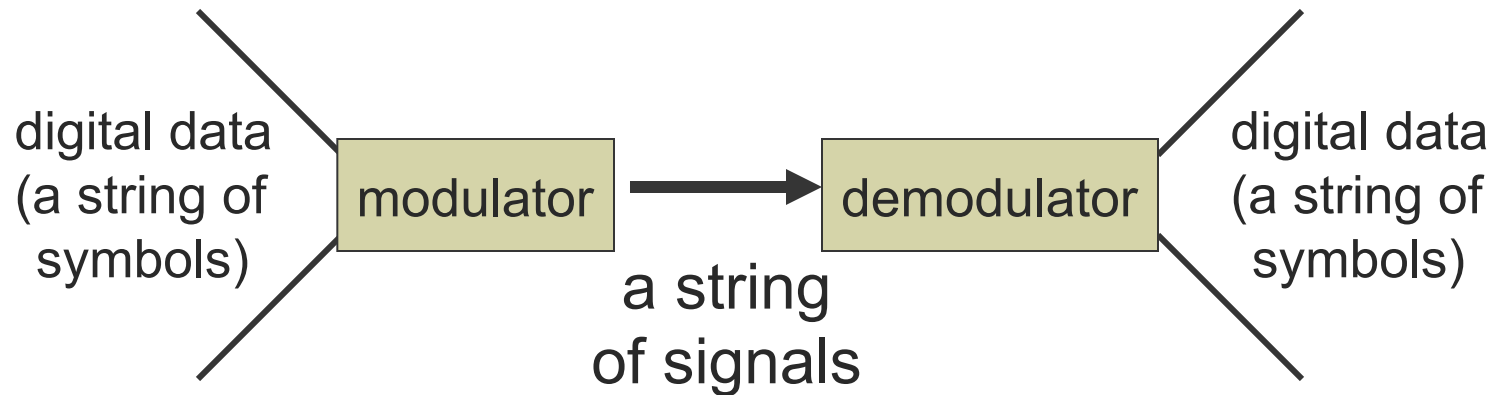




Direct Link Networks - Framing

Reading: Peterson and Davie,
Chapter 2

[Framing]



- Encoding translates symbols to signals
- Framing demarcates units of transfer
 - Separates continuous stream of bits into frames
 - Marks start and end of each frame



[Benefits of framing]

- Synchronization recovery
 - Breaks up continuous streams of unframed bytes
 - Recall RS-232 start and stop bits
- Link multiplexing
 - Multiple hosts on shared medium
 - Simplifies multiplexing of logical channels
- Efficient error detection
 - Per-frame error checking and recovery



[Framing]

- Demarcates units of transfer
- Goal
 - Enable nodes to exchange blocks of data
- Challenge
 - How can we determine exactly what set of bits constitute a frame?
 - How do we determine the beginning and end of a frame?



[Framing]

■ Approaches

- Sentinel: delimiter at end of frame (like C strings)
- Length-based: length field in header (like Pascal strings)
- Clock-based: periodic, time-based

■ Characteristics

- Bit- or byte-oriented
- Fixed or variable length
- Data-dependent or data-independent length



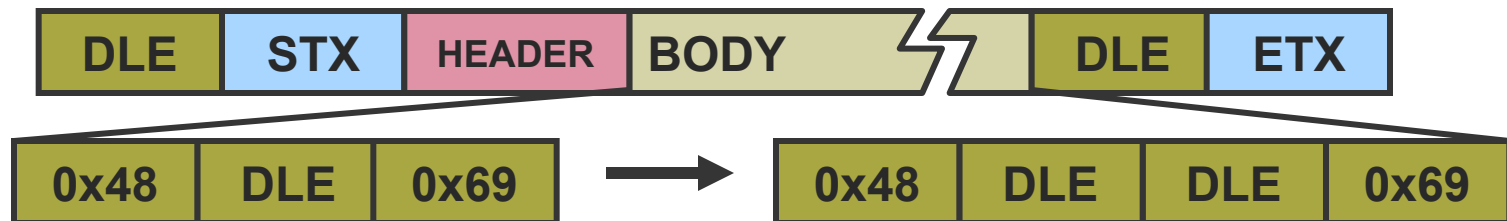
[Sentinel-Based Framing]

- End of Frame
 - Marked with a special byte or bit pattern
 - Frame length is data-dependent
 - Challenge
 - Frame marker may exist in data
 - Requires stuffing
- Examples
 - BISYNC, HDLC, PPP, IEEE 802.4 (token bus)



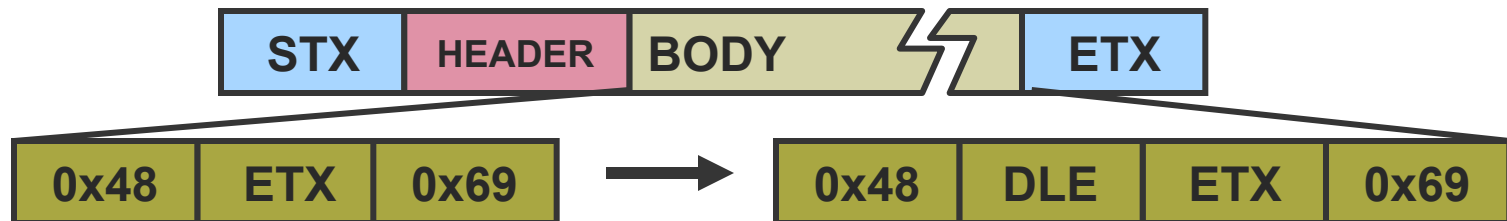
ARPANET IMP-IMP

- Interface Message processors (IMPs)
 - Packet switching nodes in the original ARPANET
 - Byte oriented, Variable length, Data dependent
 - Frame marker bytes
 - STX/ETX start of text/end of text
 - DLE data link escape
 - Byte Stuffing
 - DLE byte in data sent as two DLE bytes back-to-back



BISYNC

- Binary SYNchronous Communication
 - Developed by IBM in late 1960' s
 - Byte oriented, Variable length, Data dependent
 - Frame marker bytes:
 - STX/ETX start of text/end of text
 - DLE data link escape
 - Byte Stuffing
 - ETX/DLE bytes in data prefixed with DLE' s



[Byte Stuffing: BISYNC]

0000 0011 1110 0111 1111

1110 0001 0000 0001 1111

- ETX/DLE bytes in data prefixed with DLE's
 - DLE = 16; STX = 2; ETX = 3

■ Ans: **0000 0010 0001 0000** 0000 0011
 1110 0111 1111 1110 **0001 0000**
 0001 0000 0001 1111 **0000 0011**



[Byte Stuffing: Efficiency]

0000 0011 1110 0111 1111

1110 0001 0000 0001 1111

■ Frame: **0000 0010 0001 0000** 0000 0011
 1110 0111 1111 1110 **0001 0000**
 0001 0000 0001 1111 **0000 0011**

■ Efficiency:

- 72 bits were sent for 40 bits of data
- Efficiency is $40/72 = 55.6\%$



High-Level Data Link Control Protocol (HDLC)

- Bit oriented, Variable length, Data-dependent
- Frame Marker
 - 01111110
- Bit Stuffing
 - Insert 0 after pattern 011111 in data
 - Example
 - 01111110 end of frame
 - 01111111 error! lose one or two frames



[Bit Stuffing: HDLC]

0000 0011 1110 0111 1111

1110 0001 0000 0001 1111

- Insert 0 after pattern 011111 in data

- Ans: **0111 1110** 0000 0011 111**0** 0111
 11**0**11 1110 0001 0000 0001 1111**0**
 0111 1110



[Bit Stuffing: Efficiency]

0000 0011 1110 0111 1111

1110 0001 0000 0001 1111

- Frame: **0111 1110** 0000 0011 111**00** 0111
11**0**11 1110 0001 0000 0001 1111**0**
0111 1110

- Efficiency
 - 59 bits were sent for 40 bits of data
 - Efficiency = 67.8%



[IEEE 802.4 (token bus)]

- Alternative to Ethernet (802.3) with fairer arbitration
- End of frame marked by encoding violation,
 - i.e., physical signal not used by valid data symbol
 - Recall Manchester encoding
 - low-high means “0”
 - high-low means “1”
 - low-low and high-high are invalid
- IEEE 802.4
 - byte-oriented, variable-length, data-independent
- Another example
 - Fiber Distributed Data Interface (FDDI) uses 4B/5B
- Technique also applicable to bit-oriented framing



[Length-Based Framing]

- End of frame
 - Calculated from length sent at start of frame
 - Challenge
 - Corrupt length markers
- Examples
 - DECNET's DDCMP
 - Byte-oriented, variable-length
 - RS-232 framing
 - Bit-oriented, implicit fixed-length



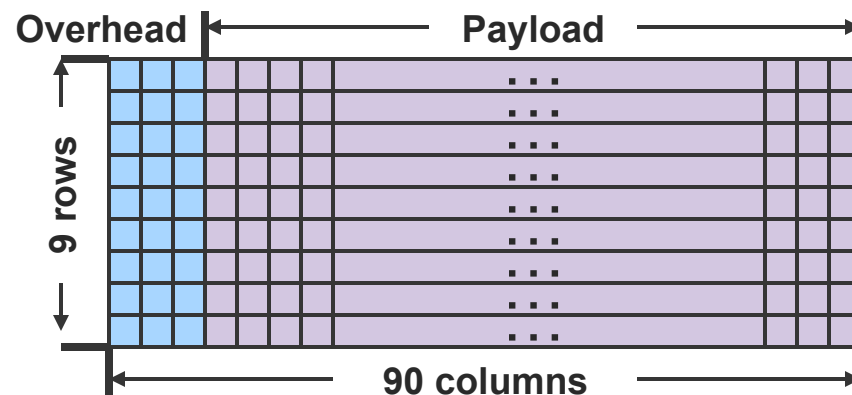
Clock-Based Framing

- Continuous stream of fixed-length frames
 - Clocks must remain synchronized
- STS-1 frames - $125\mu\text{s}$ long
 - No bit or byte stuffing
- Example
 - Synchronous Optical Network (SONET)
- Problems
 - Frame synchronization
 - Clock synchronization



[SONET]

- Frames (all STS formats) are 125 μ sec long
 - Ex: STS-1 – 51.84 Mbps = 90 bytes
- Frame Synchronization
 - 2-byte synchronization pattern at start of each frame



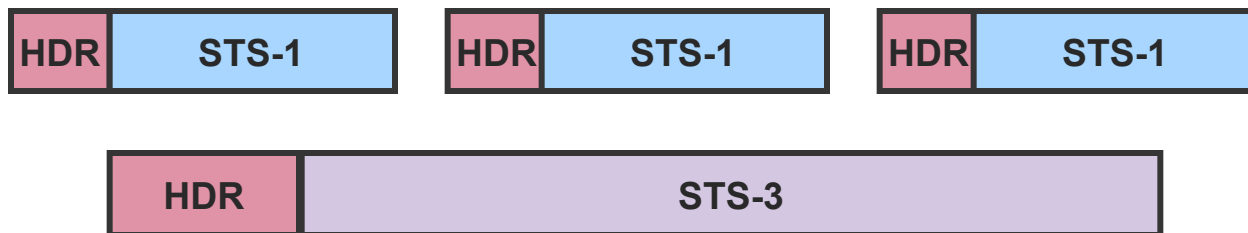
[SONET: Challenges]

- How to recover frame synchronization
 - Synchronization pattern unlikely to occur in data
 - Wait until pattern appears in same place repeatedly
- How to maintain clock synchronization
 - NRZ encoding
 - Data scrambled (XOR' d) with 127-bit pattern
 - Creates transitions
 - Also reduces chance of finding false sync. pattern



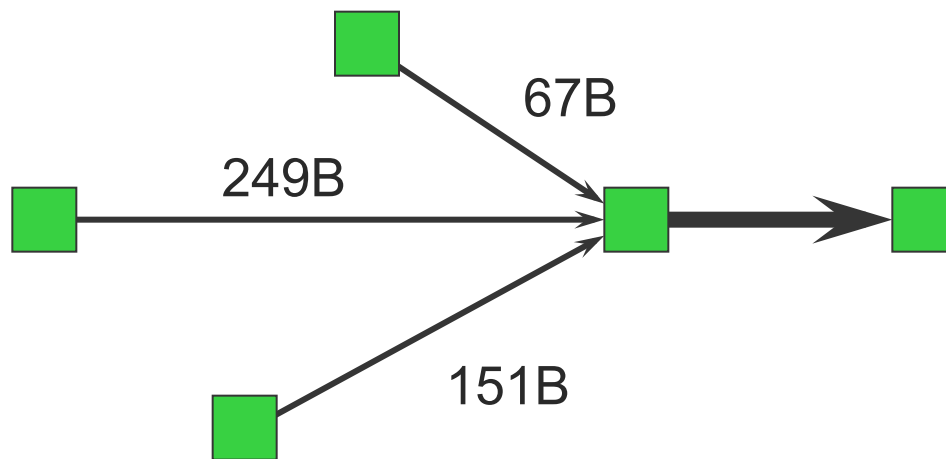
[SONET]

- A single SONET frame may contain multiple smaller SONET frames
- Bytes from multiple SONET frames are interleaved to ensure pacing



[SONET]

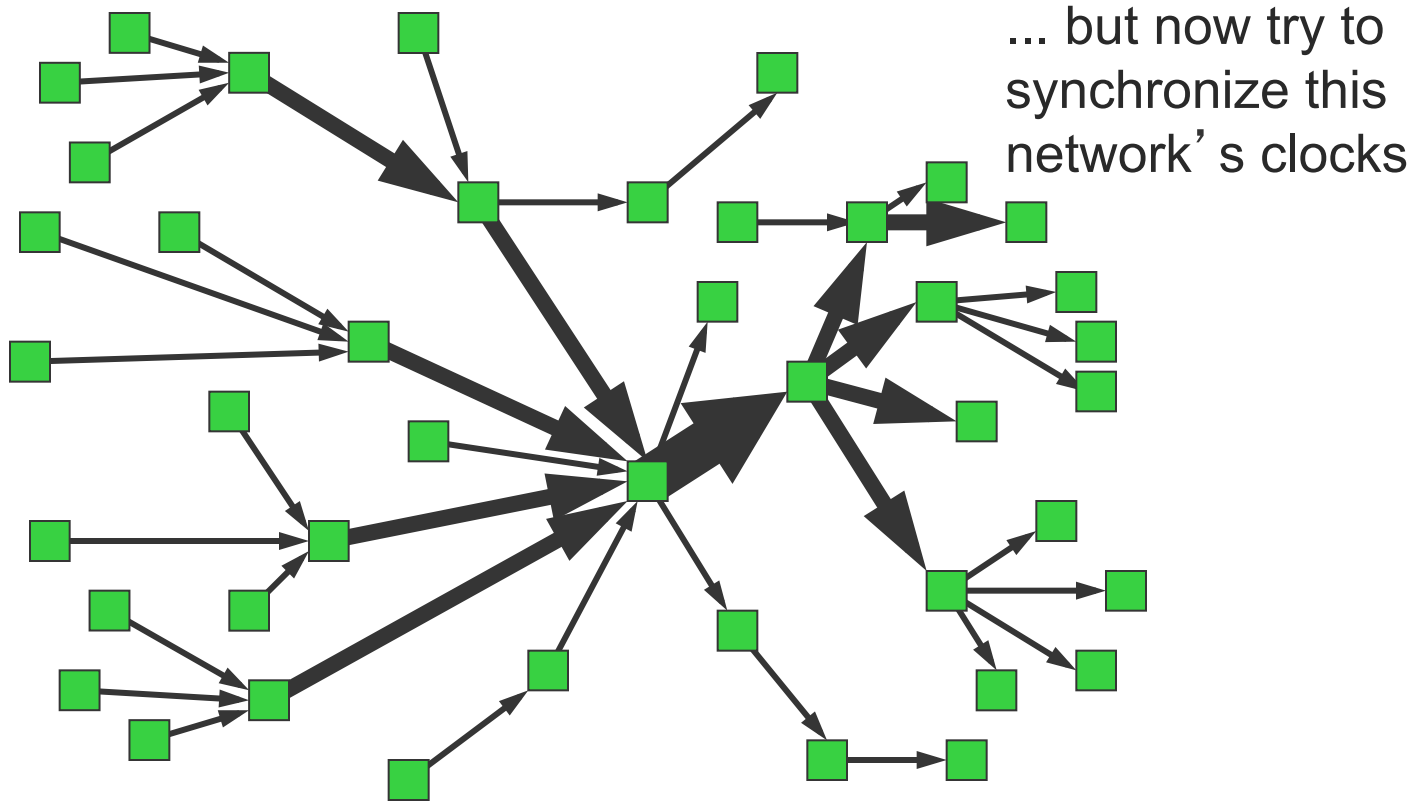
- STS-1 merged bitwise round-robin into STS-3
- Unmerged (single-source) format called STS-3c
- Problem: simultaneous synchronization of many distributed clocks



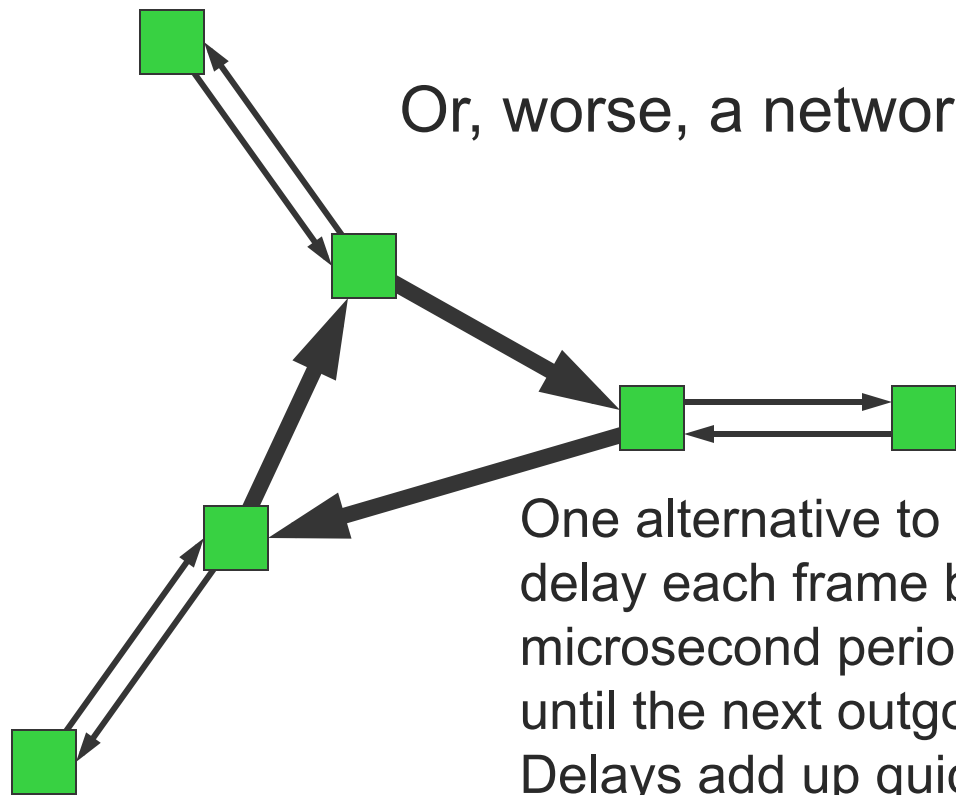
not too difficult to synchronize clocks such that first byte of all incoming flows arrives just before sending first 3 bytes of outgoing flow



[SONET



[SONET]



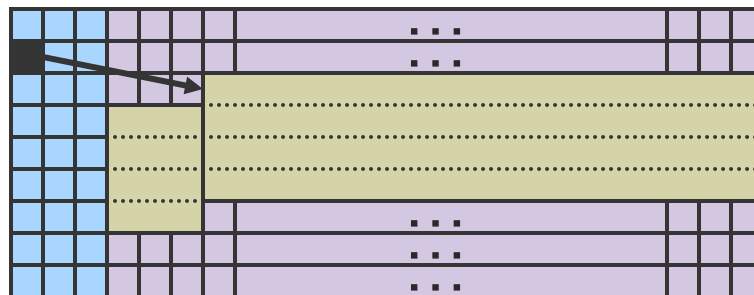
Or, worse, a network with cycles.

One alternative to synchronization is to delay each frame by some fraction of a 125 microsecond period at each switch (i.e., until the next outgoing frame starts). Delays add up quickly...



[SONET]

- Problem
 - Clock synchronization across multiple machines
- Solution
 - Allow payload to float across frame boundaries
 - Part of overhead specifies first byte of payload



[Framing Summary]

- Technique

- Demarcate units of transfer

- Benefits

- Synchronization recovery
- Link multiplexing
- Efficient error detection

- Approaches

- Sentinel
- Length-based
- Clock based

- Characteristics

- Bit- or byte-oriented
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