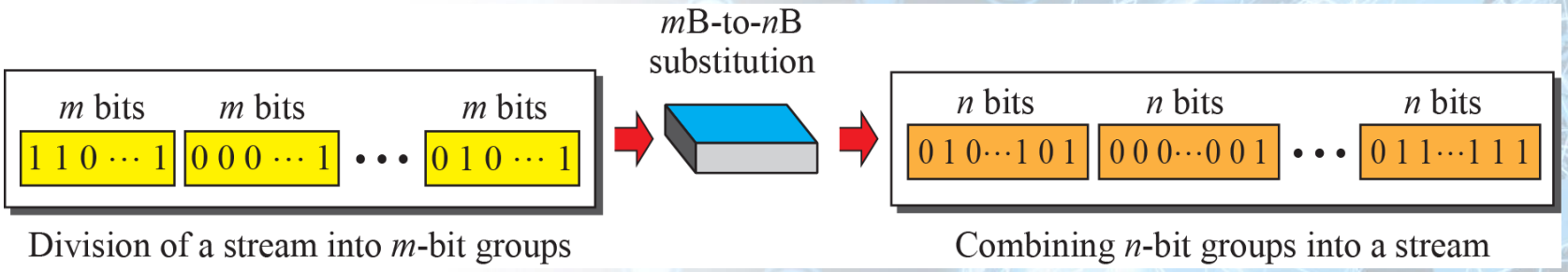
Block Coding

- Block coding changes a block of ‘m’ bits into a block of ‘n’ bits (n>m)
- mB/nB encoding technique
- We need Redundancy to ensure Synchronization
- Block coding gives us redundancy and improves line coding performance

Block coding concept



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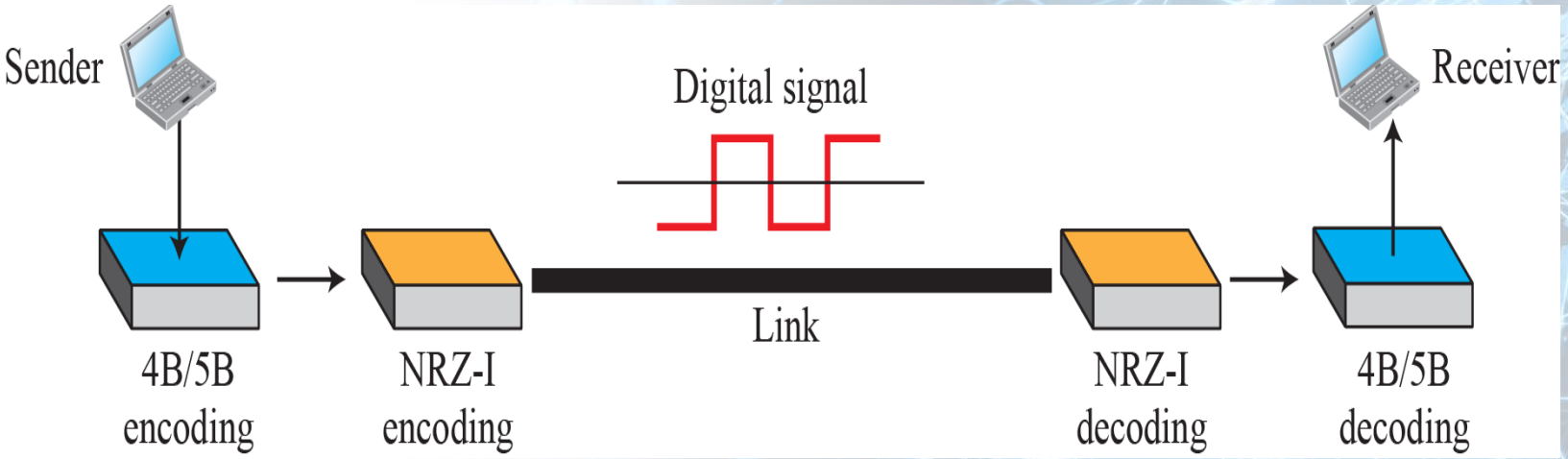
Using block coding 4B/5B with NRZ-I line coding



Block Coding

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4B/5B mapping codes

Data Sequence	*Encoded Sequence*	*Control Sequence*	*Encoded Sequence*
0000	11110	Q (Quiet)	00000
0001	01001	I (Idle)	11111
0010	10100	H (Halt)	00100
0011	10101	J (Start delimiter)	11000
0100	01010	K (Start delimiter)	10001
0101	01011	T (End delimiter)	01101
0110	01110	S (Set)	11001
0111	01111	R (Reset)	00111
1000	10010		
1001	10011		
1010	10110		
1011	10111		
1100	11010		
1101	11011		
1110	11100		
1111	11101		

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- Block coding changes a block of ‘m’ bits into a block of ‘n’ bits (n>m)
- mB/nB encoding technique
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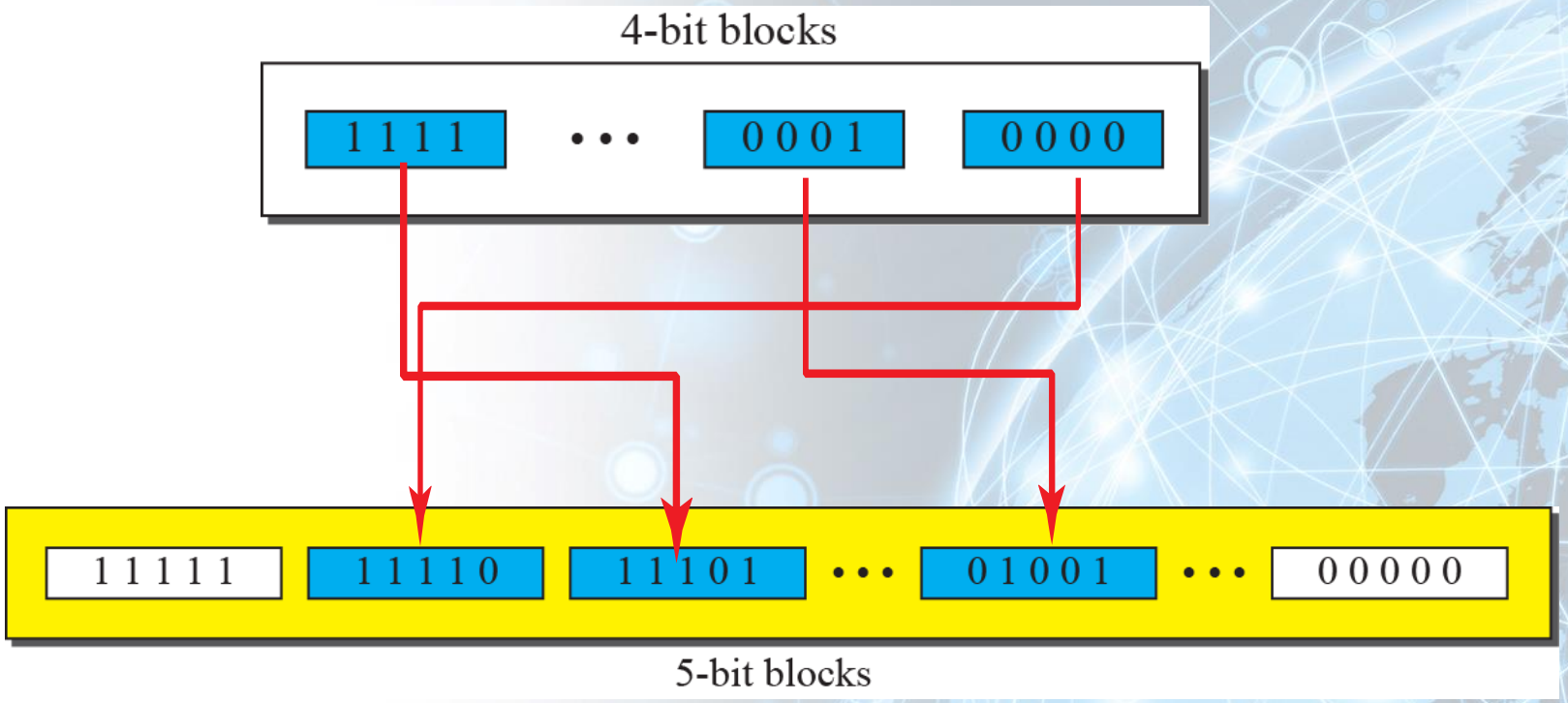
- Block coding gives us redundancy and improves line coding performance

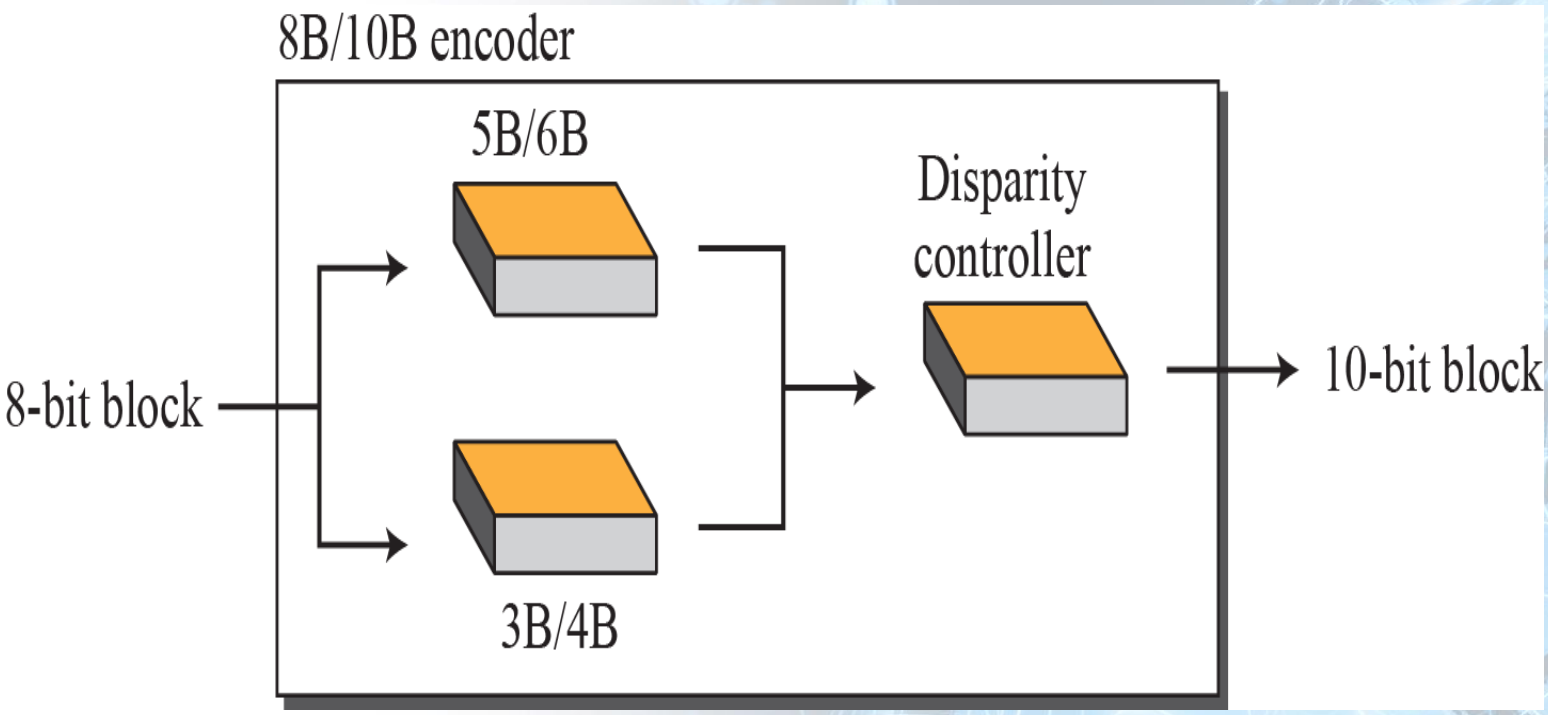
Example

We need to send data at a 1-Mbps rate. What is the minimum required bandwidth, using a combination of 4B/5B and NRZ-I or Manchester coding?

Example


4-bit blocks
1 1 1 1
• • •
0 0 0 1
0 0 0 0
1 1 1 1 1
1 1 1 1 0
1 1 1 0 1
• • •
0 1 0 0 1
• • •
0 0 0 0 0
5-bit blocks

8B/10B block encoding



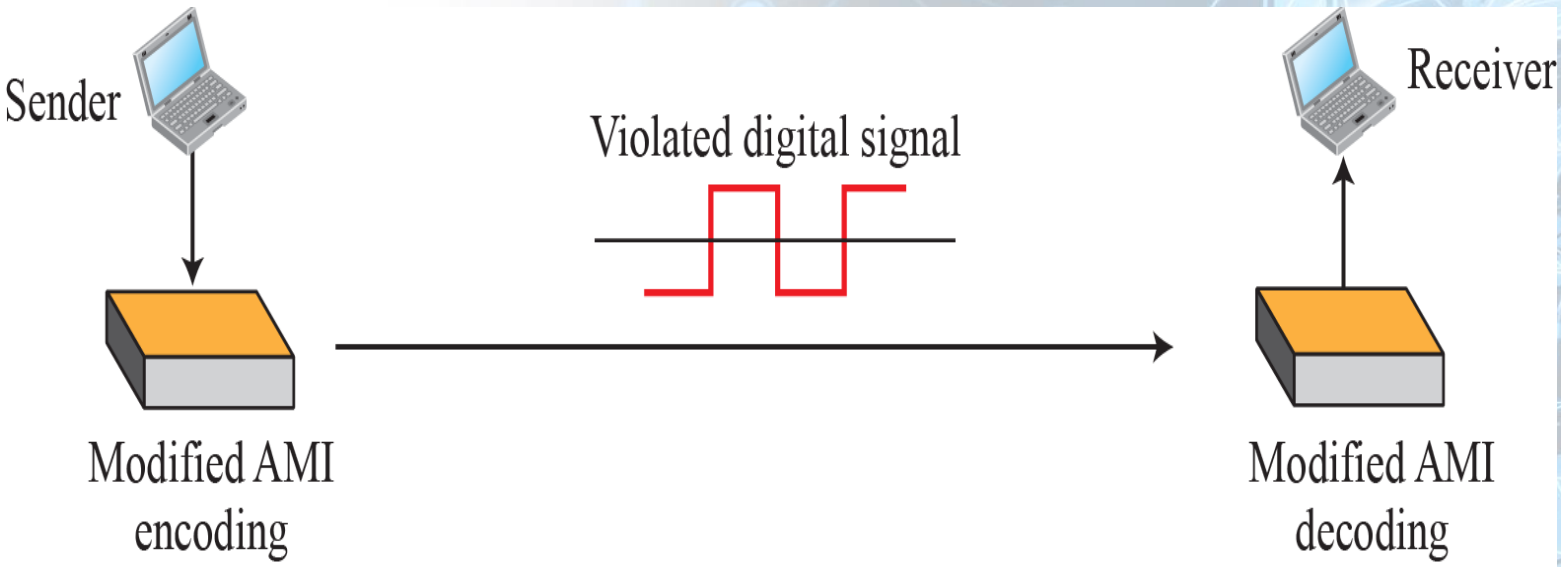
Scrambling

- Biphase schemes suitable for LAN but not for Long Distance
- Block Coding + NRZ-I solves synch issue but has DC component
- Bipolar AMI has a narrow bandwidth (no DC Component) but synch issue (long series of 0s)

Scrambling

- The system needs to insert the required pulses based on the defined scrambling rules

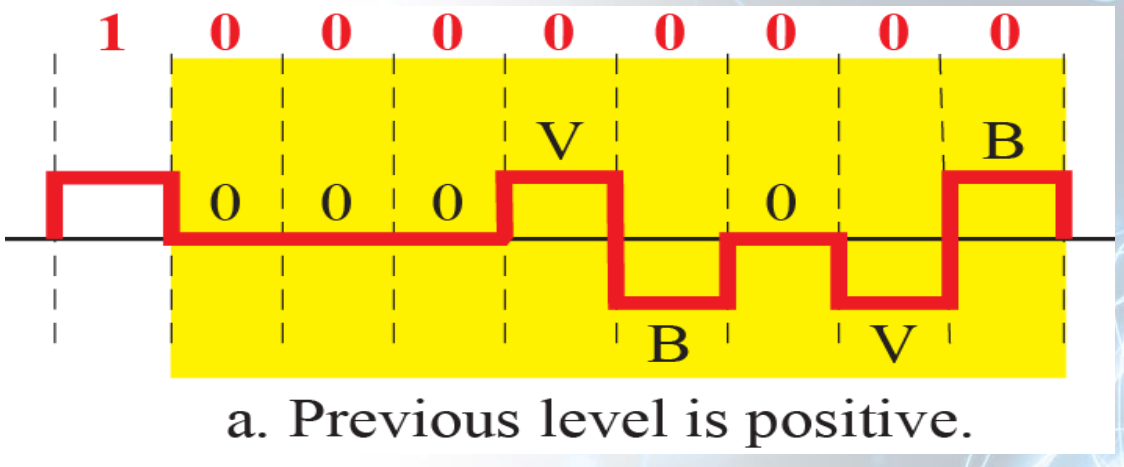
AMI used with scrambling



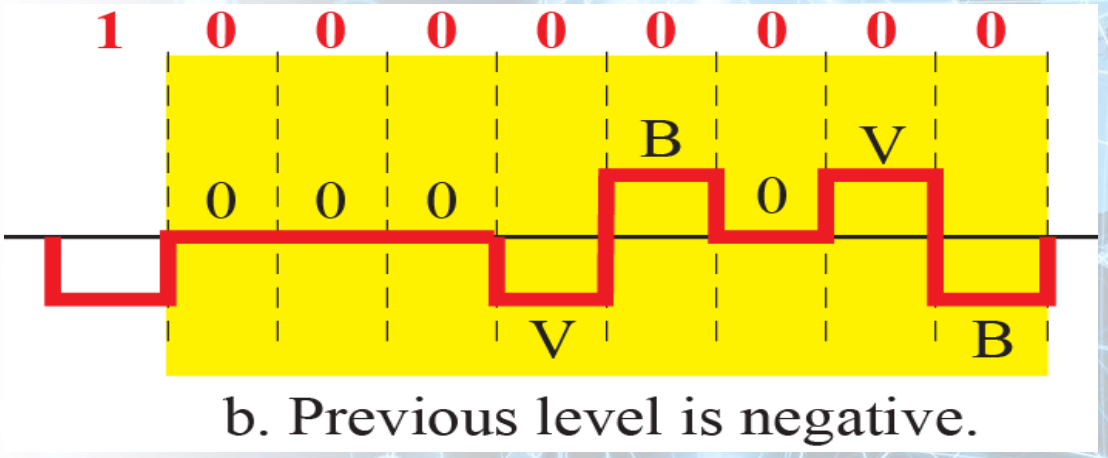
Types of Scrambling Techniques

- Two common scrambling techniques are B8ZS and HDB3
- Bipolar with 8-Zero Substitution (B8ZS)
- High-density bipolar 3-zero (HDB3)

Two cases of B8ZS scrambling technique



a. Previous level is positive.

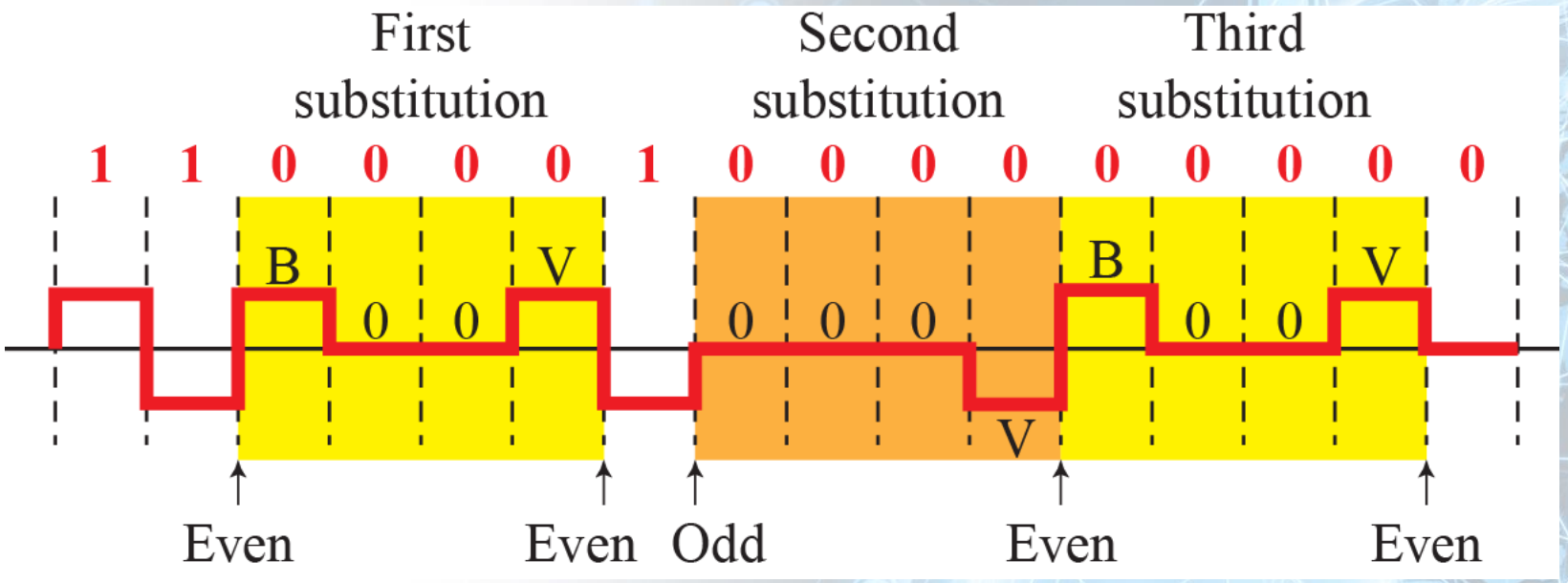


b. Previous level is negative.

Types of Scrambling Techniques

- Two common scrambling techniques are B8ZS and HDB3
- Bipolar with 8-Zero Substitution (B8ZS)
- High-density bipolar 3-zero (HDB3)

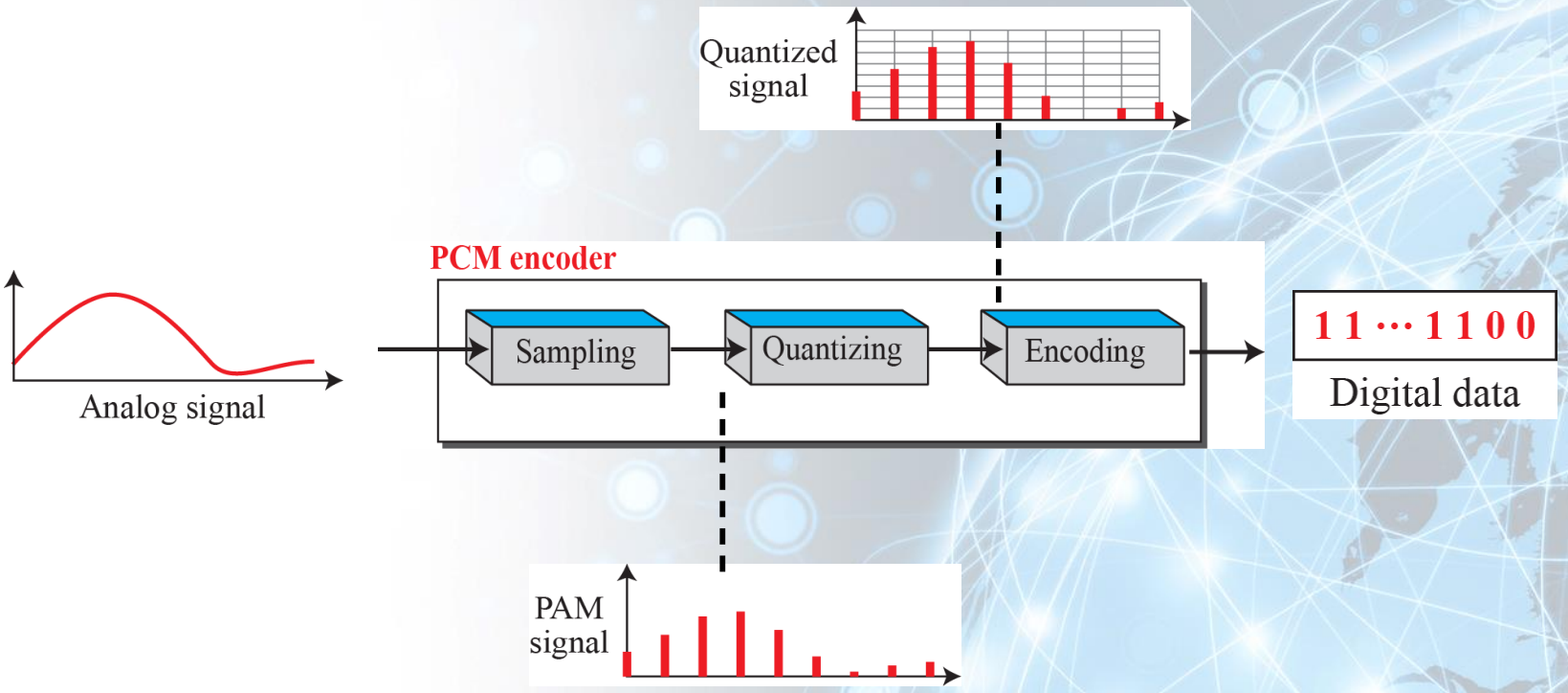
Different situations in HDB3 scrambling technique



Analog-to-digital Conversion

- Analog Data to Digital Data
- Process of Digitization
- Two techniques:
  - ✓ Pulse Code Modulation (PCM)
  - ✓ Delta Modulation (DM)

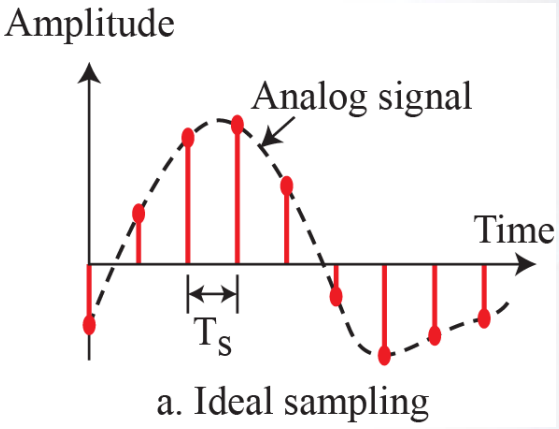
Pulse Code Modulation (PCM)



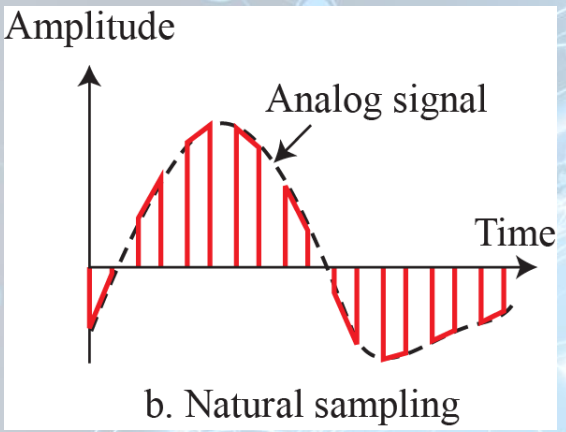
Pulse Code Modulation (PCM)

- Sampling
- Quantization
- Encoding

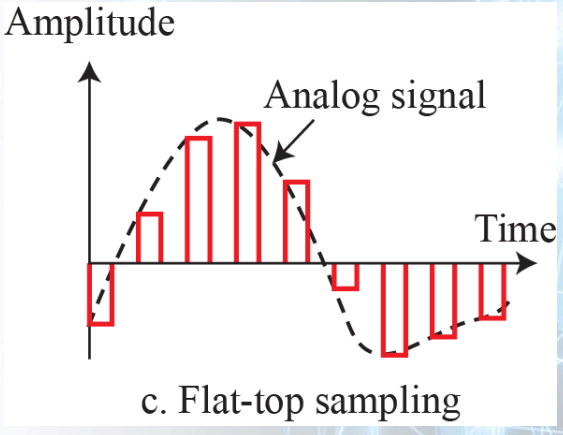
Three different sampling methods for PCM



a. Ideal sampling



b. Natural sampling

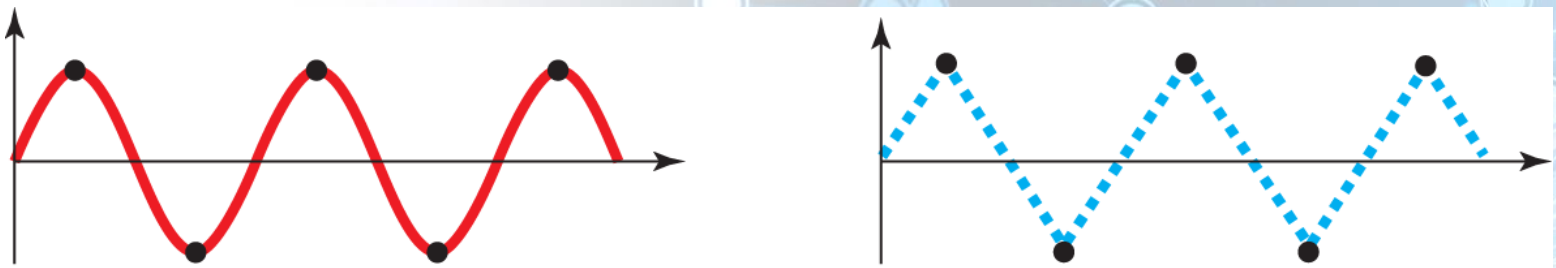


c. Flat-top sampling

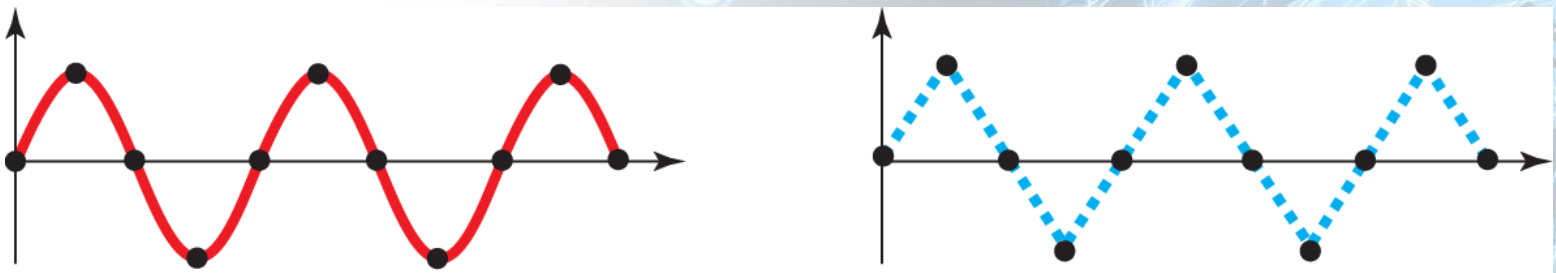
Nyquist Sampling Rate

- Nyquist → $f_s = 2f_h$
- Sampling sine wave at three sampling rates:
  - ✓ $f_s = 4f$ (2 times the Nyquist rate)
  - ✓ $f_s = 2f$ (Nyquist rate)
  - ✓ fs = f (one-half the Nyquist rate)

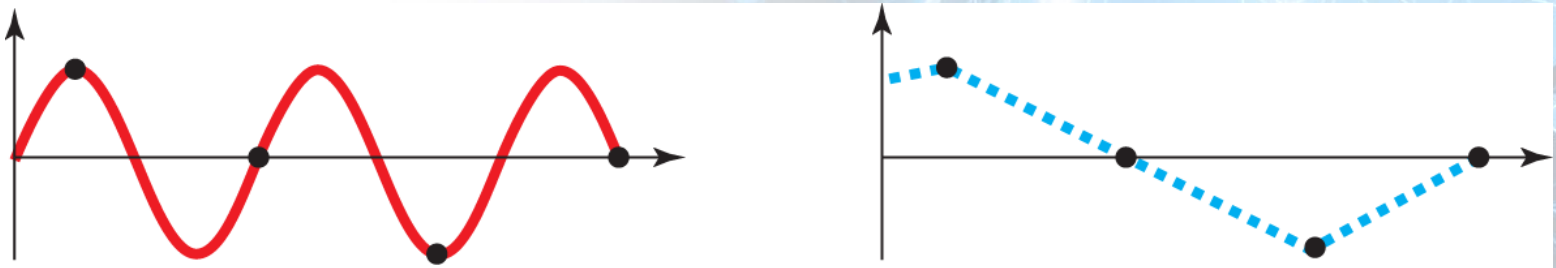
Nyquist Sampling Rate



a. Nyquist rate sampling: $f_s = 2\ f$



b. Oversampling: $f_s = 4\ f$

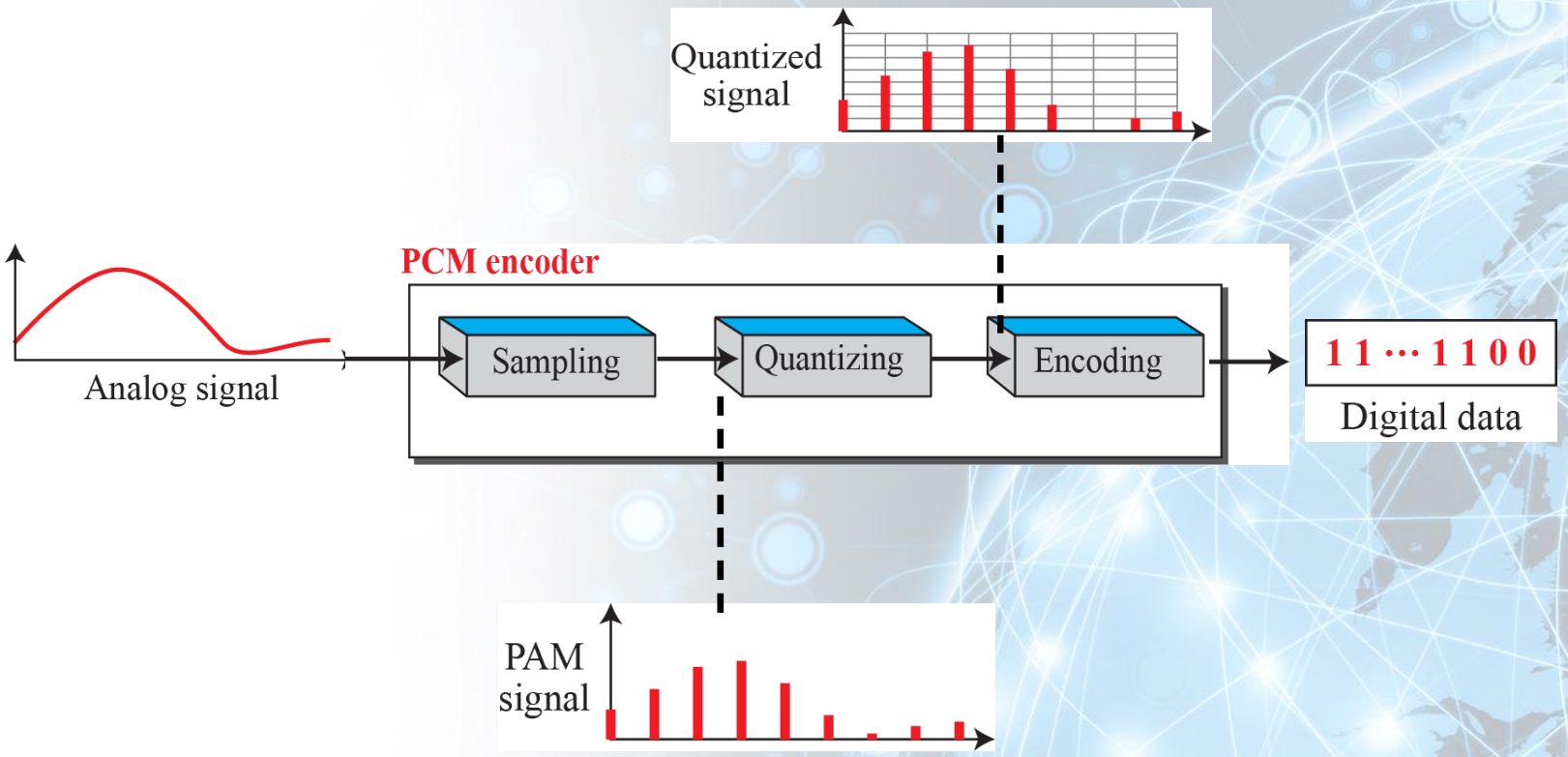


c. Undersampling: $f_s = f$

Pulse Code Modulation (PCM)

- Most common technique
- Employs a PCM Encoder
- A PCM encoder has three processes:
  - ✓ Sampling
  - ✓ Quantization
  - ✓ Encoding

Components of PCM encoder



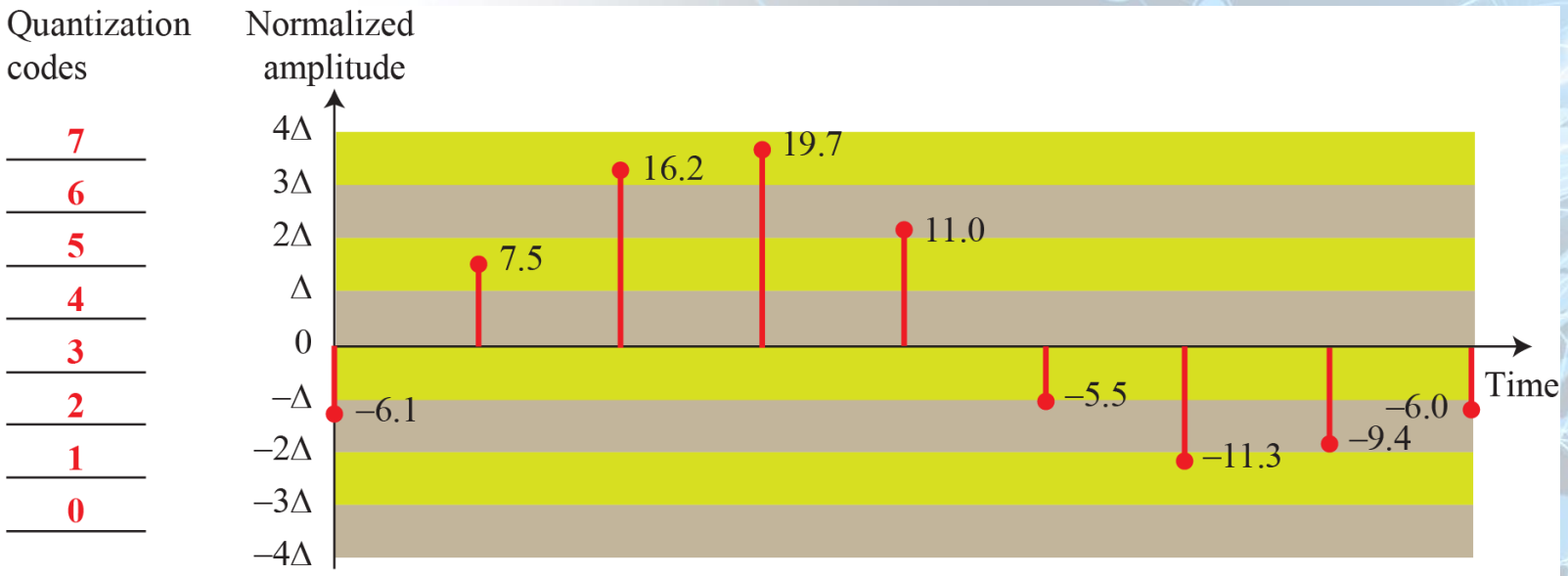
Pulse Code Modulation (PCM)

- Sampling
- Quantization
- Encoding

Quantization & encoding of a sampled signal

- Sampling → Series of pulses with amplitude values between min and max signal amplitude
- Infinite set with non-integral values not suitable for encoding
- We quantize the sampling output into certain levels based on range of amplitudes and how much accuracy is needed

Quantization & encoding of a sampled signal

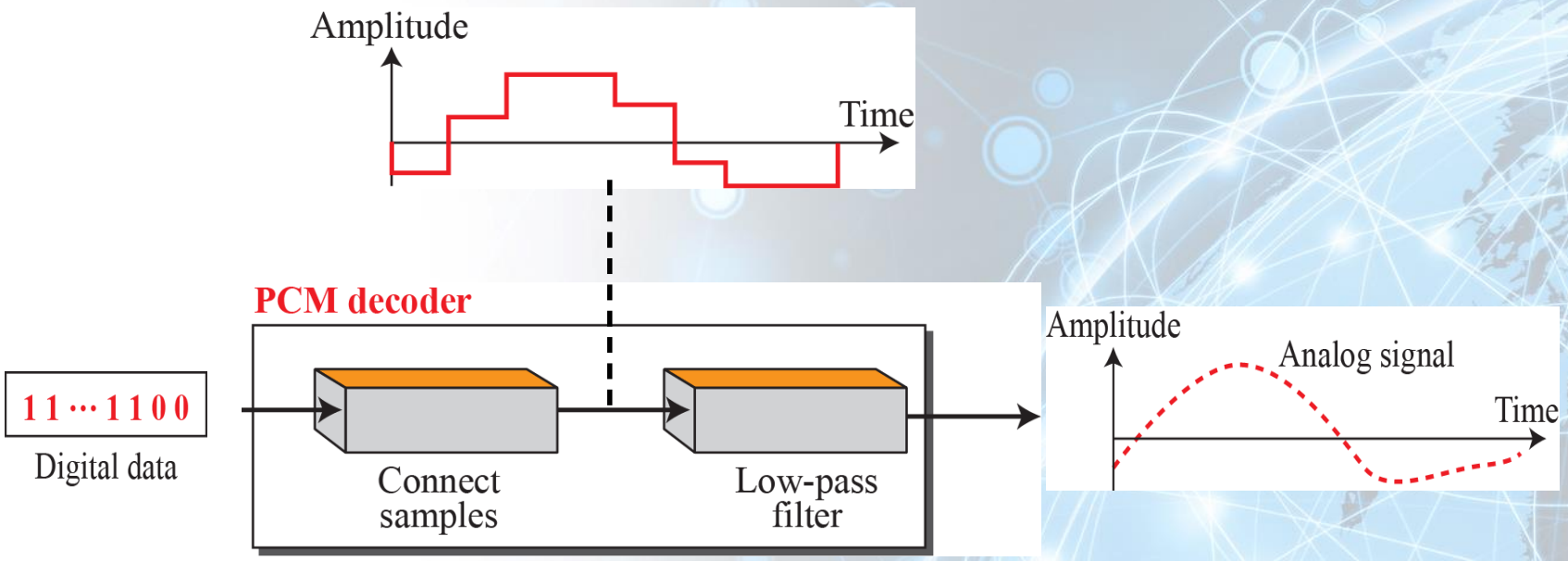


Normalized PAM values	−1.22	1.50	3.24	3.94	2.20	−1.10	−2.26	−1.88	−1.20
Normalized quantized values	−1.50	1.50	3.50	3.50	2.50	−1.50	−2.50	−1.50	−1.50
Normalized error	−0.28	0	+0.26	−0.44	+0.30	−0.40	−0.24	+0.38	−0.30
Quantization code	2	5	7	7	6	2	1	2	2
Encoded words	010	101	111	111	110	010	001	010	010

Pulse Code Modulation (PCM)

- Encoding
  - ✓ Sampling
  - ✓ Quantization
  - ✓ Encoding
- Decoding

Original Signal Recovery- PCM Decoder



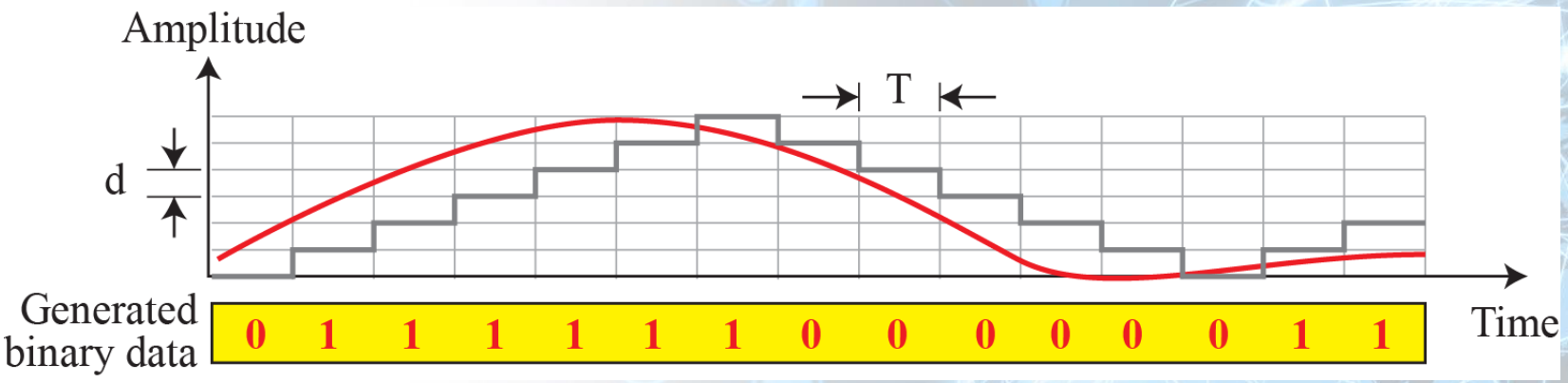
Analog-to-digital Conversion

- Analog Data to Digital Data
- Process of Digitization
- Two techniques:
  - ✓ Pulse Code Modulation (PCM)
  - ✓ Delta Modulation (DM)

Delta Modulation (DM)

- PCM is a very complex technique
- Delta modulation is a simpler technique
- PCM finds the value of the signal amplitude for each sample; DM finds the change from the previous sample
- No code words

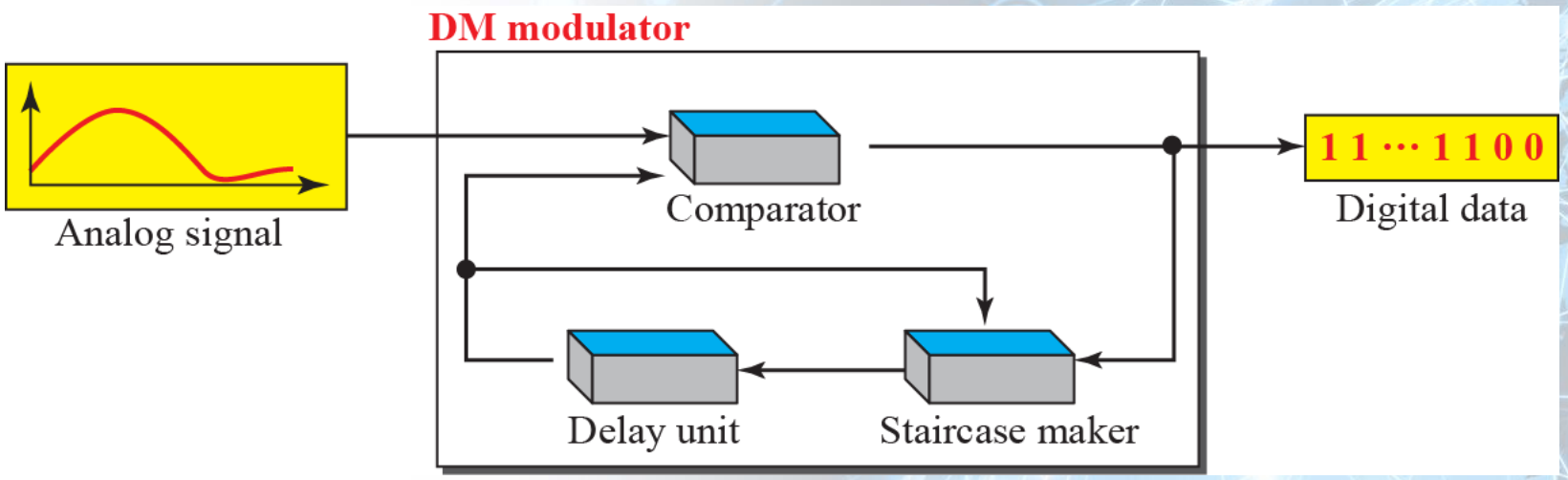
The process of delta modulation



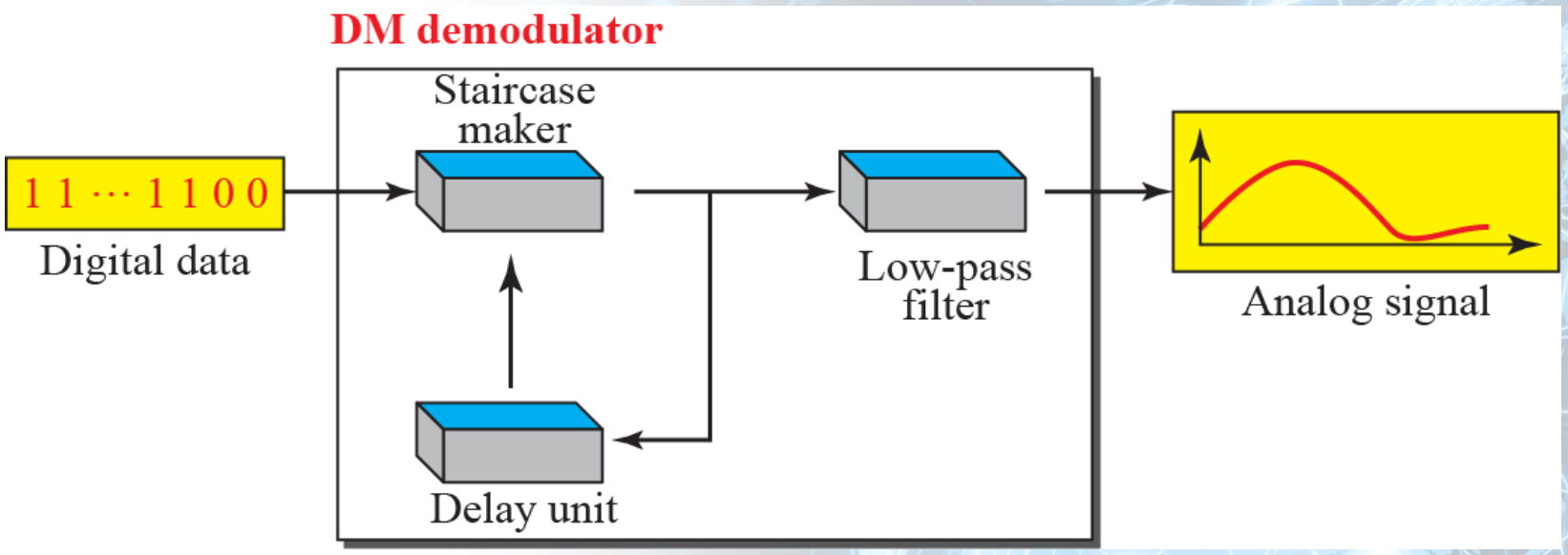
Delta Modulation (DM)

- Delta modulation is a simpler technique
- DM finds the change from the previous sample
- No code words

Delta Modulation Components



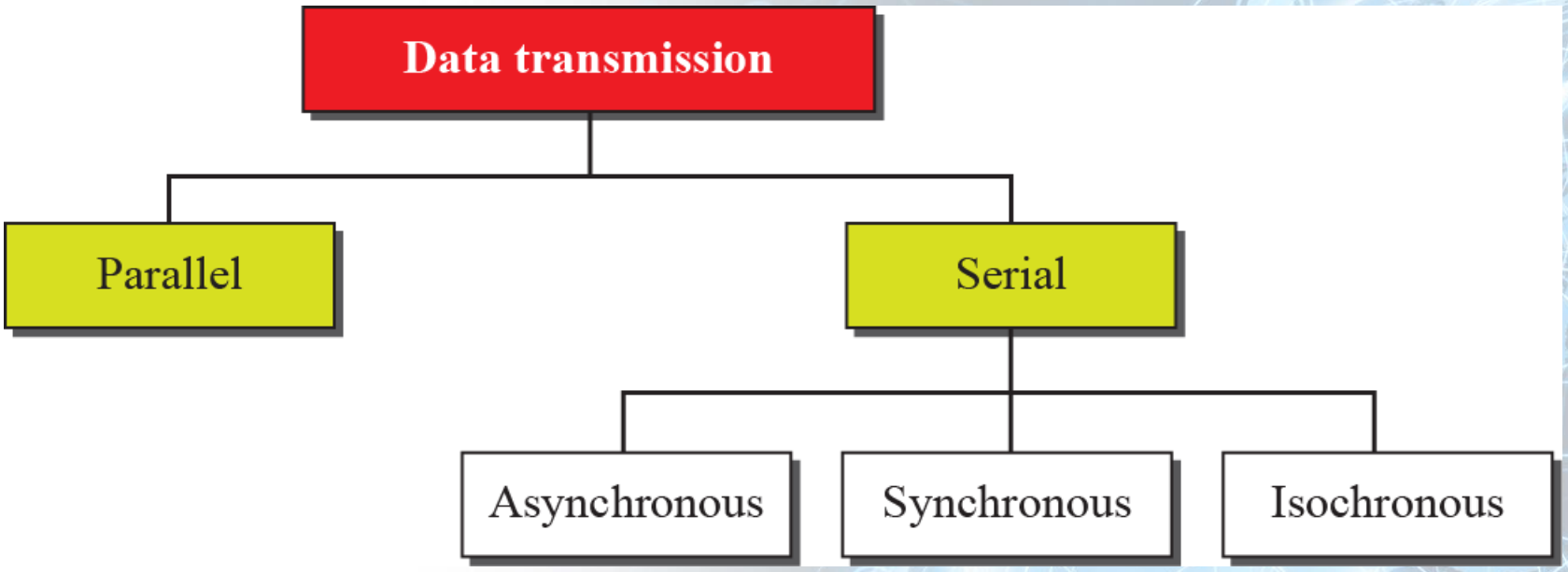
Delta Demodulation Components



Transmission Modes

- Transmission of Data:
  - ✓ Wiring
    - ➢ Data Stream
- Do we send 1 bit at a time; or do we group bits into larger groups and, if so, how?
- Parallel or Serial Transmission

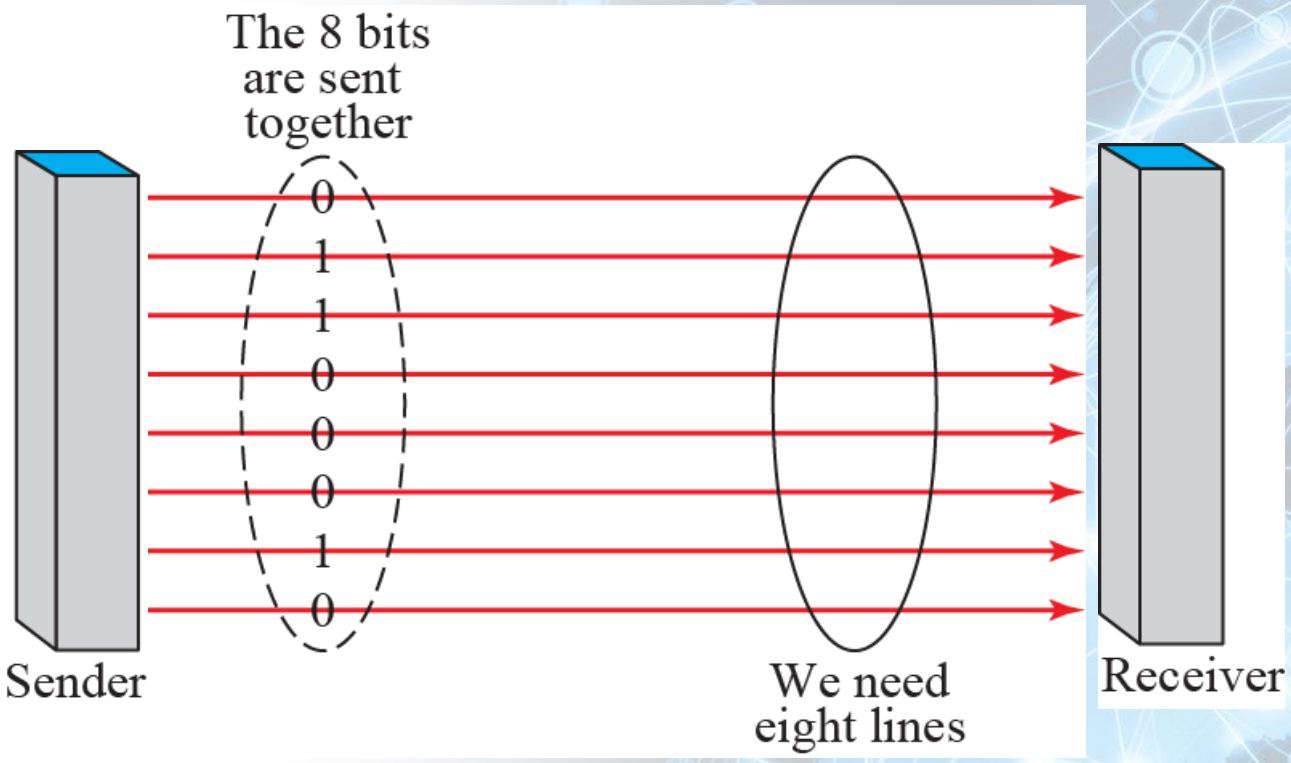
Data transmission modes



Parallel Transmission

- Binary data (1s ad 0s) organized in groups of ‘n’ bits
- We send ‘n’ bits at a time instead of just one
- ‘n’ wires required to send ‘n’ bits at one time

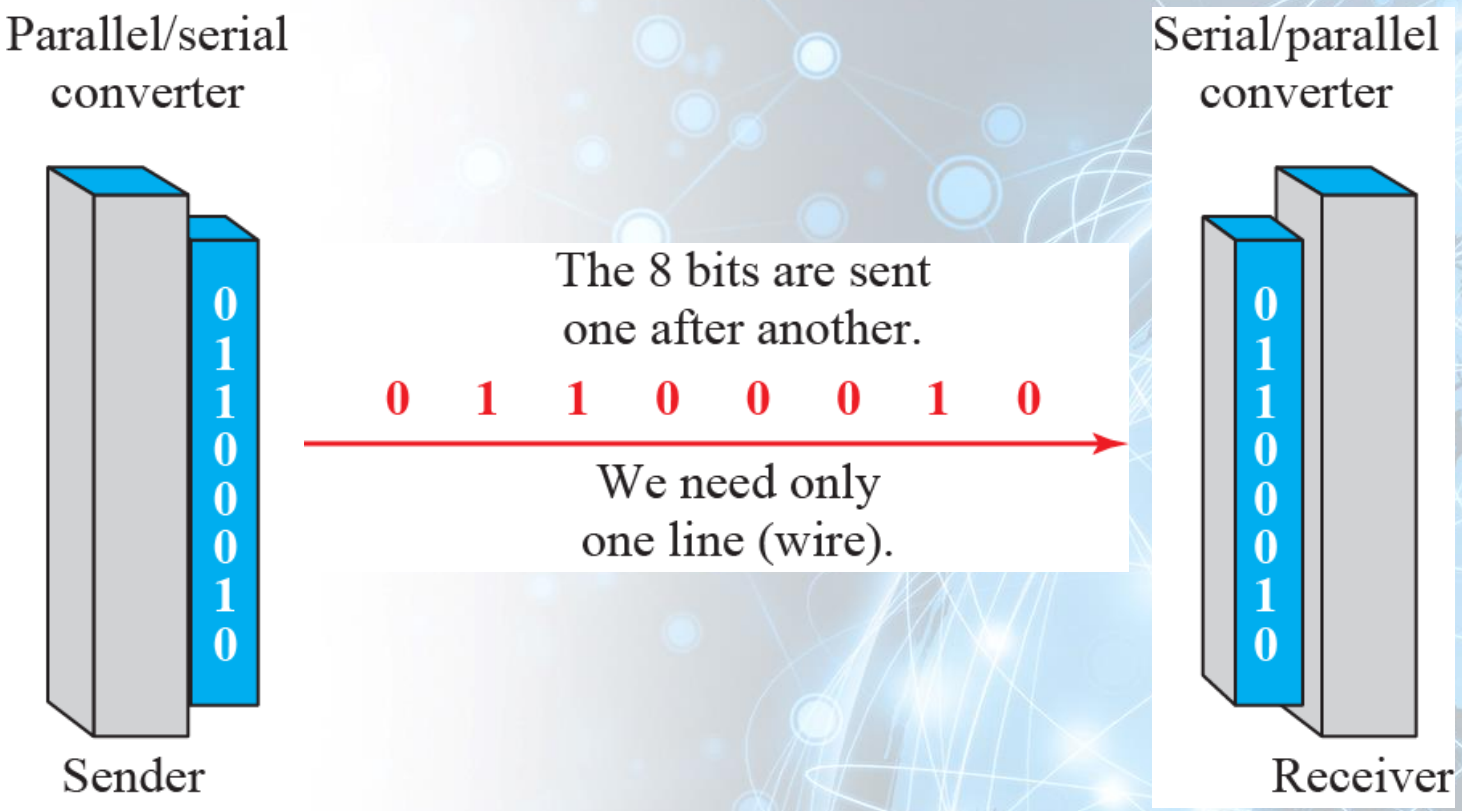
Parallel Transmission



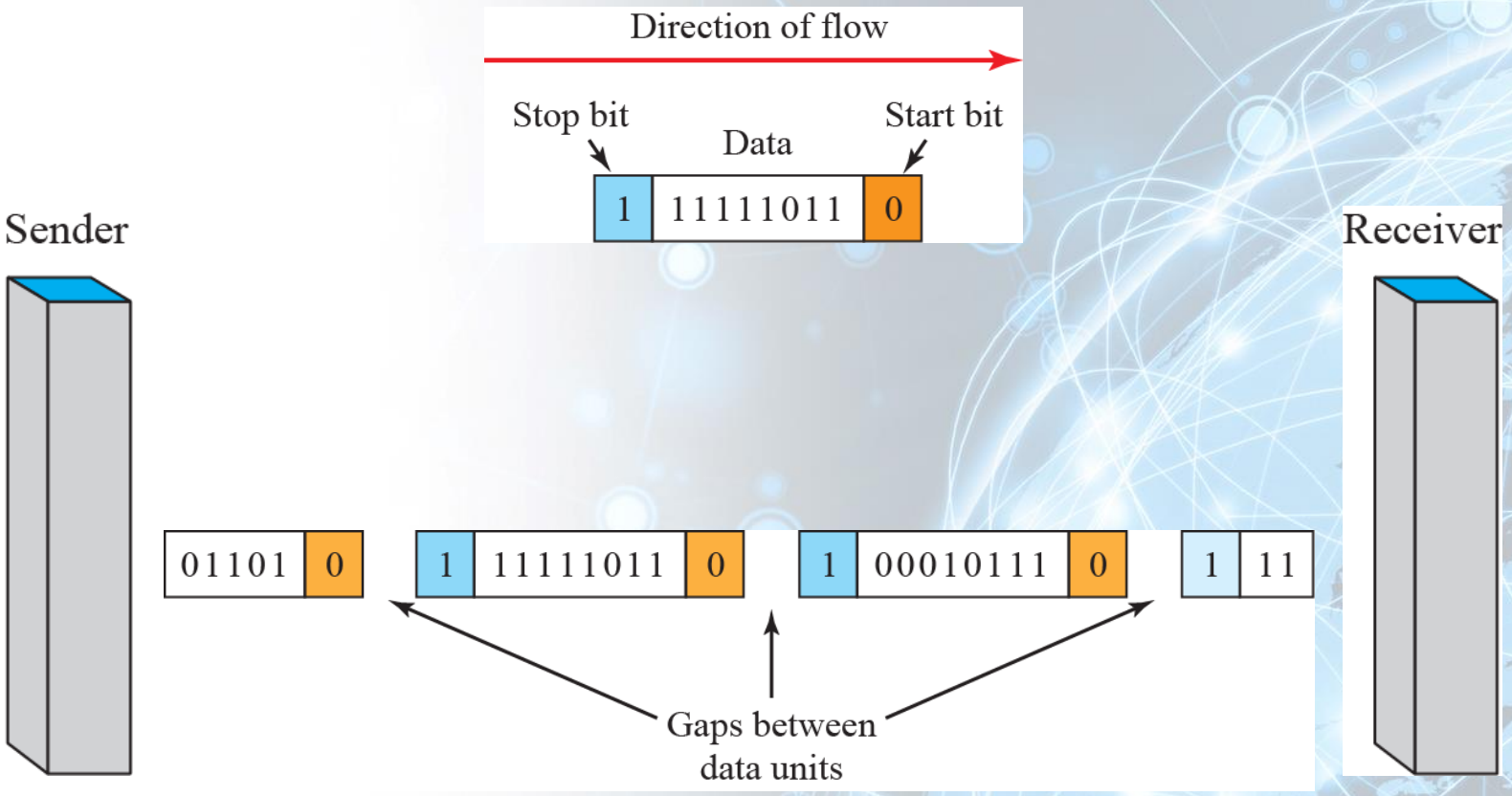
Serial Transmission

- In serial transmission one bit follows another
- Only one communication channel rather than ‘n’ to transmit data

Serial Transmission



Asynchronous Transmission



Serial Transmission

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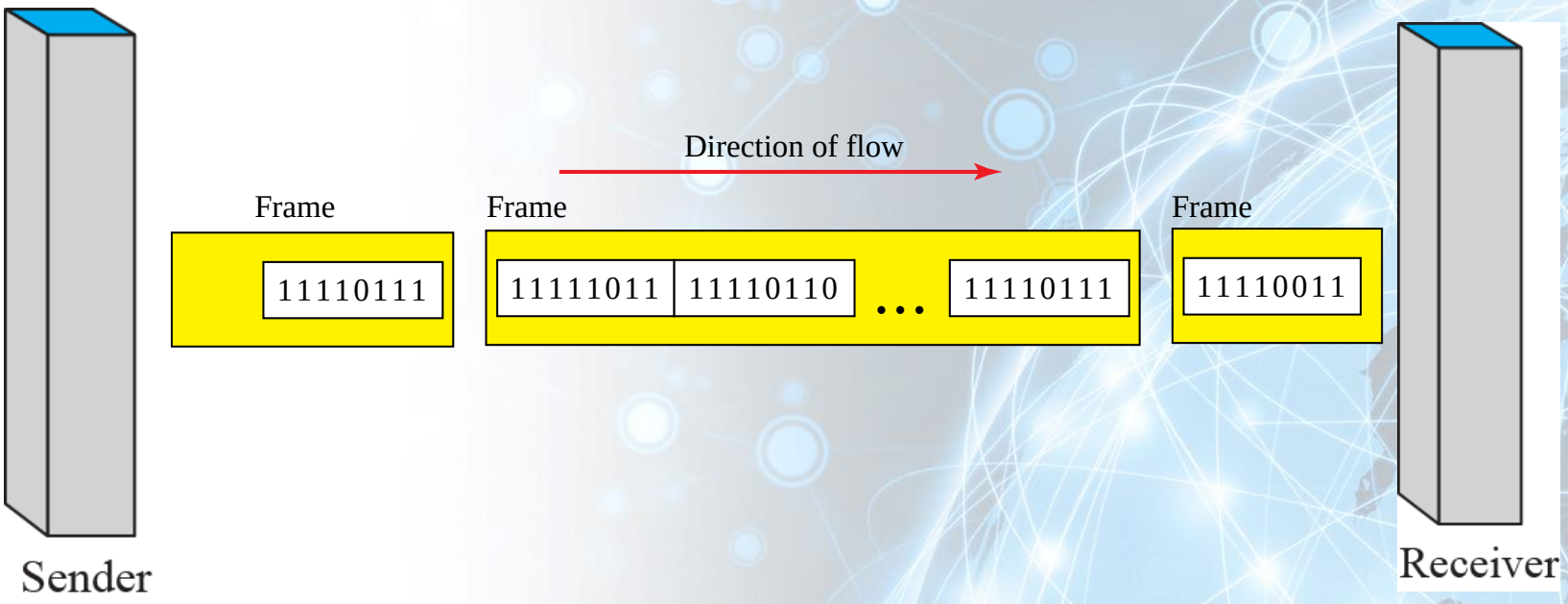
Synchronous Transmission



Isochronous Transmission

- Real time Audio and Video
- Synchronization between characters is not enough
- Entire stream should be synchronized
- Isochronous guarantees fixed rate data