Traffic theory -

Definition of terms -

1) **Set up time** - Time required to allocate a radio channel to requesting user.

2) **Blocked Call** - A call that cannot be completed at the time of request due to congestion. (lost call)

3) **Holding time - (T)** - Average duration of a typical call.

4) **Request rate (λ)** - Average number of calls per unit time

5) **Traffic Intensity** - it's a measurement of channel time utilization. (Erlangs)

6) **Load** - Traffic intensity across entire radio system

A channel kept busy for one hour is defined as having a load of one erlang.

Grade of Service -

A measure of the congestion which is specified as probability.

1) Probability of call being blocked (Erlang B)
2) Probability of call being delayed beyond a certain amount of time (Erlang C)

Traffic theory –

Average number of MS's requesting service (requests / time), average arrival rate λ

unit → no of calls / Hr.

Average time for which MS required service average holding time = T

So, offered load $a = \lambda T$ (Erlangs)

Ex – In a cell with 100 MS, on an average 30 requests are generated during an hour (3600 sec) with average holding time $T = 360$ sec (6 min.)

arrival rate $\lambda = \frac{30}{3600}$ req / sec

$a = \lambda T$

offered load $a = \frac{30}{3600} \times 360$

$$\boxed{a = 3 \text{ Erlangs}}$$

Assuming poisson's distribution of service request the probability $P(n,t)$ for n calls to arrive in an interval of length t is given by

$$P(n,t) = \frac{(\lambda t)^n}{n!} e^{-\lambda t} \quad \left(\frac{m^n e^{-m}}{n!} \right)$$

Assuming μ to be service rate probability of each call to terminate during interval t is given by μt

Prob. of given call requesting services for time t or less is given by $\boxed{S(t) = 1 - e^{-\mu t}}$

Probability of an arriving call being blocked is given by Erlang B formula.

Erlang B –

$$B(s, a) = \frac{a^s}{s!} \times \frac{1}{\sum_{K=0}^{s} \frac{a^K}{K!}}$$

where s is number of channels in group and a is offered load.

Probability of an arriving call being delayed is given by Erlang C formula.

$$C(s, A) = \frac{a^s}{a^s + s!\left(1 - \frac{a}{s}\right)\sum_{K=0}^{s-1} \frac{a^K}{K!}}$$

Efficiency of system

$$= \frac{\text{Traffic non blocked}}{\text{Capacity}}$$

$$= \frac{\text{Erlangs} \times \text{portions of non re-routed traffic}}{\text{No. of trunks (channels)}}$$

Ex-1- Consider a very small cell

$S = 2$ channels, 100 mobile stations generating on an average 30 requests / Hour average holding time $T = 360$ seconds (6min)

Offered load $a = \lambda \times T$

$$= \frac{30}{3600} \times 360 = 3 \text{ Erlangs}$$

$$B(S, A) = \frac{a^S}{S!} \times \frac{1}{\sum_{K=0}^{S} \frac{a^K}{K!}} \qquad S = 2$$

$$= \frac{(3)^2}{2!} \times \frac{1}{\frac{a^0}{0!} + \frac{a^1}{1!} + \frac{a^2}{2!}}$$

$$= \frac{9}{2} \times \frac{1}{1 + 3 + \frac{(3)^2}{2!}}$$

$$= 4.5 \times \frac{1}{4 + 4.5} = \frac{4.5}{8.5}$$

$$\simeq 0.53.$$

total number of rerouted calls $= 30 \times 0.53$

$= 16$

$$\text{Efficiency} = \frac{3 \times (1 - 0.53)}{2}$$

$$= 0.7 \times 100 = 70\%$$

Ex-2

Consider a larger system with 100 cells
Each cell has $S = 20$ channels

$$\lambda = 2 \text{ calls/Hr}$$
$$T = 3 \text{ min}$$

How many number of users can be supported if the allowed prob. of blocking is 2%.

→

From Erlang B chart
total carried traffic = 13 erlangs

Traffic intensity per user = λT

$$= 2 \times \frac{3}{60} = 0.1 \text{ Erlangs}$$

total number of users that can be supported per cell = $\dfrac{\text{total carried traffic}}{\text{traffic intensity per user}}$

$$= \frac{13}{0.1} = 130 \text{ users/cell}$$

Total number of users that can be supported
$$= 130 \times 100 = 13,000 \text{ users.}$$

Competitor -
100 cells, $S = 20$ channel, $\lambda = 2$ call/Hr
How many users can be supported if the allowed prob. of blocking is 0.2%.
from Erlang B chart, total carried traffic = 10 Erlangs
so, traffic intensity per user = 0.1 Erlangs
number of users = $\frac{10}{0.1} = 100$
by system number of users = $100 \times 100 = 10,000$

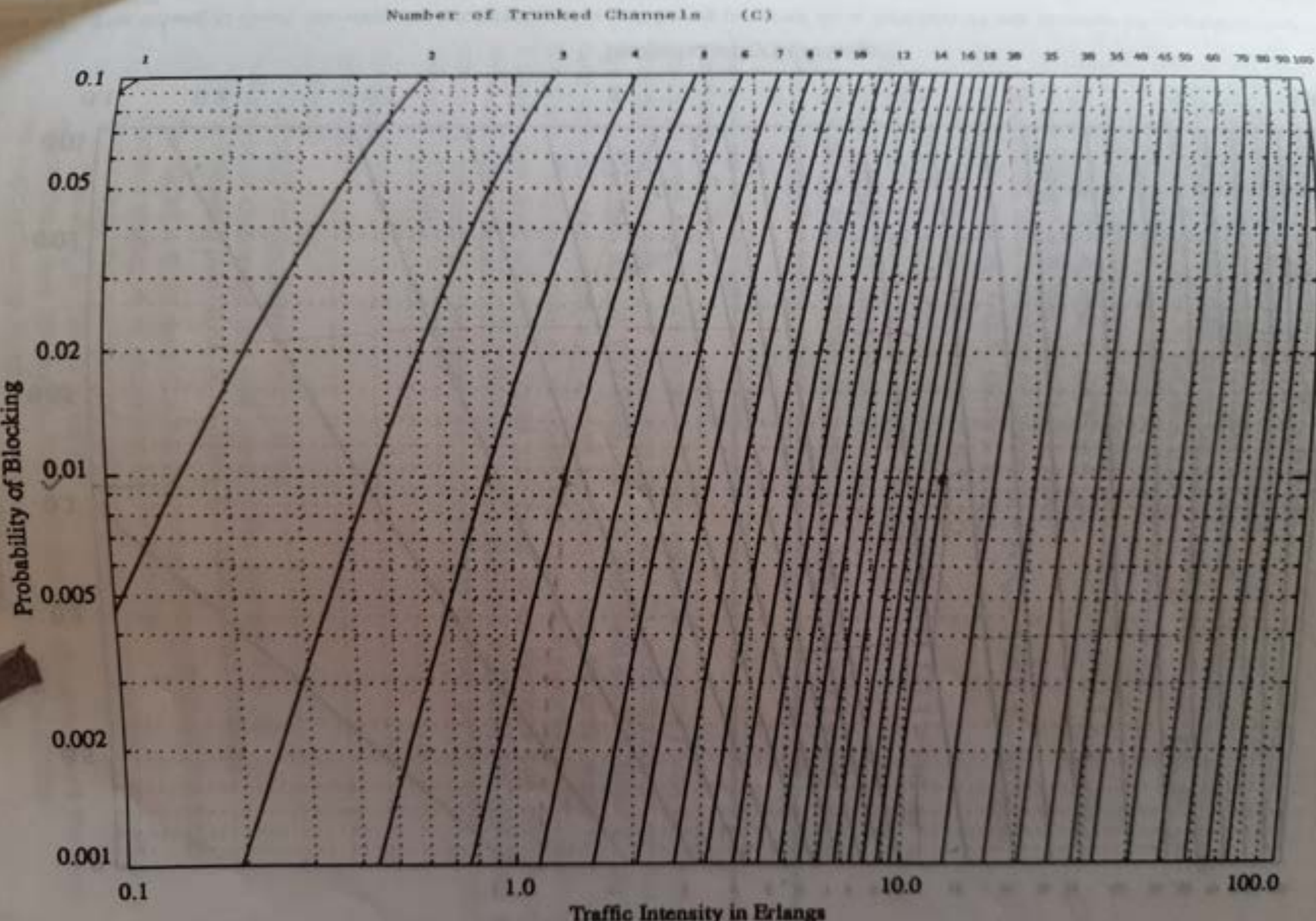

Figure 3.6 The Erlang B chart showing the probability of blocking as functions of the number of channels and traffic intensity in Erlangs.

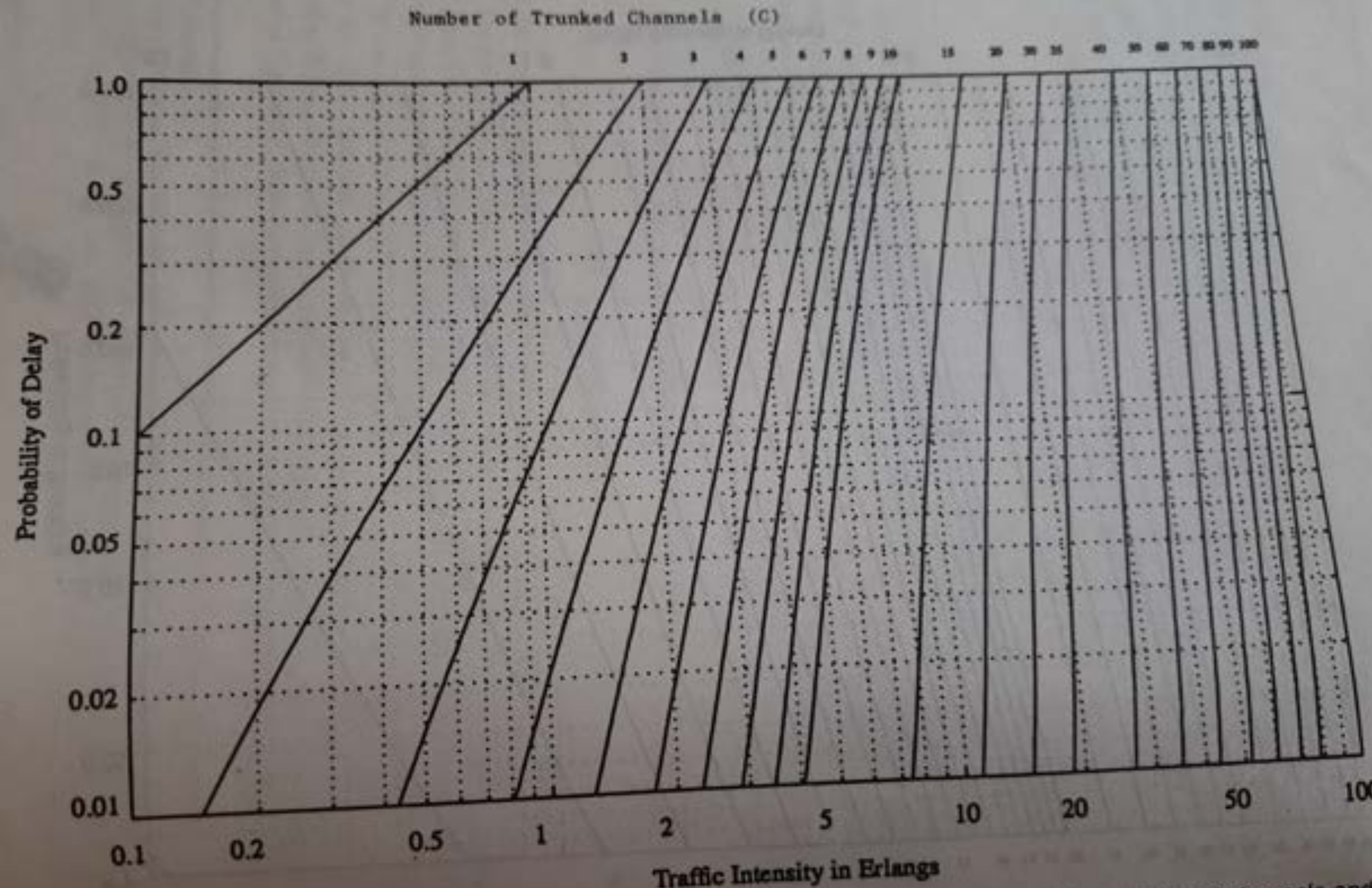

Figure 3.7 The Erlang C chart showing the probability of a call being delayed as a function of the number of channels and traffic intensity in Erlangs.