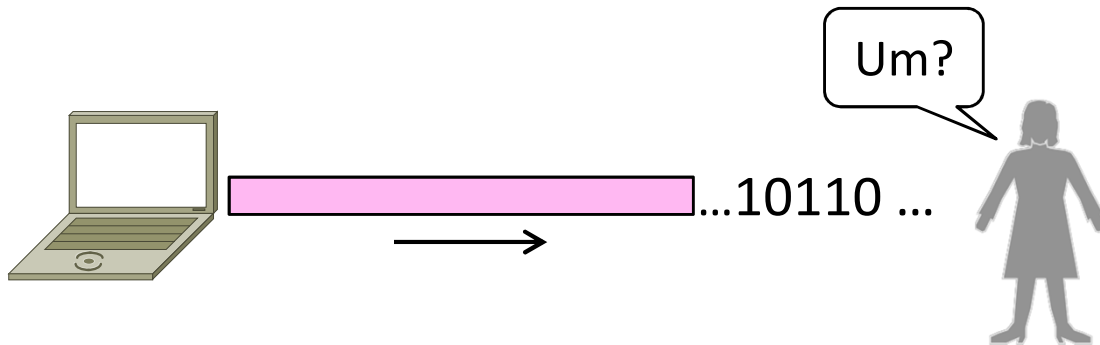# Computer Networks

Framing (§3.1.2)

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Topic

- The Physical layer gives us a stream of bits. How do we interpret it as a sequence of frames?
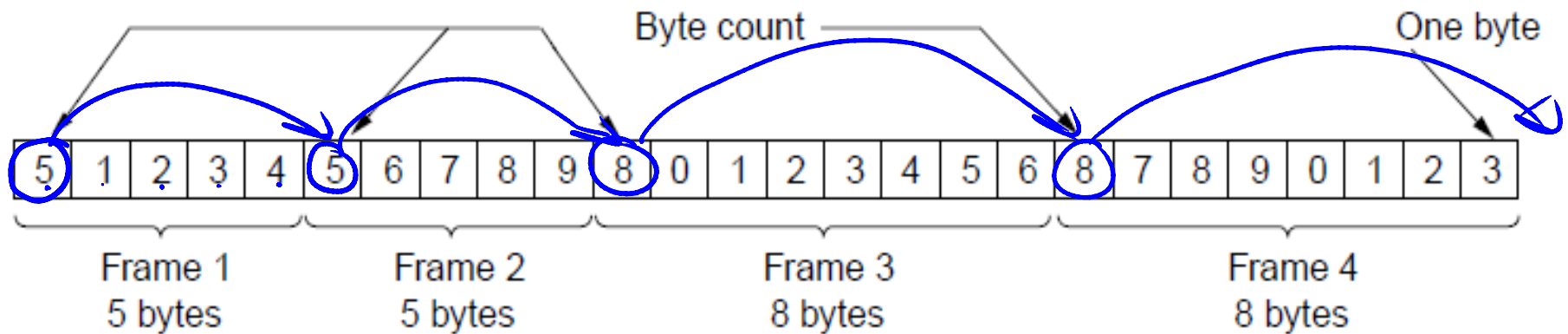

...10110 ...

Um?

Framing Methods

- We'll look at:
  - Byte count (motivation)»
  - Byte stuffing »
  - Bit stuffing »

- In practice, the physical layer often helps to identify frame boundaries
  - E.g., Ethernet, 802.11

Byte Count

- First try:
  - Let's start each frame with a length field!
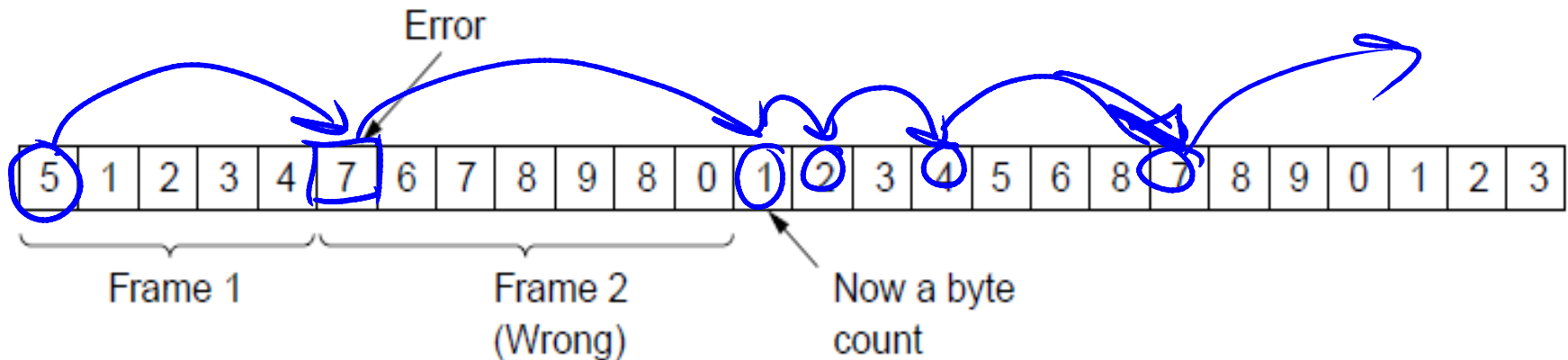 - It's simple, and hopefully good enough …

Byte Count (2)
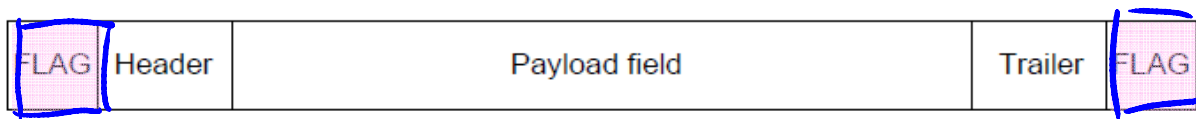

- How well do you think it works?

Byte Count (3)

- Difficult to re-synchronize after framing error
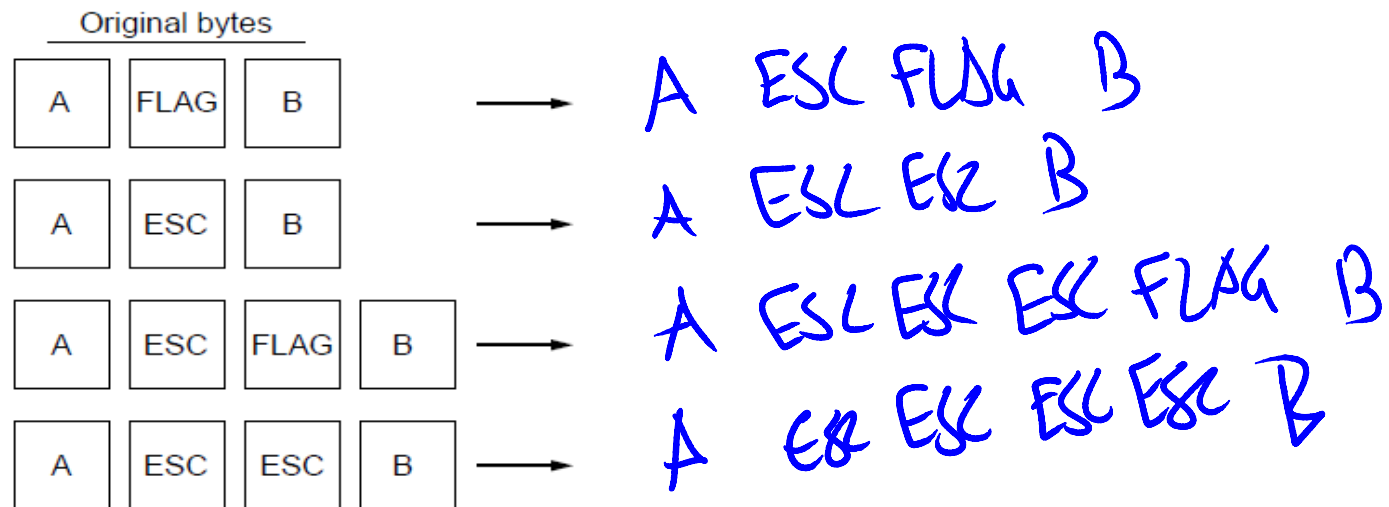 - Want a way to scan for a start of frame

Byte Stuffing

- Better idea:
  - Have a special flag byte value that means start/end of frame
  - Replace ("stuff") the flag inside the frame with an escape code
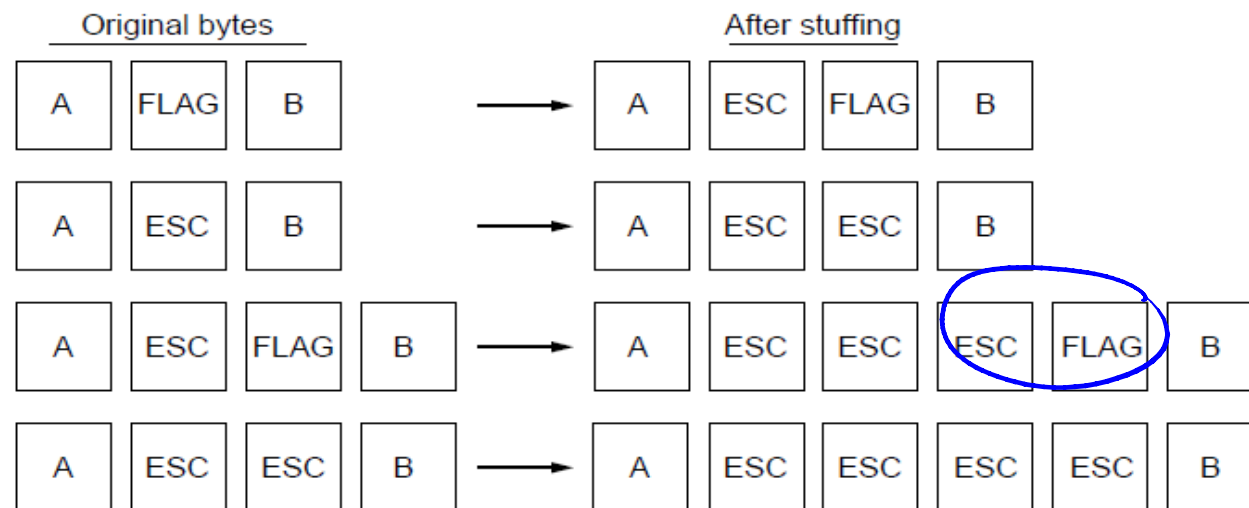 - Complication: have to escape the escape code too!

FLAG	Header	Payload field	Trailer	FLAG

Byte Stuffing (2)

- ## Rules:
  - Replace each FLAG in data with ESC FLAG
  - Replace each ESC in data with ESC ESC

Original bytes

A	FLAG	B		→	A ESC FLAG B
A	ESC	B		→	A ESC ESC B
A	ESC	FLAG	B	→	A ESC ESC ESC FLAG B
A	ESC	ESC	B	→	A ESC ESC ESC ESC B

Byte Stuffing (3)

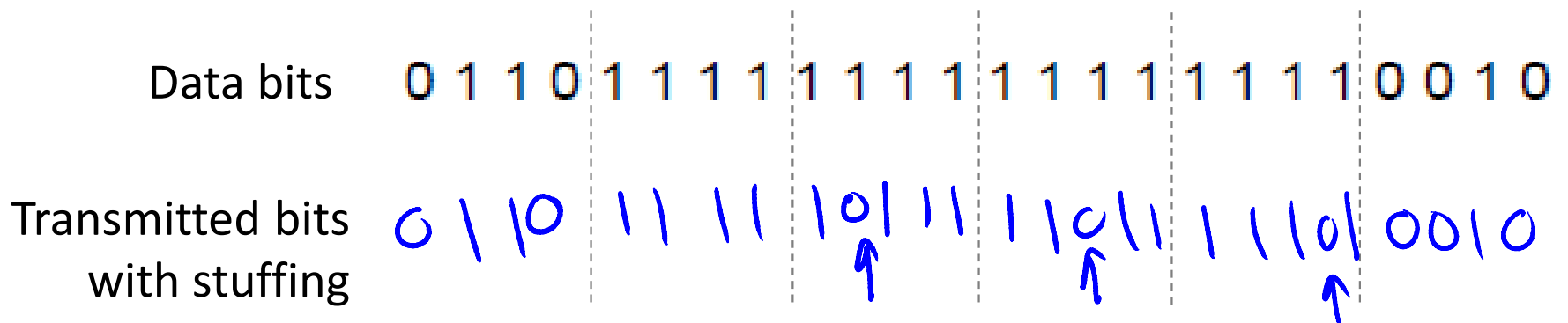- Now any unescaped FLAG is the start/end of a frame

Bit Stuffing

- Can stuff at the bit level too
  - Call a flag six consecutive 1s
  - On transmit, after five 1s in the data, insert a 0
  - On receive, a 0 after five 1s is deleted

Bit Stuffing (2)

- Example:

Data bits   0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0

Transmitted bits
with stuffing   0 1 1 0 1 1 1 1 1 0 1 1 1 1 1 0 1 1 1 1 1 0 0 0 1 0

Bit Stuffing (3)

- So how does it compare with byte stuffing?

Data bits

0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0

Transmitted bits
with stuffing

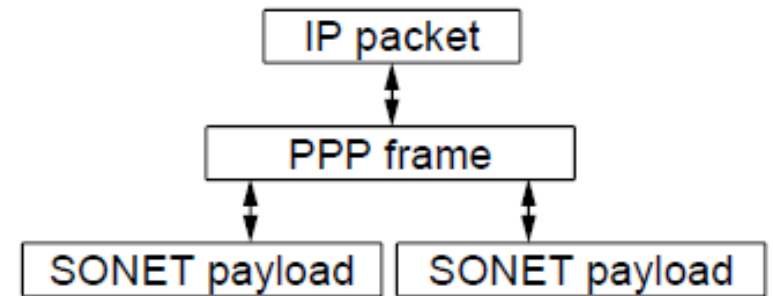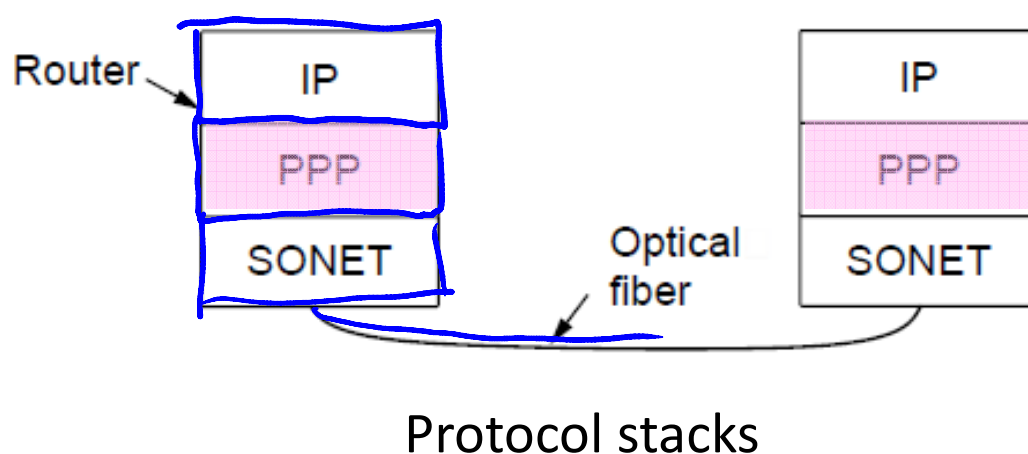0 1 1 0 1 1 1 1 1 0 1 1 1 1 1 0 1 1 1 1 1 0 1 0 0 1 0

Stuffed bits

Link Example: PPP over SONET

- PPP is Point-to-Point Protocol

- Widely used for link framing
  - E.g., it is used to frame IP packets that are sent over SONET optical links
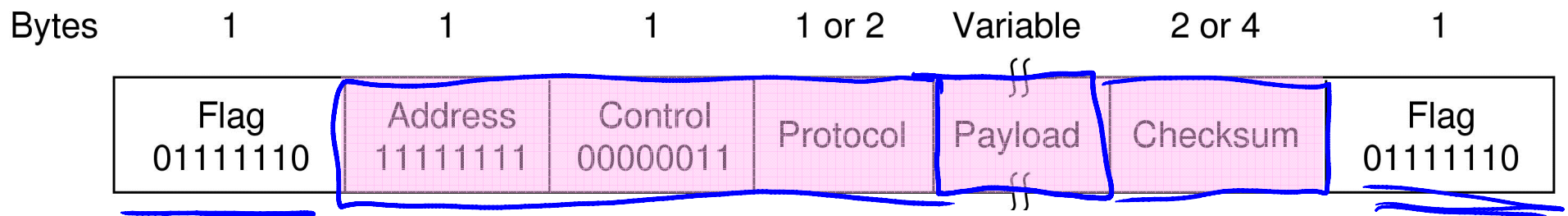
Link Example: PPP over SONET (2)

- Think of SONET as a bit stream, and PPP as the framing that carries an IP packet over the link

Protocol stacks

PPP frames may be split over SONET payloads

Link Example: PPP over SONET (3)

- Framing uses byte stuffing
  - FLAG is 0x7E and ESC is 0x7D

Bytes	1	1	1	1 or 2	Variable	2 or 4	1
	Flag 01111110	Address 11111111	Control 00000011	Protocol	Payload	Checksum	Flag 01111110

Link Example: PPP over SONET (4)

- Byte stuffing method:
  - To stuff (unstuff) a byte, add (remove) ESC (0x7D), and **XOR byte with 0x20** ~ toggle 5th bit
  - Removes FLAG from the contents of the frame

  $0x7E \rightarrow 0x7D5E$

  $0x7D \rightarrow 0x7D5D$

END

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