

L4: Basic Networking Calculations



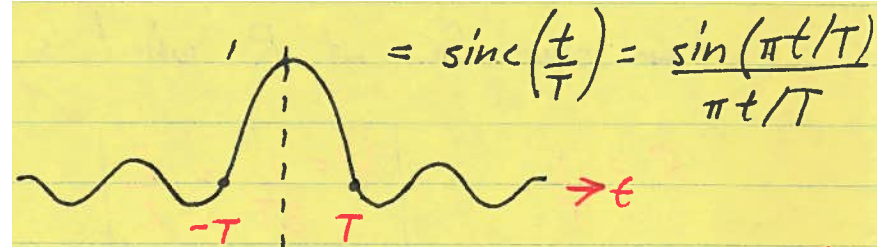
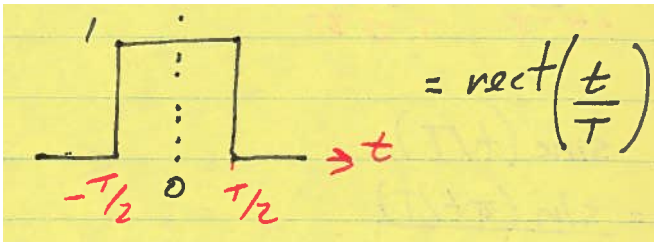
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Outline

- Calculating basic physical properties of networks
 - What do bits look like?
 - What's R
 - What's bandwidth
 - What's the delay
 - The value of partitioning data
 - Queuing
 - Throughput
 - Errors

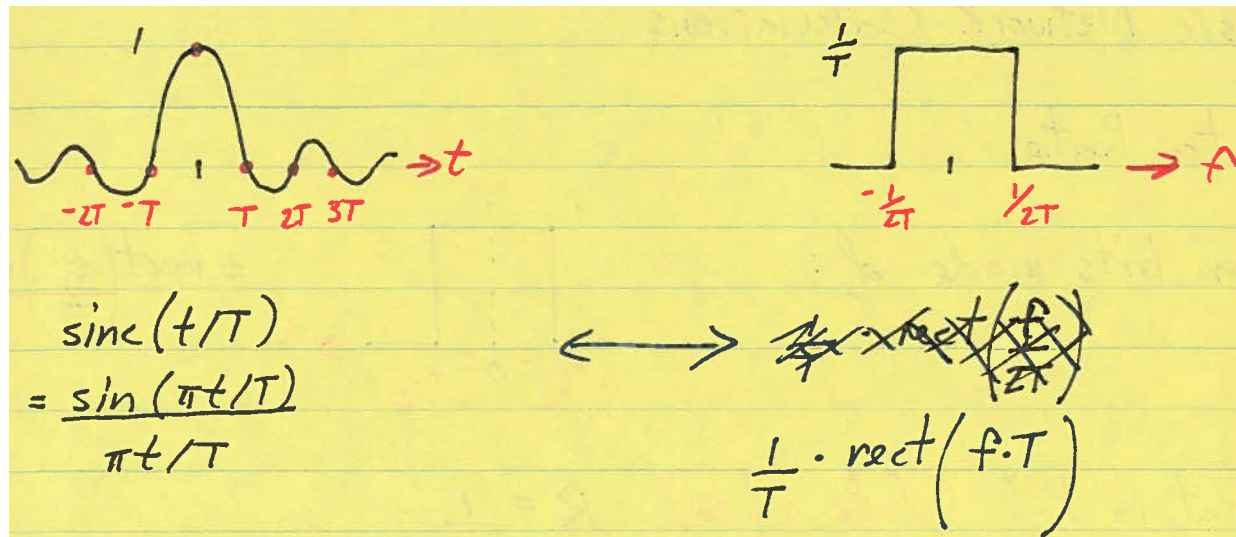
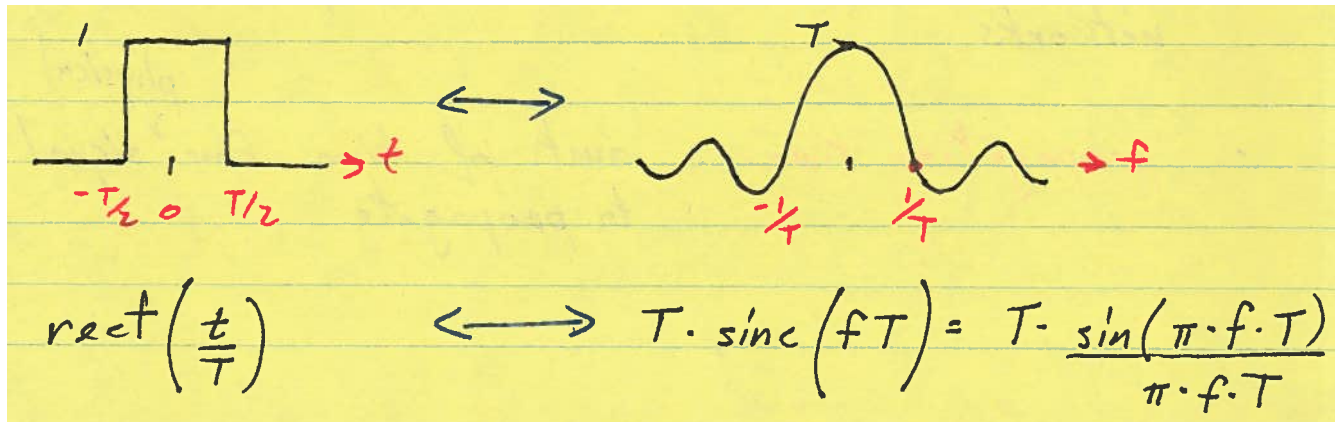
4.1 Data Rate

- Consider what bits look like
 - What's the R (data rate, data bandwidth)



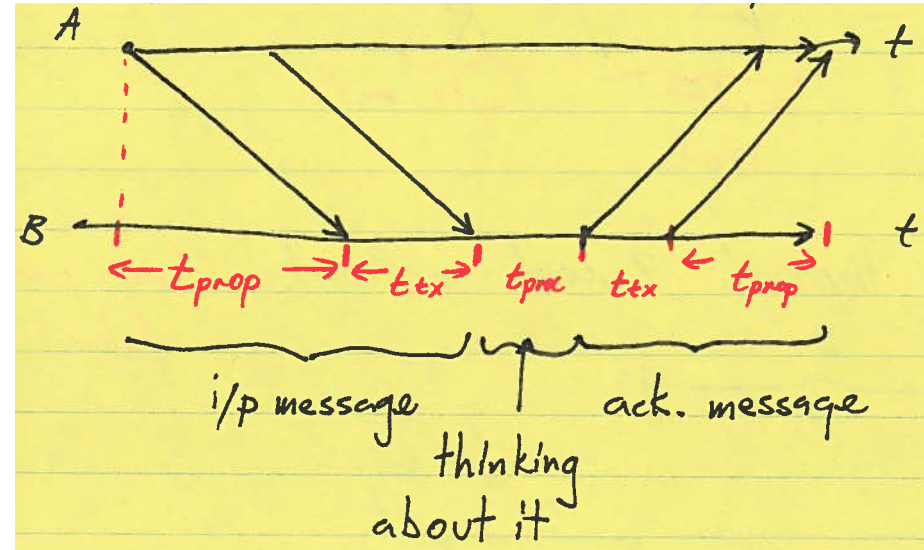
4.2 Signal Bandwidth

- The extent of signal energy as a function of frequency



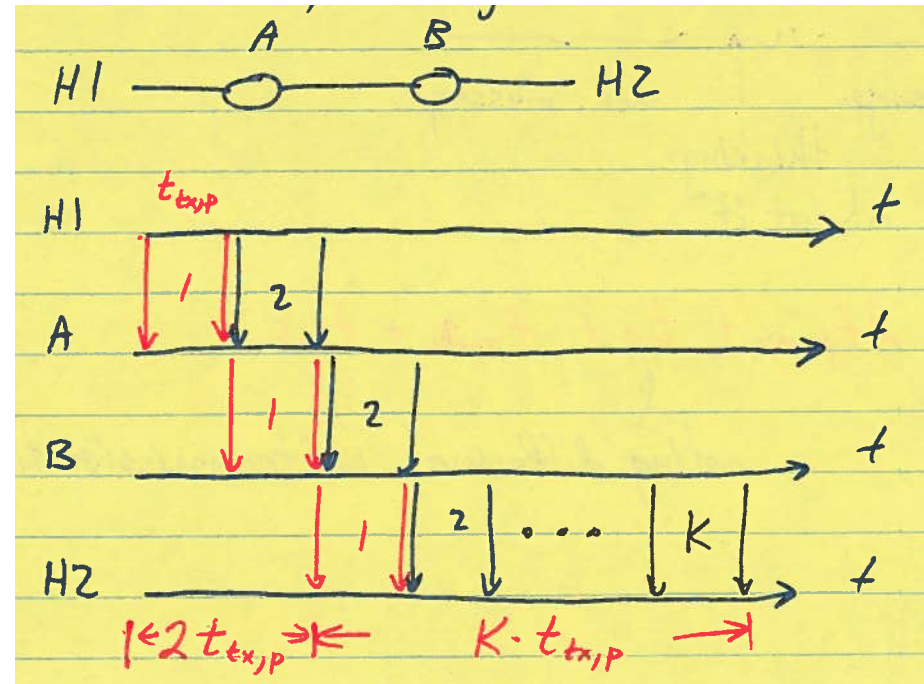
4.3 Delay

- propagation time
- transmission time



4.4 Delay of Packets Through Network

- Finding the spectrum of a periodic signal



4.5 Queuing Delay

- λ : packets arriving per second
- μ : packets processed per second
- ρ (G): offered load = λ/μ
- Rate at which a queue is emptied?
- Avg. time to empty a queue (or to get out of node)?
- Avg. wait time to get to front of queue?
- Avg. number of packets in queue?

Queuing Delay Details

• at what rate do I empty queue = $\mu - \lambda$

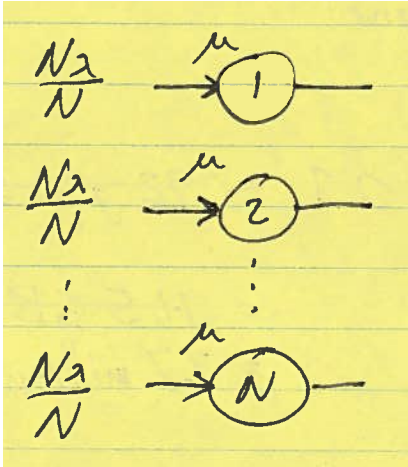
$T = \frac{1}{\mu - \lambda}$ -OR- avg. time to get out of ~~the~~ node

• \therefore avg. # of packets in queue = $\lambda \cdot T = \frac{\lambda}{\mu - \lambda} = K$

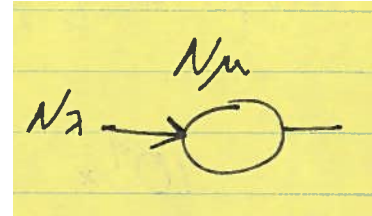
• \therefore avg. time to get to front of queue = $T - \frac{1}{\mu}$

4.6 Link Sharing

- Slow in parallel



- One fast

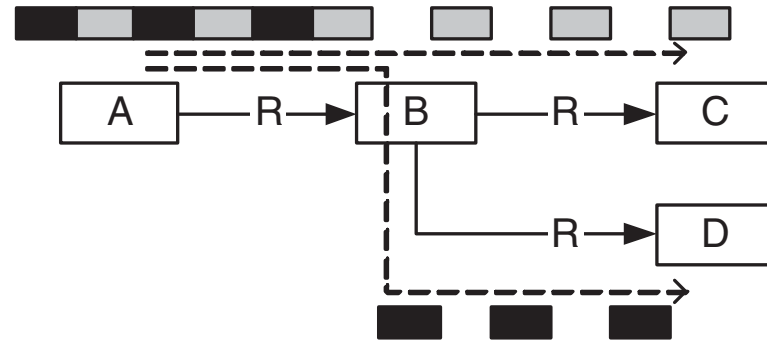
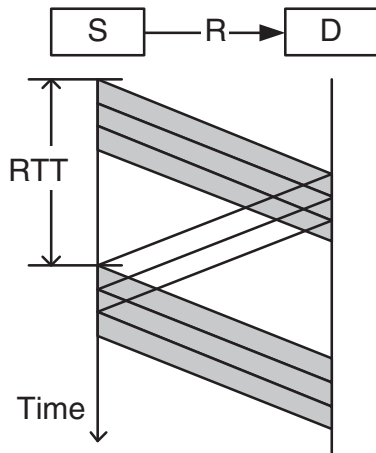


4.7 Little's Formula

- $N = \lambda \cdot T$
- N : avg. number of packets in the system (i.e. network)
- T : avg. time spent in the system
- λ : avg. packet arrival per second in the system

4.8 Throughput

- Rate of data transfer but...
 - ...accounts for overhead of communication and network details



- 3 MB file takes 2 minutes to download
 - T is?

4.9 Errors

- Message size, error, rates and hops

$$P_c = \underbrace{(1-p)}^L \approx e^{-Lp} = e^{-1}$$

*no error
in any bit*

