CSN08704

Telecommunications

1. Introduction

Data, Audio, Video and Images

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Prof Bill Buchanan

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1. Introduction: History

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Stages of communications

- **Foundation**. This was the foundation of electrical engineering and radio wave transmission, and owes a great deal to the founding fathers of electrical engineering such as Coulomb, Ampère, Ohm, Gauss, Faraday, Henry and Maxwell, who laid down the basic principles of electrical engineering.
- **Electronics revolution**. This brought increased reliability, improved operations, improved sensitization and increased miniaturization.
- **Desktop computer revolution**. This accelerated the usage of digital communication and has finally integrated all forms of electronic communications: text, speech, images and video.
- **Modern communication**. This increased the ways of connections, and has steadily increased the speed of the connection, such as from satellite communications, local area networks and digital networks. Along with the integration of text, speech, images and video has came the integration of different type's carriers.

History

- Automated telephone switching.
- Radio transmission.
- Trans-continental cables.
- Satellites.
- Digital transmission and coding.
- Fiber-optic transmissions.
- The Internet.

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1. Introduction: Principles

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Bit rate

- Transfer rate = 7.5 (characters per second) x 8 (bits per character) = **60 bps**

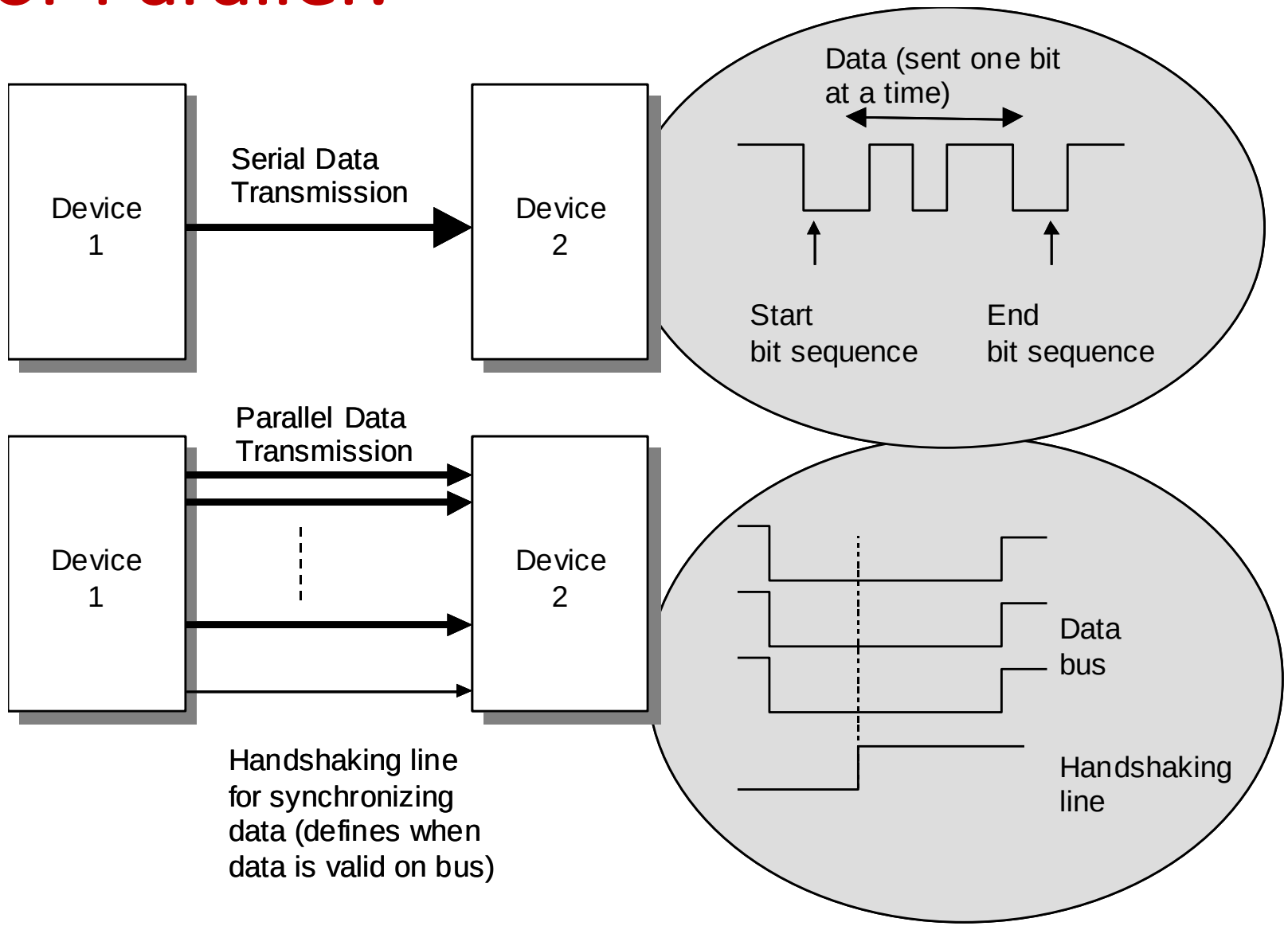
Variations in Communication Systems

- Bandwidth contention, bandwidth sharing or reserved bandwidth.
- Virtual path, dedicated line or datagram.
- Global addressing, local addressing or no addressing.

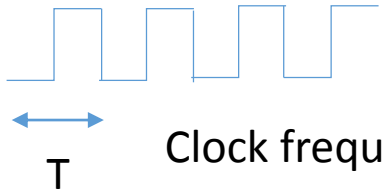
Communication Mechanisms

- **Simplex communication.** Only one device can communicate with the other, and thus only requires handshaking lines for one direction.
- **Half-duplex communication.** This allows communications from one device to the other, in any direction, and thus requires handshaking for either direction.
- **Full-duplex communications.** This allows communication from one device to another, in either direction, at the same time. A good example of this is in a telephone system, where a caller can send and receive at the same time. This requires separate transmit and receive data lines, and separate handshaking for either direction.

Serial or Parallel?



Data Transfer Rate



$$T = \frac{1}{f}\,\text{sec}$$

$$T = \frac{1}{8\times10^{6}} = 0.000000125\,\text{sec}$$
$$= 0.125\,\mu\text{s}$$

$$\text{Data transfer rate (bps)} = \frac{\text{Number of bits transmitted per operation (bits)}}{\text{Transfer time per operation (s)}}$$

$$\text{Data transfer rate} = 16\times8\times10^{6} = 128\times10^{6}\ \text{bps} = 128\,\text{Mbps}$$

$$\text{Data transfer rate} = 128\,\text{Mbps}$$
$$= \frac{128}{8}\,\text{Mbps} = 16\,\text{MB/s}$$

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1. Introduction: Data Formats

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Binary and Hex

	128	64	32	16	8	4	2	1	Decimal
	b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0	
Val1	0	0	1	1	0	1	0	1	53
Val2	0	1	1	0	1	0	1	0	106
Val3	0	0	0	1	1	0	1	0	26

What is 0010 1011 in decimal?

What is 93 in binary?

Val	Hex		Val	Hex
0000	0		1000	8
0001	1		1001	9
0010	2		1010	A
0011	3		1011	B
0100	4		1100	C
0101	5		1101	D
0110	6		1110	E
0111	7		1111	F

What is 0010 1011 in hex?

Boolean Logic Operations

AND			OR			X-OR		
A	**B**	**Z**	**A**	**B**	**Z**	**A**	**B**	**Z**
0	0	0	0	0	0	0	0	0
0	1	0	0	1	1	0	1	1
1	0	0	1	0	1	1	0	1
1	1	1	1	1	1	1	1	0

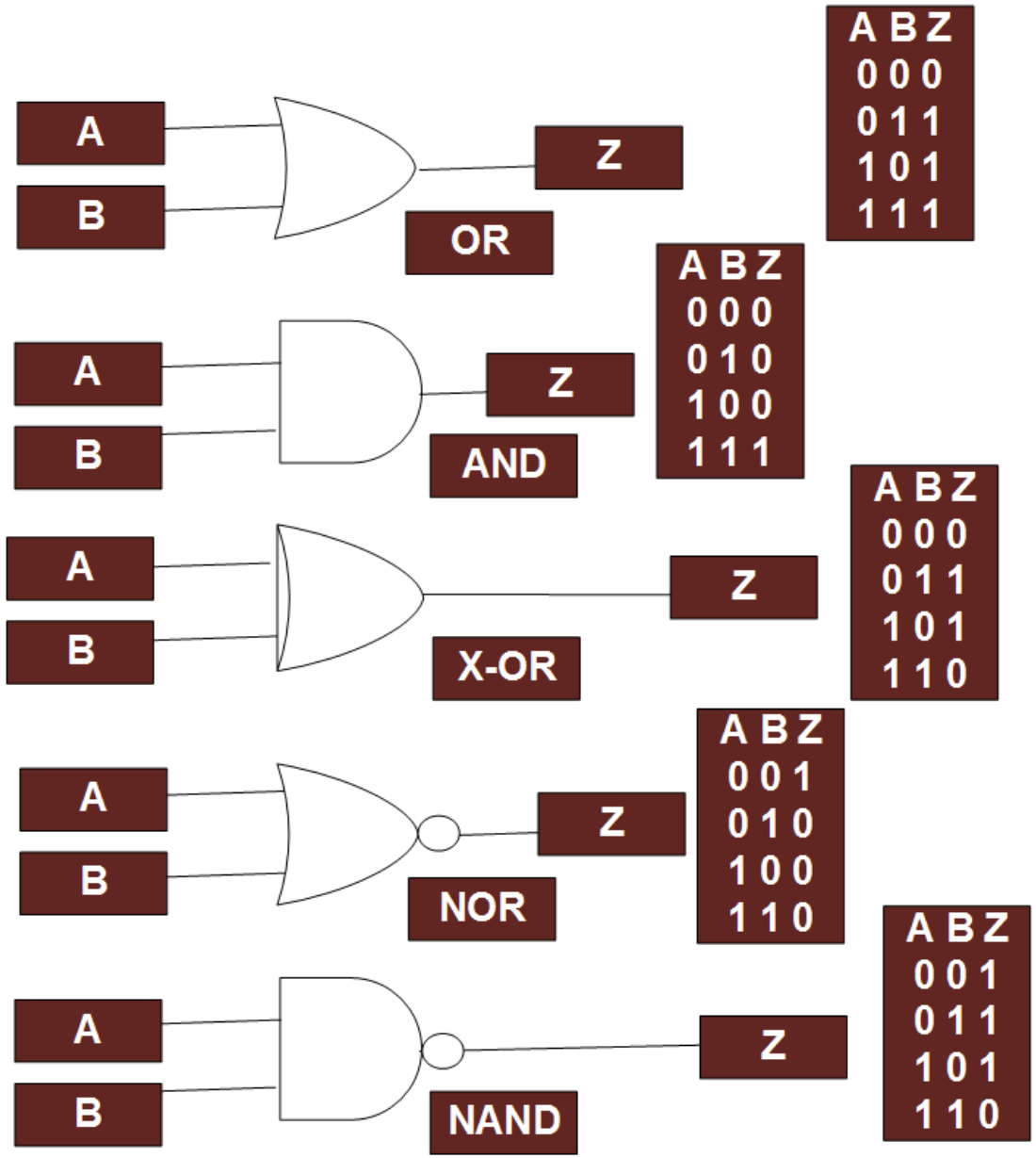
Bit shifts

	128	**64**	**32**	**16**	**8**	**4**	**2**	**1**	**Decimal**
	b_7	**b_6**	**b_5**	**b_4**	**b_3**	**b_2**	**b_1**	**b_0**	
Val	0	0	1	1	0	1	0	1	53
Val << 1	0	1	1	0	1	0	1	0	106
Val >> 1	0	0	0	1	1	0	1	0	26

Bit masking

	128	**64**	**32**	**16**	**8**	**4**	**2**	**1**	**Decimal**
	b_7	**b_6**	**b_5**	**b_4**	**b_3**	**b_2**	**b_1**	**b_0**	
Val	0	0	1	1	0	1	0	1	53
Val & 0x1	0	0	0	0	0	0	0	1	1
Val & 0x2	0	0	0	0	0	0	1	0	2
Val & 0x3	0	0	0	0	0	0	0	1	1

Logic gates


A
B
Z
OR
A B Z
0 0 0
0 1 1
1 0 1
1 1 1
A
B
Z
AND
A B Z
0 0 0
0 1 0
1 0 0
1 1 1
A
B
Z
X-OR
A B Z
0 0 0
0 1 1
1 0 1
1 1 0
A
B
Z
NOR
A B Z
0 0 1
0 1 0
1 0 0
1 1 0
A
B
Z
NAND
A B Z
0 0 1
0 1 1
1 0 1
1 1 0

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Matrix operations

$$A = \begin{bmatrix} 5 & 7 & 8 \end{bmatrix}$$

Single row (1×m)

$$A = \begin{bmatrix} 5 \\ 7 \\ 8 \end{bmatrix}$$

Single column (n×1)

$$B = \begin{bmatrix} 6 & 2 & 3 \\ 1 & 3 & 5 \\ 5 & 3 & 8 \end{bmatrix}$$

Multiple row and column (n×m)

$$B = \begin{bmatrix} 5 & 7 & 8 \end{bmatrix} \times \begin{bmatrix} 6 & 2 & 3 \\ 1 & 3 & 5 \\ 5 & 3 & 8 \end{bmatrix} = \begin{bmatrix} 5\times6 & 7\times2 & 8\times3 \\ 5\times1 & 7\times3 & 8\times5 \\ 5\times5 & 7\times3 & 8\times8 \end{bmatrix} = \begin{bmatrix} 30 & 14 & 24 \\ 5 & 21 & 40 \\ 25 & 21 & 64 \end{bmatrix}$$

Multiple matrices

$$B = \begin{bmatrix} 5 & 7 & 8 \end{bmatrix} \bullet \begin{bmatrix} 6 & 2 & 3 \\ 1 & 3 & 5 \\ 5 & 3 & 8 \end{bmatrix} = \begin{bmatrix} 5\times6+7\times1+8\times5 & 5\times2+7\times3+8\times3 & 5\times3+7\times5+8\times8 \end{bmatrix} = \begin{bmatrix} 77 & 55 & 114 \end{bmatrix}$$

Dot product

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