Internet das Coisas

IoT – Protocol Stack

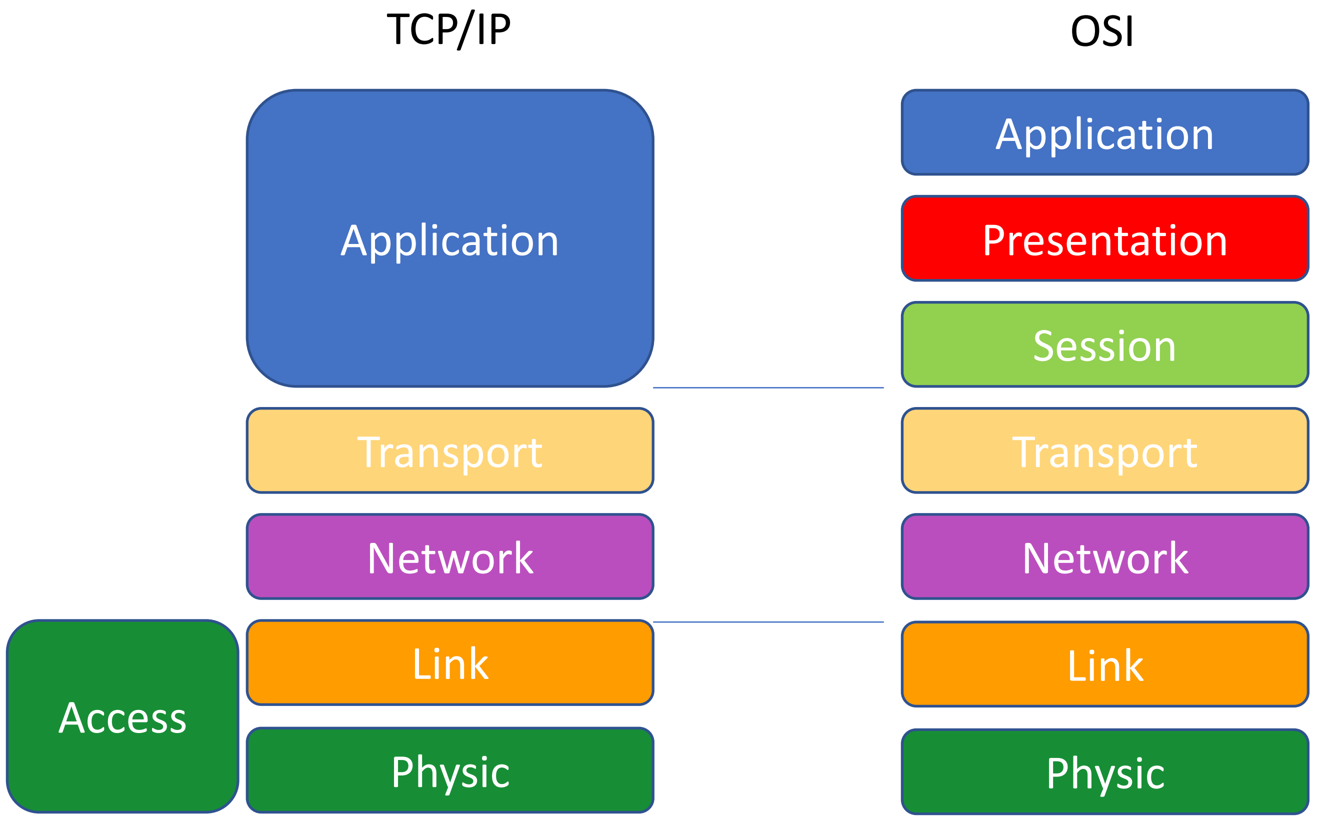
FACULDADE ENGENHARIA
Departamento de Informática

2023/2024

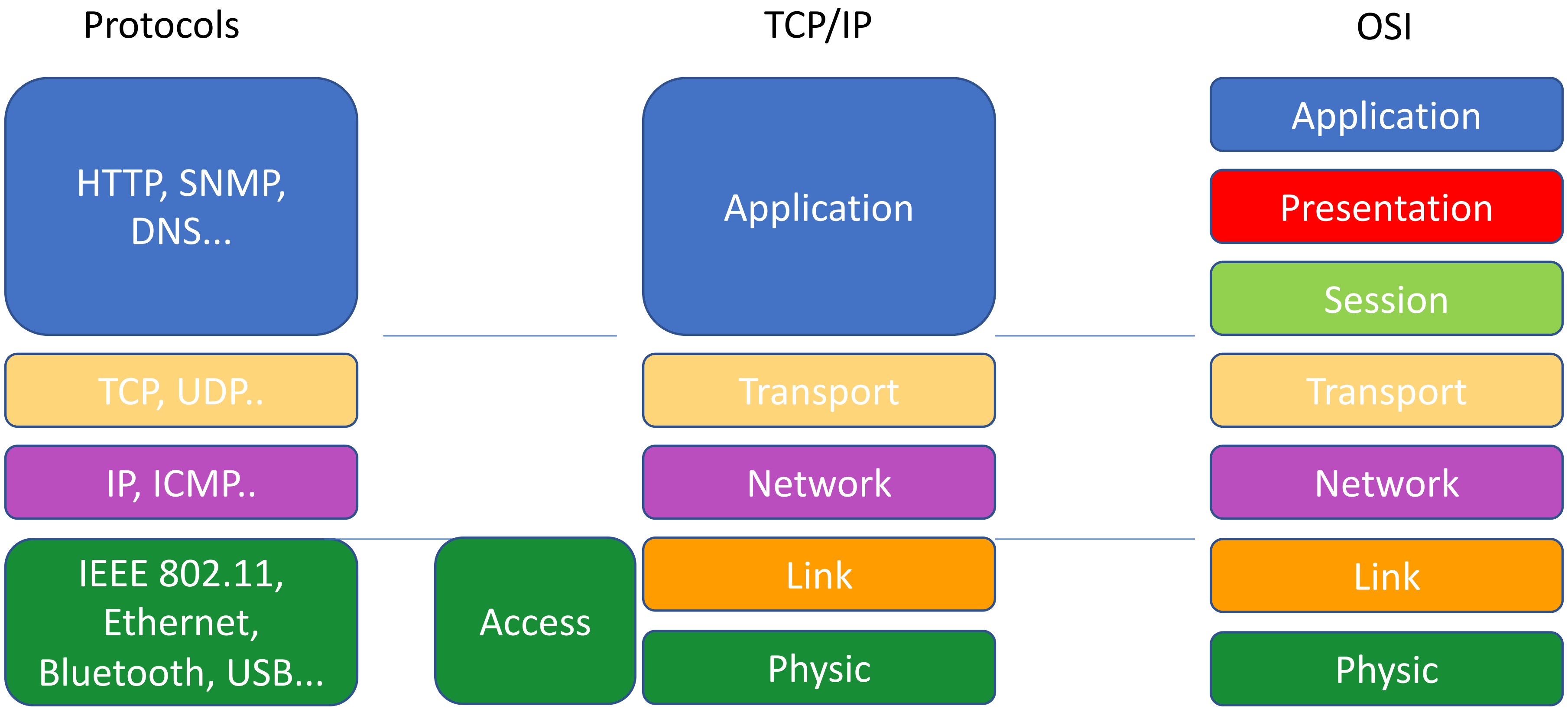
Na aula de hoje

- IoT protocol stack
- Comunication Protocols

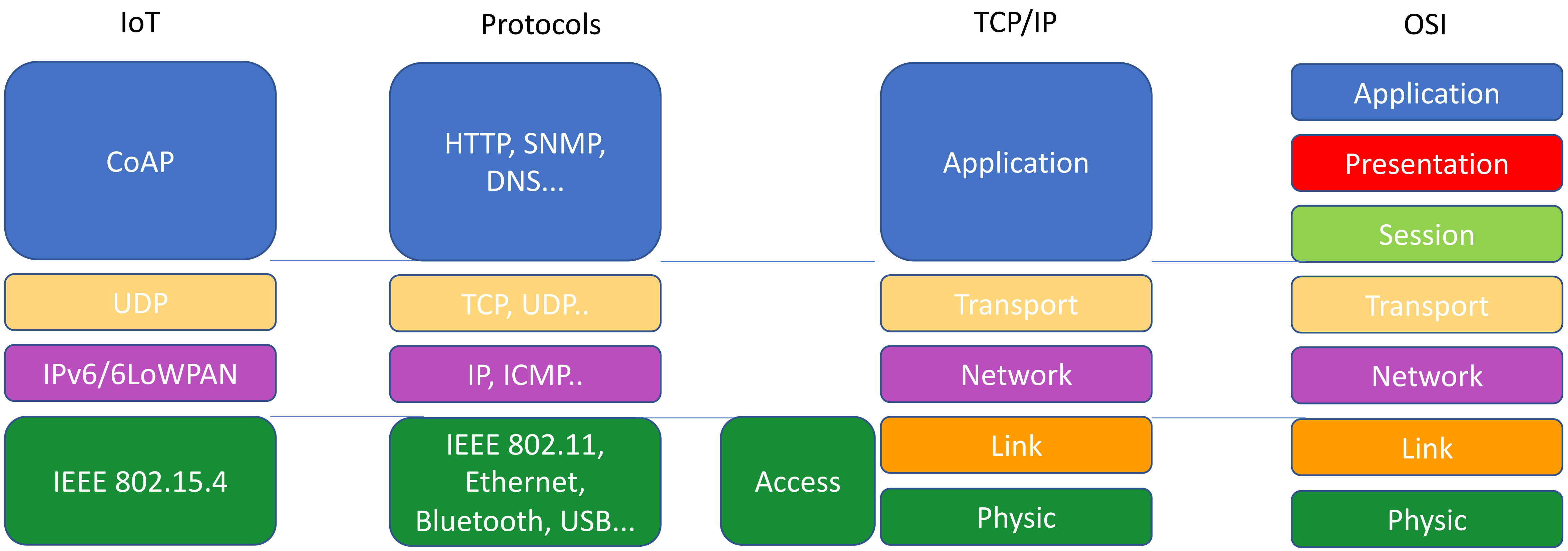
TCP/IP and OSI



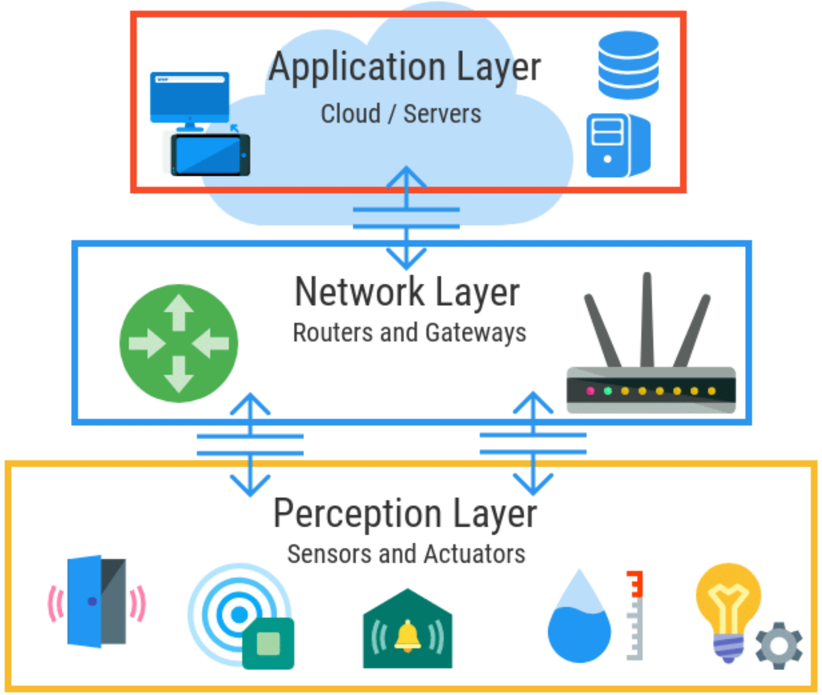
TCP/IP and OSI



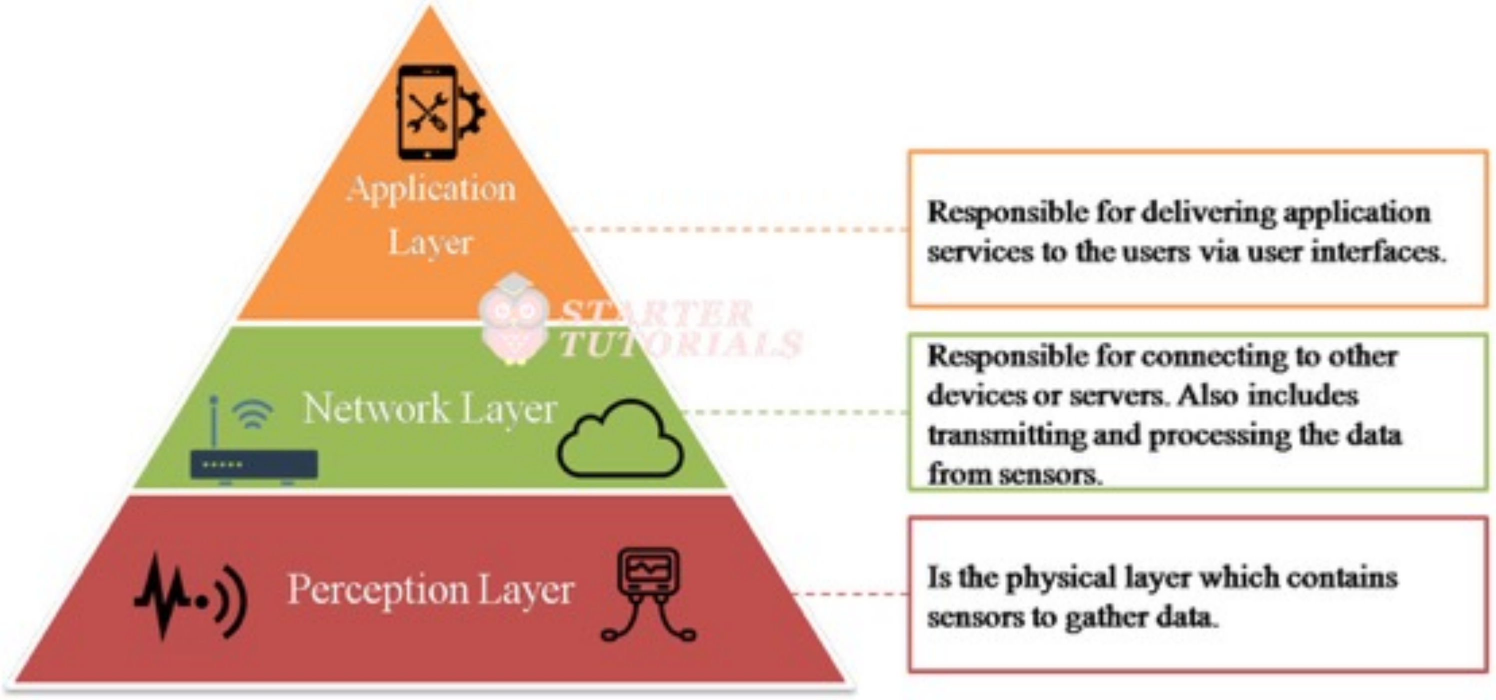
TCP/IP and OSI



IoT protocol stack

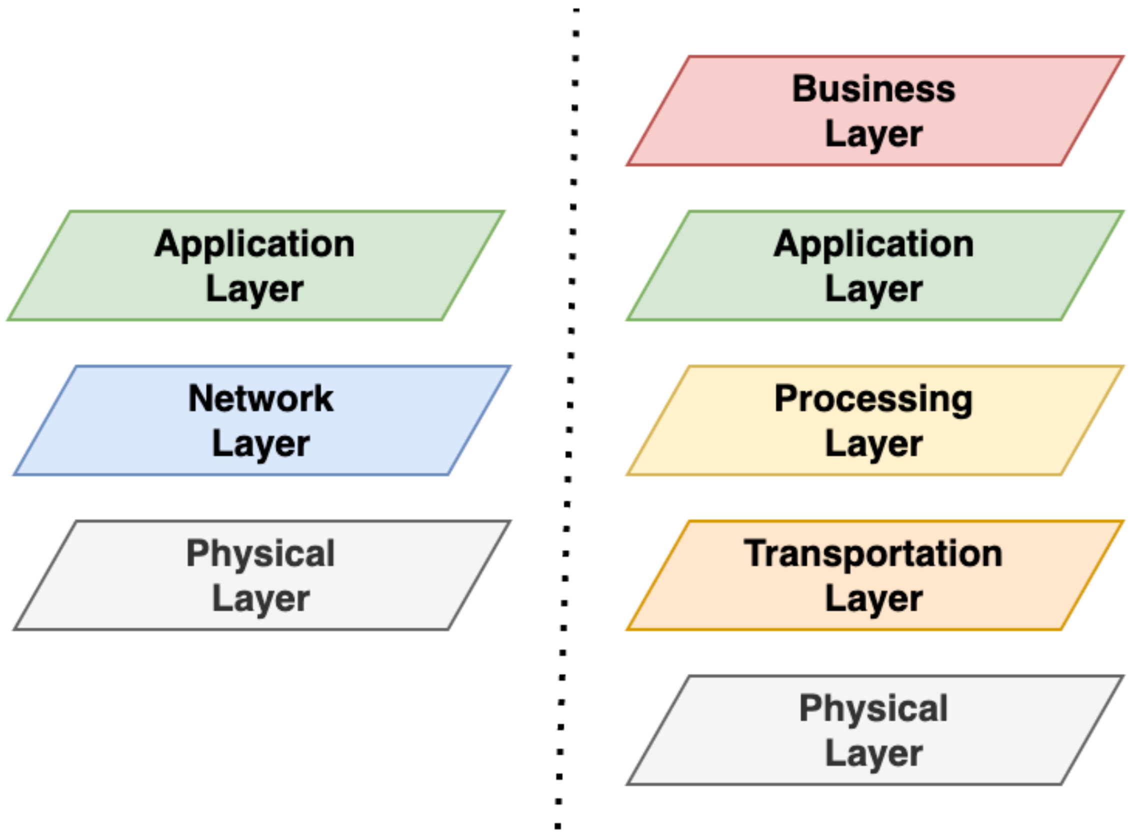


https://www.researchgate.net/figure/The-Basic-Architecture-of-IoT-Perception-layer-To-fix-the-issue-of-data-collecting-in_fig2_351986473



https://www.startertutorials.com/blog/iot-architecture-layers.html

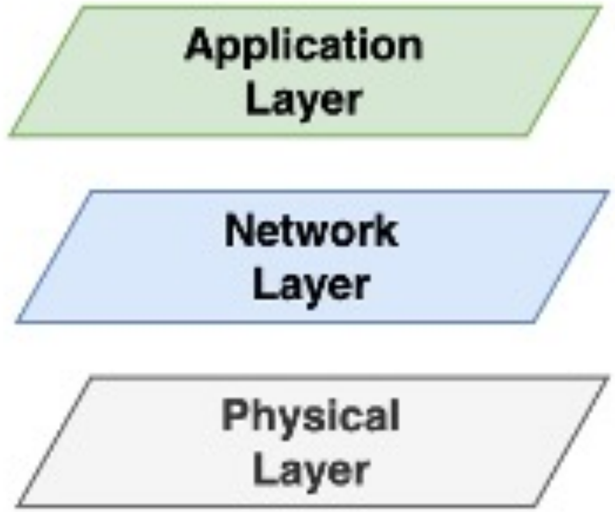
IoT protocol stack



The IoT protocol stacks changes from implementation to implementation, yet the basic architectures established in the early research in this area of study are **three and five-layer protocol stacks**.

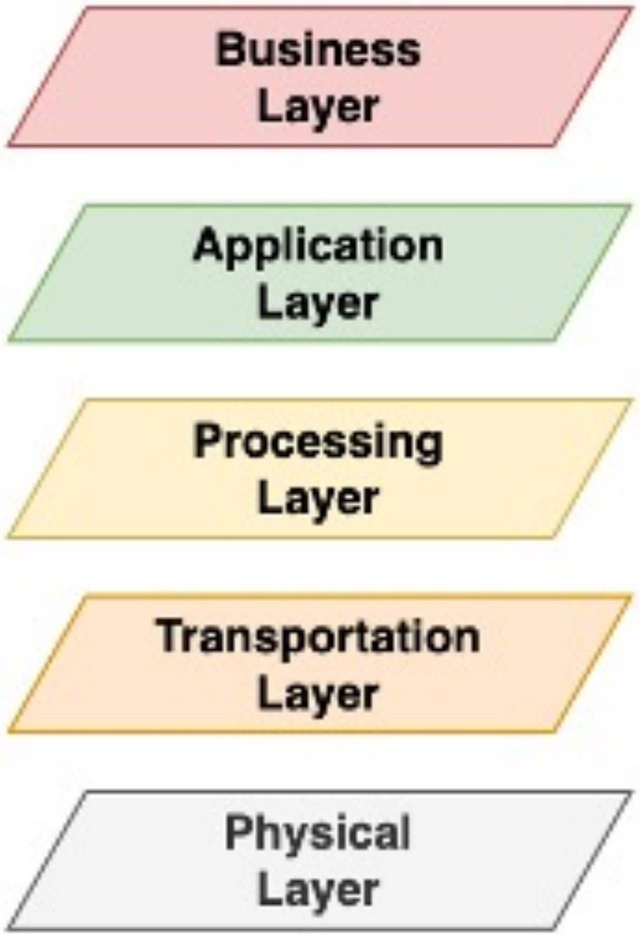
IoT 3 layer protocol stack

- **Application Layer** - responsible for the distribution of the processed and formatted data in applications to the end-users;
- **Network Layer** - used to enable the connection, transferring, and processing of the gathered data between sensors and devices;
- **Physical Layer** - also known as the **perception layer**, is the layer of the “things” in IoT. It is composed of devices or sensors capable of identifying parameters of the environment and other devices or sensors in the network;



IoT 5 layer protocol stack

- **Business Layer** - gathers business insights by the analysis of data acquired in the Application Layer.
- **Processing Layer** - used to analyze, process, and store the data provided by the transport layer by the implementation of databases and Cloud computing;
- **Transport Layer** - enables the communication between the physical layer and processing layer. This communication is implemented via networks namely 5G, Bluetooth, NFC, and RFID;



IoT Communication Protocols

From bottom up

Link and Physical Layer

- IEEE 802.15.4
  - Low power consumption
  - Low data rate
  - Low cost and high message transfer rate
  - High level of security, encryption, and authentication services.

https://www.ieee802.org/15/pub/TG4.html

Link and Physical Layer

- IEEE 802.15.4

- Average distance of 10 meters
  - 802.11n can reach up to 300 meters

- Transfer rate of 250 kbits/s
  - 802.11n goes up to 600 Mbits/s

User Guide: https://www.nxp.com/docs/en/user-guide/JN-UG-3024.pdf

Link and Physical Layer

- IEEE 802.15.4 (recomended reading)

  https://pt.mouser.com/Embedded-Solutions/Wireless-RF-Modules/Zigbee-802154-Modules/_/N-6l7r4?Keyword=Embedded+Solutions&No=50&FS=True

  https://industry.panasonic.eu/products/devices/wireless-connectivity/ieee-802154-modules

  http://ww1.microchip.com/downloads/en/DeviceDoc/7911P-MCUWireless_E_US_021014_online.pdf

Link and Physical Layer

- Honorable mentioned
  - Z-Wave and 802.11ah
    - Designed for PANs or Smart Grids.
    - Especially used in the context of Smart Homes or small commercial applications.
    - Suitable for small messages (power control, alarms, etc.).

https://z-wave.pt/

https://ieeexplore.ieee.org/document/7920364

Network Layer

- 6LoWPAN – Ipv6 over Low-Power Personal Area Networks
  - **Allows the use of IPv6 in IEEE 802.15.4 networks.**
  - **Allows the use of IPv6 in wireless sensor networks.**
  - Problem?
    - MTU(Maximum Transmission Unit) on IPv6 is 1280 bytes.
    - A *frame* in IEEE 802.15.4 is 127 bytes.

https://datatracker.ietf.org/wg/6lowpan/documents/

Network Layer

- 6LoWPAN – Ipv6 over Low-Power Personal Area Networks
  - Solution?
- Usage of fragmentation and defragmentation to accommodate maximum MTUs.
- Compression of IPv6 headers.
- 6LoWPAN creates an adaptation layer between 802.15.4 and IPv6. Specific headers can be added or removed as needed, allowing only the necessary data to be sent.

Network Layer

- 6LoWPAN – Ipv6 over Low-Power Personal Area Networks
  - Allows for different address lengths
  - Supports different network topologies
  - Low bandwidth
  - Low power consumption
  - Cost-eficiente
  - Mobility
  - Reliability
  - Long periods of inactivity.

Network Layer

- 6LoWPAN (recommended reading)

IPSO IEEE802.15.4/**6LoWPAN** Gateway **Solution**. White Paper. May 2017

https://www.ti.com/lit/ug/tidue96a/tidue96a.pdf?ts=1617622582892&ref_url=https%253A%252F%252Fwww.google.com%252F

https://www.lobaro.com/portfolio/coap-over-6lowpan-solutions/

Network Layer

- Honorable mentions
  - IPv4 e IPv6
    - There are numerous scenarios in which the addressing of an IoT network can be IPv4 and/or IPv6. Especially IPv6, which has several advantages over IPv4 in IoT.
    - It allows for the creation and transport of data delivered to each device.
    - It enables secure identification of devices (through ID and IP address).

Network Layer

- Honorable mentions
  - RPL (Routing Protocol for Low power and Lossy Networks)
    - Supports minimum forwarding requirements.
    - Builds its routes and topology at random intervals.
    - Supports simple and complex models (point-to-multipoint, multipoint-to-point, etc.).

https://tools.ietf.org/html/rfc6550

Transport Layer

- UDP (User Datagram Protocol)
  - Message exchange between devices
  - Lightweight header compared to TCP
  - Faster
  - More energy-efficient
  - Less reliable

https://tools.ietf.org/html/rfc768

Node.js UDP: https://nodejs.org/api/dgram.html

https://gist.github.com/sid24rane/6e6698e93360f2694e310dd347a2e2eb

Application Layer

- CoAP – Constrained Application Protocol
  - Built on top of UDP.
  - Based on the REST model (GET, POST, etc.).
  - Enables and integrates with various data formats (XML, JSON, etc.).
  - Uses DTLS parameters and achieves security similar to that of the Web.

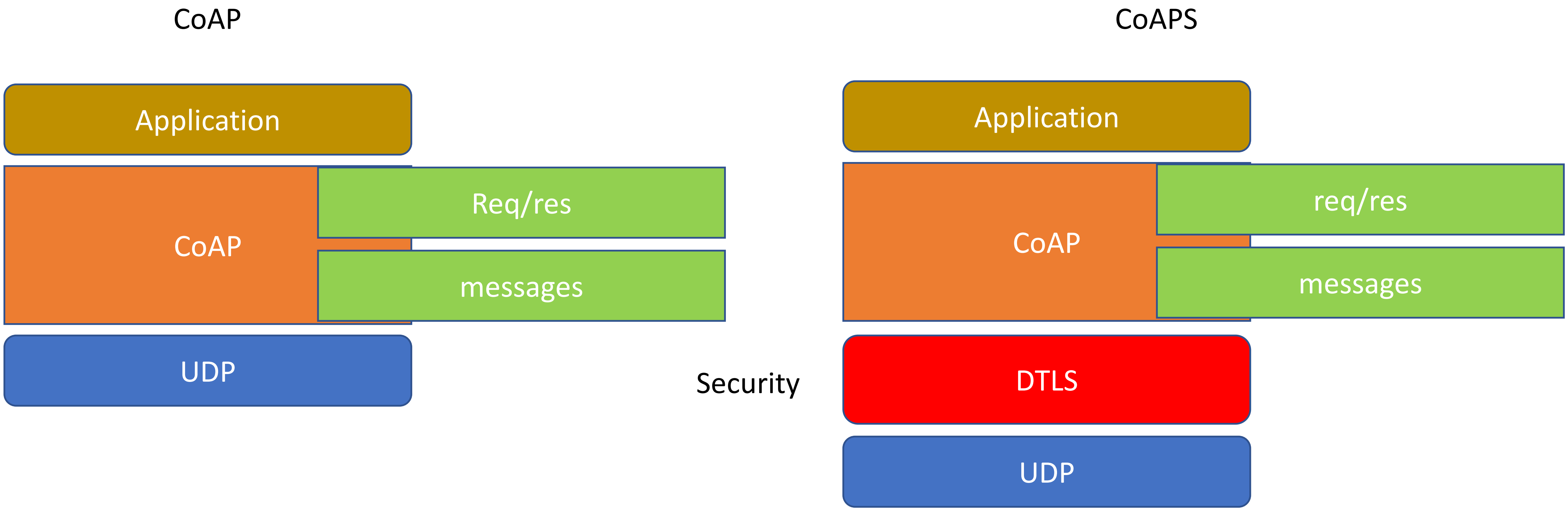
https://tools.ietf.org/html/rfc7252

Application Layer

- CoAP – Constrained Application Protocol

  - Exchange of asynchronous messages. Provides a request-response model between devices.
  - Low overhead and easy to parse.
  - Proxy and cache feature.
  - Supports REST methods - GET, POST, PUT, DELETE.

Application Layer



Application Layer

- CoAP – (recommend reading)

https://www.ericsson.com/en/reports-and-papers/research-papers/3enabling-coap-based-communication-across-network-boundaries-challenges-and-solutions

https://ieeexplore.ieee.org/document/8875313

https://cloud.google.com/community/tutorials/cloud-iot-coap-proxy

https://tools.ietf.org/html/draft-ietf-lwig-coap-06

Camada de Aplicação

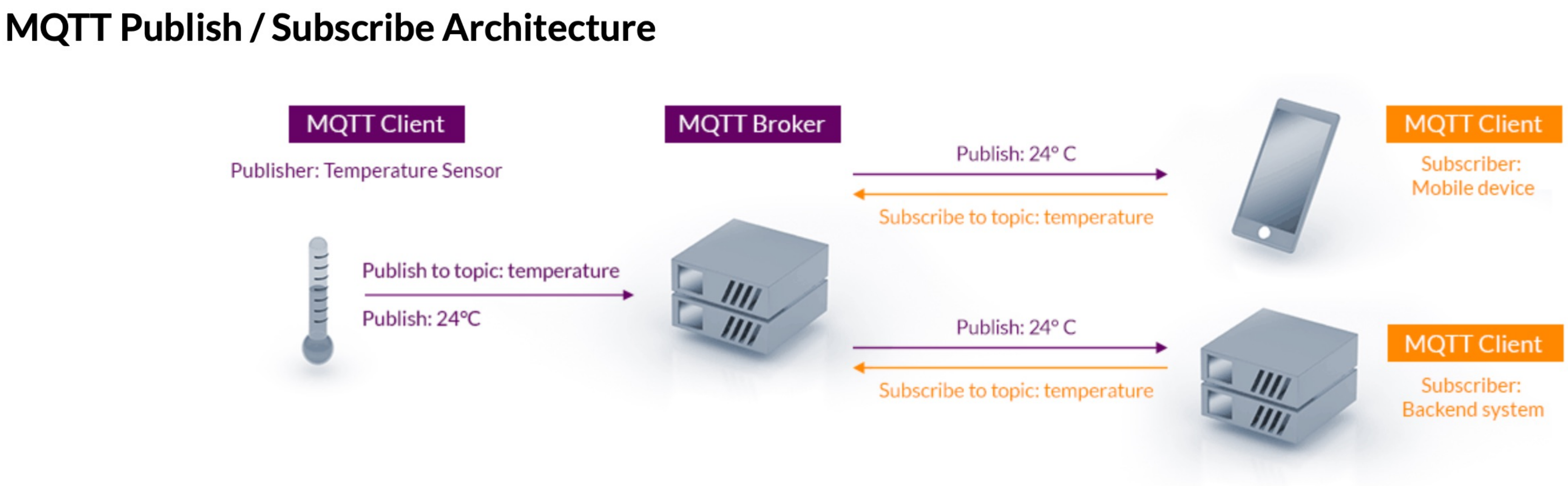
MQTT - Message Queue Telemetry Transport (developed by IBM)

- It’s a message protocol optimized for TCP/IP networks.
- Applied to sensor networks and small mobile devices.
- The message exchange scheme is based on the publisher-subscriber model and is extremely simple and lightweight.

Camada de Aplicação

MQTT - Message Queue Telemetry Transport

- https://mqtt.org



Referências

- IEEE 802.15.4, https://www.ieee802.org/15/pub/TG4.html
- Z-Wave, https://z-wave.pt/
- IEEE 802.11ah, https://ieeexplore.ieee.org/document/7920364
- 6LowPAN, https://datatracker.ietf.org/wg/6lowpan/documents/
- RPL, https://tools.ietf.org/html/rfc6550
- UDP, https://tools.ietf.org/html/rfc768
- Node.js UDP: https://nodejs.org/api/dgram.html
- CoAP, https://tools.ietf.org/html/rfc7252
- MQTT, https://mqtt.org