SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECT312 – EMBEDDED SYSTEM DESIGN

III YEAR/ VI SEMESTER

UNIT 2 : **DEVICES AND EMERGING BUS STANDARDS**

TOPIC 2. 8 : **CAN & Bluetooth**

CAN (Controller Area Network) protocol

- CAN stands for **Controller Area Network** protocol. It is a protocol that was developed by **Robert Bosch** in around 1986

- The CAN protocol is a standard designed to allow the microcontroller and other devices to communicate with each other without any host computer

- The feature that makes the CAN protocol unique among other communication protocols is the broadcast type of bus , which means that the information is transmitted to all the nodes

- The node can be a sensor, microcontroller, or a gateway that allows the computer to communicate over the network through the USB cable or ethernet port

- The CAN is a message-based protocol, which means that message carries the message identifier, and based on the identifier, priority is decided

CAN (Controller Area Network) protocol

- There is no need for node identification in the CAN network, so it becomes very easy to insert or delete it from the network
- It is a serial half-duplex and asynchronous type of communication protocol
- The CAN is a two-wired communication protocol as the CAN network is connected through the two-wired bus
- The wires are twisted pair having 120Ω characteristics impedance connected at each end. Initially, it was mainly designed for communication within the vehicles, but it is now used in many other contexts
- Like UDS, and KWP 2000, CAN also be used for the on-board diagnostics
- A Controller Area Network (CAN bus) is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other's applications without a host computer

What does CAN stand for in embedded system?

- A Controller Area Network (CAN bus) is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other's applications without a host computer

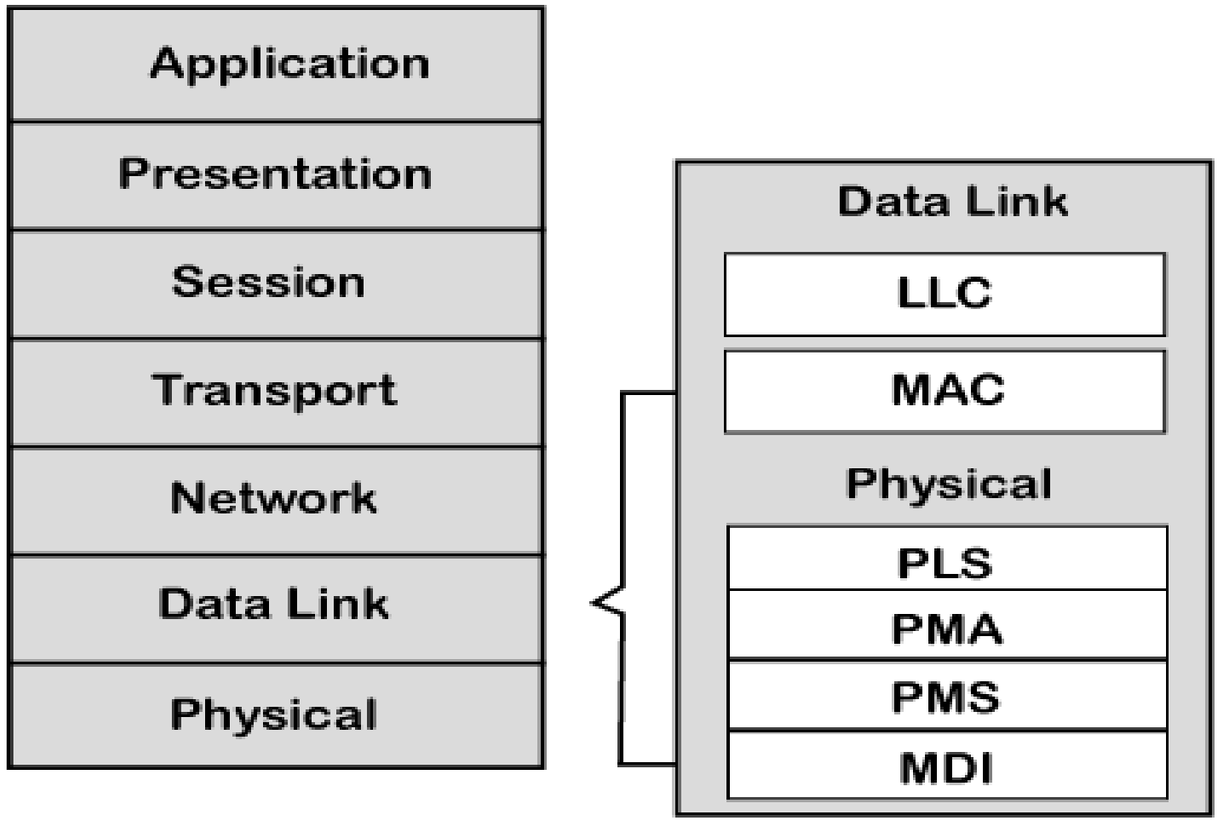
Why CAN?

- The need for a centralized standard communication protocol came because of the increase in the number of electronic devices
- Ex. there can be more than 7 TCU for various subsystems such as dashboard, transmission control, engine control unit, and many more in a modern vehicle
- If all the nodes are connected one-to-one, then the speed of the communication would be very high, but the complexity and cost of the wires would be very high
- In the above example, a single dashboard requires 8 connectors, so to overcome this issue, CAN was introduced as a centralized solution that requires two wires, i.e., CAN high and CAN low
- The solution of using CAN protocol is quite efficient due to its message prioritization, and flexible as a node can be inserted or removed without affecting the network

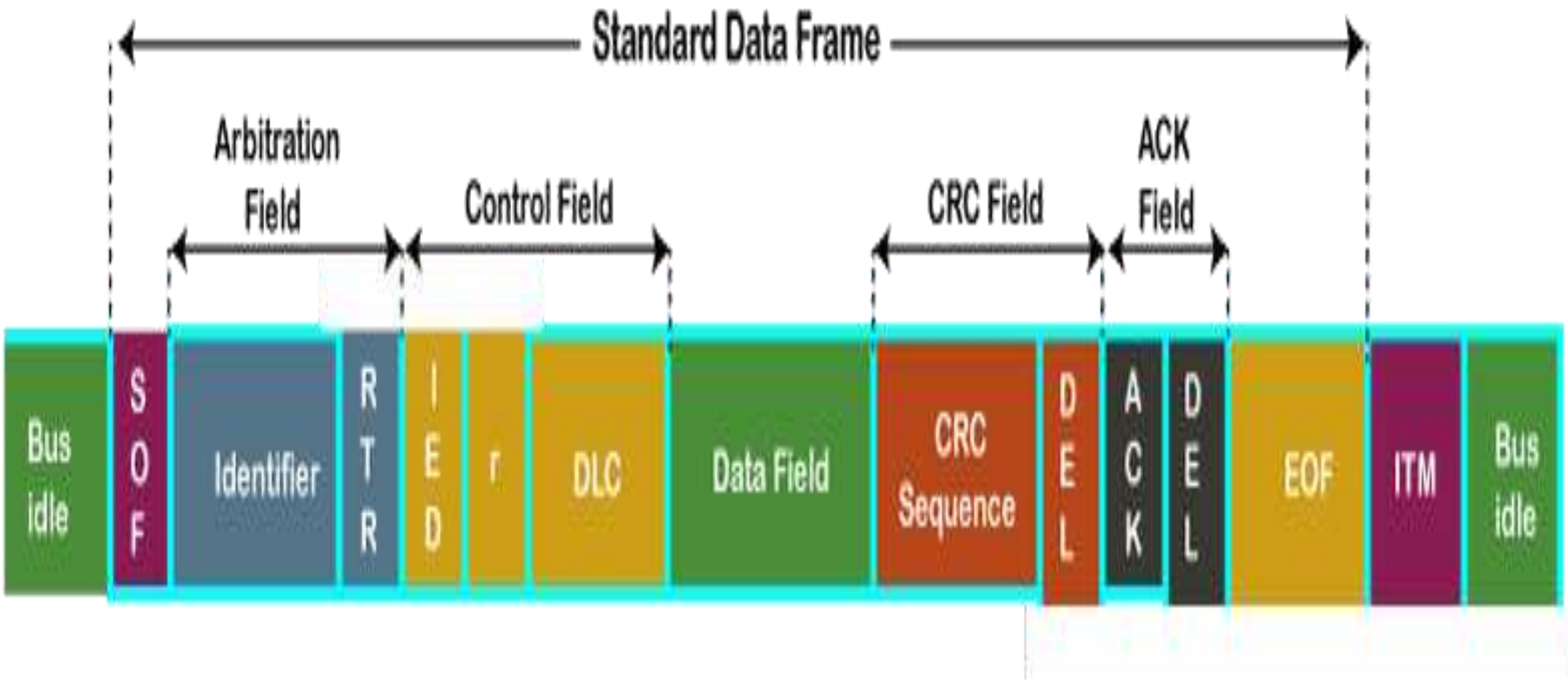
Applications of CAN protocol

- Automotive (passenger vehicles, trucks, buses)
- Electronic equipment for aviation and navigation
- Industrial automation and mechanical control
- Elevator and escalators
- Building automation
- Medical instruments and equipment
- Marine, medical, industrial, medical

CAN layered architecture



CAN Framing


Standard Data Frame
Arbitration Field
Control Field
CRC Field
ACK Field
Bus idle
SOF
Identifier
RTR
IED
r
DLC
Data Field
CRC Sequence
DEL
ACK
DEL
EOF
ITM
Bus idle

CAN Framing

SOF: SOF stands for the start of frame, which indicates that the new frame is entered in a network. It is of 1 bit.

Identifier: A standard data format defined under the CAN 2.0 A specification uses an 11-bit message identifier for arbitration. Basically, this message identifier sets the priority of the data frame.

RTR: RTR stands for Remote Transmission Request, which defines the frame type, whether it is a data frame or a remote frame. It is of 1-bit.

Control field: It has user-defined functions.

IDE: An IDE bit in a control field stands for identifier extension. A dominant IDE bit defines the 11-bit standard identifier, whereas recessive IDE bit defines the 29-bit extended identifier.

DLC: DLC stands for Data Length Code, which defines the data length in a data field. It is of 4 bits.

Data field: The data field can contain upto 8 bytes.

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CAN Framing

CRC field:

The data frame also contains a cyclic redundancy check field of 15 bit, which is used to detect the corruption if it occurs during the transmission time. The sender will compute the CRC before sending the data frame, and the receiver also computes the CRC and then compares the computed CRC with the CRC received from the sender. If the CRC does not match, then the receiver will generate the error.

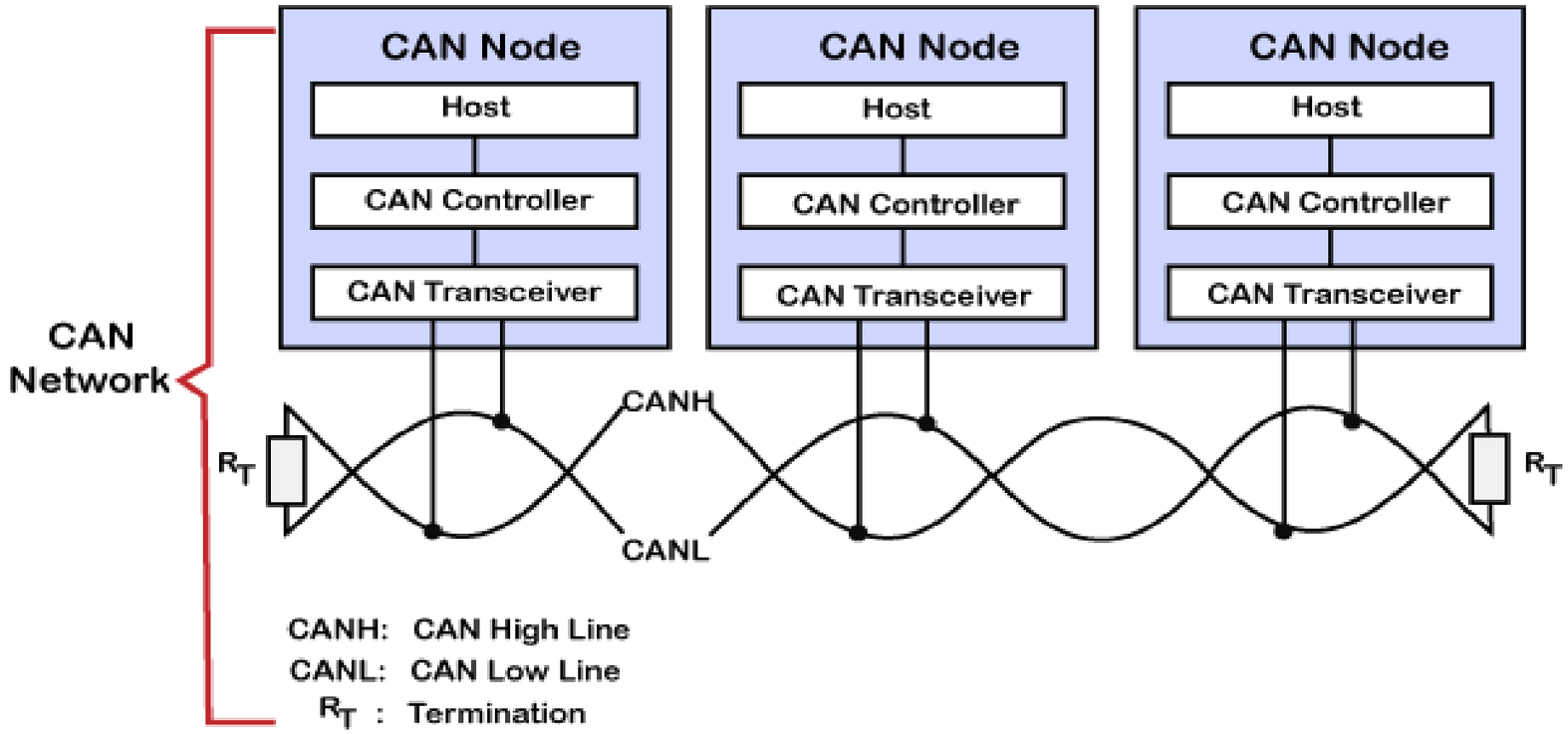
ACK field:

This is the receiver's acknowledgment. In other protocols, a separate packet for an acknowledgment is sent after receiving all the packets, but in case of CAN protocol, no separate packet is sent for an acknowledgment.

EOF:

EOF stands for end of frame. It contains 7 consecutive recessive bits known End of frame.

How data is transmitted through the CAN network



How data is transmitted through the CAN network

- A CAN network consists of multiple of CAN nodes. In the above case, we have considered three CAN nodes, and named them as node A, node B, and node C. CAN node consists of three elements which are given below

Host

A host is a microcontroller or microprocessor which is running some application to do a specific job. A host decides what the received message means and what message it should send next.

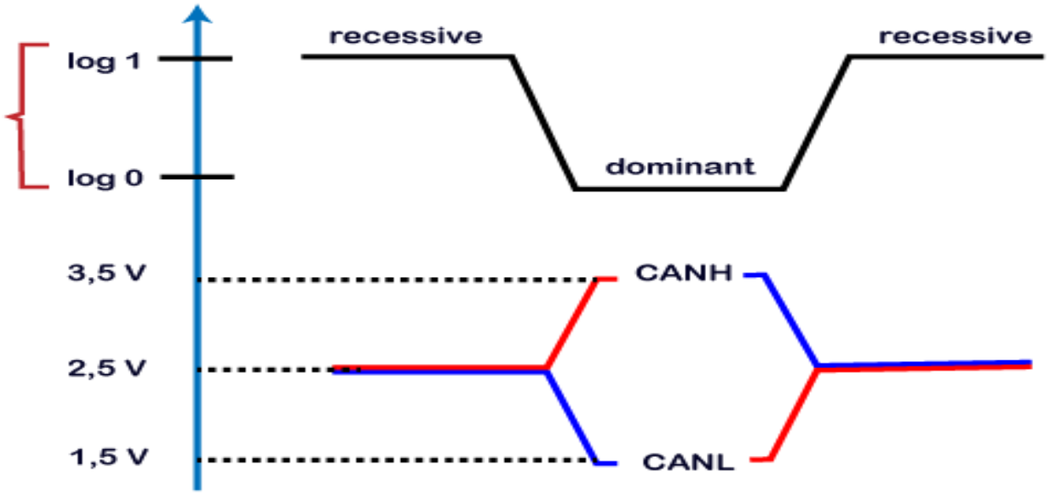
CAN Controller

CAN controller deals with the communication functions described by the CAN protocol. It also triggers the transmission, or the reception of the CAN messages.

CAN Transceiver

CAN transceiver is responsible for the transmission or the reception of the data on the CAN bus. It converts the data signal into the stream of data collected from the CAN bus that the CAN controller can understand.

CAN Characteristics



Key points learnt from the CAN characteristics

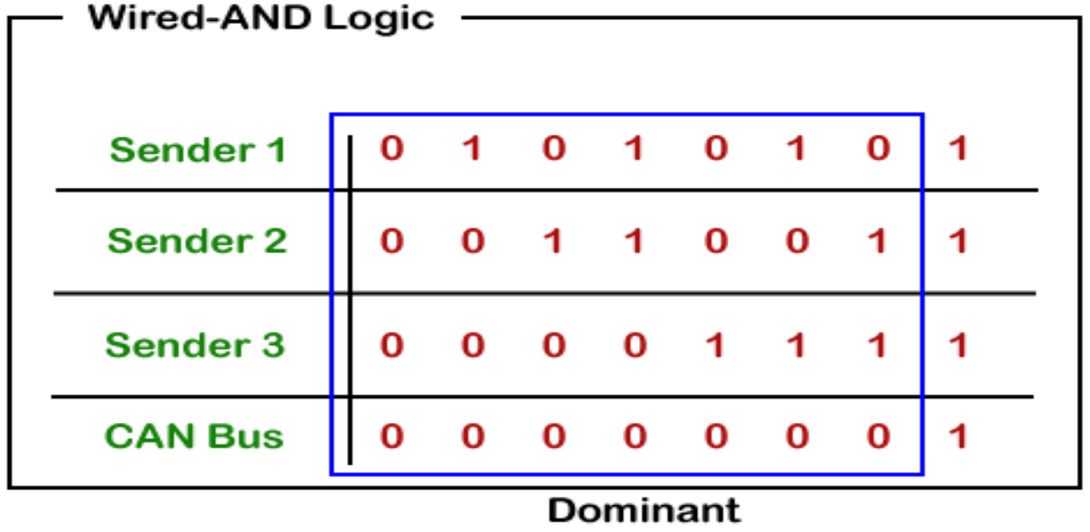
Logic 1 is a recessive state. To transmit 1 on CAN bus, both CAN high and CAN low should be applied with 2.5V

Logic 0 is a dominant state. To transmit 0 on CAN bus, CAN high should be applied at 3.5V and CAN low should be applied at 1.5V.

The ideal state of the bus is recessive.

If the node reaches the dominant state, it cannot move back to the recessive state by any other node.

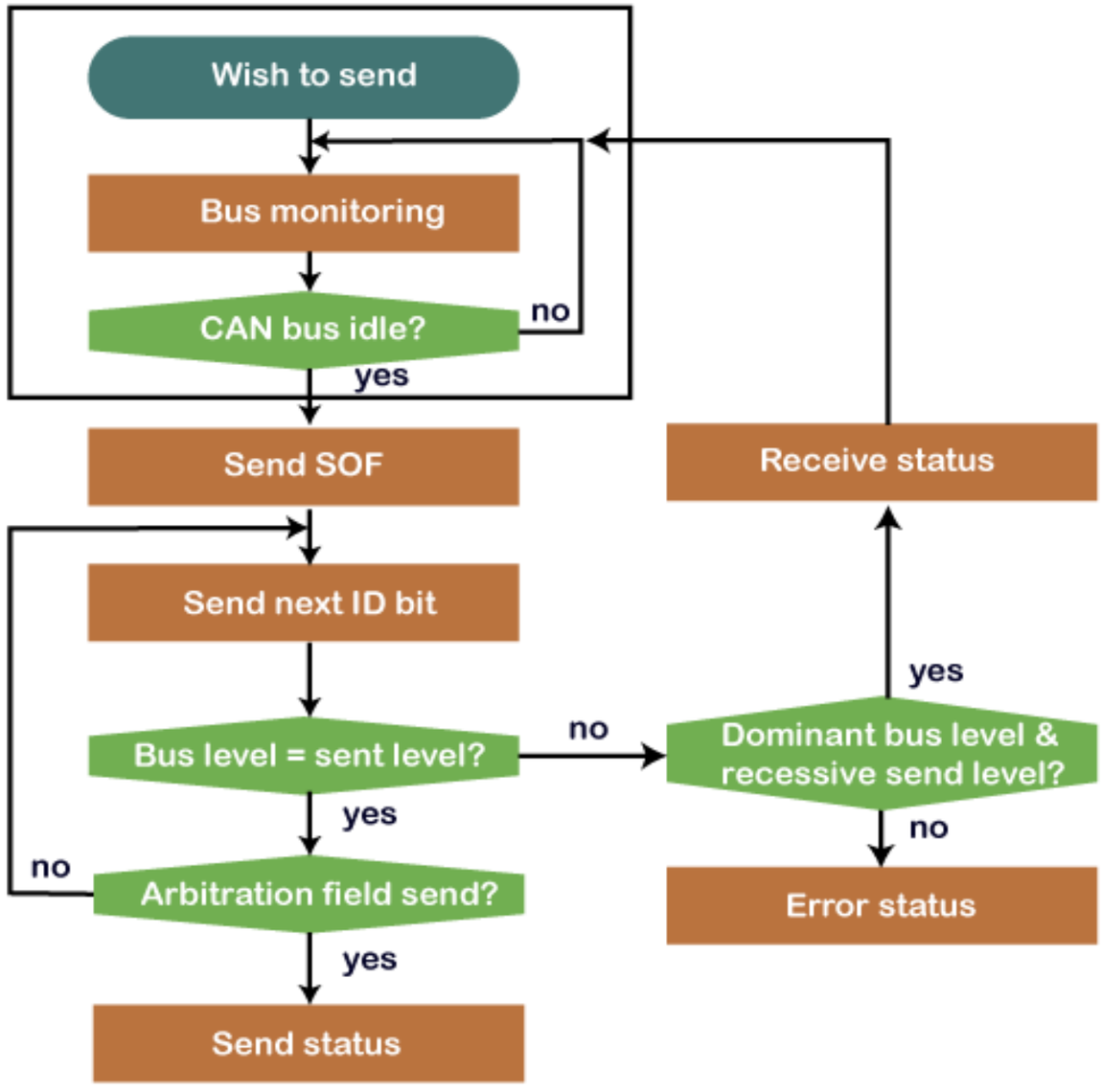
CAN bus logic



- From the above fig,we get to know that the dominant state overwrites the recessive state. When the node sends the dominant and the recessive bit simultaneously, then the bus remains dominant

- The recessive level occurs only when all the nodes send the recessive bit. Such logic is known as AND logic, and physically it is implemented as an open collector circuit

CAN Communication Principle



CAN Communication Principle

- For the standard frame, the message identifier is 11 bit, while for the extended frame, the message identifier is 29 bit
- It allows the system designer to design the message identifier at the design itself.
- The smaller the message identifier, the higher, would be the message priority

- The sender wants to send the message and waiting for the CAN bus to become idle. If the CAN bus is idle, then the sender sends the SOF or the dominant bit for the bus access
- Then, it sends the message identifier bit in the most significant bit. If the node detects the dominant bit on the bus while it has transmitted the recessive bit, it means that the node has lost the arbitration and stops transmitting further bits
- The sender will wait and resend the message once the bus is free.

Bluetooth

- Bluetooth is a wireless technology that enables a wireless device to communicate in the 2.4 GHz industrial, scientific and medical (ISM) band

- It has been specifically designed as a low cost, low power radio technology, which is particularly suited for the short range personal area network (PAN) application.

Bluetooth

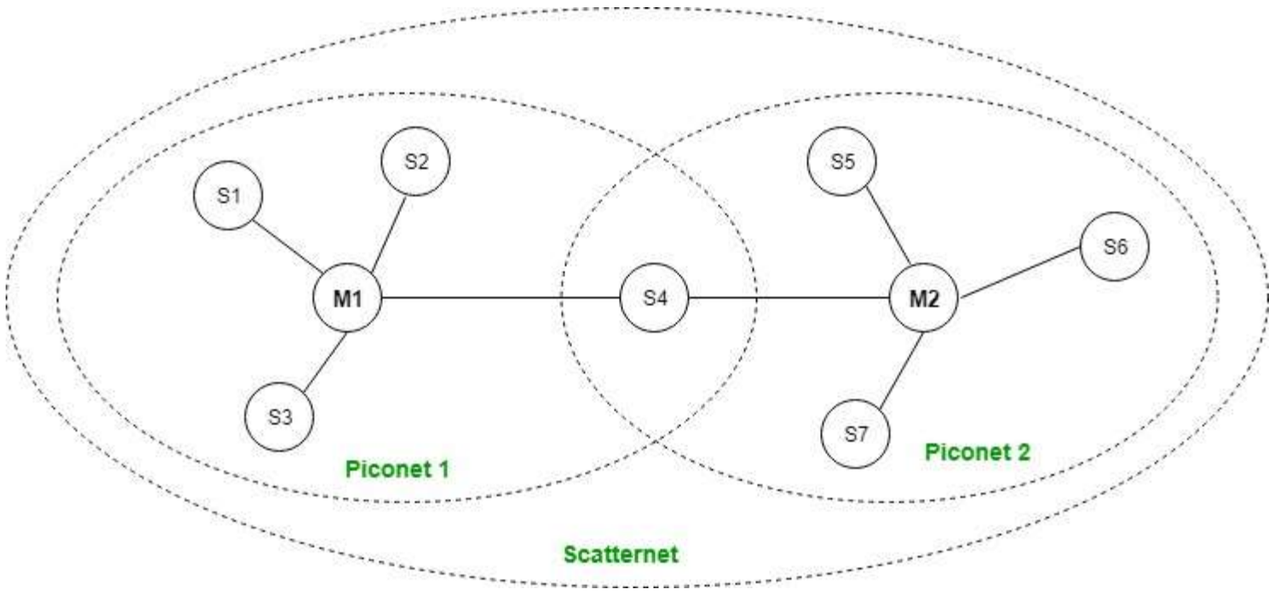
- Bluetooth simply follows the principle of transmitting and receiving data using radio waves
- It can be paired with the other device which has also Bluetooth but it should be within the estimated communication range to connect
- When two devices start to share data, they form a network called piconet which can further accommodate more than five devices

Points to remember for Bluetooth:

- Bluetooth Transmission capacity 720 kbps
- Bluetooth is Wireless
- Bluetooth is a Low-cost short-distance radio communications standard
- Bluetooth is robust and flexible.
- Bluetooth is cable replacement technology that can be used to connect almost any device to any other device.
- The basic architecture unit of Bluetooth is a piconet.

Bluetooth Architecture

1. Piconet
2. Scatternet



Bluetooth Architecture

Piconet:

- Piconet is a type of Bluetooth network that contains **one primary node** called the master node and **seven active secondary nodes** called slave nodes
- Thus, we can say that there is a total of 8 active nodes which are present at a distance of 10 meters. The communication between the primary and secondary nodes can be one-to-one or one-to-many
- Possible communication is only between the master and slave; Slave-slave communication is not possible
- It also has **255 parked nodes**, these are secondary nodes and cannot take participation in communication unless it gets converted to the active state.

Scatternet:

- It is formed by using **various piconets**. A slave that is present in one piconet can act as master or we can say primary in another piconet.
- This kind of node can receive a message from a master in one piconet and deliver the message to its slave in the other piconet where it is acting as a master.
- This type of node is referred to as a bridge node. A station cannot be mastered in two piconets

Bluetooth Architecture

Types of Bluetooth

- Various types of Bluetooth are available in the market nowadays. Let us look at them
- In-Car Headset: One can make calls from the car speaker system without the use of mobile phones
- Stereo Headset: To listen to music in car or in music players at home
- Webcam: One can link the camera with the help of Bluetooth with their laptop or phone
- Bluetooth-equipped Printer: The printer can be used when connected via Bluetooth with mobile phone or laptop.
- Bluetooth Global Positioning System (GPS): To use GPS in cars, one can connect their phone with car system via Bluetooth to fetch the directions of the address

Bluetooth Architecture

Advantage:

It is a low-cost and easy-to-use device.
It can also penetrate through walls.
It creates an Ad-hoc connection immediately without any wires.
It is used for voice and data transfer.

Disadvantages:

It can be hacked and hence, less secure.
It has a slow data transfer rate: of 3 Mbps.
It has a small range: 10 meters.
Bluetooth communication does not support routing.
The issues of handoffs have not been addressed.

Applications:

It can be used in laptops, and in wireless PCs, printers.
It can be used in wireless headsets, wireless PANs, and LANs.
It can connect a digital camera wirelessly to a mobile phone.
It can transfer data in terms of videos, songs, photographs, or files from one cell phone to another cell phone or computer.
It is used in the sectors of Medical health care, sports and fitness, Military.

THANK YOU