Link Budget Analysis :-

In wireless commⁿ, link budget analysis is the systematic listing of power losses and gains of different componenet in the channel.

- The link budget Analysis takes into consideration various parameters such as transmitted power, antenna gains, various losses, etc.

- Different components in Link Budget Analysis

~~Additive~~ loss/ gain	Component	Symbol
+	Transmitted power	P_t
+	Tra. Antenna gain	G_t
+	~~To~~ Receive Anten. gain	G_r
~~+~~ −	margin	
−	Path Loss	L_{PO}
−	cabbling losses	L_c
−	~~Rece~~ Noise + Interference	$(N+I)$

The power received can be given as:

$$P_{r(dBW)} = P_{t(dBW)} + \Sigma dB\ Gains - \Sigma dB\ losses.$$

- In SNR,
  - $SNR_{req(dB)} = P_{t(dB)} + G_{t(dB)} - L_{PO(dB)} + G_{r(dB)} - L_{c(dB)} - (N+I)_{dB}.$

~~$P_{t(dB)}$~~ =

Traffic:-

- Traffic is average no. of calls in progress ~~at~~ ~~time~~.
- Unit is Erlangs.

  1 E = 36 CCS = 3600 CS = 60 CM.

- The carried traffic is volume of traffic actually carried by switch.
- The offered traffic is volume of traffic offered to a switch.
- Offered load is sum of carried load and overflow.

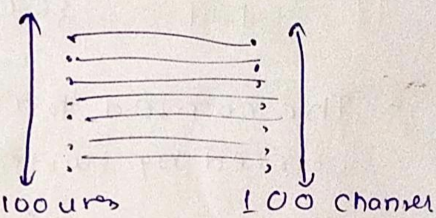
  offered load = carried load + overflow.

- Traffic Intensity:- Avg. no. of calls simultaneously in progress during particular period of time.
- Traffic per user (A_u) = user call rate × Avg. call duration.
- Total traffic (A) = No. of users (N) × Traffic per user (A_u)

Trunking :-

- Cellular system employs principle of 'Trunking' to increase the system capacity and meet the demands of users, with limited number of channels.

- Consider 100 users in system, It has 100 channels allocated for 100 users.



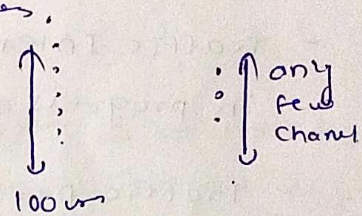
- Such one-to-one channel allocation is wastage of resource, as probability of users active at given time instant is low.

- Only small number of users are likely to be active at given time.

- Hence, ~~probability~~ practically only few channels are necessary to meet the demands of users.

- So, only few channels are allocated to users.

- This technique is called as trunking where large no. of. users share very few channels.



Blocking Probability :-

- In trunking, large no. of. users share very few channels. However, since no. of. users is much greater than no. of. channels, there is always a finite probability that all lines are occupied.

- Hence, when a new call request then it is blocked as there are no channels available for communication.

- The probability with which calls are blocked is termed as blocking probability.

$$\boxed{B.P. = \frac{\text{No. of. calls lost}}{\text{No. of. calls offered}}}$$

Q.1. $T = 293k$, $B = 30$ KHz, noise figure $F = 5$ dB,

median Path loss is -150 dB, margin = 20 dB.,

$G_r = 5$ dB, $L_c = 3$ dB, $G_t = 12$ dB., $P_t = ?$, SNR = 40 dB

$\Rightarrow P_t = SNR_{(dB)} - G_{t(dB)} - G_{r(dB)} + L_{50(dB)} + L_{c(dB)} + (N+I)_{dB}$

$\Rightarrow$ Noise power $= n_o B$ $\quad F = 5$ dB

$= KTFB \quad 10^{0.5}$

$= 1.38 \times 10^{-23} \times 293 \times 10^{0.5} \times 30 \times 10^3$

$= 3.84 \times 10^{-16}$

For dB $= 10 \log_{10}(3.84 \times 10^{-16})$

For dB $= -154$ dB

$I = -154$ dB

$P_t = 40 - 12 - 5 - 150 + 3 - 2 \times 154$

$\boxed{P_t = -432 \text{ dB}}$

$\boxed{P_t = -452 \text{ dB}}$

probability
∴ The system is in state k ,

$$P_k = P_k(1 - \lambda \Delta t - k\mu \Delta t) + P_{k-1}\lambda(\Delta t) + P_{k+1}(k+1)(\mu \Delta t).$$

$$(\lambda \Delta t + k\mu \Delta t) = P_{k-1}\lambda \Delta t + P_{k+1}(k+1)\mu(\Delta t)$$

$$(\lambda + k\mu) = P_{k-1}\lambda + P_{k+1}\mu(k+1).$$ — steady state probability eqn.

∴ steady state prob of state S_k is,

$$P_k = \frac{1}{k!}\left(\frac{\lambda}{\mu}\right)^k P_0$$

Here,
$$P_0 = \frac{1}{\sum_{k=1}^{N} \frac{1}{k!}\left(\frac{\lambda}{\mu}\right)^k}$$

For state N,

$$P_N = \frac{1}{N!}\left(\frac{\lambda}{\mu}\right)^N P_0$$

$$P_N = \frac{\frac{1}{N!}\left(\frac{\lambda}{\mu}\right)^N}{\sum_{k=1}^{N} \frac{1}{k!}\left(\frac{\lambda}{\mu}\right)^k}$$

λ = call arrival rate, μ = call departure rate.
$\mu = \left(\frac{1}{T}\right)$.

Total traffic $= \lambda \times \frac{1}{\mu}$

$$A = \frac{\lambda}{\mu}$$

$$\therefore \boxed{P_N = \frac{\frac{1}{N!}A^N}{\sum_{k=0}^{N} \frac{A^k}{k!}}}$$ → Blocking probability.

Teletraffic System Modelling :-

- Consider a cell having N channels available and support maximum of N users ~~can be supported~~.

- The states of wireless system is no. of. channels occupied. at given point of time. system can be in states $s_0, s_1, \ldots s_n$

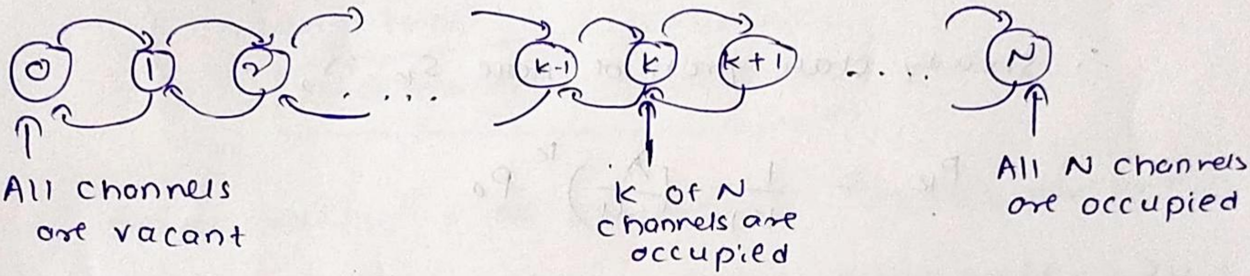


Fig. state - space Diagram.

- Let P_K denotes the probability that system is in state k. and P_N denotes probability that system is is state N. which is Blocking Probability.
- At P_N state, any new call will be blocked.
- The system is in state S_k at time $t + \Delta t$ if one of following occurs :-

1. System is in state $k-1$ at time t and one call arrives in Δt. Prob $= (P_{k-1} \lambda \Delta t)$

2. System is in state $k+1$ at time t and one call departs in Δt. Prob $= P_{k+1} (k+1)(\mu \Delta t)$

3. System is in state k, neither call arrives nor departs
   prob $= P_K - P_K \lambda \Delta t - P_{k+1} (k+1)(\mu \Delta t)$.

b] cell radius $= 1250$ m $= 1.25$ km.

one cell area $= \frac{3\sqrt{3}}{2} \times R^2 = \frac{3\sqrt{3}}{2} \times (1.25)^2 = 4.06\,km^2$

No. of. cells $= \frac{\text{city area}}{\text{one cell area}} = \frac{552}{4.06} \simeq \underline{\underline{136}}$

No. of. users $=$ No. of. cells $\times$ No. of. users per cell

$= 136 \times 715$

No. of. users $= 97,240$

c] cell radius $= 1750$ m $= 1.75$ km.

Area of one cell $= \frac{3\sqrt{3}}{2} \times (1.75)^2 = 7.96 \simeq 8$ km^2

No. of. cells $= \frac{\text{city area}}{\text{one cell area}} = \frac{552}{8} = \underline{\underline{69}}$

No. of. users $= 69 \times 715 = \underline{49335}$

.1. A cellular system with 42 channels per cell and blocking probability of 3%. assuming traffic per user 0.048E. what is no of users that can be supported in city of 552 km^2 area if cell radius are changed as a] 750m, b] 1250 m c) 1750 m

⇒ No. of channels = 42 , P_B = 3%.

By Erlang table,

$\boxed{\text{Total traffic} = 34.73 \text{ E}}$

Total traffic = No. of users × Traffic per user

Traffic per user = 0.048 E, and Total traffic = 34.3.

∴ No. of. users = $\frac{\text{Total traffic}}{\text{traffic per user}}$

= $\frac{34.3}{0.048}$

No. of. users. ≃ 715

Now
a] cell radius = 750 m = 0.75 km

∴ cell area = $\frac{3\sqrt{3}}{2} \times R^2 = \frac{3\sqrt{3}}{2} \times (0.75)^2$ = 1.46 km^2

Now, No. of cells = $\frac{\text{city area}}{\text{one cell area}} = \frac{552}{1.46}$ = 378 cells

No. of. users = No. of. cells × user per cell
= 378 × 715 = 270270