Data and Computer Communications

Chapter 6 – Digital Data Communications Techniques

Eighth Edition

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Digital Data Communications Techniques

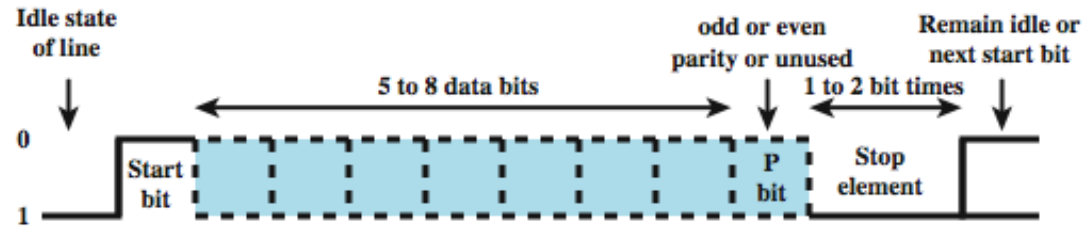
- *A conversation forms a two-way communication link; there is a measure of symmetry between the two parties, and messages pass to and fro. There is a continual stimulus-response, cyclic action; remarks call up other remarks, and the behavior of the two individuals becomes concerted, co-operative, and directed toward some goal. This is true communication.*

  —*On Human Communication*, Colin Cherry

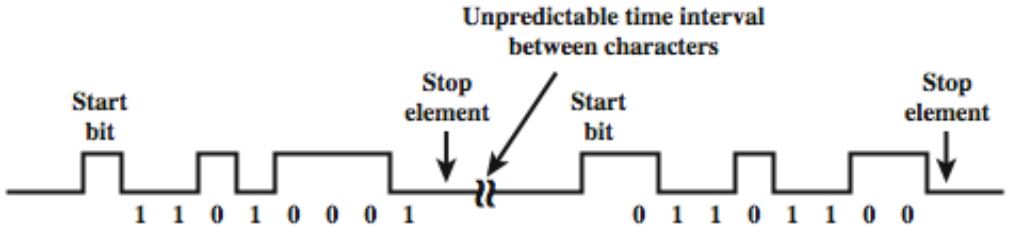
Asynchronous and Synchronous Transmission

- timing problems require a mechanism to synchronize the transmitter and receiver
  - receiver samples stream at bit intervals
  - if clocks not aligned and drifting will sample at wrong time after sufficient bits are sent
- two solutions to synchronizing clocks
  - asynchronous transmission
  - synchronous transmission

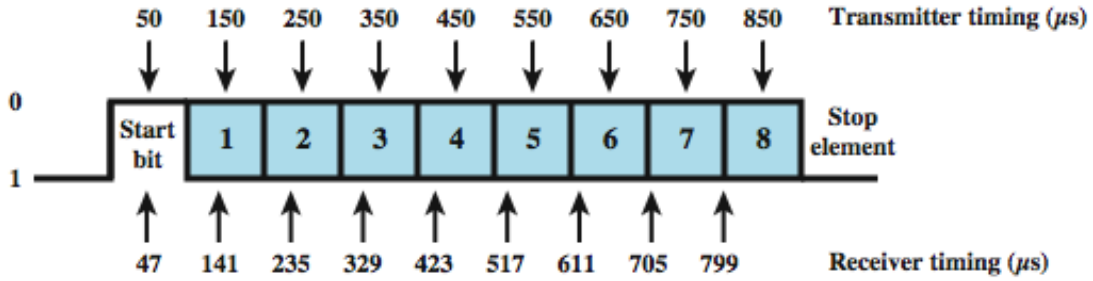
Asynchronous Transmission



(a) Character format



(b) 8-bit asynchronous character stream



(c) Effect of timing error

Asynchronous - Behavior

- simple
- cheap
- overhead of 2 or 3 bits per char (~20%)
- good for data with large gaps (keyboard)

Synchronous Transmission

- block of data transmitted sent as a frame
- clocks must be synchronized
  - can use separate clock line
  - or embed clock signal in data
- need to indicate start and end of block
  - use preamble and postamble
- more efficient (lower overhead) than async

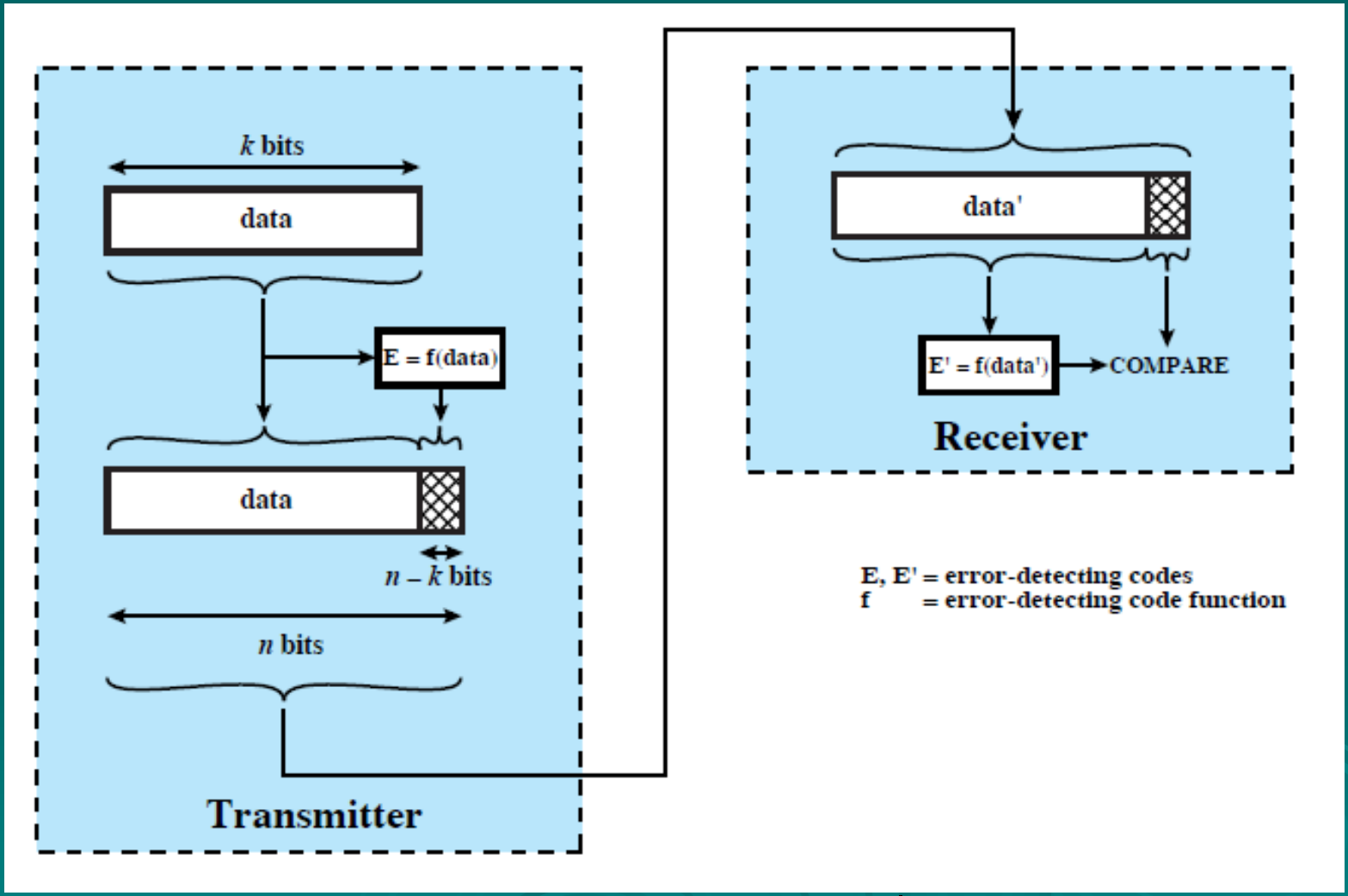
Types of Error

- an error occurs when a bit is altered between transmission and reception
- single bit errors
  - only one bit altered
  - caused by white noise
- burst errors
  - contiguous sequence of *B* bits in which first last and any number of intermediate bits in error
  - caused by impulse noise or by fading in wireless
  - effect greater at higher data rates

Error Detection

- will have errors
- detect using error-detecting code
- added by transmitter
- recalculated and checked by receiver
- still chance of undetected error
- parity
  - parity bit set so character has even (even parity) or odd (odd parity) number of ones
  - even number of bit errors goes undetected

Error Detection Process



Cyclic Redundancy Check

- one of most common and powerful checks
- for block of *k* bits transmitter generates an *n* bit frame check sequence (FCS)
- transmits *k*+*n* bits which is exactly divisible by some number
- receiver divides frame by that number
  - if no remainder, assume no error
  - for math, see Stallings chapter 6

Modulo 2 Arithmetic (XOR)

- Define:
  - T = (k+n)-bit frame to be transmitted, n < k
  - M = k-bit message, the first k bits of T
  - F = n-bit FCS, the last n bits of T
  - P = pattern of n+1 bits, the predetermined divisor
- We would like T/P to have no remainder
  - $T = 2^nM + F$
  - $2^nM/P = Q + R/P$, R is at least one bit less than P
  - Use R as the FCS (i.e. F), i.e. $T = 2^nM + R$
  - Examine if T/P have no remainder?
    - $T/P = (2^nM + R)/P = Q + R/P + R/P = Q + (R+R)/P = Q$

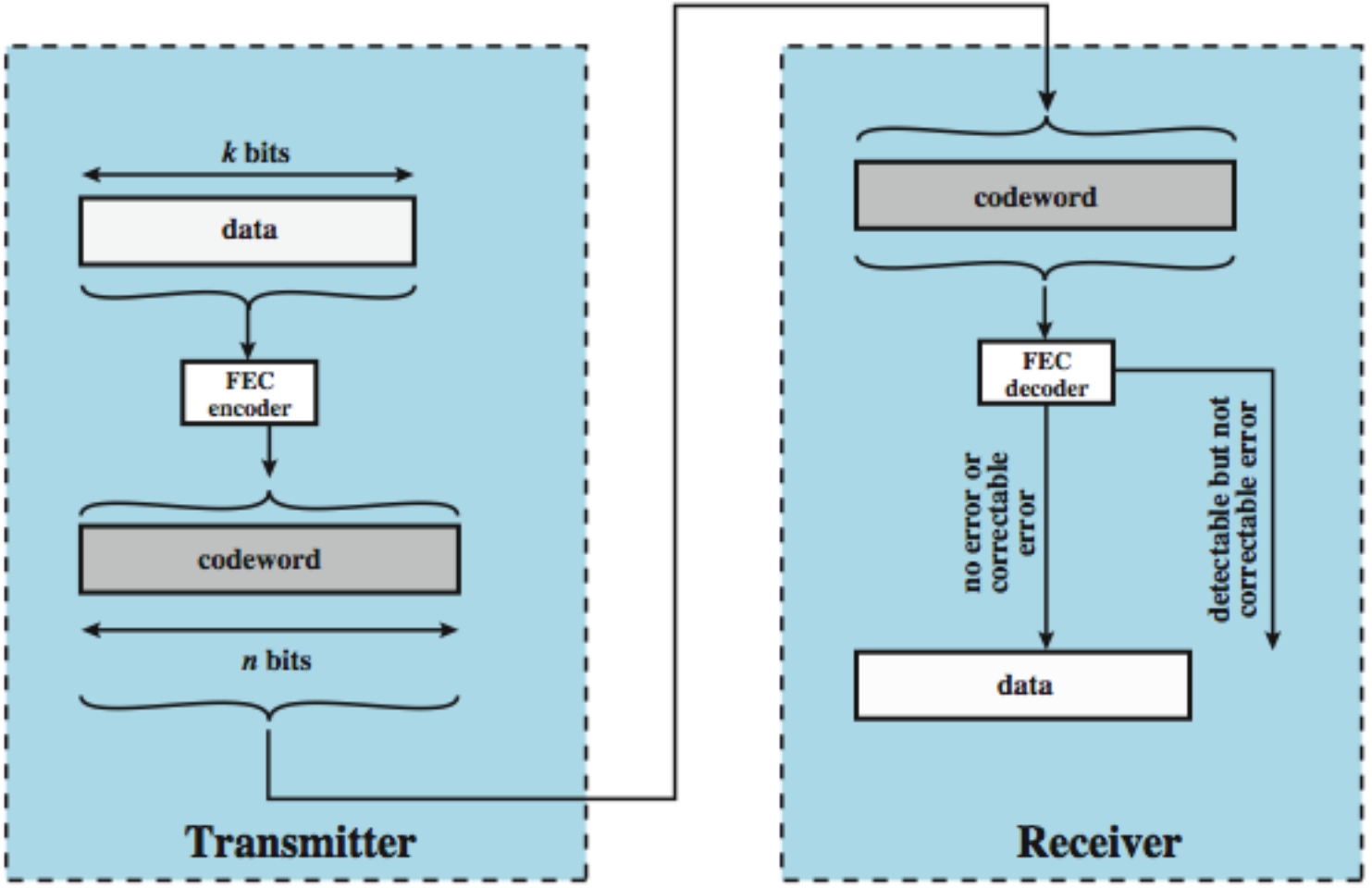
Modulo 2 Arithmetic (cont)

- Occurrence of errors
  - $T_r = T + E$
  - T = transmitted frame
  - E = error pattern with 1s in positions of error
  - T_r = received frame
- Fail to detect an error if and only if T_r is divisible by P
  - i.e. if and only if E is divisible by P

Error Correction

- correction of detected errors usually requires data block to be retransmitted
- not appropriate for wireless applications
  - bit error rate is high causing lots of retransmissions
  - when propagation delay long (satellite) compared with frame transmission time, resulting in retransmission of frame in error plus many subsequent frames
- instead need to correct errors on basis of bits received
- error correction provides this

Error Correction Process



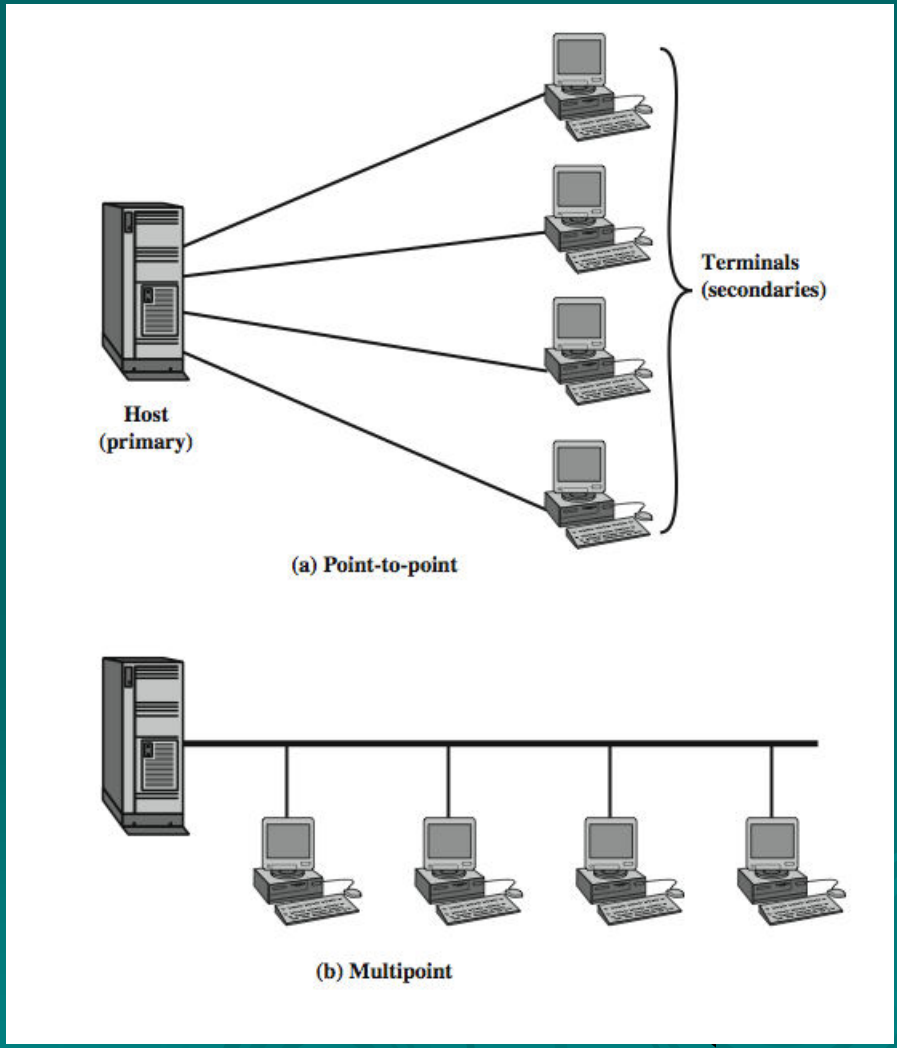
How Error Correction Works

- adds redundancy to transmitted message
- can deduce original despite some errors
- eg. block error correction code
  - map *k* bit input onto an *n* bit codeword
  - each distinctly different
  - if get error assume codeword sent was closest to that received
- for math, see Stallings chapter 6
- means have reduced effective data rate

Line Configuration - Topology

- physical arrangement of stations on medium
  - point to point - two stations
    - such as between two routers / computers
  - multi point - multiple stations
    - traditionally mainframe computer and terminals
    - now typically a local area network (LAN)

Line Configuration - Topology



Line Configuration - Duplex

- classify data exchange as half or full duplex
- half duplex (two-way alternate)
  - only one station may transmit at a time
  - requires one data path
- full duplex (two-way simultaneous)
  - simultaneous transmission and reception between two stations
  - requires two data paths
    - separate media or frequencies used for each direction
  - or echo canceling

Summary

- asynchronous verses synchronous transmission
- error detection and correction
- line configuration issues