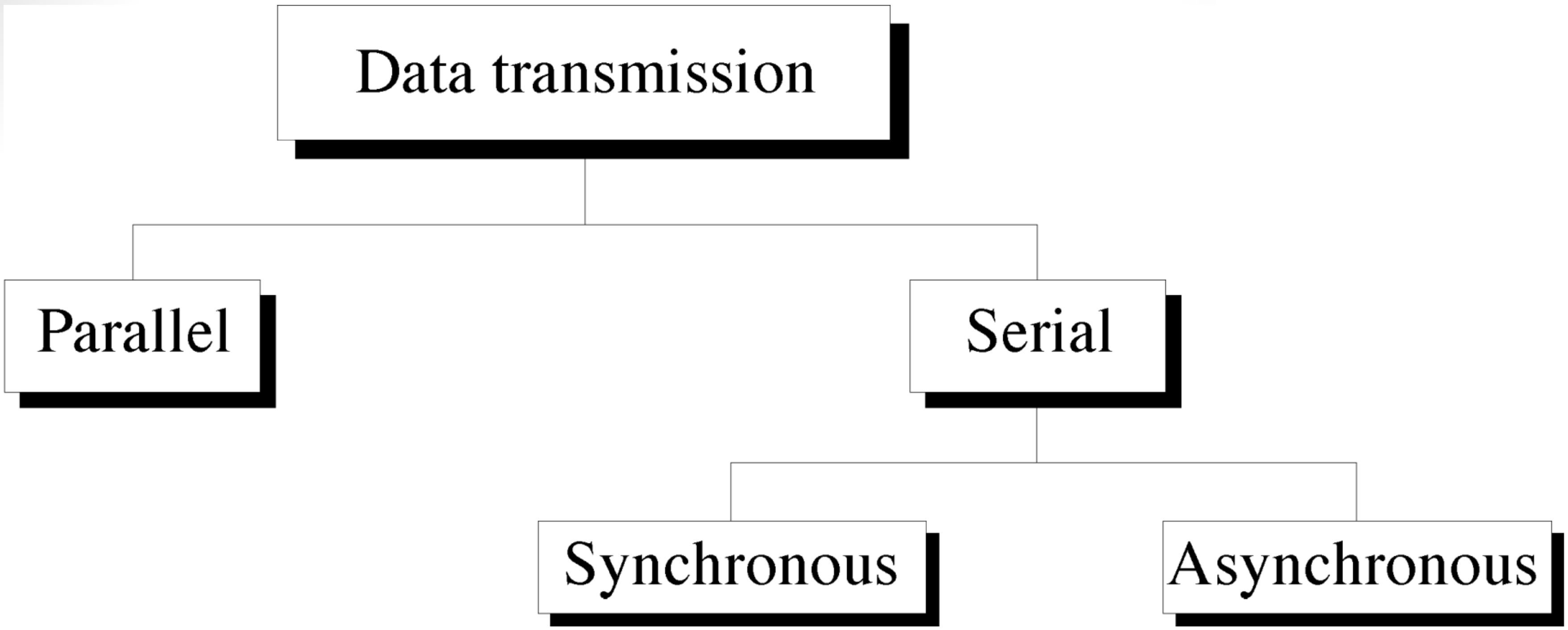
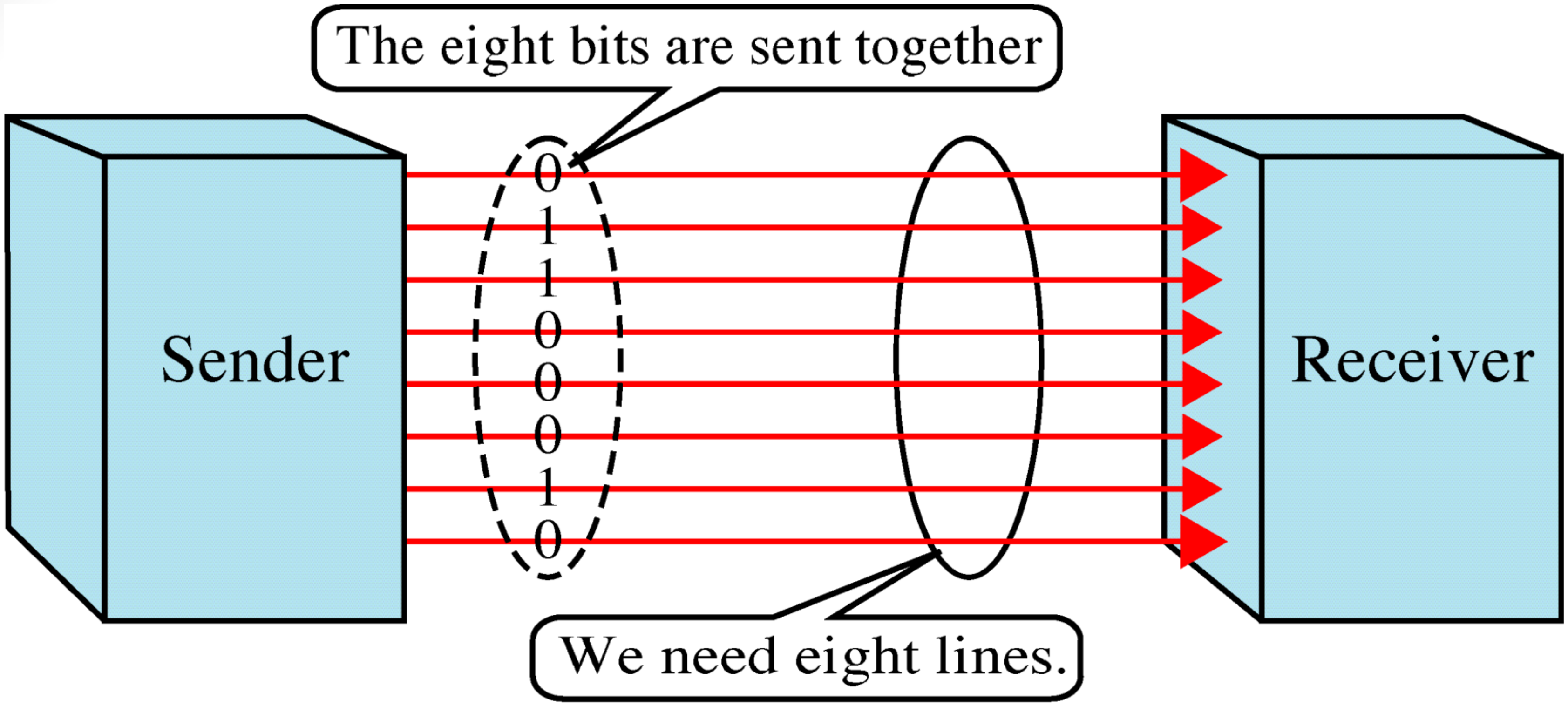
Transmission of Digital Data

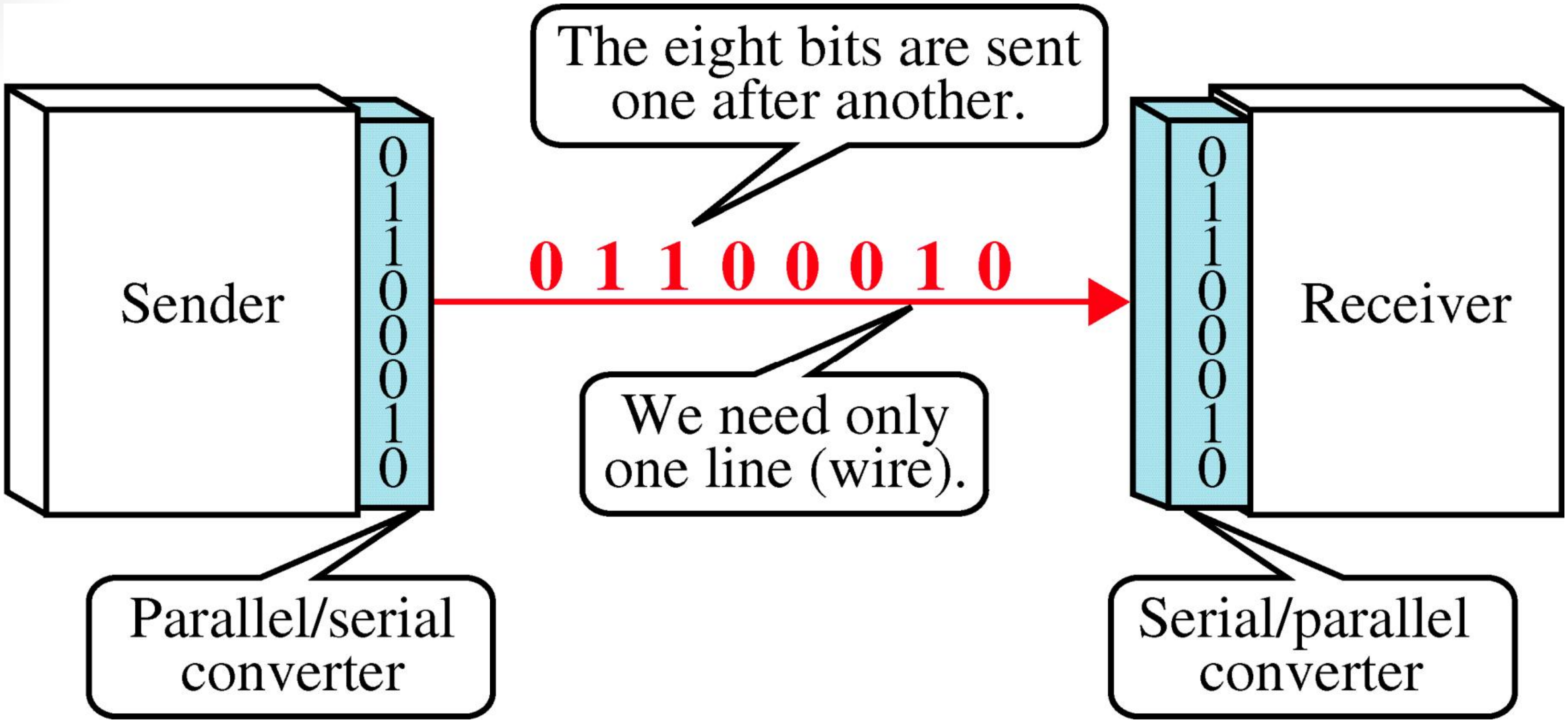
Interfaces and Modems


Data transmission
Parallel
Serial
Synchronous
Asynchronous

Parallel Transmission

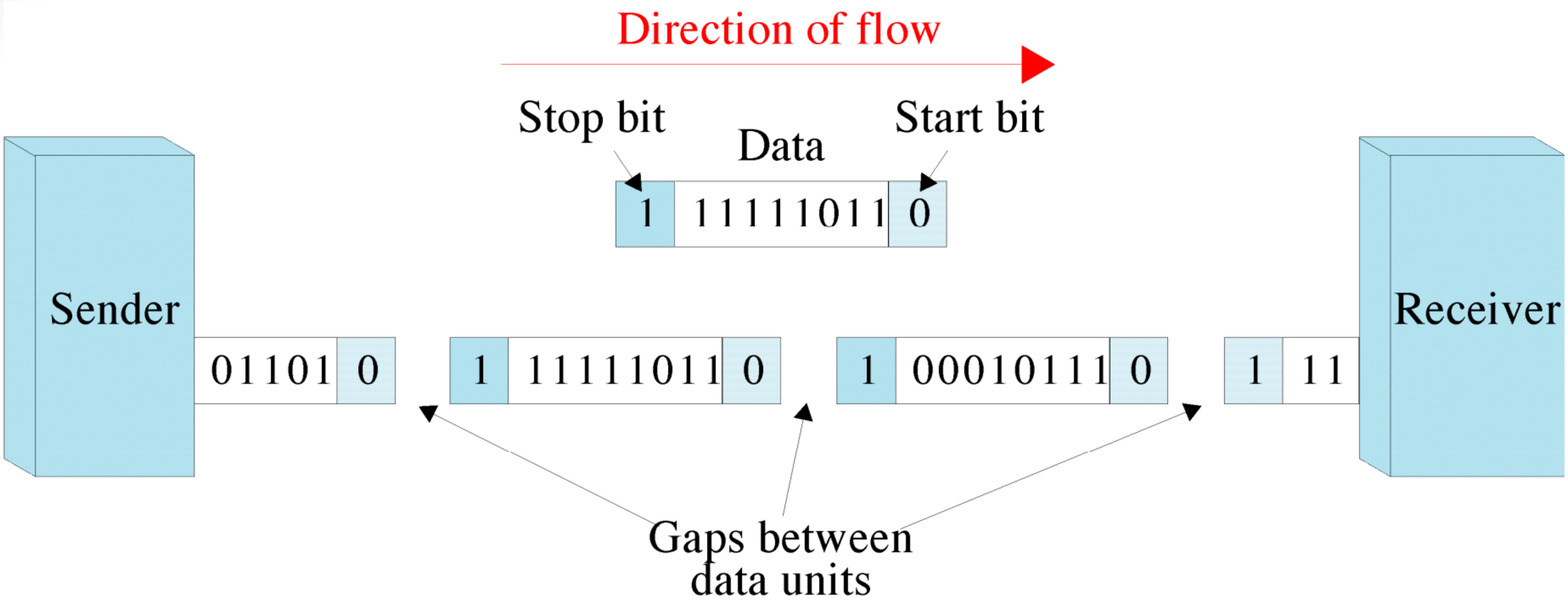


Serial Transmission



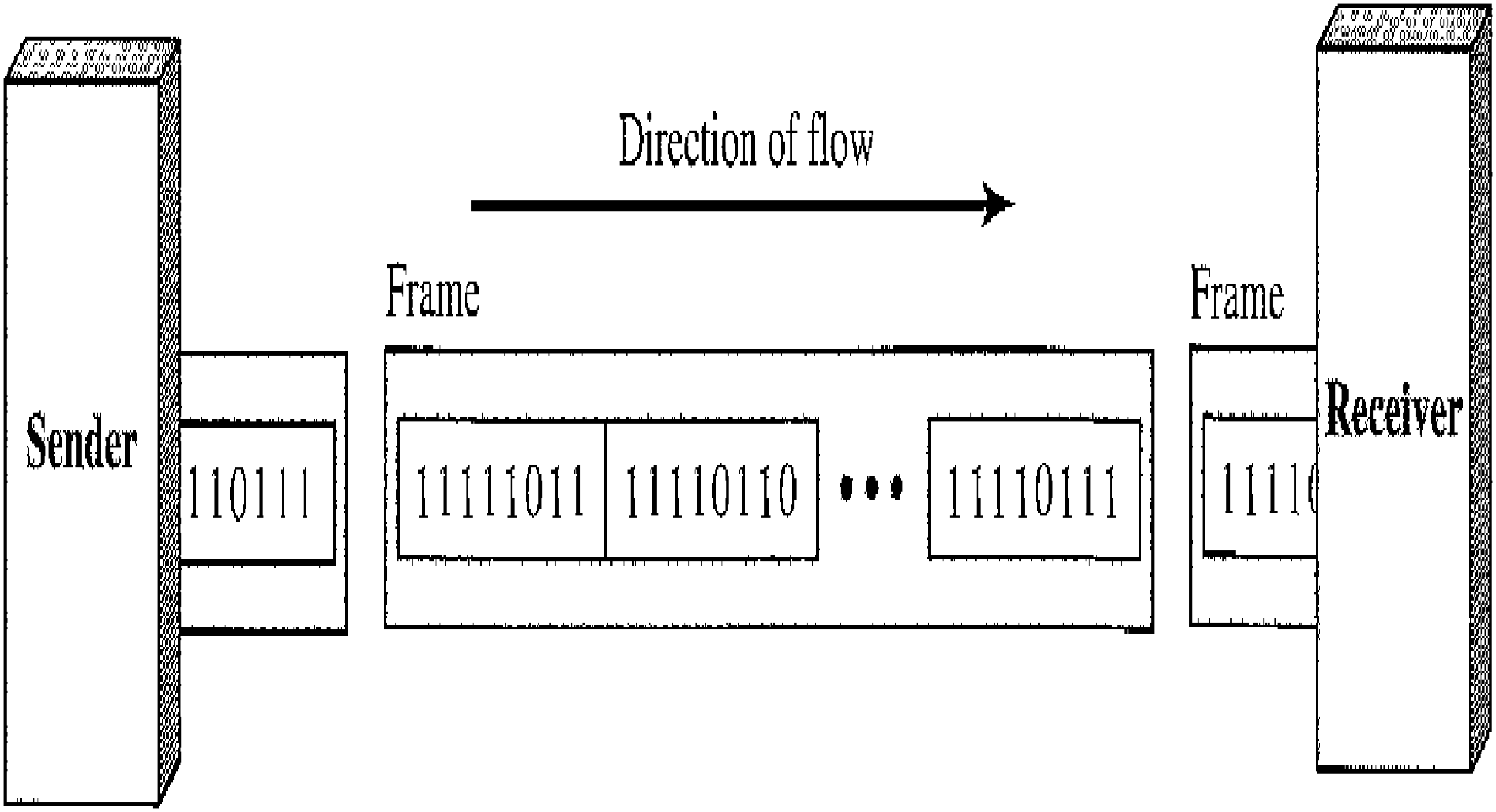
Advantage: reduces the cost of transmission over parallel by roughly a factor of n.

Asynchronous Transmission



In asynchronous transmission, we send 1 start bit (0) at the beginning and 1 or more stop bits (1s) at the end of each byte. There may be a gap between each byte.

Synchronous Transmission



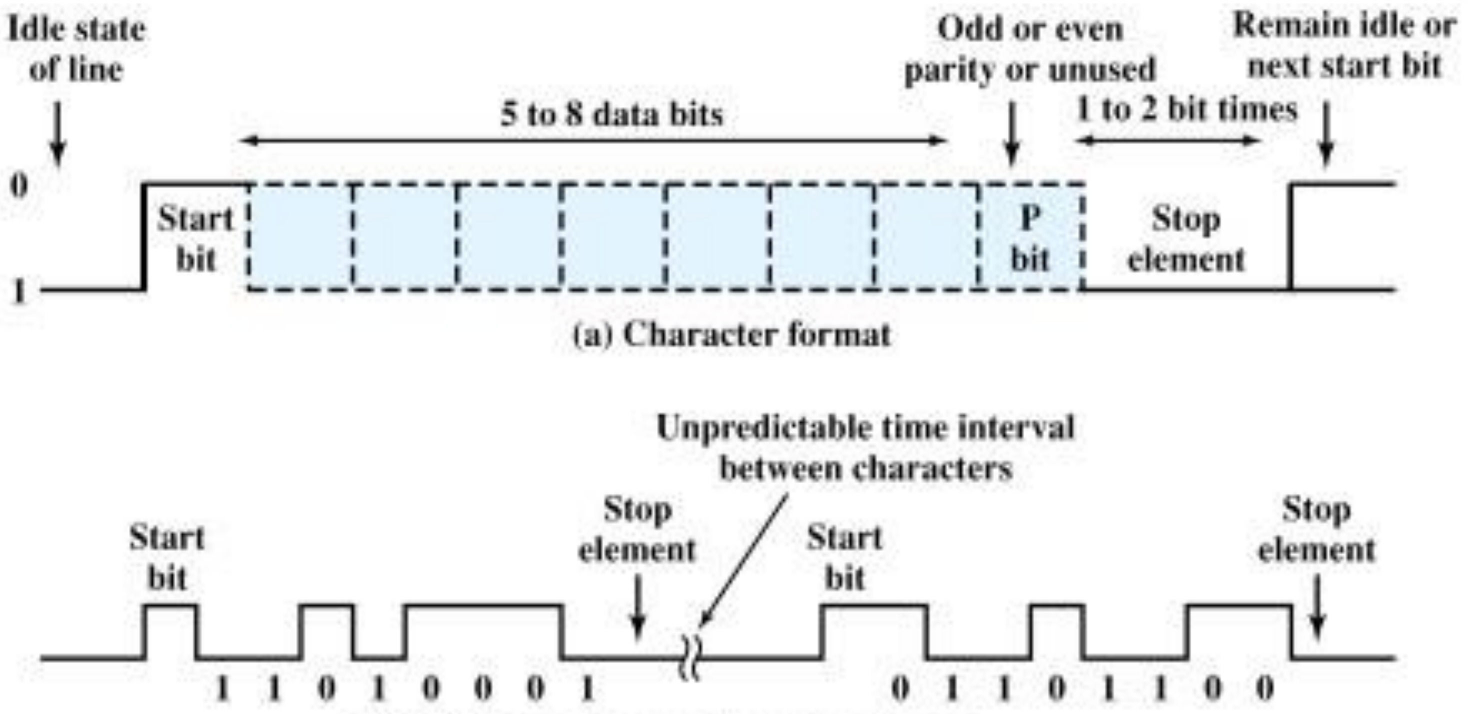
In synchronous transmission, we send bits one after another without start or stop bits or gaps. It is the responsibility of the receiver to group the bits.

Asynchronous & Synchronous Transmission

- Concerned with timing issues
- How does the receiver know when the bit period begins and ends?
- Small timing difference become more significant over time if no synchronization takes place between sender and receiver

Asynchronous Transmission

- Data transmitted 1 character at a time
- Character format is 1 start & 1+ stop bit, plus data (typically between 5 and 8 bits)
- Character may include parity bit
- Timing needed only within each character
- Resynchronization with each start bit
- Uses simple, cheap technology
- Wastes 20-30% of bandwidth
- Low-speed terminals and PCs commonly use asynchronous transmission

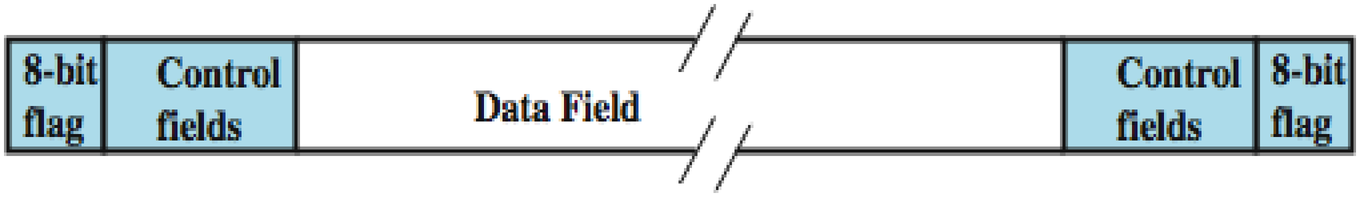


(a) Character format

(b) 8-bit asynchronous character stream

Synchronous Transmission

- Large blocks of bits transmitted without start/stop codes
- Synchronized by clock signal or clocking data
- Data framed by preamble and postamble bit patterns to establish timing
- More efficient than asynchronous
- Overhead typically below 5%
- Used at higher speeds than asynchronous
- Requires error checking



•Large systems and networks commonly use synchronous transmission

Errors

- An error occurs when a bit is altered between transmission and reception
  - binary 1 is transmitted and binary 0 is received or binary 0 is transmitted and binary 1 is received
- Single bit error
  - isolated error that alters one bit but not nearby bits
  - caused by white noise
- Burst error
  - contiguous sequence of *B* bits where first and last bits and any
    number of intermediate bits are received in error
  - caused by impulse noise or by fading in wireless
  - effects greater at higher data rates

Error Detection

- regardless of design you will have errors
- can detect errors by using an error-detecting code added by the transmitter
    - code is also referred to as *"check bits"*
- recalculated and checked by receiver
- still chance of undetected error

Parity Check

- parity
  - parity bit set so character has even or odd # of ones
    - even parity – used in synchronous transmission
    - odd parity – used in asynchronous transmission
  - even number of bit errors goes undetected
- problem
  - noise impulses often long enough to destroy more than one bit, especially at high data rates

Cyclic Redundancy Check (CRC)

- one of most common and powerful checks
- for a block of *k* bits, transmitter generates an *n*-bit frame by adding an (*n*-*k*)-bit frame check sequence (FCS)
- Transmits *n* bits which is exactly divisible by some predetermined number
- receiver divides frame by that number
  - if no remainder, assume no error

Error Control

- Two types of errors
  - Lost frame - never arrives or too error filled
  - Damaged frame - error in bits but recognizable
- Techniques involve
  - Error detection (e.g. CRC)
  - Positive acknowledgement – if error free
  - Retransmission after timeout – no ACK received
  - Negative acknowledgement and retransmission

ARQ

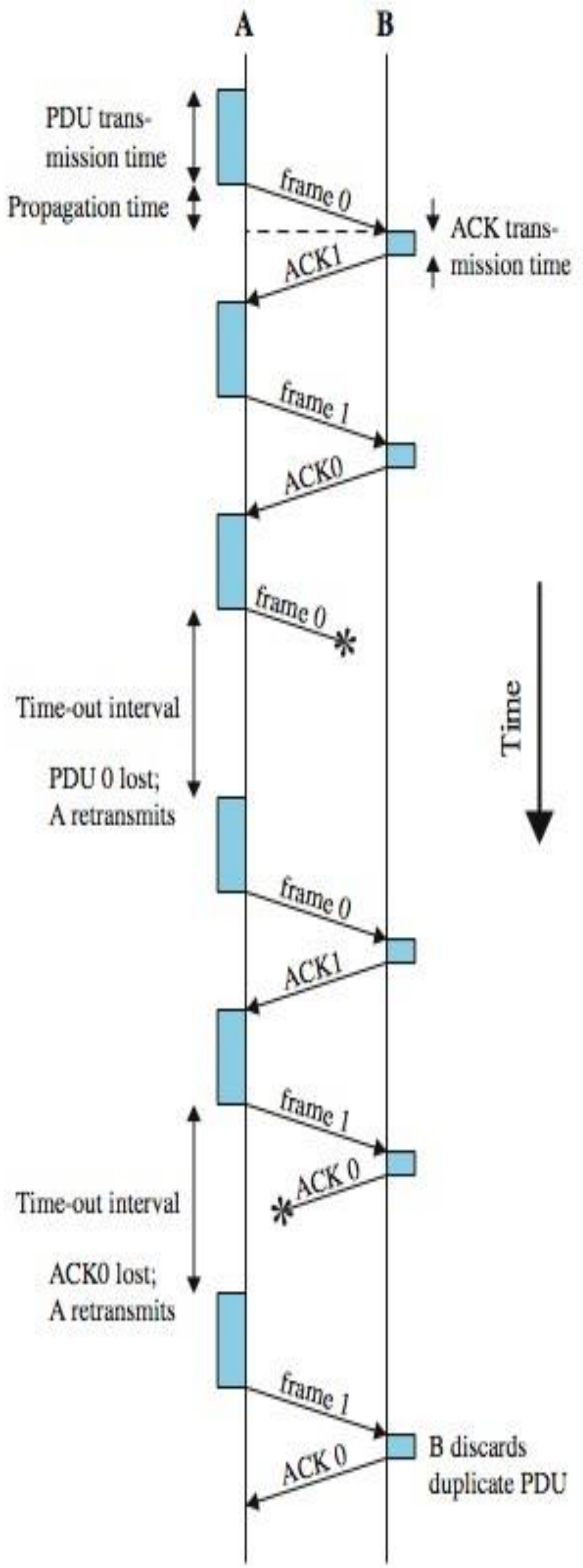
- Automatic Repeat reQuest (ARQ)
  - Collective name for error control techniques
  - Make potentially unreliable data link reliable
- Three versions
  - Stop-and-wait ARQ
  - Go-back-N ARQ
  - Selective-reject ARQ

Stop-and-Wait ARQ

- source transmits single frame
- waits for ACK
  - no other data can be sent until destination's reply arrives
- if frame received is damaged, discard it
  - transmitter has timeout
  - if no ACK within timeout, retransmit
- if ACK is damaged, transmitter will not recognize it
  - transmitter will retransmit after timeout
  - receiver will get two copies of same frame
  - use alternate frame numbering and ACK0 / ACK1 (one bit)

Stop and Wait ARQ

- Pros
  - Simplistic
- Cons
  - inefficient



Go-Back-N ARQ

- most commonly used error control
- based on sliding-window
  - use window size to control number of outstanding frames
- if no error, ACK as usual with frame number
- if error, reply with rejection REJ
  - destination will discard that frame and all future frames until frame in error is received correctly
  - transmitter must go back and retransmit that frame and all subsequent frames

Selective Reject ARQ

- also called selective retransmission
- only rejected frames are retransmitted
- subsequent frames are accepted by the receiver and buffered
- minimizes retransmission
- receiver must maintain large enough buffer
- more complex logic in transmitter
  - less widely used
- useful for satellite links with long propagation delays

FROM SPEECH TO RADIO TRANSMISSION