Class: 4th

MOBILE COMMUNICATIONS

Lecture 6

Chapter Three

Traffic Engineering

By

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Lecture Outlines

3Traffic Engineering

3.1 Trunking

Teaching Tools:

- White Board, white board marker and eraser

Teaching Methods:

1. Method of lecture.

2. Method of discussion and dialogue.

3. Brain storming

3.1 Trunking and Grade of Service

A- Trunking

- A trunk : is a communications line or link designed to carry multiple signals simultaneously to provide network access between two points. The number of trunks connecting the MSC 1 with another MSC 2 are the number of voice pairs used in the connection.

- One of the most important steps in telecommunication engineering is to determine the number of trunks required on a route or a connection between MSCs. To dimension a route correctly, we must have some idea of its usage, that is, how many subscribers are expected to talk at one time over the route.

- The concept of trunking allows a large number of users to share the relatively small number of channels in a cell by providing access to each user, on demand, from the available channels.

- In a trunked radio system, each user is allocated a channel on a per call basis, and upon termination of the call, the previously occupied channel is immediately returned to the pool of available channels.

- The telephone company uses trunking theory to determine the number of telephone circuits that need to be allocated and this same principle is used in designing cellular radio systems.

- In a trunked mobile radio system,
  - When a particular user requests service and all of the radio channels are already in use, the user is blocked, or denied access to the system.
  - In some systems, a queue may be used to hold the requesting users until a channel becomes available.

- To design trunked radio systems that can handle a specific capacity at a specific "grade of service", it is essential to understand trunking theory and queuing theory.

- The fundamentals of trunking theory were developed by Erlang, a Danish who, in the late 19th century.

- One Erlang represents the amount of traffic intensity carried by a channel that is completely occupied (i.e. 1 call-hour per hour or 1 call-minute per minute).

- Traffic is measured in either:
  - Erlangs,
  - Percentage of occupancy,
  - Centrum (100) call seconds (CCS),

B- The grade of service (GOS):

is a measure of the ability of a user to access a trunked system during the busiest hour.

- The grade of service is a benchmark used to define the desired performance of a particular trunked system by specifying a desired probability of a user obtaining channel access given a specific number of channels available in the system.

- It is the wireless designer's job to estimate the maximum required capacity and to allocate the proper number of channels in order to meet the GOS.

- GOS is typically given as the probability that a call is blocked, or the probability of a call experiencing a delay greater than a certain queuing time.

Traffic intensity is the average number of calls simultaneously in progress during a particular period of time. It is measured either in units of *Erlangs* or *CCS*.

The traffic intensity offered by each user is equal to the call request rate multiplied by the holding time (in hours). That is, each user generates a traffic intensity of A_U Erlangs given by

$$A_U = \lambda H$$

where

       H is the average duration of a call (Holding time).

       λ is the average number of call requests per unit time.

For a system containing U users and an unspecified number of channels, the total offered traffic intensity A, is given as

$$A = UA_U$$

And

$$Overflow\ (O) = (Offered\ load) - (Carried\ load)$$

   ❖ *CCS to Erlang conversion*

An average of one call in progress during an hour represents a traffic intensity of 1 *Erlang*; thus 1 *Erlang* equals 1×3600 call seconds (36 *CCS*). The Erlang is a dimensionless number.

Example 1

If the carried load for a component is 3000 *CCS* at 5% blocking, what is the offered load?

Solution

$$Offered\ load = \frac{3000}{(1-0.05)} \approx 3158\ CCS$$

Overflow = (Offered load) – (Carried load) = 3158 – 3000 = 158 CCS

Example 2

In a wireless network each subscriber generates two calls per hour on the average and a typical call holding time is 120 seconds. What is the traffic intensity?

Solution

$$A_u = \lambda H = 2 \times \frac{120}{3600} = 0.0667\ Erlangs = 2.4\ CCS$$

Example 3

In order to determine voice traffic on a line, we collected the following data during a period of 90 minutes. Calculate the traffic intensity in *Erlangs* and *CCS*.

Traffic data used to estimate traffic intensity.

Call no.	Duration of call (s)
1	60
2	74
3	80
4	90
5	92
6	70
7	96
8	48
9	64
10	126

Solution

$$\lambda = \frac{10}{1.5} = 6.667 \, calls \, / \, hour$$

Average call holding time:

$$H = \frac{(60 + 74 + 80 + 90 + 92 + 70 + 96 + 48 + 64 + 126)}{10} = 80 \, Sec/call$$

$$A_u = \lambda H = 6.667 \times \frac{80}{3600} = 0.148 \, Erlangs = 5.33 \, CCS$$

Example 4

We record data in the Table below by observing the activity of a single customer line during an eight-hour period from 9:00 A.M. to 5:00 P.M. Find the traffic intensity during the eight-hour period, and during busy hour (BH) which occurs between 4:00 P.M. and 5:00 P.M.

Call no.	Call started	Call ended	Call duration (min.)
1	9:15	9:18	3.0
2	9:31	9:41	10.0
3	10:17	10:24	7.0
4	10:24	10:34	10.0
5	10:37	10:42	5.0
6	10:55	11:00	5.0
7	12:01	12:02	1.0
8	2:09	2:14	5.0
9	3:15	3:30	15.0
10	4:01	4:35	34.0
11	4:38	4:43	5.0

Solution

$$\lambda = \frac{11}{8} = 1.375 \, calls \, / \, hour$$

Total call minutes = 3 + 10 + 7 + 10 + 5 + 5 + 1 + 5 + 15 + 34 + 5 = 100 minutes

The average holding time in hours per call is:

$$H = \frac{100}{11} \times \frac{1}{60} = 0.1515 \, hours \, / \, call$$

The traffic intensity is

$$A = \lambda H = 1.375 \times 0.1515 = 0.208 \, Erlangs = 7.5 \, CCS$$

The busy hour (BH) is between 4:00 P.M. and 5:00 P.M. Since there are only two calls between this period, we can write:

Call arrival rate = 2 calls/hour

The average call holding time during BH:

$$H = \frac{34+5}{2} = 19.5 \, min/\, call = 0.325 \, hours/\, call$$

The traffic intensity during BH is

$$A = \lambda H = 2 \times 0.325 = 0.65 \, Erlangs = 23.4 \, CCS$$

Example 6

If the mean holding time in Example 5 is 100 seconds, find the average number of busy hour call attempts (BHCAs).

Solution

$A_u = 0.0375 \, Erlangs = 135 \, call/sec$

$$\lambda_{BH} = \frac{A_u}{100} = 1.35$$

In a C channel trunked system, if the traffic is equally distributed among the channels, then the traffic intensity per channel, A_c, is given as

$$A_C = \frac{U A_U}{C}$$

When the offered traffic exceeds the maximum capacity of the system, the carried traffic becomes limited due to the limited capacity (i.e. limited number of channels).

- The maximum possible carried traffic is the total number of channels, C, in *Erlangs*.