PSI3542 2023
SISTEMAS EMBARCADOS PARA IOT

AULA 06 – DISPOSITIVO MQTT THINGSPEAK

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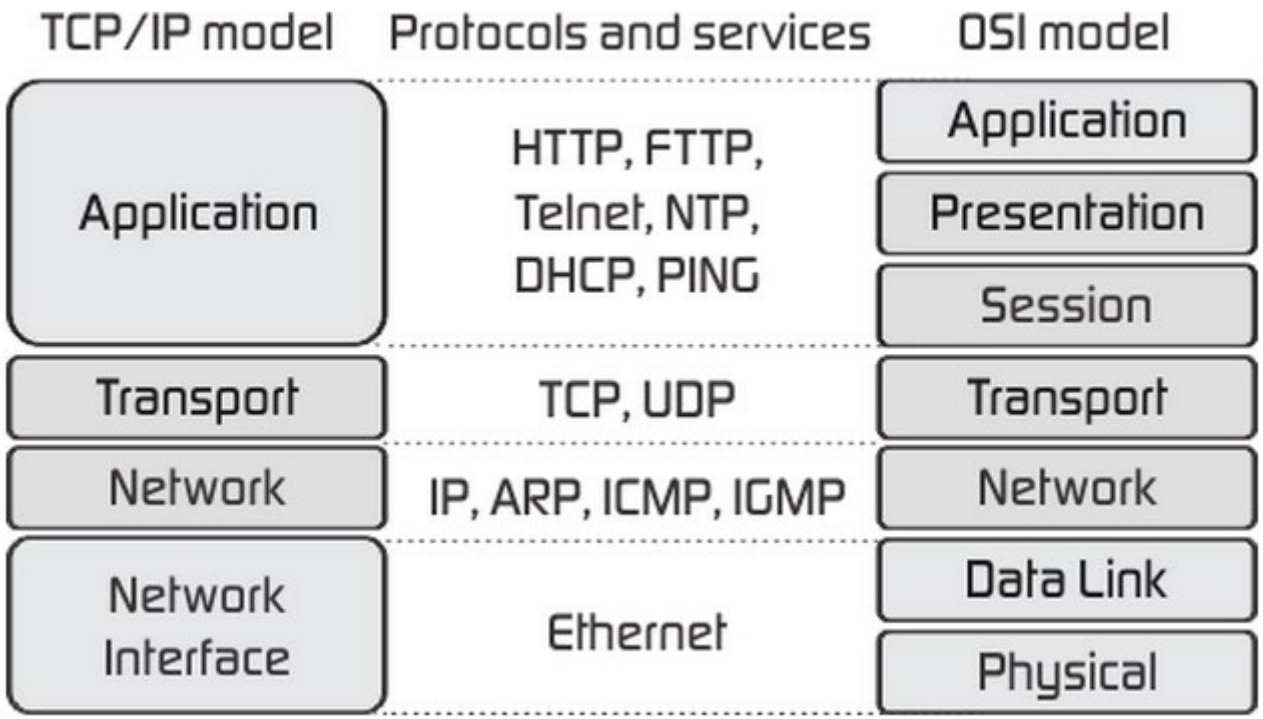
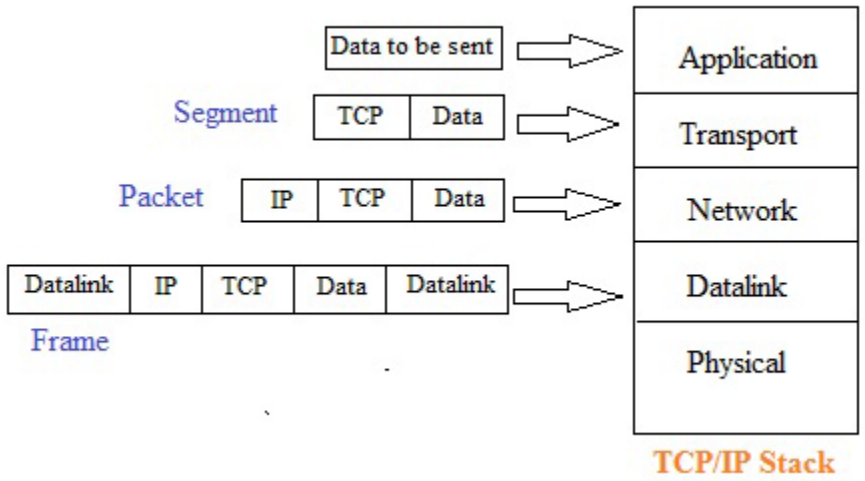
Recordação

TCP/IP vs OSI

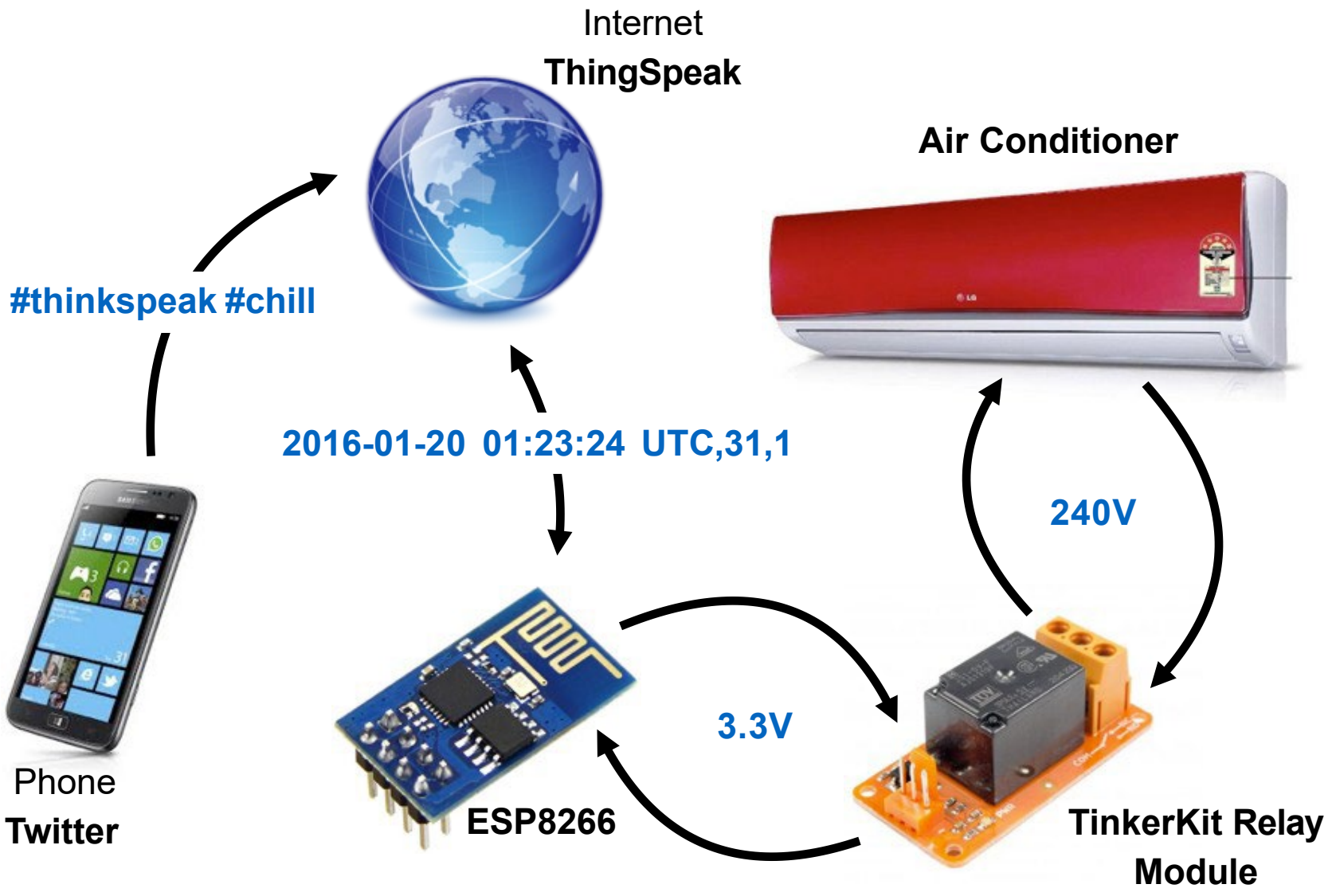

TCP/IP model
Protocols and services
OSI model
Application
HTTP, FTTP,
Telnet, NTP,
DHCP, PING
Application
Presentation
Session
Transport
TCP, UDP
Transport
Network
IP, ARP, ICMP, IGMP
Network
Network
Interface
Ethernet
Data Link
Physical

TCP/IP stack with 5 layers

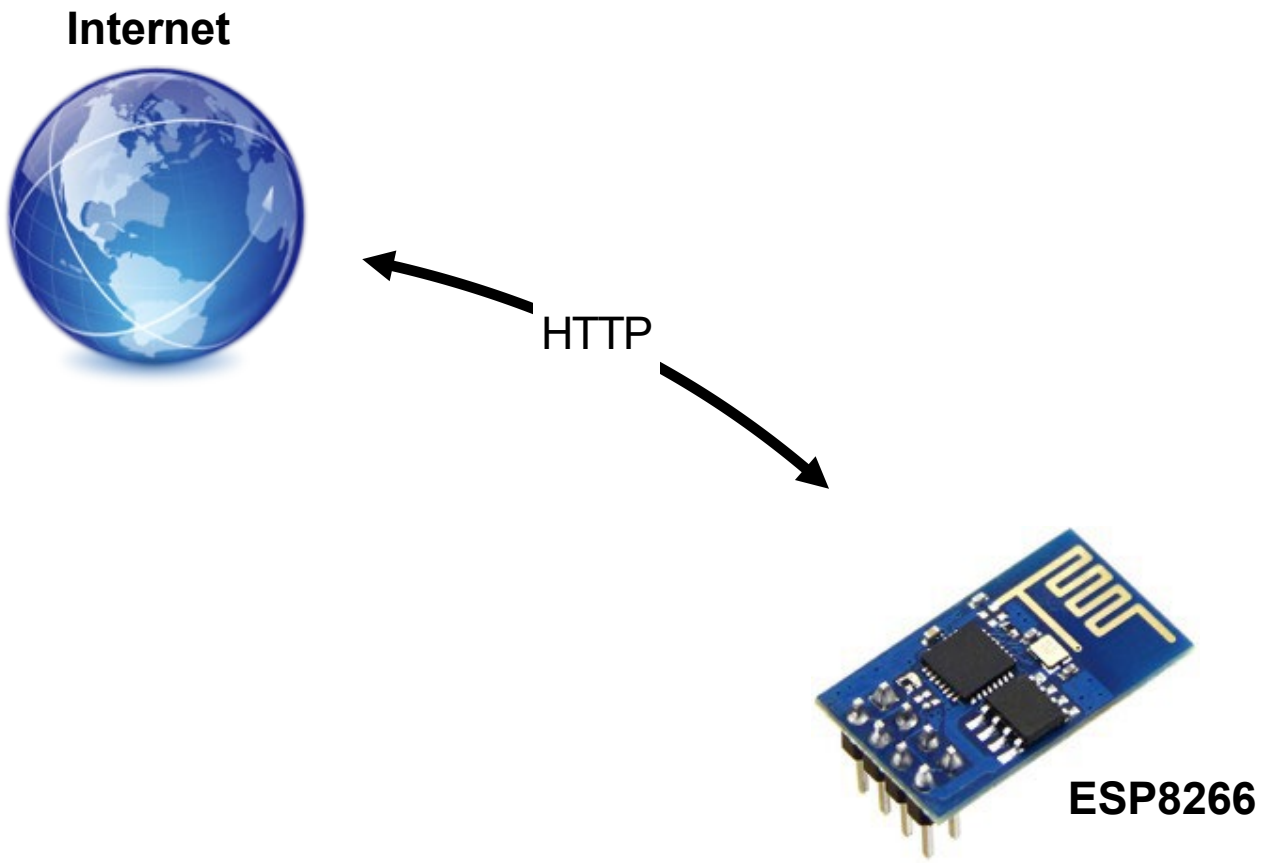


MQTT

IoT Ecosystem



IoT Ecosystem



MQTT: Key Features

Open

- Open published spec designed for the world of “devices”
  - Invented by IBM and Eurotech
  - MQTT client code (C and Java) donated to the Eclipse "Paho" M2M project

Lean

- Minimized on-the-wire format
  - Smallest possible packet size is 2 bytes
  - No application message headers
- Reduced complexity/footprint
  - Clients: C=30Kb; Java=100Kb

Reliable

- Three qualities of service:
  - 0 – at most once delivery
  - 1 – assured delivery but may be duplicated
  - 2 – once and once only delivery
- In-built constructs to support loss of contact between client and server.
  - “Last will and testament” to publish a message if the client goes offline.
- Stateful “roll-forward” semantics and “durable” subscriptions.

Simple

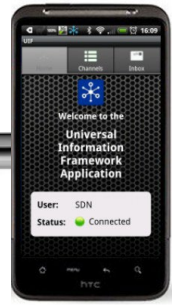
- Simple / minimal pub/sub messaging semantics
  - Asynchronous (“push”) delivery
  - Simple set of verbs -- connect, publish, subscribe and disconnect.

MQTT: Key Features

Scalable

- 240,000 concurrent clients tested with <5% CPU on a single IBM WebSphere MQ queue manager
- By comparison:
  - Apache Web Servers max out at 25,000 connections

Secure



- Direct connection between your enterprise and devices
- Network: TLS/SSL
- Authentication: JAAS
- Authorization: OAM

MQTT uses (much) less bandwidth than HTTP

IBM Hursley Lab

Scenario	HTTP	MQTT
1. Get a single piece of data from the server	302 bytes	69 bytes (~4 times)
2. Put a single piece of data to the server	320 bytes	47 bytes (~7 times)
3. Get 100 pieces of data from the server	12600 bytes	2445 bytes (~5 times)
4. Put 100 pieces of data to the server	14100 bytes	2126 bytes (~7 times)

European automobile manufacturer

Vehicle Telematics

Mobile Network Estimated Data Costs/Vehicle/Year*

HTTP	MQTT
220€/vehicle /year	23€/vehicle /year

*Comparison based on 100 messages/day, 200Bytes/Msg payload, 1-2€ /100MB TCP transfer costs.

Communication Model

HTTP

Has client-server model.

Communicates over TCP.

Server accepts requests.

MQTT

Has client-server model.

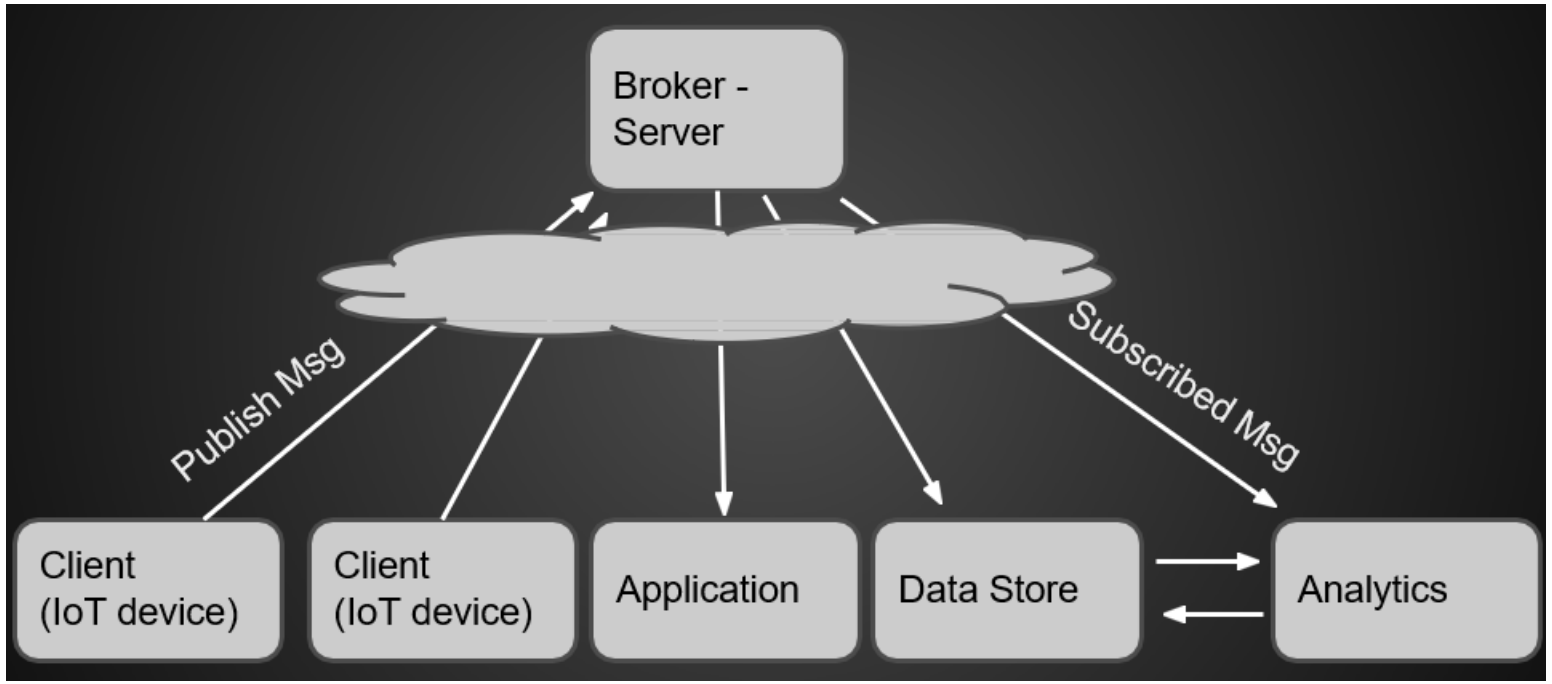
Communicates over TCP.

Broker accepts messages.

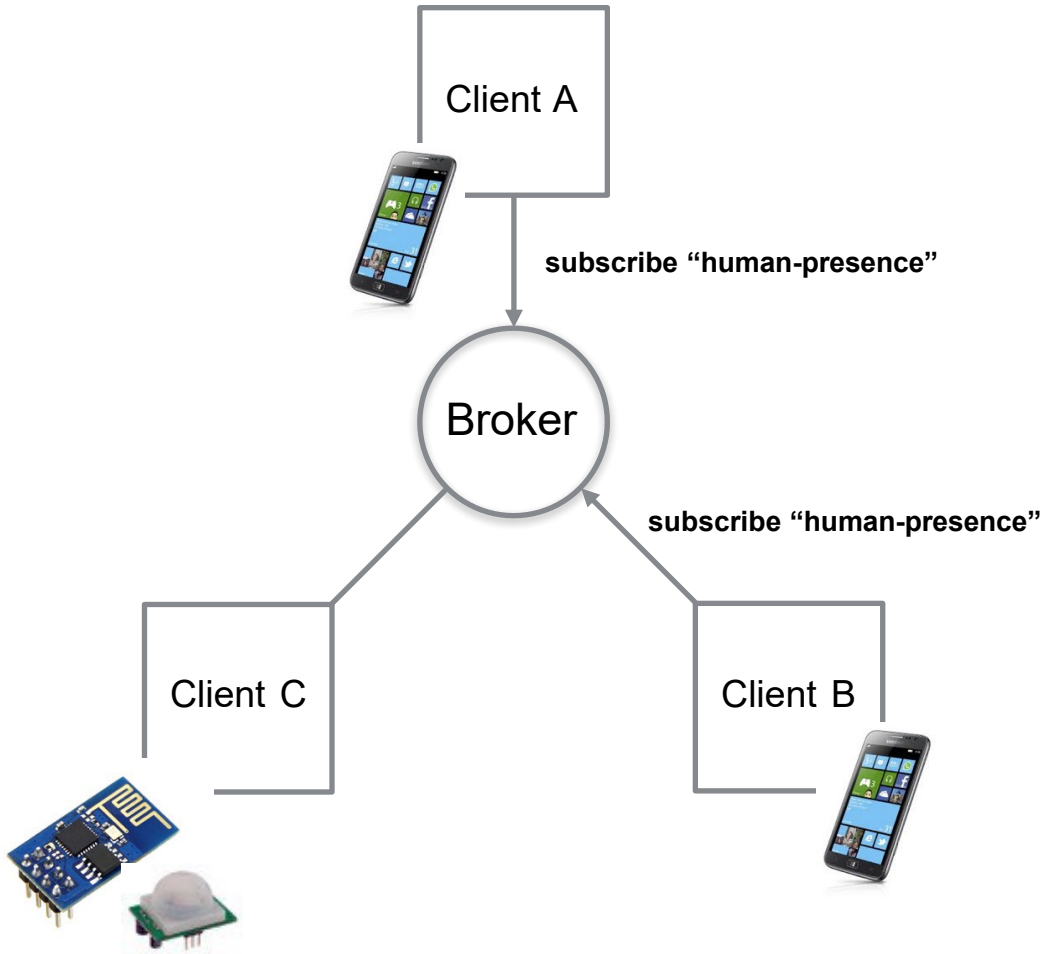
Verbs

HTTP	MQTT
GET	Connect
POST	Subscribe
PUT	UnSubscribe
PATCH	Publish
DELETE	Disconnect

Broker/Client - Pub/Sub

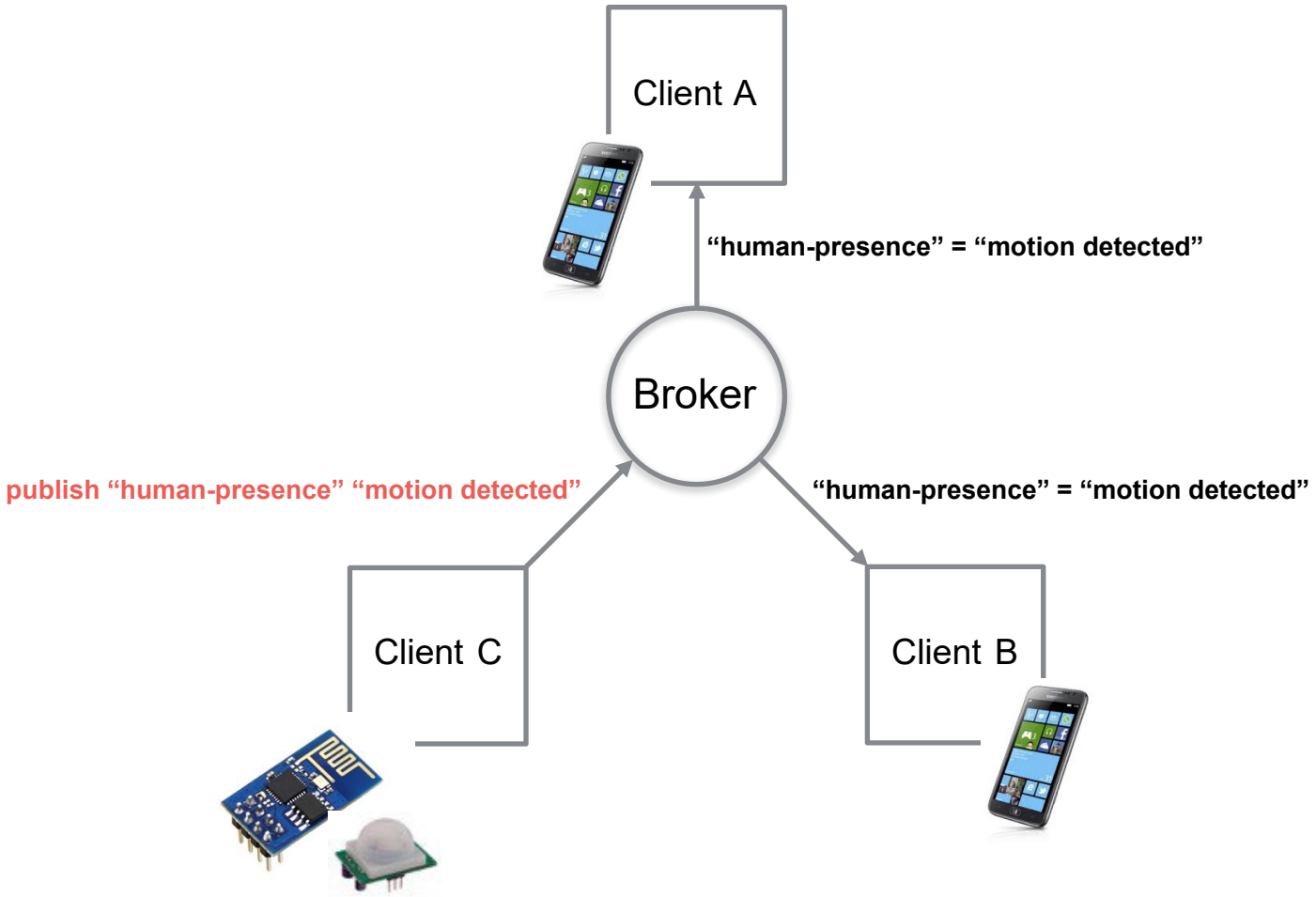


Implementation



https://eclipse.org/community/eclipse_newsletter/2014/february/article2.php

Implementation



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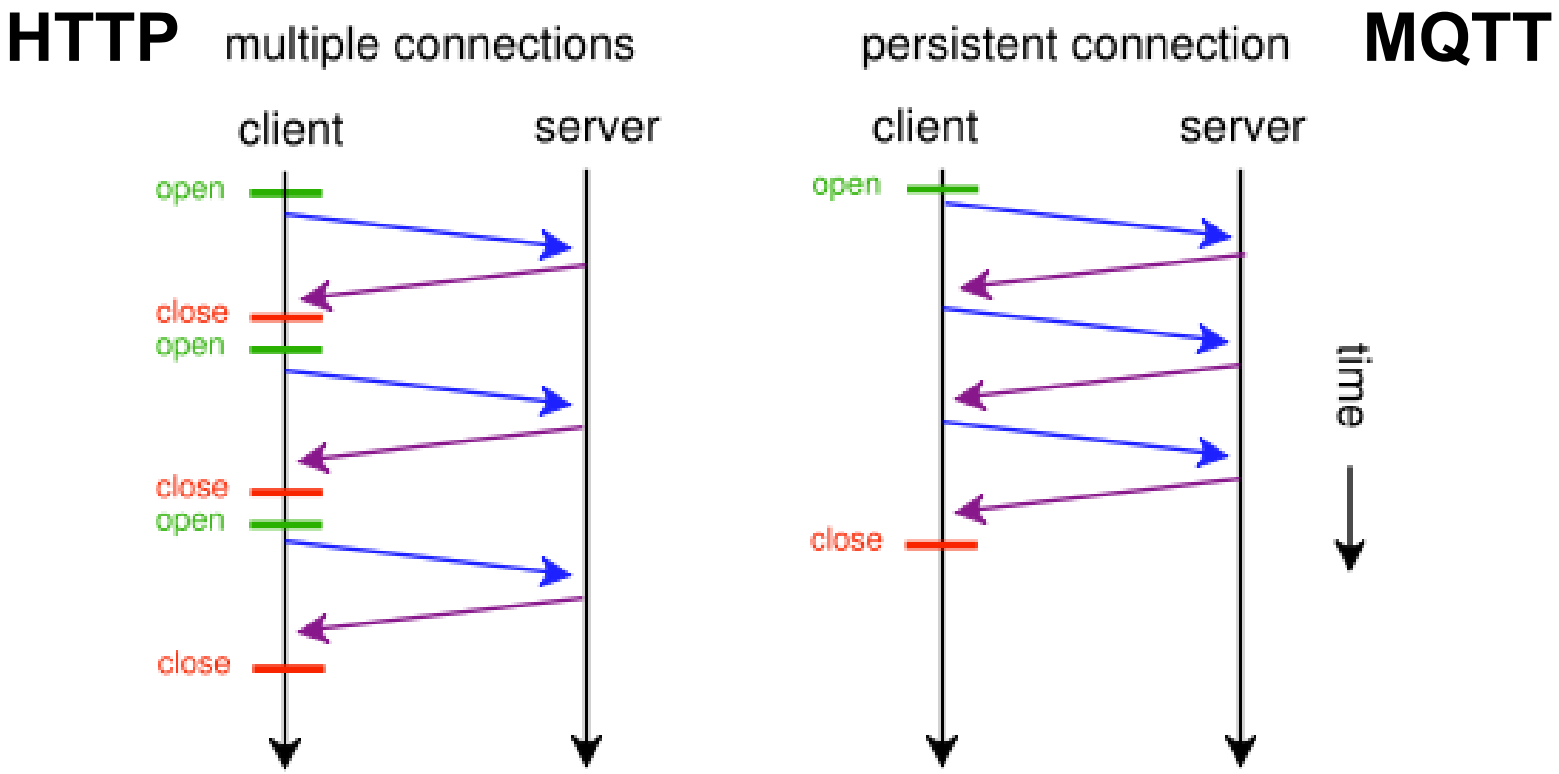
Response Times



https://en.wikipedia.org/wiki/HTTP_persistent_connection#/media/File:HTTP_persistent_connection.svg

Response Times

	3G		Wifi	
	HTTPS	MQTT	HTTPS	MQTT
% Battery / Hour	18.43%	**16.13%**	**3.45%**	4.23%
Messages / Hour	1708	**160278**	3628	**263314**
% Battery / Message *	0.01709	**0.00010**	0.00095	**0.00002**
Messages Received	240 / 1024	**1024 / 1024**	524 / 1024	**1024 / 1024**

Credit: Stephen Nicolas
http://stephendnicholas.com/archives/1217

Low Battery Use

Initial connection to server

% Battery Used			
3G		Wifi	
HTTPS	MQTT	HTTPS	MQTT
0.02972	0.04563	**0.00228**	0.00276

Credit: Stephen Nicolas
http://stephendnicholas.com/archives/1217

Low Battery Use

Subsequent connections to server

	% Battery / Hour			
	3G		Wifi	
Keep Alive (Seconds)	HTTPS	MQTT	HTTPS	MQTT
60	1.11553	**0.72465**	0.15839	**0.01055**
120	0.48697	**0.32041**	0.08774	**0.00478**
240	0.33277	**0.16027**	0.02897	**0.00230**
480	0.08263	**0.07991**	0.00824	**0.00112**

Credit: Stephen Nicolas
http://stephendnicholas.com/archives/1217

Broker/Client - Pub/Sub

MQTT Broker

- Accepts client connections, TCP/websocket
- Receives messages sent with a “topic”
- Receives subscription request for a “topic”
- Forwards to subscribers for their “topic”
- Has some QOS and retention ability

MQTT Message

- Parts:
  - Control (2-bytes) - What the message does
  - Topic - Named content
  - Payload - The content

MQTT Message - Control part

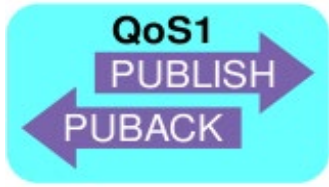
- 14 types of MQTT packets.
- Connection Related
  - Connect, Connack, Disconnect, PingREQ, PingRESP
- Publish - sending a message
  - Publish, PubACK, PubREC, PubREL, PubCOMP
- Subscribe - Asking to get messages by topic
  - Subscribe, SubACK, Unsubscribe, UnSubAck

Qualities of Service

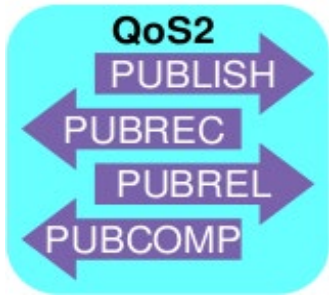
QoS value	bit 2	bit 1	Description		
0	0	0	At most once	Fire and Forget	<=1
1	0	1	At least once	Acknowledged delivery	>=1
2	1	0	Exactly once	Assured delivery	=1
3	1	1	Reserved		

- **QoS 0: At most once delivery (non-persistent)**
- – No retry semantics are defined in the protocol.
- – The message arrives either once or not at all.

- **QoS 1: At least once delivery (persistent, dups possible)**
- – Client sends message with Message ID in the message header
- – Server acknowledges with a PUBACK control message
- – Message resent with a DUP bit set if the PUBACK message is not seen

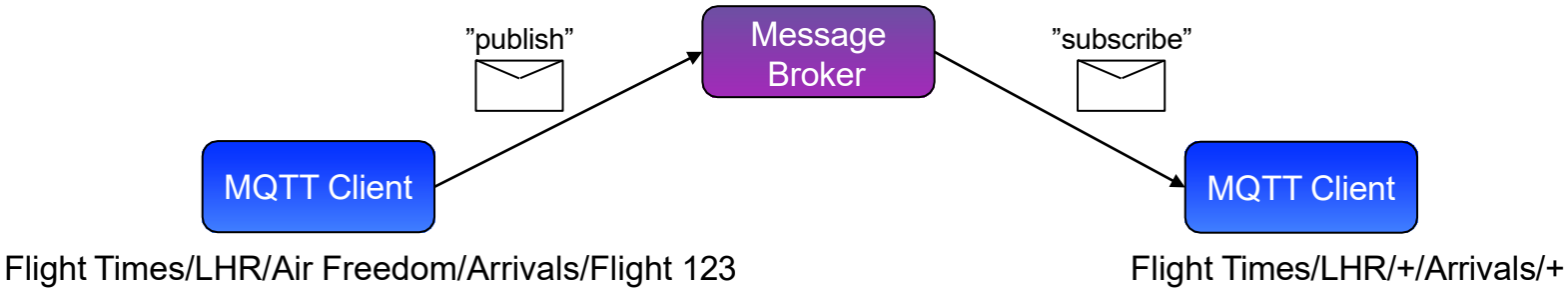


- **QoS 2: Exactly once delivery (persistent)**
- – Uses additional flows to ensure that message is not duplicated
- – Server acknowledges with a PUBREC control message
- – Client releases message with a PUBREL control message
- – Server acknowledges completion with a PUBCOMP control message

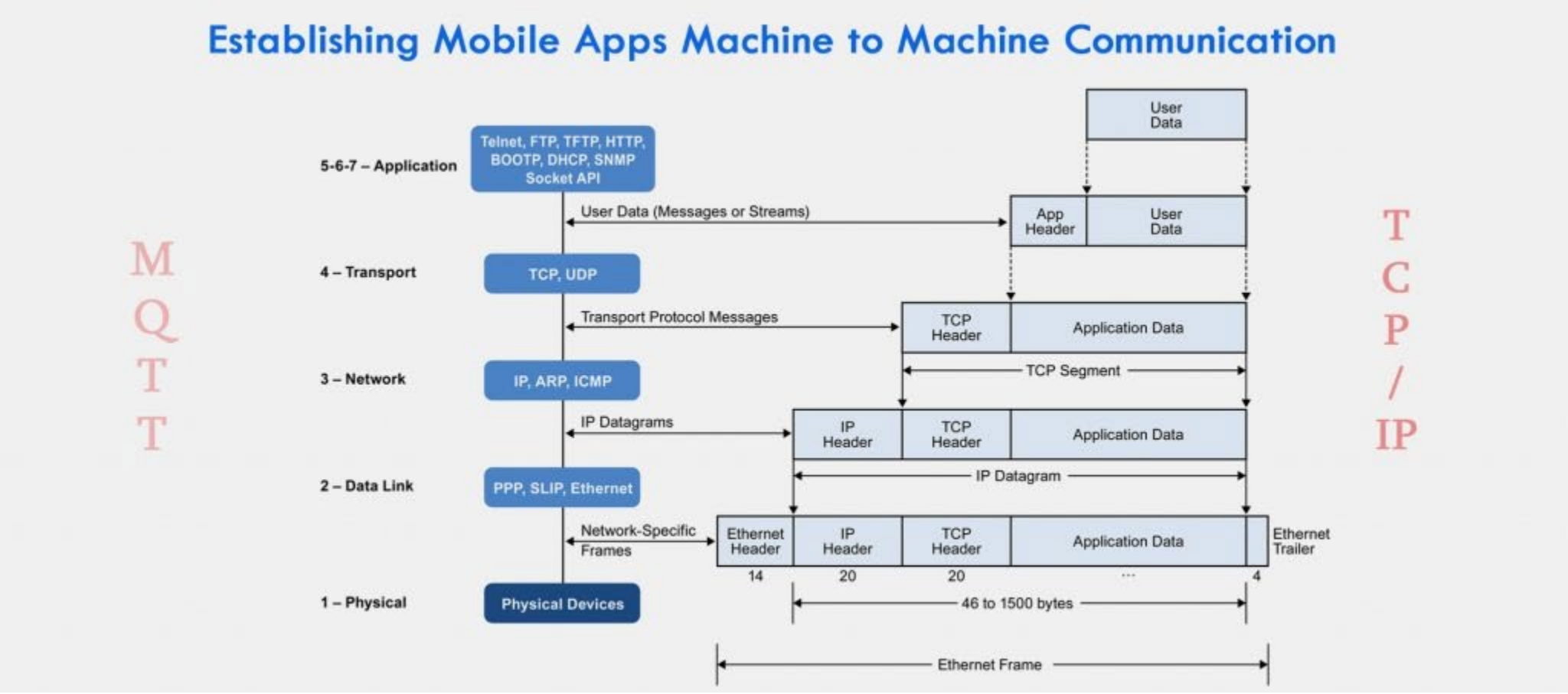


MQTT Topics

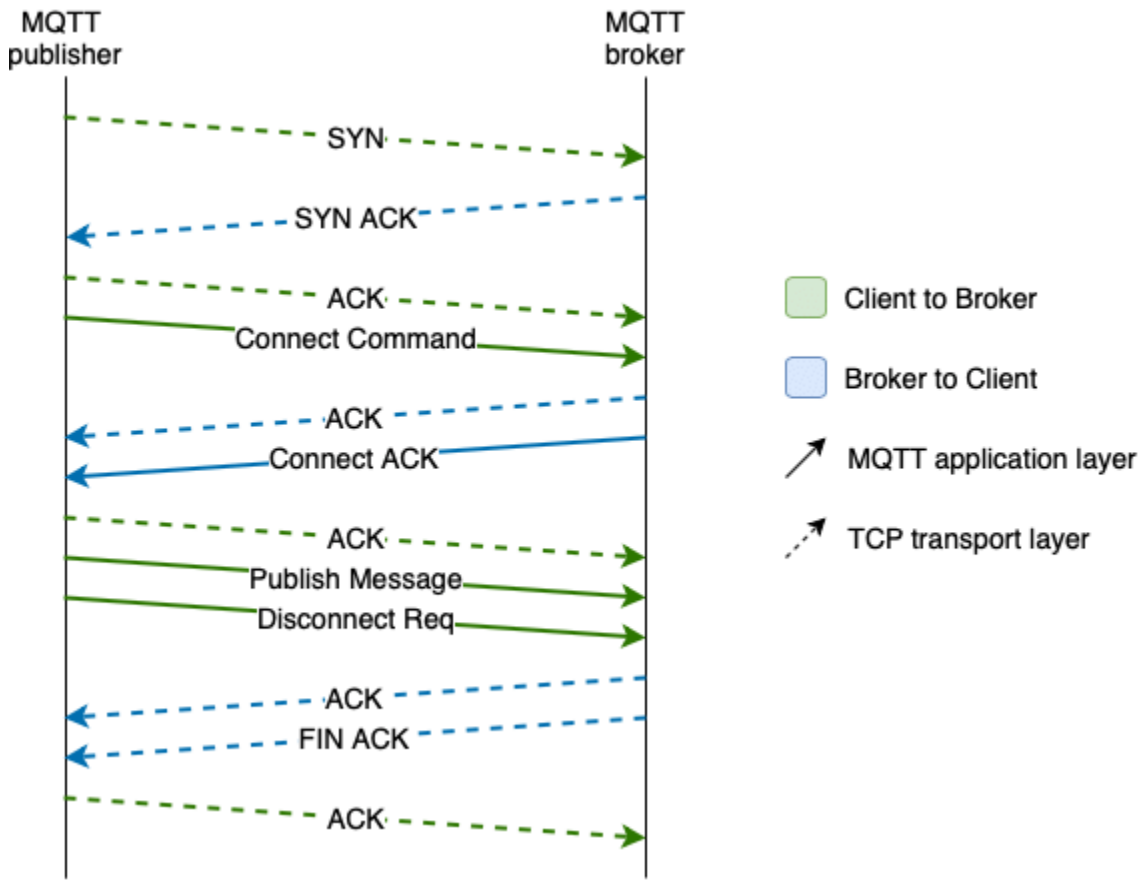
- All subscriptions are to a topic space
- All messages are published to an individual topic
- Topic names are hierarchical
  - Levels separated by “/”
  - Single-level only wildcards “+” can appear anywhere in the topic string
  - Multi-level (whole subtree) wildcards “#” must appear at the end of the string
    - Wildcards must be next to a separator
    - Can't use wildcards when publishing
- MQTT topics can be 64KB long



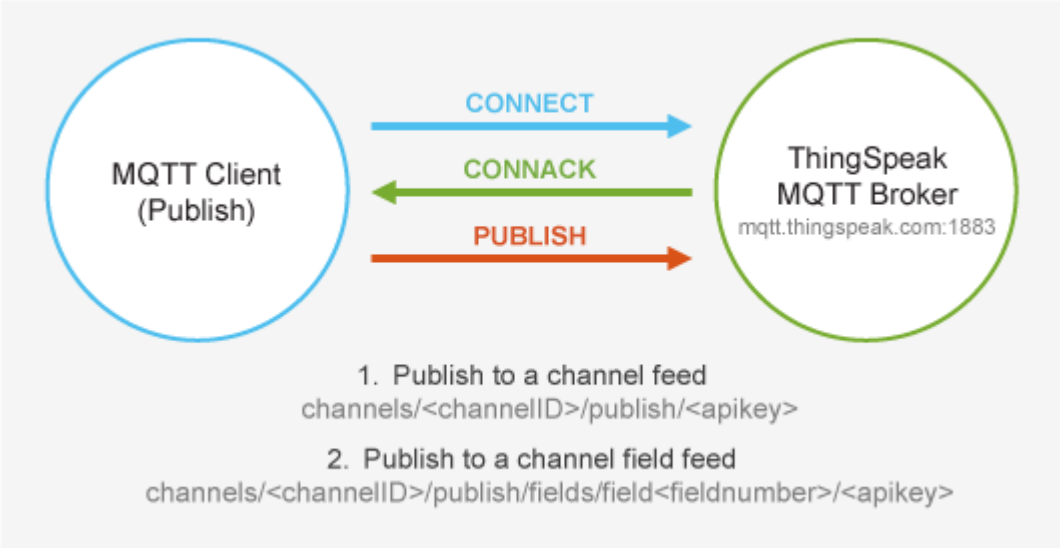
MQTT over TCP/IP



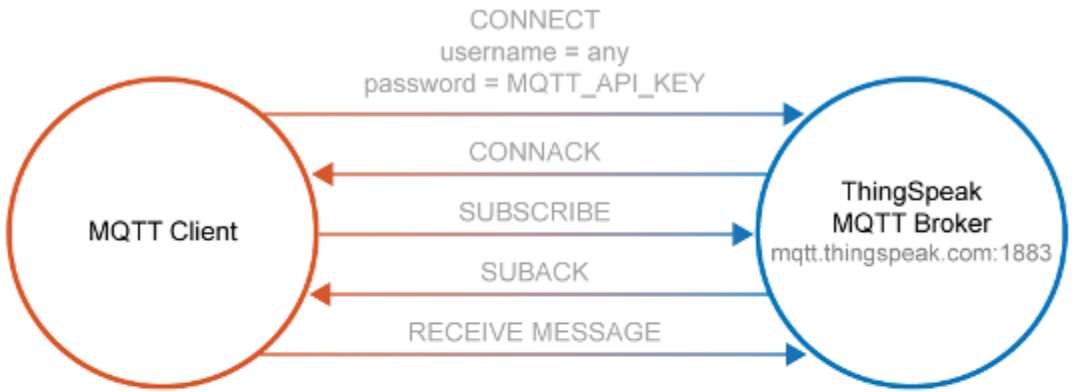
MQTT protocol messages for a MQTT publication



MQTT Publish to Thingspeak



MQTT Subscribe to Thingspeak



1. Subscribe to a channel feed
channels/<channelID>/subscribe/<format>/<api_key>

2. Subscribe to a private channel feed
channels/<channelID>/subscribe/fields/field<fieldNumber>/<apiKey>

3. Subscribe to all fields of a channel
channels/<channelID>/subscribe/fields/+/<apiKey>

<api_key> is not required to subscribe to public channels

Dúvidas?

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