A Quantitative View: Delay, Throughput, Loss

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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?

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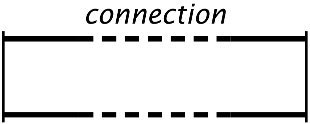
- *Delay* or *Latency*
  - the time it takes for *one bit* to go through the connection (from one end to the other)

- *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)



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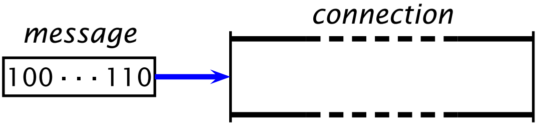

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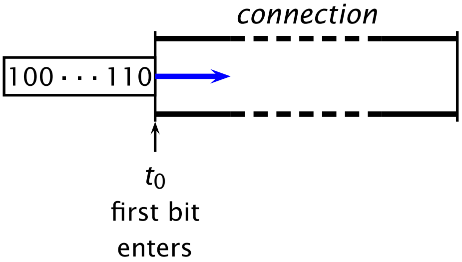

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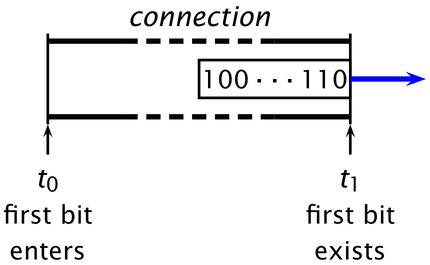

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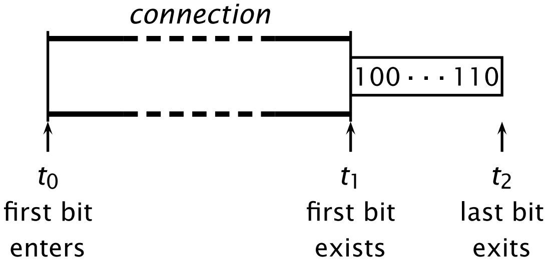

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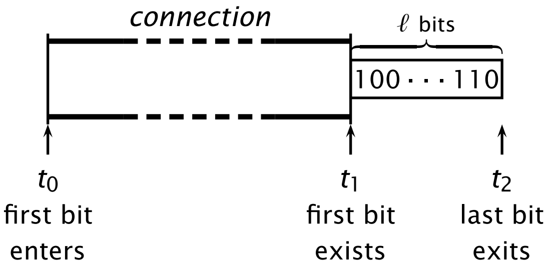

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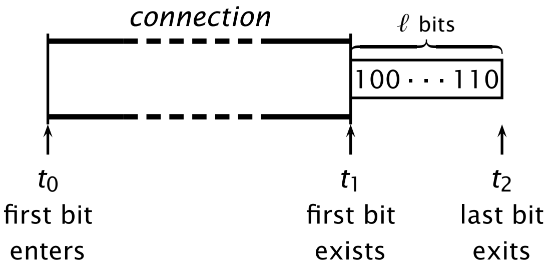

Propagation Delay $\qquad d_{prop} = t_1 - t_0 \qquad$ sec

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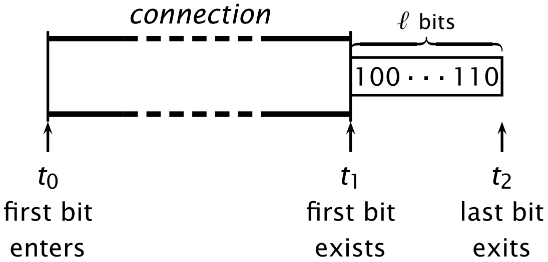

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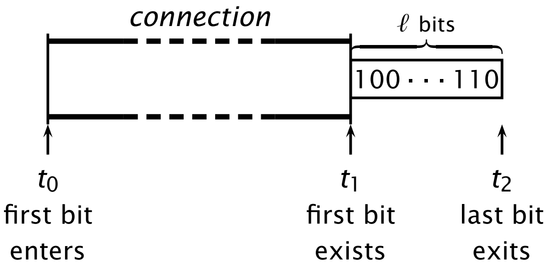

Propagation Delay	$d_{prop} = t_1 - t_0$	sec
Transmission Rate	$R = \dfrac{\ell}{t_2 - t_1}$	bits/sec
Total transfer time	$d_{end\text{-}end} = d + \dfrac{\ell}{R}$	sec

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

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If you need to transfer 10 DVDs from Lugano to Zürich and time is crucial... then you might be better off riding your Vespa to Zürich rather than using the Internet

Two Hops (Stream)

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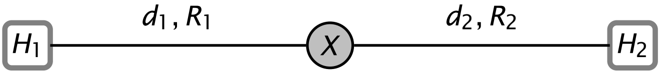

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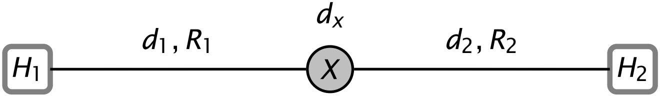

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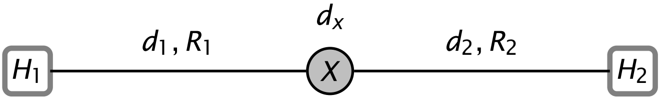

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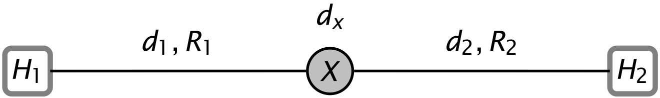

$(R_1 < R_2)$ $\quad d_{end\text{-}end} = d_1 + \frac{\ell}{R_1} + d_x$

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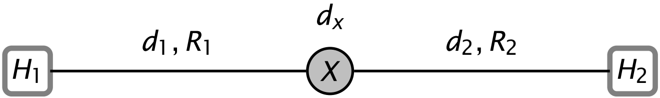

$$(R_1 < R_2) \qquad d_{end\text{-}end} = d_1 + \frac{\ell}{R_1} + d_x + d_2 \quad \text{sec}$$

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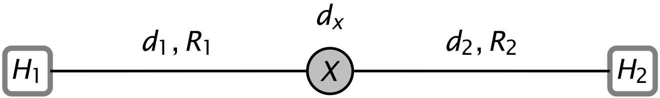

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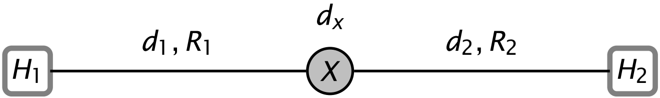

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$$d_{end\text{-}end} = d_1 + d_x + d_2 + \frac{\ell}{\min\{R_1, R_2\}} \quad \text{sec}$$

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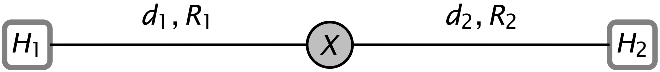

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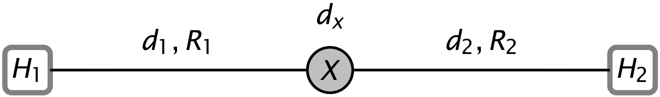

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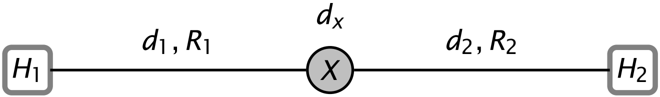

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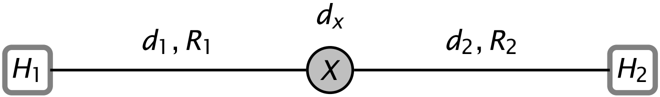

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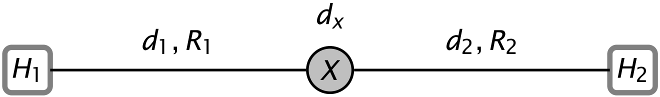

$$d_{\textit{end-end}} = d_1 + \frac{\ell}{R_1} + d_x + \frac{\ell}{R_2}$$

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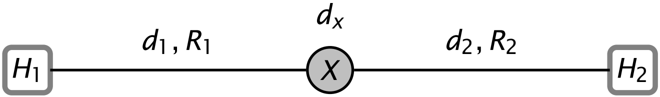

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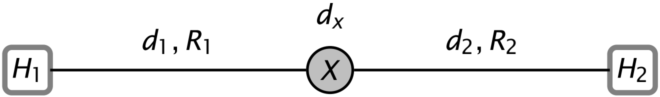

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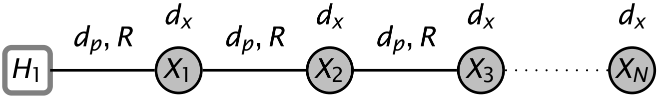

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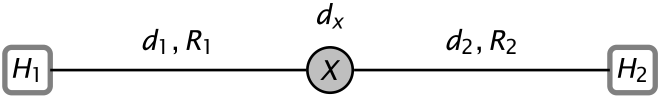

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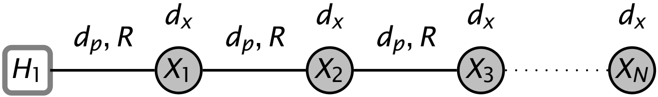

$$d_{end\text{-}end} = N\left(d_p + \frac{\ell}{R} + d_x\right)$$