Internet of Things (IoT)
MQTT vs CoAP

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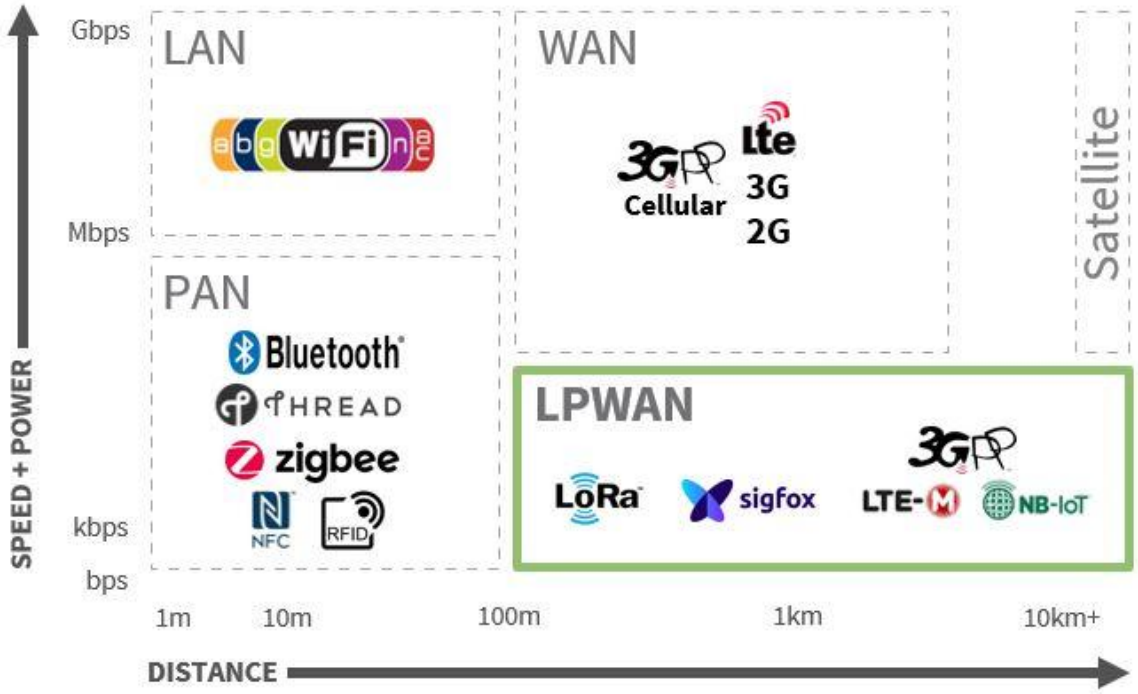
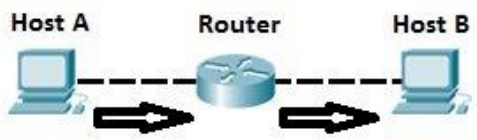
Types of networks used in the IoT

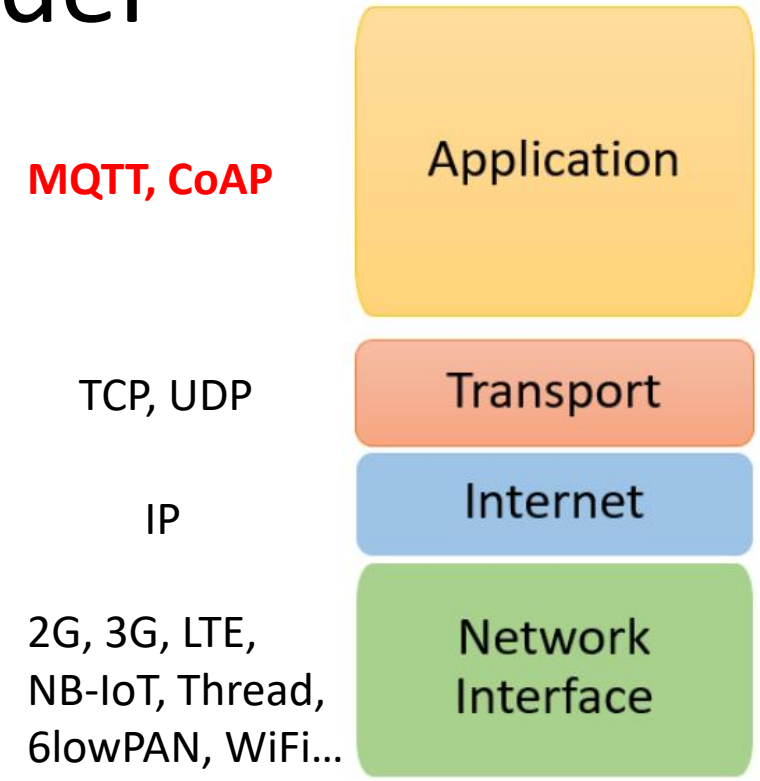


TCP/IP model

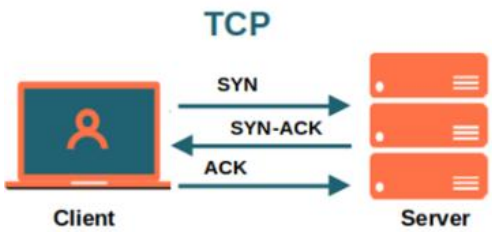
- IP Protocol
  - Relays packets across network boundaries
    - Based solely based on the IP addresses

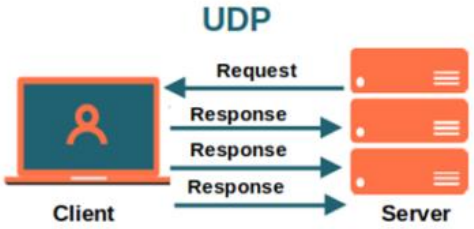


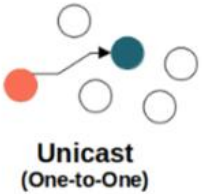
Homework
What are the difficulties in transition from IPv4 to IPv6?

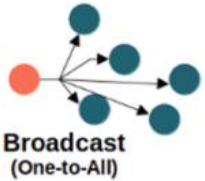


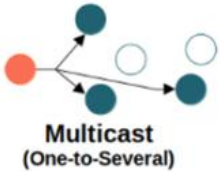
TCP/UDP









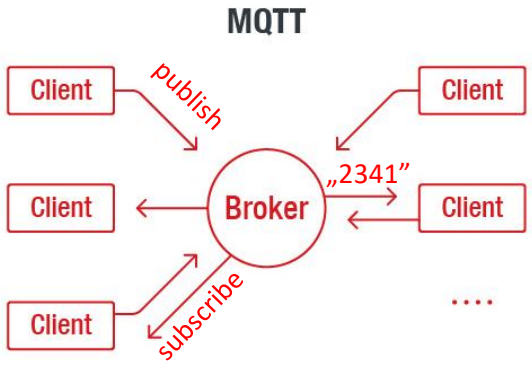


Connection-Oriented
Guaranteed Transmission
Flow Control
20 Bytes header
Three-Way Handshake

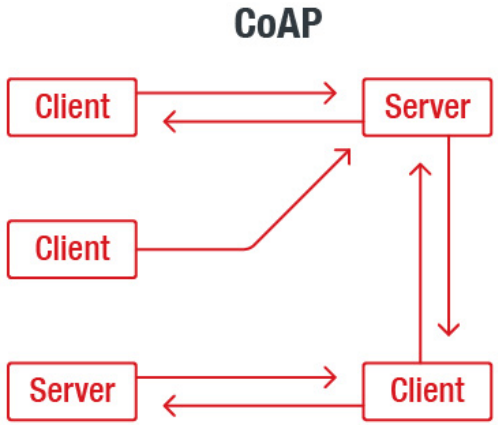
Connectionless
No guarantee
No Flow Control
8 Bytes Header
No Handshake Mechanism

IoT Application Protocols

- **MQTT**
  - Pub/sub communication for binary data
  - Two-way communication



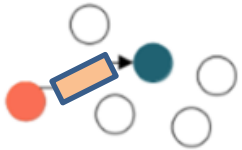
- **CoAP (Constrained Application Protocol)**
  - Web service oriented architecture
  - Used for resource constrained devices
  - Based on the UDP



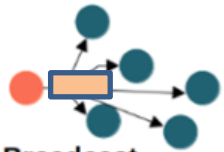
MQTT

MQTT

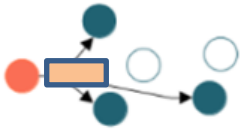
- MQTT is a publish/subscribe messaging protocol
  - designed for lightweight M2M communications
- Every message is published to an address, known as a topic
  - Clients may publish to multiple topics
  - Clients may subscribe to multiple topics
  - Every client subscribed to a topic receives every message published to that topic
- The publisher subscriber model allows MQTT clients to communicate
  - one-to-one
  - one-to-many
  - many-to-one



Unicast
(One-to-One)



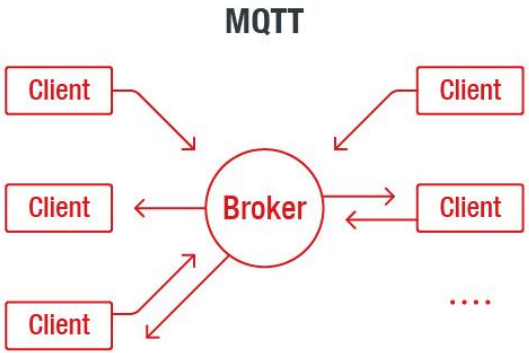
Broadcast
(One-to-All)



Multicast
(One-to-Several)

MQTT Architecture

- MQTT has a client/server model
  - every sensor is a client
    - and connects to a server, known as a broker, over TCP

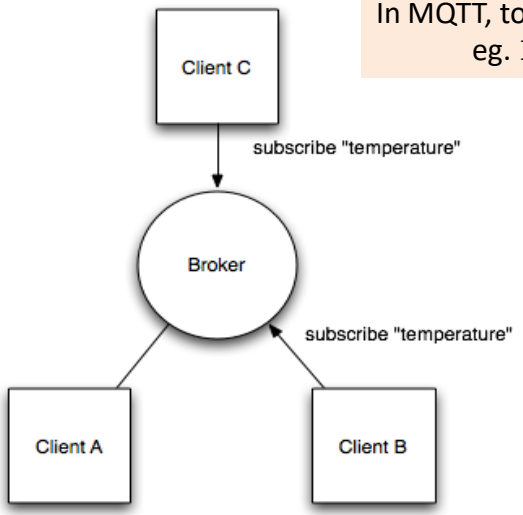


- MQTT is message oriented
  - Every message is a discrete chunk of data, opaque to the broker

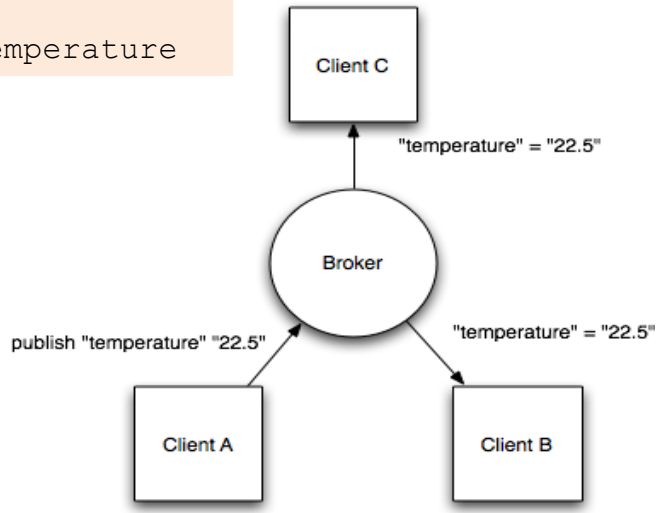
- It was originally developed by IBM and is now an open standard

MQTT Example

In MQTT, topics are hierarchical
eg. `kitchen/oven/temperature`



All three clients open TCP connections with the broker. Clients B and C subscribe to the topic temperature.



At a later time, Client A publishes a value of 22.5 for topic temperature. The broker forwards the message to all subscribed clients.

Quality of Service (QoS) for MQTT

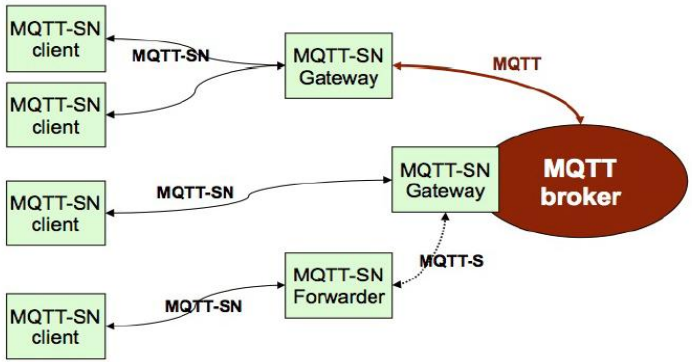
- Quality of service (QoS) levels determine how each MQTT message is delivered and must be specified for every message sent through MQTT
  - **QoS 0 (At most once)** - where messages are delivered according to the best efforts of the operating environment. Message loss can occur
  - **QoS 1 (At least once)** - where messages are assured to arrive but duplicates can occur
  - **QoS 2 (Exactly once)** - where message are assured to arrive exactly once

Homework

What is MQTT Last Will And Testament?

MQTT-S

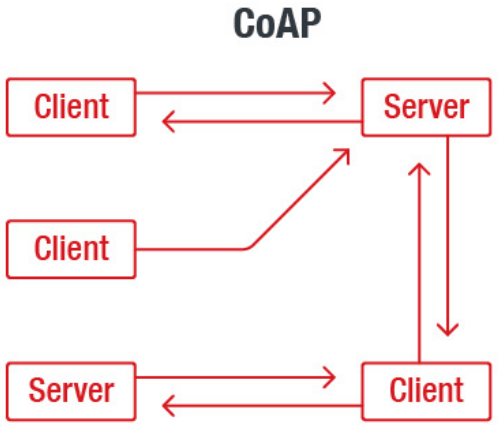
- Extension of MQTT for WSN
  - Uses UDP instead of TCP
- Implements several optimizations
  - Topic strings replaced by a topic ID
  - Discovery procedure for clients to find brokers
  - Support for sleeping nodes (messages are buffered for sleepy nodes)
- MQTT-S gateways



COAP

The Constrained Application Protocol

- A RESTful protocol (coap://)
  - GET, POST, PUT, DELETE methods
- Both synchronous and asynchronous
  - Supports notifications via *observation pattern*!
- UDP binding with reliability and multicast su
- For constrained devices and networks
- Specialized for M2M applications
- Easy to proxy to/from HTTP

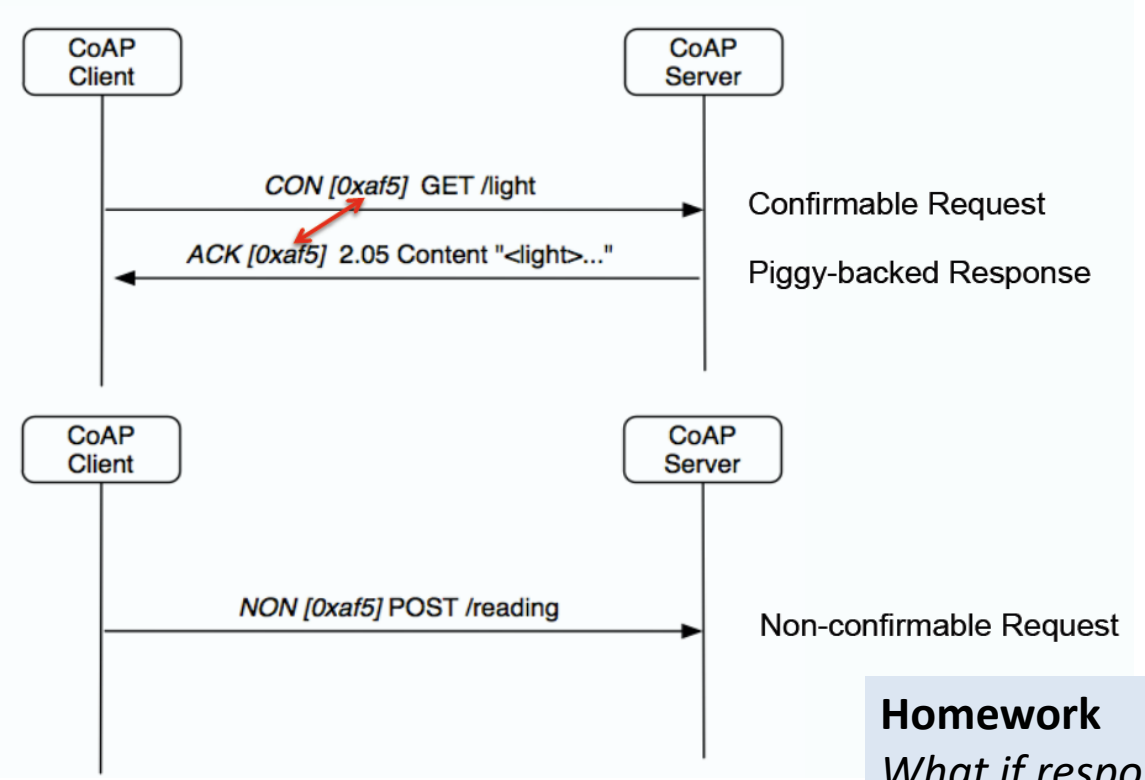


CoAP transaction messages

No TCP <-> No transport later retransmissions!

- **Confirmable (CON)**
  - Some messages require an acknowledgment, either just to know they did arrive or also to deliver the reply to a request.
- **Non-Confirmable (NON)**
  - Some other messages do not require an acknowledgment. This is particularly true for messages that are repeated regularly for application requirements, such as repeated readings from a sensor where eventual arrival is sufficient.

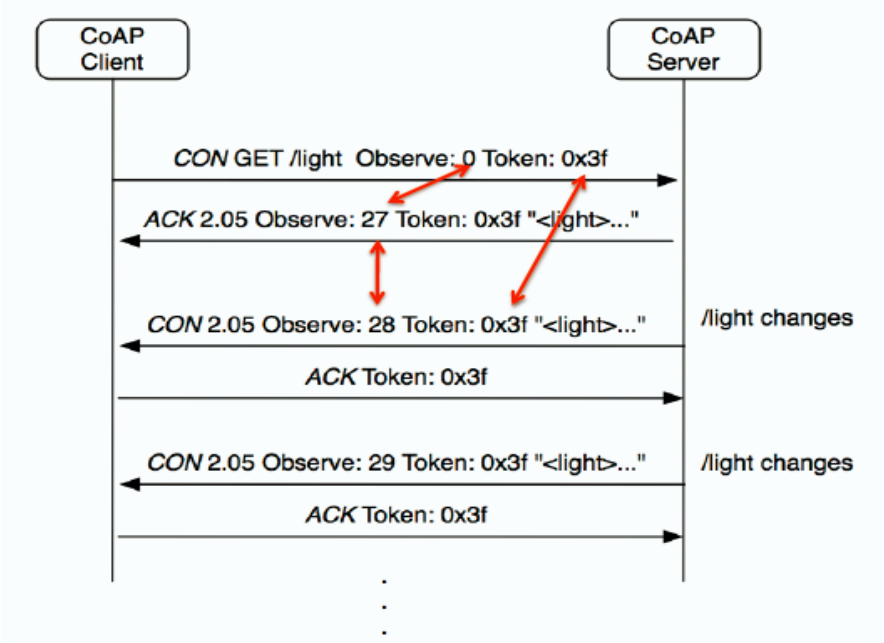
Request example



Homework

What if response is larger than maximum datagram payload?

CoAP observation pattern



Protocol comparison

Protocol	MQTT	CoAP
Transport	TCP	UDP
Messaging	Publish/Subscribe	Request/Response
2G, 3G, 4G, LTE suitability LPWAN suitability	Excelent Fair	Excellent Excelent
Succsess stories	IoT extension to enterprise messaging	Utility Field Meters (gas, water meters)

Summary

- IoT is complex due to the heterogenity of devices and technologies
  - Low-Power Personal Area Networks
    - OpenThread, 6lowPAN, Bluetooth Mesh, …
  - Non-IP LPWAN
    - LoRaWAN, Sigfox, …
  - Device Management
    - LwM2M, CUPS, …
  - Data serialization
    - CBOR, JSON, SenML, ProtoBuf, …
- Which protocol should be used?
  - There is no simple answer. It depends…

Q&A