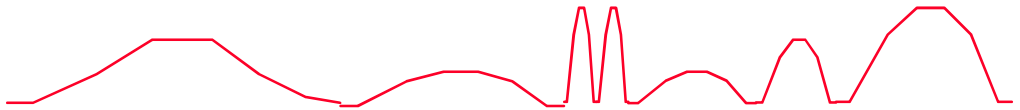
From Signals to Packets

Analog Signal

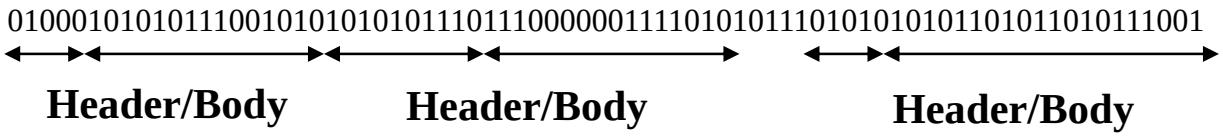


“Digital” Signal

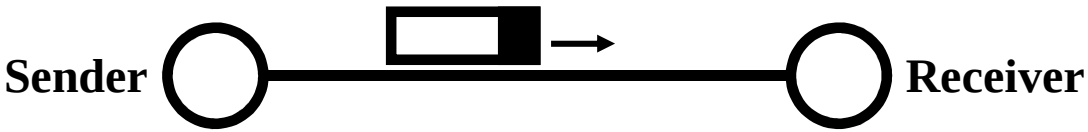
Bit Stream

0 0 1 0 1 1 1 0 0 0 1

Packets



Packet Transmission



Datalink Functions

- **Framing: encapsulating a network layer datagram into a bit stream.**
  - » **Add header, mark and detect frame boundaries, …**
- **Media access: controlling which frame should be sent over the link next.**
  - » **Easy for point-to-point links; half versus full duplex**
  - » **Harder for multi-access links: who gets to send?**
- **Error control: error detection and correction to deal with bit errors.**
  - » **May also include other reliability support, e.g. retransmission**
- **Flow control: avoid that the sender outruns the receiver.**

Framing

- A link layer function, defining which bits have which function.
- Minimal functionality: mark the beginning and end of packets (or frames).
- Some techniques:
  - » out of band delimiters (e.g. FDDI 4B/5B control symbols)
  - » frame delimiter characters with character stuffing
  - » frame delimiter codes with bit stuffing
  - » synchronous transmission (e.g. SONET)

Character and Bit Stuffing

- **Mark frames with special character.**
  - » What happens when the user sends this character?
  - » Use escape character when controls appear in data:

    *abc*def -> *abc*def
  - » Very common on serial lines, in editors, etc.
- **Mark frames with special bit sequence**
  - » must ensure data containing this sequence can be transmitted
  - » example: suppose 11111111 is a special sequence.
  - » transmitter inserts a 0 when this appears in the data:
  - » 11111111 -> 111111101
  - » must stuff a zero any time seven 1s appear:
  - » 11111110 -> 111111100
  - » receiver unstuffs.

Example: Ethernet Framing

- **Preamble is 7 bytes of 10101010 (5 MHz square wave) followed by one byte of 10101011**
- **Allows receivers to recognize start of transmission after idle channel**

SONET

- SONET is the Synchronous Optical Network standard for data transport over optical fiber.
- One of the design goals was to be backwards compatible with many older telco standards.
- Beside minimal framing functionality, it provides many other functions:
  - » operation, administration and maintenance (OAM) communications
  - » synchronization
  - » multiplexing of lower rate signals
  - » multiplexing for higher rates