GLS University
Faculty of Computer Application & IT

SY BCA
Semester - IV
2024-2025

210301404
Data Communication & Networks (DCN)
(Core Subject)

Unit 2
Multiplexing and Demultiplexing

Supplementary Reading :

1. Forouzan, B. A. (2001). Data Communication and Networking. Tata McGraw Hill Education Private Limited.
2. Godbole, A. S. (2002). Data Communication and Computer Networks. Tata McGraw-Hill Companies.

Topics to be Covered :

Transmission Errors: Detection and correction
- Introduction
- **Error classification**
    - o Delay Distortion
    - o Attenuation
    - o Noise
- **Types of Error**
- **Error Detection**
    - o Checksum
    - o VRC
    - o LRC
    - o CRC
- **Recovery from errors**
    - o Stop and Wait
    - o Go back n
    - o Sliding Window

Concept of Multiplexing and Demultiplexing

- Types of Multiplexing

o FDM

o TDM

o WDM

- FDM versus TDM

# TDM – Time Division Multiplexing - Synchronous
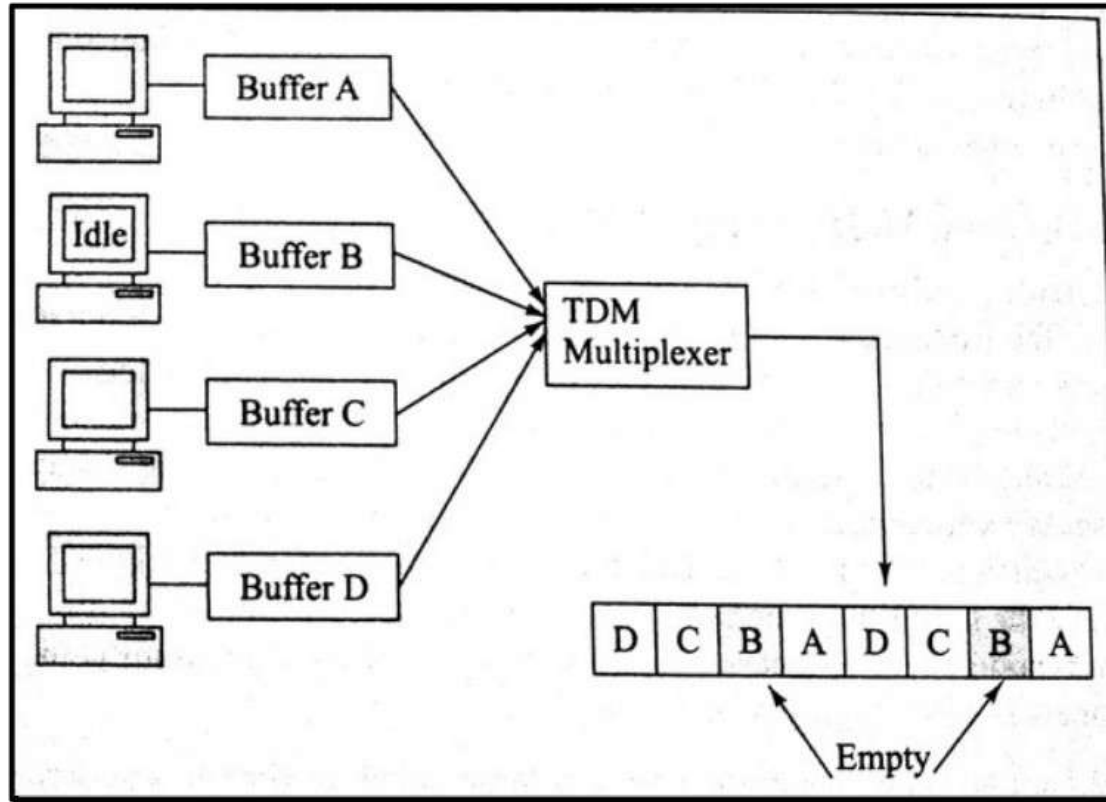
TDM – Time Division Multiplexing - Asynchronous

- An asynchronous TDM is also called as a Statistical TDM. ATDM has been designed to solve the problem of wastage of the multiplexed channels in synchronous TDM.
- In ATDM, if there are n input lines, then each slot can contain m frames, where m is less than n, as shown in the figure .
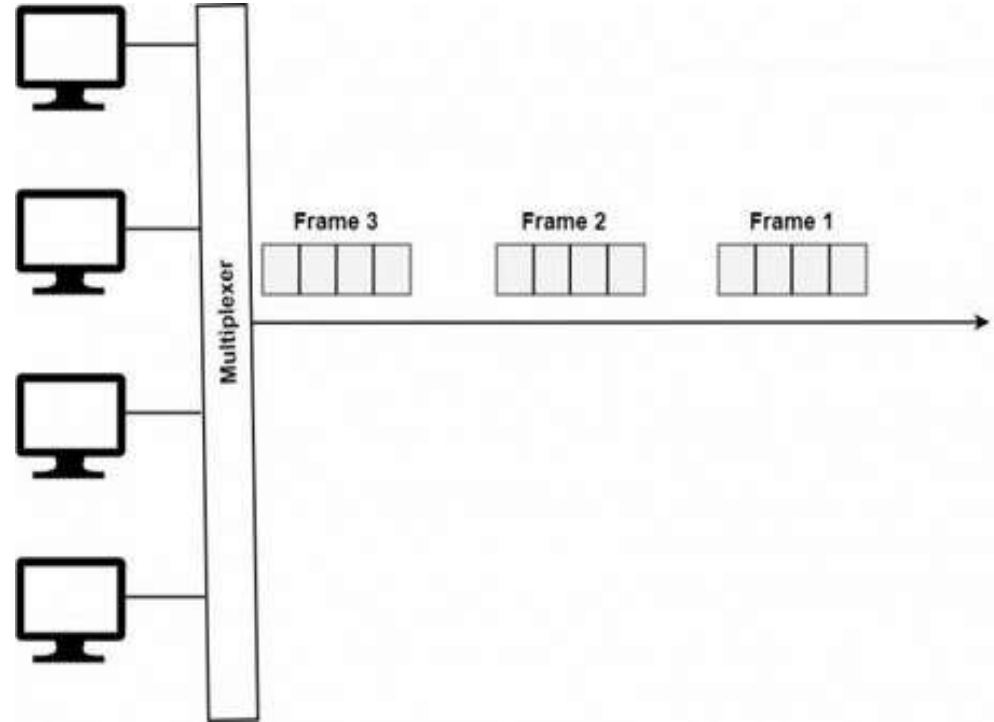
TDM – Time Division Multiplexing - Asynchronous

In ATDM, the **multiplexer scans all the input lines and accepts the portions of data till the frame is filled. When the frame is filled, it is sent across the link. If the senders don't have enough data to fill the frame, it is transmitted as partially filled. This is depicted in the figure.**
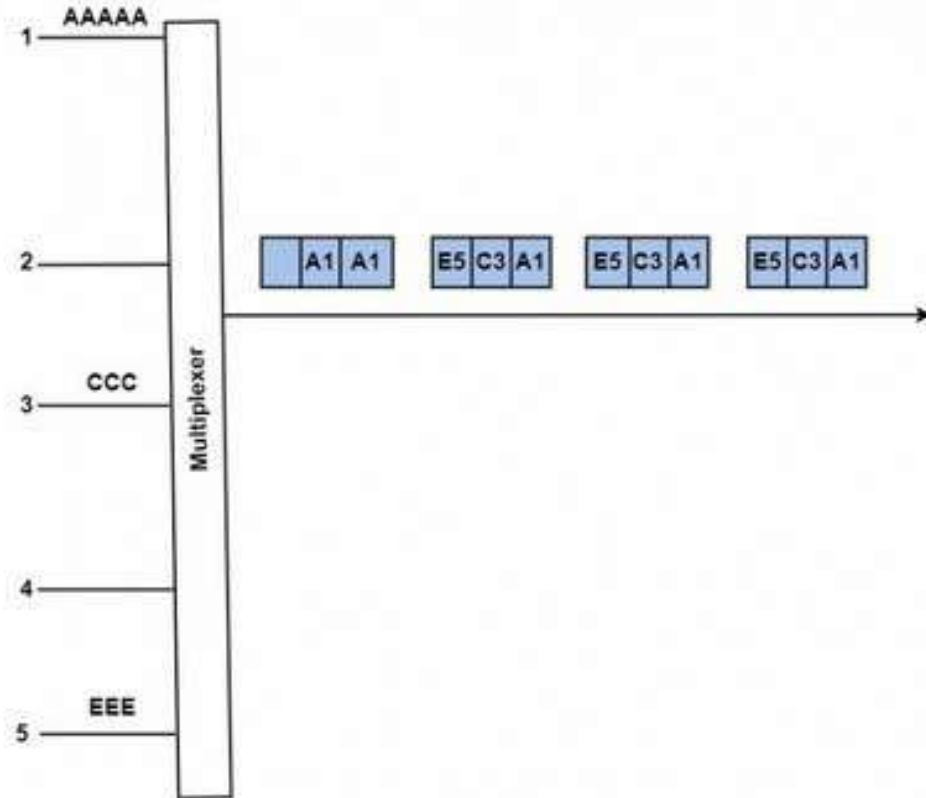
WDM – Wavelength Division Multiplexing

- In this transmission medium, copper wire is not used but it uses optical fiber.   Also it is variation of the basic FDM scheme.
- In WDM transmission multiple optical fibers are combined and sent together.
- In FDM the transmission from various sources are combined and sent together   on the basis of their frequencies, here in WDM transmissions are combined on the basis of the difference between the wavelengths.
- The transmissions from various optical fibers are combined on the sender's side. These transmissions have different wavelengths. The combined transmission is sent to the other side via a single and more powerful optical fibers.
- At the receiver's end, the individual transmissions are retrieved by filtering out the individual source signals on the basis of their wavelengths.
- WDM is similar to FDM, except that very high frequencies are used in WDM. When there are more than 200 different channels to share a single high capacity optical fiber line. In such a case, where a significant number of input sources are combined into a single channel, we call it as Dense WDM(DWDM).

WDM – Wavelength Division Multiplexing
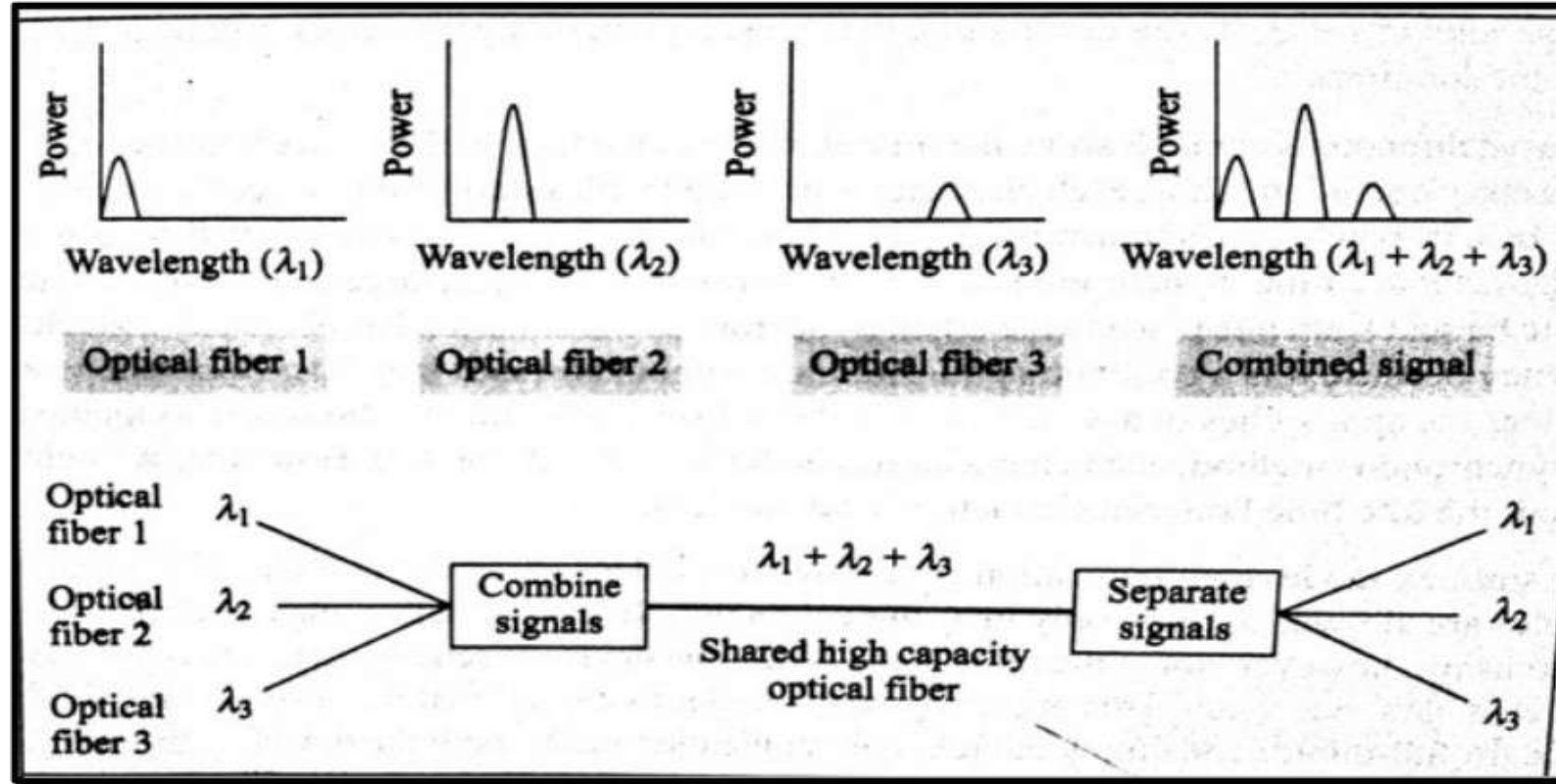
FDM Vs. TDM

| S.NO	TDM	FDM
1.	TDM stands for Time division multiplexing.	FDM stands for Frequency division multiplexing.
2.	TDM works with digital signals as well as analog signals.	While FDM works with only analog signals.
3.	TDM has low conflict.	While it has high conflict.
4.	Wiring or chip of TDM is simple.	While it's wiring or chip is complex rather than simple.
5.	TDM is efficient.	While it is inefficient.
6.	In TDM, time sharing takes place.	While in this, frequency sharing takes place.
7.	In TDM, synchronization pulse is necessary.	While in it Guard band is necessary.

Transmission Errors: Detection and correction

- In Data Communication Networks **electromagnetic signals** can cause incorrect delivery of data. Due to this data in the communication can be received incorrectly or data can be lost or unwanted data can be generated. Any of these problems are called transmission errors in communication networks.
- Error is a condition when the output information does not match with the input information. During transmission, digital signals suffer from noise that can introduce errors in the binary bits travelling from one system to other. That means a 0 bit may change to 1 or a 1 bit may change to 0.
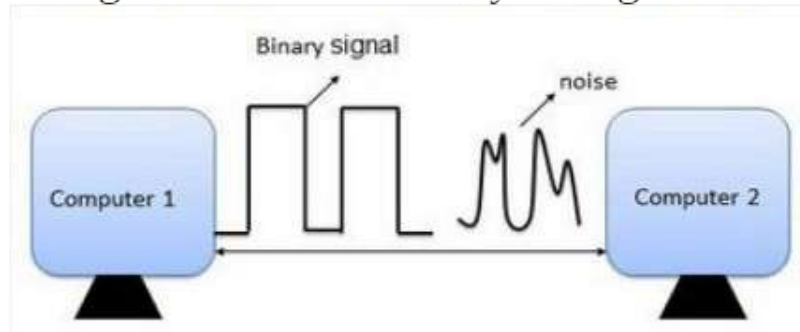
Transmission Errors: Detection and correction

- The errors can be classified in three basic categories as given below:
  - **Delay distortion**
  - **Attenuation**
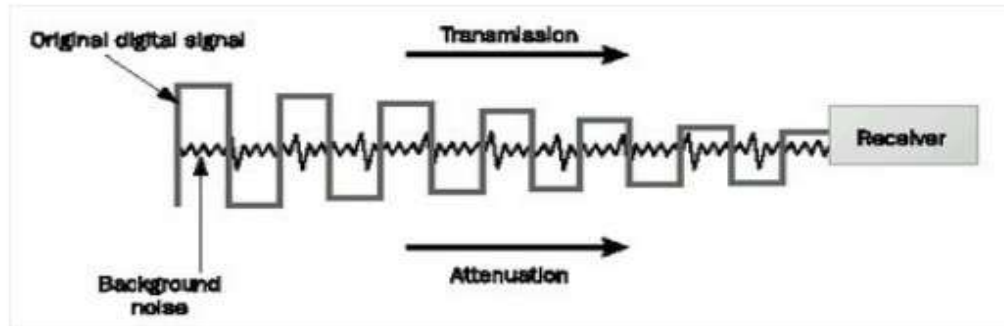 - **Noise**
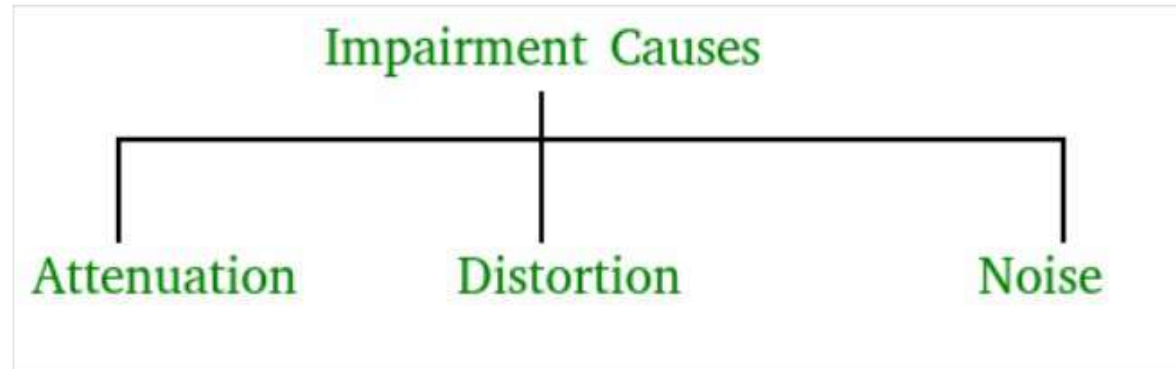
Transmission Errors: Detection and correction

- The errors can be classified in three basic categories as given below:
  - **Delay distortion**
  - **Attenuation**
  - **Noise**
- **Delay Distortion**
- Delay   Distortion is caused because signals at different frequencies travel at   different speeds along the medium.
- Any complex signal can be decomposed into different sinusoidal signals (Component signals) of different frequencies resulting in a frequency   bandwidth for every signal.
- The property of signal propagation is such that the speed of travel of frequency at the center of this bandwidth is highest and this speed is low at both ends of the frequency bandwidth.
- At the receiving end, signals with different frequency in a given bandwidth will arrive at different times. Hence at the receiver, if the receiving frequencies are measured at a specific time, they will not measure up to the original signal   resulting in its **misinterpretation**.

Transmission Errors: Detection and correction

- **Attenuation:**
- Attenuation is another form of **distortion**.
- In attenuation , as a signal travels through any medium, its strength decreases. For ex. Just like our voice becomes weak over a distance and loses its contents beyond a certain distance.
- Attenuation means loss of energy. When any signal travels over a medium or channel, it loses some of its energy in the form of heat in the resistance of the medium. Attenuation decides the signal to noise ratio hence the quality of received signal.
- Attenuation is very small at short distances, it increases with distance.

Original digital signal   Transmission

Receiver

Background noise   Attenuation

Transmission Errors: Detection and correction

- **Noise:**
- The random/unwanted signal mixes up with the original signal is called noise.
- When signals travel as electromagnetic signals through any medium, some electromagnetic energy get inserted somewhere during transmission – **called Noise**
- There are several types of noise such as induced noise, crosstalk noise, thermal noise and impulse noise which may corrupt the signal.
- **Induced noise** comes from sources such as motors and appliances. These devices act as sending antenna and transmission medium act as receiving antenna. **Thermal noise** is movement of electrons in wire which creates an extra signal. **Crosstalk noise** is when one wire affects the other wire**. Impulse noise** is a signal with high energy that comes from lightning or power lines.
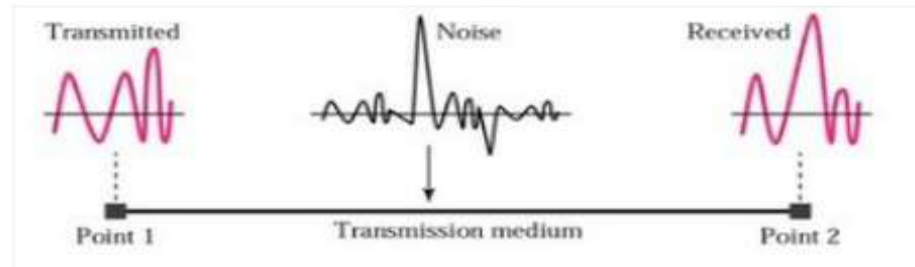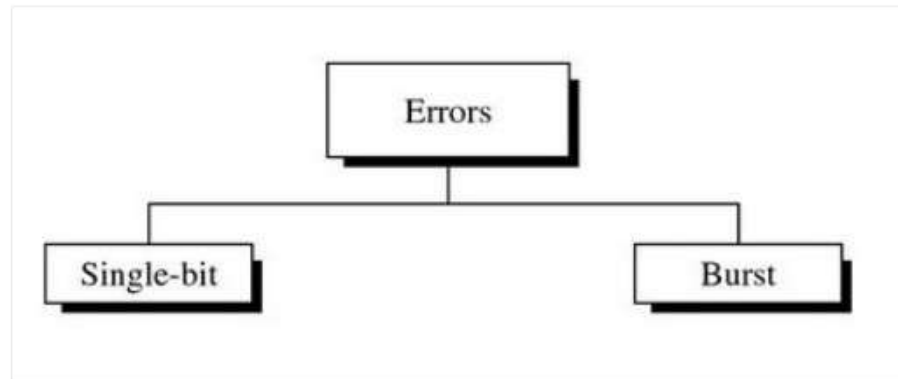
Types of Errors

- **Types of Errors:**
  - If the signal is carrying binary data there can be two types of errors.
   **1. Single bit errors**
  - **2. burst errors.**
  - In single bit errors a bit value of 0 changes to 1 and vice versa.
  - In burst error, multiple bits of binary value are changed.

Types of Errors

- **Single Bit Error:**
- It means only one bit of data unit is changed from 1 to 0 or from 0 to 1 as shown in fig:
- Single bit error can happen in **parallel transmission** where all the data bits are transmitted using separate wires.

0	0	1	0	0	1	1	0	Data Sent

Changed bit

| 0	0	1	0	0	0	1	0	Data received

Single Bit error
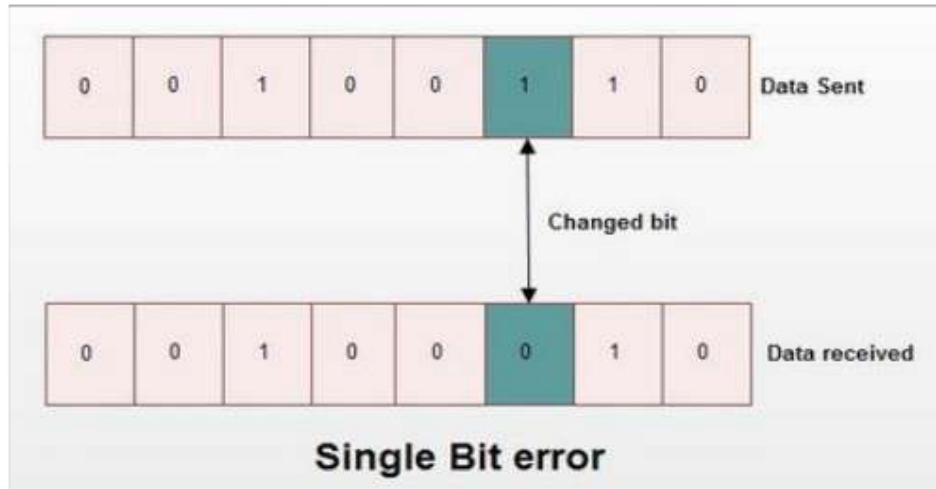
Types of Errors

- **Burst Error:**
- It means two or more bits in data unit are changed from 1 to 0 from 0 to 1 as shown in fig:
- Burst error does not necessarily mean that errors occur in consecutive bits.
- Most likely to happen in **serial transmission.**
- The length of burst error is measured from first changed bit to last changed bit.
- As shown in fig. length of burst error is 8, although some bits are unchanged in between.
- Number of bits affected depends on the data rate and duration of noise.

Burst Error

Types of Errors

Figure 1
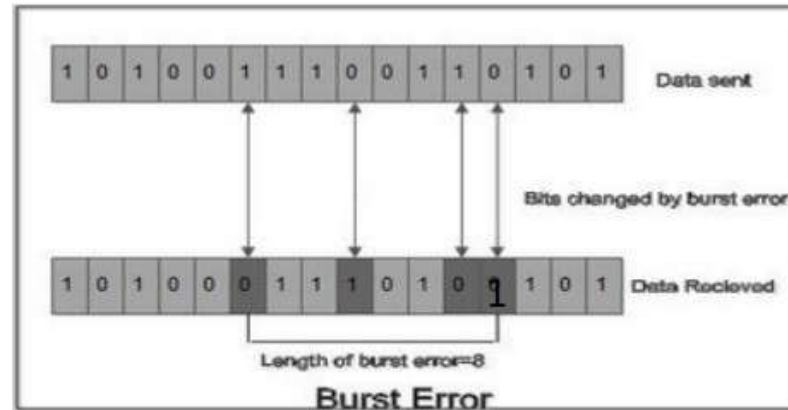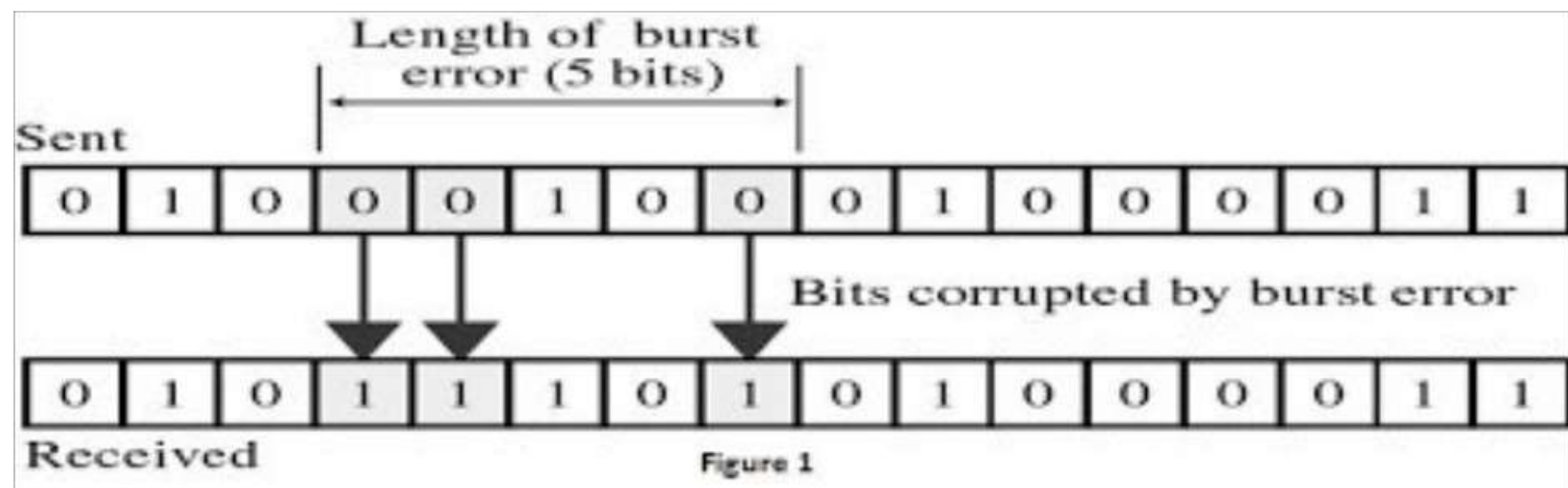
Error Detection

- **Error Detection:**
- Whenever a message is transmitted, it may get scrambled by noise or data may get corrupted. To avoid this, we use error-detecting codes which are additional data added to a given digital message to help us detect if any error has occurred during transmission of the message.
- Basic approach used for error detection is the use of redundancy bits, where additional bits are added to facilitate detection of errors.
- **Some popular techniques for error detection are:**
  - **Checksum**
  - **Vertical Redundancy Check(VRC) or Parity Check**
  - **Longitudinal Redundancy Check(LRC)**
  - **Cyclic Redundancy Check(CRC)**

Error Detection

- **Checksum:**
- A **checksum** also called **hash sum** is fixed-length data that is the result of performing certain operations on the data to be sent from the sender to the receiver.
- The sender runs the appropriate checksum algorithm to compute the checksum of the data, appends it as a field in the packet that contains data to be sent as well as headers.
- When the receiver receives the data the receiver runs the same checksum algorithm to compute a fresh checksum.
- The receiver compares freshly computed checksum with the checksum that was computed by the sender.
- If the two checksums match, the receiver of the data is assured that the data has not changed during transmission.
- Various checksum algorithms are popular. Most common are **parity check, modular sum, position-dependent checksum, etc.**
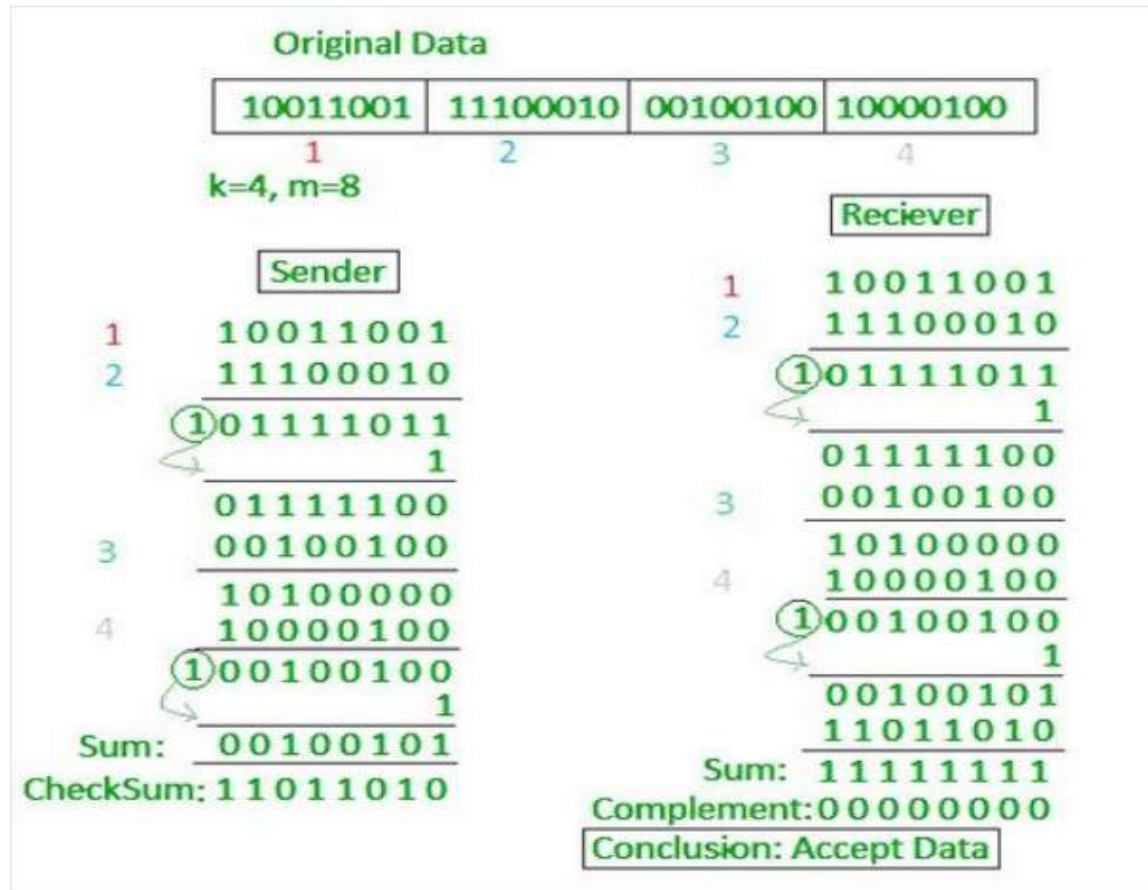
Error Detection

- **Checksum:**
- In **modular sum**, the data that the sender is sending is arranged into smaller blocks called **words.** For example, if the data stream that needs to be sent is 11001000011111100110, then we can make up 5 words, each containing 4 bits.   The 5 words are:
  - 1100   1000   0111   1110   0110
  - This is the 5 words are added.

$$
\begin{array}{r}
1100 \\
1000 \\
0111 \\
1110 \\
0110 \\
\hline
101111
\end{array}
$$

- The result is 101111. Find complement – 010000. Then 2's complement of the result is found, which is equal to 010001. This value is considered as the checksum and is sent along with the data. The receiver computes a fresh   checksum and compares it with received checksum.

Error Detection

- **Checksum:**
- Example- 4-bit numbers are: 7, 11, 12, 0, 6
- Message to be sent:7,11,12,0,6,36 [7+11+12+0+6=36]
- Receiver adds actual nos. and compares with the sum(36)
- If the two are the same receiver assumes no error, nos. accepted and sum discarded.
- Else an error somewhere and data are not accepted.
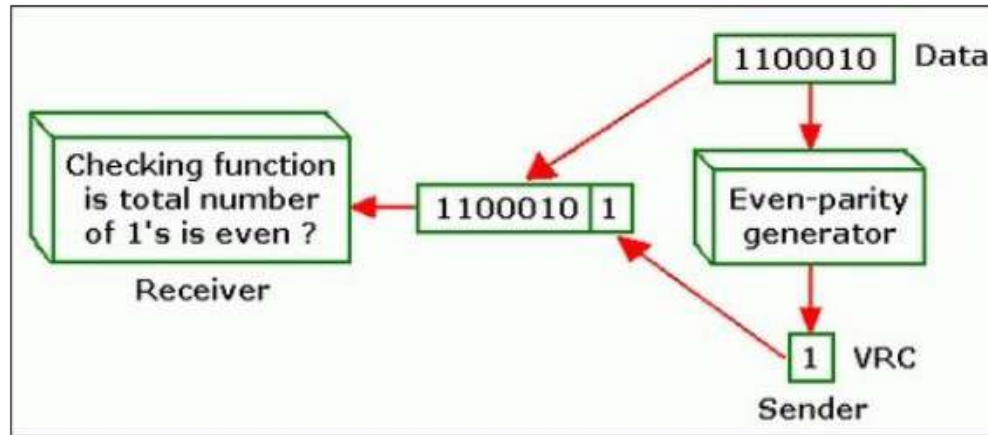
Error Detection- checksum

Error Detection

- **Vertical Redundancy Check(VRC) or Parity Check:**
- **Vertical Redundancy Check(VRC)** also known as **parity check**.
- It is least expensive technique.
- In this method, the sender appends a single additional bit called the **parity bit,** to the message before transmitting it.
- There are two types i.e. **odd parity and even parity.**
- In **odd parity,** given some bits, an additional bit is added in such a way that the number of 1s in the bits inclusive of the parity bit is **odd**.
- In **even parity**, the parity bit is added such that the number of 1s inclusive if the parity bit is **even**.

Error Detection

- **Vertical Redundancy Check(VRC) or Parity Check:**
- Suppose we want to transmit the binary data unit 1100001, adding the number of 1s gives us 3, an odd number. Before transmitting, a parity generator counts the 1s and appends the parity bit (a 1 in this case) to the end. The total number of 1 becomes 4 now (even number). The system now transmits the entire appended unit across the network link.

Error Detection

- **Vertical Redundancy Check(VRC) or Parity Check:**
- When the data unit is reached its destination, the receiver puts all eight bits through an even-parity checking function. If the receiver sees 11100001, it counts and gets four 1s, an even number.
- But if the receiver sees 11100101, or total number of 1s is odd. The receiver knows that an error has been occurred into the data somewhere and therefore   rejects the whole unit.
- **This method VRC can detect only single-bit errors.**

Error Detection

- **Longitudinal Redundancy Check(LRC):**
- In this error detection method, a block of bits is organized in a table with rows and columns.
- For instance, if we want to send 32 bits we arrange them into a list of four rows. Then parity bit for each column is calculated and a new row of eight bits is created. These become the parity bits for the whole block.
- After that the new calculated parity bits are attached to the original data and sends to the receiver.
- LRC increases the likelihood of detecting burst error. An LRC of n bits can easily detects a burst error of n bits.

Error Detection