecture
  - Ensuring low-latency data dissemination
  - Able to manage different types of subscriptions

III. Proposed Architecture



Main features of our architecture :

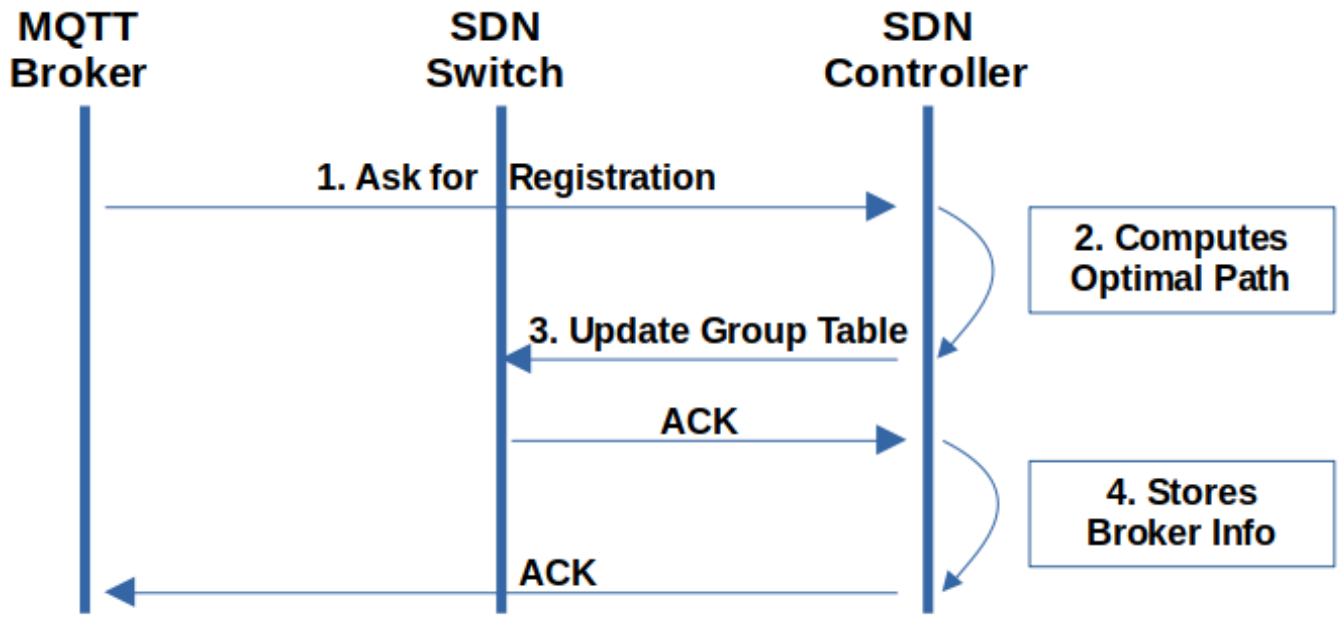
1. The idea of Local and Remote MQTT Broker
2. The standardization of exchanges between MQTT brokers and SDN controllers
3. the use of OpenFlow Group Tables at the SDN switch level for data dissemination within MQTT clusters

IV.1 MQTT Brokers Management

Idea

- Ensure a simultaneous and low latency data distribution to the different brokers located within a same cluster

Proposed mechanism



IV.2 MQTT Messages Management

Two types of messages

- Messages generated by publishers
- Messages generated by subscribers

Distinguished by the use of different TCP ports

- SUB PORT intended for actions related to subscribers: new subscription, Keep-Alive Message, etc
  - Only transmitted to the MQTT Broker managing the geographical area in which this subscriber is located
- PUB PORT 0 intended for simple publishing actions
  - Messages are transmitted to all brokers located within a cluster
- PUB PORT 1-X intended for more complex publishing scenarios with X sub-clusters
  - Messages can be transmitted to one broker (local transmission) N sub-clusters (N<X) or X sub-clusters

V.1 Evaluations – Aims and Setup

We seek to verify that

1. Real-time message transmission within the MQTT cluster, enabled by SoD-MQTT, can be beneficial;
2. SoD-MQTT allows to support critical application;
3. SoD-MQTT allows to optimize network management/usage.

Using a specific setup

- Mininet-WiFi
- Eclipse Mosquitto
- Iperf3

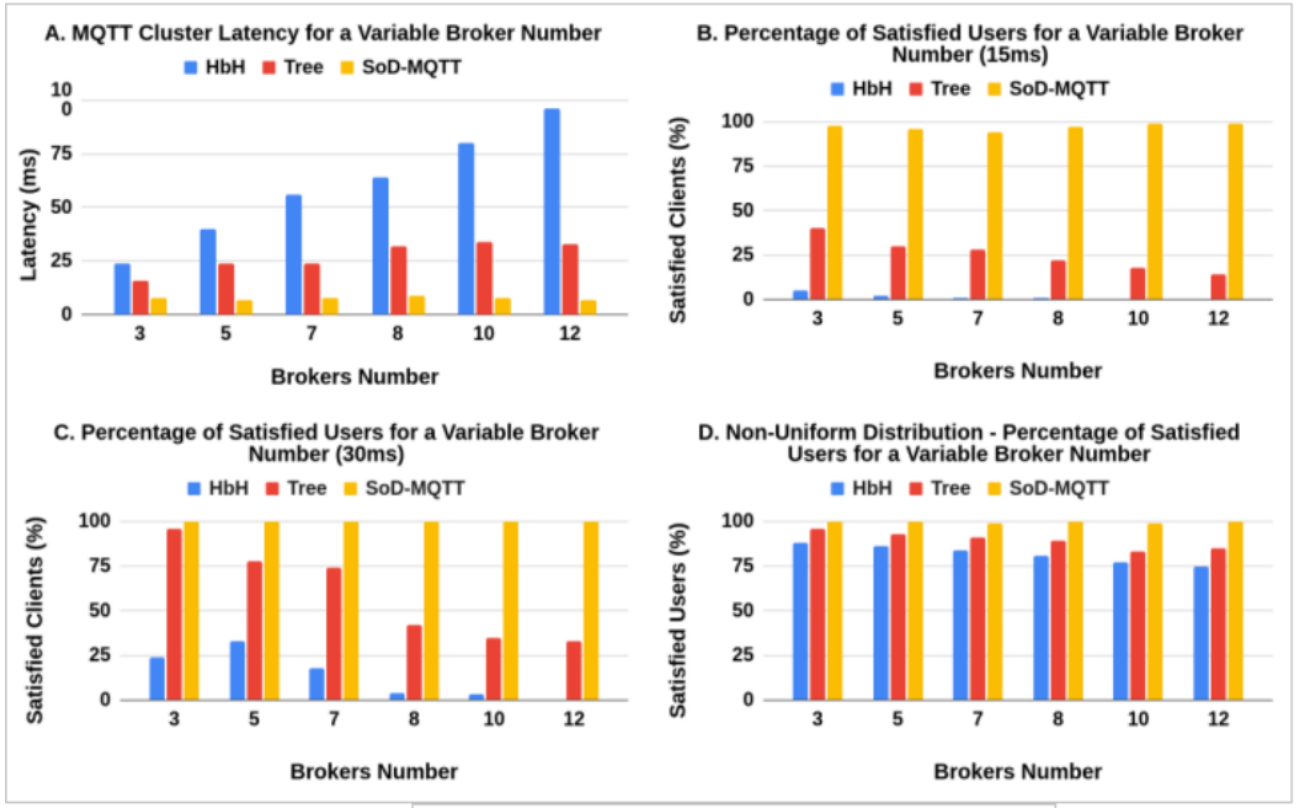
Considering specific KPI

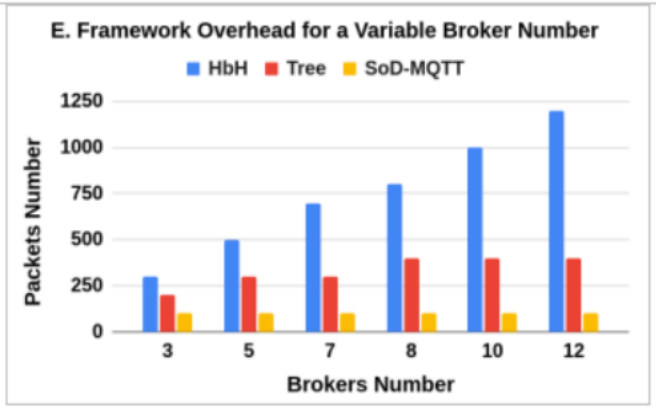
- Realistic latency parameters have been integrated into Mininet-WiFI
- A realistic number of brokers is considered (3 to 12)
- The results have been averaged over a large number of published messages (10,000)

Comparing SoD-MQTT with other solutions

- HbH in which messages are transmitted hop by hop within the MQTT cluster (broker after broker)
- Transmission of data within the cluster is organized in a tree (each broker transmits messages to two clusters)

V.2 Evaluations – Results





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VI. Conclusions

Novel SDN-based MQTT Broker

- Compatible with the currently deployed solutions and therefore integrable without impacting their current operation
- Optimizes the message transmission within the MQTT cluster by allowing the broadcast of messages to the different MQTT brokers
- Proposes effective management of MQTT clients by determining efficiently which MQTT brokers must receive the emitted messages

- SoD-MQTT could guarantee
  - Allow reducing significantly the information transmission delays within the MQTT cluster
  - Guarantee the proper functioning of very low latency applications and thus offer critical MQTT services: transportation, e-health, etc.
  - Allow to optimize the use of the available bandwidth

- Future work/New aspects that will be considered
  - Security issues and the definition of new mechanisms (firewall, intrusion detection, etc.) to deal with that
  - The use of Artificial Intelligence tools to optimize the underlying SDN architecture

Thank you for listening, any questions?

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