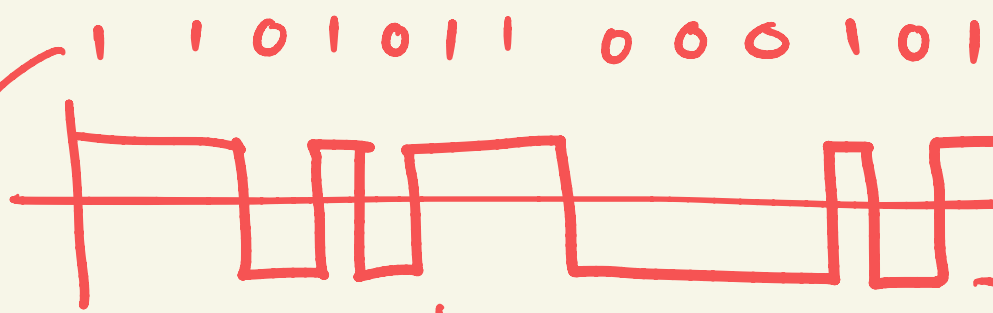
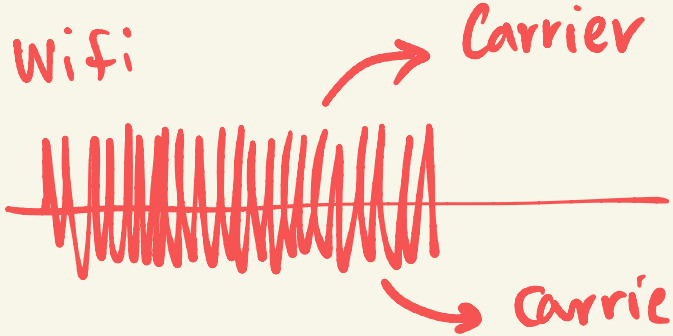
Lecture 5

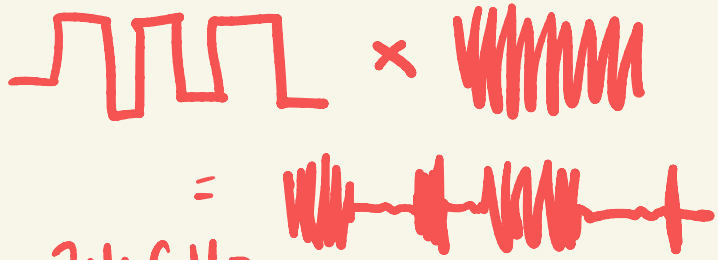
- More Foundations
- Some more keywords

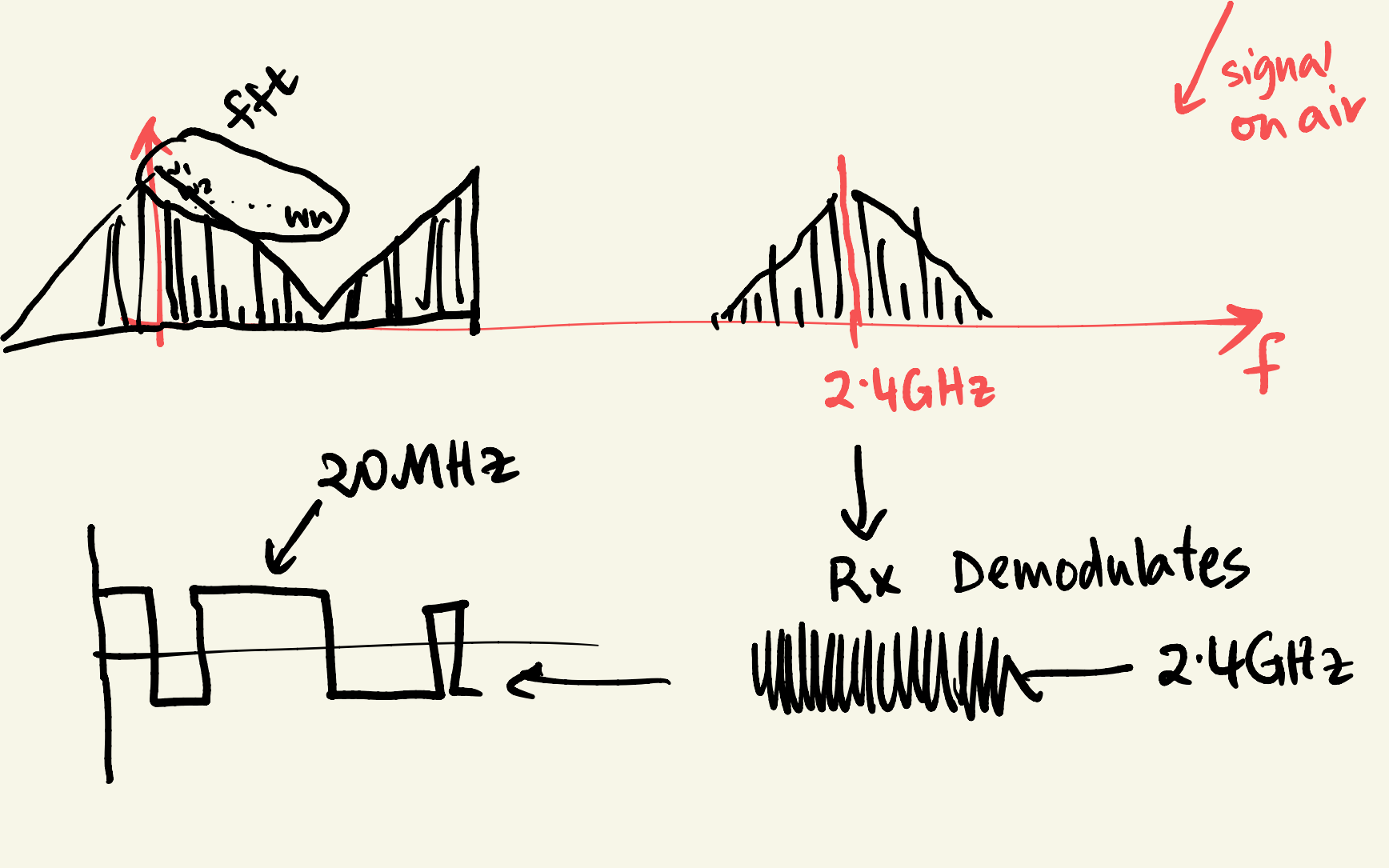


Youtube video stream over Wifi, then

$f_{max} = 20\ MHz$



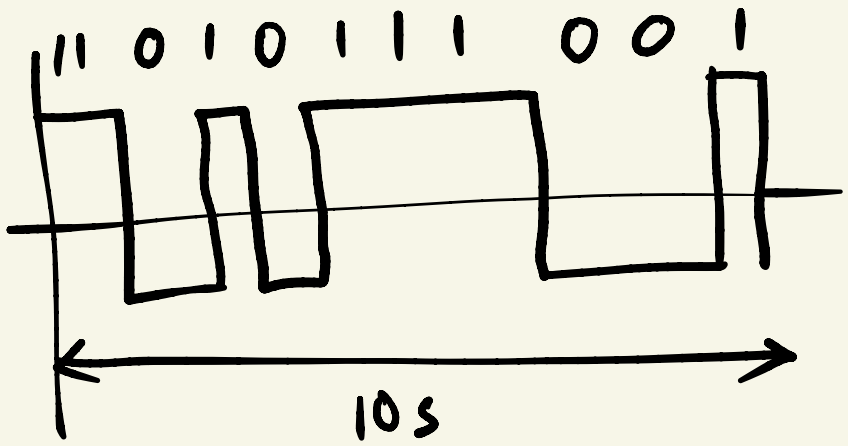



signal on air
fft
w1
w2
wn
2·4GHz
f
20MHz
Rx Demodulates
2·4GHz

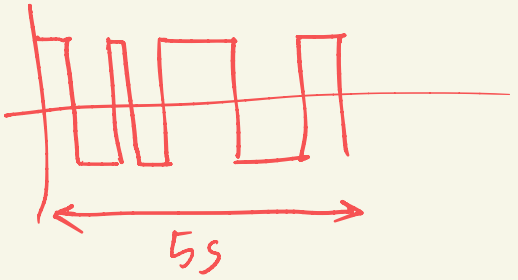
Foundations

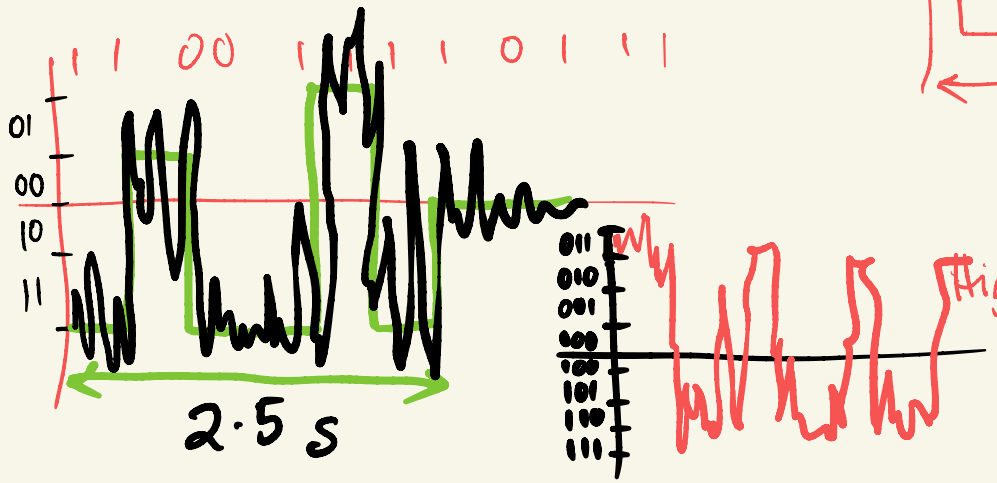
- [ ] FFT → Bandwidth → Spectrum
- [ ] Spectrum sharing → Carrier freq. → Modulation
  - amp.
  - freq.
- [ ] Baseband
- [ ] Bit rate → BER → SINR
  - noise
  - interference
  - Received power
- [ ] Shannon Capacity
- [ ] PER → Throughput → Goodput
- [ ] Inter packet time Vs. throughput
- [ ] End to end latency → Processing + Q + T.T + P.D

Bit Rate & Bit error



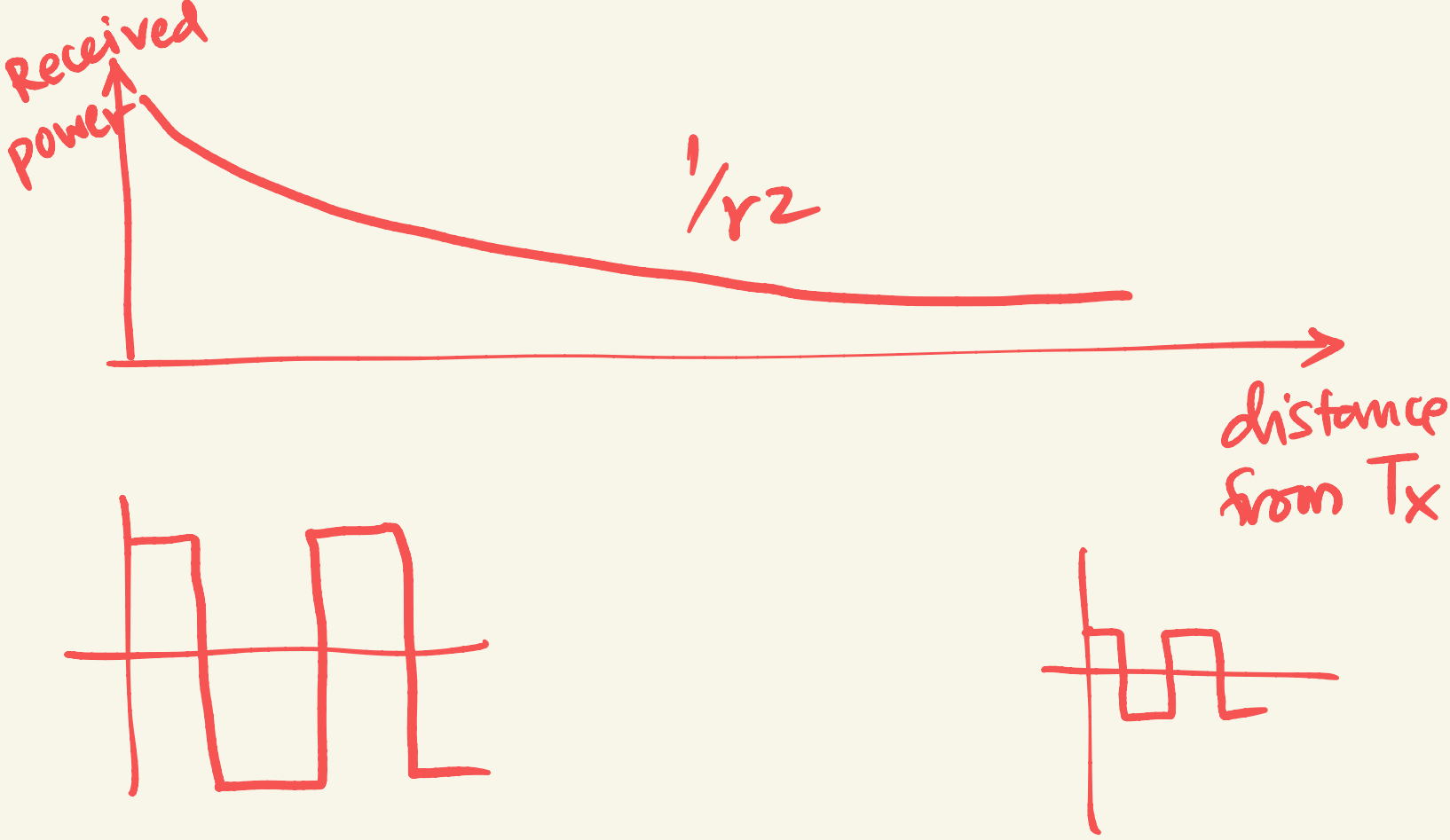
If I want to increase the rate of sending bits (i.e., bits/s), I can increase the frequency of the signal (i.e., bandwidth)

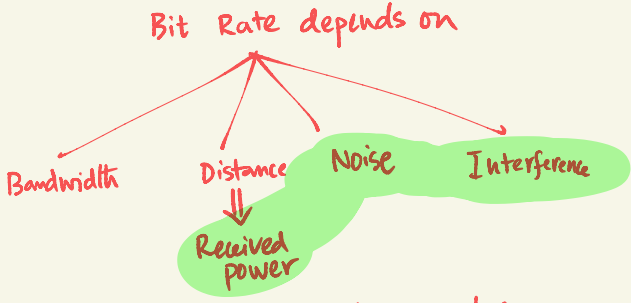




⇓

Higher b/w ≡ higher bit rate.


Received power
1/r2
distance from Tx



SINR = Signal to Interference plus Noise Ratio

$$SINR = \frac{P_r}{P_N + P_I}$$

$$\text{Bit error} \propto \frac{1}{SINR}$$

Power of a signal = ?

$x[n]$ =

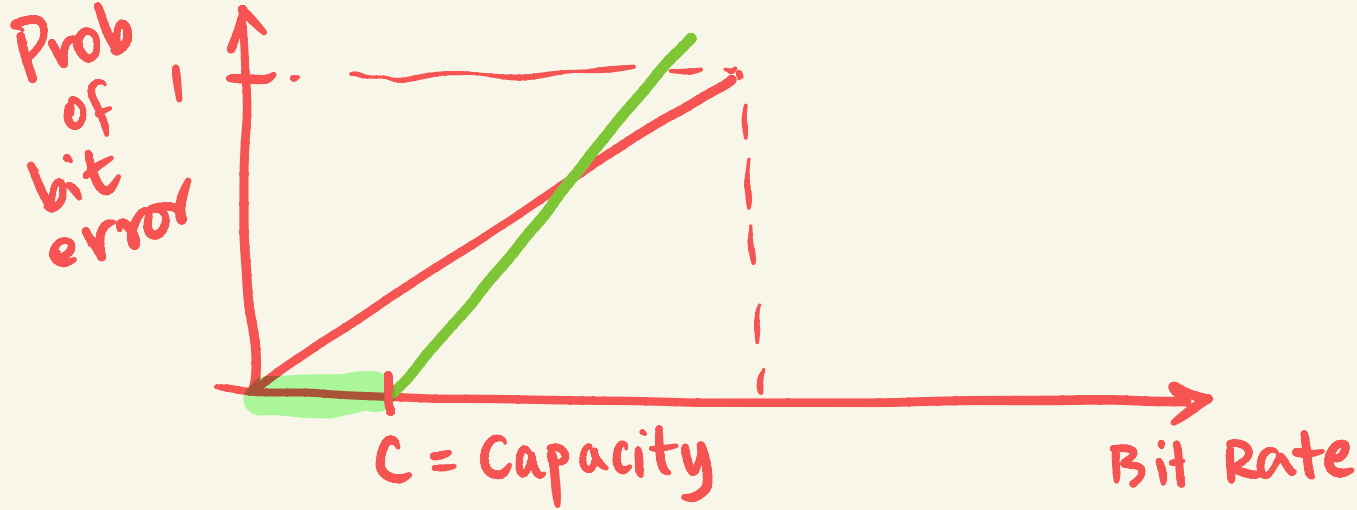
$$P_x = \frac{1}{N}\sum_{i=1}^{N} x_i^2 \qquad E_x = \sum_{i=1}^{N} x_i^2$$

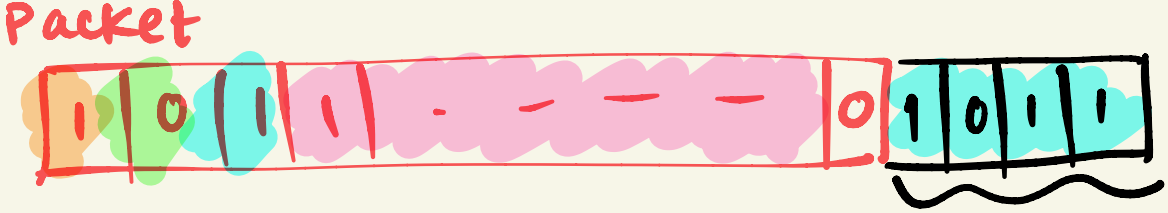
$$SINR = \frac{P}{N+I}$$ → Power of the signal of interest

Bit Rate = $B \log(1 + SINR)$

(R)

$$R = B \log\left(1 + \frac{P}{N+I}\right)$$





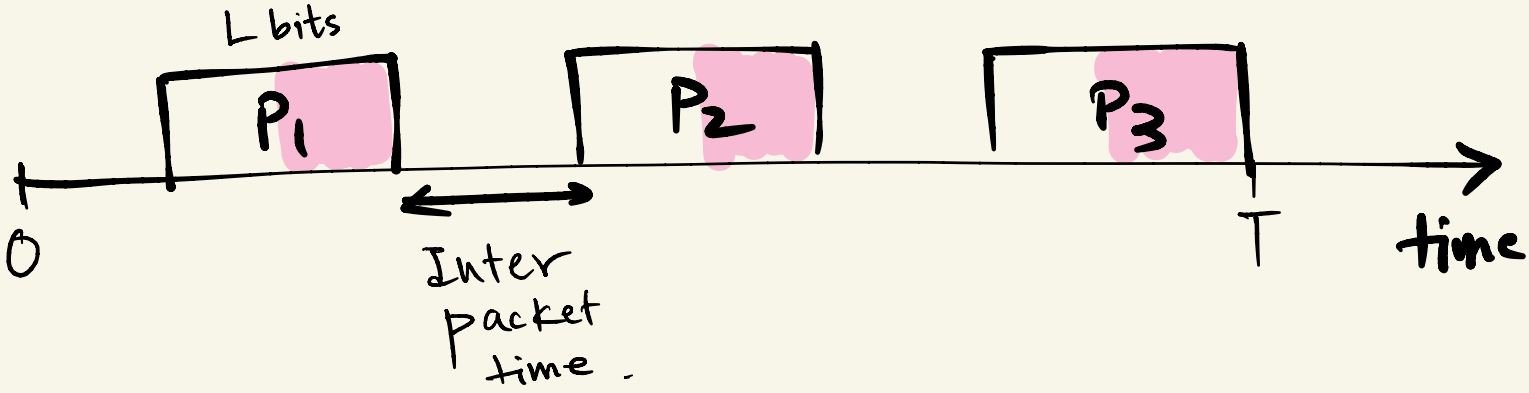
Coding Theory.

↳ Hamming codes.

Throughput ≡ No. of correctly delivered bits in unit time

Goodput ≡ No. of app^{n} layer bits (payload) delivered in unit time (bits/s).

Inter - Packet time



$$Tput = \frac{3L}{T}$$

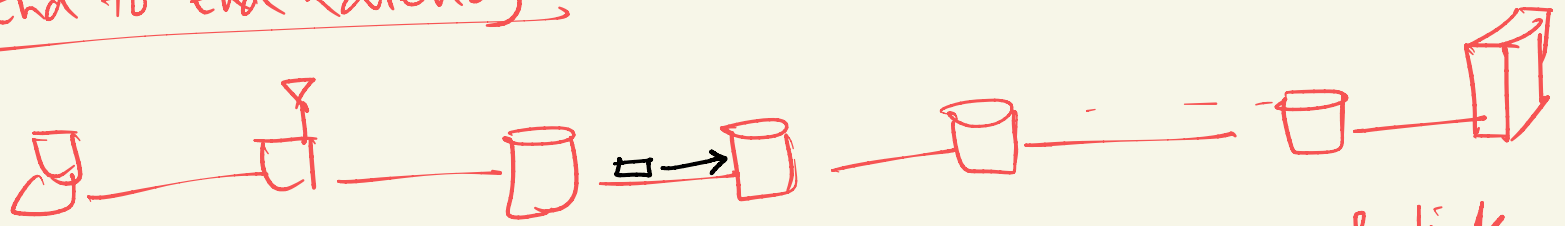
$$Gput = \frac{3L \times \frac{1}{2}}{T}$$

ISP Romit ≡ Avg IPT $= \frac{T}{3}$ ✗

ISP Yuyang ≡ Avg. Tput

3 pkts / T time.

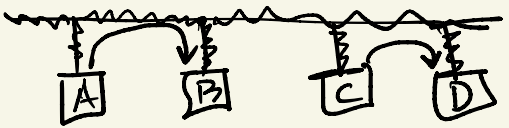
End to End Latency

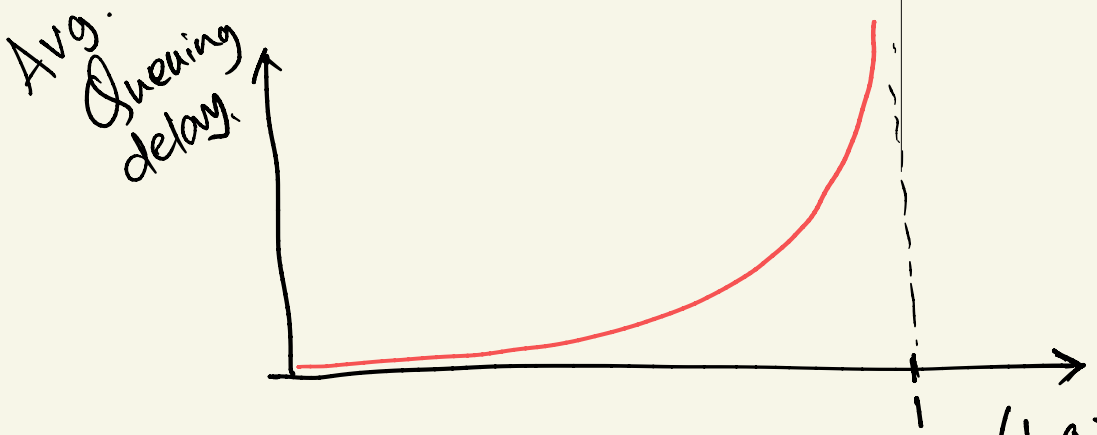


$$\gamma = \sum_{i=1}^{\alpha} l_i \qquad l_i = \text{latency on each link}$$

Total e2e latency

l_i = Proc Delay + Queuing Delay + Transmit time + Propagation Delay





L = bits of each packet

a = arrival rate (packets/s)

R = Service rate (bits/s)

$\text{avg}\left(\frac{La}{R}\right)$

Traffic Intensity.