

**Lecture – 7 (Dt. 12<sup>th</sup> April 2020)**

**Electronic Switching ( EC- 8<sup>th</sup> Sem)**

**Traffic Engineering- Part-1**

**References :**

- 1) S. Agrawal : Lecture Notes (VSSUT)
- 2) Telecommunication Switching Systems & Networks, Thiagrajan
- 3) Telecommunication System Engineering, R.L. Freeman
- 4) Telecommunication Switching and Networks, By, P. Gnanasivam
- 5) Internet sources

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### **Module-III: TRAFFIC ENGINEERING**

Traffic pattern, Grade of Service and blocking probability, modeling of switching systems: Markov Process, Birth-Death Process.

Telephone network organization: Network management, Network services, various networking plans, types of networks, Routing plan, International numbering plan, National numbering plan, Numbering plan in India, Signaling: in channel signaling, common channel signaling.

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The telecommunication system has to service the voice traffic and data traffic. The traffic is defined as the occupancy of the server. The basic purpose of the traffic engineering is to determine the conditions under which adequate service is provided to subscribers while making economical use of the resources providing the service. The functions performed by the telecommunication network depends on the applications it handles. Some major functions are switching, routing, flow control, security, failure monitoring, traffic monitoring, accountability internetworking and network management. To perform the above functions, a telephone network is composed of variety of common equipment such as digit receivers, call processors, inter stage switching links and interoffice links etc. Thus traffic engineering provides the basis for analysis and design of telecommunication networks or model. It provides means to determine the quantum of common equipment required to provide a particular level of service for a given traffic pattern and volume. The developed model is capable to provide best accessibility and greater utilization of their lines and trunks. Also the design is to provide cost effectiveness of various sizes and configuration of networks. The traffic engineering also determines the ability of a telecom network to carry a given traffic at a particular loss probability. Traffic theory and queuing theory are used to estimate the probability of the occurrence of call blocking. Earlier traffic analysis based purely on analytical approach that involved advanced mathematical concepts and complicated operations research techniques. Present day approaches combine the advent of powerful and affordable software tools that aim to implement traffic engineering concepts and automate network engineering tasks. In the study of tele traffic engineering, to model a system and to analyse the change in traffic after designing, the static characteristics of an exchange should be studied. The incoming traffic undergoes variations in many ways. Due to peak hours, business hours, seasons, weekends, festival, location of exchange, tourism area etc., and the traffic is unpredictable and random in nature. So, the traffic pattern/characteristics of an exchange should be analysed for the system design. The grade of service and the blocking probability are also important parameters for the traffic study.

The following statistical information provides answer for the requirement of trunk circuits for a given volume of offered traffic and grade of service to interconnect the end offices. The statistical descriptions of a traffic is important for the analysis and design of any switching network.

1. **Calling rate.** This is the average number of requests for connection that are made per unit time. If the instant in time that a call request arises is a random variable, the calling rate may be stated as the probability that a call request will occur in a certain short interval of time. If 'n' is the average number of calls to and from a terminal during a period T seconds, the calling rate is defined as  $\lambda = n/T$

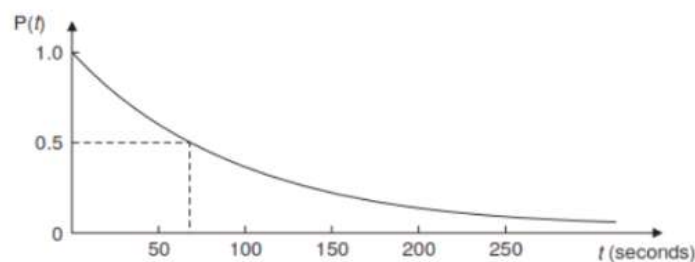
In telecommunication system, voice traffic and data traffic are the two types of traffic. The calling rate ( $\lambda$ ) is also referred as average arrival rate. The average calling rate is measured in calls per hour.

2. **Holding time.** The average holding time or service time 'h' is the average duration of occupancy of a traffic path by a call. For voice traffic, it is the average holding time per call in hours or 100 seconds and for data traffic, average transmission per message in seconds. The reciprocal of the average holding time referred to as service rate ( $\mu$ ) in calls per hour is given as  $\mu = 1/h$

Sometimes, the statistical distribution of holding time is needed. The distribution leads to a convenient analytic equation. The most commonly used distribution is the negative exponential distribution. The probability of a call lasting at least t seconds is given by

$$P(t) = \exp(-t/h)$$

For a mean holding time of  $h = 100$  seconds, the negative exponential distribution function is shown in Fig.



3. **Distribution of destinations.** Number of calls receiving at a exchange may be destined to its own exchange or remoted exchange or a foreign exchange. The destination distribution is

described as the probability of a call request being for particular destination. As the hierarchical structure of telecommunication network includes many intermediate exchanges, the knowledge of this parameter helps in determining the number of trunks needed between individual centres.

**4. User behaviour.** The statistical properties of the switching system are a function of the behaviour of users who encounter call blocking. The system behaves differently for different users. The user may abandon the request if his first attempt to make a call is failed. The user may makes repeated attempts to setup a call. Otherwise the user may wait some times to make next attempt to setup a call. These behaviour varies person to person and also depends on the situation.

**5. Average occupancy.** If the average number of calls to and from a terminal during a period T seconds is 'n' and the average holding time is 'h' seconds, the average occupancy of the terminal is given by

$$A = nh/T = \lambda h = \lambda/\mu$$

Thus, average occupancy is the ratio of average arrival rate to the average service rate. It is measured in Erlangs. Average occupancy is also referred as traffic flow or traffic intensity or carried traffic.

### **Traffic Pattern**

An understanding of the nature of telephone traffic and its distribution with respect to time (traffic load) which is normally 24 hours is essential. It helps in determining the amount of lines required to serve the subscriber needs. According to the needs of telephone subscribers, the telephone traffic varies greatly. The variations are not uniform and varies season to season, month to month, day to day and hour to hour. But the degree of hourly variations is greater than that of any other period.

Various parameters related to traffic pattern are discussed below:

**Busy hour.** Traditionally, a telecommunication facility is engineered on the intensity of traffic during the busy hour in the busy session. The busy hour vary from exchange to exchange, month to month and day to day and even season to season. The busy hour can be defined in a variety of ways. In general, the busy hour is defined as the 60 minutes interval in a day, in which the traffic is the highest. Taking into account the fluctuations in traffic, CCITT in its recommendations E.600 defined the busy hour as follows.

1. **Busy hour.** Continuous 60 minutes interval for which the traffic volume or the number of call attempts is greatest.
2. **Peak busy hour.** It is the busy hour each day varies from day to day, over a number of days.
3. **Time consistent busy hour.** The 1 hour period starting at the same time each day for which the average traffic volume or the number of call attempts is greatest over the days under consideration. In order to simplify the traffic measurement, the busy hour always commences on the hour, half hour, or quarter hour and is the busiest of such hours. The busy hour can also be expressed as a percentage (usually between 10 and 15%) of the traffic occurring in a 24 hour period.

**Call completion rate (CCR).** Based on the status of the called subscriber or the design of switching system the call attempted may be successful or not. The call completion rate is defined as the ratio of the number of successful calls to the number of call attempts. A CCR value of 0.75 is considered excellent and 0.70 is usually expected.

**Busy hour call attempts.** It is an important parameter in deciding the processing capacity of an exchange. It is defined as the number of call attempts in a busy hour.

**Busy hour calling rate.** It is a useful parameter in designing a local office to handle the peak hour traffic. It is defined as the average number of calls originated by a subscriber during the busy hour.

**Day-to-day hour traffic ratio.** It is defined as the ratio of busy hour calling rate to the average calling rate for that day. It is normally 6 or 7 for rural areas and over 20 for city exchanges.

### **Units of Telephone Traffic**

Traffic intensity is measured in two ways. They are (a) Erlangs and (b) Cent call seconds (CCS).

**Erlangs.** The international unit of traffic is the Erlangs. It is named after the Danish Mathematician, A.K. Erlang, who laid the foundation to traffic theory in the work he did for the Copenhagen telephone company starting 1908. A server is said to have 1 erlang of traffic if it is occupied for the entire period of observation. More simply, one erlang represents one circuit occupied for one hour.

The maximum capacity of a single server (or channel) is 1 erlang (server is always busy). Thus the maximum capacity in erlangs of a group of servers is merely equal to the number of servers.

For example problems on traffic engg. Please refer text books.

**Cent call seconds (CCS).** It is also referred as hundred call seconds. CCS as a measure of traffic intensity is valid only in telephone circuits. CCS represents a call time product. This is used as a measure of the amount of traffic expressed in units of 100 seconds. Sometimes call seconds (CS) and call minutes (CM) are also used as a measure of traffic intensity. The relation between erlang and CCS is given by

$$1E = 36 \text{ CCS} = 3600 \text{ CS} = 60 \text{ CM}$$

### **Grade of Service (GOS)**

For non-blocking service of an exchange, it is necessary to provide as many lines as there are subscribers. But it is not economical. So, some calls have to be rejected and retried when the lines are being used by other subscribers. The grade of service refers to the proportion of unsuccessful calls relative to the total number of calls. GOS is defined as the ratio of lost traffic to offered traffic.

$$\text{GOS} = \frac{\text{Blocked Busy Hour calls}}{\text{Offered Busy Hour calls}}$$
$$\text{GOS} = \frac{A - A_0}{A}$$

where  $A_0$  = carried traffic

$A$  = offered traffic

$A - A_0$  = lost traffic.

The smaller the value of grade of service, the better is the service. The recommended GOS is 0.002, *i.e.* 2 call per 1000 offered may lost. In a system, with equal no. of servers and subscribers, GOS is equal to zero. GOS is applied to a terminal to terminal connection. But usually a switching centre is broken into following components

- (a) an internal call (subscriber to switching office)
- (b) an outgoing call to the trunk network (switching office to trunk)
- (c) the trunk network (trunk to trunk)
- (d) a terminating call (switching office to subscriber).

The GOS calculated for each component is called component GOS. The overall GOS is in fact approximately the sum of the component grade of service.

There are two possibilities of call blocking. They are (a) Lost system and (b) Waiting system. In lost system, a suitable GOS is a percentage of calls which are lost because no equipment is available at the instant of call request. In waiting system, a GOS objective could be either the percentage of calls which are delayed or the percentage which are delayed more than a certain length of time.