ASSIGNMENT-2

Q.1) If 0dBm is equal to 1mW (10^{-3} W) over a 50 Ω load; express 10W in units of dBm.

Solution:-

10W = 10,000 mW

$$P_{dBm} = 10 \log_{10} \left(\frac{P_{mW}}{1\,mW} \right)$$

$$= 10 \log_{10} (10,000)$$

$$= 40\ dBm$$

Q.2) A total of 24MHz of bandwidth is allocated to a particular FDD cellular telephone system that uses two 30kHz simplex channels to provide full duplex voice & control channels. Assume each cell phone user generates 0.1 Erlangs of traffic. Assume Erlang B is used.

a) Find the number of channels in each cell for a four-cell reuse system.

Solution:

Total bandwidth = 24MHz = 24,000kHz

Simplex channel = 30kHz (duplex) so — two Simplex

User = 0.1

Reuse factor N = 4

Total duplex channels:

$$\text{channels}_{\text{total}} = \frac{24,000 \text{ kHz}}{60 \text{ kHz}} = 400$$

channels per cell (with N=4)

$$\text{channels per cell} = \frac{400}{4} = 100$$

b) If each cell is to offer capacity that is 90% of perfect scheduling, find the maximum number of users that can be supported per cell when omnidirectional antennas are used at each base station.

Solution:

90% of perfect scheduling = 0.9 x no. of channel

Carried erlangs target per cell = 0.9 x 100 = 90 Erlangs

Users supported per cell: $\frac{\text{Carried Erlangs}}{\text{Erlangs/user}}$

$$= \frac{90}{0.1}$$

$$= 900$$

Erlang → Unit of load of traffic

Traffic Intensity (Erlangs) = Avg call arival rate / Avg call / No. of channels

e) If each cell covers five square kilometers, then how many subscribers could be supported in an urban market that is 50km x 50km for the case of omnidirectional base station antennas?

Soln:

Market area : 50km x 50km = 2500 km²

Area per cell : 5 km²

No. of cell in market :

$$\text{Cell} = \frac{2500}{5} = 500$$

We have,

Users supported cell = 900 Erlang (From que B)

Now,

Total subscriber supported in market = 900 x 500

= 450000 subscr

f) If each cell covers five square km, then how many subscribers could be supported in an urban market that is 50km x 50km for the case of 120° sectored antennas?

Soln:

users supported cell ≈ 765.10 (from que d)

Total subscriber = 765.10 x 500 ≈ 382551.42 subscr

(Q.n. 3) If 20MHz of total spectrum is allocated for a duplex wireless cellular system & each simplex channel has 25 KHz RF bandwidth, find
(a) the number of duplex channels.
(b) The total no. of channels per site, if N = 4 cell reuse is used.

Solution:

Total spectrum = 20MHz = 20×10^6 Hz

Simplex channel bandwidth = 25 KHz = $25 \text{ KH} \times 10^3$ Hz

N = 4

a) No. of Simplex channel possible: $\frac{20 \times 10^6}{25 \times 10^3}$

$= 800$

b) Since 1 duplex = 2 Simplex = $\frac{800}{2} = 400$

b) Channels per Cell Site N = 4

In reuse, sys. channels are divided equall in N cells in a cluster. So

$\frac{400}{N} = \frac{400}{4} = 100$

(Q.n. 4) A certain area is covered by a cellular radio system with 84 cells & a cluster size. N. 300 voice channels are available for the system. Users are uniformly distributed over the area

covered by the cellular system, & the offered traffic per user is 0.04 Erlang. Assume that blocked calls are cleared & the designated blocking Probability is $P_b = 1\%$.

a) Determine the maximum carried traffic per cell if cluster size $N = 4$ is used. Repeat for cluster sizes $N = 7$ & 12.

Solution:

Given:

Total voice channel = 300

& N = 4, 7, 12

offered traffic /user = 0.04

Blocking model $P_b = 1\%$.

No. of calls = 84

Now,

At each cell = 300/N = Total voice channe / N

For N = 4

C = 300/4 = 75 channels /cell

For N = 7

C = 300/7 = 42 chanels /cell

For N = 12

C = 300/12 = 25 ch— /cell

$P_b = 1\% = 0.01$

$B(C, A) = 0.01$ (Erlang B) for A & compute carried traffic $A_{carried} = A(1 - P_b) = A(1 - 0.01) = 0.99$

$B(C, A) = \frac{\frac{A^C}{C!}}{\sum_{k=0}^{C} \frac{A^k}{k!}}$

N = 4, C = 75:
$A_{off} \approx 60.728$, $A_{carried} = 60.728 \times 0.99 \approx 60.120$ Erlang/cell

N = 7, C = 42:
$A_{off} \approx 30.771$, $A_{carried} \approx 30.463$ Erlangs/cell

N = 12, C = 25:
$A_{off} \approx 16.125$, $A_{carried} \approx 15.963$ Erlangs/cell

b) Determine the maximum number of users that can be served by the system for a blocking probability of 1% & cluster size N = 4. Repeat for cluster sizes N = 7 & 12.

Soln:

*Converting Erlang to users: (0.04 Erlang/user)

User per cell = $A_{carried}/0.04$ System users = User/cell × 84.

N = 4

Users/cell $\approx 60.120/0.04 = 1503 \rightarrow$ system $\approx 1503 \times 84$
$= 126,253$

For N = 7:

User/cell $\approx 30.463/0.04 = 761.586 \rightarrow$ Sys $\approx 761.586 \times 84$
$= 63,973$

For N = 12

User/cell $\approx 95.963/0.04 = 399.083 \rightarrow$ Sys $\approx 399.083 \times 84$
$= 33,523$

Qn.5) The GSM TDMA system uses a 270.833 kbps data rate to support eight users per frame.
a) What is the raw data rate provided for each user
b) If guard time, ramp-up time, & synchronization bits occupy 10.1 kbps, determine the traffic efficiency for each user.

Solutions:
GSM TDMA total data rate = 270.833
& user per frame
overhead = 10.1 kbps

a) Raw data rate per user = $\frac{\text{Total data rate}}{\text{no. of users}}$

$= \frac{270.833 \text{ kbps}}{8}$

≈ 33.854 kbps/user

b) Traffic efficiency

$\eta = \frac{\text{Raw data rate} - \text{overhead}}{\text{Raw data rate}} \times 100$

$= \frac{33.8541 - 10.1}{33.854} \times 100\ \%$

$= 70.21\ \%$

Q.6) Consider a cellular network with 12 cells arranged in a hexagonal pattern. Each cell needs to be assigned a frequency channel to support communicatio for mobile device. The available frequency channels are numbered from 1 to 20.

a) Determine the total number of channels available.

b) Assign the channel using channel assignment strategies.

Solution:-

a) Given:

channels numbered from 1 to 20.

∴ Total channels = 20

b) Solution:

Q.n.7) Features collectively make DECT a reliable & versatile Wireless communication solution, well-suited for both residential & business environments. Emphasize on features, frequency of DECT.
Solution:

Ans Digital Enhanced cordless Telecommunication (DECT) a widely adopted wireless communication standard that provides reliable & flexible voice & data transmission. Its advanced design & capabilities mak it suitable for both residential use, such as cordless home phones, & business environments, su as office communication system & PBX integrati Digital Enhanced cordless Telecommunication ensur consistent call quality, secure connection & seamless mobility which collectively make it a dependable & versatile solution for different communication needs.

While below here are the features of Digital enhanced cordless Telecommunication.

i) High-quality digital voice transmission with low interference.
ii) Strong security through encryption & authentication.
iii) Supports multiple users & handsets per base station
iv) Low power consumption, increasing battery life of handsets.
v) Flexibility to support both voice & limited data services.

Frequency of Digital enhanced Cordless Telecommunications

Europe/Asia : 1.88 - 1.90 GHz band
USA : 1.92 - 1.93 GHz band

Qn. 8) Assume a system of 32 cells with a cell radius of 1.6 km, a total of 32 cells, a total freqency bandwidth that supports 336 traffic channels & a reuse factor of N = 7. If there are 32 total cells, what geographic area is covered, how many channels are there per cell, & what is the total number of concurrent calls that can be handled?

Given:
32 Hexagonal cell
R = 1.6 km
N = Reuse factor = 7
Total traffic channel = 336

Area of one hexagonal cell : $Area_{hex} = \frac{3\sqrt{3}}{2} \cdot R^2$

$= \frac{3\sqrt{3}}{2} \times (1.6)^2$

$= 6.651 \text{ km}^2$

Total geographic area for 32 cells.

$32 \times 6.651 \approx 212.834 \text{ km}^2$.

channels per cell : $\frac{336}{7}$ = 48 channels per cell.

Total concurrent calls system-wide = 48 calls/cell x 32
= 1536 concurrent calls.

Q.9) ISDN has been more widely accepted as a network solution, there are various types of ISDN; clarify it, include speed, uses.

Ans Integrated Services Digital Network (ISDN) is a circuit-switched telephone network system that transmits voice, video & data over traditional telephone lines in a digital form, providing better quality & higher speeds compared to analog systems.

Types of Integrated Services Digital Network

a) Basic Rate Interface (BRI)
- Structure: Two 64kbps B-channels + One 16 kbps D-Channel (2B+D)
- Speed: 2 x 64 + 16 = 144 kbps total
- Use:
Suitable for home users & small business.
Used for internet access, video conferencing & voice calls.

b) Primary Rate Interface (PRI):
Structure: In Europe (E1): 30 B-channels + 1 D-ch
= 2.048 Mbps.

In North America / Japan (T1) : 23 B-channels + 1 D- channel
= 1.544 mbps.

Uses :
Suitable for large organizations.
Used for corporate telephone systems (PBX), data transfer, & video conferencing.

c) Broadband ISDN (B-ISDN)
Speed : supports greater than 2mbps
Use :
For high-speed multimedia, video on demand, & broadband internet services.
less common, since modern broadband replaced it.

n.10) Consider GSM which is a TDMA/FDD system that uses 20MHz for the forward link, which is broken into radio channels of 20kHz. If 6 speech channels are supported on a single radio channel, & if no guard band is assumed. Find the number of simultaneous users that can accomodate in GSM.

Given :
Forward-link Bandwidth = 20MHz = 20,000 KHz
Radio channel spacing = 20kHz
Each radio channel supports 6 speech channels.
Assume no guard band.
Number of radio channels: $\frac{20,000}{20kHz}$ = 1000 radio channels.

Speech channels (simultaneous users)
= 1000 radio channels x 6 $\frac{\text{Speech}}{\text{radio channel}}$

= 6000

Thus, the system can accomodate 6,000 simultaneous users on the forward link.

Qn. ii) Describe the key features & functions of signalling system no. 7 (SS7) in telecommunications. Explain how SS7 facilities call setup, routing & termination processes. Discuss the advantages of using SS7 in comparison to in-band signalling techniques.

Ans Key-features of signalling system no. 7 (SS7) are:

i) Out-of band signalling: uses a seperate signalling network instead of voice channel.

ii) Fast call setup & termination - Reduces the time to connect & disconnect calls.

iii) Support for multiple services - Enables caller ID, call forwarding, SMS & roaming.

iv) Reliable & robust - Error detection, correction & rerouting mechanisms.

v) Global standardization - Ensures interoparability across networks world wide.

* Functions of Signalling system No. 7 are :-

i) Call setup - Establishes a connection between calling & called parties.

ii) Call routing : Determines the optimal path & queries databases like HLR for mobile users.

iii) Call termination : Releases channels & frees network resources after a call ends.

iv) Number translation : Supports toll-free numbers, virtual numbers & mobile roaming.

v) Network management : Monitors signalling links & ensures network reliability

SS7 facilities call setup, Routing & Termination by the following steps :-

i) Call Setup :
When a user dials a number, SS7 sends signalling messages to establish a path between the calling & called parties through the PSTN or mobile network.

ii) Routing : SS7 queries database (like HLR for mobile subscribers) to find the exact location of the called party, ensuring correct routing.

iii) Call Termination : When the conversation ends, SS7 signals to release the channels & free resources for other users.

Advantages of SS7 in comparison to in-band signalling techniques are as follows :-

i) Faster call setup & termination due to out-of band signalling.
ii) Improved security signaling is on a seperate netw harder to hack.
iii) Efficient use of voice channels no need to waste channel bandwidth for signaling tones.
iv) Supports advanced services like Call forwarding, caller ID, roaming, SMS, Prepaid billing etc.

Qn.12) On average, there are 1800 new calls in an hour, & the average holding time is 3 minutes. Calculate the traffic intensity.

Ans

Solution:

No. of calls per hour = 1800 calls/hour

Average holding time H = 3min

H = 3 min = 3/60 hours = 0.05 hours.

Traffic Intensity in Erlangs:

A = No. of calls x Average holding time

= 1800 x 0.05

= 90 Erlangs.

Q.13) If a particular FDD cellular telephone system has a total bandwidth of 33MHz & if the phone system uses two 25kHz Simplex channels to provide full duplex voice & control channels. Compute the number of channels per cell if N = 4, 7, 12.

Solution :-

Total duplex channels = $\frac{\text{Total bandwidth}}{\text{Bandwidth per duplex channel}}$

$= \frac{33000}{50}$

= 600 channels

Channels per cell = $\frac{\text{Total channels}}{N}$

For N = 4 : 660/4 = 165 channels per cell
" N = 7 : 660/7 = 94.28 ≈ 94 " " "
" N = 12 : 660/12 = 55 " " "

Q.14) The US Digital cellular TDMA system uses a 48.6 kbps data rate to support three users per frame. Each user occupies two of the six time slots per frame. What is the raw data rate provided for each user?

Solution:

Given:

Total TDMA data rate = 48.6 kbps

Each frame supports 3 users

Each user occupies 2 of 6 time slots per frame.

Data rate per time slot

$$= \frac{\text{Total data rate}}{\text{No. of time slots}}$$

$$= \frac{48.6}{6}$$

$$\approx 8.1 \text{ kbps}$$

Each user occupies 2 time slots, so:

Raw data rate per user

$$= 8.1 \times 2$$

$$= 16.2 \text{ kbps}$$