A Quantitative View: Delay, Throughput, Loss

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Textbook Chap. #1 Section 1.4

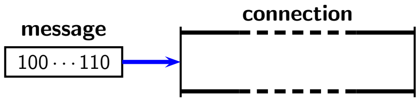
Outline

- Quantitative analysis of data transfer concepts for network applications
- Propagation delay and transmission rate
- Multi-hop scenario

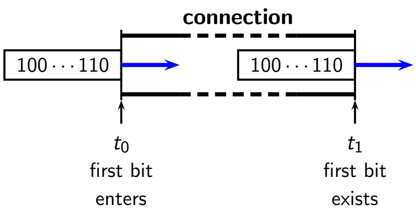
Quantifying Data Transfer

- How do we measure the "speed" and "capacity" of a network connection ?
- Intuition
  - water moving in a pipeline
  - cars moving on a road
- Delay or Latency
  - the time it takes for **one bit** to go through the connection (from one end to the other)
- Transmission rate or Throughput
  - the amount of information that can get into (or out of) the connection in a time unit

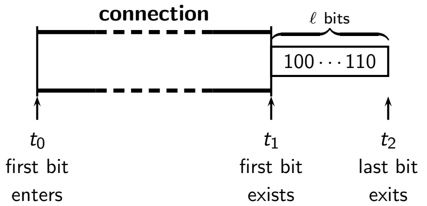
Delay (Latency) and Rate (Throughput)



Delay (Latency) and Rate (Throughput)



Delay (Latency) and Rate (Throughput)



Propagation Delay	$d_{prop} = t_1 - t_0$	sec
Transmission Rate	$R = \dfrac{\ell}{t_2 - t_1}$	bits/sec
Total transfer time	$d_{end\text{-}end} = d + \dfrac{\ell}{R}$	sec

Examples

- How long does it take to tranfer a file between, say, ISAE-Toulouse and LIP6-Paris ?
- How big is this file ? And **how fast** is our connection ?

  E.g., a (short) e-mail message

$$
\begin{aligned}
\ell &= 4\text{Kb} \\
d_{prop} &= 50\text{ms} \\
R &= 1\text{Mb/s} \\
d_{end\text{-}end} &= \ ?
\end{aligned}
$$

Examples

- How about a big file ? (E.g., a CD)

$$
\begin{aligned}
\ell &= 400Mb \\
d_{prop} &= 50ms \\
R &= 1Mb/s \\
d_{end\text{-}end} &= \ ?
\end{aligned}
$$

- How about a bigger file ? (E.g., 10 DVDs)

$$
\begin{aligned}
\ell &= 40Gb \\
d_{prop} &= 50ms \\
R &= 1Mb/s \\
d_{end\text{-}end} &= \ ?
\end{aligned}
$$

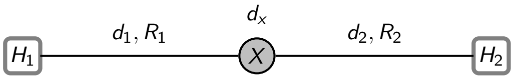
Examples

- How about going to Paris by car ?
  - assuming you can carry more or less 100 DVDs in your backpack
  - assuming it takes you four seconds to take the DVDs out of your backpack

$$
\begin{aligned}
\ell &= 40Gb \\
d_{prop} &= ? \\
R &= ? \\
d_{end\text{-}end} &= ?
\end{aligned}
$$

So what ?

Two Hops (Stream)

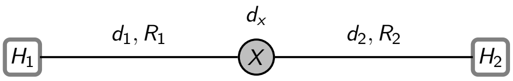


$$(R_1 < R_2) \quad d_{end\text{-}end} = d_1 + \frac{\ell}{R_1} + d_x + d_2 \quad \text{sec}$$

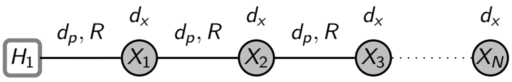
$$(R_1 \geq R_2) \quad d_{end\text{-}end} = d_1 + d_x + d_2 + \frac{\ell}{R_2} \quad \text{sec}$$

$$d_{end\text{-}end} = d_1 + d_x + d_2 + \frac{\ell}{\min\{R_1, R_2\}} \quad \text{sec}$$

Store-And-Forward (Packet)



$$d_{end\text{-}end} = d_1 + \frac{\ell}{R_1} + d_x + \frac{\ell}{R_2} + d_2$$



$$d_{end\text{-}end} = N\left(d_p + \frac{\ell}{R} + d_x\right)$$