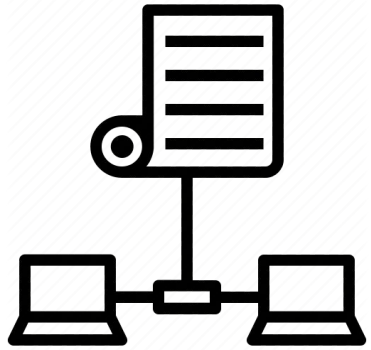
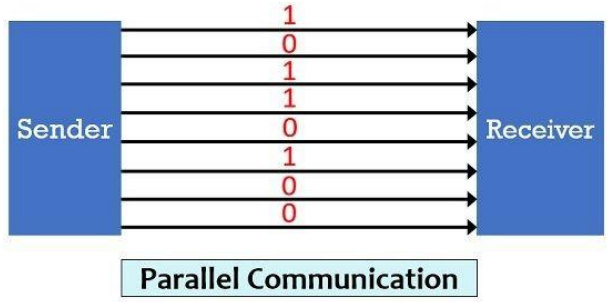
Introduction

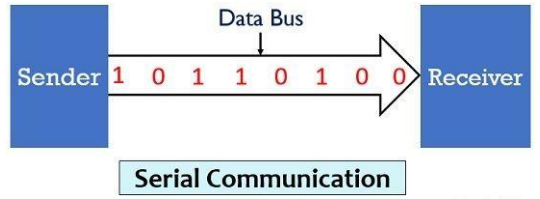
Communication Protocols

Serial Communication

- Communication
  - Exchange of information from an entity to another entity via a medium
- Protocol: A set of rules and regulations
- Communication Protocol
  - A set of rules that allows two or more entities to communicate with each other.
- Data Transmission Methods
  - Serial
    - Single wire is used to transfer data bit by bit sequentially
  - Parallel
    - Multiple wires are used to transfer multiple bits simultaneously





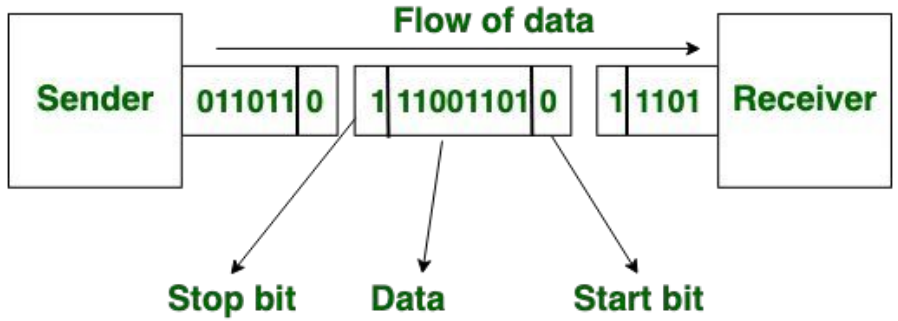


Communication Protocols (Serial vs. Parallel)

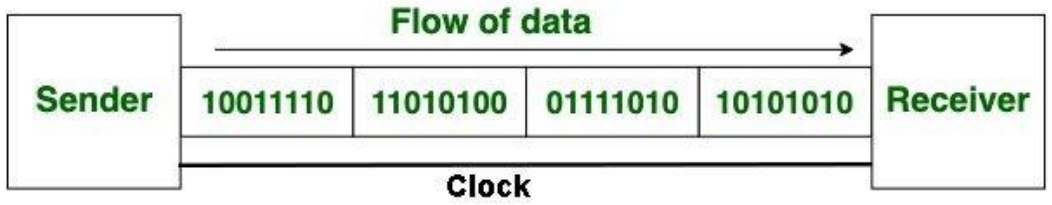
	Serial	**Parallel**
Data Transfer	Transfers data bit by bit sequentially	Transfers multiple bits simultaneously
Direction of Communication	Simplex, Half Duplex and Full Duplex	Simplex and Half Duplex
Speed	Slow; 1 bit per clock cycle	Faster; N bits per clock cycle But the speed is decreased by increasing the length of the wires
Cost	Economical	Expensive, more pins and wires are required
Physical Space	Less space	More space; because of connectors and wires
Need of converters	Converters are required to convert the data between parallel and serial forms	
Sync/Async	Synchronous and Asynchronous	Synchronous; a clock signal is required. Length of the wires, wiring and crosstalk are some serious challenges
Applications	Used for long-distance communication.	Used for short-distance communication.

Communication Protocols (Serial Communication)

- Asynchronous Serial Communication
  - Communication without dedicated clock signal
  - Both parts need to agree on the speed
  - No dedicated master or slave.

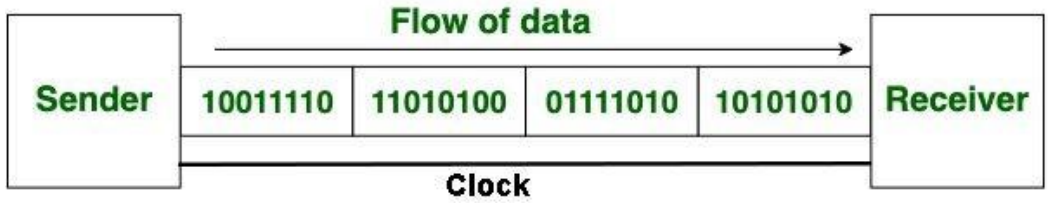


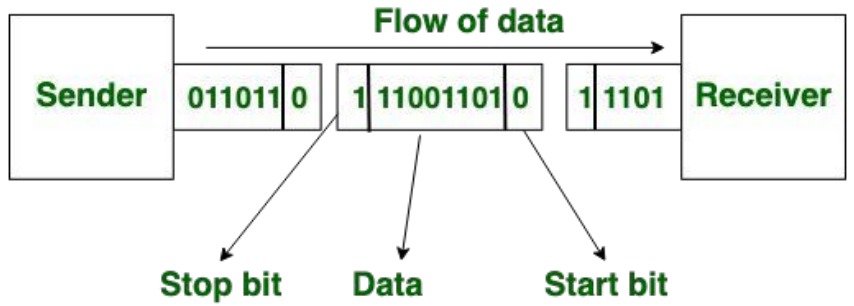
- Synchronous Serial Communication
  - Communication with a dedicated clock
  - Usually one part is master and another part is slave
  - Speed is decided by clock. It can theoretically be different in each direction



Serial Communication Protocols (Asynchronous vs. Synchronous)

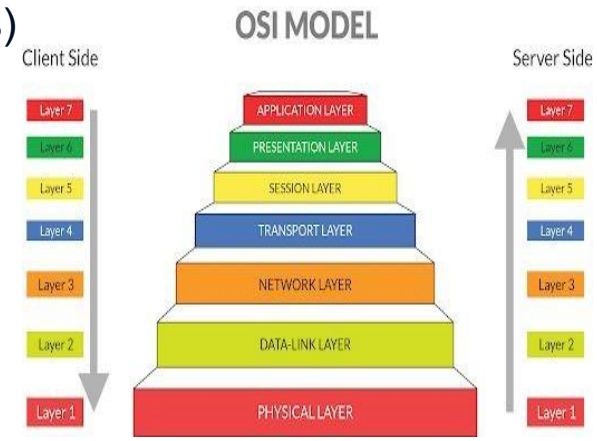
SYNCHRONOUS TRANSMISSION	ASYNCHRONOUS TRANSMISSION
Data is sent in form of blocks or frames	Data is sent in form of byte or character
A dedicated clock is required to synchronize the communication	Both parts need to agree on speed (baud rate/bit rate) Some UART Standard baud rates: 110, 300, 600, 1200, 2400, 4800, 9600, 14400, 19200, 38400, 57600, 115200 bps
Fast. By starting and stopping the clock signal, there is no need to have start/stop bits. Blocks of data can be sent without having any gap between the bytes.	Slow. E.g. in UART, up to 115200 bps
Examples: SPI, I2C, PCI Express and etc.	Examples: UART, CAN and etc.

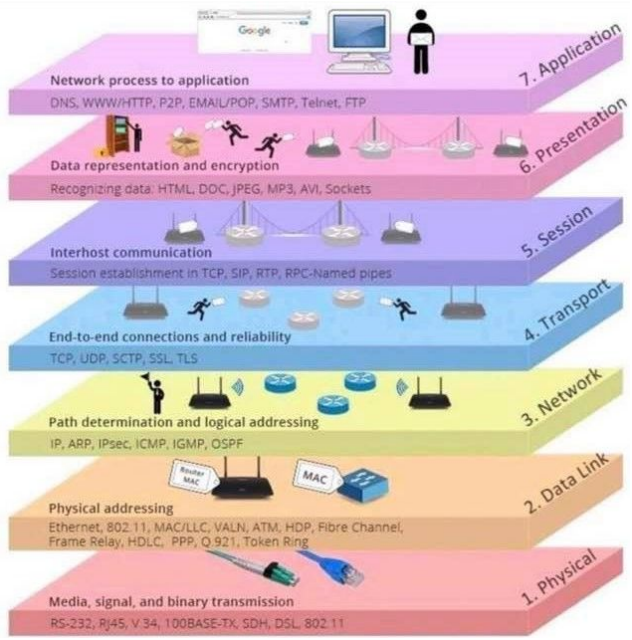




Communication Protocols (OSI Model)

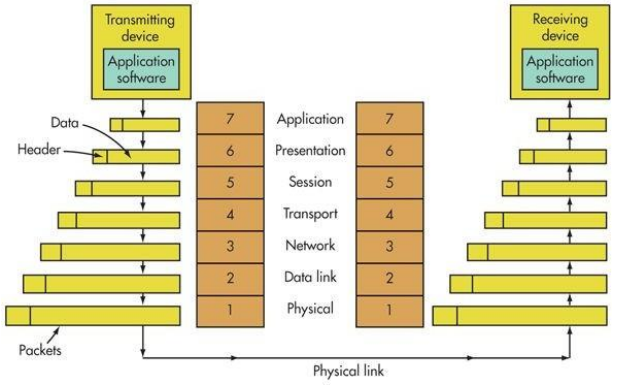
- Open Systems Interconnection(OSI) model
  - Is a conceptual model that explains the communication functions of a system
  - Developed by ISO (International Organization of Standardization) in 1984
  - Forms the basis of modern communications systems
  - Uses the concept of abstraction layers
    - To explain the steps in the process of sending/receiving data
    - Each layer provides some features to the one above
    - Layers of OSI Model (7 layers)
      - **Application Layer**
      - **Presentation Layer**
      - **Session Layer**
      - **Transport Layer**
      - **Network Layer**
      - **Data Link Layer**
      - **Physical Layer**





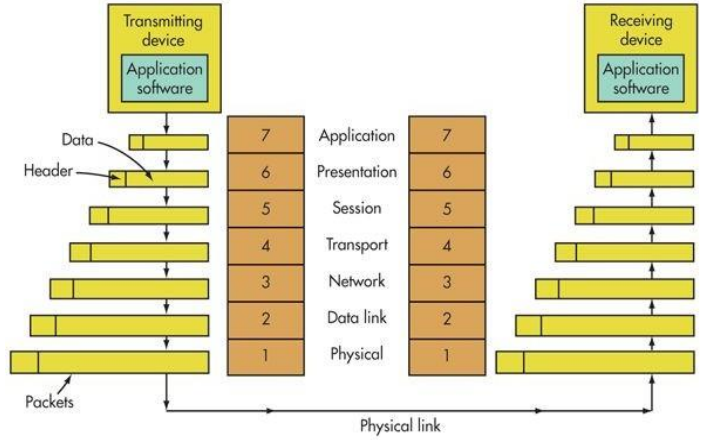
Communication Protocols (OSI Model - Layers)

- Application Layer
  - Takes the user interaction with the software and formulates a communication request
  - Examples: HTTP, DNS, SMTP and etc.
- Presentation Layer (is also called the Translation layer)
  - Provides format and structure of the data, possibly encryption
  - Functions: Translation (e.g. encoding), Encryption (e.g. HTTPS), and Compression (e.g. gzip)
  - For example: SSL(Secure Socket Layer), TLS (Transport Layer Security)
- Session Layer
  - Manages the connection between sender and receiver
    - Session establishment, maintenance and termination
    - Authentication and Dialog Controller (half-duplex or full-duplex)
    - E.g. Sockets, PPTP (Point-to-Point Tunneling Protocol) and etc.



Communication Protocols (OSI Model - Layers)

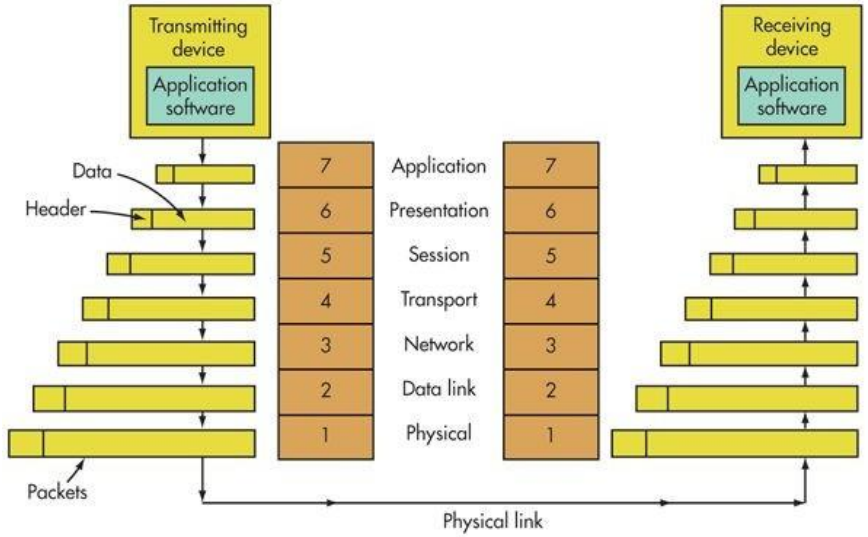
- Transport Layer
  - Moves blocks of data in a reliable manner, even if they are larger than the lower levels can handle (segmentation). E.g. TCP and UDP in the TCP/IP
  - Implements Flow & Error control to ensure proper data transmission
  - Functions:
    - Segmentation and Reassembly
    - Service Point Addressing
      - Delivers the message to correct process by including a type of address called service point address or port address



  - Services:
    - Connection Oriented Service
      - The receiver acknowledges the sender after a packet or group of packet is received.
      - This type of transmission is reliable and secure.
    - Connectionless service:
      - In this type of transmission, the receiver does not acknowledge receipt of a packet.

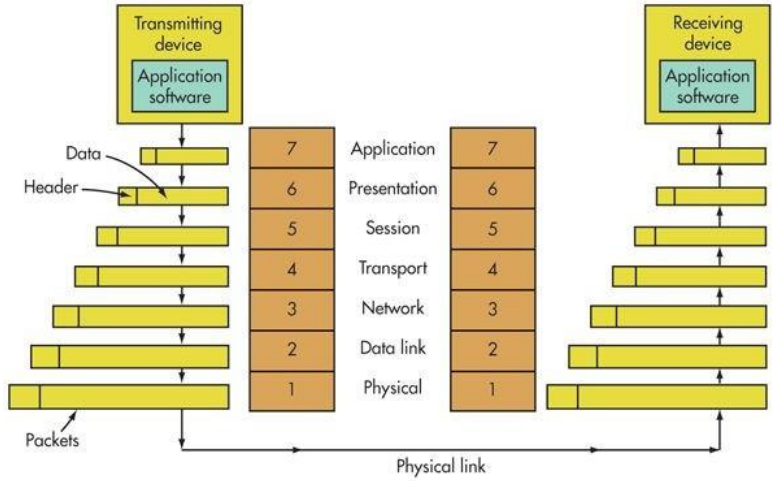
Communication Protocols (OSI Model - Layers)

- Network Layer
  - Gets a variable length of information from one place to another
  - Breaks up big blocks of data (**packet**) into **frames** that can be transferred by the Data Link layer
  - Determines which route is suitable from source to destination (**Routing**)
  - Defines the addressing to identify each device on network uniquely (**Logical Addressing**)
  - Examples:
    - Internet Protocol (IP) in the TCP/IP
    - Multidrop RS-485



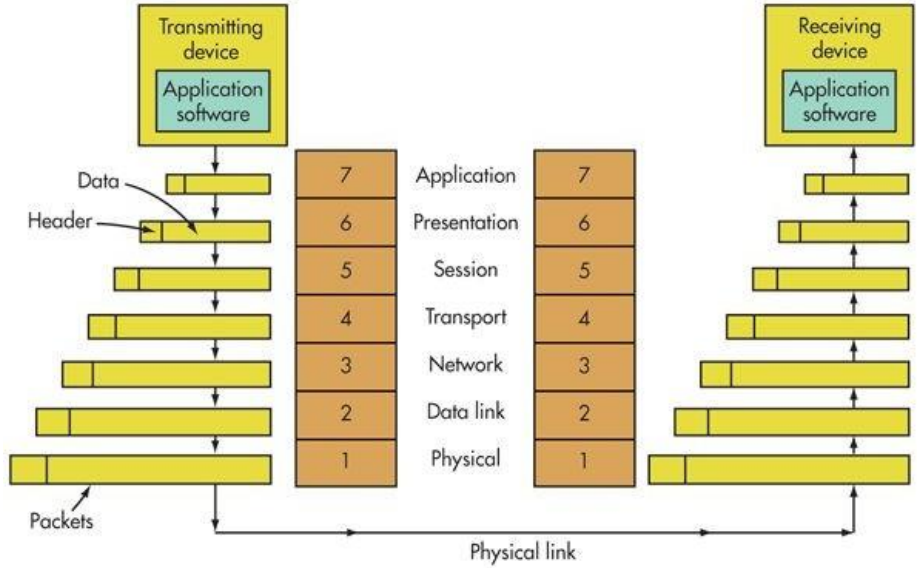
Communication Protocols (OSI Model - Layers)

- Data Link Layer
  - Describes how bytes flow over the physical media
  - Is responsible for the node to node delivery of the message
  - Makes sure data transfer is error-free from one node to another, over the physical layer
  - Functions:
    - Framing: How many bits sent/received in each frame?
    - Physical addressing: E.g. MAC address
    - Error control: E.g. retransmits damaged or lost frames
    - Flow Control: The data rate must be constant on both sides
    - Access control: which device has control over a shared channel by multiple devices at a given time
  - E.g. Ethernet (802.xx), CAN and etc.



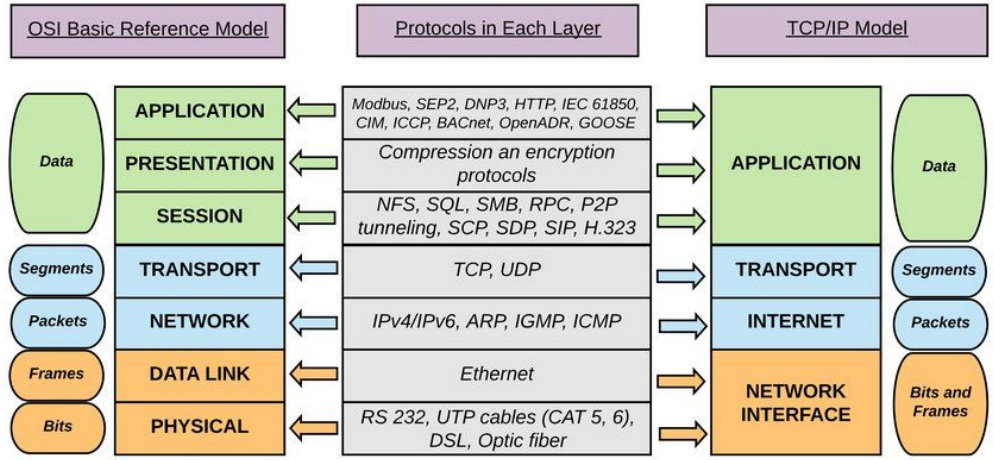
Communication Protocols (OSI Model - Layers)

- Physical Layer
  - Provides electrical and physical specification
  - Is responsible for the actual physical connection between the devices
  - It contains information in the form of bit stream
  - Functions:
    - Bit synchronization
    - Bit rate control
    - Physical topologies
    - Transmission mode
      - Simplex? Half-duplex? Full-duplex?
    - Example protocols: RS-232, UTP cables, and etc.



Communication Protocols (OSI Model - Layers)

- OSI model is more complex than what we need for most embedded systems
- OSI model as a reference model can give us some ideas how simple and complex communication protocols work
- Most of the protocols combine or skip some layers of the OSI model
  - For examples:
    - RS-232 defines the physical layer
    - CAN defines physical and data link layers
    - TCP/IP defines four layers
  - In embedded system programming
    - Few lower layers are important
      - Especially the data link layer and how to move data from one node to another



Ethernet and TCP/IP

- Some useful links
  - What's the Difference Between Parallel and Serial?
  - Difference Between Serial and Parallel Transmission
  - OSI Model Explained | Real World Example
  - The OSI Model Demystified
  - Layers of OSI Model
  - Synchronous vs. Asynchronous Transmission