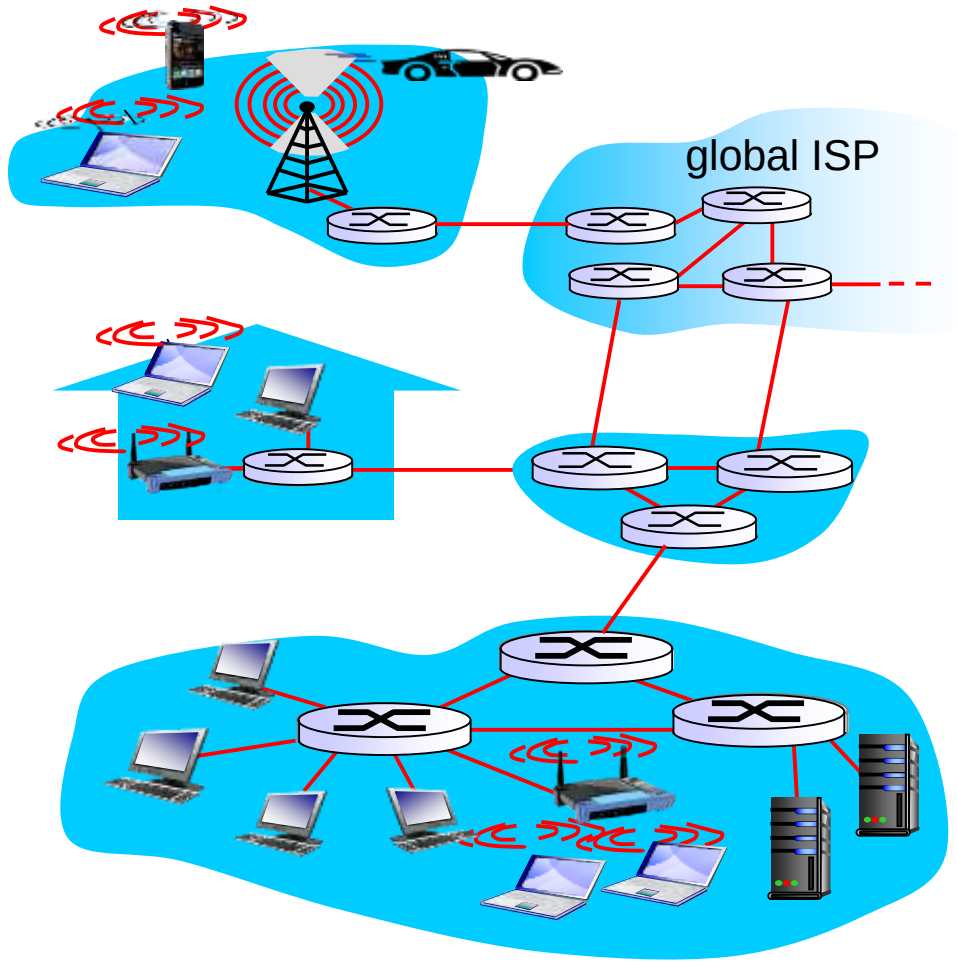
Introduction of Data Link Layer

Introduction

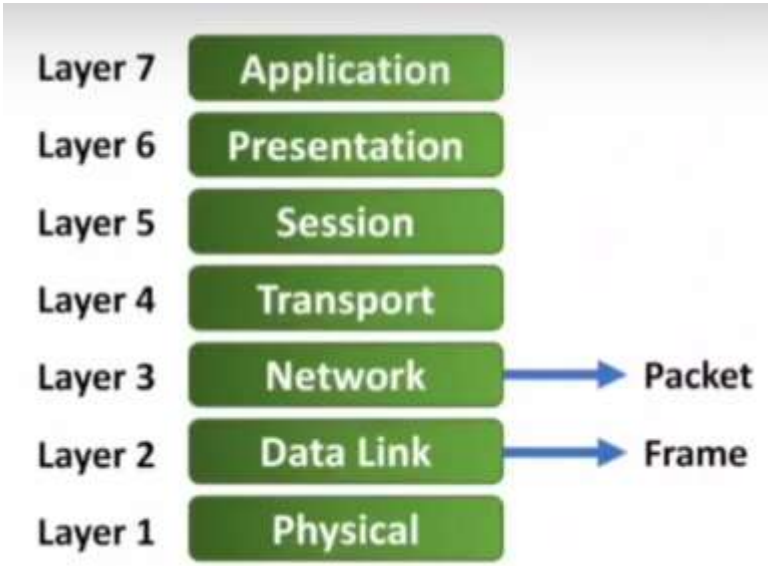
- Host and routers are as nodes.
- Communication channels that connect adjacent nodes along communication path, it's called links.
  - Wired links
  - Wireless links
  - LANs
- In this layer, Frame is form from packets.
- It does physical addressing by adding MAC Address of source and destination.
- This layer has responsibility of transferring datagram from one node to physically adjacent node over a link.

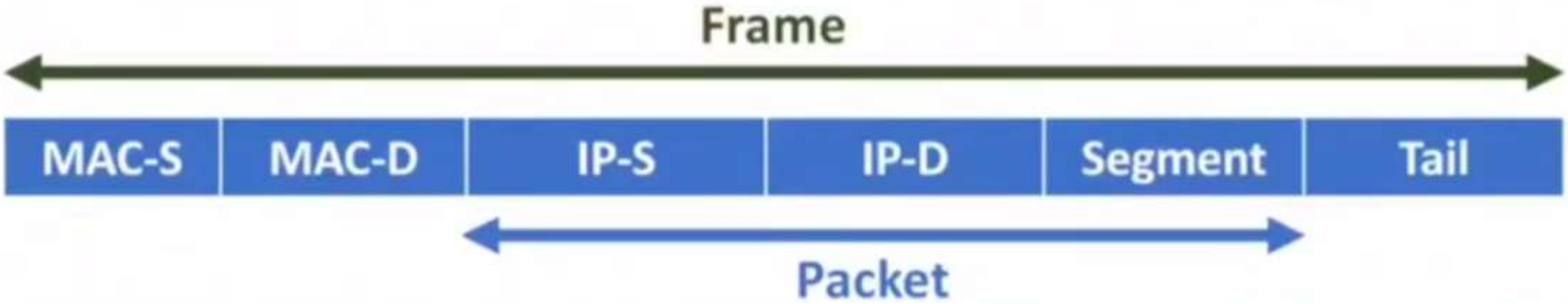


Diff of IP & MAC Address

- IP stands for Internet Protocol
- IP addess is a Logical Address.
- Ex.ITM University,paldi,Vadodara,gujrat
- The length of IP is 32 bit for IPV4 & 128 bit for IPV6.
- ISP provides IP address.
- We can change the IP address any device at any time.
- It is software oriented.
- An IP address identifies a connection to the device.
- Ex.---- 192.168.23.10

- MAC stands for Media Access Control.
- MAC is a Physical Address.
- ITM university
- The length of MAC is 48 bit.
- NIC manufacturer provides the MAC address.
- MAC address can be changed only if we change the LAN card of the device.
- It is hardware oriented
- MAC address identifies a device.
- Ex- 50-15-6d-9e-a5-30


Layer 7
Application
Layer 6
Presentation
Layer 5
Session
Layer 4
Transport
Layer 3
Network
Packet
Layer 2
Data Link
Frame
Layer 1
Physical


Frame
MAC-S
MAC-D
IP-S
IP-D
Segment
Tail
Packet

Link Layer Services

- **Framing**
  - Encapsulate datagram into frame.
  - Adding header and trailer.
- **Link Access**
  - “MAC” addresses used in frame headers to identify source and destination. It is different from IP address.
- **Reliable Delivery**
  - If this layer protocol provides reliable delivery service, it guarantees to move each network-layer datagram across the link without error.
  - A link-layer reliable delivery service can be achieved with acknowledgments and retransmissions.
- **Flow Control**
  - Pacing between adjacent sending and receiving nodes.

Link Layer Services – Cont…

- Error Detection & Correction
  - Errors caused by signal attenuation and noise.
  - Receiver detects presence of errors.
  - Sender send signal for retransmission or drops frame.
  - Receiver identifies *and corrects* bit error(s) without resorting to retransmission.

Error Detection & Correction Technique

- Techniques for error detection
  - Parity Check
  - Checksum Method
  - Cyclic Redundancy Check

Parity Check

- One extra bit is sent along with the original bits to make number of 1s either even in case of even parity, or odd in case of odd parity.
- For example, if even parity is used and number of 1s is even then one bit with value 0 is added. This way number of 1s remains even.
- If the number of 1s is odd, to make it even a bit with value 1 is added.

Parity Check – Cont…

- Receiver counts the number of 1s in a frame. If the count of 1s is even and even parity is used, the frame is considered to be not-corrupted and is accepted.
- If the count of 1s is odd and odd parity is used, the frame is still not corrupted.
- If a single bit flips in transit, the receiver can detect it by counting the number of 1s.
- But when more than one bits are erroneous, then it is very hard for the receiver to detect the error.

Parameters	Even Parity	Odd Parity
Definition	Ensures that total count of bits is even.	Ensures that total count of bits is odd.
Parity bit assignment	Set to 1 if count of ones is odd.	Set to 1 if count of ones is even.
Error detection	Detects errors based on even count of bits.	Detects errors based on odd count of bits.
Bit manipulation	Adjust parity bit for the even count of bits.	Adjust the parity bit for the odd count of bits.
Implementation	Sets parity bit to ensure the even count of bits.	Sets parity bit to ensure the odd count of bits
Transmission overhead	Adds overhead based on the even count of bits.	Adds overhead based on odd count of bits.
Robustness	Robust against single-bit errors.	Provides robustness against single-bit errors.
Common usage	More common in certain systems and protocols.	Preferred in other systems and protocols.
Error correction	Can detect errors but cannot correct them.	Can detect errors but cannot correct them.
Verification process	Check if total count satisfies even parity.	Check if total count satisfies odd parity.

Datawords & Codewards

0-15

Simple parity-check code C(5, 4)

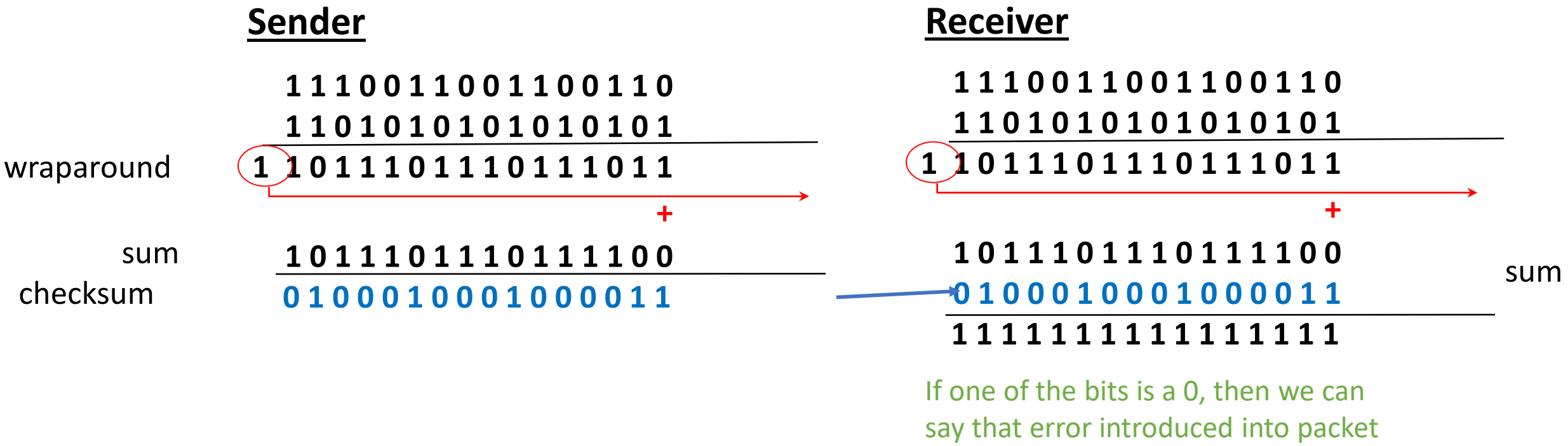
Datawords	Codewords	Datawords	Codewords
0000	00000	1000	10001
0001	00011	1001	10010
0010	00101	1010	10100
0011	00110	1011	10111
0100	01001	1100	11000
0101	01010	1101	11011
0110	01100	1110	11101
0111	01111	1111	11110

Checksum

- Data is divided into k segments each of n bits.
- Sender Side: Segments are added using 1’s complement arithmetic to get the sum.
- Sum is complemented to get the checksum.
- Checksum segment is sent along with the data segments.
- Receiver Side: All received segments are added using 1’s complement arithmetic to get complemented sum.
- If the result is zero, the received data is accepted; otherwise discarded.

Checksum - Example

- Add two 16-bit integers word



Note *:* when adding numbers, a carryout from the most significant bit needs to be added to the result

Cyclic Redundancy Check

- CRC is the most powerful and easy to implement technique.
- CRC is based on binary division.
- In CRC, a sequence of redundant bits, are appended to the end of data unit so that the resulting data unit becomes exactly divisible by a second, predetermined binary number.
- At the destination, the incoming data unit is divided by the same number.
- If at this step there is no remainder, the data unit is assumed to be correct and is therefore accepted.
- A remainder indicates that the data unit has been damaged in transit and therefore must be rejected.
- The binary number, which is (r+1) bit in length, can also be considered as the coefficients of a polynomial, called Generator Polynomial.

CRC – Example:1

original message
1 0 1 0 0 0 0

@ means X-OR

Generator polynomial
x^3+1
$1.x^3+0.x^2+0.x^1+1.x^0$
CRC generator
1 0 0 1 4-bit

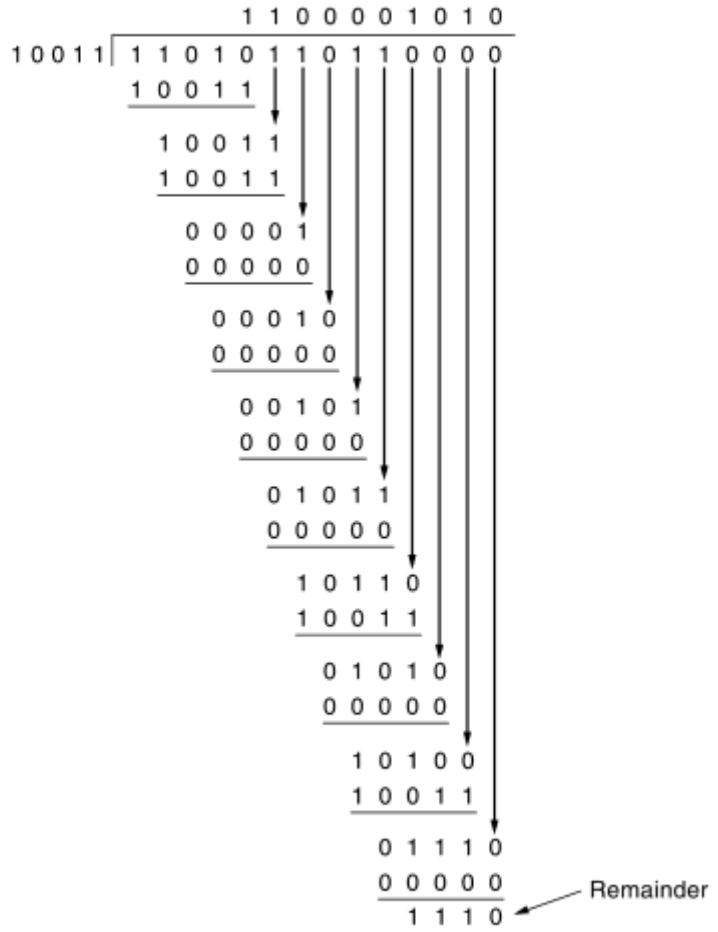
If CRC generator is of n bit then append (n-1) zeros in the end of original message

CRC – Example:2

Frame : 1 1 0 1 0 1 1 0 1 1

Generator: 1 0 0 1 1

Message after 4 zero bits are appended: 1 1 0 1 0 1 1 0 1 1 0 0 0



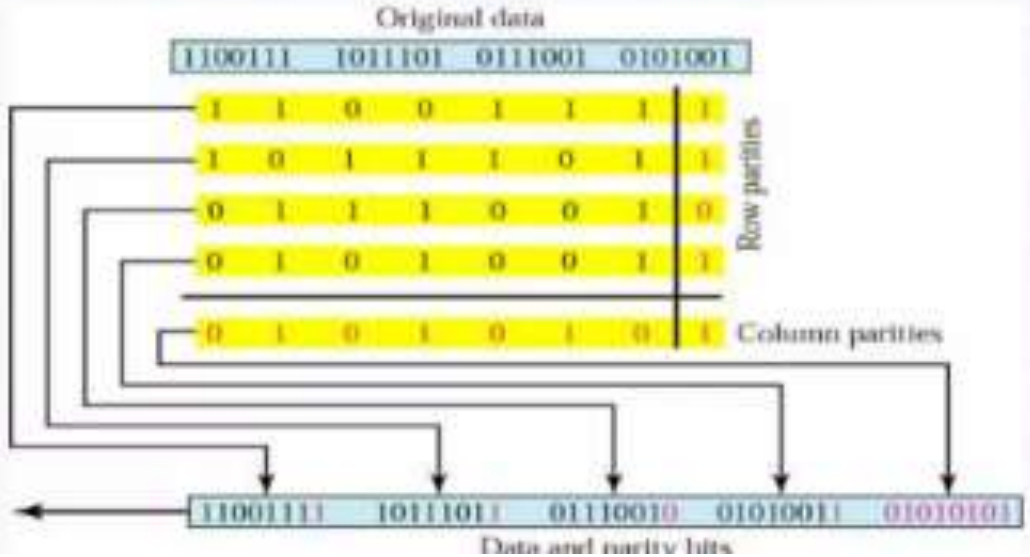
Transmitted frame: 1 1 0 1 0 1 1 0 1 1 1 1 0

BLOCK PARITY

Two Dimensional Parity Check(LRC)

Longitudinal Redundancy Check

- In two-dimensional parity check, a block of bits is divided into rows and a redundant row of bits is added to the whole block.
- Even Parity Concept



Two Dimensional Parity check(Cont.)

Parity Generation

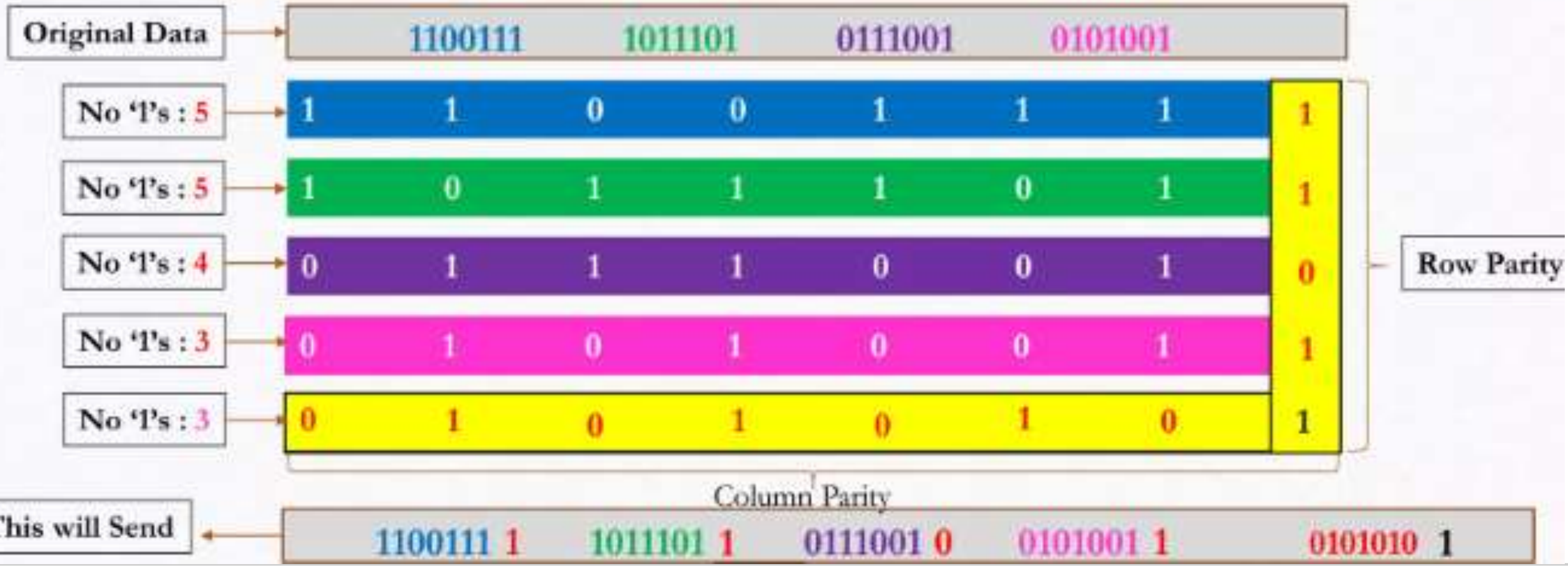
- **A block of bits is organized in a table (rows & columns) a parity bit is calculated for each row and column.**
- **Compute (m + n + 1) parity bits and send (mn + m + n + 1) bits**

1) Adds a parity bit to each character then adds a row of parity bits after a block of characters
2) The row of parity bits is actually a parity bit for each "column" of characters
3) The row of parity bits plus the column parity bits add a great amount of redundancy to a block of characters

- Lets see this with an example:

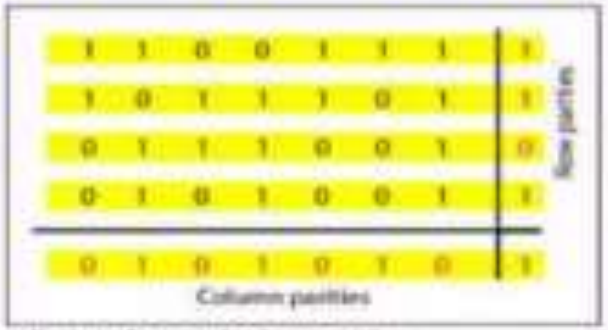
Two Dimensional Parity Generation

Even Parity Concept

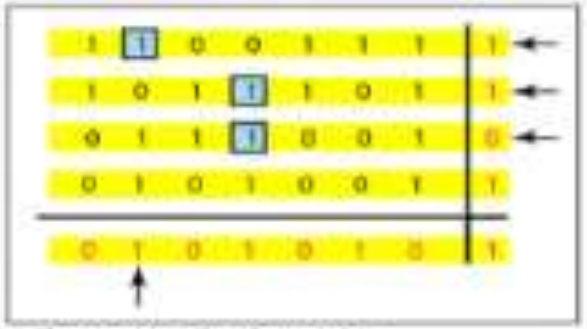


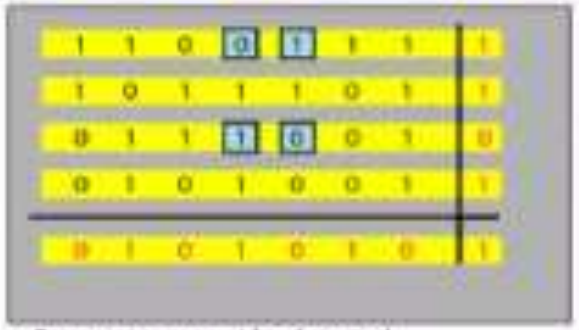
Drawbacks of 2D Parity Check

- 4- and more bit errors can be detected in some cases



a. Design of row and column parities


d. Three errors affect four parities


e. Four errors cannot be detected

- 1 affect 2 , 2 affect 3, 3 affect 4, 4 affect 4 – so Can not detect in this case
- Disadvantage: too many check bits !!!
- Can not detect errors, if 2 bits in one data unit are changed and 2 bits in exactly the same position in another data unit is changed.

SUMMARY

- Parity checking is a means of checking if the communication of a sequence of bits has been correctly received.
- Parity bit is an extra bit that is attached to the data bits/Signal that is being transferred from one location to another.
- The two types of most commonly used parity checking are:

Single Parity Check

- odd parity
- even parity

2D Parity Check

- Single Parity bit checking can detect single error only, double errors will not be detected. Even the 2D parity is not efficient and can not use in some cases.