Physical Design of IoT

History of IoT

- The first **telemetry system was rolled out in Chicago way back in** 1912. It is said to have used telephone lines to monitor data from power plants.
- Telemetry expanded to weather monitoring in the 1930s, when a device known as a **radiosonde became widely used to monitor** weather conditions from balloons.
- In 1957 the Soviet Union launched Sputnik, and with it the Space Race. This has been the entry of **aerospace telemetry that created** the basis of our global satellite communications today.

History of IoT

- Broad adoption of M2M technology began in the 1980s with wired connections for **SCADA (supervisory control and data acquisition) on** the factory floor and in home and business security systems.

- In the 1990s, **M2M began moving toward wireless Technologies.** ADEMCO built their own private radio network to address intrusion and smoke detection .

- In 1995, Siemens introduced the first cellular module built for M2M.

History of IoT

"Machine to Machine" (M2M)
(~1970s +)

Internet of Things Beginnings

Carnegie Mellon Internet
Coke Machine (1982, 1990)

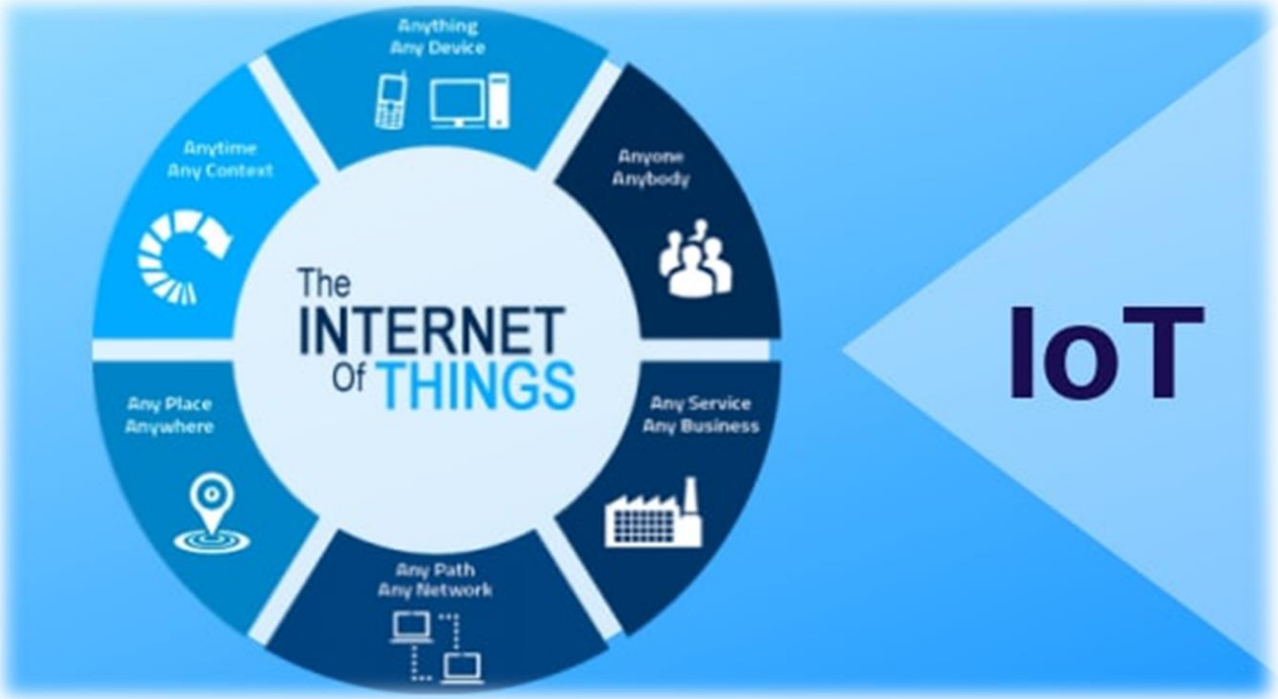
Internet Toaster
(1990)

Trojan Room Coffee
Pot
(first webcam)
(1991)

What is IoT - Definition

Internet connects all people,
so it is called “the Internet of People”

IoT connects all things,
so it is called “the Internet of Things”



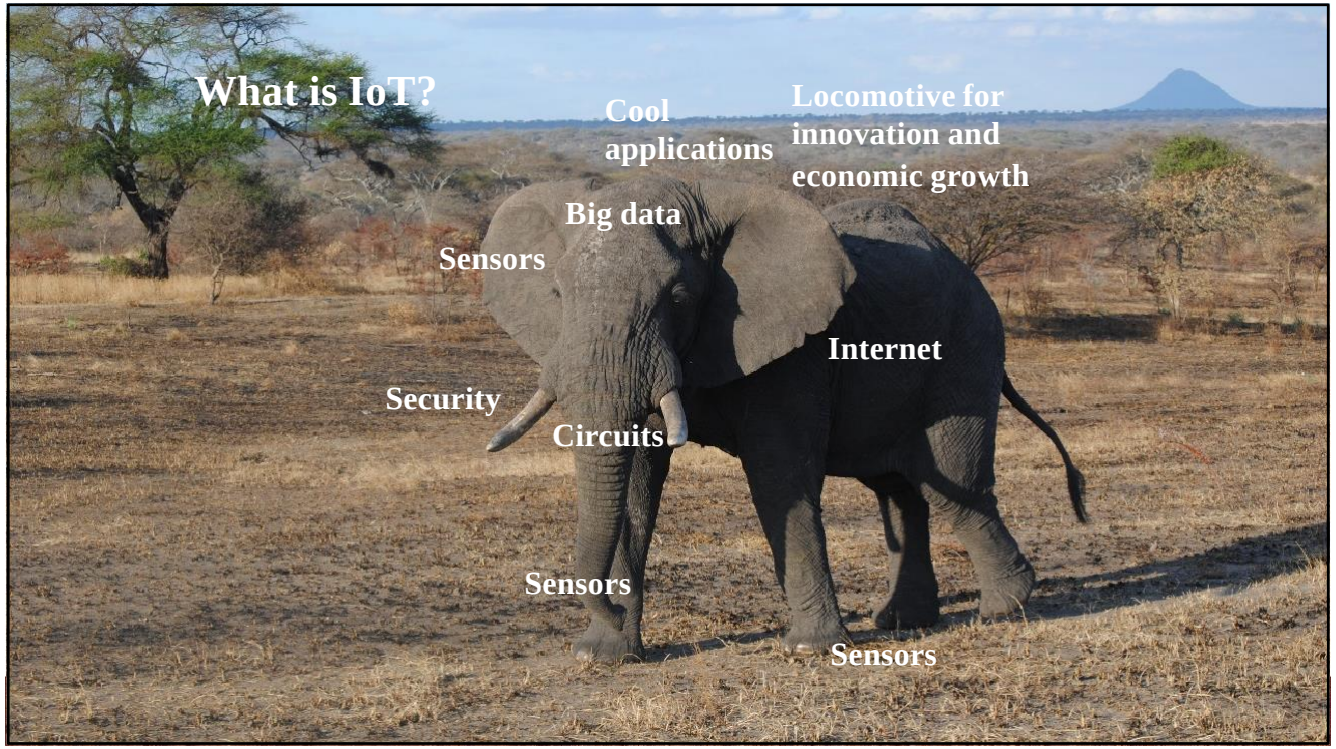
IoT – Definition

The Internet of Things, also called The Internet of Objects, refers to a wireless network between objects, usually the network will be wireless and self-configuring, such as household appliances.

------Wikipedia

The IoT can be viewed as a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies(ICT)

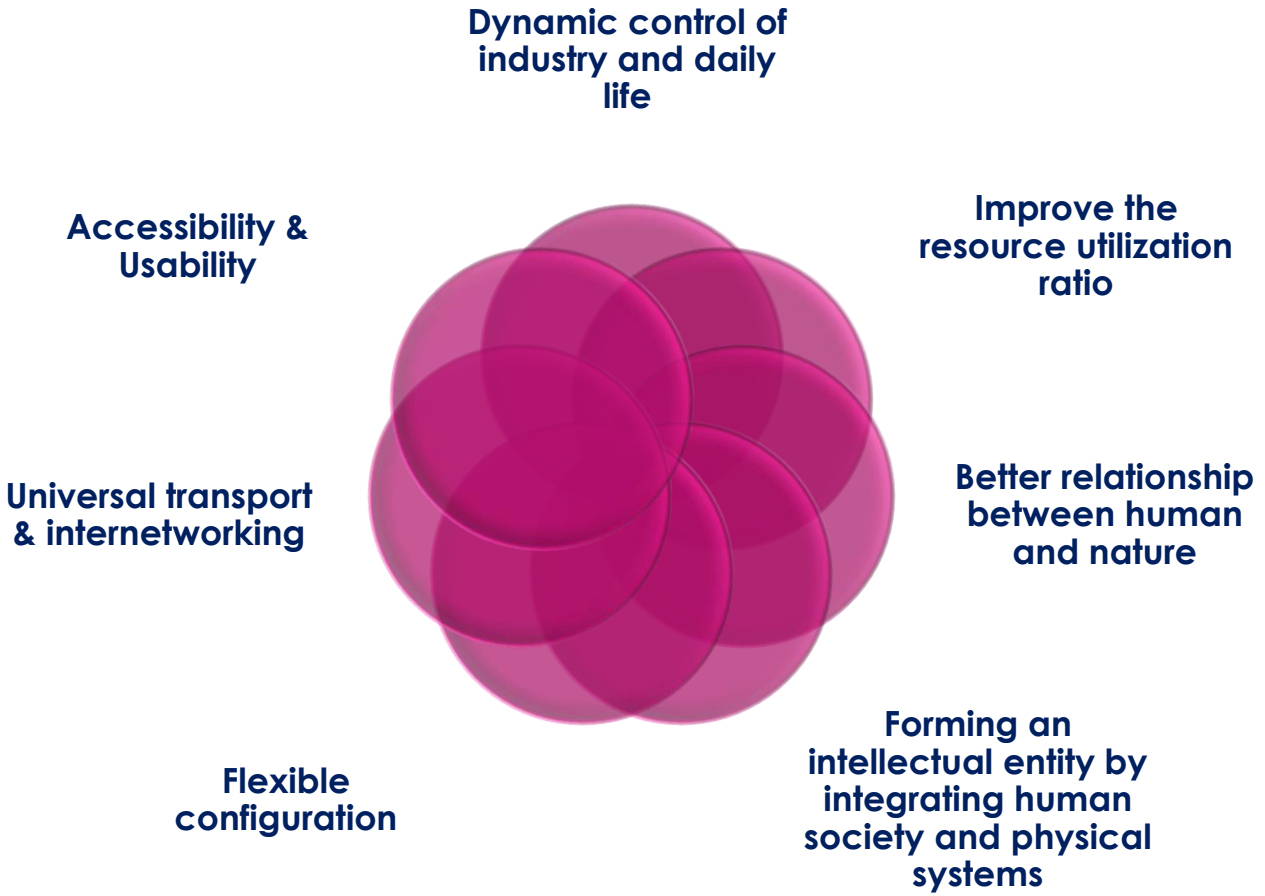
------ITU



Formal Definition of IoT

- A **dynamic global network** infrastructure with **self- configuring capabilities** based on standard and **interoperable communication protocols**, where physical and virtual "things" have **identities**, physical attributes, and use intelligent interfaces, and are seamlessly **integrated into information network** that communicate data with users and environments.

Why Internet of Things?



Characteristics of IoT

- **Dynamic Global network & Self-Adapting** : Adapt the changes w.r.t changing contexts
- **Self Configuring** : Eg. Fetching latest s/w updates without manual intervention.
- **Interoperable Communication Protocols** : Communicate through various protocols
- **Unique Identity** : Such as Unique IP Address or a URI
- **Integrated into Information Network** : This allows to communicate and exchange data with other devices to perform certain analysis.

IoT - Advantages

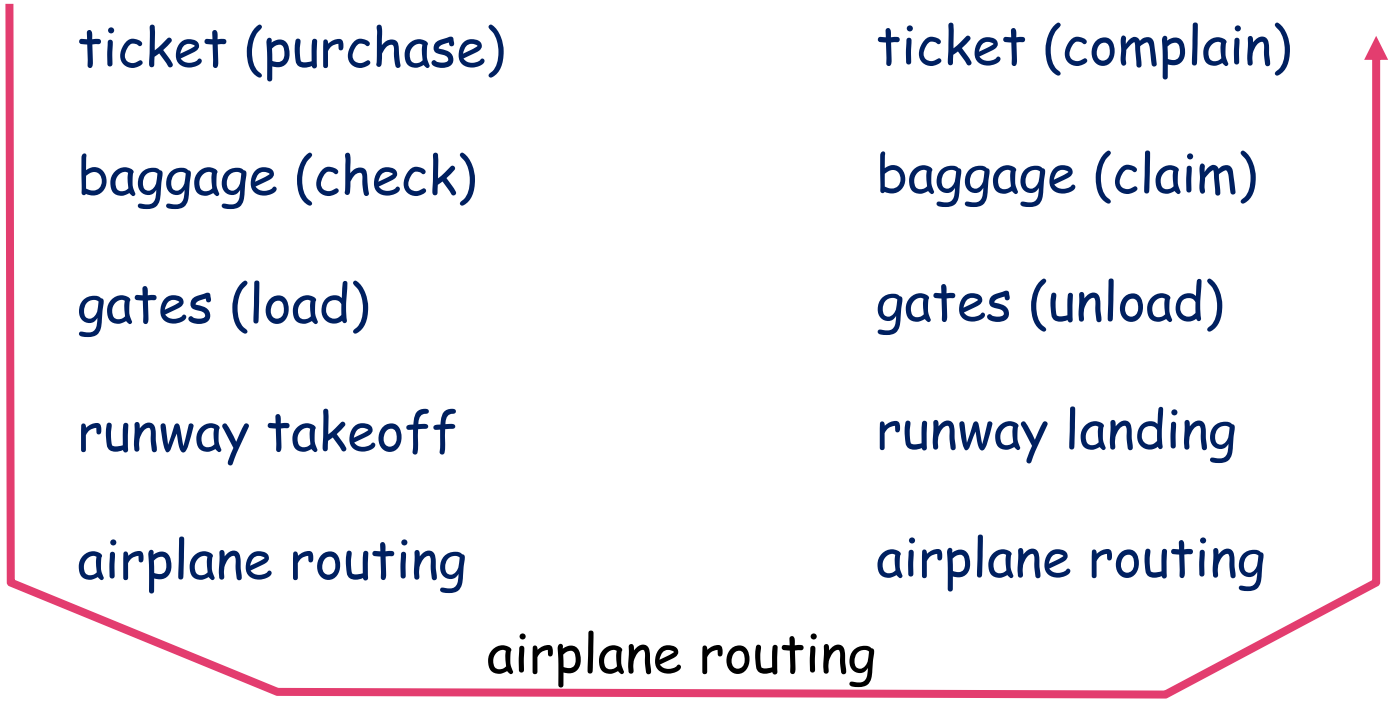
- Improved productivity of staff and reduced human labor. ...
- Efficient operation management. ...
- Better use of resources and assets. ...
- Cost-effective operation. ...
- Improved work safety. ...
- Thorough marketing and business development. ...
- Improved customer service and retention. ...
- Better business opportunities.

IoT - Drawbacks

- Security flaws
- Associated costs
- Power supply dependence
- Network dependence
- High skill requirements

Layered Architecture – What and Why?

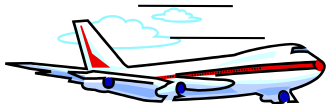
Organization of air travel

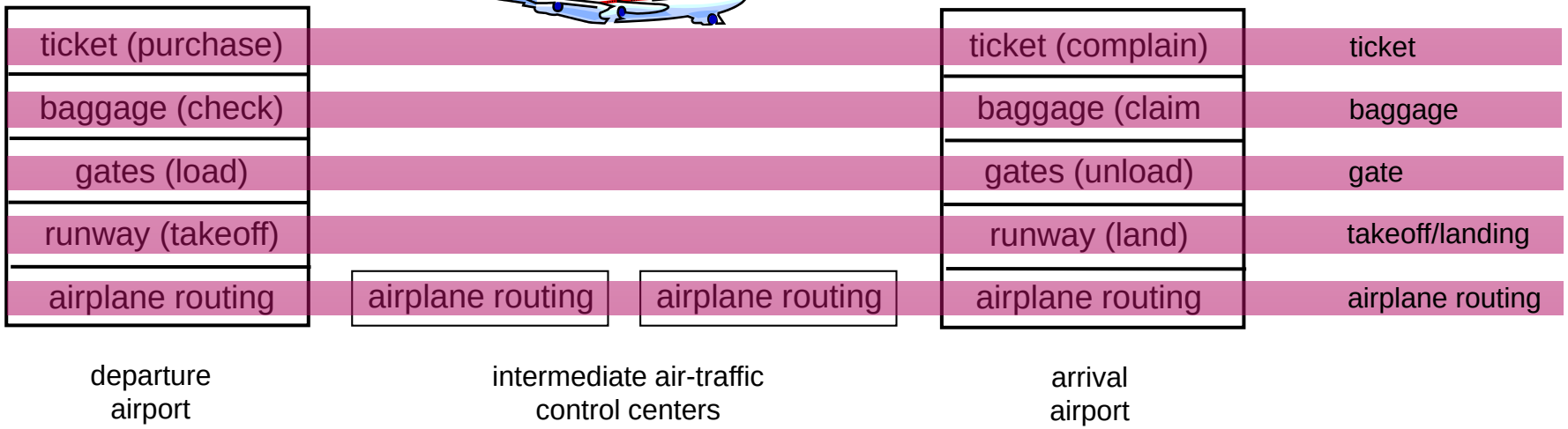


a series of steps

Layered Architecture – What and Why?

Organization of air travel





Layers: each layer implements a service

- via its own internal-layer actions
- relying on services provided by layer below

Why Layers?

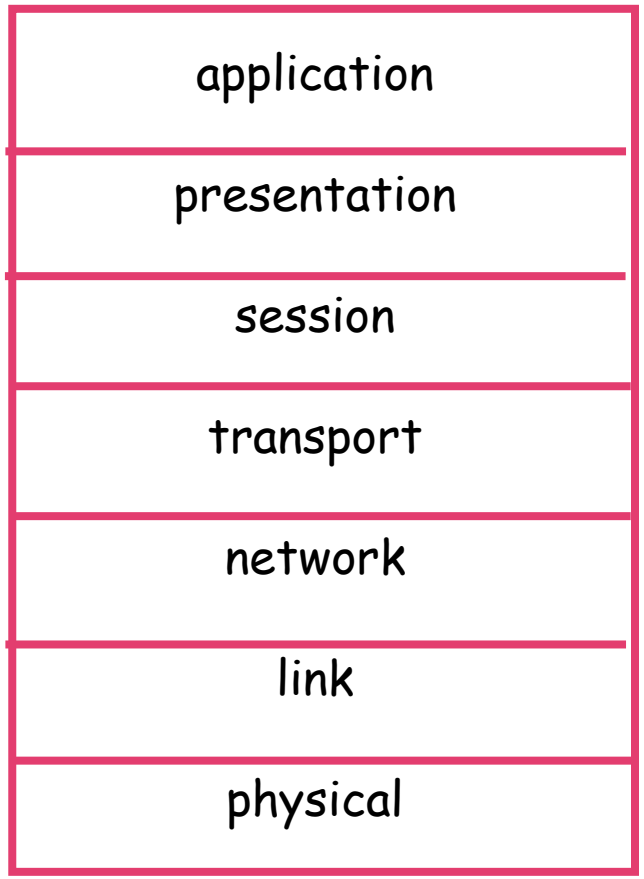
Dealing with complex systems:

- explicit structure allows identification, relationship of complex system's pieces
  - layered reference model for discussion
    - modularization eases maintenance, updating of system
    - change of implementation of layer's service transparent to rest of system
    - e.g. change in gate procedure doesn't affect rest of system

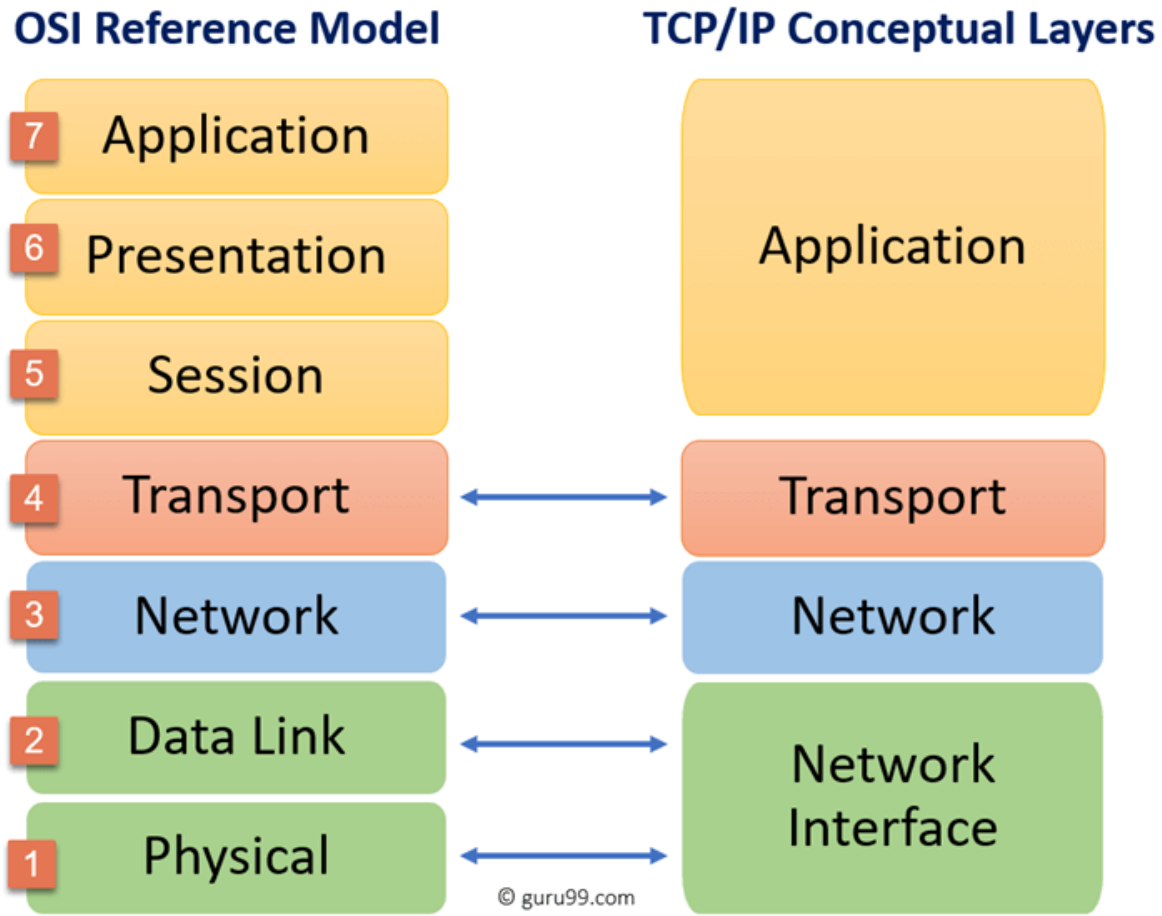
Layered Models

- application: supporting network applications
  - FTP, SMTP, HTTP
- presentation: allow applications to interpret meaning of data, e.g., encryption, compression, machine-specific conventions
- *session:* synchronization, check pointing, recovery of data exchange
- transport: process-process data transfer
  - TCP, UDP
- network: routing of datagrams from source to destination
  - IP, routing protocols
- link: data transfer between neighboring network elements
  - PPP, Ethernet
- physical: bits "on the wire"

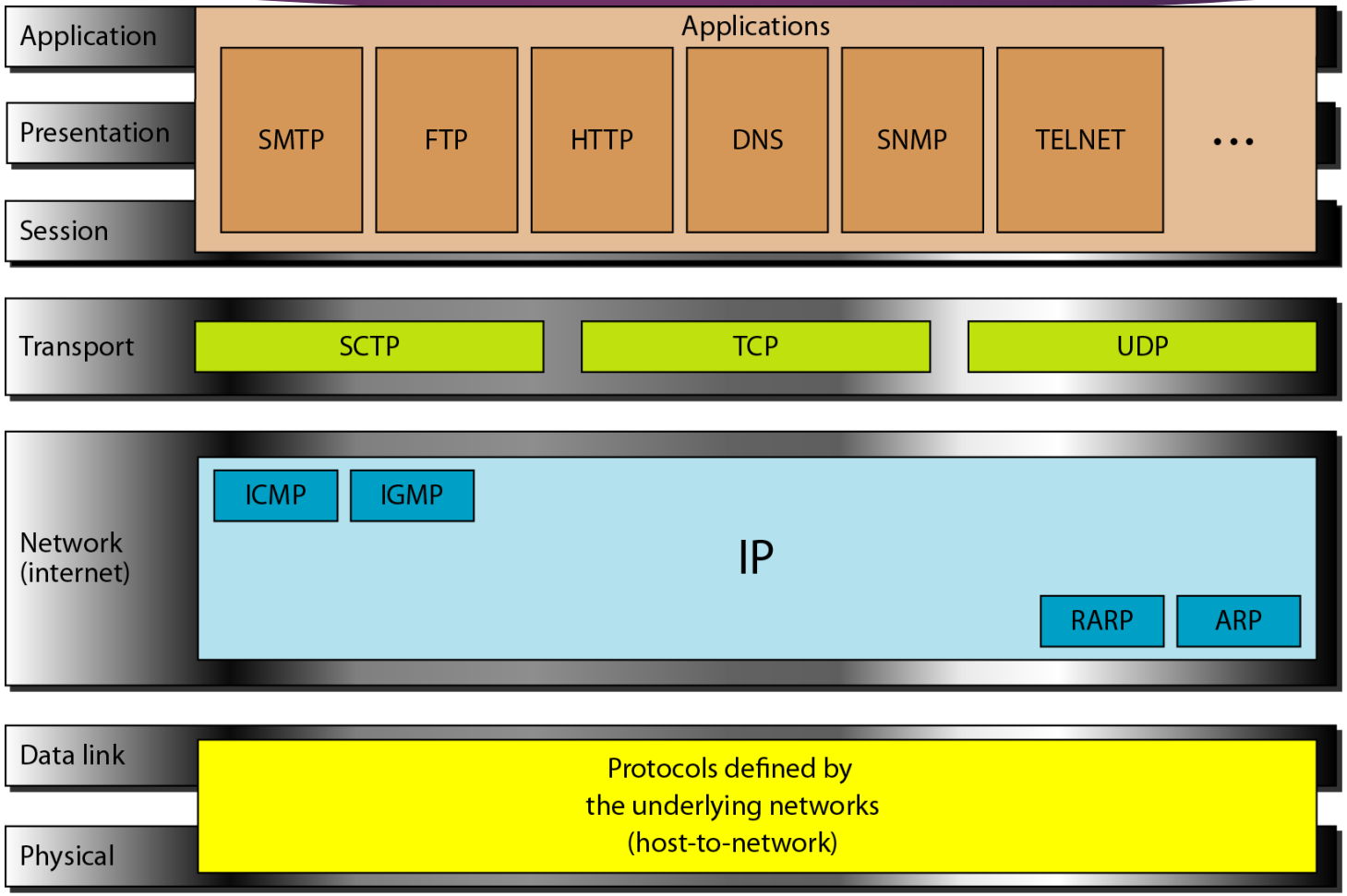
ISO OSI Reference Model



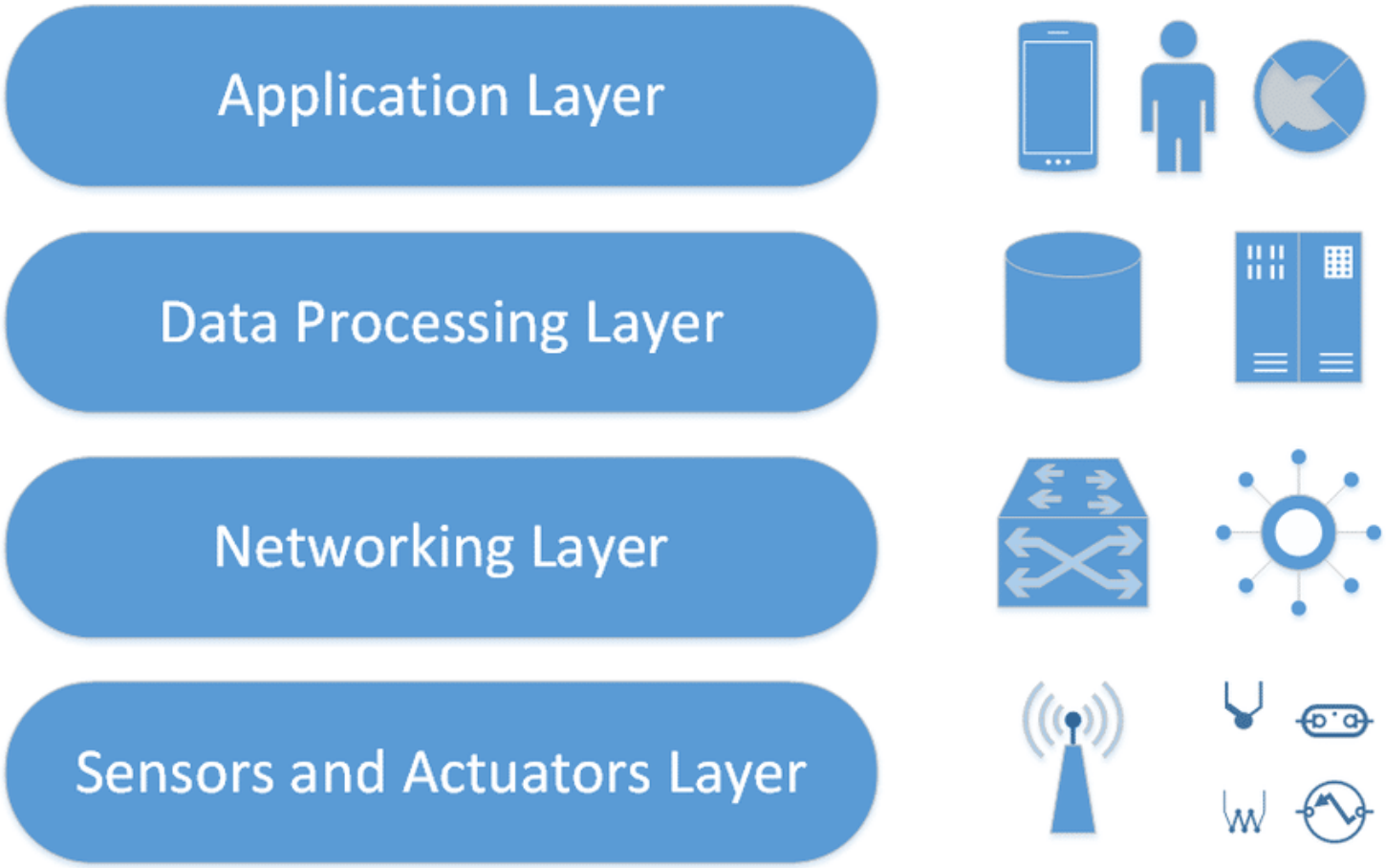
TCP/IP


OSI Reference Model
TCP/IP Conceptual Layers
7 Application
6 Presentation
5 Session
4 Transport
3 Network
2 Data Link
1 Physical
Application
Transport
Network
Network Interface
© guru99.com

Protocols


Application
Presentation
Session
Applications
SMTP
FTP
HTTP
DNS
SNMP
TELNET
...
Transport
SCTP
TCP
UDP
Network
(internet)
ICMP
IGMP
IP
RARP
ARP
Data link
Physical
Protocols defined by
the underlying networks
(host-to-network)

IoT Architecture - Stack



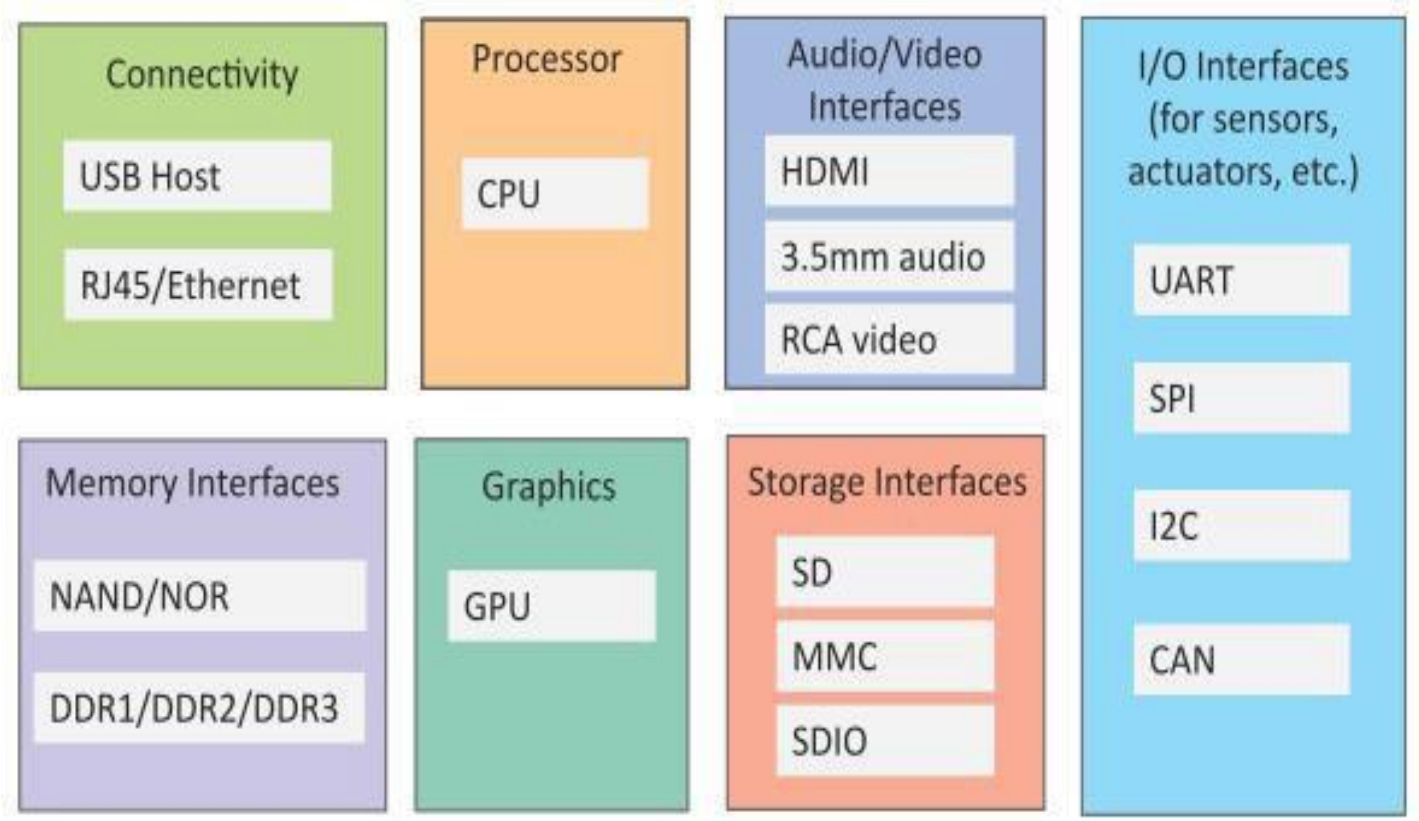
- Business Layer
- Application Layer
- Processing Layer
- Transport Layer
- Perception Layer

Physical Design of IoT

- Things in IoT – refers to devices which have unique identities and can perform remote sensing, actuating and monitoring capabilities.
- IoT devices can:
  - Exchange data with other connected devices and applications (directly or indirectly), or
  - Collect data from other devices and process the data locally or
  - Send the data to centralized servers or cloud-based application back-ends for processing the data, or
  - Perform some tasks locally and other tasks within the IoT infrastructure, based on temporal and space constraints

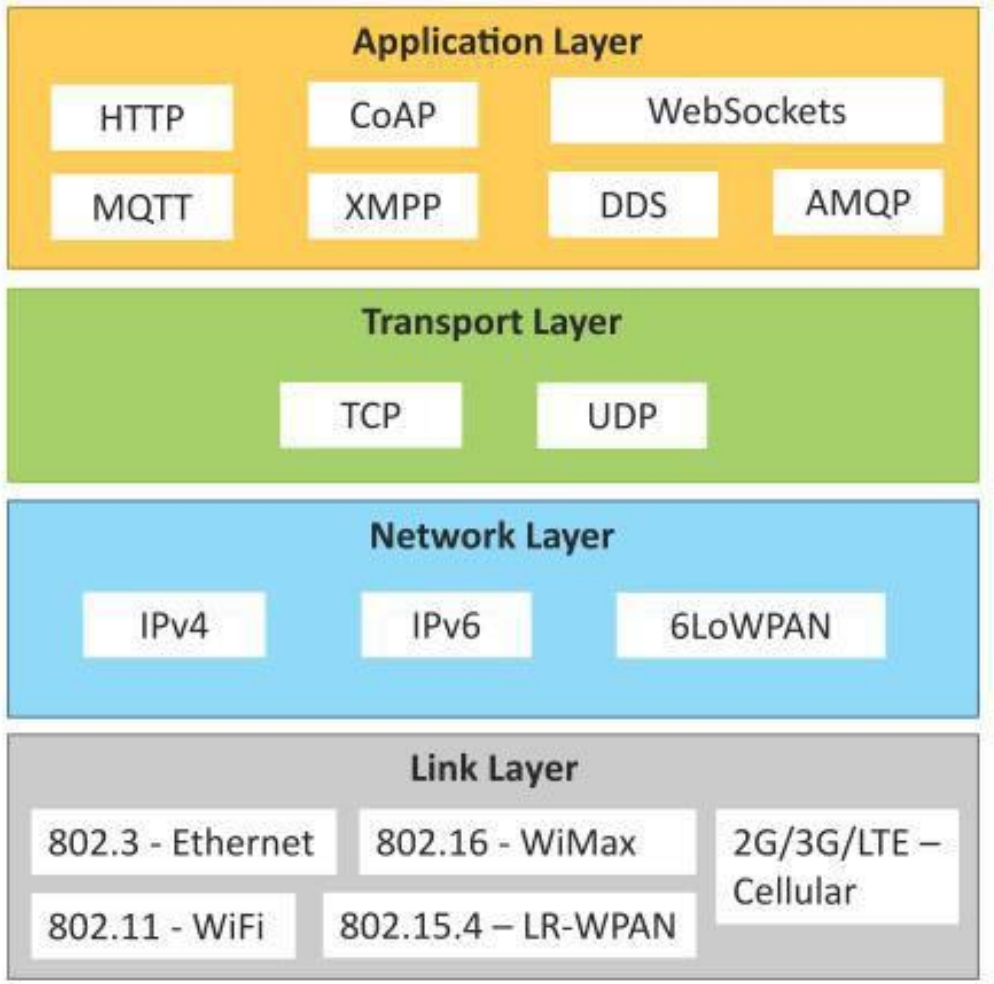
Generic block diagram of an IoT Device

- An IoT device may consist of several interfaces for connections to other devices, both wired and wireless.
  - I/O interfaces for sensors
  - Interfaces for Internet connectivity
  - Memory and storage interfaces
  - Audio/video interfaces.



IoT Protocols

- Link Layer
  - 802.3 – Ethernet
  - 802.11 – WiFi
  - 802.16 – WiMax
  - 802.15.4 – LR-WPAN
  - 2G/3G/4G
- Network/Internet Layer
  - IPv4
  - IPv6
  - 6LoWPAN
- Transport Layer
  - TCP
  - UDP
- Application Layer
  - HTTP
  - CoAP
  - WebSocket
  - MQTT
  - XMPP
  - DDS
  - AMQP



Link Layer

- Link Layer protocols determine how the data is physically sent over the networks physical layer or medium(example copper wire, electrical cable, or radio wave).
- The Scope of The Link Layer is the Last Local Network connections to which host is attached.
- Host on the same link exchange data packets over the link layer using the link layer protocol.
- Link layer determines how the packets are coded and signaled by the hardware device over the medium to which the host is attached.

Link Layer Protocols

802.3 Ethernet

Sr.No	Standard	Shared medium
1	802.3	Coaxial Cable…10BASE5
2	802.3.i	Copper Twisted pair …..10BASE-T
3	802.3.j	Fiber Optic……10BASE-F
4	802.3.ae	Fiber…..10Gbits/s

Data Rates are provided from 10Gbit/s to 40Gb/s and higher

802.1- WI-FI

Sr.No	Standard	Operates in
1	802.11a	5 GHz band
2	802.11b and 802.11g	2.4GHz band
3	802.11.n	2.4/5 GHz bands
4	802.11.ac	5GHz band
5	802.11.ad	60Hz band

Data Rates from 1Mb/s to 6.75 Gb/s

802.16 wiMAX

Sr. No	Standard	Data Rate
1	802.16m	100Mb/s for mobile stations 1Gb/s for fixed stations

Collection of Wireless Broadband standards

Data Rates from 1.5Mb/s to 1 Gb/s

Link Layer Protocols

802.15.4 LR-WPAN

- Collection of standards for low-rate wireless personal area networks
- Basis for high level communication protocols such as Zigbee
- Data Rates from 40Kb/s to 250Kb/s
- Provide low-cost and low-speed communication for power constrained devices

2G / 3G / 4G mobile communications

Sr.No	Standard	Operates in
1	2G	GSM-CDMA
2	3G	UMTS and CDMA 2000
3	4G	LTE

Data Rates from 9.6Kb/s (for 2G) to up to 100Mb/s (for 4G)

Network Layer

- The network layer are responsible for sending of IP datagrams from the source network to the destination network.
- This layer Performs the host addressing and packet routing.
- The datagrams contains a source and destination address which are used to route them from the source to the destination across multiple networks.
- Host Identification is done using the hierarchy IP addressing schemes such as ipv4 or IPv6.

Network Layer Protocols

IPV4

most deployed internet protocol that is used to identify the device is on a network

It uses 32 bit addresses scheme that allows total of 2^32 address.

As more and more devices got connected to the internet. The Ipv4 has succeeded by IPv6.

IPv6

newest versions of internet protocol

successor to IPv4.

IPv6 uses 128 bit address schemes

6LoWPAN

IPv6 over low power wireless personal area networks brings IP protocol to the low power device which have limited processing capability

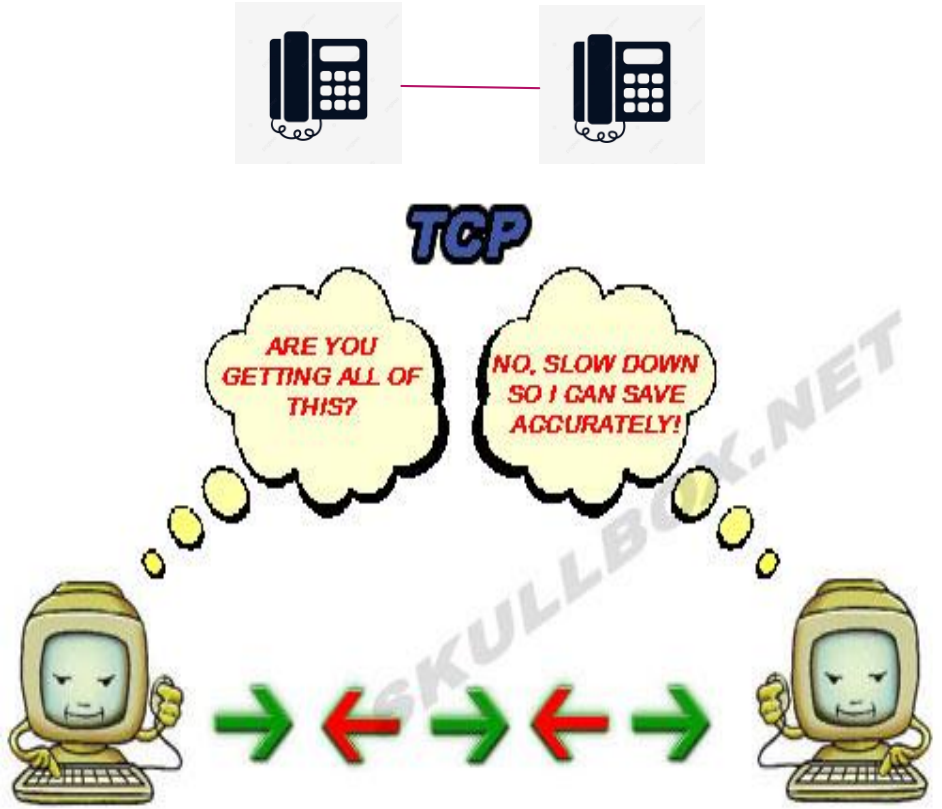
it operate in the 2.4 GHz frequency range and provide the data transfer rate up to 250 kb/s

Transport Layer

- The Transport layer protocols provides end-to-end message transfer capability independent of the underlying network.
- The message transfer capability can be set up on connections, either using handshake or without handshake acknowledgements.
- Provides functions such as error control , segmentation, flow control and congestion control.

Transport Layer Protocols - TCP

- Transmission Control Protocol
- Connection Oriented
- Ensures Reliable transmission
- Provides Error Detection Capability to ensure no duplicity of packets and retransmit lost packets
- Flow Control capability to ensure the sending data rate is not too high for the receiver process
- Congestion control capability helps in avoiding congestion which leads to degradation of n/w performance



Transport Layer Protocols - UDP

- User Datagram Protocol
- Connectionless
- Does not ensures Reliable transmission
- Does not do connection before transmitting
- Does not provide proper ordering of messages
- Transaction oriented and stateless

Application Layer

- Application layer protocol define how the application interfaces with the lower layer protocols to send the data over the network.
- Data are typically in files, is encoded by the application layer protocol and encapsulated in the transport layer protocol .
- Application layer protocol enable process-to-process connection using ports.

Application layer Protocols

Http

Hypertext transfer protocol is the application layer protocol that forms the foundations of world wide web

The protocol follows a request-response model where are client sends request to server using the http, commands.

CoAP

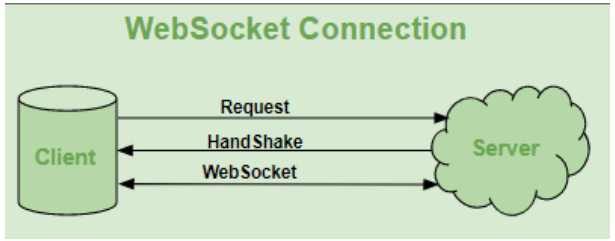
Constrained application protocol is an application layer protocol for machine to machine application

M2M meant for constrained environment with constrained devices and constrained networks.

Websocket

Websocket is based on TCP and Allows streams of messages to be sent back and forth between the client and server

The client can be a browser, a mobile application and IoT device

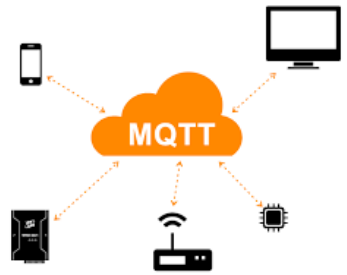


Application layer Protocols

MQTT

Message Queue Telemetry Transport it is a lightweight message protocol based on public -subscribe model

MQTT uses a client server Architecture by the clients such as an IoT device connect to the server



XMPP

Extensible Messaging and Presence Protocol it is a protocol for real-time communication and streaming XML data between network entities

XMPP powers wide range of applications including messaging, presence, data syndication, gaming multiparty chat and voice / voice calls

DDS

Data Distribution service is a data-centric middleware standard for device-to-device or machine-to-machine communication.

Publish subscribe model where publishers create topics to which subscribers can use.

Provides Quality-of-service control and configurable reliability.

Thank you!