

# Tutorial 1

These slides are based on the slides formatted by Dr Sunilkumar S. manvi and Dr Mahabaleshwar S. Kakkasageri, the authors of the textbook: Wireless and Mobile Networks, concepts and protocols.

# Review Questions

- What is modulation?
- Describe the wireless communication system and its components

# Multiple-Choice Questions

- Digital communication refers to the transmission of
  - (a) sequence of digital messages.
  - (b) Digitized analog signal
  - (c) Both (a) and (b)
  - (d) None of the above

# Determine Whether True or False

Bandwidth of a channel is defined in terms of voltage

# Fill in the blanks

- .....allows several users to share the same frequency channel by dividing the signal into different time slots.

# Problems

- **Problem:** In a communication channel, the channel bandwidth is 3.4 kHz and S/N power ratio is 100. Calculate the channel capacity.

- **Solution:**

$$\begin{aligned}C &= B \log_2(1 + S/N) \\ &= 3.4 \times 10^3 \log_2(1+100) \\ &= 3.4 \times 10^3 (6.66)\end{aligned}$$

$$C = 22\,644 \text{ bps}$$

- **Problem:** calculate the S/N required to support information transmission through the telephone channel of bandwidth 3.4 kHz at the data rate of 4800 bps

- **Solution:**

$$C = B \log_2(1 + S/N)$$

$$4800 = 3.4 \times 10^3 \log_2(1 + S/N)$$

$$\log_2(1 + S/N) = 4800/3400$$

$$\log_2(1 + S/N) = 1.411$$

$$(\log_2 2^{1.411} = 1.411) \rightarrow 1 + S/N = 2^{1.411}$$

$$S/N = 2^{1.411} - 1 = 2.66 - 1 = 1.66$$

- **Problem:** Obtain 8-bit PCM representation of the following samples.  $x(0) = 4$ ,  $x(1) = 8$ ,  $x(2) = 32$ ,  $x(3) = 16$
- **Solution:**
  - $x(0) = 00000100$
  - $x(1) = 00001000$
  - $x(2) = 00100000$
  - $x(3) = 00010000$



- **Problem:** Write the expression for BPSK, assuming a carrier  $c(t)$  with an arbitrary phase  $\phi$  and a carrier
- **Solution:**  
 $c(t) = A\sin(\omega t + \phi)$   
Let us take for instance  $\phi = 0$  and  $\phi = \pi/2$   
 $c(t) = A\sin\omega t$  (for instance to encode 1)  
 $c(t) = A\sin(\omega t + \pi/2)$  (for instance to encode 0)

- **Problem:** A message signal representing the sequence of data  $D = 1011001$  is to be transmitted using BPSK scheme. Draw the message signal, the carrier signal and the modulated signal.

- **Problem:** Consider that the data to be transmitted,  $D$ , is 101110 using CRC error checking method. Suppose the generator polynomial  $G$  is chosen as 1001. Find the final value that the transmitter sends and show how the error detection process at the receiver.
- **Solution:**

# CRC: at transmitter

		1 0 1 0 1 1	<b>Quotient</b>
<b>(Divisor)</b>	1 0 0 1	1 0 1 1 1 0 0 0 0	<b>Dividend</b>
<b>Generator</b>		<div style="display: flex; justify-content: space-between; align-items: center;"> <span style="border-bottom: 1px solid black; padding-bottom: 2px;">1 0 0 1</span> <span style="font-size: 2em;">}</span> </div> <div style="display: flex; justify-content: space-between; align-items: center; margin-top: 5px;"> <span>0 1 0 1</span> <span style="font-size: 2em;">}</span> </div> <div style="display: flex; justify-content: space-between; align-items: center; margin-top: 5px;"> <span style="border-bottom: 1px solid black; padding-bottom: 2px;">0 0 0 0</span> <span style="font-size: 2em;">}</span> </div> <div style="display: flex; justify-content: space-between; align-items: center; margin-top: 5px;"> <span>1 0 1 0</span> <span style="font-size: 2em;">}</span> </div> <div style="display: flex; justify-content: space-between; align-items: center; margin-top: 5px;"> <span style="border-bottom: 1px solid black; padding-bottom: 2px;">1 0 0 1</span> <span style="font-size: 2em;">}</span> </div> <div style="display: flex; justify-content: space-between; align-items: center; margin-top: 5px;"> <span>0 1 1 0</span> <span style="font-size: 2em;">}</span> </div> <div style="display: flex; justify-content: space-between; align-items: center; margin-top: 5px;"> <span style="border-bottom: 1px solid black; padding-bottom: 2px;">0 0 0 0</span> <span style="font-size: 2em;">}</span> </div> <div style="display: flex; justify-content: space-between; align-items: center; margin-top: 5px;"> <span>1 1 0 0</span> <span style="font-size: 2em;">}</span> </div> <div style="display: flex; justify-content: space-between; align-items: center; margin-top: 5px;"> <span style="border-bottom: 1px solid black; padding-bottom: 2px;">1 0 0 1</span> <span style="font-size: 2em;">}</span> </div> <div style="display: flex; justify-content: space-between; align-items: center; margin-top: 5px;"> <span>1 0 1 0</span> <span style="font-size: 2em;">}</span> </div> <div style="display: flex; justify-content: space-between; align-items: center; margin-top: 5px;"> <span style="border-bottom: 1px solid black; padding-bottom: 2px;">1 0 0 1</span> <span style="font-size: 2em;">}</span> </div>	<b>(Data with appended zeros)</b>
		0 1 1	<b>Remainder (CRC)</b>

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# CRC: at receiver

<b>Divisor</b> <b>(Generator)</b>	1 0 0 1	<table style="border-collapse: collapse; margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: right; padding-right: 5px;">1 0 1 0 1 1</td> <td style="padding-left: 5px;"><b>Quotient</b></td> </tr> <tr> <td style="border-top: 1px solid black; border-bottom: 1px solid black; padding: 2px 5px;">1 0 1 1 1 0 0 1 1</td> <td style="padding-left: 5px;"><b>Dividend</b></td> </tr> <tr> <td style="padding: 2px 5px;">1 0 0 1</td> <td style="padding-left: 5px;"><b>(Data with CRC)</b></td> </tr> <tr> <td style="padding: 2px 5px;">0 1 0 1</td> <td style="padding-left: 5px;">↓</td> </tr> <tr> <td style="padding: 2px 5px;">0 0 0 0</td> <td style="padding-left: 5px;">↓</td> </tr> <tr> <td style="padding: 2px 5px;">1 0 1 0</td> <td style="padding-left: 5px;">↓</td> </tr> <tr> <td style="padding: 2px 5px;">1 0 0 1</td> <td style="padding-left: 5px;">↓</td> </tr> <tr> <td style="padding: 2px 5px;">0 1 1 0</td> <td style="padding-left: 5px;">↓</td> </tr> <tr> <td style="padding: 2px 5px;">0 0 0 0</td> <td style="padding-left: 5px;">↓</td> </tr> <tr> <td style="padding: 2px 5px;">1 1 0 1</td> <td style="padding-left: 5px;">↓</td> </tr> <tr> <td style="padding: 2px 5px;">1 0 0 1</td> <td style="padding-left: 5px;">↓</td> </tr> <tr> <td style="padding: 2px 5px;">1 0 0 1</td> <td style="padding-left: 5px;">↓</td> </tr> <tr> <td style="padding: 2px 5px;">1 0 0 1</td> <td style="padding-left: 5px;">↓</td> </tr> <tr> <td style="padding: 2px 5px;">0 0 0 0</td> <td style="padding-left: 5px;"><b>Remainder</b></td> </tr> </table>	1 0 1 0 1 1	<b>Quotient</b>	1 0 1 1 1 0 0 1 1	<b>Dividend</b>	1 0 0 1	<b>(Data with CRC)</b>	0 1 0 1	↓	0 0 0 0	↓	1 0 1 0	↓	1 0 0 1	↓	0 1 1 0	↓	0 0 0 0	↓	1 1 0 1	↓	1 0 0 1	↓	1 0 0 1	↓	1 0 0 1	↓	0 0 0 0	<b>Remainder</b>
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