3.17 A cellular system using a cluster size of seven is described in Problem 3.16. It is operated with 660 channels. 30 of which are designated as a setup (control) channels so that there are about 90 voice channels available per cell. If there is a potential user density of 9000 users/km^2 in the system, and each user makes an average of one call per hour and each call lasts 1 minute during peak hours.
→ determine the probability that a user will experiance a delay greater than 20 sec if all calls are queued.

End Problem. 3.17

Given

cluster size = N = 7

channels = C = 660

Voice channels/cell = 90

Control channel = 30

potienal user density = 9000 users/km^2

Call last (holding time) = H = 1 mint

delay = greater than 20 sec

Probability of delay

Solution:-

Probability of delay can be found by Erlang C chart. If we know the No of channels and traffic intensity. Since number of channels are given but we have to calculate the value of traffic intensity.

$$A = U A_u$$

and

$$A_u = \lambda H$$

where A_u = user traffic intensity

λ = average No of calls requests/unit → 1 call per hr, 1/60

H = average duration of call.

$A_u = \lambda H$

$A_u = \left(\frac{1}{60}\right)(1) = 0.016$

and $A = U A_u$ ——— (i)

For finding the number of users

U = No of users in a cell = Area of cell × user density —(ii)

Since we know user density (9000) but area of cell have to calculate by

$\text{Area} \rightarrow A = \frac{3\sqrt{3}}{2} r^2$

if $r = 470.1m$

$A = \frac{3\sqrt{3}}{2}(0.4701)^2$

$A = 0.574 km$

Putting values in equation (ii), we get.

No of users $= 0.574 \times 9000$

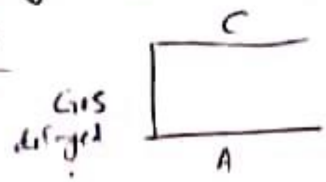
$\boxed{U = 5167 \text{ users}}$

Now for finding total traffic intensity, putting values in eq (i)

traffic intensity $A = 5167 \times 0.016$

$\boxed{A = 86.1 \text{ Erlang}}$

For finding the probability of Delay. We use Erlang C chart for $C = 90$ & $A = 86.1\,E$



$$\boxed{P_r\left[\text{delay} > 0\right] = 0.5}$$

For determine the probability that a user will experience a delay greater than 20 seconds if all calls are queued.

$$P_r\left[\text{delay} > 20\text{sec}\right] = \underline{P_r\left[\text{delay} > 0\right]} \times \underline{P_r\left[\text{delay} > \frac{20}{\text{delay}}\right]}$$

$$= P_r\left[\text{delay} > 0\right] \exp\left[-(C-A)t/H\right]$$

$$= 0.5 \times \exp\left[-(90-86.1) \times 20 \times \frac{1}{60}\right]$$

Putting values

$$= 0.5 \times \exp\left(-(90-86.1) \times \frac{20}{60}\right)$$

$$\boxed{= 0.136}$$

cal $\boxed{4.4}$ – End Problem 34

, space propagation: Assume the transmitter ower is 1W at 60 GHz fed into the transmitter antenna. Using the horn antenna gain 29 dB at both the transmitter and receiver:

Given:

$P_T = 1W$

$f = 60GHz$

$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{60GHz} = 0.005m$

(a) Calculate the free space path loss at 1m, 100m, 1000m.

$d_0 = 1m$

$d_1 = 100m$

$d_2 = 1000m$

$G_t = G_r = 29dB$

Using formula

$$PL(d_0) = 20\log \frac{4\pi d_0}{\lambda}$$

$$= 20\log \frac{4\pi \times 1m}{0.005}$$

$$\boxed{PL(d_0) = 68dB}$$

Using log distance path loss formula

$$\boxed{PL(dB) = PL(d_0) + 10n\log\left(\frac{d}{d_0}\right)}$$

where n is path loss exponent

$\rightarrow n = 2$ (for free space)

$$L(d_1) = 20\log \frac{4\pi d_0}{\lambda} + 20\log \frac{d_1}{d_0}$$

$$= 68dB + 20\log \frac{100m}{1m}$$

$$= 68dB + 40dB$$

$$\boxed{PL(d_1) = 108dB}$$

$$PL(d_2) = PL(d_0) + 20\log\left(\frac{d_2}{d_0}\right)$$

$$= 68dB + 20\log\left(\frac{1000m}{1m}\right)$$

$$= 68dB + 60dB$$

$$\boxed{PL(d_2) = 128dB}$$

(b) Calculate the received signal power at these distance

$$\boxed{P_r(d)(dBm) = P_t(dBm) - PL(d)(dB)}$$

$$P_r = P_t + G_t + G_r - PL \quad \text{--- (1)}$$

$$P_t = 1W = 10\log(1000\times P) = 30dBm$$

Putting values in (1)

$$P_r = 30dBm + 29 + 29 - PL$$

$$P_r = 88 - PL$$

$$\boxed{P_r(d_0) = 88 - 68 = 20dBm}$$

$$\boxed{P_r(d_1) = 88 - 108 = -20dBm}$$

$$\boxed{P_r(d_2) = 88 - 128 = -40dBm}$$

P-30(2)

what is rms voltage received at the antenna if the Rx antenna has purely real impedance of 50Ω is matched to the receiver?

Using formula

$$P_r(d) = \frac{V^2}{4R_{ant}}$$

$$\boxed{V = \sqrt{4P_r R_{ant}}}$$

$$V = \sqrt{4P_r \times 50}$$

$$\rightarrow P_r(d_1) = -20\,dBm = 10^{-20 \div 10} = \frac{0.01}{1000} = 1 \times 10^{-5}$$

$$V(d_1) = \sqrt{4 \times 10^{-5} \times 50}$$

$$\boxed{V(d_1) = 0.0447V}$$

$$\rightarrow P_r(d_2) = -40\,dBm = 10^{-40 \div 10} = 10^{-4} \times 10^{-3} = 10^{-7}$$

$$V(d_2) = \sqrt{4 \times 10^{-7} \times 50}$$

$$\boxed{V(d_2) = 0.0045V}$$