Packet transmission delay = time needed to transmit L-bit packet into link = $\frac{L\,(Bits)}{R\,(Bits/sec)}$

*Breaks into smaller chunks, known as **packets**, of length **L** bits*

Four sources of packet delay

$d(nodal) = d(proc) + d(queue) + d(transe) + d(prop)$

d(proc); nodal processing

*chk bit error
*determine output link
*typically < msec

d(queue); queueing delay

* time waiting at output link for transmission

d(trans); transmission delay

*L: packet length (bits)
*R: link bandwith (bps)
*d(trans) = L/R

d(prop); propagation delay

*d: length of physical link
*s: propagation speed in medium ($2*10^8$ m/sec)
*d(prop) = d/s

d(trans) and **d(prop)** are very different from each other #NOTTHESAME

Queueing delay

- R: link bandwith (bps)
- L: packet length (bits)
- a: average packet arrival rate

La/R = 0: avg kø delay is small
La/R -> 1: avg kø delay large
La/R > 1: more “work” arriving

The nodal delays accumulate and give an end-to-end delay, d(end)-(end) =
N (dproc + dtrans + dprop)