Lecture – 2 (Dt. 3rd April 2020)

Electronic Switching (EC- 8th Sem)

Classification of Switching Systems

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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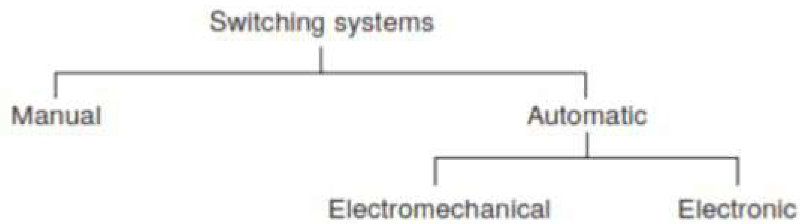
Classification of Switching System

In early days, the human exchange provided switching facilities. In manual exchanges, a human operator and the elements like switches, plugs and sacks were used to connect two subscribers. Around 1890's many electromechanical switching devices were introduced. Till 1940, different electromechanical switching system were invented, of which strowger switching system and cross bar switching system were still popular. The later invention of electronic switching system (ESS) which uses stored program control (SPC) and computer controlled switching systems are presently dominating the worldwide exchanges. Fig. shows the classification of switching system.



The electronic switching system (ESS) uses stored program control. The further classification of ESS are space division switching and time division switching. The time division switching is divided into digital and analog switching systems. The digital switching system is classified into space switch, time switch and combination switch.

Requirements of Switching System

All practical switching system should satisfy the following requirements for the economic use of the equipment of the system and to provide efficient service to the subscribers. Depends on the place (Rural or town, big town, city or big cities). The local exchange located, the service provided to the subscriber may vary. Some important requirements are discussed briefly.

High availability. The telephone system must be very reliable. System reliability can be expressed mathematically as the ratio of uptime to sum of the uptime and down time. The uptime is the total time that the system is operating satisfactorily and the down time is the total time that is not. In telephone switching networks, the availability or full accessibility is possible if all of the lines are equally accessible to all incoming calls. The full accessibility is also defined as the capacity or number of outlets of a switch to access a given route. If each incoming trunk has access to a sufficient number of trunks on each route to give the required grade of service is known as limited availability. The availability is defined as

$$A = \frac{\text{Uptime}}{\text{Uptime} + \text{down time}} \qquad A = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$$

MTBF = Mean time between failure

MTTR = Mean time to repair.

The unavailability of the system is given by

$$U = 1 - A < \frac{\text{MTTR}}{\text{MTBF} + \text{MTTR}}$$

High speed. The switching speed should be high enough to make use of the switching system efficiently. The speed of switching depends on how quickly the control signals are transmitted. For instance, the seize signal from the calling terminal must be identified quickly by the system to realise the need of path setup by the subscriber. The common control should be used effectively to identify the called terminal or the free trunks to setup a path. Thus the switching system must have the facility of quick access of the switching equipment and networks.

Low down time. The down time is the total time the switching system is not operating satisfactorily. The down time is low enough to have high availability. The unavailability of switching system may be due to failure of equipment, troubles in transmission media, and human errors in switching etc.

Good facilities. A switching system must have various facilities to serve the subscriber. For example wake up calls, address identification on phone number or phone number identification on address, recording facilities, quick service for the emergency numbers, good accessibility etc. Also it should have good servicing facilities in case of repair of equipment, skilled technicians, standby systems, etc. Good facilities is possible any switching system whether it is at rural or town or in cities, if that exchange is not overloaded.

High security. To ensure satisfied or correct operation (*i.e.* providing path and supervising the entire calls to pass necessary control signals) provision should be provided in the switching system.

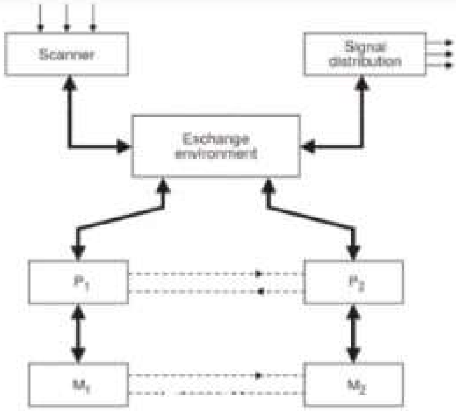


Fig. Centralized SPC.

Early electronic switching systems are centralised SPC exchanges and used a single processor to perform the exchange functions. Presently centralised exchanges uses dual processor for high reliability. All the control equipment are replaced by the processors. A dual processor architecture may be configured to operate in (*a*) standby mode (*b*) synchronous duplex mode and (*c*) Load sharing mode.

Standby mode. In this mode, any one of the processors will be active and the rest is standby. The standby processor is brought online only when the active processor fail. This mode of exchange uses a secondary storage common to both processors. The active processor copies the status of the system periodically and stores in axis secondary storage. In this mode the processors are not connected directly. In secondary storage, programs and instructions related to the control functions, routine programs and other required information are stored.

Synchronous duplex mode. In this mode, the processors $p1$ and $p2$ are connected together to exchange instructions and controls. Instead of a secondary storage common to P1 and P2, separate memory M1 and M2 are used. These processors are coupled to exchange stored data. This mode of operation also uses a comparator in between $p2$. The comparator compares the result of the processors. During normal operation, both processors receives all the information from the exchange and receives related data from their memories. Although only one processor actually controls the exchange and remaining is in synchronism with first one. If a mismatch occurs, the fault is identified by the comparator, and the faulty processor is identified by operating both individually. After the rectification of fault, the processor is brought into service.

Load sharing mode. In this mode, the comparator is removed and alternatively an exclusion device (ED) is used. The processors calls for ED to share the resources, so that both the processors do not seek the same resource at the same time. In this mode, both the processor are active simultaneously and share the resources of exchange and the load dynamically. If one processor fails, with the help of ED, the other processor takes over the entire load of the exchange. Under normal operation, each processor handles one half of the calls on a statistical basis. However the exchange operator can vary the processor

Single processor.

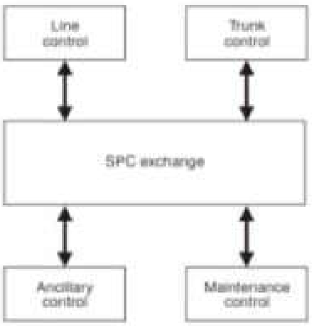
Availability where MTBF = Mean time between failures, MTTR = Mean time to repair.

Unavailability = 1 − A

$$A = \frac{MTBF}{MTBF + MTTR}$$

Duplicated common control circuits, registers, processors and standby systems are used provide high security.

There are two classes of switching system based on the division of information in space, time. They are (*i*) Space division switch (*ii*) Time division switch. The space division provides fixed path for the entire duration of a call. Simply, unlimited bandwidth, cross talk limitations are the advantages of space division switches. But these space switches are slow to operate, bulky, and involves large amount of wiring. In time division switching all inlets and outlet one connected to a common switch mechanism. The switch is connected to the required inlet and outlet for short durations. Each input is sampled to change the connecting pattern. Thus switch is fast and compact. This technique may only be used where the signal is not affected by the sampling process. Time division switches of analog signals have limited applications. Thus time division switches have more practical value only when the signal is already in digital form.



In 1965, Bell system installed the first computer controlled switching system which uses a stored program digital computer for its control functions. The SPC concepts permits the features like abbreviated dialling, call forwarding, call waiting etc. The SPC provides significant advantages to end users. The SPC enables easier number changes, automated call tracing message unit accounting (for billing) etc.

In SPC, a programme or a set of instructions are stored in its memory and executed automatically one by one by the processor. Carrying out the exchange control functions through programs stored in the memory of a computer led to the name stored program control. A computer can be programmed to test the conditions of the inputs and last states and decide on new outputs and states. The decisions are expressed as programs which can be rewritten to modify or extend the functions of control system. All switching systems manufactured for use as public switching systems now use computers and software programming to control the switching of calls. Using SPC, 20 mA transmitter (old transmitter need 23 mA) with 52 V battery feed and longer subscriber loop can be achieved.

The SPC uses processors designed to meet the various requirements of the exchange. More than one processors are used for the reliability. Normally these processors are duplicated. Also the SPC system uses distributed software and hardware architectures. To carry over the maintenance functions of the switching system, a separate processor is used. Using the above setup, the SPC performs trunk routing to other control or tandem offices. Special features and functions are also enabled with sophisticated equipment's and in compact form. There are two types in SPC exchanges, namely centralised SPC and distributed SPC.

$$U = 1 - \frac{MTBF}{MTBF + MTTR} \; ; \; U = \frac{MTTR}{MTBF + MTTR}$$

If MTBF >> MTTR,

Dual Processor. A dual processor system is said to have failed only when both processor fails and the total system is unavailable. The MTBF of dual processor is given by

$$(MTBF)_D = \frac{(MTBF)^2}{2MTTR}$$

where $(MTBF)_D$ = MTBF of dual processor, MTBF = MTBF single processor

Availability $$A_D = \frac{(MTBF)_D}{MTTR + (MTBF)_D}$$

Substituting $(MTBF)_D$ in the above equation, we have

$$A_D = \frac{(MTBF)^2 / 2MTTR}{MTTR + \frac{(MTBF)^2}{2MTTR}}$$

$$A_D = \frac{(MTBF)^2}{(MTBF)^2 + 2(MTTR)^2}$$

Unavailability $$U = 1 - A_D = 1 - \frac{(MTBF)^2}{(MTBF)^2 + 2(MTTR)^2}$$

$$= \frac{2(MTTR)^2}{(MTBF)^2 + 2(MTTR)^2}$$

If MTBF >> MTTR, $$U_D = \frac{2(MTTR)^2}{(MTBF)^2}$$

For example problems, please refer text books.

The introduction of **distributed SPC** enabled customers to be provided with a wider range of services than those available with centralised and electromechanical switching system. Instead of all processing being performed by a one or two processor in centralised switching, functions are delegated to separate small processors (referred as regional processors). But central processors is still required to direct the regional processors and to perform more complex tasks.

$$U = \frac{MTTR}{MTBF}$$

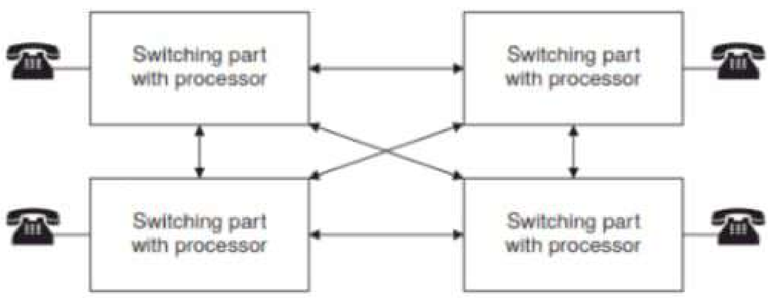


Fig. Distributed SPC