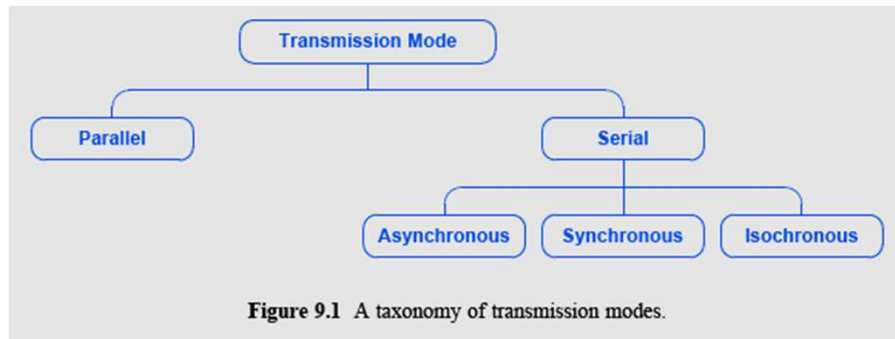# Transmission Modes

1

A Taxonomy of Transmission Modes

- We use the term *transmission mode* to refer to the manner in which data is sent over the underlying medium

- Transmission modes can be divided into two fundamental categories:

- Serial — one bit is sent at a time
  - Serial transmission is further categorized according to timing of transmissions

- Parallel — multiple bits are sent at the same time

- Figure 9.1 gives an overall taxonomy of the transmission modes discussed in the chapter
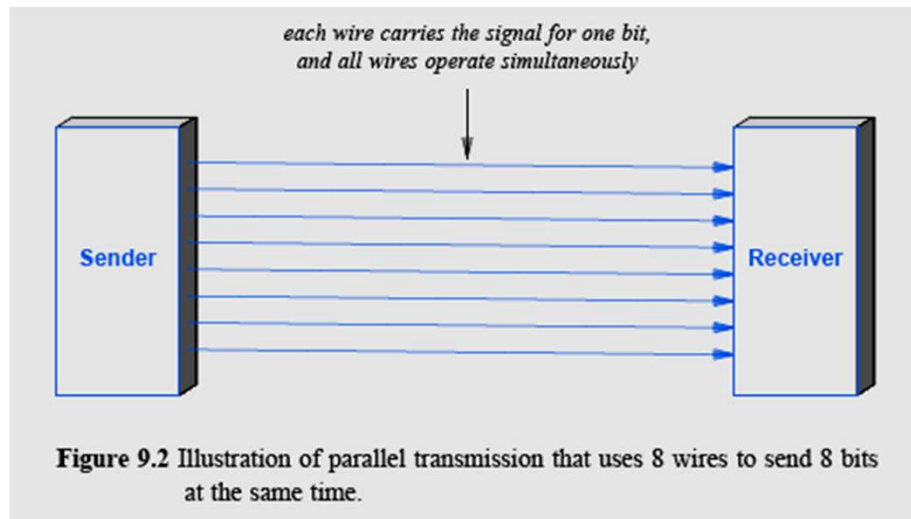
2

A Taxonomy of Transmission Modes

Figure 9.1 A taxonomy of transmission modes.

3

Parallel Transmission

- Parallel transmission allows transfers of multiple data bits at the same time over separate media
- In general, parallel transmission is used with a wired medium that uses multiple, independent wires
- Furthermore, the signals on all wires are synchronized so that a bit travels across each of the wires at precisely the same time
- Figure 9.2 illustrates the concept, and shows why engineers use the term parallel to characterize the wiring

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9.3 Parallel Transmission

each wire carries the signal for one bit,
and all wires operate simultaneously

Sender   Receiver

Figure 9.2 Illustration of parallel transmission that uses 8 wires to send 8 bits at the same time.

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Parallel Transmission

- The figure omits two important details:
  - First, in addition to the parallel wires that each carry data
    - a parallel interface usually contains other wires that allow the sender and receiver to coordinate
  - Second, to make installation and troubleshooting easy
    - the wires for a parallel transmission system are placed in a single physical cable
- A parallel mode of transmission has two chief advantages:
  - High speed: it can send N bits at the same time
    - a parallel interface can operate N times faster than an equivalent serial interface
  - Match to underlying hardware: Internally, computer and communication hardware uses parallel circuitry
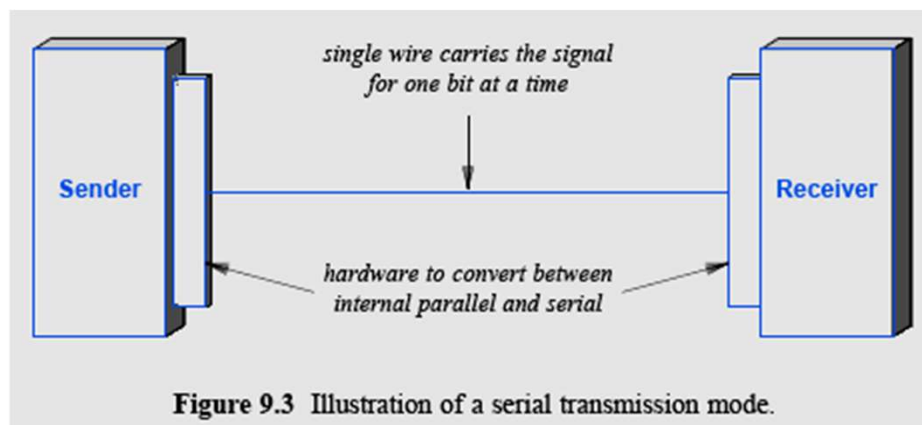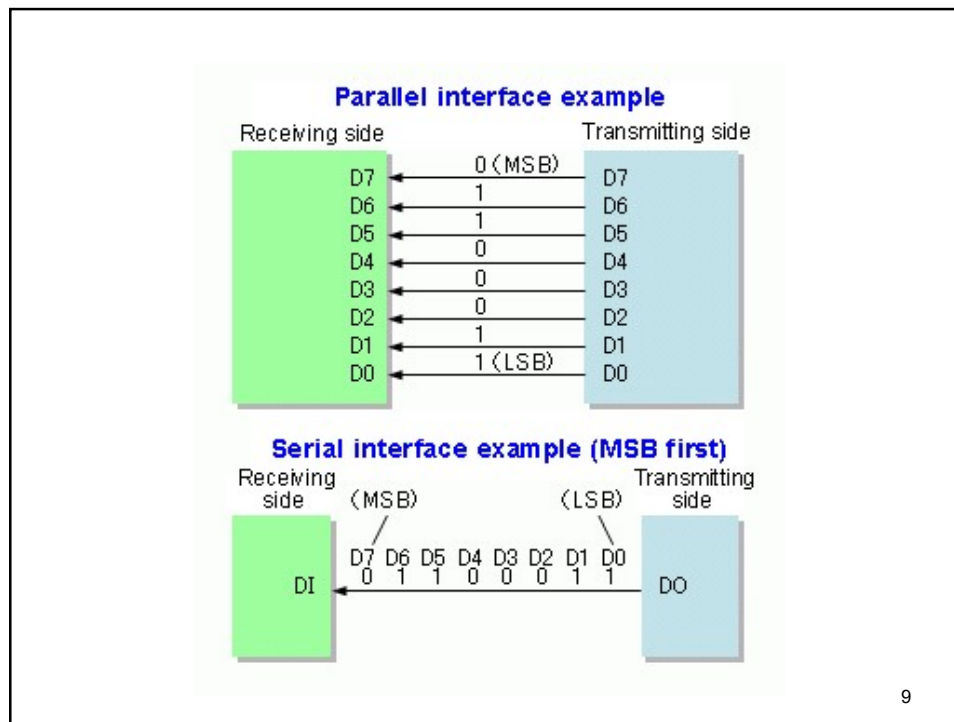   - a parallel interface matches the internal hardware well   6

Serial Transmission

- Serial transmission
  - sends one bit at a time
- It may seem that anyone would choose parallel transmission for high speeds
  - However, most communication systems use serial mode
- There are two main reasons
  - First, serial networks can be extended over long distances at much less cost
  - Second, using only one physical wire means that there is never a timing problem caused by one wire being slightly longer than another
- Sender and receiver must contain a hardware that converts data from the parallel form used in the device to the serial form used on the wire
- Figure 9.3 illustrates the configuration

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Serial Transmission

Figure 9.3 Illustration of a serial transmission mode.

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Parallel interface example

Receiving side — Transmitting side

D7	0 (MSB)	D7
D6	1	D6
D5	1	D5
D4	0	D4
D3	0	D3
D2	0	D2
D1	1	D1
D0	1 (LSB)	D0

Serial interface example (MSB first)

Receiving side (MSB) ... (LSB) Transmitting side

DI — D7 D6 D5 D4 D3 D2 D1 D0 — DO
0 1 1 0 0 0 1 1

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Serial Transmission

- The hardware needed to convert data between an internal parallel form and a serial form can be straightforward or complex
  - depending on the type of serial communication mechanism
- In the simplest case, a single chip that is known as a Universal Asynchronous Receiver and Transmitter (UART) performs the conversion
- A related chip, Universal Synchronous-Asynchronous Receiver and Transmitter (USART) handles conversion for synchronous networks

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Transmission Order: Bits and Bytes

- In serial mode, when sending bits, which bit should be sent across the medium first?
- Consider an integer: Should a sender transmit
  - the Most Significant Bit (MSB)
  - or the Least Significant Bit (LSB) first?
- We use the term little-endian to describe a system that sends the LSB first
- We use the term big-endian to describe a system that sends the MSB first
- Either form can be used, but the sender and receiver must agree

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Transmission Order: Bits and Bytes

- The order in which bits are transmitted does not settle the entire question of transmission order
  - Data in a computer is divided into bytes, and each byte is further divided into bits (typically 8 bits per byte)
  - Thus, it is possible to choose a byte order and a bit order independently
  - For example, Ethernet technology specifies that data is sent byte big-endian and bit little-endian
- Figure 9.4 illustrates the order in which Ethernet sends bits from a 32-bit quantity

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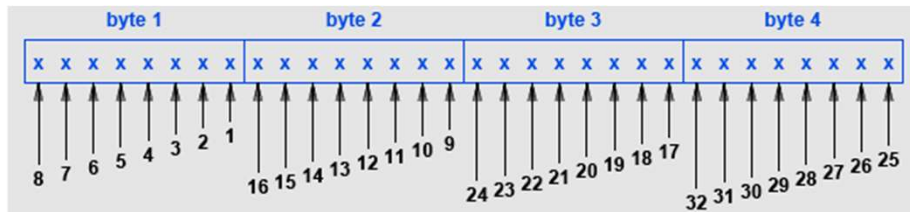## Transmission Order: Bits and Bytes

Figure 9.4 Illustration of byte big-endian, bit little-endian order in which the least-significant bit of the most-significant byte is sent first.

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Timing of Serial Transmission

- Serial transmission mechanisms can be divided into three broad categories (depending on how transmissions are spaced in time):
- Asynchronous transmission can occur at any time
  - with an arbitrary delay between the transmission of two data items
- Synchronous transmission occurs continuously
  - with no gap between the transmission of two data items
- Isochronous transmission occurs at regular intervals
  - with a fixed gap between the transmission of two data items

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Asynchronous Transmission

- It is asynchronous if the system allows the physical medium to be idle for an arbitrary time between two transmissions
- The asynchronous style of communication is well-suited to applications that generate data at random
  - (e.g., a user typing on a keyboard or a user that clicks on a link)
- The disadvantage of asynchrony arises from the lack of coordination between sender and receiver
  - While the medium is idle, a receiver cannot know how long the medium will remain idle before more data arrives
- Asynchronous technologies usually arrange for a sender to transmit a few extra bits before each data item
  - to inform the receiver that a data transfer is starting
  - extra bits allow the receiver to synchronize with the incoming signal
  - the extra bits are known as a preamble or start bits

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RS-232 Asynchronous Character Transmission

- Consider the transfer of characters across copper wires between a computer and a device such as a keyboard
  - each data item represents one character
- It is standardized by the Electronic Industries Alliance (EIA)
  - It has become the most widely used for character communication
  - Known as RS-232-C, and commonly abbreviated RS-232
- EIA standard specifies the details, such as
  - physical connection size (max cable length 50 feet long)
  - electrical details (range between -15v +15v)
  - the line coding being used
  - It can be configured to control the exact number of bits per second
  - It can be configured to send 7-bit or 8-bit characters
- Figure 9.5 illustrates how voltage varies at different stages
  - when a start bit, eight bits of a character, and a stop bit are sent

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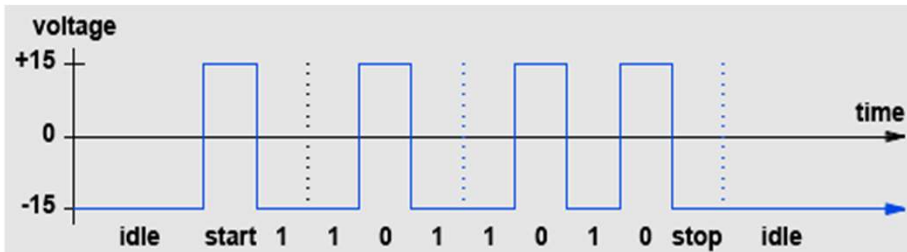## RS-232 Asynchronous Character Transmission

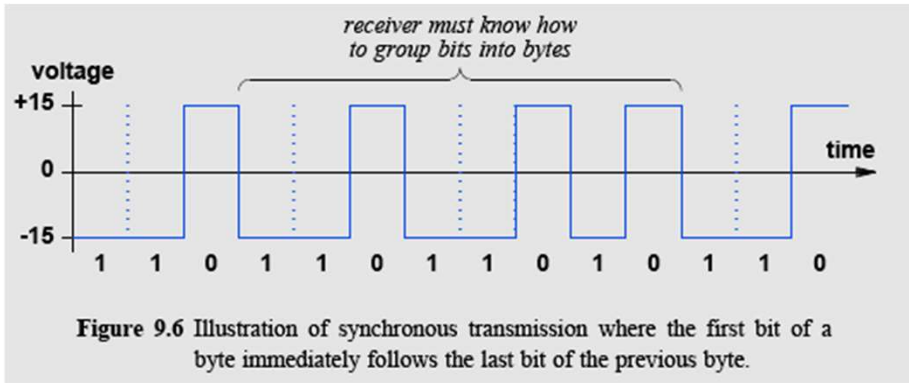Figure 9.5 Illustration of voltage during transmission of an 8-bit character when using RS-232.

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Synchronous Transmission

- A synchronous mechanism transmits bits of data continually
  - with no idle time between bits
  - after transmitting the final bit of one data byte, the sender transmits a bit of the next data byte
- The sender and receiver constantly remain synchronized
  - which means less synchronization overhead
- Compare the 8-bit characters on
  - an asynchronous system as illustrated in Figure 9.5
  - and a synchronous system as illustrated in Figure 9.6
- Each character sent using RS-232 requires an extra start bit and stop bit
  - meaning that each 8-bit character requires a minimum of 10 bit times, even if no idle time is inserted
- On a synchronous system
  - each character is sent without start or stop bits

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Synchronous Transmission

Figure 9.6 Illustration of synchronous transmission where the first bit of a byte immediately follows the last bit of the previous byte.
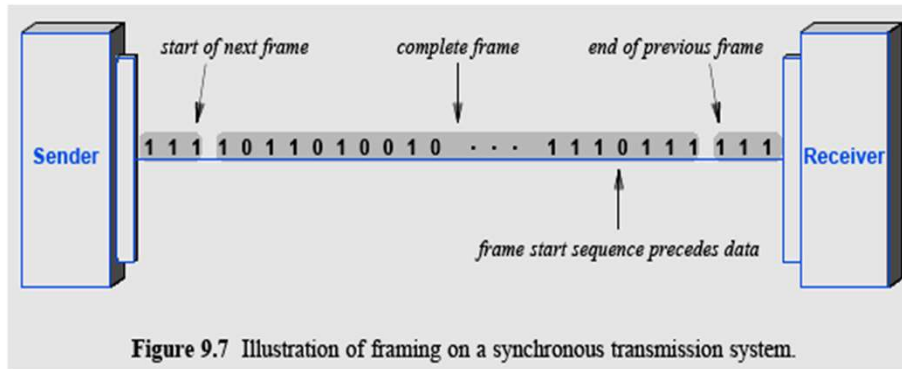
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Bytes, Blocks, and Frames

- If the underlying synchronous mechanism must send bits continually
  - What happens if a sender does not have data ready to send at all times?
  - The answer lies in a technique known as framing:
    - an interface is added to a synchronous mechanism that accepts and delivers a block of bytes known as a frame
  - To insure that the sender and receiver stay synchronized
    - a frame starts with a special sequence of bits
  - Most synchronous systems include an idle sequence (or idle byte)
    - that is transmitted when the sender has no data to send
- Figure 9.7 illustrates the concept

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Bytes, Blocks, and Frames

Figure 9.7 Illustration of framing on a synchronous transmission system.

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Isochronous Transmission

- Isochronous transmission
  - is designed to provide steady bit flow for multimedia applications
- Delivering such data at a steady rate is essential
  - because variations in delay known as jitter can disrupt reception (cause pops or clicks in audio/make video freeze for a short time)
- Isochronous network is designed to accept and send data at a fixed rate, R
  - Network interface is such that data must be handed to the network for transmission at exactly R bits per second
- For example, an isochronous mechanism designed to transfer voice operates at a rate of 64,000 bits per second
  - A sender must generate digitized audio continuously
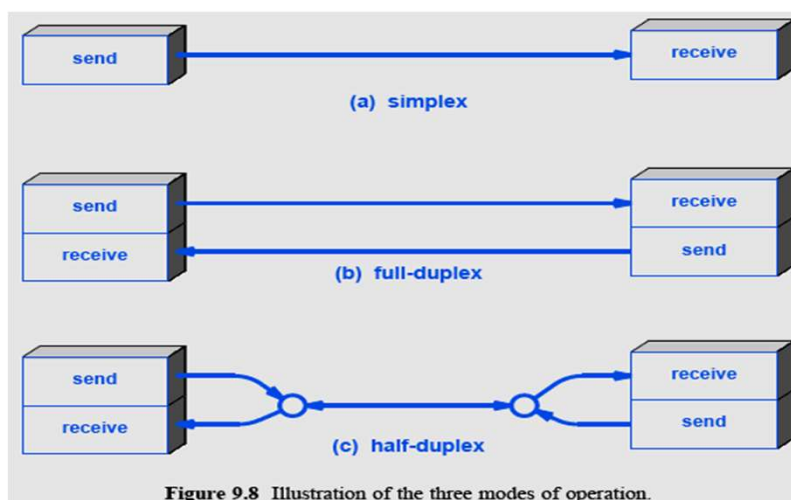 - A receiver must be able to accept and play the stream

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Simplex, Half-Duplex, and Full-Duplex Transmission

- A communications channel is classified as one of three types:
  (depending on the direction of transfer)
  - Simplex
  - Full-Duplex
  - Half-Duplex
- Simplex: a simplex mechanism can only transfer data in a single direction
  - It is analogous to broadcast radio or television
  - Figure 9.8a illustrates simplex communication
- Full-Duplex: allows transmission in two directions simultaneously
  - It is analogous to a voice telephone conversation
    - in which a participant can speak even if they are able to hear background music at the other end
  - Figure 9.8b illustrates the concept

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Simplex, Half-Duplex, and Full-Duplex Transmission

Figure 9.8 Illustration of the three modes of operation.

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9.12 Simplex, Half-Duplex, and Full-Duplex Transmission

- Half-Duplex: A half-duplex mechanism involves a shared transmission medium
  - The shared medium can be used for communication in each direction
  - But the communication cannot proceed simultaneously
  - It is analogous to using walkie-talkies where only one side can transmit at a time
- An additional mechanism is needed at each end of a half-duplex communication that coordinates transmission
  - to insure that only one side transmits at a given time
- Figure 9.8c illustrates half-duplex communication

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