Chapter 1: Conceptual Basis

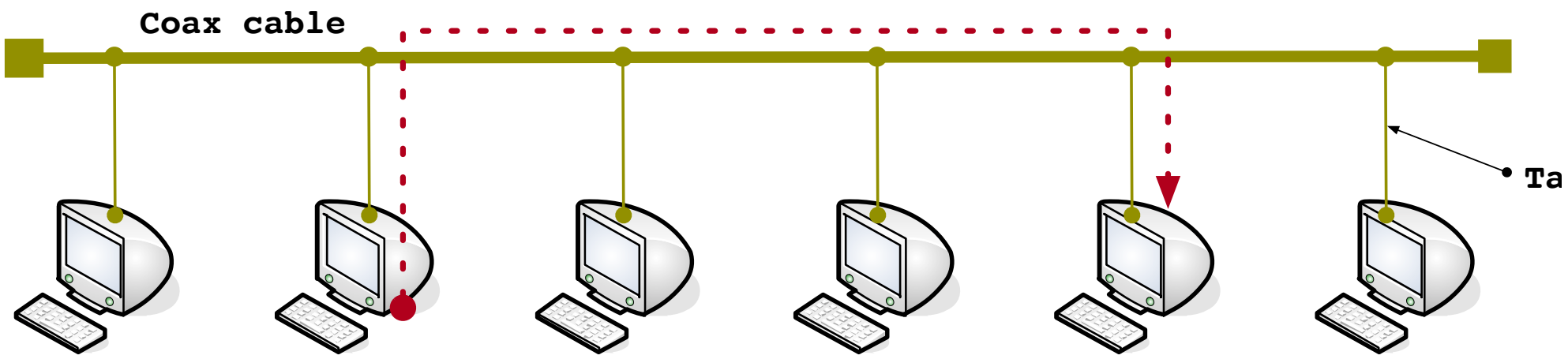
Review Sect. 1-4

V 1.1

Units and multipliers

- **Bandwidth**
  - Directly related to the acceptable speed of bit transmission over some medium
  - Number of bits transmitted in one second:
    - Bps (Bits Per Second = Bits/Sec)
  - Since bandwidth is a rate, the multipliers take on the following values:
    - K (Kilo = 10^3)
    - M (Mega = 10^6)
    - G (Giga = 10^9)
    - T (Tera = 10^{12})
- **Delay**
  - Seconds
  - How much time it takes to transport one bit from a source to a destination directly connected
  - Propagation delay
- **Jitter**
  - The variance of the delay
- **Aggregates of bits**
  - K = 2^{10}
  - M = 2^{20}
  - G = 2^{30}
  - 1 Bytes = 8 bits

Ethernet

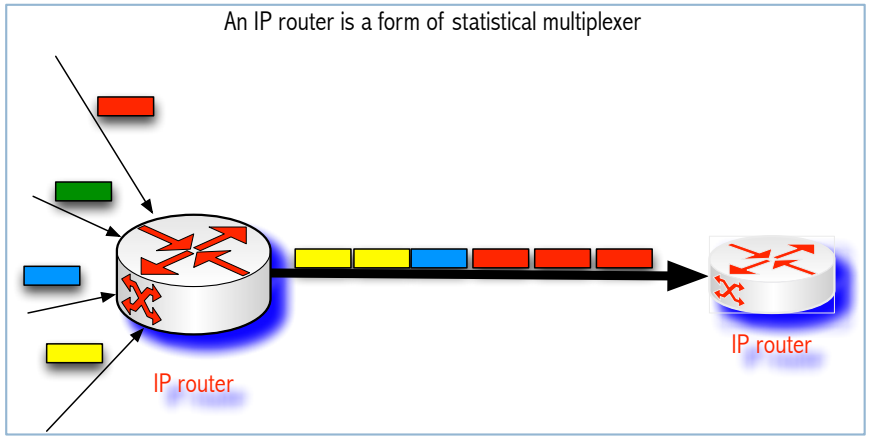


Latency = total time to transfer one packet

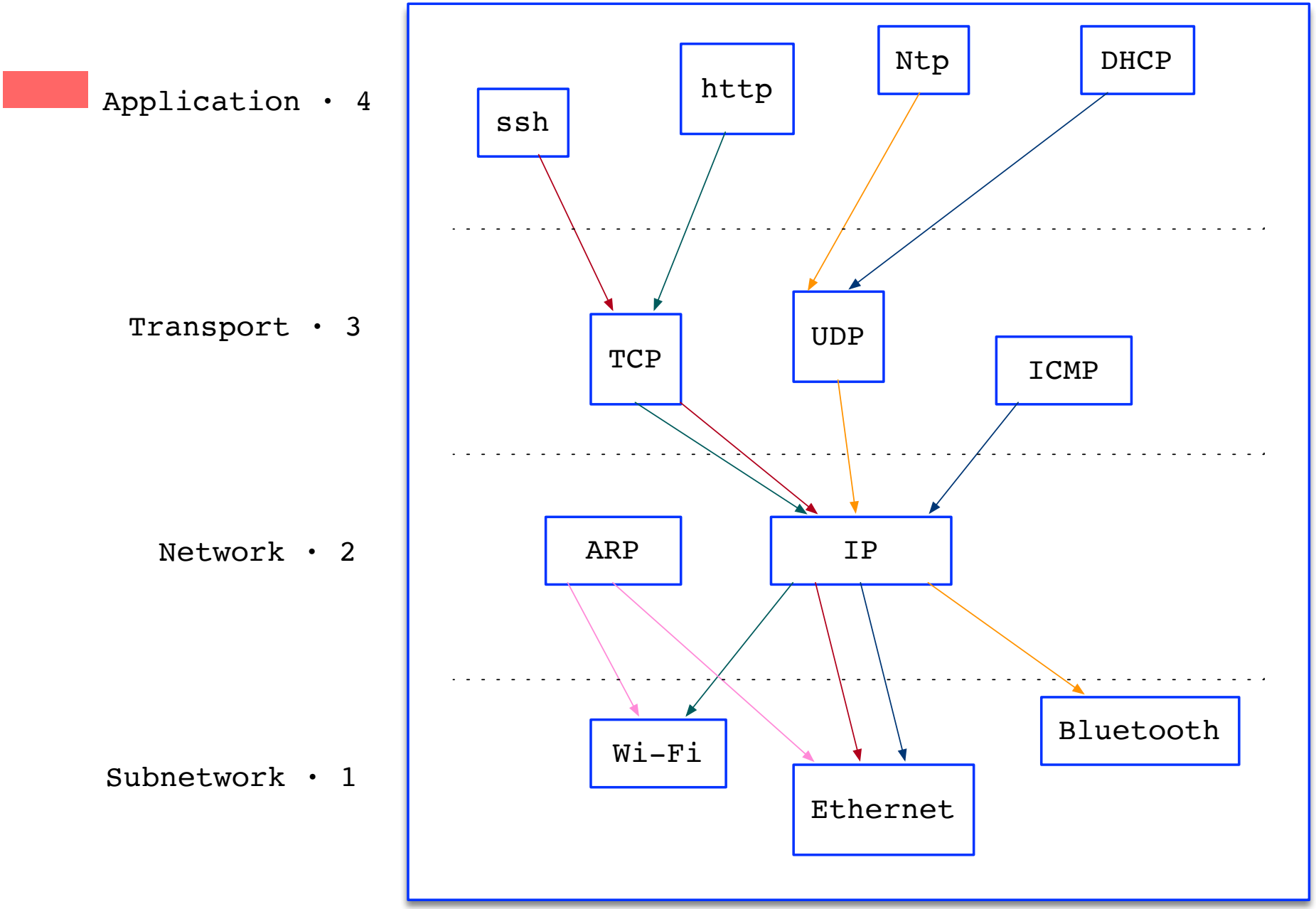
(Point-to-point connection)

- Latency = Propagation + transmit + queue
- Propagation time = physical link distance/speed of light m / (m/s)
- Transmit time = packet size/bandwidth bits / (bits/sec)

- If only one bit is transmitted => propagation is important
  - Or a small amount of bits
- If the amount of bits transmitted is large => bandwidth is important



Typical Internet Protocol Stack



Exercise: Total time to transfer a block of data onto a direct connection

- Assume an Ethernet segment connects two end stations, A and B which are at a distance of 2500 m. How much time does it take to transfer a 1KB file from A to B?
  - Time from start of transmission of first bit at A to the moment at which B finishes receiving the last bit
  - In Ethernet 2500 m => Rtt = 51,2μs
  - Transmission speed is 10Mbps
  - Assume:
    - UDP header takes 20 Bytes
    - IP header takes 20 Bytes
    - Max allowable payload size = 1500 Bytes

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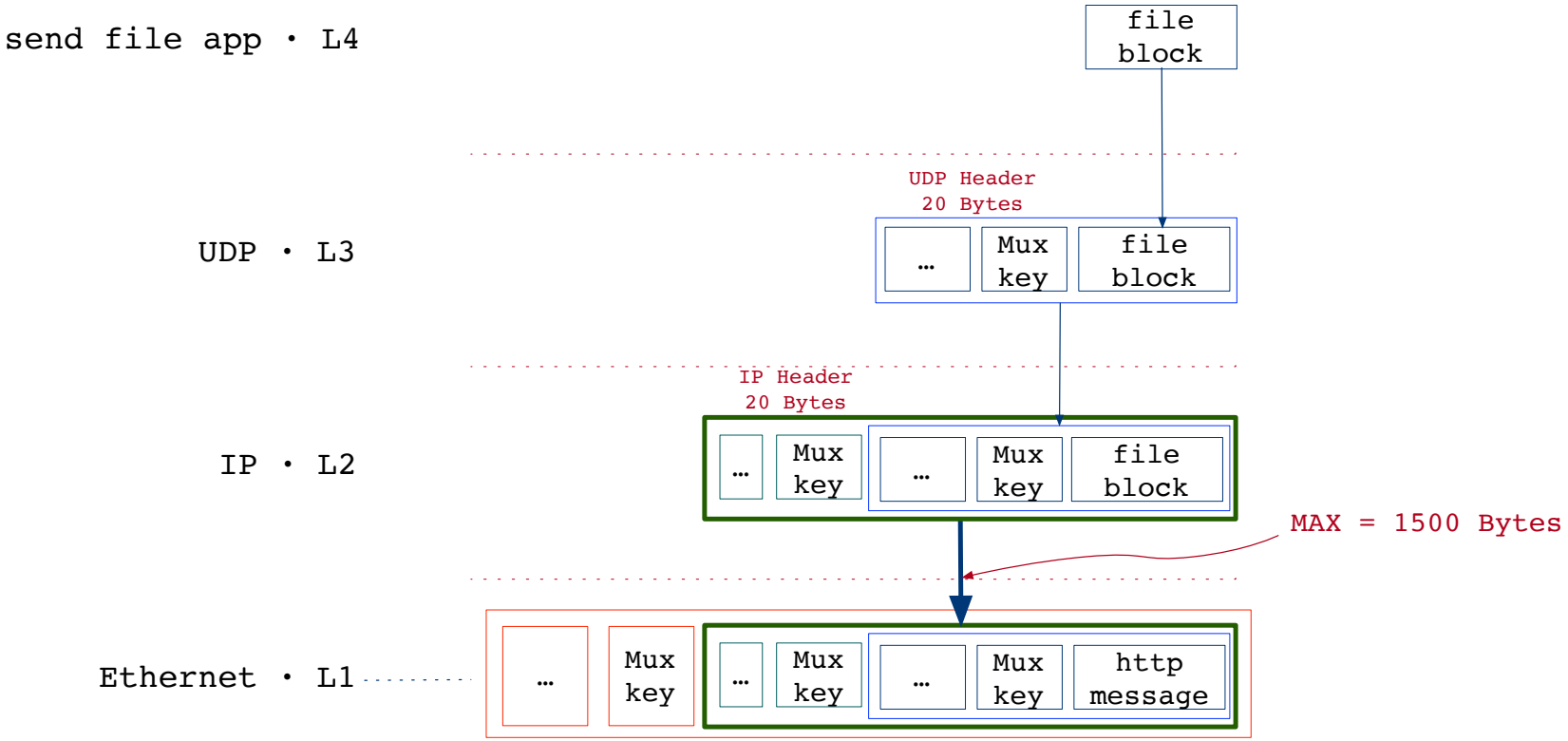

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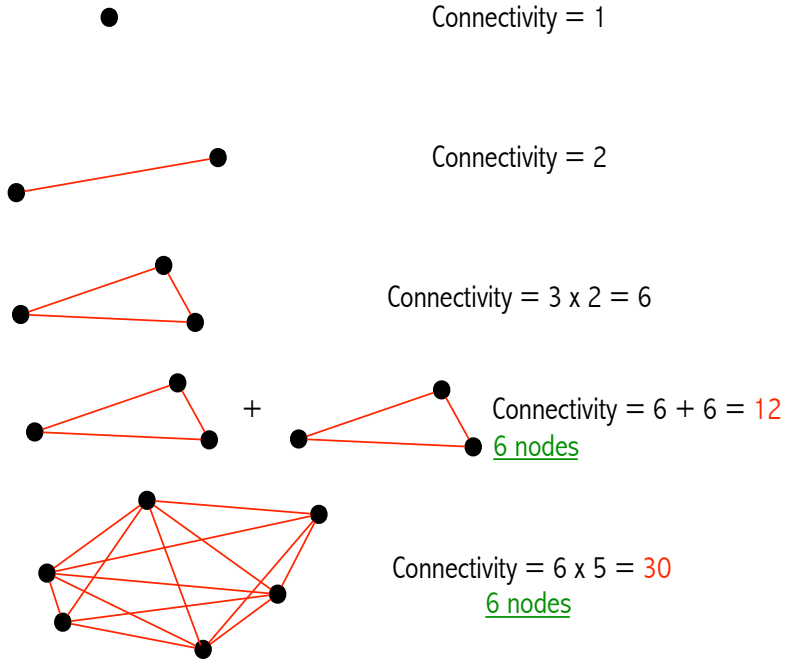
  - Time from start of transmission of first bit at A to the moment at which B finishes receiving the last bit
  - In Ethernet 2500 m => Rtt=51,2μs
  - Transmission speed is 10Mbps
  - Break down into max size frames and transfer
  - Assume:
    - UDP header takes 20 Bytes
    - IP header takes 20 Bytes
    - Max allowable Ethernet payload size = 1500 Bytes

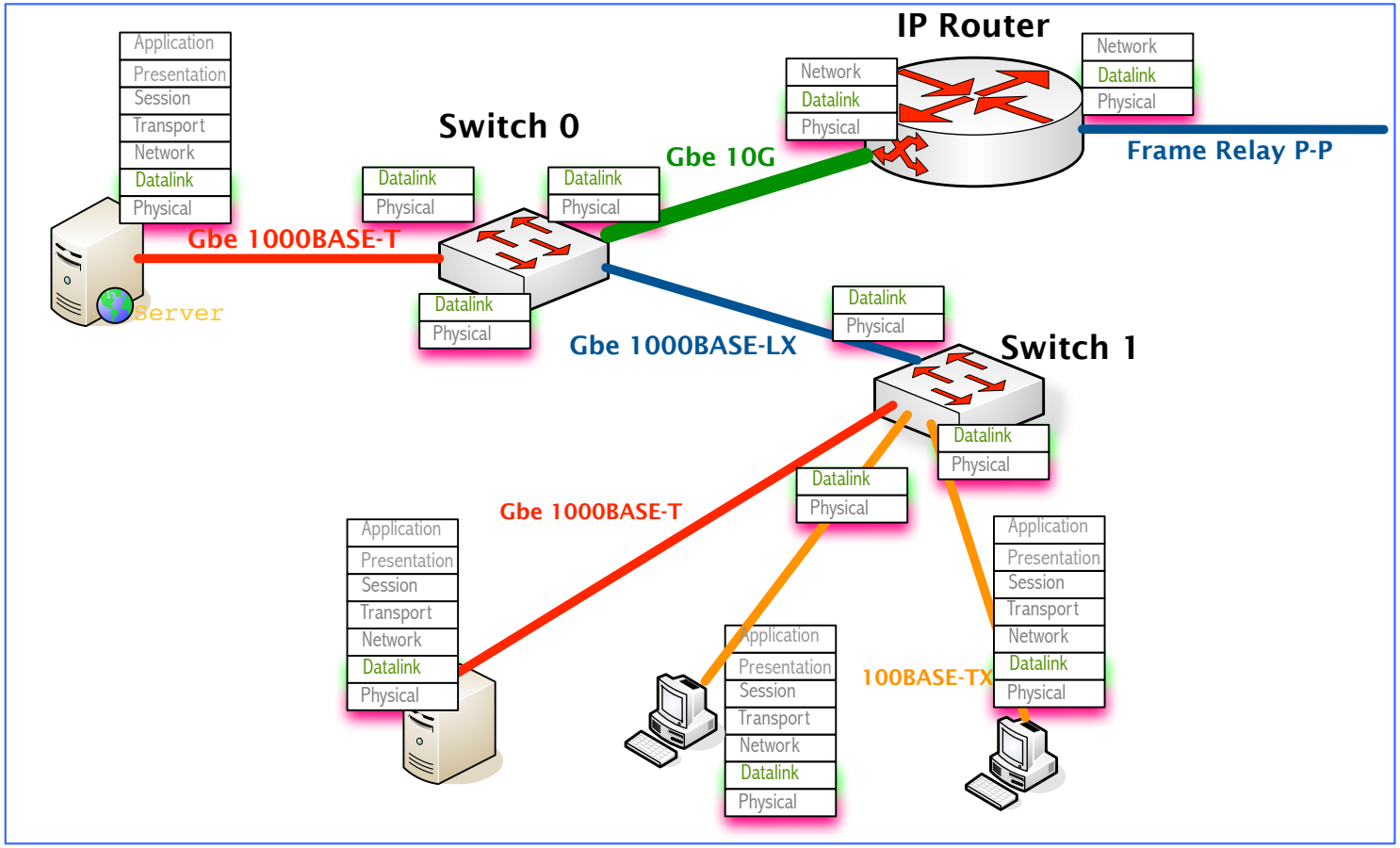
Theroretical connectivity is bounded by network *technology*

- Metcalf's law: Represents the potential connectivity of a network
- Nodes communicate by sending/receiving messages through the links which **bandwidth is limited**
- Each node must 'have some knowledge' about the **topology** of the network
- These factors limit the use of the potential connectivity



Datalink protocols in an Internetwork

- Each direct connection between two network nodes has a link (Hosts, switches, routers)

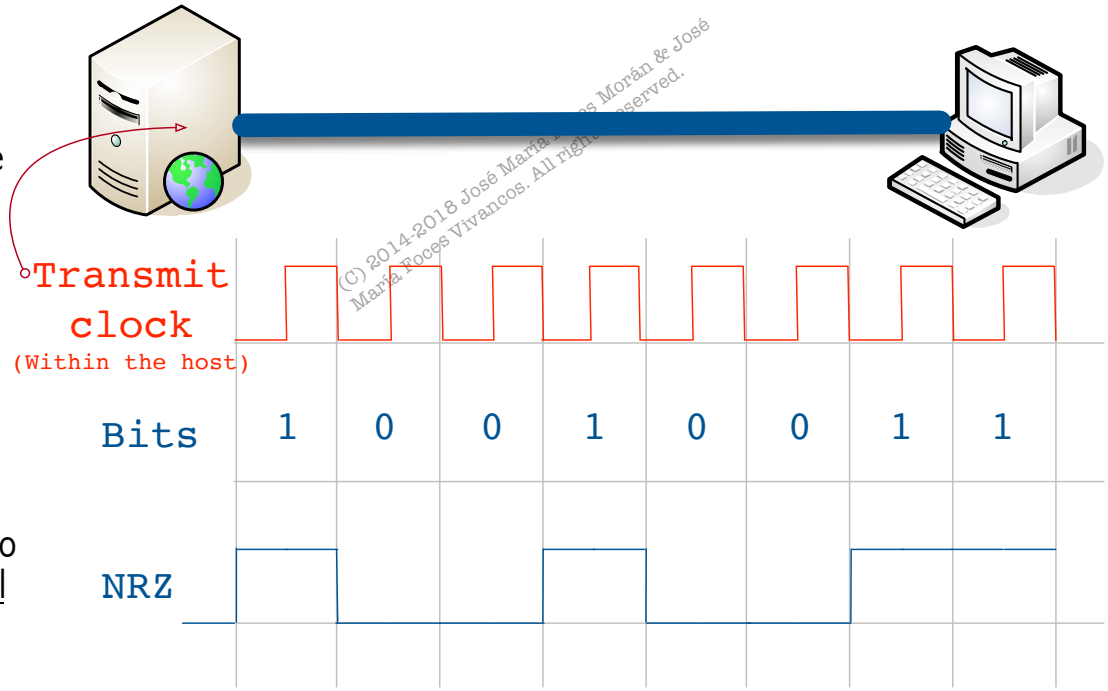


Problems with NRZ

Clock recovery

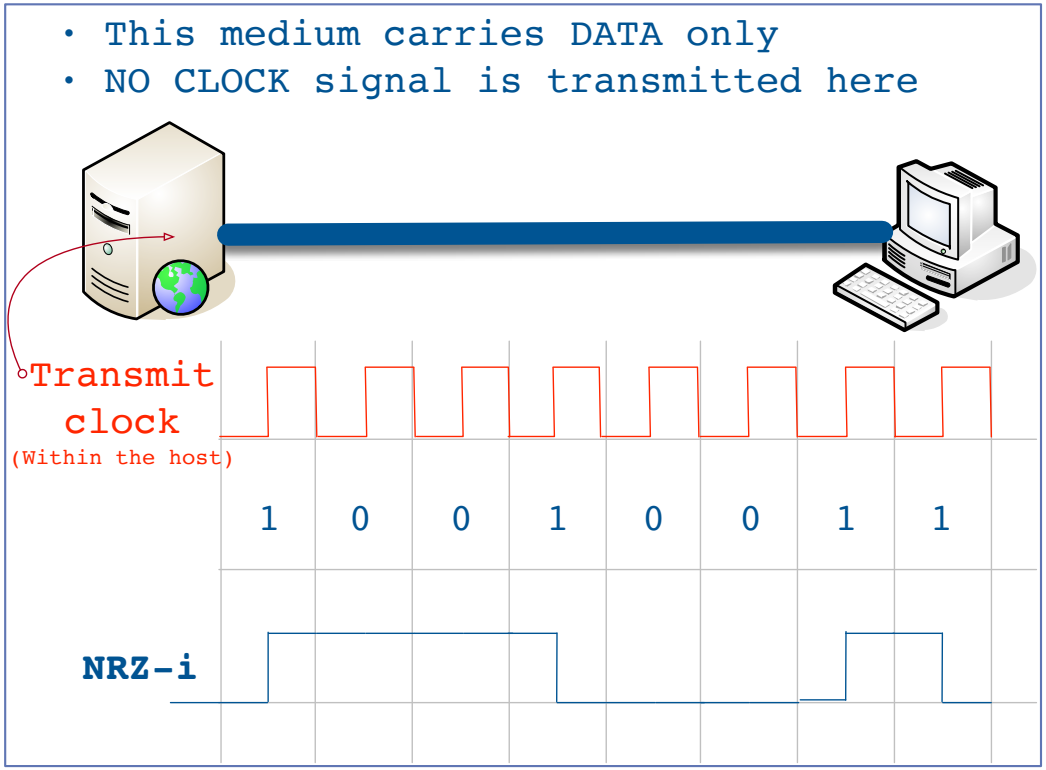
- The transmitter sends symbols (0/1) at some transmission speed determined by an internal clock signal
  - In data communications this clock signal is not sent from sender to receiver
  - Then, how does the receiver become aware of the used transmission speed?
- At every clock cycle, the sender transmits a bit
- The receiver must be able to deduce the transmission speed from the signal containing the data
  - This entails frequent transitions from high to low or vice versa in the received data signal
  - This is known as clock recovery
  - Clock recovery yields a precise synchronization of sender and receiver

- This medium carries DATA only
- NO CLOCK signal is transmitted here



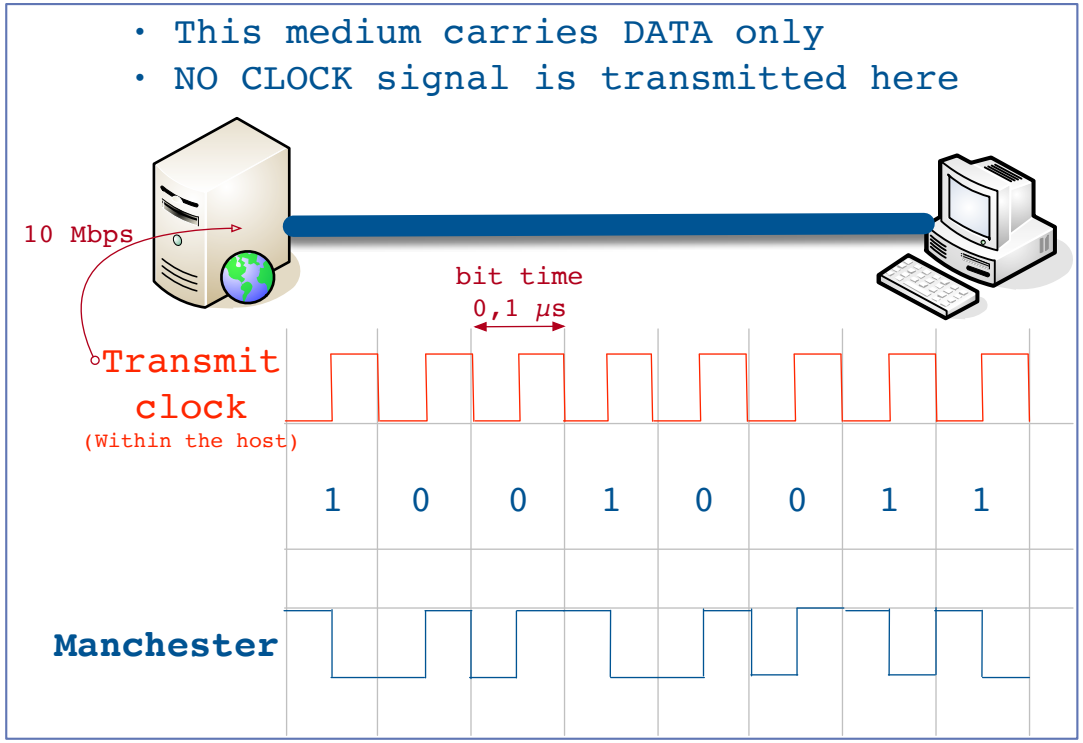
NRZ-i: a partial solution to NRZ

- NRZI
- Non Return to Zero Inverted
- Sender makes a transition from the current signal level to encode 1 and stays at the current signal level to encode a 0
- Solves for the consecutive 1's problem of NRZ



Manchester: complete solution to NRZ

- Strategy:
  - Merge the clock with signal by transmitting Ex-OR of the NRZ encoded data and the clock
  - Clock is an internal signal that alternates from low to high, a low/high pair is considered as one clock cycle
  - In Manchester encoding
    - 0: low→ high transition
    - 1: high→ low transition



Links

- Another important link characteristic is the *frequency*
  - Measured in hertz, with which the electromagnetic waves oscillate
  - Electromagnetic waves propagate as the electric field generates a magnetic field that generates an electric field …

- Distance between the adjacent pair of maxima or minima of an electromagnetic wave measured in meters is called *wavelength:* $\lambda = v / f$
  - Speed of light divided by frequency gives the wavelength.
  - Frequency on a copper cable range from 300Hz to 3300Hz; Wavelength for 300Hz wave through copper is speed of light on a copper / frequency
  - $2/3 \times 3 \times 10^8 / 300 = 667 \times 10^3$ meters.
- Placing binary data on a signal is called *encoding*
- *Modulation* involves modifying the signals in terms of their frequency, amplitude, and phase
  - So that transmission over the physical medium is improved