CS3200: Computer Networks

Lecture 5

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Introduction to Link Layer

- We will refer to any device that runs a link-layer protocol as **node**.
- The communication channels that connect adjacent nodes along the communication path as **links**.
- In order to transfer data transferred from source node to destination node, it must be moved over each of the individual links in the end-to-end path.
- Transmitting nodes encapsulate datagram in a **link-layer frame** and transmits the frame into the link.

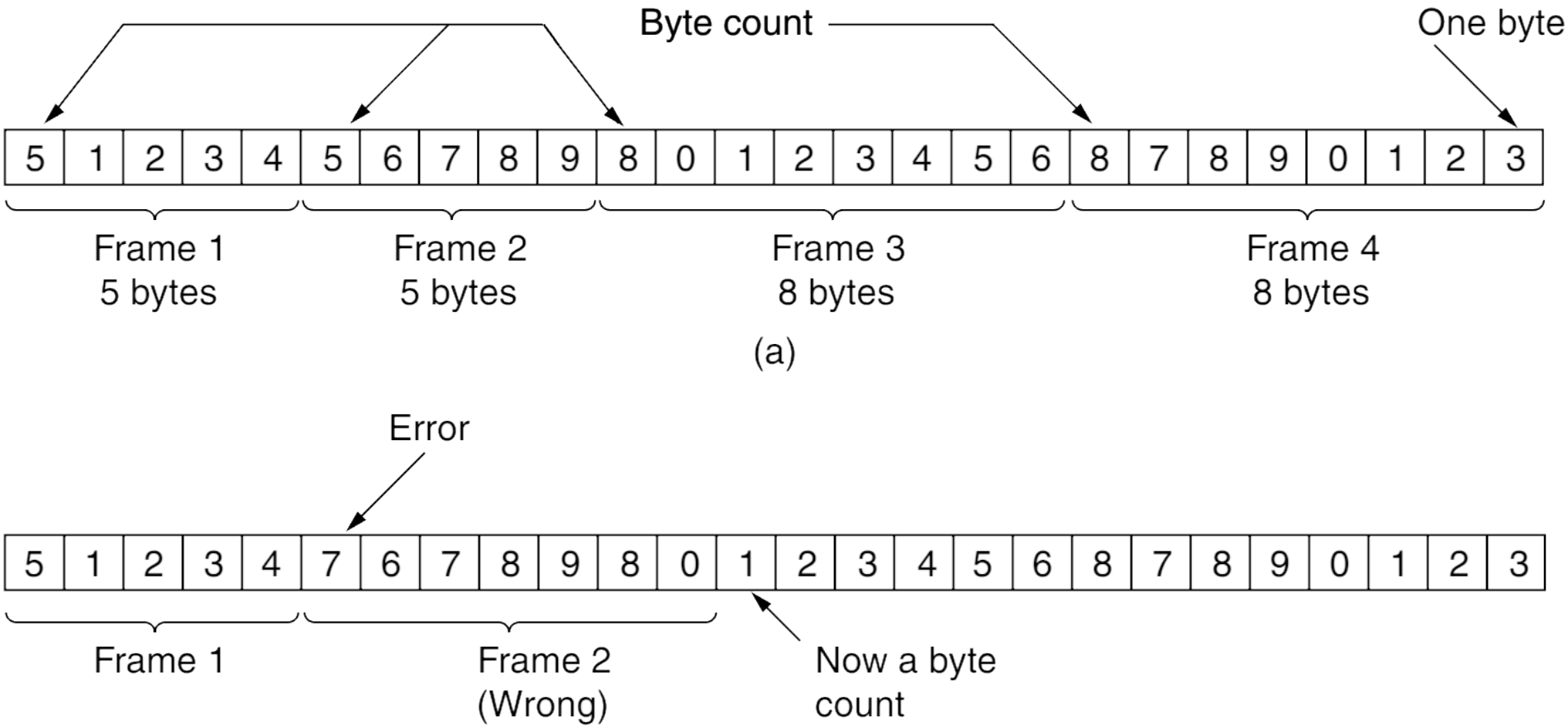
Link Layer Services

- **Framing**: A frame consists of a data field, in which the network-layer datagram is inserted, and a number of header fields.
- **Reliable delivery**: When a link-layer protocol provides reliable delivery service, it guarantees to move each network-layer datagram across the link without error.
- **Link access**: A medium access control (MAC) protocol specifies the rules by which a frame is transmitted onto the link. For point-to-point links, the MAC protocol is simple. The more interesting case is when multiple nodes share a single broadcast link—the so-called multiple access problem.
- **Error detection and correction:** The link-layer hardware in a receiving node can incor- rectly decide that a bit in a frame is zero when it was transmitted as a one, and vice versa

Framing

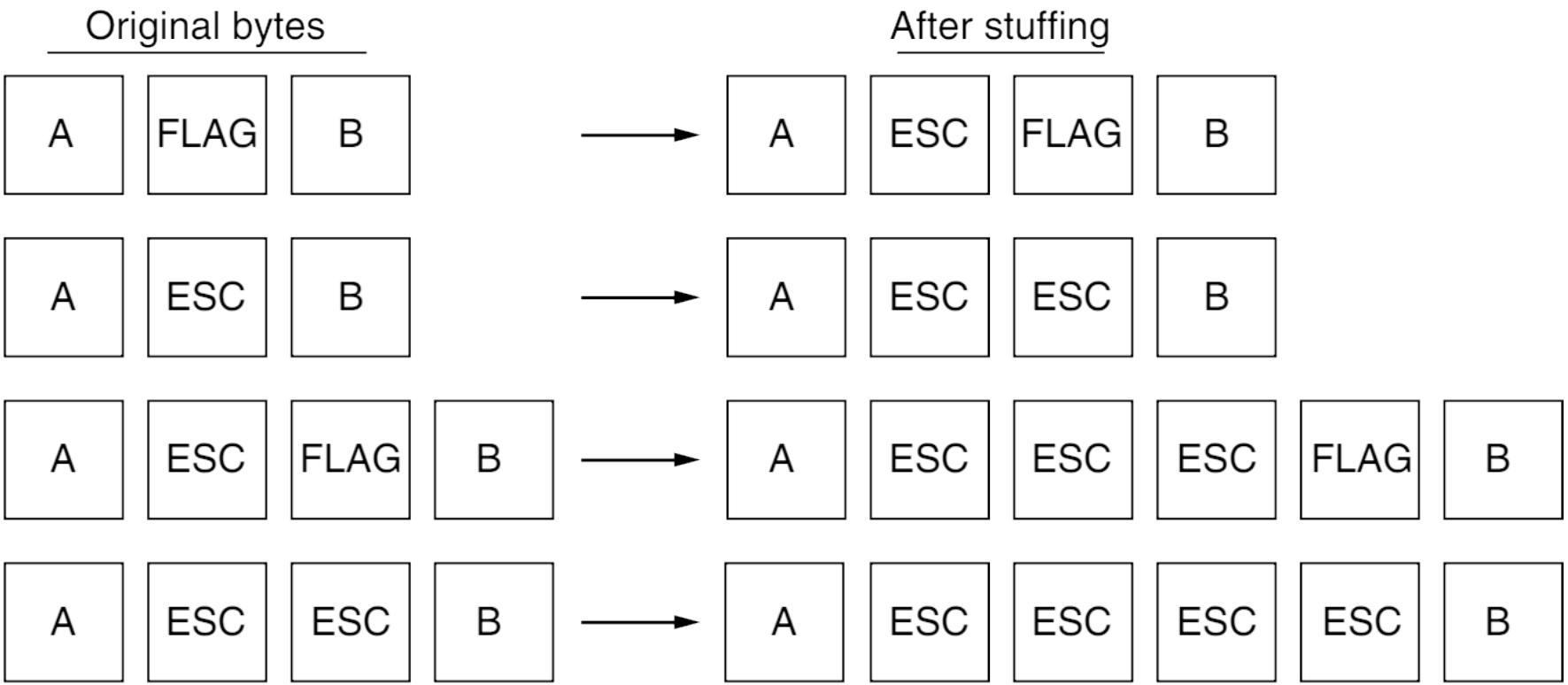
- The bit stream received by the data link layer is not guaranteed to be error free.
- It is up to the data link layer to detect and, if necessary, correct errors.
- Data link layer to break up the bit stream into discrete frames, compute a short token called a checksum for each frame, and include the checksum in the frame when it is transmitted.
- When a frame arrives at the destination, the checksum is recomputed. If the newly computed checksum is different from the one contained in the frame, the data link layer knows that an error has occurred and takes steps to deal with it.

Byte Count


Byte count
One byte
5 1 2 3 4 5 6 7 8 9 8 0 1 2 3 4 5 6 8 7 8 9 0 1 2 3
Frame 1
5 bytes
Frame 2
5 bytes
Frame 3
8 bytes
Frame 4
8 bytes
(a)
Error
5 1 2 3 4 7 6 7 8 9 8 0 1 2 3 4 5 6 8 7 8 9 0 1 2 3
Frame 1
Frame 2
(Wrong)
Now a byte
count

Flag Bytes With Byte Stuffing

(a)



Flag Bytes With Bit Stuffing

Each frame begins and ends with a special bit pattern, 01111110 or 0x7E in hexadecimal. This pattern is a flag byte. Whenever the sender's data link layer encounters five consecutive 1s in the data, it automatically stuffs a 0 bit into the outgoing bit stream.

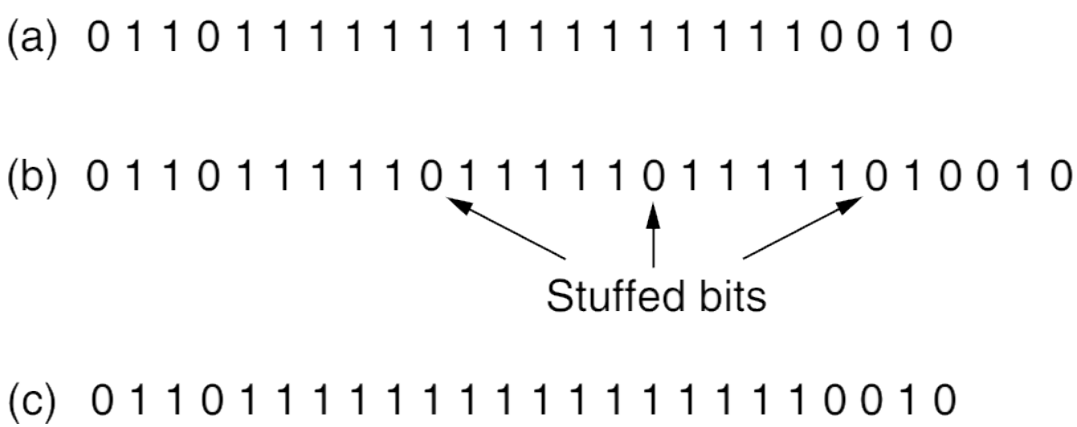


Figure: Bit stuffing. (a) Original data. (b) The data as they appear on the line. (c) The data as they are stored in the receiver's memory after destuffing

Physical Layer Coding Violations

- Encoding of bits as signals often includes redundancy to help the receiver.
- For example, in the 4B/5B line code 4 data bits are mapped to 5 signal bits to ensure sufficient bit transitions. We can use some reserved signals to indicate the start and end of frames.
- We are using "coding violations" to delimit frames.
- It is easy to find the start and end of frames and there is no need to stuff the data.

Reliable delivery: Error Control

- How to ensure all frames are eventually delivered to the network layer at the destination and in the proper order?
- To ensure reliable delivery is to provide the sender with some feedback about what is happening at the other end of the line.
- Special control frames bearing positive or negative acknowledgments about the incoming frames.
- But what to do is frames or acknowledgments are lost? — Timers
- Due to re-transmissions, same frame may be pass to the network layer more than once — Sequence numbers

Reliable delivery: Flow Control

- What to do when a sender that systematically wants to transmit frames faster than the receiver can accept them?
- **Feedback-based flow control**: receiver sends back information to the sender giving it permission to send more data, or at least telling the sender how the receiver is doing.
- **Rate-based flow control**: the protocol has a built-in mechanism that limits the rate at which senders may transmit data, without using feedback from the receiver.