

# MQTT & CoAP

# Background

- **Polling Model:**
  - Applications send **queries** to sensor nodes to retrieve information.
  - Problem?
  - When an event of interest occurs, in order to react in real-time, the sensor nodes have to be **queried continuously**.
    - Waste of resources such as energy, processing and bandwidth.

# Background

- **Publish/Subscribe Model**
  - Entities:
    - Publisher: generate events
    - Subscriber: express interest in events
  - Subscription:
    - Register interest in the event
  - Advantages:
    - Decouple in time: publishers and subscribers do not need to be actively participating in the interaction at the same time
    - Decouple in space: publishers and subscribers do not need to know each other
    - Publishers and subscribers can produce or consume events in an asynchronous way.

# Publication Discipline

- Activation: when there is a pending confirmation of a publication message, and a new publication is generated
- MQTT-S publication discipline:
  - Discard the new publication message
- CoAP publication discipline:
  - Discard the old publication message
- An **inappropriate** fixed RTO will result in a higher probability of a new publication message being generated while the RTO is active. Therefore, the publication discipline will discard the publication message (Old or New).

# MQTT-S

- Extension of the Message Queuing Telemetry Transport (MQTT) Optimized for WSN.

- Components:

- Broker node:

- responsible for managing subscriptions as well as storing and sending publications to corresponding WSN subscriber nodes.

- Publisher nodes:

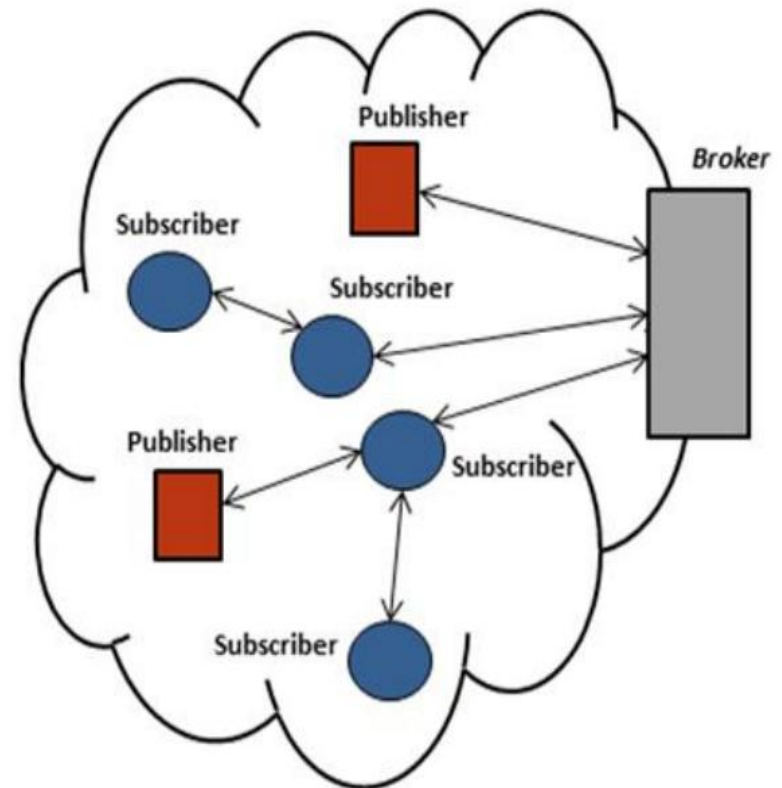
- generate event

- Subscriber nodes:

- express interest in events

- Relay nodes:

- for multi-hop scenario.



# MQTT-S

- Reliability:
  - QoS Level 0 (QoS0)
    - Offers a best-effort delivery service, no retransmission or Acknowledgements.
  - QoS Level 1 (QoS1)
    - Allows the retransmission of messages until Acked
    - Does not prevent duplicate reception
  - QoS Level 2 (QoS2)
    - Ensures the reception of message
    - Ensures to deliver only once to the destination by four message handshake.
  - Parameters for QoS1 and QoS2:
    - Fixed RTO: 10-15 seconds.
    - Retransmission number: 3-5

# MQTT-S

- Publication Discipline:
  - “stop and wait” mechanism for the transmissions of publication messages with QoS1 and QoS2.
  - A publisher node has to wait for the termination of its publication message flow with the broker node before it can start a new one.
  - If more than one publications are generated, publication discipline is needed.
  - Activity 1: Queue the new publication messages
    - Drawback: cost more source
  - Activity 2: Drop the new publication messages
    - Always attempts to retransmit the old publication message till receive the ACK.
    - Called ‘Persistent mode’ discipline

# CoAP

- Characteristics:
  - RESTful (Representational State Transfer)
  - Resources are identified by Universal Resource Identifiers (URI)
  - UDP based
- Model:
  - Client/server interaction model
    - Request messages initiate a transaction with a server, which may send a response to the client with a matching transaction ID
    - Polling based: not suitable for requiring information in real-time in order to react when an event of interest occurs.
  - Publish/subscribe interaction model
    - A.k.a: Observer Model
    - A **publisher** node can send **publications** to a **subscriber** node (observer) about a event that the subscriber is interested in receiving .



# CoAP

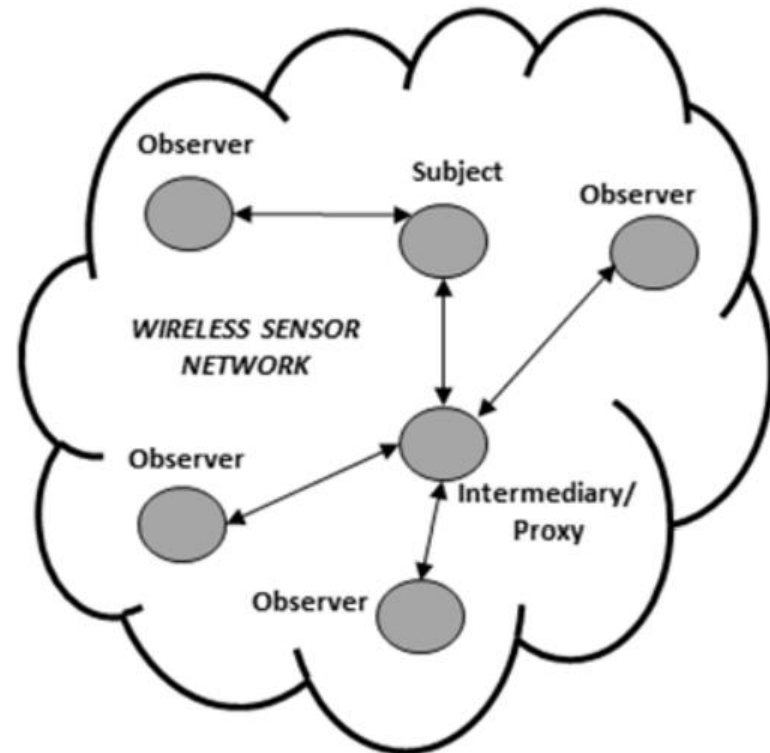
- Publish/subscribe interaction model
- A subscriber constantly to observe the events by registering its interest in the event (GET request to the publisher node).

- Subscription Action:

- Publisher node establishes an observation relationship between the subscriber and the event.
- The publisher notifies each subscriber node that has an observation relationship with the event.

- Observer Model:

- High scalability
- Use caches and proxy nodes that multiplex the interest of multiple subscribers in the same event into a single association



# CoAP

- Reliability:
  - Non-Confirmable (NON) message:
    - Correspond to MQTT-S QoS 0
    - No ACK to messages
  - Confirmable (CON) message:
    - Correspond to MQTT-S QoS 1
    - ACK messages received
    - Fixed RTO
      - Random number between and ACK TIMEOUT constant and an ACK TIMEOUT multiplied by ACK-RANDOM-FACTOR
      - UnACKed messages within RTO are retransmitted
      - RTO is doubled (Exponential back-off mechanism)
    - MAX\_RETRANSMIT: Maximum retransmission numbers

Protocol Constants	Value
ACK_TIMEOUT	2 s
MAX_RETRANSMIT	4
ACK_RANDOM_FACTOR	1.5

# CoAP

- Publication Discipline:
  - “stop and wait” mechanism for the transmission of CON messages. Same with MQTT-S.
  - Publication discipline is also needed to handle publication messages generated while the publication message flow is in progress (RTO is active)
- Activity:
  - Stop the retransmission of **old** publication message
  - Transmit the **new** publication message with the number of attempts remaining from the old publication message.

# MQTT-S and CoAP

- Fixed RTO:
  - Too short: give rise to spurious retransmissions, waste bandwidth, energy and computation.
  - Too long: lead to slow or late reaction to the loss of packets, increase delay ,decrease PDR.
  - Suitable for deployments when RTT is close to the defined RTO value.
  - Not suitable for scalability and flexibility features by the publish/subscribe model on WSN.
- Adaptive RTO:
  - Compute smoothed RTT (SRTT)
    - $SRTT = (1 - a) \times SRTT + a \times RTT$
  - Compute RTO
    - $RTO = SRTT \times K$