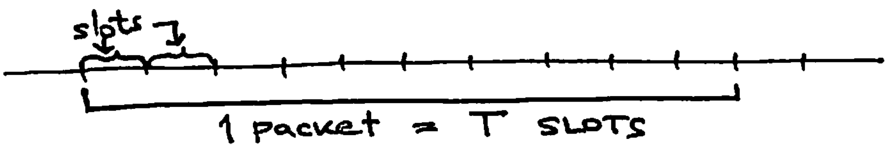
MAC PROTOCOLS: UTILIZATION, THROUGHPUT

we do analytical calculations for the setups <u>without</u> stabilization algorithms (i.e. "p=const")
with stabilization, we resort to <u>simulation</u>

"UN" SLOTTED ALOHA



$p = \mathbb{P}$ (start sending a packet now)
at a given node

$\mathbb{P}$ (a packet is being sent out at time n } with no collision)

$$= \sum_{i \in \text{backlogged nodes}} \sum_{k=0}^{T-1} \mathbb{P}(\text{packet started at node } i \text{ at time } n-k, \text{ no packets started at other nodes at times } n-k-T+1, n-k-T+2, \ldots, n-k+T-1)$$

$$\geq NTp\,(1-p)^{(2T-1)(N-1)+2T-2}$$

"=" FOR "COMPULSIVE-OBSESSIVE" NODES, WHICH KEEP STARTING NEW PACKETS EVEN WHILE TRANSMITTING OLDER ONES

MAXIMIZATION w.r.t. "p":

$$\log(\ldots) = \text{const} + \log(p) + [(2T-1)N-1]\log(1-p)$$

DERIVATIVE:

$$\frac{1}{p} - \frac{(2T-1)N-1}{1-p} \qquad \left(=0 \text{ AT } p = \frac{1}{(2T-1)N}\right)$$

"UN"SLOTTED ALOHA (continued)

MAXIMAL $\mathbb{P}$ (doing something useful at a given slot)

$$= NT \frac{1}{(2T-1)N} \left(1 - \frac{1}{(2T-1)N}\right)^{(2T-1)N-1} \to \frac{1}{2e} \text{ AS } T \to \infty$$

(REASONABLE: TWICE THE NUMBER OF COLLISION IF COMPARED TO SLOTTED ALOHA)

Ex. 1 (#5 in lecture 10/11 notes)

CALCULATING THROUGHPUT WHEN 2-WAY COLLISIONS ARE OK (BUT $\geq$3-WAY GETS EVERYTHING LOST)

- N BACKLOGGED NODES
- $\mathbb{P}(\text{SEND}) = p$

$\mathbb{P}$ (getting exactly 1 packet in a given slot)

$$= \cancel{N} \cdot p(1-p)^{N-1}$$

$\mathbb{P}$ (get exactly 1 pckt in some slot)

$$= Np(1-p)^{N-1}$$

$\mathbb{P}$ (get exactly 2 packets from two given slots)

$$= p^2(1-p)^{N-2}$$

$\mathbb{P}$ (get exactly 2 packets from some slots)

$$= \binom{N}{2} p^2 (1-p)^{N-2} = \frac{N(N-1)}{2} p^2 (1-p)^{N-2}$$

AVERAGE THROUGHPUT

$$= 1 \cdot Np(1-p)^{N-1} + 2 \cdot \frac{N(N-1)}{2} p^2$$

MAX. THROUGHPUT = ? (EITHER 1 OR 2)

$$\text{UTILIZATION} = \frac{\text{AVG. THROUGHPUT}}{\text{MAX. THROUGHPUT}} =$$

Ex. 2

100 NODES
20 BACKLOGGED
TOKEN-PASSING TDMA MAC PROTOCOL

$$\frac{\text{DATA PACKET TIME}}{\text{TOKEN TIME}} = 3$$

"tt" → TOKEN TIME

HOW MUCH BETTER THAN THE "TRIVIAL" TDMA?

TOKEN CASE:

$$\left.\begin{array}{ll} \text{TIME AROUND:} & 100 \cdot tt + 20 \cdot 3 \cdot tt \\ \text{PACKETS SENT:} & 20 \end{array}\right\} \underbrace{\frac{20}{160 \cdot tt}}_{\text{THROUGHPUT}}$$

"TRIVIAL":

$$\left.\begin{array}{ll} \text{TIME AROUND:} & 100 \cdot 3 \cdot tt \\ \text{PACKETS SENT:} & 20 \end{array}\right\} \underbrace{\frac{20}{300 \cdot tt}}_{\text{THROUGHPUT}}$$

$\sim \frac{300}{160}$ TIMES BETTER.