Capa de aplicación

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Objetivos

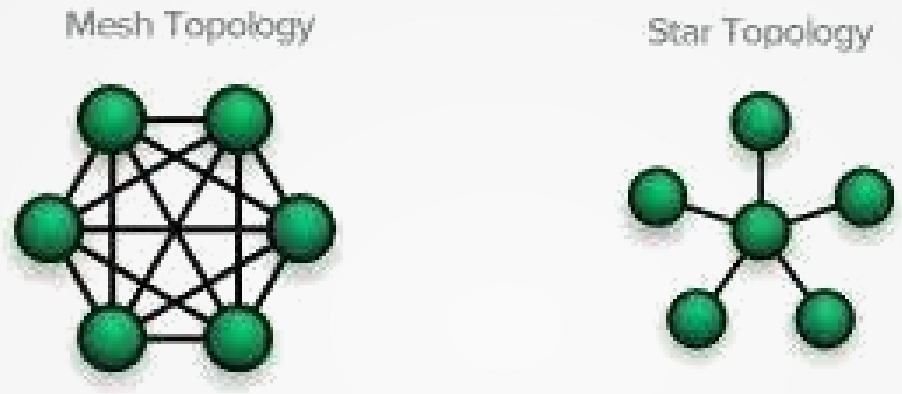
- Describir conceptos de la capa de aplicación en general
- Enumerar y describir las características de los principales protocolos: CoAP, MQTT.
- Explicar el uso de los protocolos de aplicación en los diferentes tipos de redes

Agenda

- Introducción y motivación
- Repaso tecnologías de comunicación.
- REST / CoAP
- Pub-Sub / MQTT
- Conclusiones

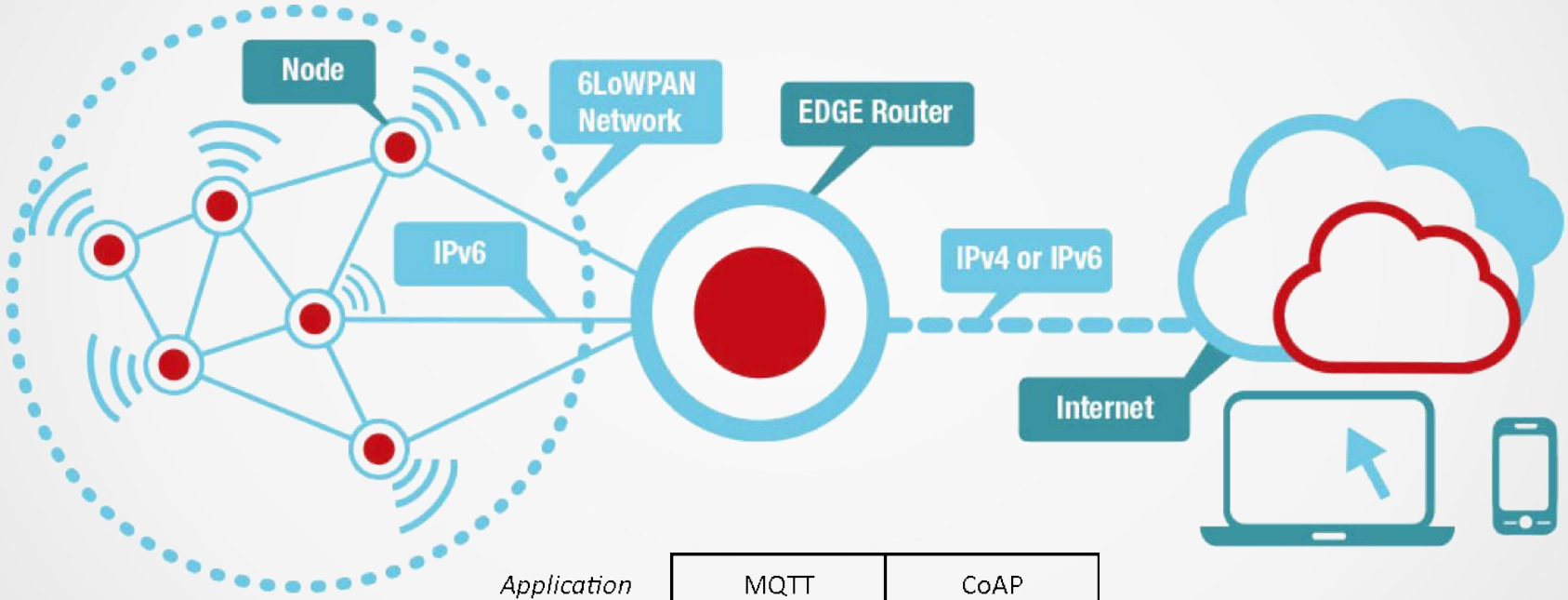
Diferentes casos

- Topologías



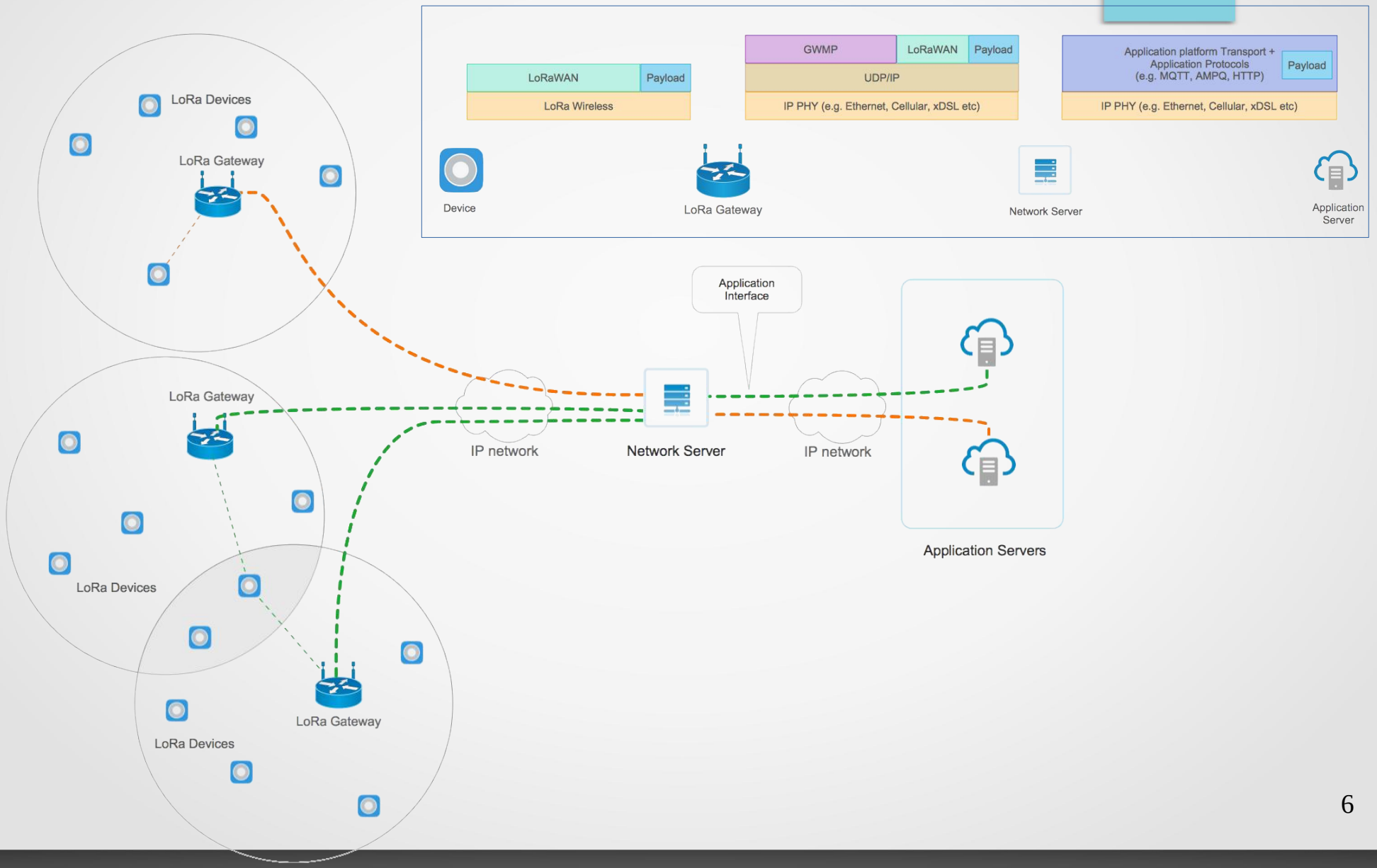
- Tecnologías: diferencias y similitudes
  - IEEE 802.15.4 / 6LoWPAN
  - LoRaWAN
  - NB-IoT

IEEE 802.15.4 / 6lowpan

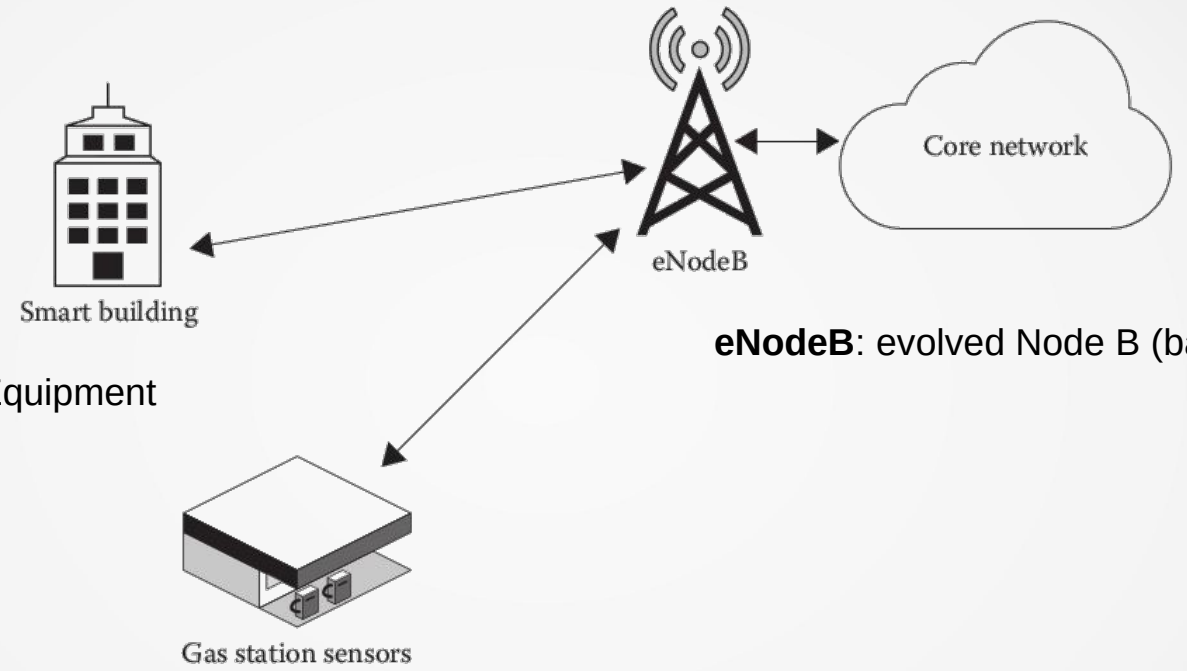


Application	MQTT	CoAP
Transport	TCP	UDP
Network	IPv6	
Adaptation	6LoWPAN	
Link Physical	IEEE 802.15.4	Bluetooth Low Energy

LoRaWAN


LoRaWAN
Payload
LoRa Wireless
GWMP
LoRaWAN
Payload
UDP/IP
IP PHY (e.g. Ethernet, Cellular, xDSL etc)
Application platform Transport + Application Protocols (e.g. MQTT, AMPQ, HTTP)
Payload
IP PHY (e.g. Ethernet, Cellular, xDSL etc)
Device
LoRa Gateway
Network Server
Application Server
LoRa Devices
LoRa Gateway
Application Interface
IP network
Network Server
IP network
Application Servers
LoRa Gateway
LoRa Devices
LoRa Gateway
LoRa Devices

NB-IoT



eNodeB: evolved Node B (base)

UE: User Equipment

Figure 1.2: Internet of Things applications in smart building and meters.

Fattah, Hossam. 5G LTE Narrowband Internet of Things (NB-IoT). CRC Press, 2018.

Opciones

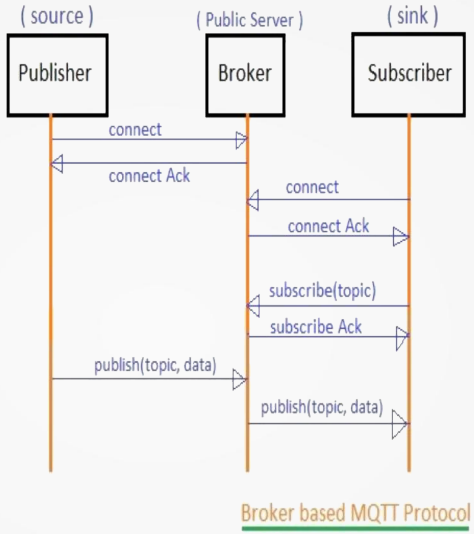
- Soluciones a medida o propietarias
  - aproximación: pensar comunicación entre:
    - un *IoT device* y *IoT platform*

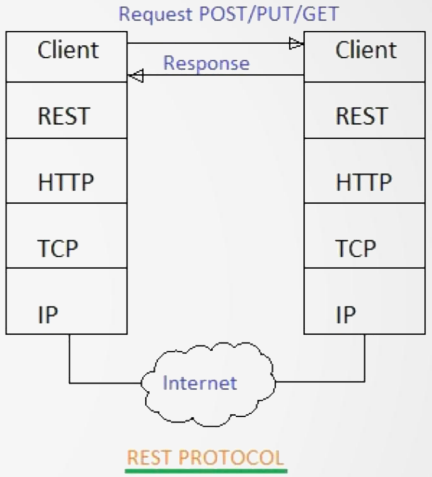
Debate grupal

- Protocolo de aplicación para:
  - obtener de nodos datos de sensores (por ejemplo: temperatura)
  - configurar el período de muestreo de los sensores.

Opciones

- Soluciones a medida o propietarias
  - desventajas
- Soluciones existentes
  - Cliente - Servidor
  - Publish – Subscribe

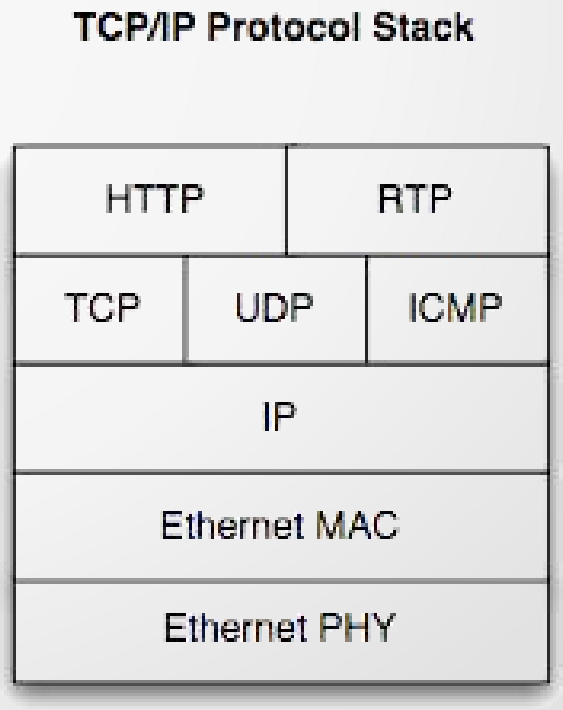




- Ejemplo: Extender el uso de web services (cliente servidor)
  - Hypertext Transfer Protocol (HTTP)
  - Nuevos protocolos

Cliente-servidor: de HTTP a CoAP

- Comunicación entre procesos
- Servicios disponibles (de capas inferiores)
  - UDP datagrama a {dirección, puerto}
  - TCP conexión a {dirección, puerto}
- Diferencias entre UDP y TCP



Conceptos

- HTTP es un servicio web basado en modelo REST
- **REST (REpresentational State Transfer)**
  - Arquitectura para sistemas aplicados para diseñar sistemas de **servicios web**
  - Arquitectura cliente/servidor
  - “Transferencia de Estado Representacional”

Conceptos

- **REST**
  - Arquitectura cliente/servidor
  - Servidores
    - no mantienen estados de transferencia (*stateless*)
    - no necesitan mantener diálogos abiertos
  - Cliente
    - Inicia consulta:

      Petición/Respuesta (Request/Response)

Conceptos

- Recurso:
  - abstracción controlada por un servidor
  - identificada por un Universal Resource Identifier (URI)
- Cada recurso
  - tiene una representación
    - contenido, valor o estado (en un momento dado)
- **REST** se basa en:
  - solicitudes y respuestas que transfieren representaciones de recursos.

Conceptos: uniform resource identifier

URI = scheme:[//authority]path[?query][#fragment]

- Esquema (*scheme*):

  protocolo de acceso al recurso (e.g. http:, mailto:, coap:, etc.)
- Autoridad (*authority*):

  autoridad: dirección y puerto (e.g. www.home.com:80)
- Ruta (*path*):

  información de estructura jerárquica, que identifica al recurso (e.g. /casa/cocina)
- Consulta (*query*):

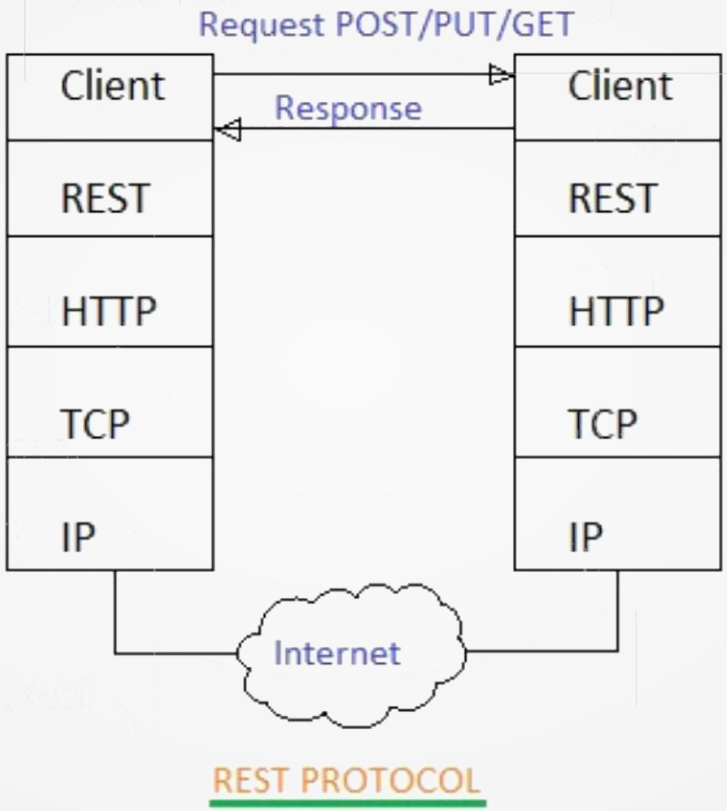
  información no jerárquica (pares "clave=valor"). Comienzo: '?'.
- Fragmento (*fragment*):

  para identificar una parte. Comienzo: '#'

Conceptos

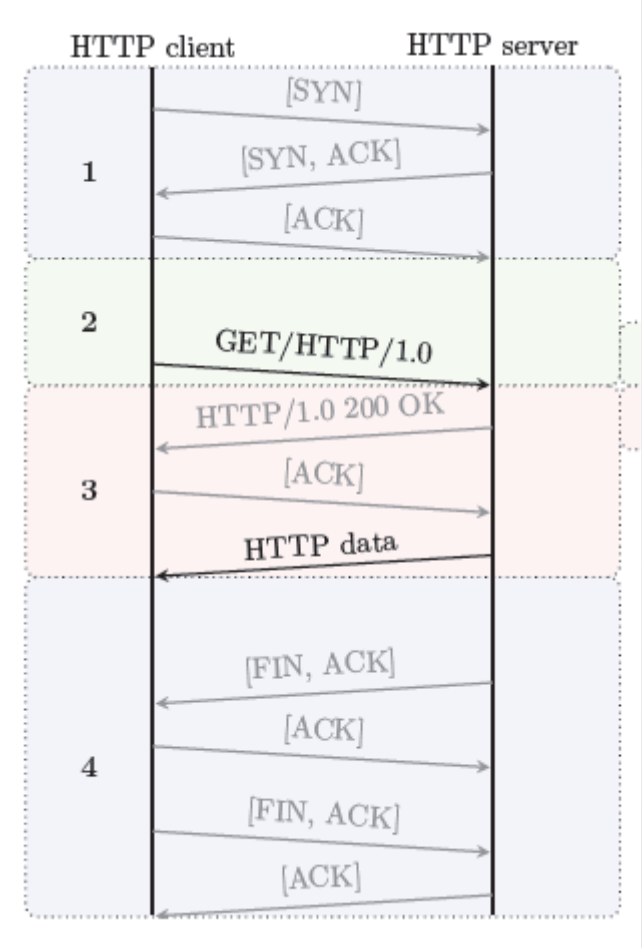
- Modelo REST
  - no especifica qué protocolo se debe utilizar, pero
  - requiere que un conjunto de métodos uniformes
- Métodos:
  - POST
  - GET
  - PUT
  - DELETE
- Correspondencia con: CRUD (Create, Read, Update, Delete)

Conceptos


Request POST/PUT/GET
Client
Response
Client
REST
REST
HTTP
HTTP
TCP
TCP
IP
IP
Internet
REST PROTOCOL

Ejemplo: HTTP

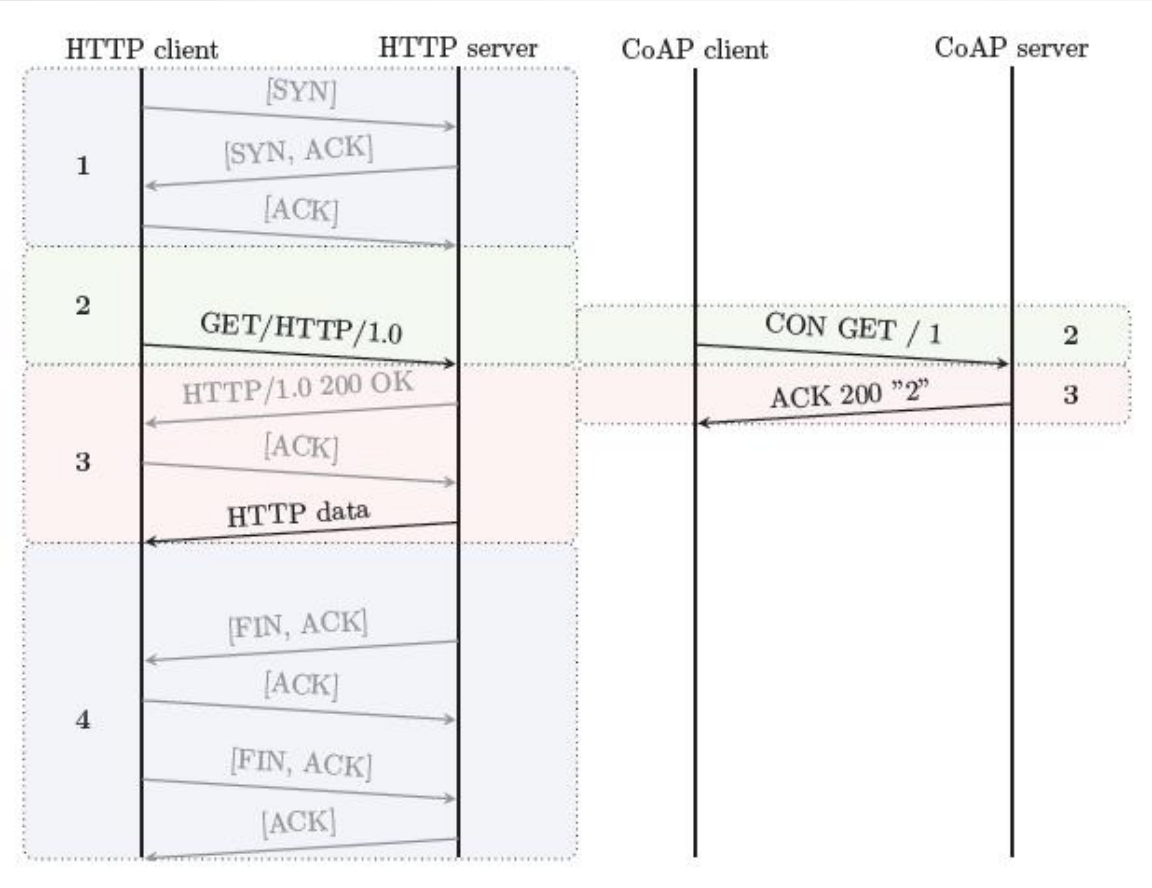
- Características
  - Transporte: TCP
- No apropiado para nodos pocos recursos
- Ejemplo:
  - Firefox → Developer → Network (Ctrl+Shift+E)
  - visitar: www.fing.edu.uy y buscar



Nueva propuesta: CoAP

- IETF WG Constrained RESTful Environments (core)
  - RFC 7252: The **Co**nstrained **A**pplication **P**rotocol (CoAP)
    - RESTful pero diseñado desde cero
- Transporte: UDP (opcionalmente DTLS)

CoAP vs HTTP


HTTP client
HTTP server
CoAP client
CoAP server
[SYN]
[SYN, ACK]
[ACK]
1
2
GET/HTTP/1.0
CON GET / 1
2
HTTP/1.0 200 OK
ACK 200 "2"
3
[ACK]
3
HTTP data
[FIN, ACK]
[ACK]
4
[FIN, ACK]
[ACK]

Ejemplo de URIs

- coap:// host [:port] /path ["?" query]

- coap://[aaaa::212:4b00:430:501d]:**5683**/node/sensors/air_temperature?type=measure

  coap://[aaaa::212:4b00:430:501d]:5683/node/sensors/air_temperature?type=measure

- coap://[aaaa::212:4b00:430:501d]:5683/node/
- sensors/air_temperature?type=sample_period

  coap://[aaaa::212:4b00:430:501d]:5683/node/sensors/air_temperature?type=sample_period

Diseño CoAP

- Repaso: modelo cliente/servidor
  - M2M (machine-to-machine): típico ambos roles:
  - cliente:
    - envía **request** de una acción sobre un recurso usando un **método**.
  - servidor:
    - envía **response** (puede incluir representación del recurso.

Diseño: dos capas

- Objetivos:
  - Mensajes:
    - interacciones asíncronas
    - UDP como transporte
  - Métodos
    - interacción request/response

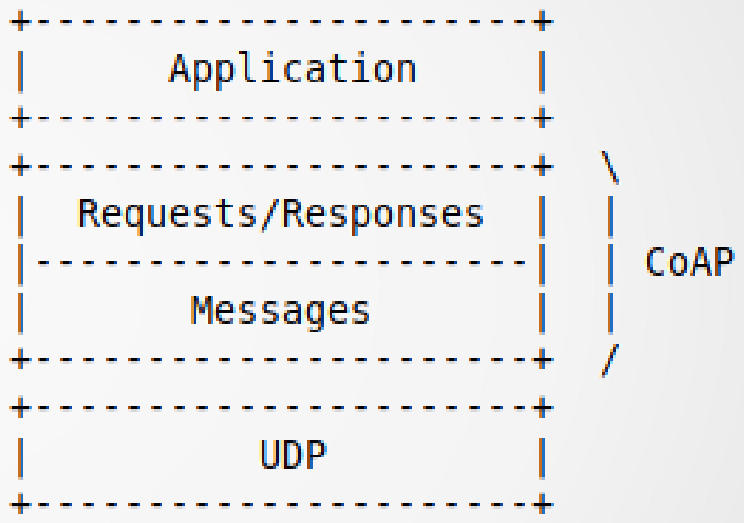


Figure 1: Abstract Layering of CoAP

Diseño: dos capas

- Mensajes
  - Confirmable
  - Non-confirmable
  - Acknowledgement
  - Reset
- Métodos
  - GET
  - PUT
  - POST
  - DELETE

Mensajes: Confirmable (CON)

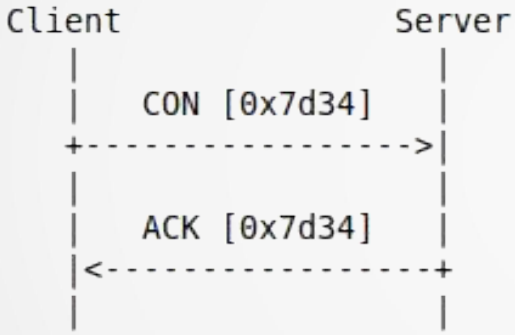


Figure 2: Reliable Message Transmission

- Confirmable (confiable)
  - se retransmite hasta tener respuesta
    - ACK
    - RESET
  - *Message ID*
    - identificar resp.

Mensajes: No-Confirmable (NON)

- No-Confirmable

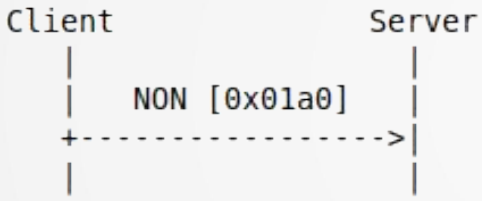


Figure 3: Unreliable Message Transmission

Modelo request/response

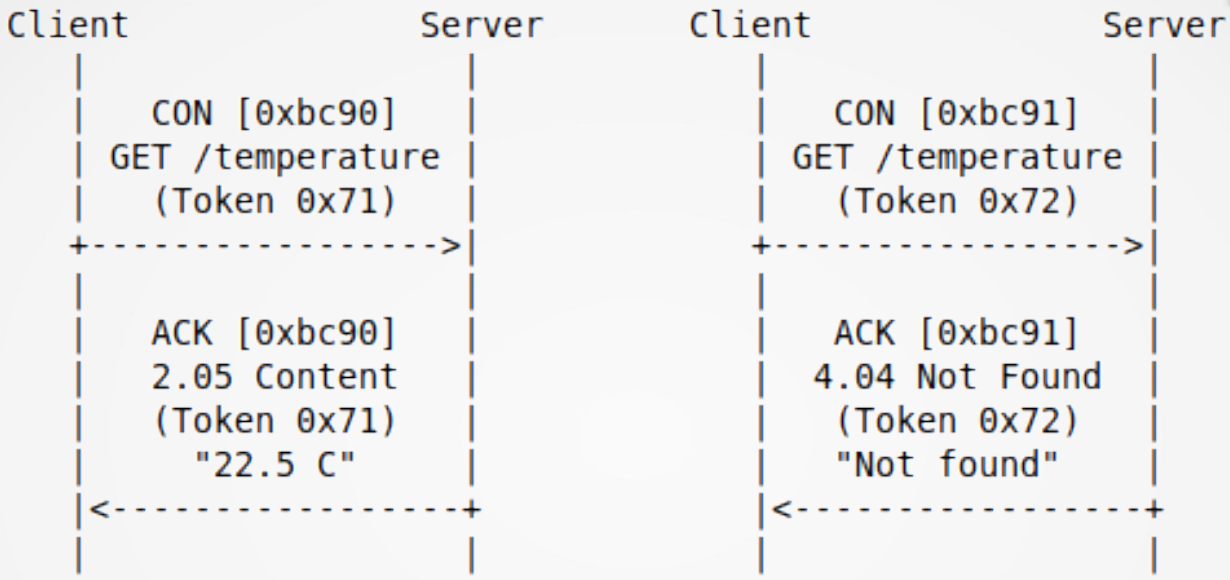


Figure 4: Two GET Requests with Piggybacked Responses

- *Token*
  - asociar response a request. (indep. de mensjaes)

Modelo request/response

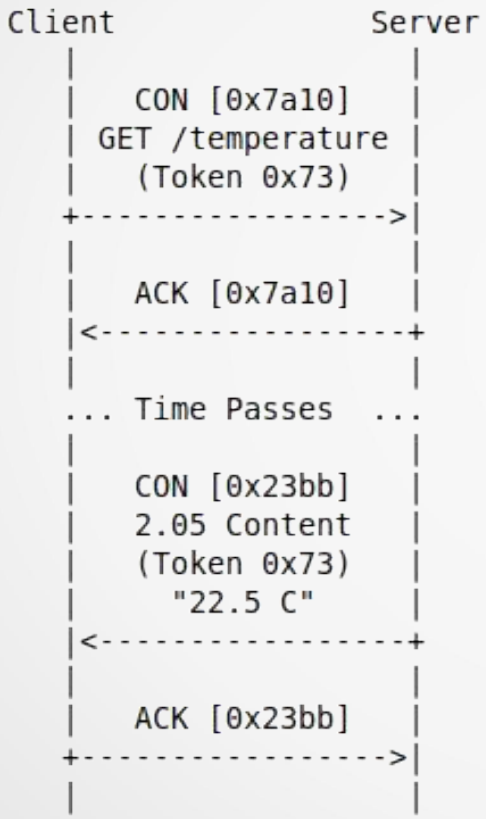


Figure 5: A GET Request with a Separate Response

- Respuesta separada
- Observar:
  - *Token y Message ID*

Modelo request/response

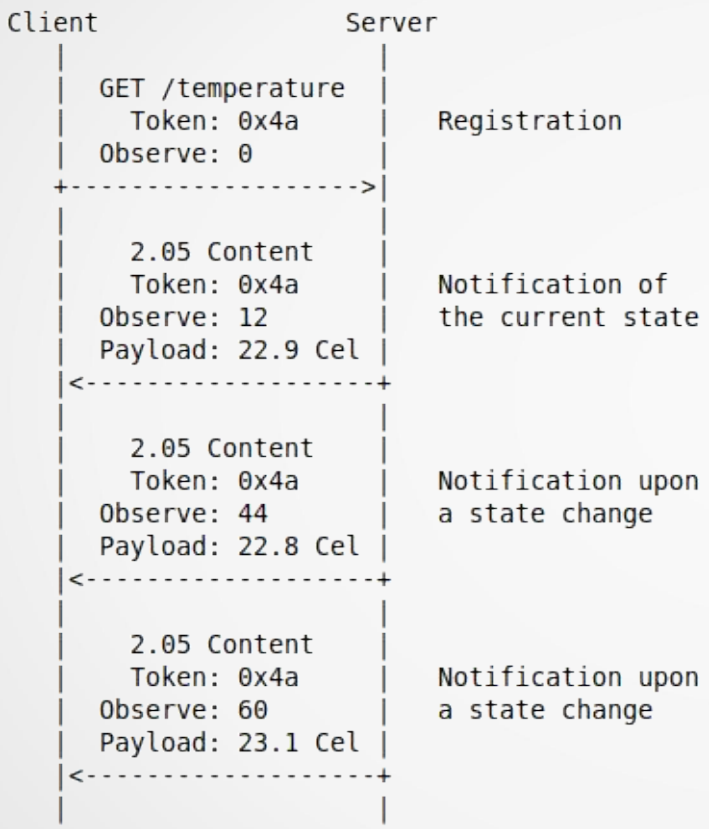


Figure 2: Observing a Resource in CoAP

- Observable (RFC 7641):
  - patrón: publish-subscribe

RFC 7641 “Observing Resources in the Constrained Application Protocol (CoAP)”

Diseño: resumen

GET, **POST**, **PUT**, **DELETE**
URIs and Internet Media Types

Deduplication
Optional retransmissions
(Confirmables “CON”)

CoAP: formato

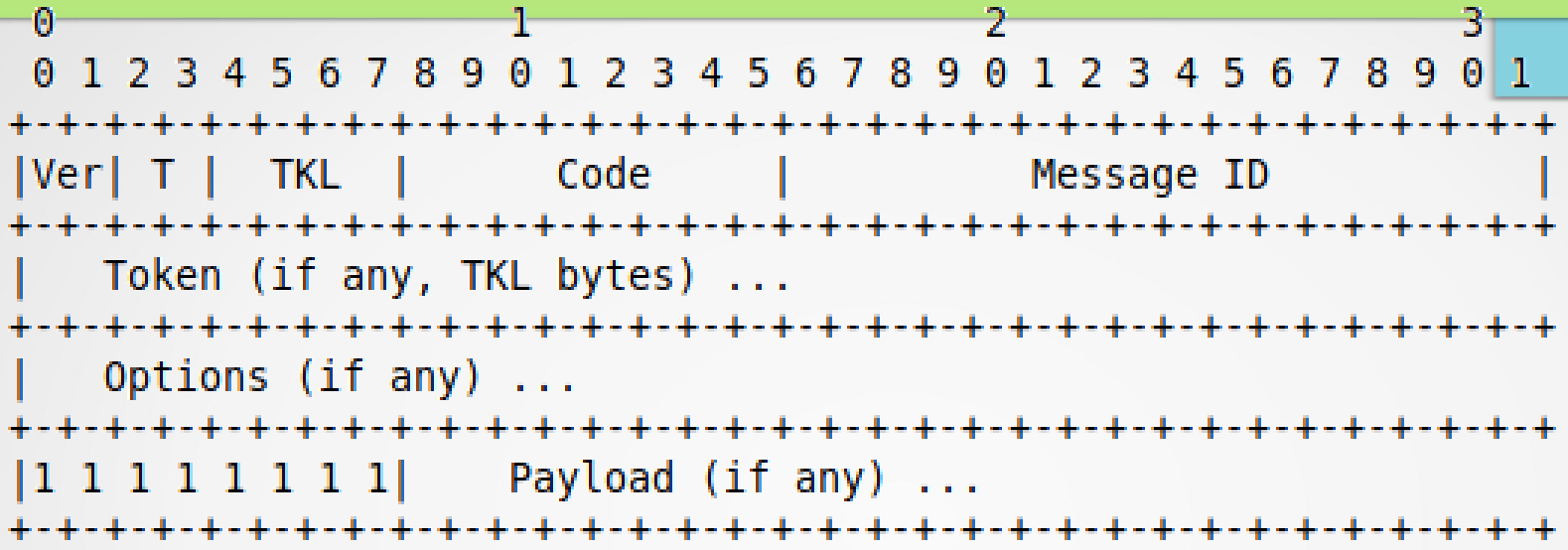


Figure 7: Message Format

- *Type (T): Tipo de mensaje*
  - Confirmable, Non-confirmable, Ack, Reset
- *Code: Dividido en "c.dd"*
  - *class (3-bit):*
    - *request (0), a success response (2), a client error response (4), or a server error response (5)*
  - *detail (5-bit)*
- *Message ID:*
  - para detectar duplicados y asociar Ack/Reset a mensajes Confirmable/Non-confirmable.

Response codes

Code	Description	Reference
2.01	Created	[RFC7252]
2.02	Deleted	[RFC7252]
2.03	Valid	[RFC7252]
2.04	Changed	[RFC7252]
2.05	Content	[RFC7252]
4.00	Bad Request	[RFC7252]
4.01	Unauthorized	[RFC7252]
4.02	Bad Option	[RFC7252]
4.03	Forbidden	[RFC7252]
4.04	Not Found	[RFC7252]
4.05	Method Not Allowed	[RFC7252]
4.06	Not Acceptable	[RFC7252]
4.12	Precondition Failed	[RFC7252]
4.13	Request Entity Too Large	[RFC7252]
4.15	Unsupported Content-Format	[RFC7252]
5.00	Internal Server Error	[RFC7252]
5.01	Not Implemented	[RFC7252]
5.02	Bad Gateway	[RFC7252]
5.03	Service Unavailable	[RFC7252]
5.04	Gateway Timeout	[RFC7252]
5.05	Proxying Not Supported	[RFC7252]

Table 6: CoAP Response Codes

Payload: *media type*

Media type	Encoding	ID	Reference
text/plain; charset=utf-8	-	0	[RFC2046] [RFC3676] [RFC5147]
application/link-format	-	40	[RFC6690]
application/xml	-	41	[RFC3023]
application/octet-stream	-	42	[RFC2045] [RFC2046]
application/exi	-	47	[REC-exi-20140211]
application/json	-	50	[RFC7159]

Table 9: CoAP Content-Formats

- Especificado como opción

Otras consideraciones

- Descubrimiento de recursos
  - path: /.well-known/core

- Transferencia de bloques (RFC 7929)
  - blockwise transfer

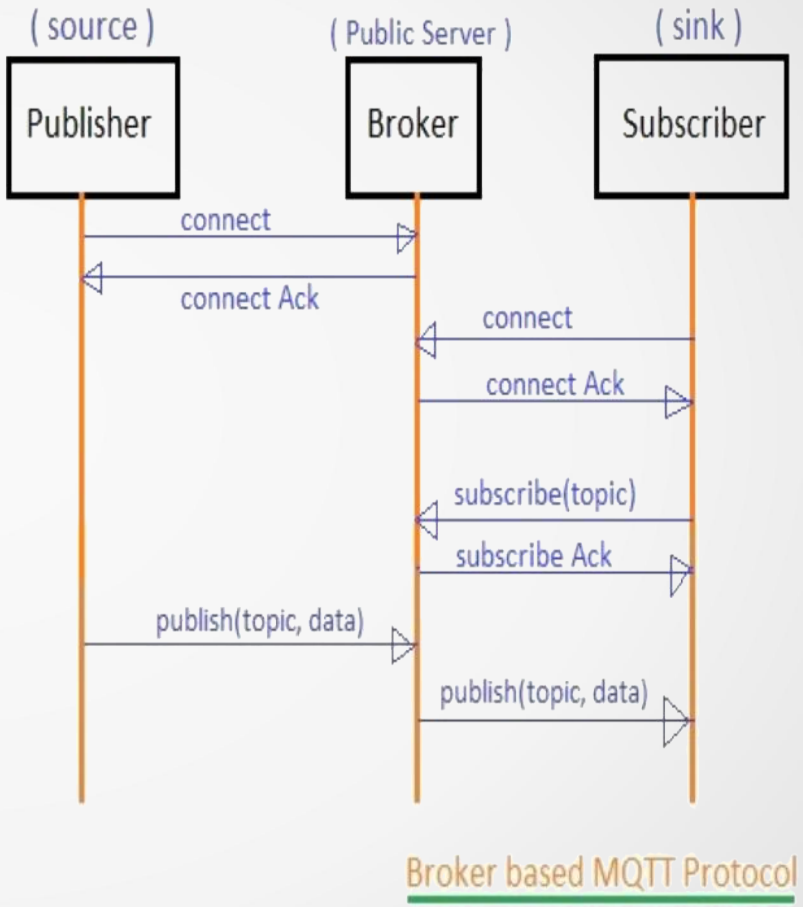
RFC 7929 “Block-Wise Transfers in the Constrained Application Protocol (CoAP)”

Normalización

- IETF WG Constrained RESTful Environments (core)
  - RFC 7252: “The Constrained Application Protocol (CoAP)”
  - RFC 7641: “Observing Resources in the Constrained Application Protocol (CoAP)”
  - RFC 7929: “Block-Wise Transfers in the Constrained Application Protocol (CoAP)”

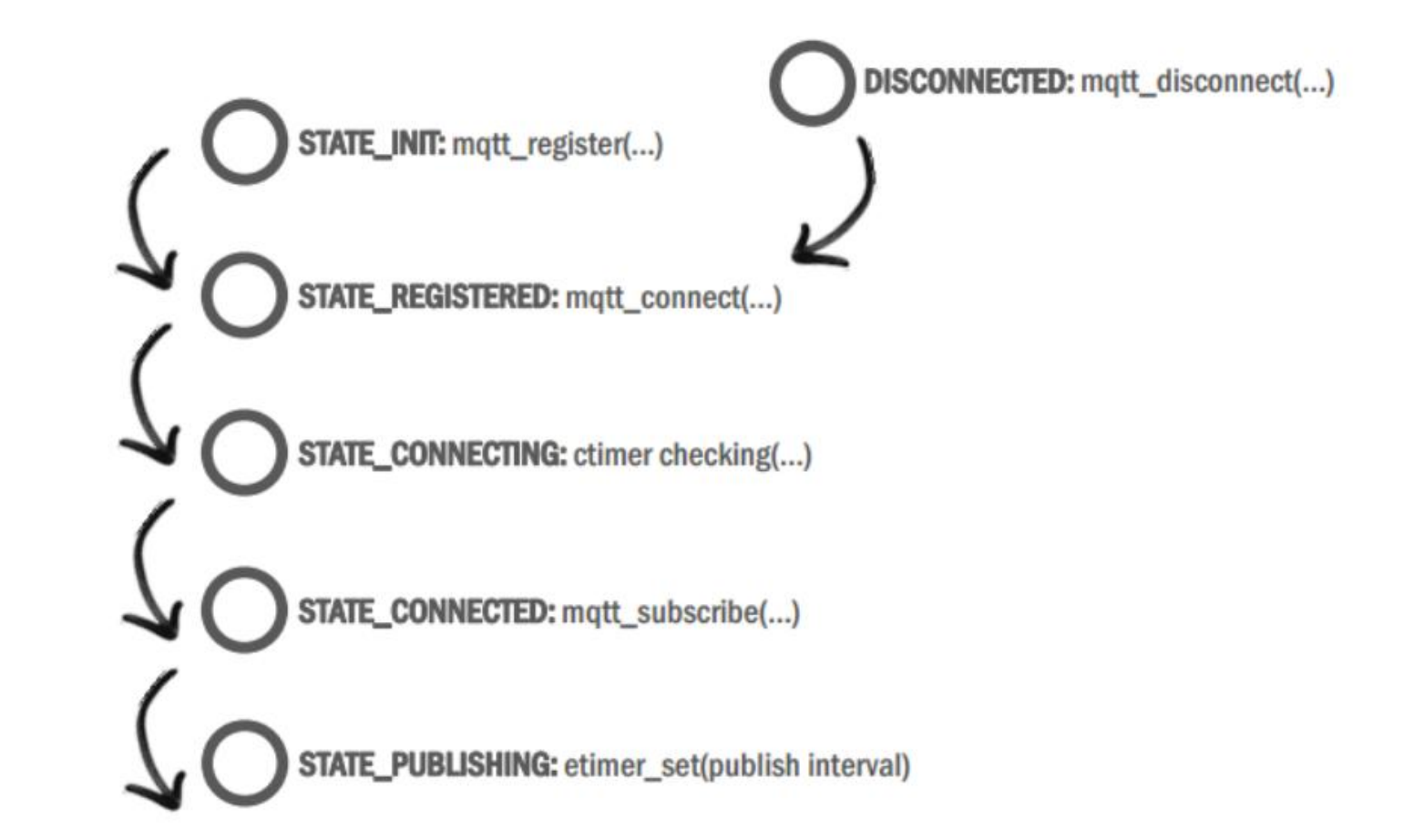
Publish-subscribe: MQTT

- Publish Subscribe
  - desacopla:
    - envío
    - recepción
- Open standard
- Capa de transporte: TCP

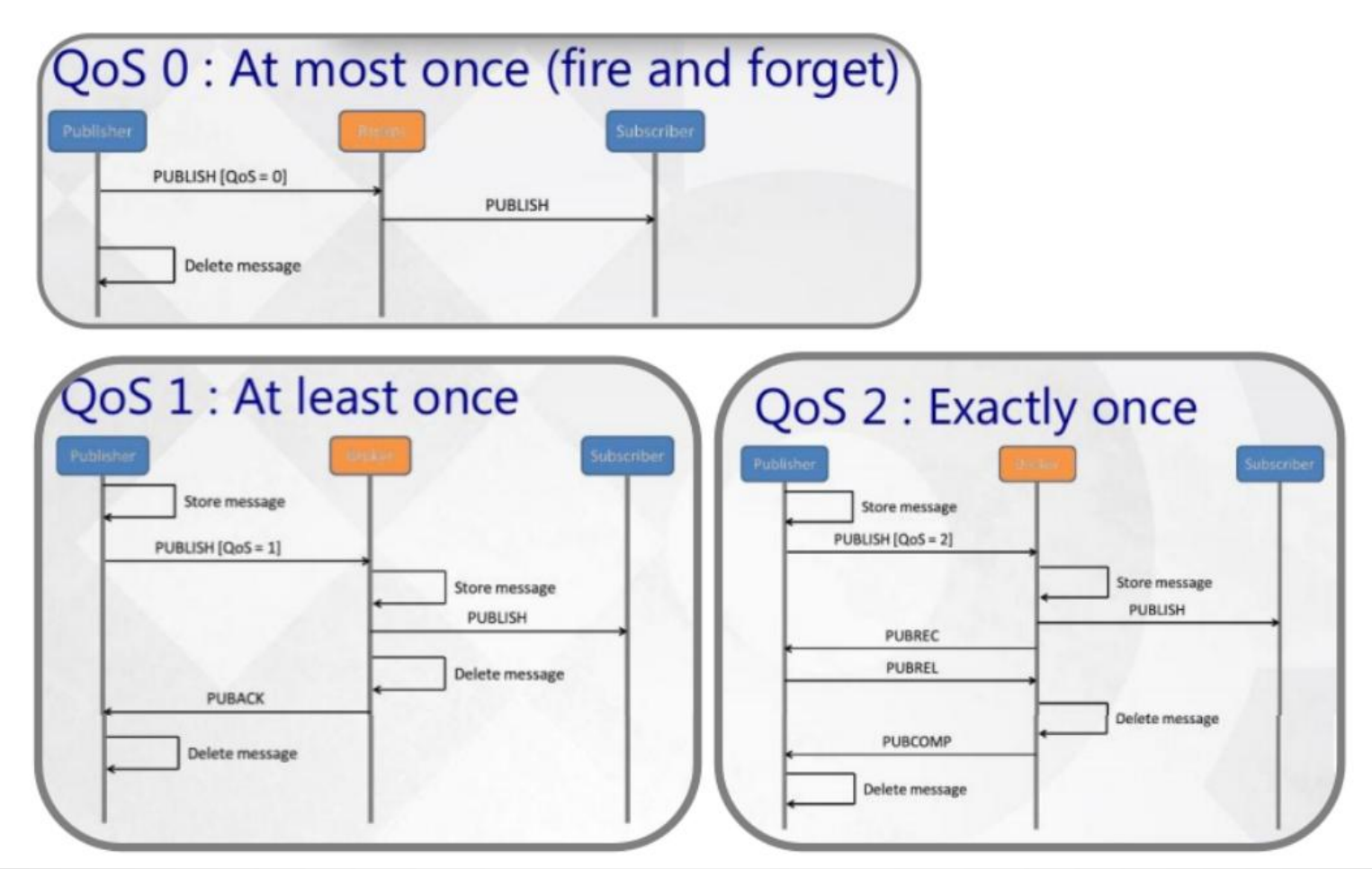


Broker based MQTT Protocol

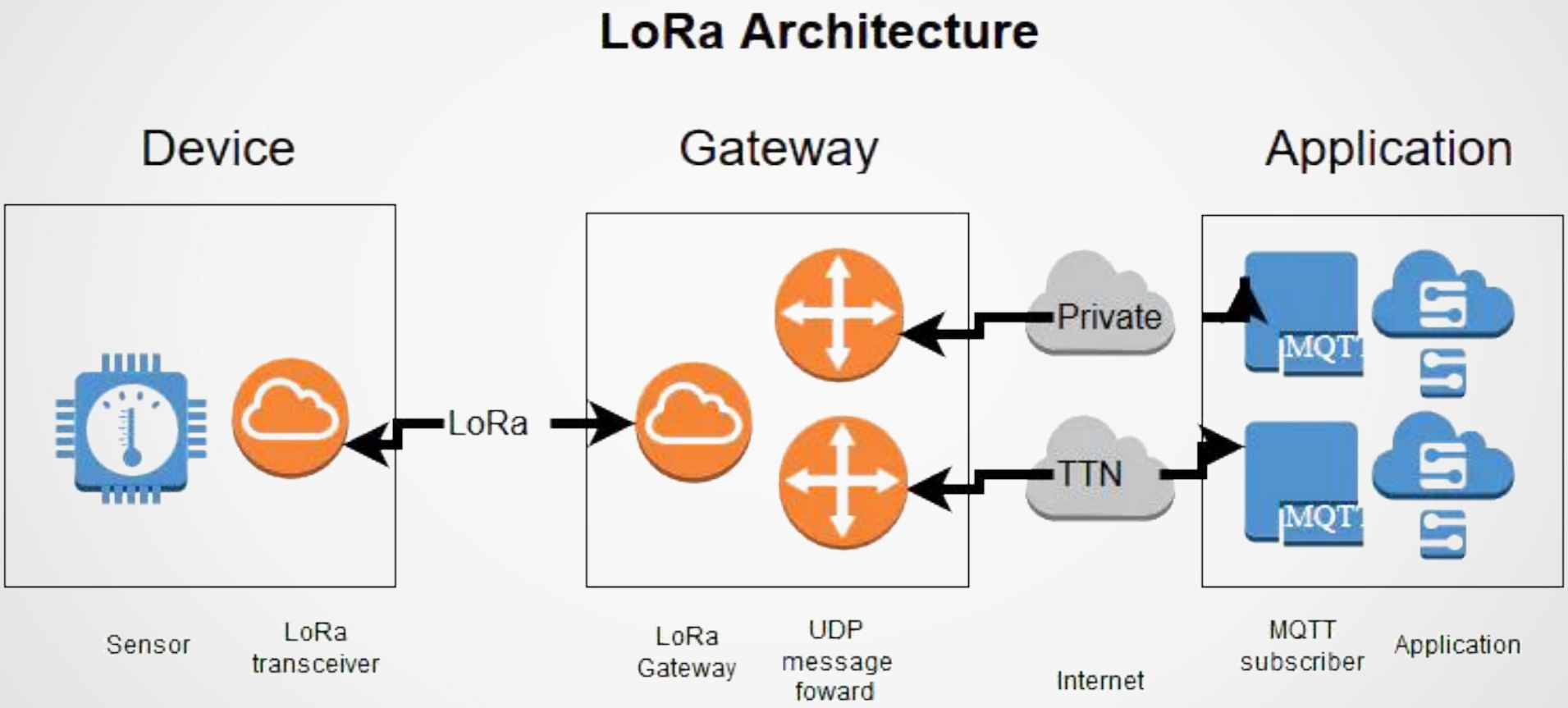
MQTT: estados



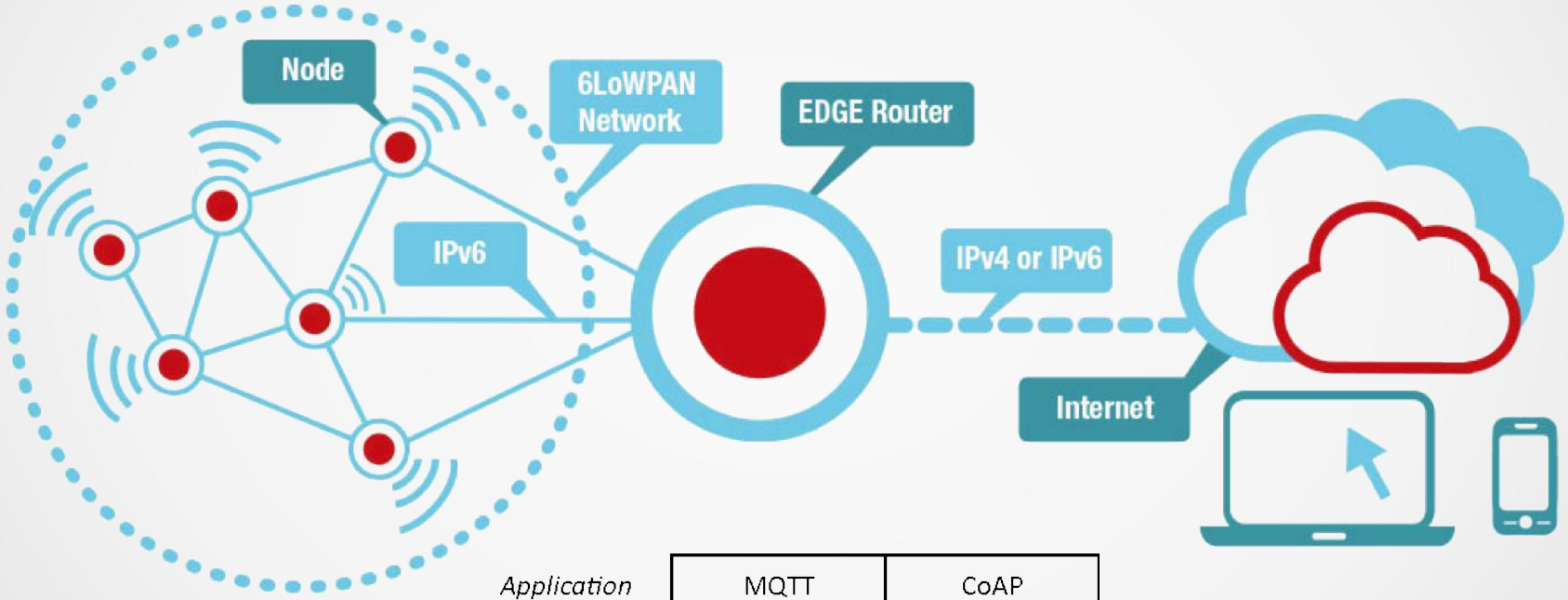
MQTT: QoS


QoS 0 : At most once (fire and forget)
Publisher
Subscriber
PUBLISH [QoS = 0]
PUBLISH
Delete message
QoS 1 : At least once
Publisher
Subscriber
Store message
PUBLISH [QoS = 1]
Store message
PUBLISH
Delete message
PUBACK
Delete message
QoS 2 : Exactly once
Publisher
Subscriber
Store message
PUBLISH [QoS = 2]
Store message
PUBLISH
PUBREC
PUBREL
Delete message
PUBCOMP
Delete message

MQTT en LoRaWAN



MQTT en 6lowpan



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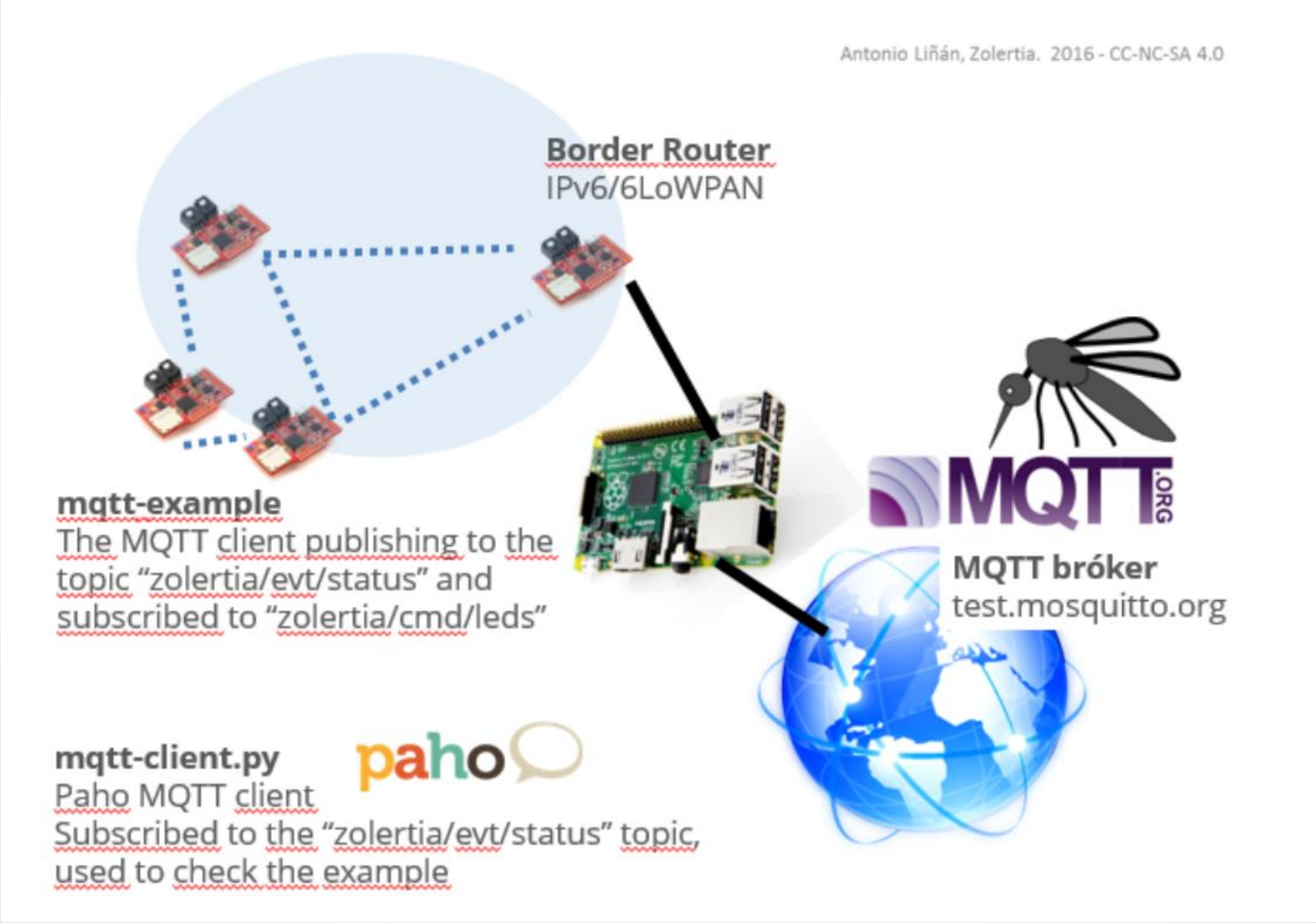
Transport	TCP	UDP
Network	IPv6	
Adaptation	6LoWPAN	
Link Physical	IEEE 802.15.4	Bluetooth Low Energy

MQTT: general



Bibliografía

- RFC 7252 y documentos asociados
- M. Kovatsch, S. Duquennoy and A. Dunkels, "A Low-Power CoAP for Contiki," 2011 IEEE Eighth International Conference on Mobile Ad-Hoc and Sensor Systems, Valencia, 2011, pp. 855-860.
- Johan Westö & Dag Björklund, *An Overview of Enabling Technologies for THE INTERNET OF THINGS*, Novia University of Applied Sciences, Novia publikation och produktion, serie R: Rapporter 1/2014

FIN... ¿más preguntas?