Computer Networks

CMP2205

Lecture 5

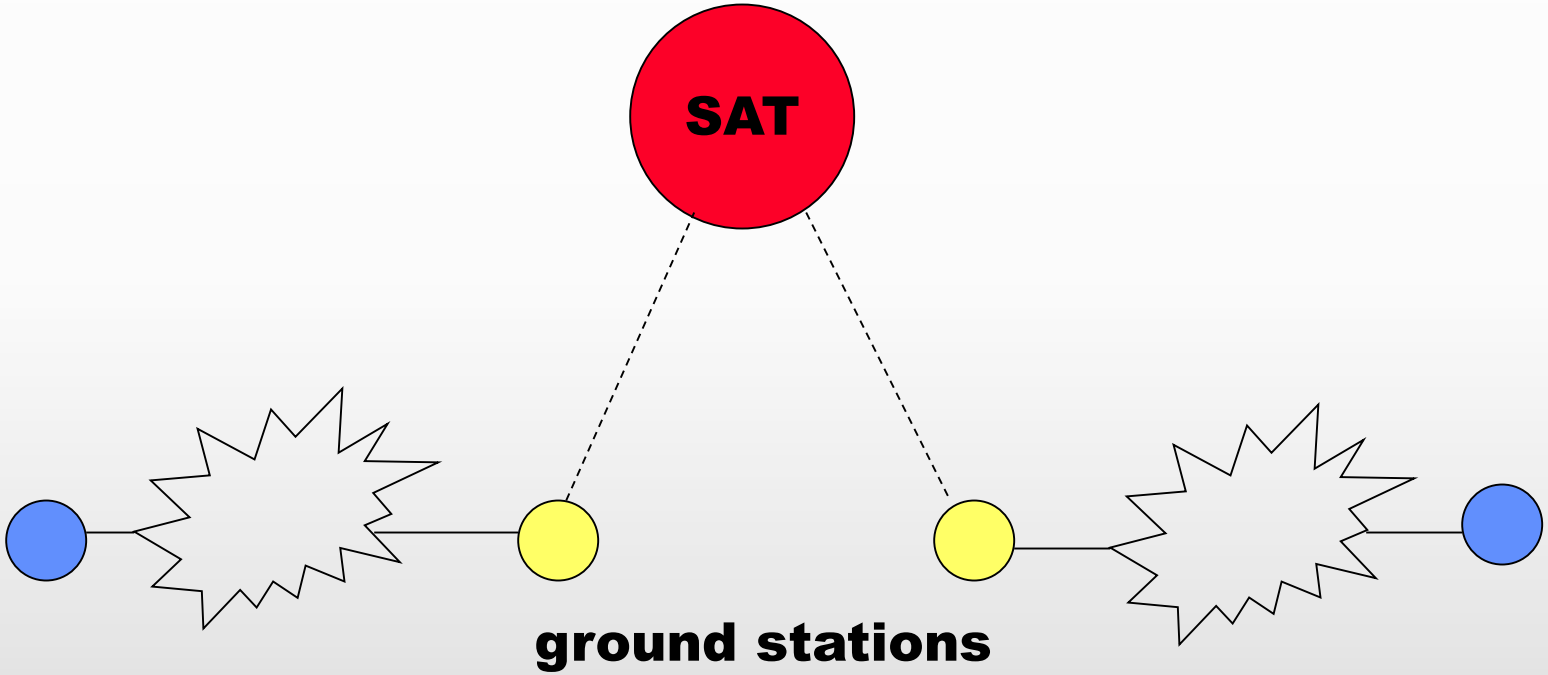
Spread Spectrum

- *Narrow frequency band -> good reception (power, bandwidth).*
- *But in some cases, wide band is used, aka, spread spectrum.*
  - *Modulate signal to increase bandwidth of signal to be transmitted.*
- *2 variations:*
  - *Frequency Hopping (FH).*
    - *Transmitter hops frequencies*
  - *Direct Sequence (DS).*
    - *Use spreading code to convert each bit of the original signal into multiple bits.*

Communication Satellites

- *Weather balloons.*
- *The moon.*
- *Artificial satellites:*
  - *Geostationary.*
  - *Medium-Earth Orbit.*
  - *Low-Earth Orbit.*

Satellite Communications



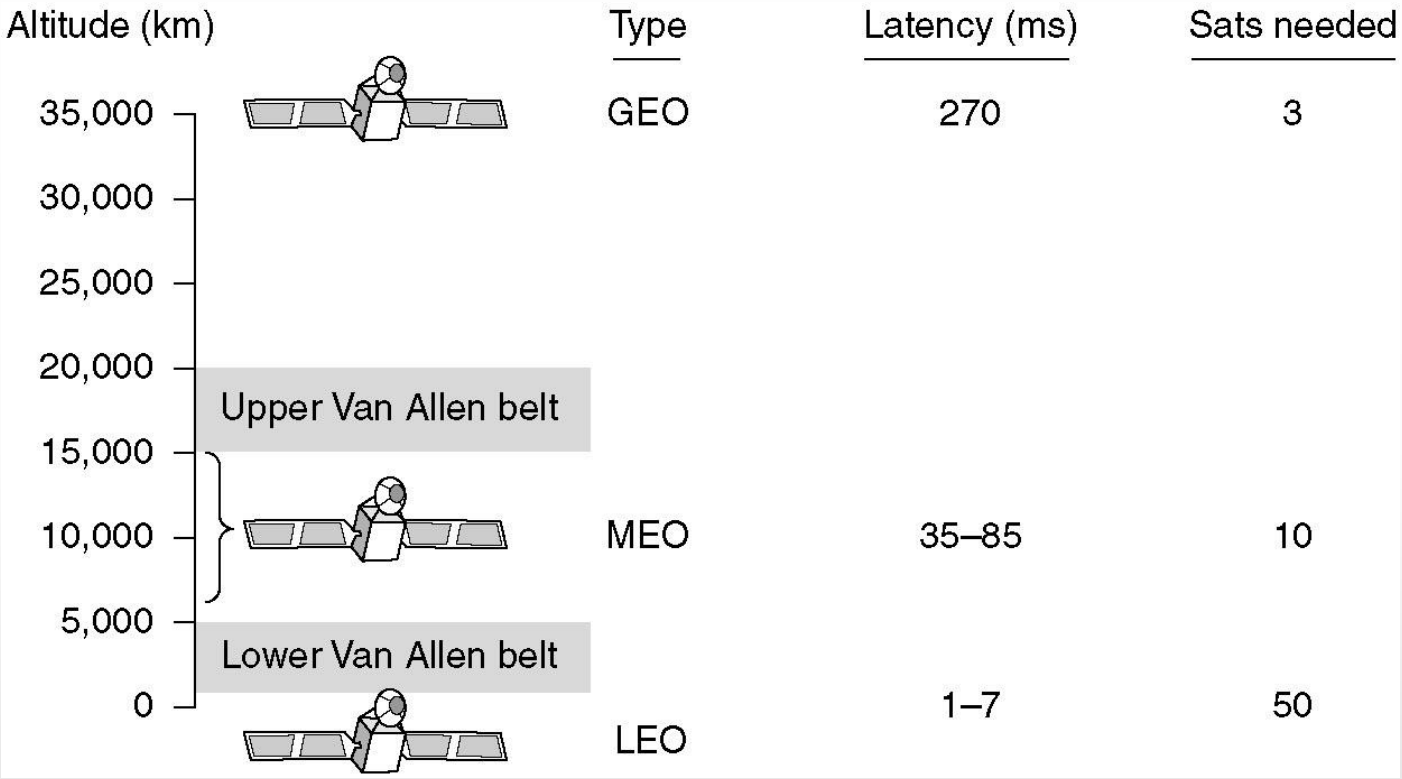
Satellite Communications

- *Satellite-based antenna(e) in stable orbit above earth.*
- *Two or more (earth) stations communicate via one or more satellites serving as relay(s) in space.*
- *Uplink: earth->satellite.*
- *Downlink: satellite->earth.*
- *Transponder: satellite electronics converting uplink signal to downlink.*

Orbits

- *Shape: circular, elliptical.*
- *Plane: equatorial, polar.*
- *Altitude: geostationary (GEO), medium earth (MEO), low earth (LEO).*

Communication Satellites



GEOs

- *High-flying satellites.*
- *Orbit at 35,863 Km above earth and rotates in equatorial plane.*
- *Many GEO satellites up there!*

GEO: Plus's and minus's

- *Plus's:*
  - *Stationarity: no frequency changes due to movement.*
  - *Tracking by earth stations simplified.*
  - *At that altitude, provides good coverage of the earth.*
- *Minus's:*
  - *Weakening of signal.*
  - *Polar regions poorly served.*
  - *Delay!*
  - *Spectral waste for point-to-point communications.*

Principal Satellite Bands

Band	Downlink	Uplink	Bandwidth	Problems
L	1.5 GHz	1.6 GHz	15 MHz	Low bandwidth; crowded
S	1.9 GHz	2.2 GHz	70 MHz	Low bandwidth; crowded
C	4.0 GHz	6.0 GHz	500 MHz	Terrestrial interference
Ku	11 GHz	14 GHz	500 MHz	Rain
Ka	20 GHz	30 GHz	3500 MHz	Rain, equipment cost

. Downlink frequencies interfere with microwave.
. Internationally-agreed frequency bands.

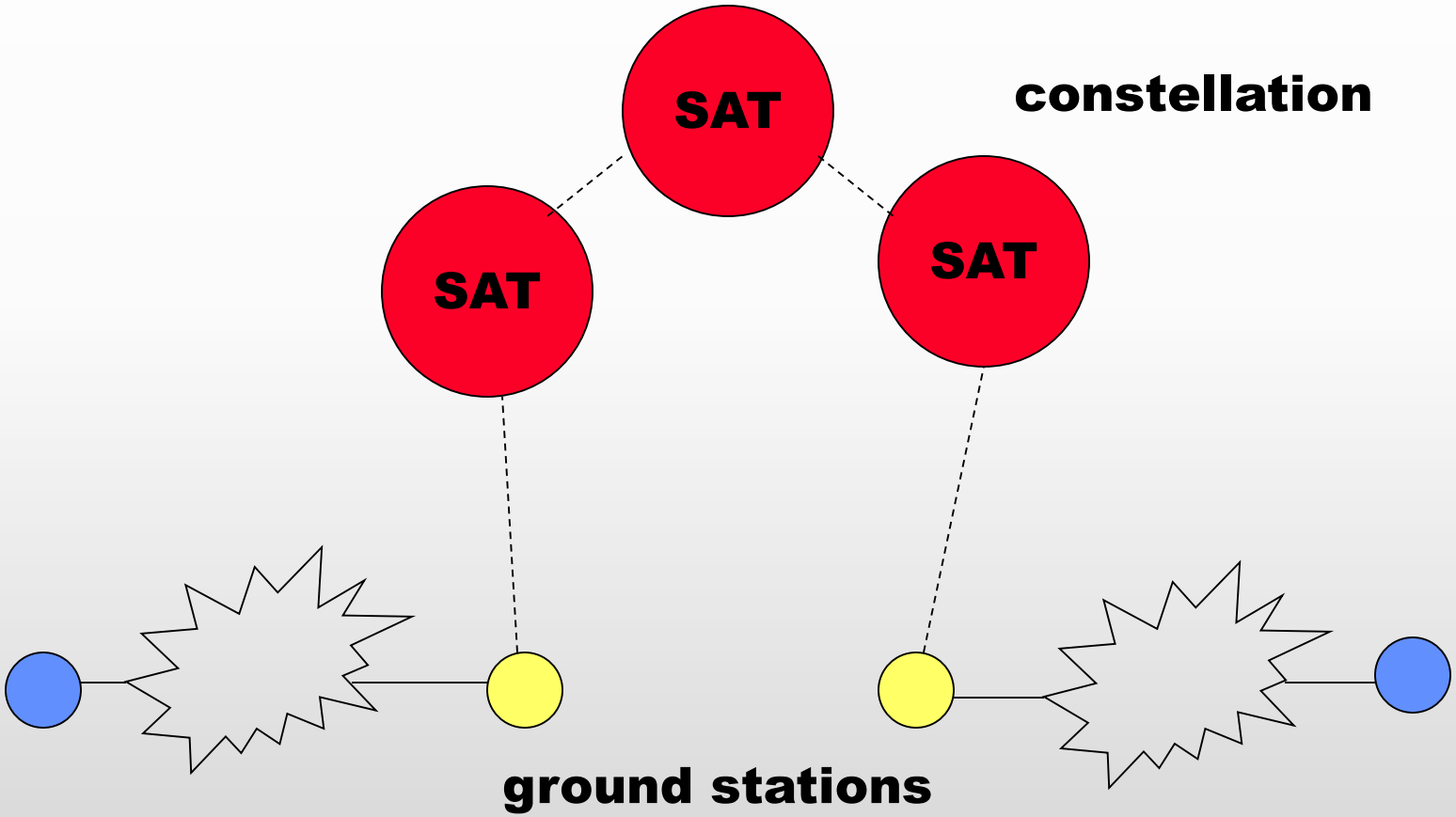
LEO Satellites

- *Circular or slightly eliptical orbit under 2,000 Km.*
- *Orbit period: 1.5 to 2 hours.*
- *Coverage diameter: 8,000 Km.*
- *RTT propagation delay < 20ms (compared to > 300ms for GEOs).*
- *Subject to large frequency changes and gradual orbit deterioration.*

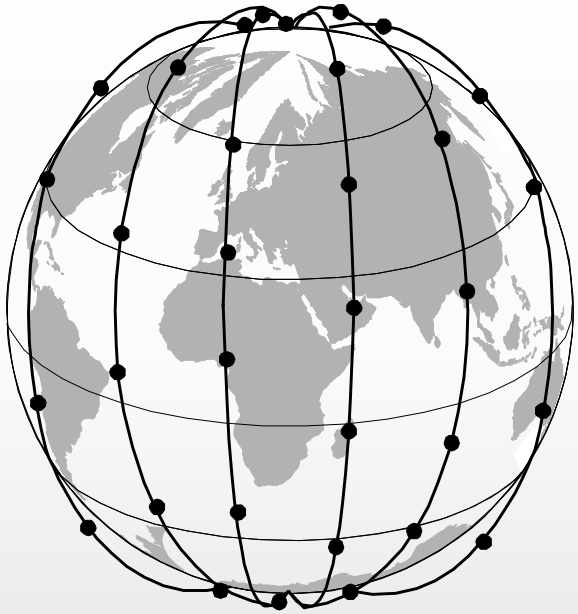
LEO Constellations

- *Advantages over GEOs:*
  - *Lower delay, stronger signal, more localized coverage.*
- *But, for broad coverage, many satellites needed.*
- *Example: Iridium (66 satellites).*

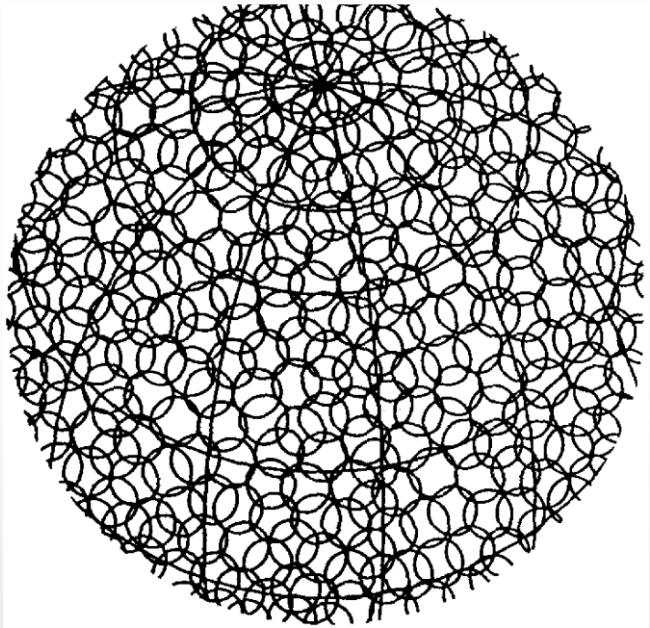
LEOs



Low-Earth Orbit Satellites Iridium



(a)



(b)

- *(a) The Iridium satellites from six necklaces around the earth.*
- *(b) 1628 moving cells cover the earth.*

In Summary…

- *GEOs*
  - *Long delay - 250-300 ms.*
- *LEOs*
  - *Relatively low delay - 40 - 200 ms.*
  - *Large variations in delay - multiple hops/route changes, relative motion of satellites, queuing.*

Satellite Data Rates

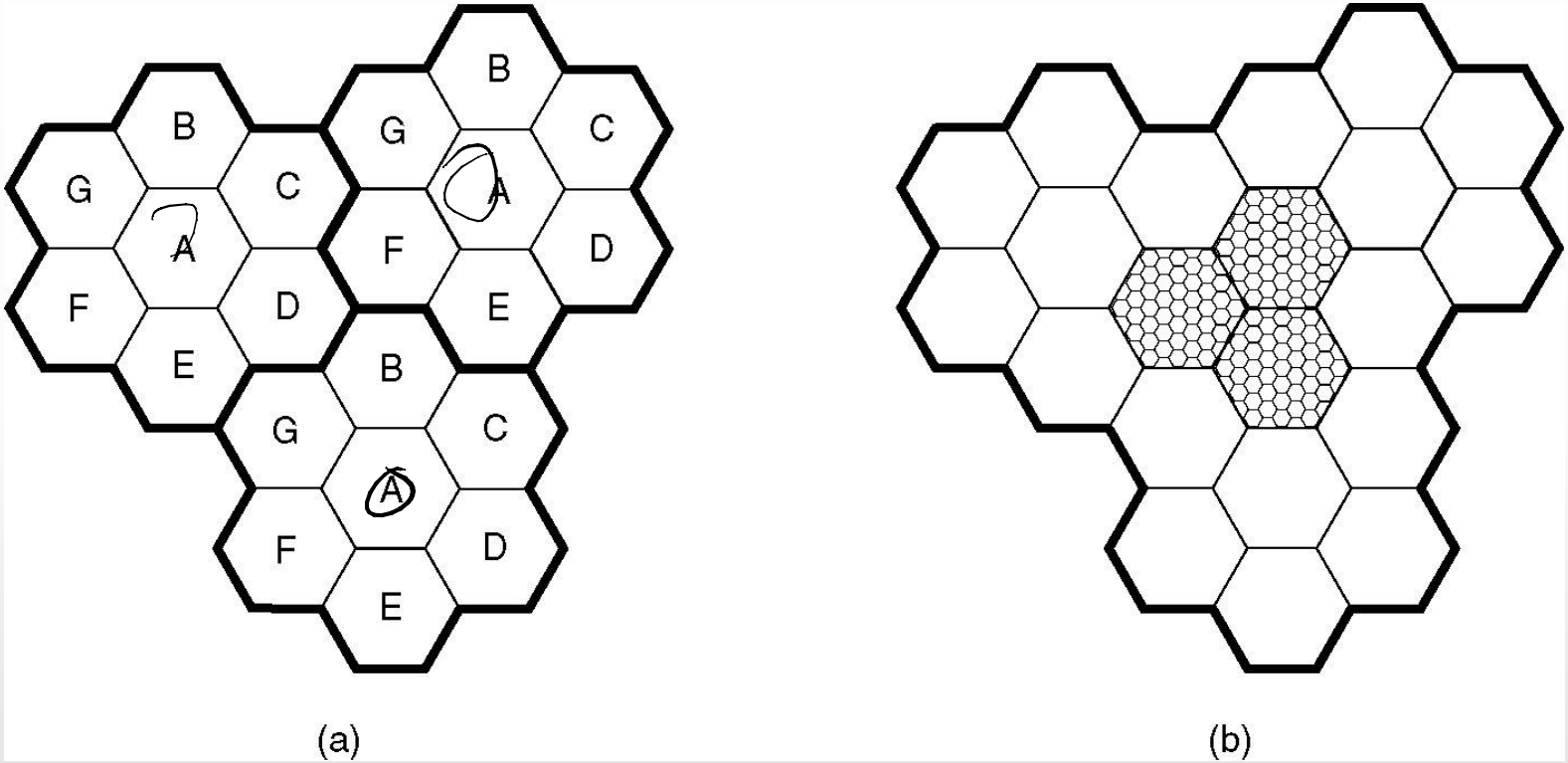
- *Satellite has 12-20 transponders, each ranging from 36-50 Mbps.*

- *T1: 1.54 Mbps.*
- *T2: 6.312 Mbps.*
- *T3: 44.736 Mbps.*
- *T4: 274.176 Mbps.*

The Mobile Telephone System

- *First-Generation Mobile Phones: Analog Voice*
- *Second-Generation Mobile Phones: Digital Voice*
- *Third-Generation Mobile Phones: Digital Voice and Data*

The “Cell” Concept



- *(a) Frequencies not reused in adjacent cells.*
- *(b) To add more users, smaller cells.*

Mobile Phone System Structure

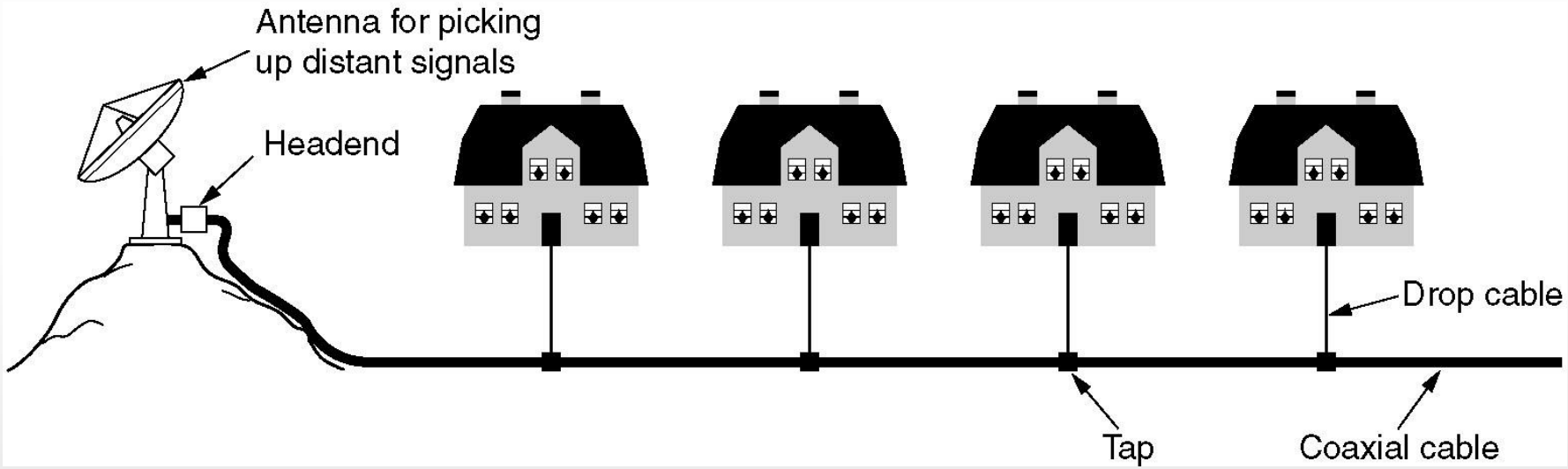
- *Hierarchy.*
- *Base station.*
- *Mobile Switching Center (MSC).*
- *MSCs connected through PSTN.*

Handoffs

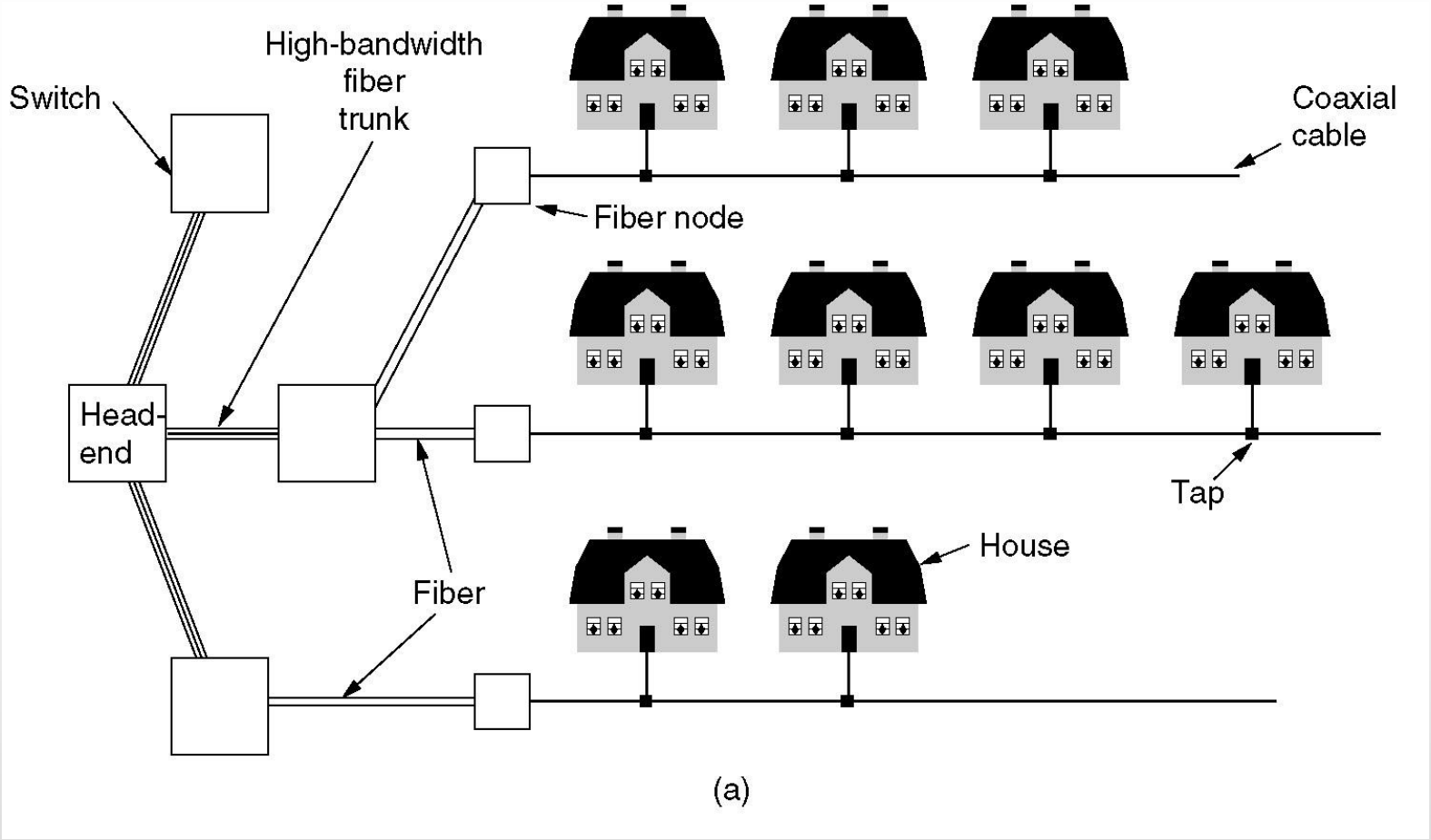
- *As mobile phones move, they switch cells, and thus base stations.*
- *Soft versus hard handoffs.*
  - *Two base stations while handoff is in progress.*
  - *Hard handoff.*
- *Roaming.*

Community Antenna Television

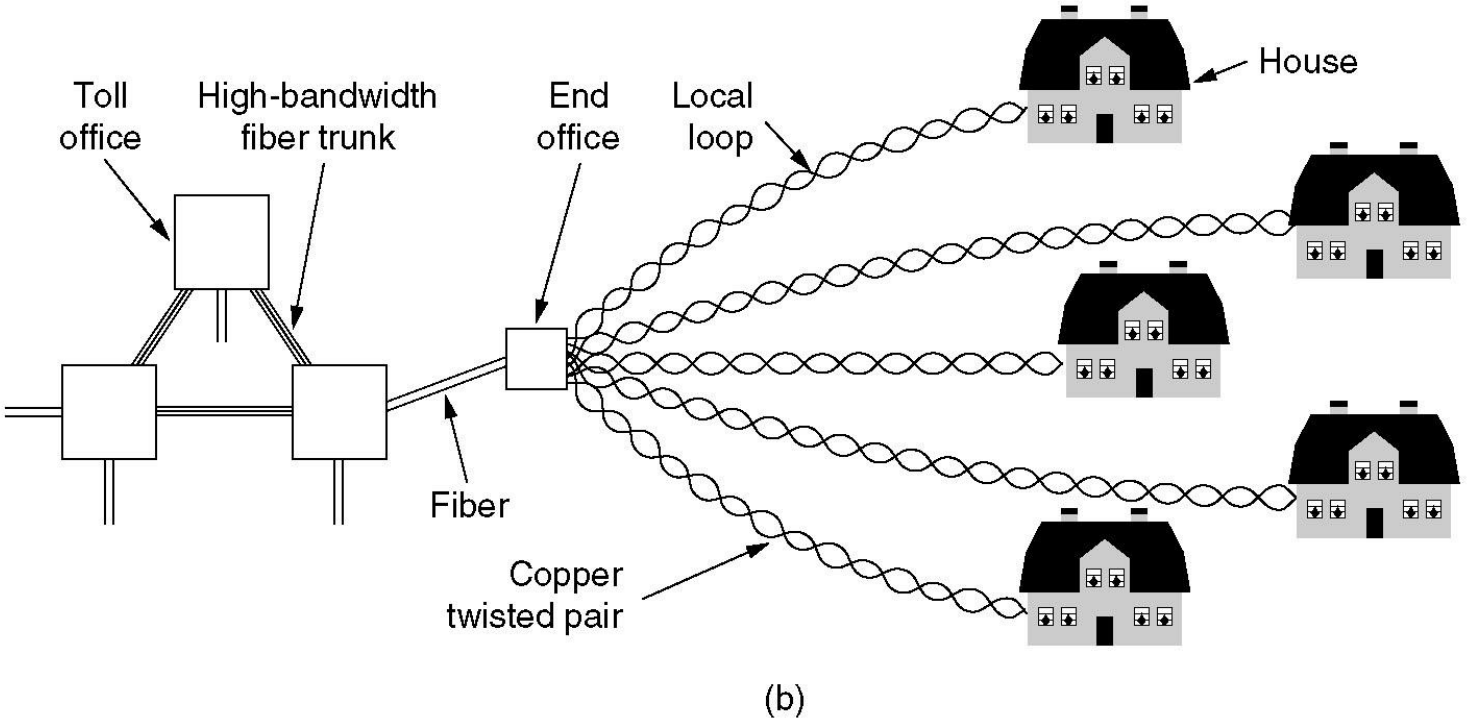
- *An early cable television system.*



Internet over Cable



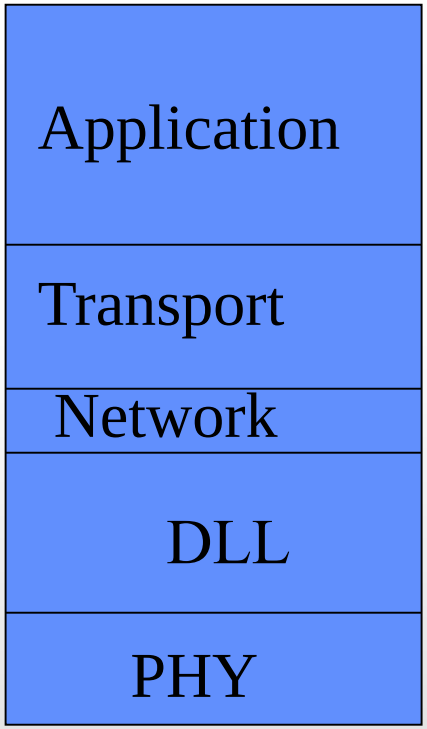
DSL


Toll office
High-bandwidth fiber trunk
End office
Local loop
House
Fiber
Copper twisted pair
(b)

ADSL versus Internet over Cable

- *Both uses fiber in the backbone.*
- *ADSL uses twisted pair and IoC uses coax on the edge.*
- *Coax has higher capacity but shared with TV.*
- *IoC's capacity is unpredicatble as it depends on how many users/traffic.*

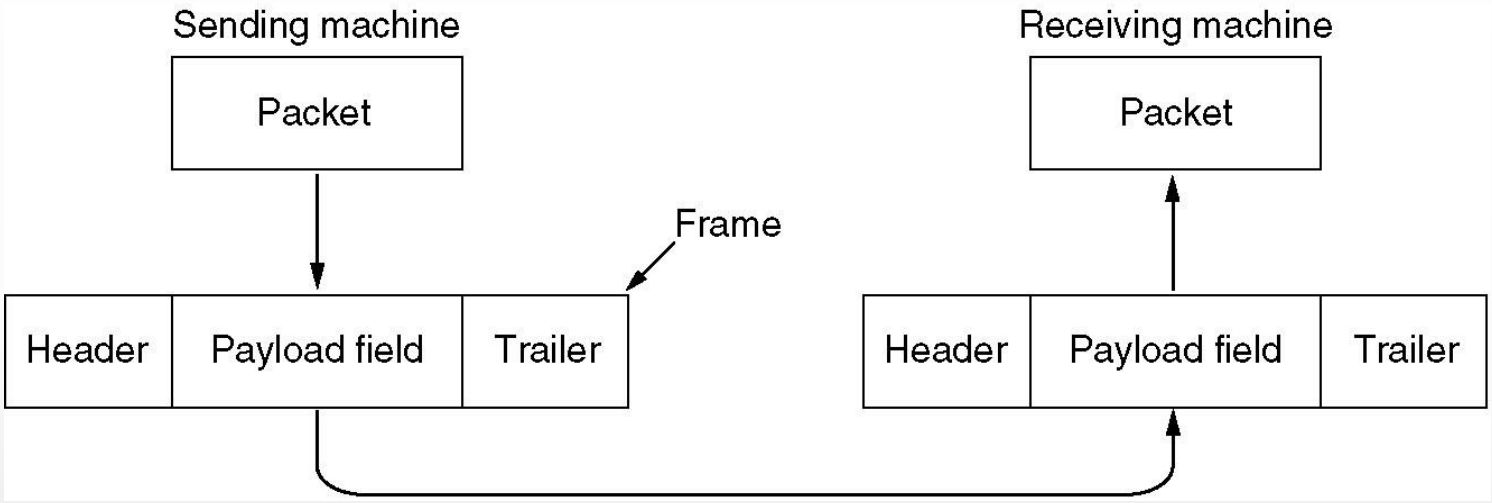
Data Link Layer



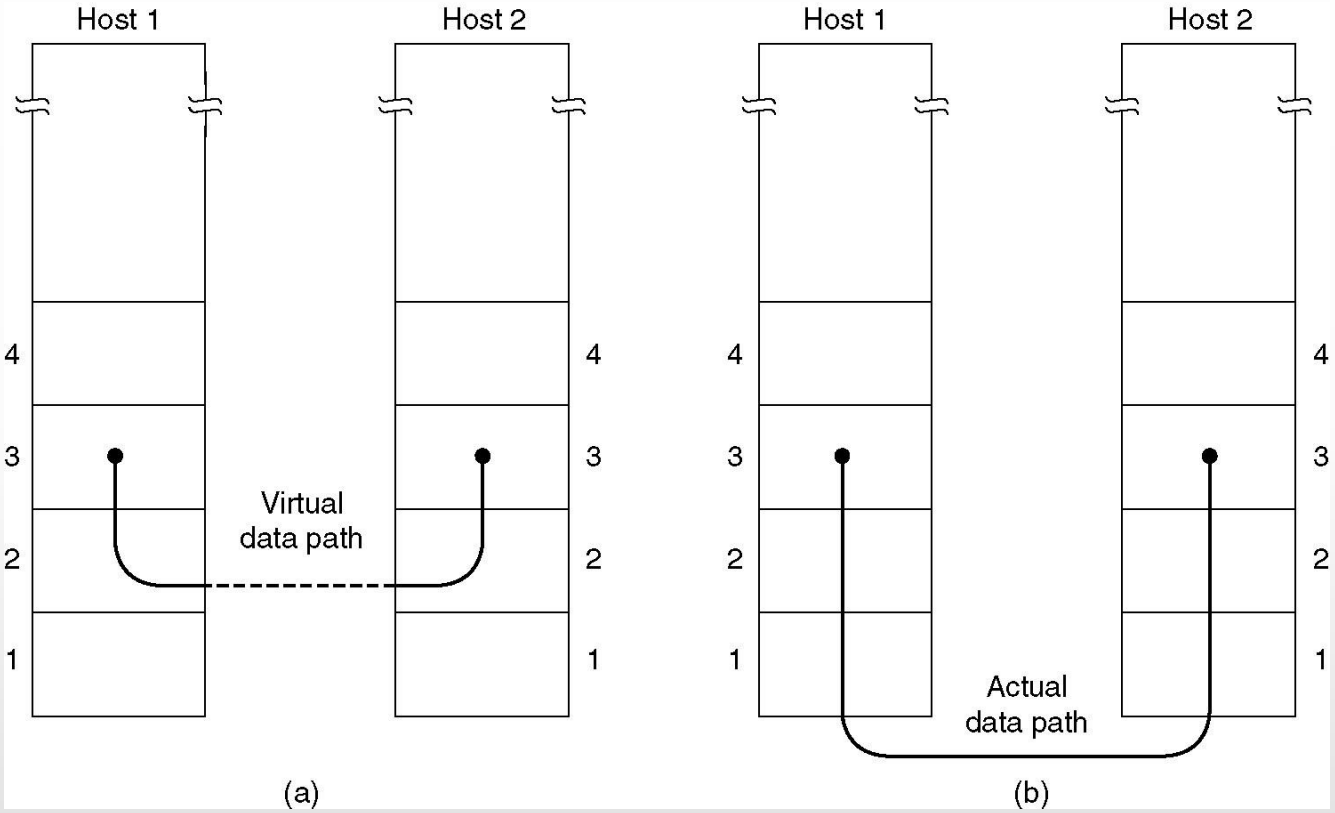
What does it do?

- *What functions it performs?*
- *Typically:*
  - *Handling transmission errors, a.k.a., error control.*
  - *Flow control.*
  - *Framing.*

Framing

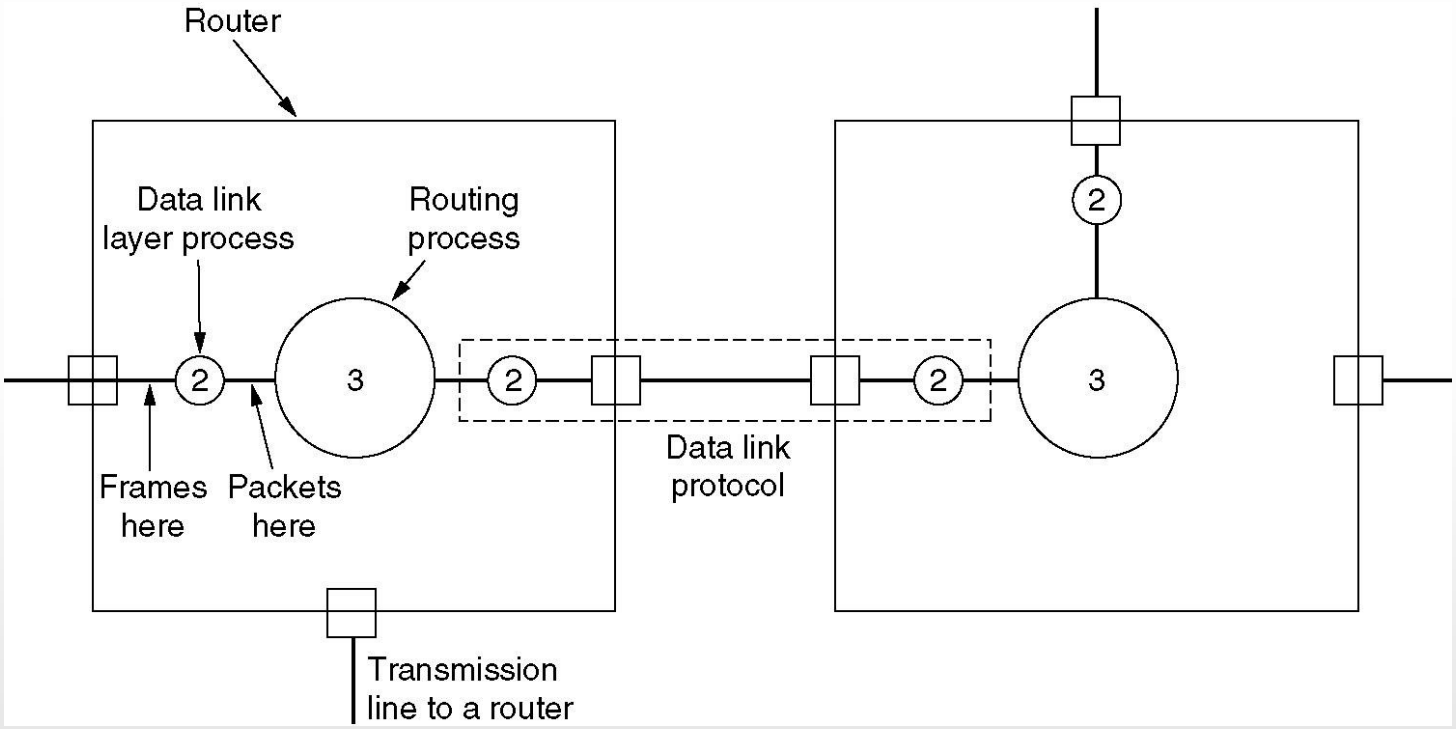

Sending machine
Packet
Frame
Header
Payload field
Trailer
Receiving machine
Packet
Header
Payload field
Trailer

DLL and the Stack



- *(a) Virtual communication*
- *(b) Actual communication*

DLL Between Routers



The DLL and PHY

- *The PHY delivers raw sequence of bits.*
  - *Unreliable service.*
- *The DLL must detect and, in some cases, correct errors.*

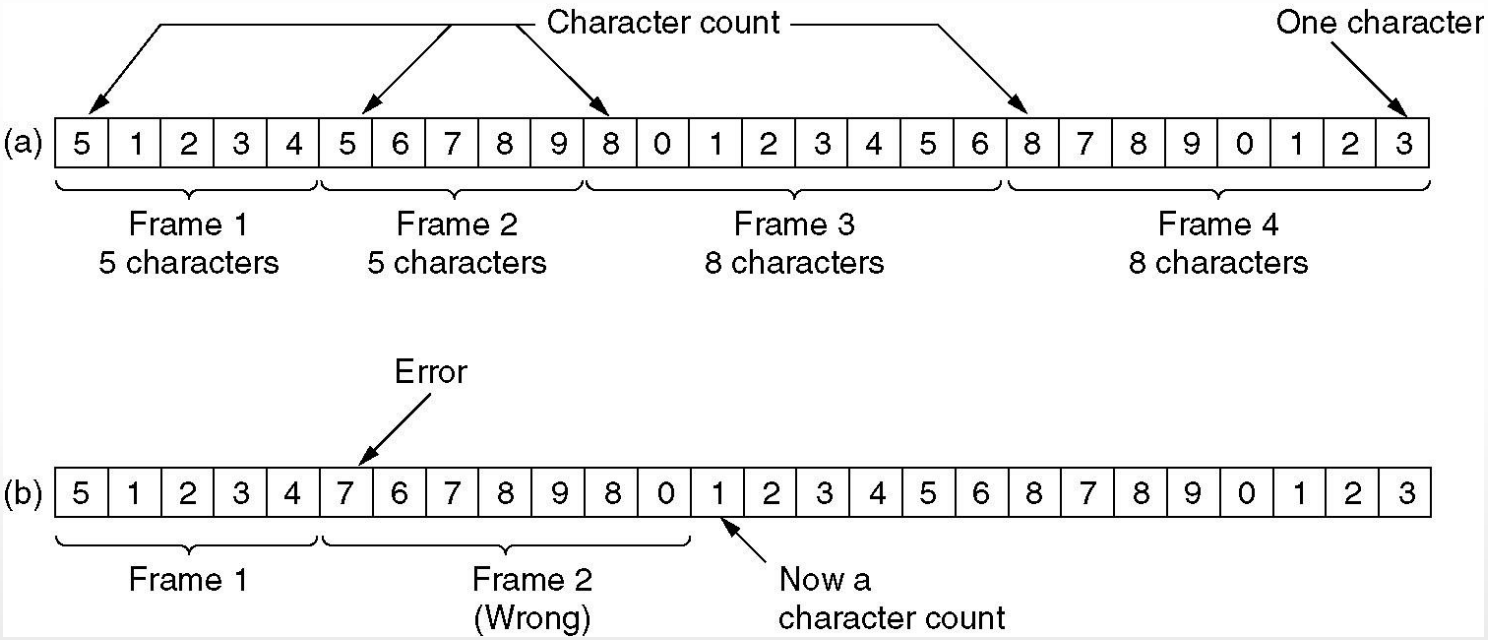
DLL's Error Control

- *Break bit stream into frames.*
- *Check if frames arrived correctly.*
- *If not:*
  - *Discards frame.*
  - *In some cases also request retransmisssion.*

Framing (Revisited)

- *Not trivial.*
- *Different methods.*

Framing: Using Counters



(a) Without errors. (b) With one error.

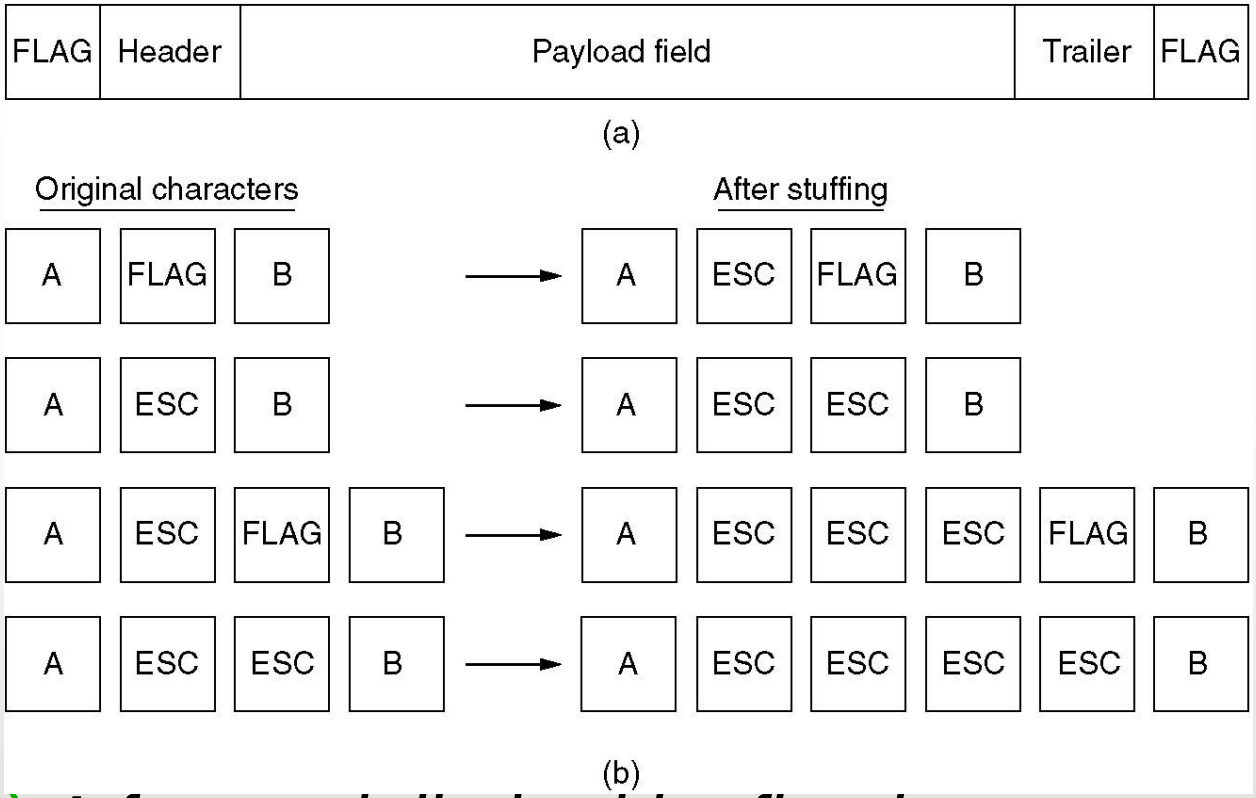
Framing: Flag Byte

- *Each frame starts and ends with special bytes: flag bytes.*
- *Two consecutive flag bytes indicate end of frame and beginning on new frame.*
- *Problem?*

Framing: Flag Byte

- *Each frame starts and ends with special bytes: flag bytes.*
- *Two consecutive flag bytes indicate end of frame and beginning on new frame.*
- *Problem?*
  - *What if flab bit pattern occurs in data?*

Byte Stuffing



- *(a) A frame delimited by flag bytes.*
- *(b) Four examples of byte sequences before and after stuffing.*

Byte Stuffing (Cont'd)

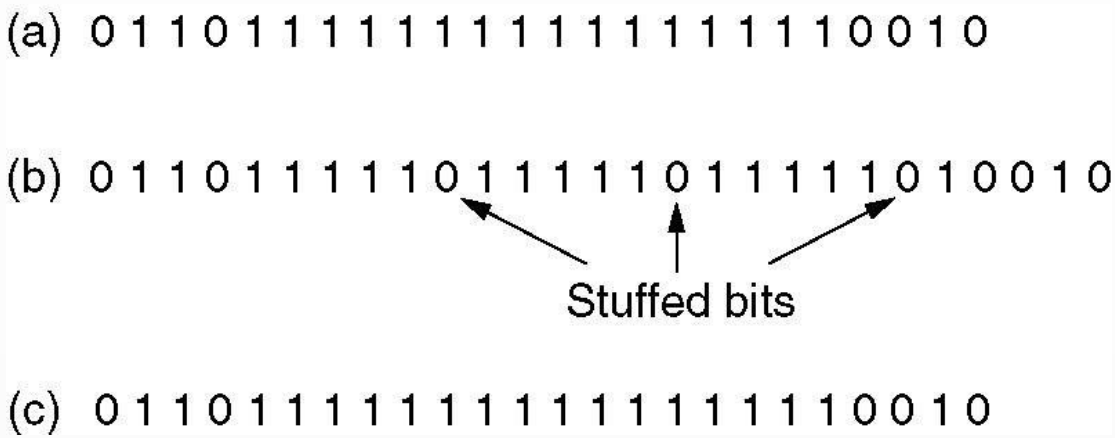
- *Single ESC: part of the escape sequence.*
- *Doubled ESC: single ESC is part of data.*
- *De-stuffing.*

- *Problem:*
  - *What if character encoding does not use 8-bit characters?*

Bit Stuffing

- *Allows character codes with arbitrary bits per character.*
- *Each frames begins and ends with special pattern.*
- *Example: 01111110.*
- *When sender's DLL finds 5 consecutive 1's in data stream, stuffs 0.*
- *When receiver sees 5 1's followed by 0, de-stuffs.*

Bit Stuffing: Example



- *(a) Original data.*
- *(b) Data as they appear on the line.*
- *(c) Data after de-stuffing.*

Error Control

- *Reliable delivery.*
  - *Hop-by-hop!*
- *Detecting errors.*
- *Detecting and correcting errors.*

Acknowledgments

- *Special control info (in the case of the DLL, control frame) acknowledging receipt of data.*
- *Positive and negative ACKs.*
  - *ACKs.*
  - *NACKs.*

- *Are ACKs sufficient?*

Reliable Delivery

- *Timers.*
- *Retransmission.*
- *Duplicate detection.*

Flow Control

- *Handles mismatch between sender's and receiver's speed.*
  - *Receiver's buffer limitation.*
- *Feedback-based flow control.*
  - *Explicit permission from receiver.*
- *Rate-based flow control.*
  - *Implicit mechanism for limiting sending rate.*
- *DLL typically uses feedback-based flow control.*