Digital Transmission

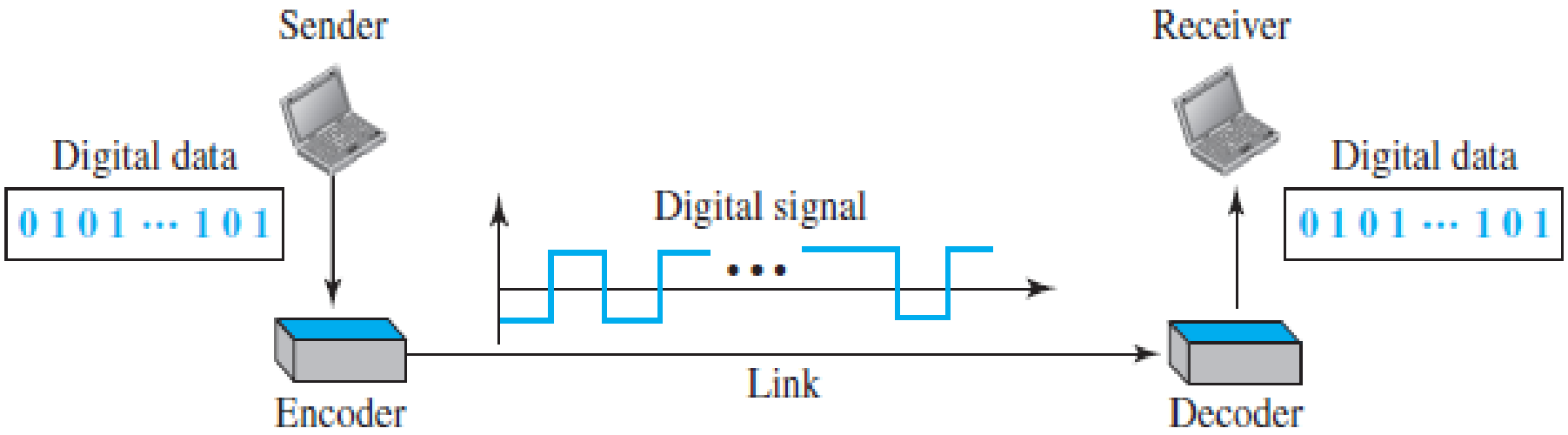
DIGITAL-TO-DIGITAL CONVERSION

- **data can be either digital or analog.**
- **Signals that represent data can also be digital or analog.**
- **Study of how we can represent digital data by using digital signals. The conversion involves three techniques:**
  - ✓ **Line coding,**
  - ✓ **Block coding, and**
  - ✓ **Scrambling**
- **Line coding is always needed; block coding and scrambling may or may not be needed.**

Line Coding

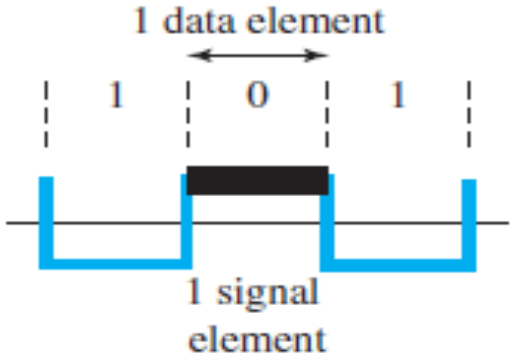
- **Line coding is the process of converting digital data to digital signals.**
- **We assume that data, in the form of text, numbers, graphical images, audio, or video, are stored in computer memory as sequences of bits. Line coding converts a sequence of bits to a digital signal.**
- **At the sender, digital data are encoded into a digital signal; at the receiver, the digital data are recreated by decoding the digital signal**

Line coding and decoding

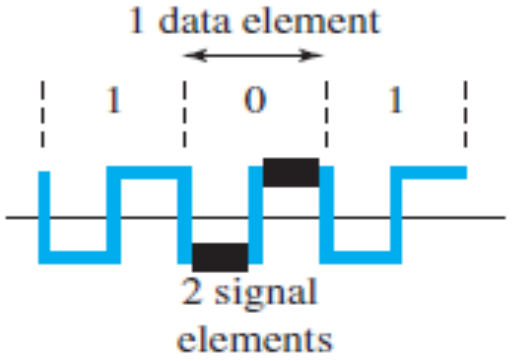


Characteristics: Signal Element Versus Data Element

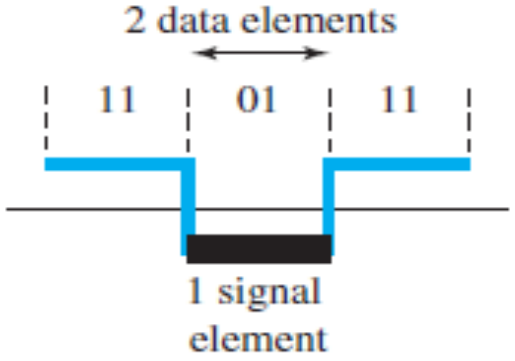
- **In data communications, our goal is to send data elements.**
- **A data element is the smallest entity that can represent a piece of information: this is the bit.**
- **In digital data communications, a signal element carries data elements. A signal element is the shortest unit (timewise) of a digital signal.**
- **Data elements are what we need to send; signal elements are what we can send.**
- **Data elements are being carried; signal elements are the carriers.**
- **For every line coding scheme, r value will be given.**



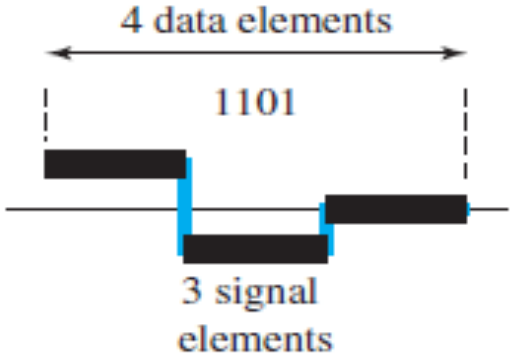
a. One data element per one signal element ($r = 1$)



b. One data element per two signal elements $\left(r = \frac{1}{2}\right)$



c. Two data elements per one signal element ($r = 2$)



d. Four data elements per three signal elements $\left(r = \frac{4}{3}\right)$

Signal element versus data element

Characteristics: Signal Element Versus Data Element

- In data communications, our goal is to send data elements.
- A data element is the smallest entity that can represent a piece of information: this is the bit.
- In digital data communications, a signal element carries data elements. A signal element is the shortest unit (timewise) of a digital signal.
- Data elements are what we need to send; signal elements are what we can send.
- Data elements are being carried; signal elements are the carriers.
- A ratio r which is the number of data elements carried by each signal element.

Data Rate Versus Signal Rate

- The data rate defines the number of data elements (bits) sent in 1s. The unit is bits per second (bps).
- The data rate is sometimes called the bit rate.
- The signal rate is the number of signal elements sent in 1s. The unit is the baud.
- The signal rate is sometimes called the pulse rate, the modulation rate, or the baud rate.
- One goal in data communications is to increase the data rate while decreasing the signal rate.
- Increasing the data rate increases the speed of transmission; decreasing the signal rate decreases the bandwidth requirement. We have a limited bandwidth.

Data Rate Versus Signal Rate

- Consider the relationship between data rate (N) and signal rate (S):

$$S = N/r$$

- This relationship, depends on the value of r and also depends on the data pattern.
- We can formulate the relationship between data rate and signal rate as:

$$S_{ave} = c \times N \times (1/r) \quad \text{baud}$$

Where

N is the data rate (bps);

c is the case factor, which varies for each case; (the worst, best, and average)

S is the number of signal elements per second;

r is the number of data elements carried by each signal element.

Example 1

A signal is carrying data in which one data element is encoded as one signal element ($r = 1$). If the bit rate is 100 kbps, what is the average value of the baud rate if c is between 0 and 1?

Solution

We assume that the average value of c is 1/2. The baud rate is then

$$S = c \times N \times (1 / \text{r}) = 1/2 \times 100{,}000 \times (1/1) = 50{,}000 = 50 \text{ kbaud}$$

References

1. Data Communications and Networking; B Forouzan; 5th Edition, Tata McGraw Hill; 2013.

2. Data and Computer Communications; W Stallings; 10th Edition, Pearson India Education Services Pvt.Ltd; 2013.

3. Computer Networks; A S Tanenbaum, ; 5th Edition, Pearson India Education Services Pvt.Ltd; 2013.