# Digital Switching and Telecommunication Networks

# (DSTN)

## Module – 1

**Contents:**

1. Fundamentals of switching system
2. Telecommunication networks
3. Basics of switching system
4. Major telecommunication networks
5. Centralised SPC
6. System availability
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8. Software architecture
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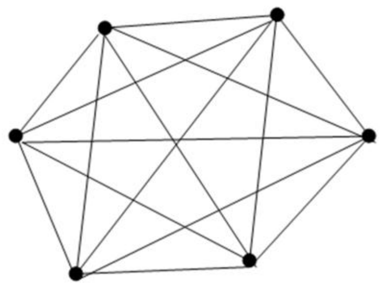
## 1. Fundamentals of switching systems

- **Communications basically in following types:**

- **Simplex** : one way communication ex: Radio
- **Half Duplex** : Two way communication shared by single channel ex: walkie talkie
- **Full Duplex** : Two way communication simultaneously ex: Telephone

Therefore we understood that, telephone is coming under the Full Duplex type of communication.

- **Point – Point Links/Fully Connected Network/Bell Proposed Network:**



To connect 'N' Points the number of Links are required are : $\frac{n(n-1)}{2}$

***Problem:*** Calculate the Number of links required to fully connect 5000 links and the number of additional links required to fully connect 5001

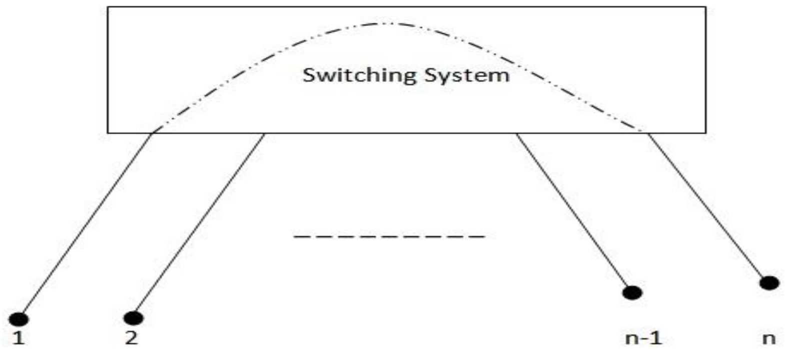
***Solution:*** to connect 5000 points, number of links required : 12497500

to connect 5001 points, number of links required: 12502500

therefore the additional links required to connect extra 1 point on a 5000 points network of fully connected are: **5000**

From the above problem it is understood that, it is highly impossible to connect large number points (telephones) as fully connected network/point-point network. To resolve this problem "Telephone Exchange" is came into existence

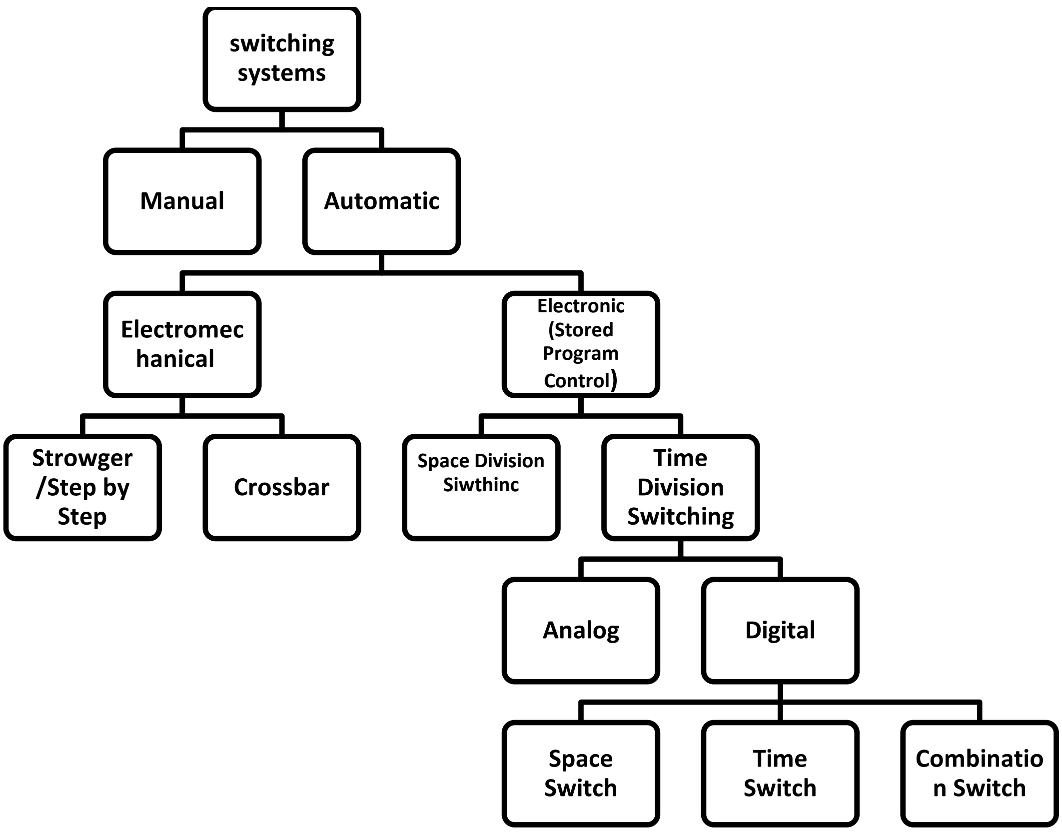
- **Concept of Telephone exchange/Switching System/Switching Matrix/Switch:**




Telephone Exchange/Switching is a system which will provide a temporary connection between any two telephones when required therefore to connect ‘n’ telephones, it requires only ‘n – links’

## 2. Telecommunication Networks

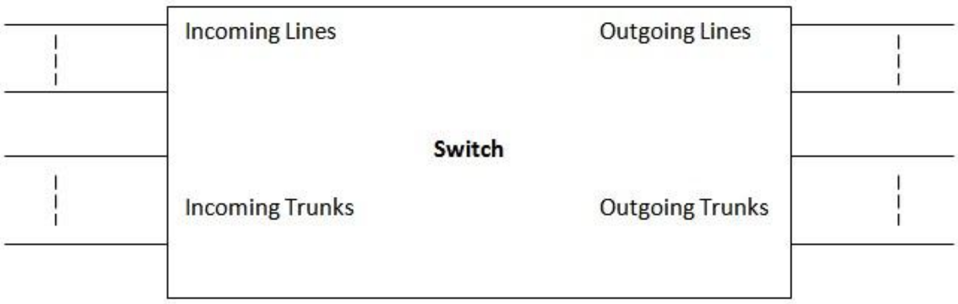
- **Classification of Exchange/Switching System**



- **Manual Exchange** : involved completely with connecting wires and human operators
- **Strowger Exchange** : Designed with Mechanical and Electronics movement mechanism
- **Crossbar Exchange** : Designed with Crosspoint Technology
- **Space division** : similar to circuit switching in networking
- **Analog Time division switching** : Speech Samples are stored and forwarded as analog amplitudes
- **Digital Time Division switching** : Speech Samples are stored and forwarded as digital samples
- Similarly in Digital Switching, Space Switch and Combination Switches are also used

## 3. Basics of Switching Systems

### A Model of Switching Network




**Calling Subscriber** : The entity who initiated a call

**Called Subscriber** : The entity who received the call

**Inlet** : An electrical line connected between subscriber and Exchange

**Outlet** : An electrical line connected between Exchange and Subscriber

**Switching Matrix/Switching Network/Switch** : A Hardware/Device used to provide a temporary connection between calling subscriber and called subscriber

**Symmetric Network** : in a switching model of N inlets and M outlets, if N Inlets are equal to M Outlets then the type of switching network is called Symmetric Network

**Folded Network :** In a Symmetric network if all outlets are folded back to inlets then, the type of network is called Folded network, a folded network will support the local calls, if the network is not folded then it cannot support any local calls

Maximum Calls : In a Folded Network the maximum numbers of calls are N/2

**The possible Connections**:

| | |
|---|---|
| Incoming Line to Outgoing Line | Incoming Trunk to Outgoing Line |
| Incoming Line to Outgoing Trunk | Incoming Trunk to Outgoing Trunk |

**4. Major Telecommunication Networks**

**<u>Stored Program Control (SPC)</u>**

- ✓ Telecommunication networks may be categorised according to their coverage of geographical areas which have distinct telecommunication requirements
- ✓ Metropolitan networks, rural networks and wide area networks are examples of large networks
- ✓ The most stupendous telecommunication network in existence is the public switched telephone network (PSTN)
- ✓ International Conservative Committee on Telephony and Telegraph(CCITT) is classified the world major telecom networks
- ✓ The first computer communication network is ARPANET & TYMNET
- ✓ IBM fist introduced its network “Systems Network Architecture (SNA)”
- ✓ Digital Equipment Corporation introduced “Digital Network Architecture (DNA)”
- ✓ Unix developed its network “Unix Users Network (USENET)” which is used to communicate all Unix operated systems with desktop posting
- ✓ Department of Computer Sciences of United State Universities developed “BITNET (Because It’s Time Network)”

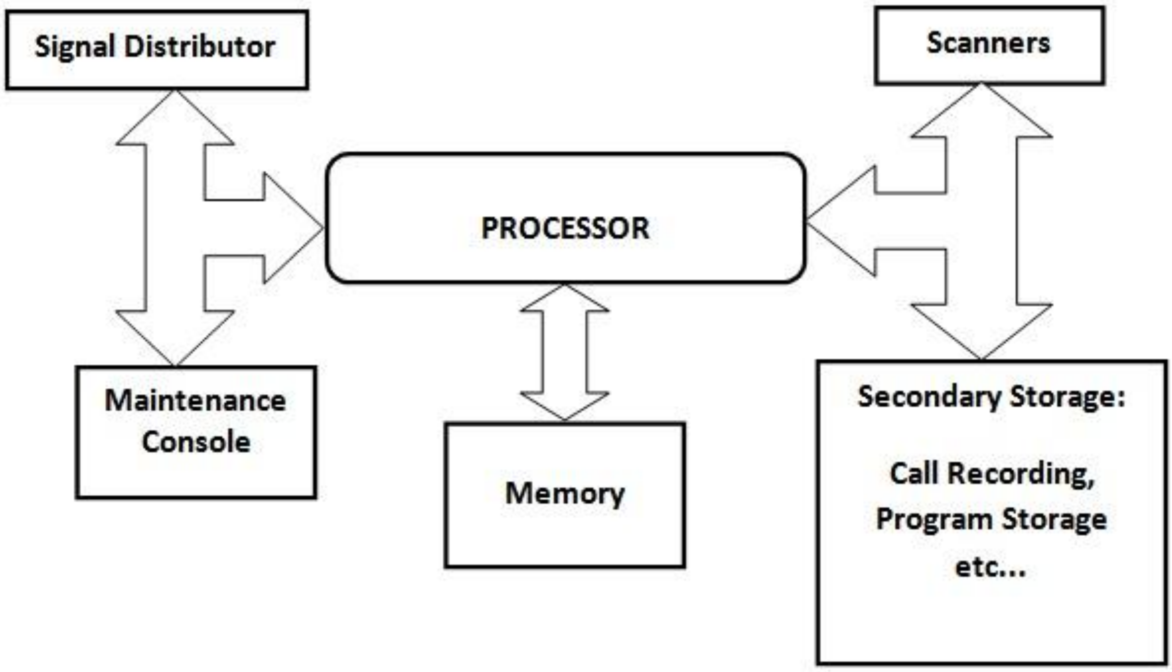
- ✓ The recent and on-going development of the major telecommunication network is "Integrated Services Digital Network (ISDN)" & "Digital Subscriber Line (DSL)"

## 5. Electronic Space Division Switching

- ✓ Early Manual Switching and Electromechanical Switching systems are used to provide communication between large scale users with limited network access because it includes tedious jobs like,
- ✓ Call Connecting, Call Processing, Call Waiting, Billing and many services are includes most of the manual operations, in order to avoid this manual operations are automated with the help of "Automatic Electronic Telephone Exchange/Switching System/Switch" it is commonly called as "**Stored Program Control (SPC)**"
- ✓ All the Exchange Functions like Call Processing, Call Waiting and Billing...etc are developed with computer programs and are stored in a memory, and a processor is provided to control all the exchange functions with help of Processor and Memory System hence the system is called "**Stored Program Control**"
- ✓ The Major Advantages of Stored Program Control (SPC)
    - Full-Scale automation of Exchange functions
    - Introduction of new services to users
    - Common Channel Signalling
    - Centralized Maintenance
    - Automatic Fault Diagnosis
    - Interactive Human-Machine Interface

- ✓ Electronic Space Division switching may be realized with
    - Electromechanical Switching with SPC
    - Electronic Switching with SPC
- ✓ Stored Program Control (SPC) is basically is classified into 2 categories
    - Centralised SPC
    - Distributed SPC

### 6. Centralised SPC

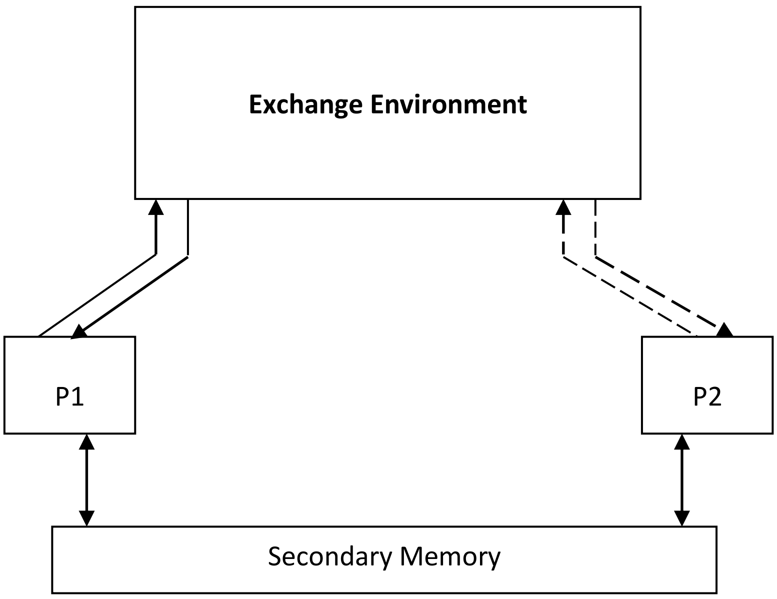



- ✓ From the above Block Diagram it is understood that, a central Processor can able to manage
  - Outgoing calls and trunks
  - Incoming calls and trunks
  - Maintenance and Operation
  - Primary memory which contain all Primary Programs
  - Secondary Memory which contain call processing results and other data of exchange
- ✓ A central processor may not be a single processor and is not a processor which is used for general purpose like desktops and laptops
- ✓ Central Processor generally a group of processors, it yields multi-processor centralized SPC System
- ✓ A processor used at the exchange is specially designed with VLSI Technology hence it's cost is very high
- ✓ In order to attain the cost effectiveness, Dual Processor system is normally is used
- ✓ Types of Dual Processor Systems:
  - Standby Mode
  - Synchronous Duplex Mode

- Load Sharing Mode

✓ The Major Advantages of the SPC

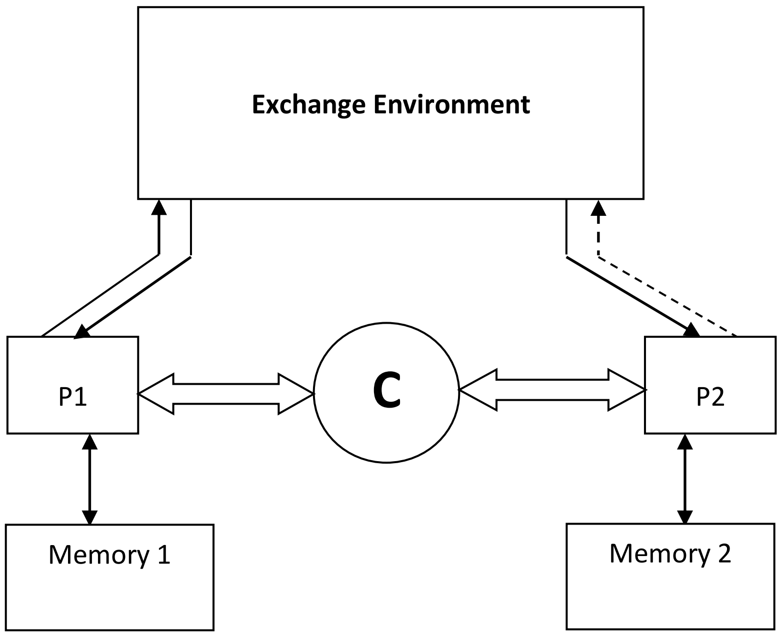
✓ **Standby Mode**:




- Exchange environment contains all functions of exchange like
    - Calling
    - Call connecting
    - Call processing
    - Call disconnecting
    - Call forwarding
    - Call diverting
    - Call bearing
    - Messaging
    - Ring tone generation
    - Busy tone generation
    - Trunk call forwarding
    - Bill charging
    - Bill generation.....etc....
- All these exchange functions are available as a full scale programs developed and kept in memory
- As it is found from the diagram that, exchange is a dual processor system, where two processors ‘P1’ and ‘P2’ are available in exchange
- Both processors are shared by single memory

- Normally processor 1 is active and other is standby these are indicated by solid lines at processor-1 and dashed lines at processor-2
- When a task is given to the processor -1 by the exchange, the task is processed by the Processor-1 and the resultant data will be stored in the common memory
- Whenever the Processor-1 is got failed, without interrupting the call processing, Processor-2 will take the control over the exchange, at this time inorder to know the status of the exchange, the Processor -2 will utilize the data from common processor,
- When Processor is got repaired, again it is brought into active mode, at this time Processor -2 is again kept in standby mode, because of this operation, this mode is called "standby mode"

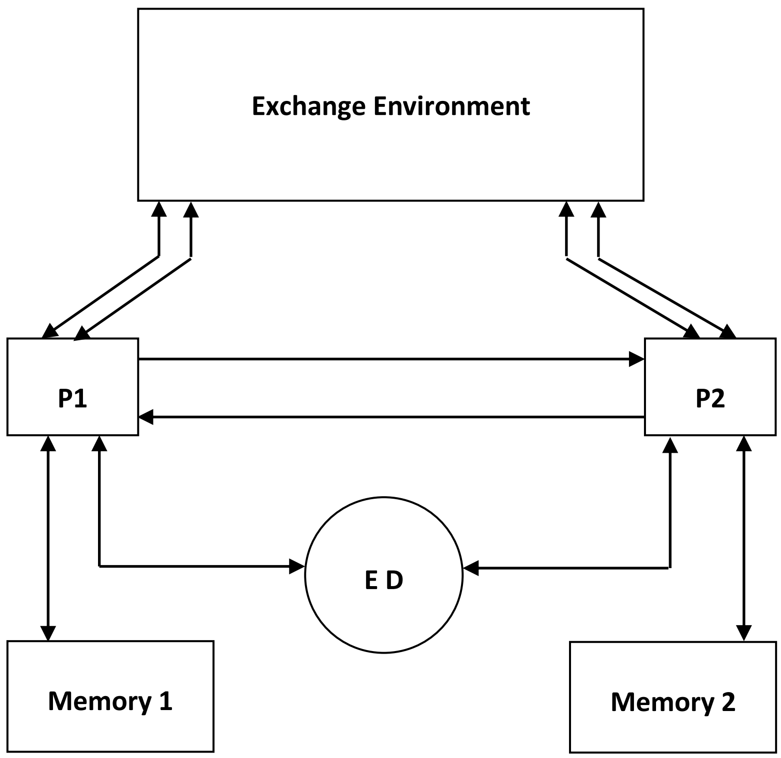
✓ **Synchronous Duplex Mode:**




- In synchronous duplex mode, two processors Processor P1 is active, Processor P2 is standby
- Both processors are coupled with a Comparator "C"
- Any task assigned by the exchange, is simultaneously processed by P1 and P2
- The results of the P1 and P2 are compared in Comparator "C"
- If both results are same it will take next task to be processed
- In this case, Processor P2 will process a task from exchange but it will not control the exchange, always Processor P1 only will control the exchange

- If comparator results are not same, then both processors are decoupled from the comparator then a self check program called "run check" is initiated, from this faulty processor is identified
- Faulty processor is removed from the exchange at this time other processor will act as a active processor until faulty processor is got repaired
- After repairing of faulty processor, again both the processors are brought into the exchange again both the processors are coupled with comparator

✓ **Load Sharing Mode:**




- In case of standby mode and synchronous duplex mode, the exchange controlled or load is taken by only one processor, the other processor is acting as standby and it will control the exchange only when the active processor is under repair
- In case of load sharing mode, both the processors will take control of the exchange

- Normally an exchange is designed to process at least 10 to 100 calls per second
- In previous modes, only one processor is processing the entire load of the exchange
- But in load sharing mode both processors P1 and P2 are equally sharing the load from the exchange
- In order to distribute the load between two processors, a device called "Exclusion Device (ED)" used
- In this mode both the processors are synchronised and memories are also got synchronised

## 7. System Availability

- ✓ **Mean Time Between Failure (MTBF):** the time taken between two successive failures of a system
- ✓ **Mean Time To Repair (MTTR):** The time taken to repair the system when a system is got repaired
- ✓ Generally an exchange is maintained with a single processor or dual processor under these conditions, we need to know about the system availability for both the cases
- ✓ So, the following are used for single processor system and dual processor system
- ✓ **For a Single Processor system:**
  - **MTBFs**: Mean Time Between Failure of single Processor System
  - **MTTRs :** Mean Time To Repair of Single Processor System
  - **As :** System Availability of Single Processor System
  - **Us :** System Unavailability of Single Processor System

$$As = \frac{MTBFs}{MTBFs + MTTRs}$$

$$Us = (1 - As)$$

$$\therefore Us = 1 - \frac{MTBFs}{MTBFs + MTTRs} = \frac{MTTRs}{MTBFs + MTTRs}$$

We know that, **MTBFs >> MTTRs**

$$\therefore Us = \frac{MTTRs}{MTBFs}$$

**Therefore for a single processor system:**

$$\boldsymbol{As} = \frac{\boldsymbol{MTBFs}}{\boldsymbol{MTBFs+MTTRs}} \qquad \boldsymbol{Us} = \frac{\boldsymbol{MTTRs}}{\boldsymbol{MTBFs}}$$

- ✓ **For a Dual Processor System**
  - **$MTBF_D$ :** Mean Time Between Failure of a Dual Processor System
  - **$MTTR_D$ :** Mean Time To Repair of a Dual Processor System
  - **$A_D$ :** System Availability of a Dual Processor System
  - **$U_D$ :** System Unavailability of Dual Processor System

  The relation between MTBF of dual Processor and Single Processor System:

$$MTBF_D = \frac{MTBF_S^2}{2MTTR_S}$$

$$MTTR_D = MTTR_S$$

By using the above relations

$$A_D = \frac{MTBF_D}{MTBF_D + MTTR_D} = \frac{\frac{MTBF_S^2}{2MTTR_S}}{\frac{MTBF_S^2}{2MTTR_S} + MTTR_S} = \frac{MTBF_S^2}{MTBF_S^2 + 2MTTR_S^2}$$

$$U_D = (1 - A_D) = 1 - \left\{\frac{MTBF_S^2}{MTBF_S^2 + 2MTTR_S^2}\right\} = \frac{2MTTR_S^2}{MTBF_S^2 + 2MTTR_S^2}$$

We Know that **MTBFs >> MTTRs**

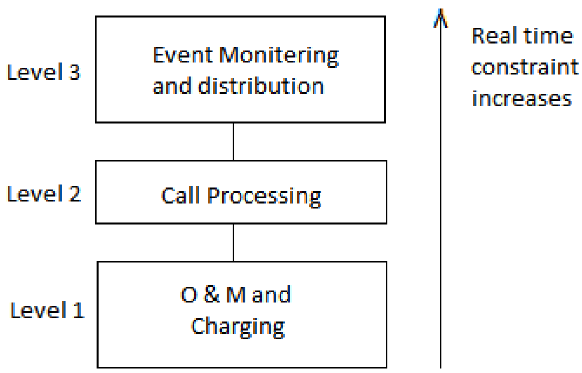
$$U_D = \frac{2MTTR_S^2}{MTBF_S^2}$$

Therefore for a Dual Processor System:

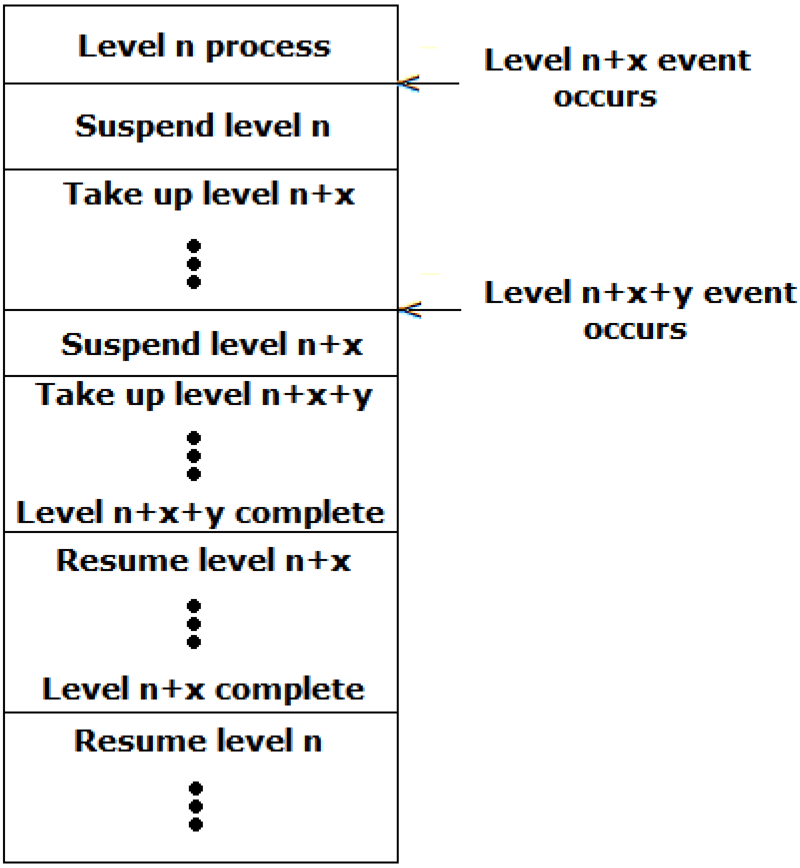
$$A_D = \frac{MTBF_S^2}{MTBF_S^2 + 2MTTR_S^2} \qquad U_D = \frac{2MTTR_S^2}{MTBF_S^2}$$

## 8. Distributed SPC

- **Interrupt Processing:** before studying the Distributed SPC there is need to study about interrupt processing
- In Exchange, all the functions are classified into following categories:
    - **Event Monitoring and Distribution**
    - **Call Processing**
    - **Operation, Maintenance & Call Charging**
- In exchange, the processor will process all the functions according to "Interrupt Processing"
- "Interrupt Processing" is done using the priority levels of the programs are being executed by the processor
- The following will interpret the concept of levels of processing or priority of the processing




- From the above diagram it is understood that
    - Level 3 Process : Event Monitoring and Distribution
    - Level2 Process : Call Processing
    - Level 1 Process : Operation, Maintenance & Call Charging
    - and the priority of Level 3 > Level 2 > Level 1
- Let a processor is currently executing a Level 1 Process like "Bill generation" of a consumer, meanwhile if exchange is assigned a new level 2 Process like "Call Connecting" then Processor will currently pause the Level 1 Process and will continue level 2 Process. After completing level 2 Process it will resume level 1 Process this depicts the "Interrupt Processing" as shown below:



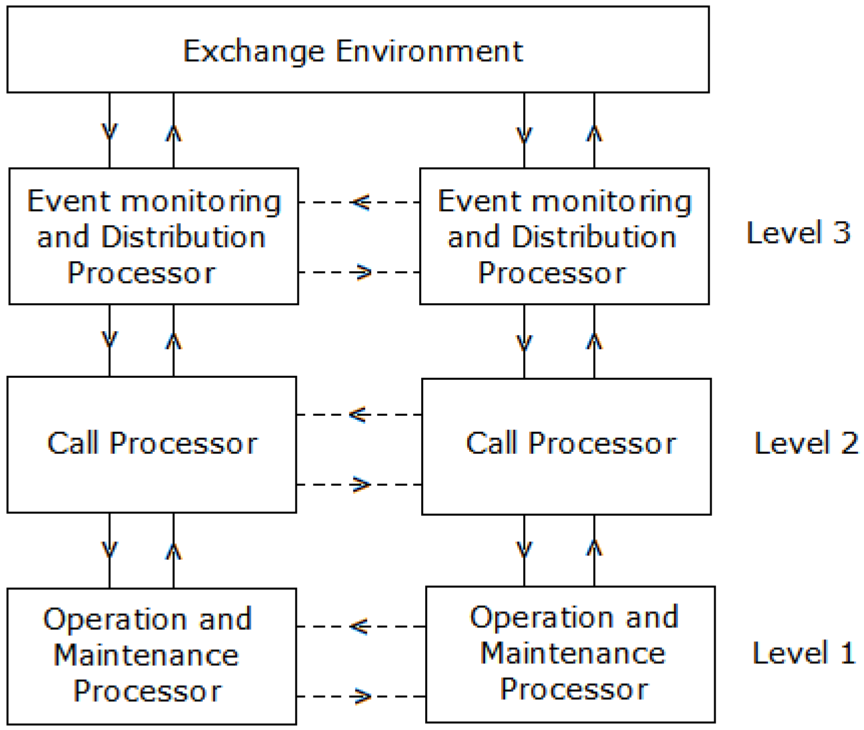

- ✓ Interrupts are basically in following types:
  - **Maskable Interrupt** : process instructions with different Priorities
  - **Non Maskable Interrupt**: The Highest Priority Interrupts like Power Failure, Reset Instruction
- ✓ In interrupt Processing when an interrupt occurs program execution is shifted to an appropriate service routine address in the memory through branch operation, this accomplishes with two methods:
  - **Vectored Interrupt**: In this method, the set of branch addresses are supplied to the processor with different interrupting sources
  - **Non Vectored Interrupt**: In this method, the set of branch addresses are supplied to the processor from fixed source
- ✓ In case of Centralized SPC, only one processor is used to process all the exchange functions where as in case of "Distributed SPC" three different processors are used for different levels of operations

**Level 3 Processing**

- ❖ Level 3 Processing will include the functions like:
  - Scanning
  - Distribution

- Marking
- Controlling all incoming & Outgoing **local calls, STD Calls, ISD Calls, Fax & Data** services
- Control of all functions are carried by specially designed Processors with "Micro-programmed Control"

❖ All levels of processing are depicted in the following figure:



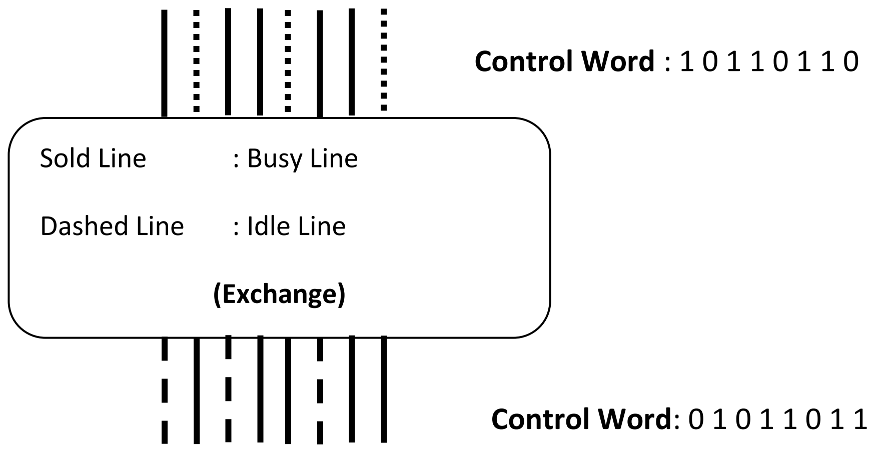

❖ Here it is understood that, at each level of processing there are two set of processors are available one set is for active processing and another set is for standby

❖ Coming back to Level 3 processing, here there is a keen difference between the classical "hard-wired control" and "Micro-programmed control"

| Micro-programmed control | Hard-wired control |
|---|---|
| Flexible, Slower, More Expensive for small exchanges, easier to implement, complex programming, Introduction to new services & Easier to maintain | Non flexible, Faster, Less Expensive for small exchanges, Fixed Processing Speed, Difficult to Implement, Complex Functions, No scope of introducing new services, Difficult to maintain because of Electromechanical and lot of wires and connectors |

❖ **Control Word:** In case of Micro-Programmed Control, all the control functions are controlled by a Control Word which contains the status and control actions in the binary codes by which processor able to understands what operations to be performed by the exchange

- **For example an exchange contain number inlets and outlets in which some line are active and some lines are idle, in the following diagram indicates the status of lines and its binary codes in control word:**




### Level 2 Processing

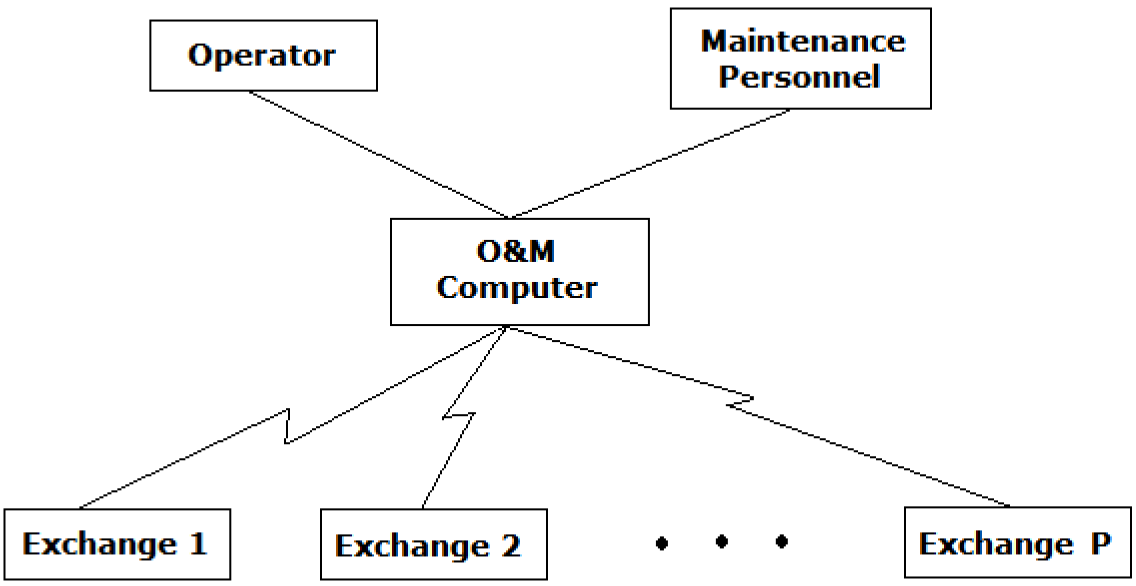
- Level 2 Processing or Processor is also called Switching Processing or Switching Processor
- we the concept of "system availability" it is understood that, the avilibility of a telephone exchange for a user is completely depending upon the availability of Switching devices at the exchange to connect any two phones are computers. So switching unit play a major role in telephone exchange
- The architecture of switching processors is designed to for 99.9% availability and fault tolerance and security operations
- **Switching Occupancy:** The traffic handling capacity of the control equipment is usually limited by the capacity of the switching processor. The load on the switching processor is measured by its occupancy **"t",** estimated by the simple formula:

$$t = a + bN$$

  - **t = Switching Processor capacity**
  - **a = fixed overhead**
  - **b = average time to process a call**
  - **N = Number of calls per unit time**

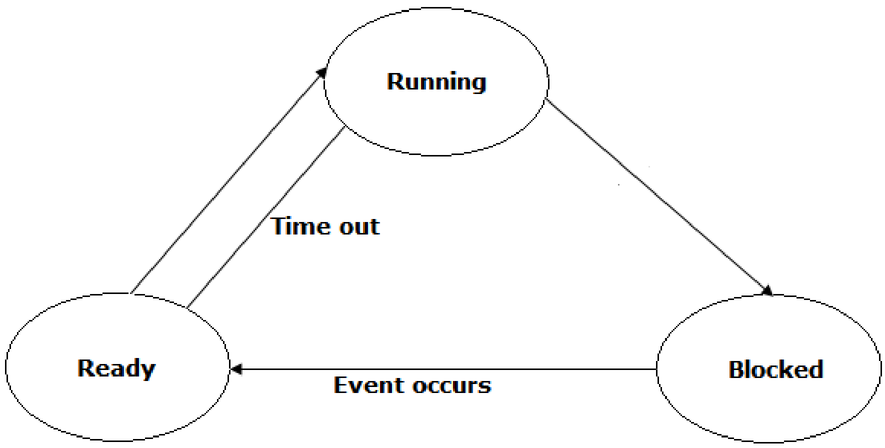
**Level 1 Processing**

- The Level 1 Processing includes a common general purpose computer to handle the following operations:
    - Bill Charging
    - Bill distributing
    - Monitor Traffic
    - Fault tolerance
    - Customer Support
    - Making a new Service
    - Disconnecting a requested service
    - Procuring new Equipment
    - Paying power bills of exchange..........etc....
- This kind of operations are not required in a huge demand like Level 3 & Level 2 Operations
- Because of this reason, a central telephone exchange will provide service of Level 1 Processing
- Meaning, all the nearby exchanges of a central exchange contain their own level 3 & Level 2 Processing units but Level 1Procesing unit is available at a central telephone exchange, in this way expenses of small exchanges are reduced
- The below diagram will depict the concept of a central Operation and Maintenance and Call Charging Unit of some nearby exchange



## 9. Software Architecture

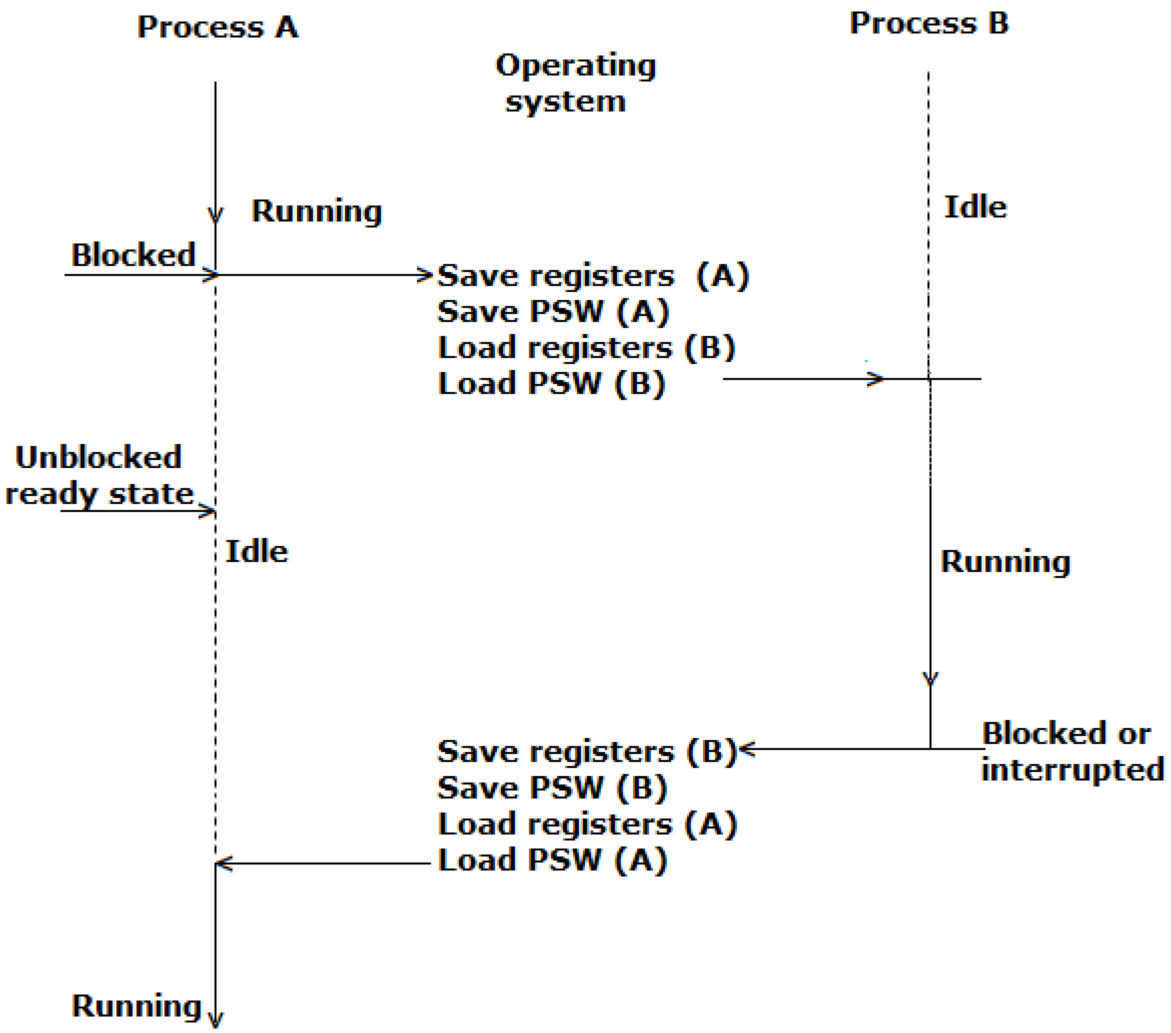
- ✓ Software is basically two types:
  - System Software (Operating System)
  - Application Software (Software based on Operating System)
- ✓ In case of Telephone exchange, the system is called “Event Oriented System” meaning, most of the exchange functions are initiated by the user
- ✓ Mainly, Switching Process, is Event Oriented
- ✓ Therefore a Special Design and Development is to be done for Switching Operating System
- ✓ **Process**: an instruction executed by the processor is commonly called as a “Process”
- ✓ **Running Process**: an instruction is currently executing by the processor
- ✓ **Ready Process**: next instruction of running process and an instruction timed out is normally called as a Ready Process
- ✓ **Blocked Process**: a Process or instruction is said to be blocked when it is conditional like “if”, “while” because the execution of this instructions are depending on the results of the conditional statements
- ✓ the bellow diagram will depict the state transitions between the “Running Process”, “Ready Process” & “Blocked Process”




- ✓ **Process Control Block:** Each Control Process is represented by the operating system by a “Process Control Block (PCB)” which is a data structure containing the following information about the process:
  - Current State of the Process
  - Process Priority and CPU Scheduling parameters
  - Memory allocated to process

- Status of events and I/O resources associated with the process

✓ **Program Status Word:** which contains the address of the next instruction to be executed, the types of interrupts enabled or disabled currently




✓ The above diagram depicts the process switching control of an operation system depending upon priority

✓ **Critical Region:** when numbers of parallel processes are running by the operating system, any time, any process may access common resources like memory space. “When a process is accessing a common resource in any time of its execution, then the process is said to be in “Critical Region”

✓ **Semaphore:** in order to avoid the problem of accessing any two or more processes are in critical state and to avoid “Deadlock” a variable “Semaphore” used

- ✓ **Semaphore** contain a number (which is equal to the number processes of accessing the common resources or be in critical state) by accessing this number operating system can manage between different processes in “Critical State” and by which, “Deadlock” is avoided

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