Chapter 1: Conceptual Basis

Review Sect. 1-4

V 1.5, 7/Mar/19

Based on textbook *Conceptual Computer Networks* by:

Textbooks and notes for CN

- Notes by professor
  - paloalto.unileon.es/cn
  - Lecture slides
  - Complementary notes
  - Questionnaires + solutions
  - Practices
  - Solved exercises
  - Exams from past terms

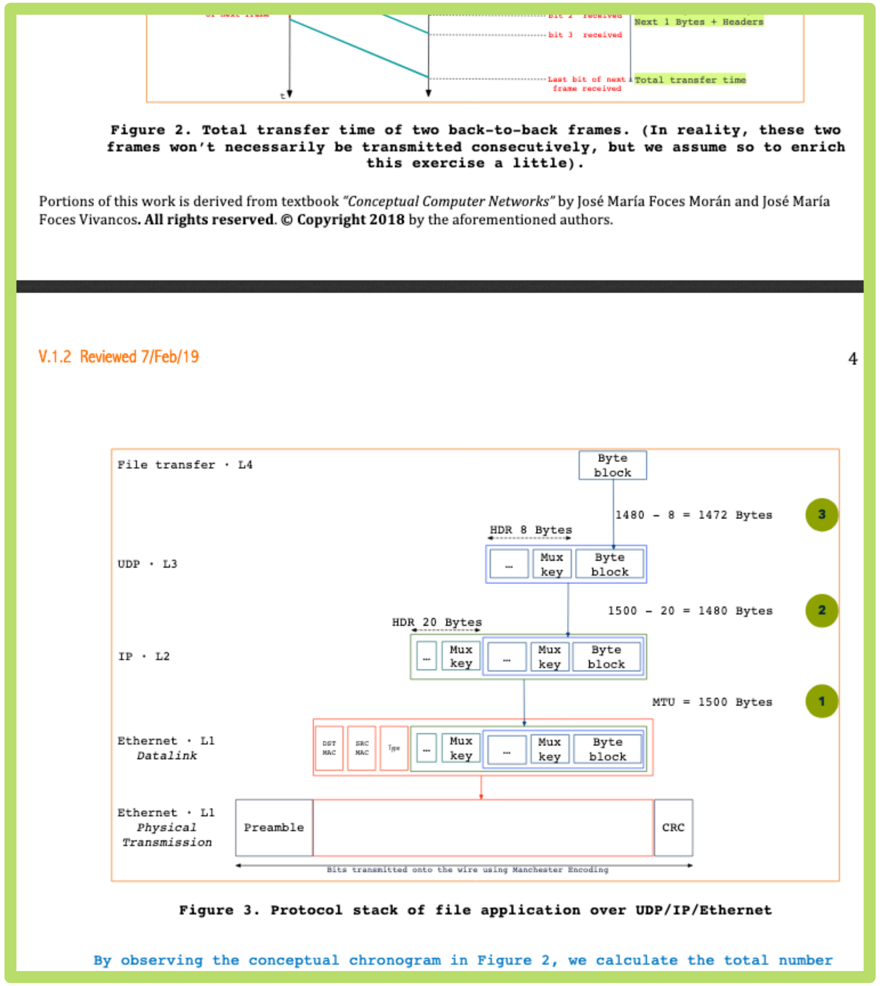


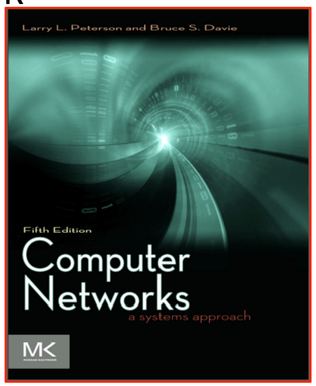
Figure 2. Total transfer time of two back-to-back frames. (In reality, these two frames won't necessarily be transmitted consecutively, but we assume so to enrich this exercise a little).

Figure 3. Protocol stack of file application over UDP/IP/Ethernet

By observing the conceptual chronogram in Figure 2, we calculate the total number

- Computer Networks Textbook

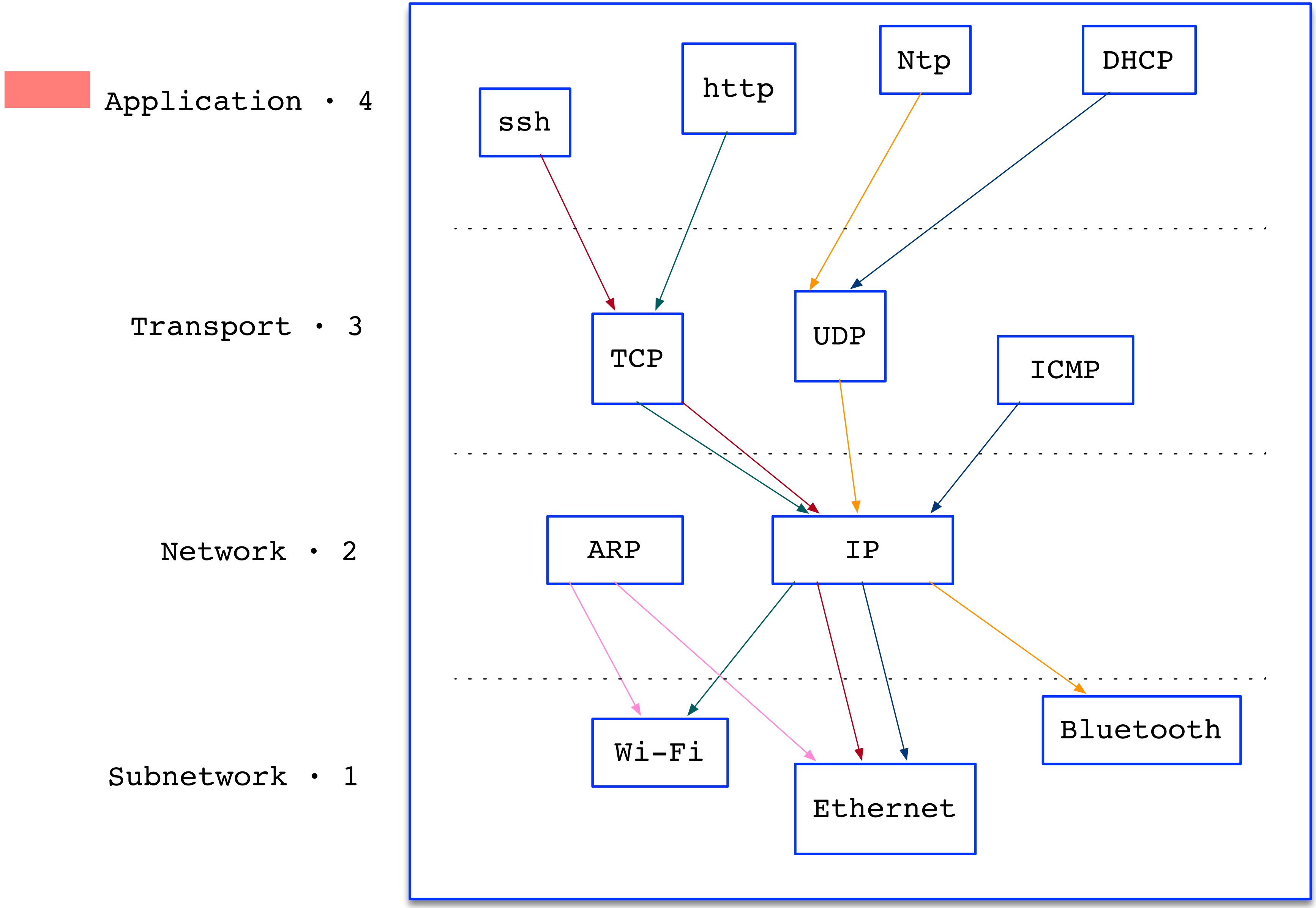
by Peterson and Davie



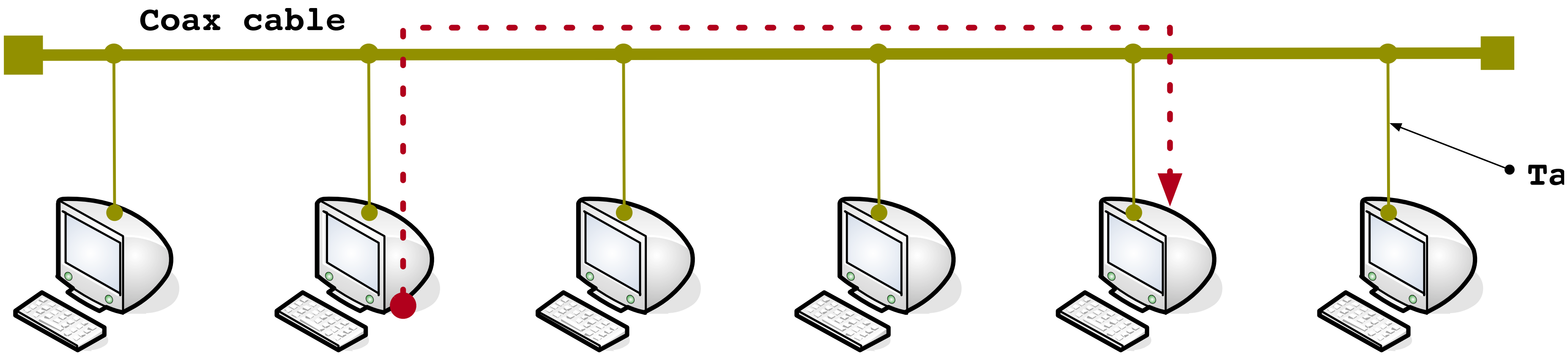
Units and multipliers

- Bandwidth
  - 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
  - The time between the start and finish of an operation: data transfer, response time of a server, etc.
- Jitter
  - The variance of the delay
- Counting aggregates of bits, bytes, etc
  - K = 2^{10}
  - M = 2^{20}
  - G = 2^{30}
  - 1 Byte = 8 bits

Typical Internet Protocol Stack



Ethernet

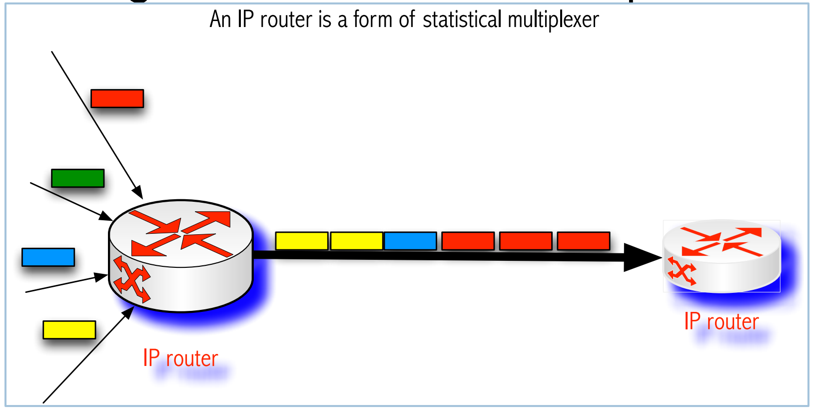


Latency = total time to transfer one packet

(Point-to-point connection)

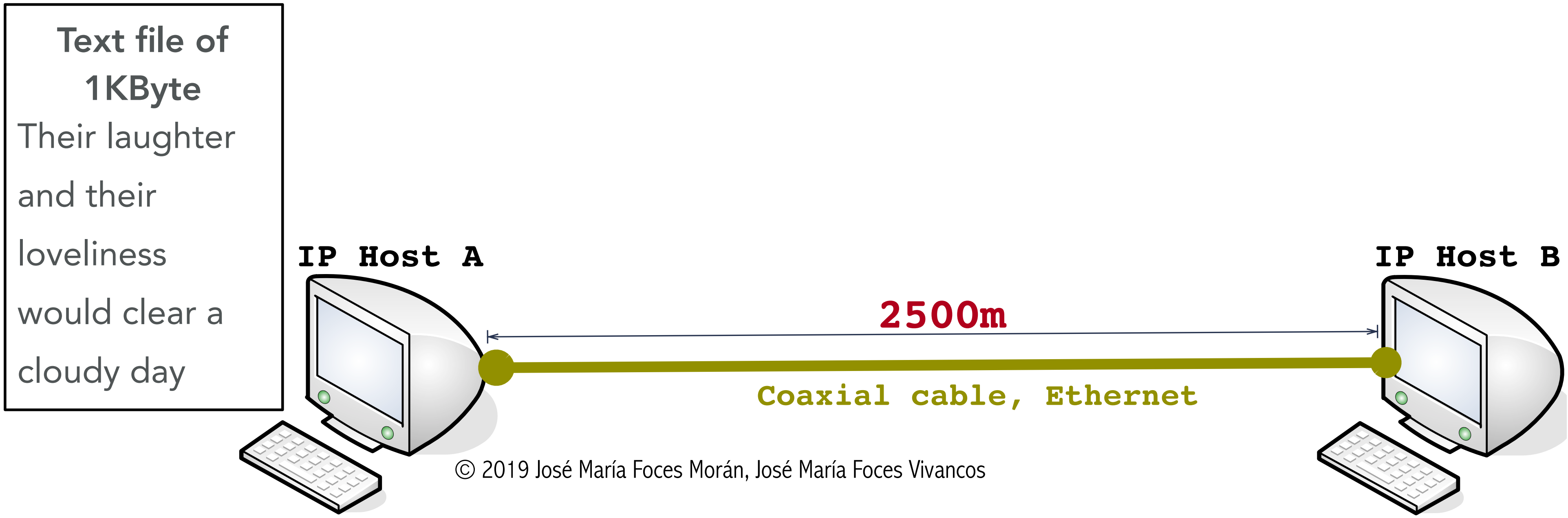
- Latency = Propagation + transmit + queue
- Propagation time = physical link distance/speed of light m / (m/s)
- Transmit time = packet size/bandwidth bits / (bits/sec)

- 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



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

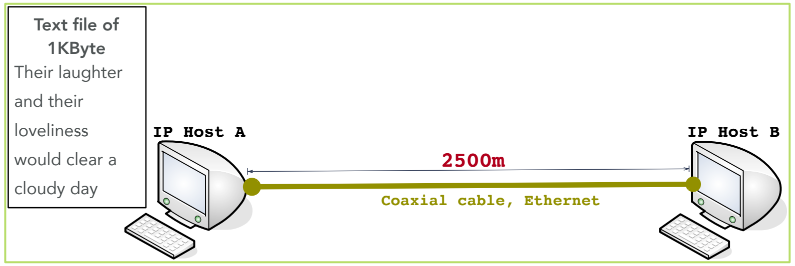
- Assume an Ethernet segment connects two end stations, A and B which are located at a distance of 2500 m from each other. How much time does it take to transfer a 1KB file from A to B?



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

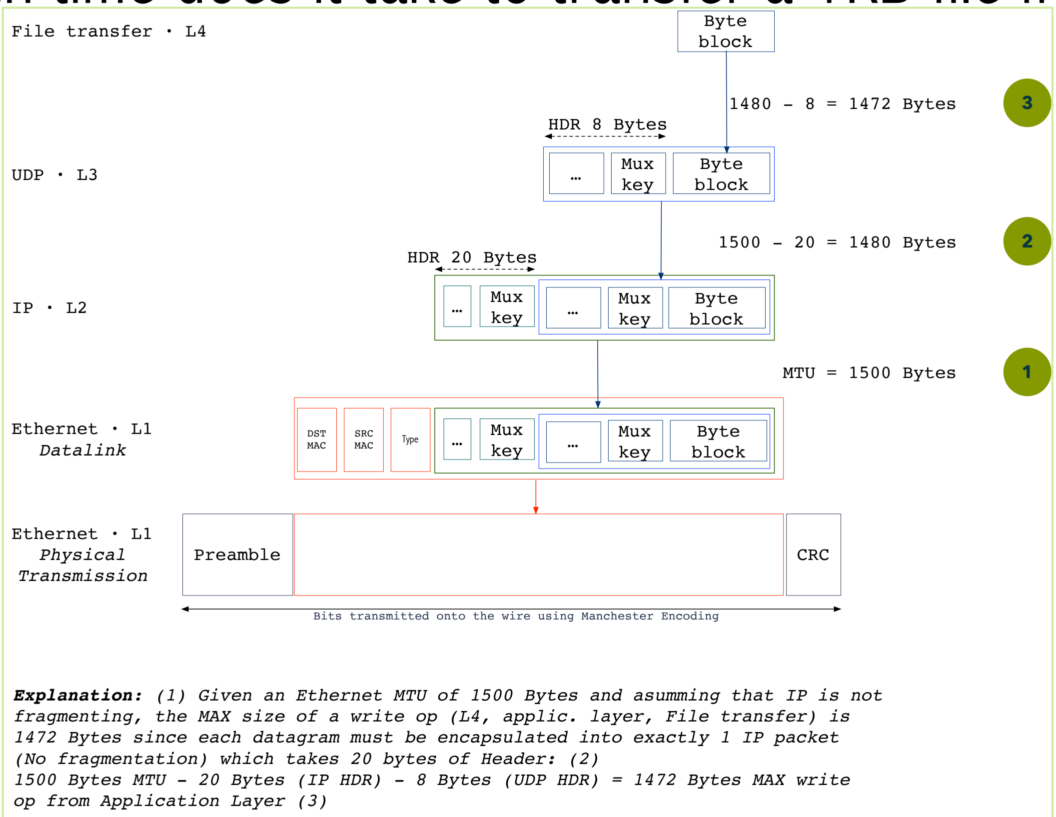
- Assume an Ethernet segment connects two end stations, A and B which are located at a distance of 2500 m from each other. How much time does it take to transfer a 1KB file from A to B?

  - 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 = 51,2 μs
  - Transmission speed is 10 Mbps
  - Assume:
    - UDP header takes 8 Bytes
    - IP header takes 20 Bytes
    - Max allowable payload size = 1500 Bytes



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 located at a distance of 2500 m from each other. How much time does it take to transfer a 1KB file from A to B?



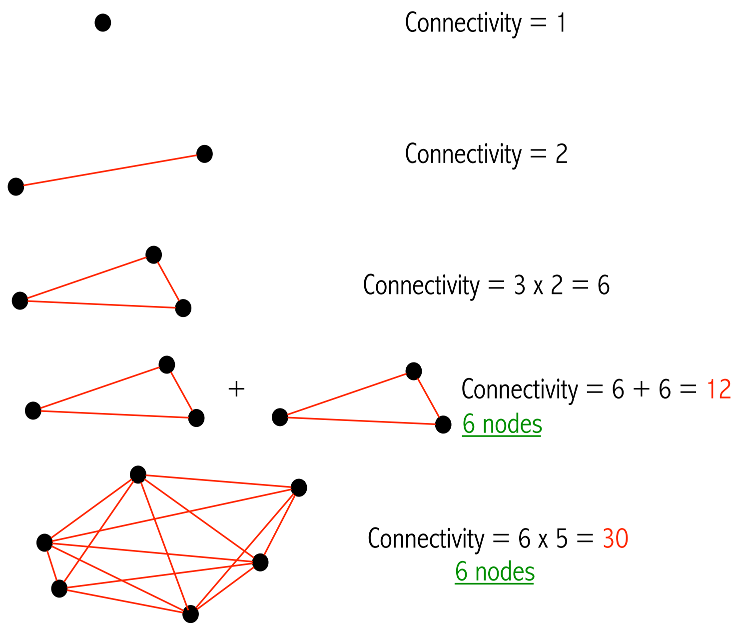
Exercise: Total time to transfer a block of data onto a direct connection

- Assume an Ethernet segment connects two end stations, A and B which are located at a distance of 2500 m from each other. How much time does it take to transfer a 1KB file from A to B?

- Full solution of *similar* exercise:
  - http://paloalto.unileon.es/cn/Q/CN-Ex1-2018-RefSOL.pdf

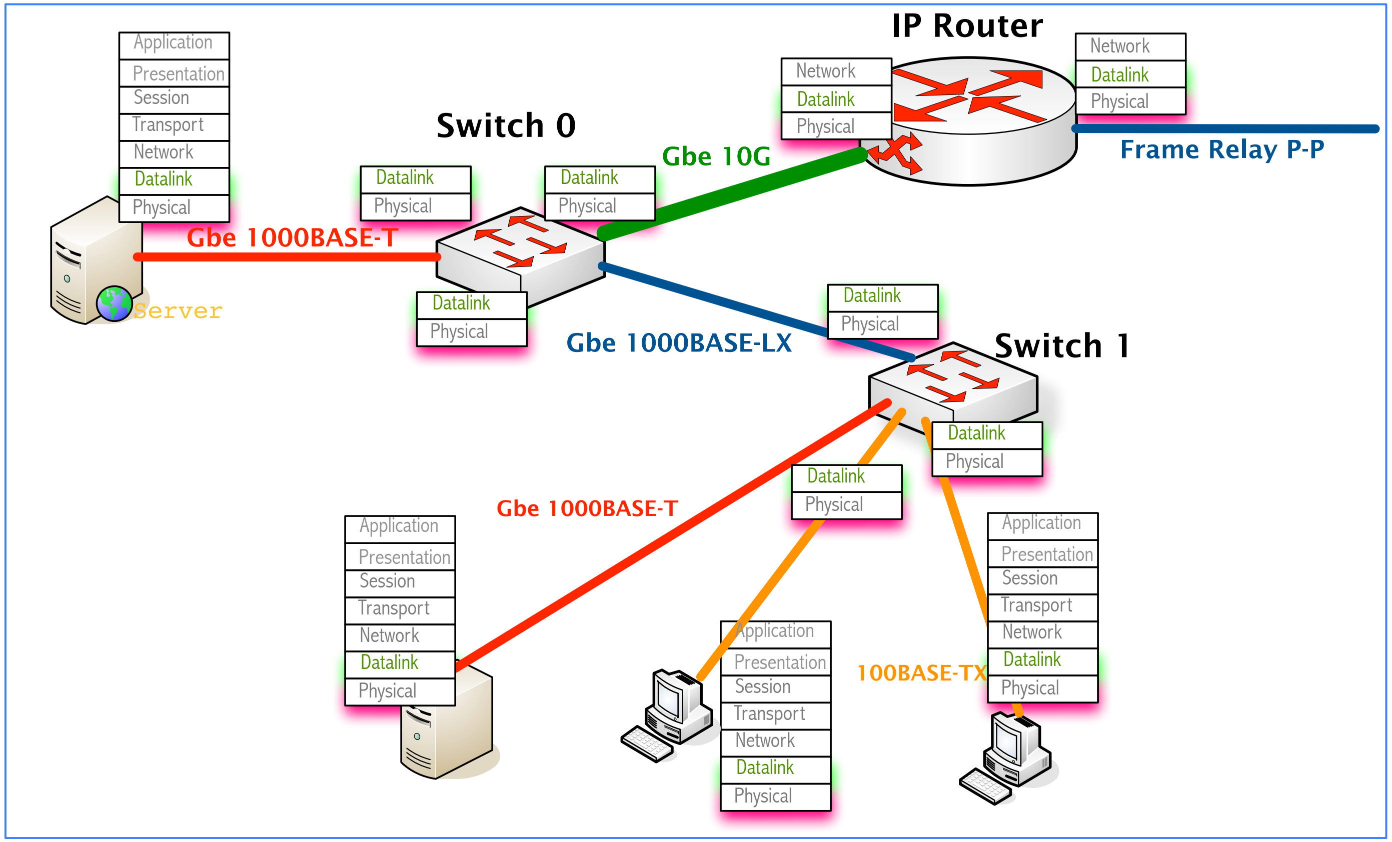
Therоretical connectivity is bounded by network *technology*

- 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

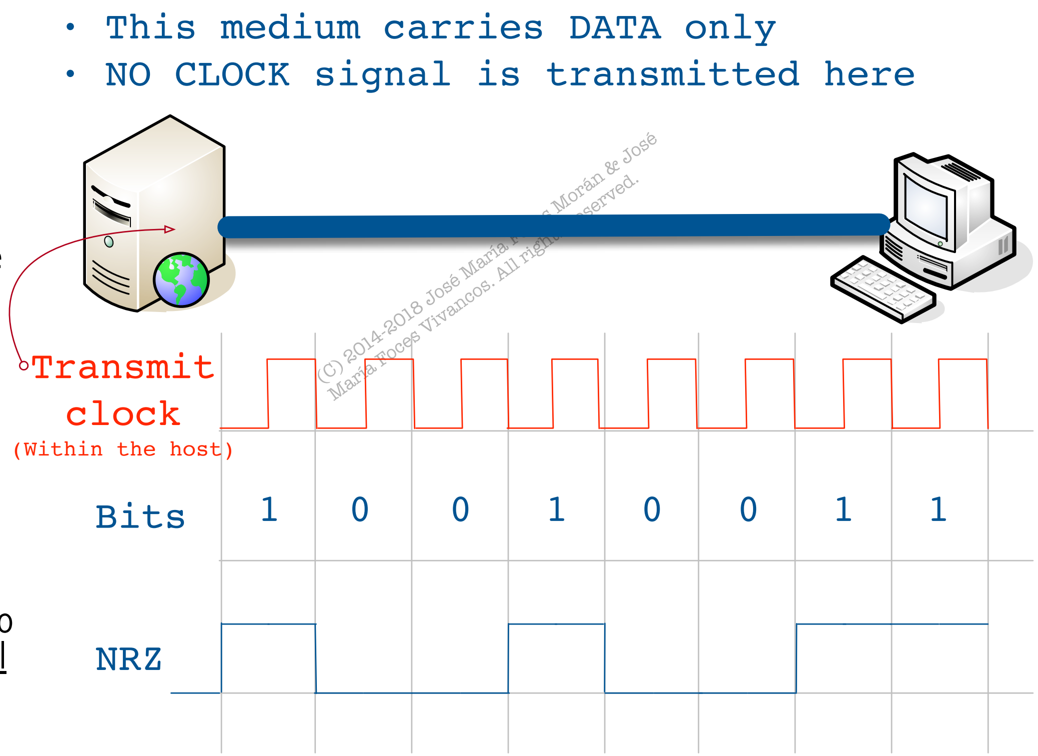
- Each direct connection between two network nodes has a link (Hosts, switches, routers)



Problems with NRZ

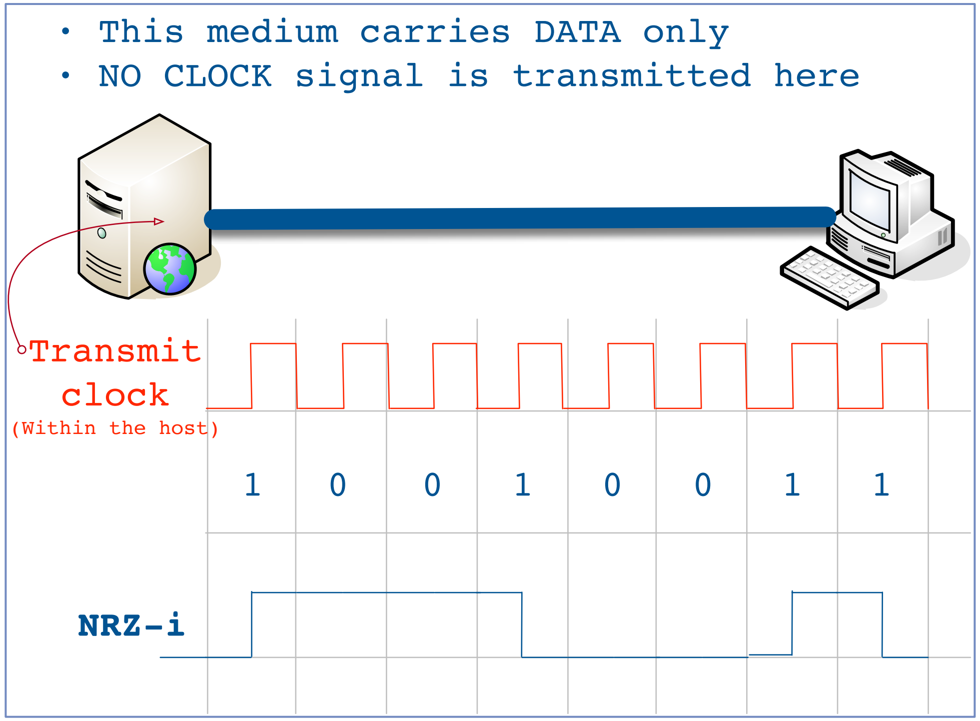
Clock recovery

- 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



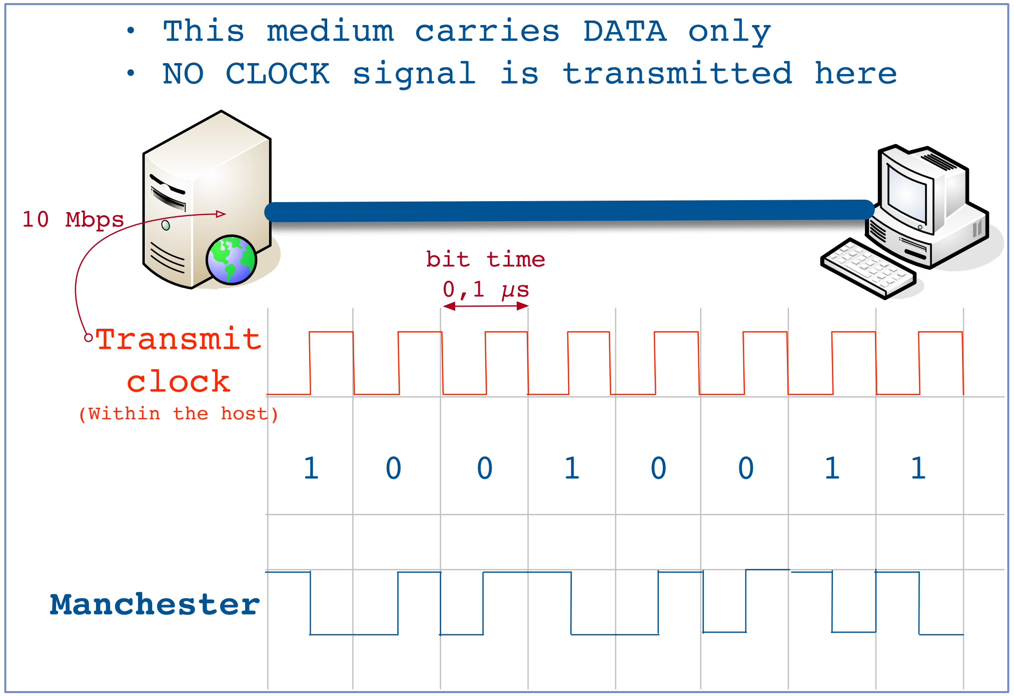
NRZ-i: a partial solution to NRZ

- 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
- <u>Solves for the consecutive 1's problem of NRZ</u>



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