Time division Switching
Digital Switching

• **Switch** is the key device in **PSTN**.
• **PSTN** is an example of **Circuit Switched Network**.
• A **Digital Switch** in **PSTN** is divided into two parts:
  1. **Space-Division Switch**.
  2. **Time-Division Switch**.
• Combination of **Space-Division Switch** and **Time-Division Switch** construct the Digital Switch.
• **Crossbar Switch** is also known as **Space-Division Switch**.

• **Space Division** refers to the fact that speech paths are physically separated in space.

• In **Space-Division Switching**, a metallic path is set up between calling and called subscriber.
A space-division switch showing connectivity from user C to user G
• **Time-Division Switch** is also known as **Time-Slot Interchanger (TSI)**.

• It permits a **single common metallic path** to be used by many **calls separated** one from the other in the **time domain**.

• With **Time-Division Switching**, the speech to be switched is **digital in nature (PCM)**.
• Where, samples of each telephone call are assigned **time-slots**, and **PCM switching** involves the distribution of these slots in sequence to the desired destination port(s) of the switch.

• Internal functional connectivities in the switch are carried out by **digital highways**.

• A **highway** consists of sequential speech path **time-slots**.
A time-division switch which is a time-slot interchanger (TSI). Connectivity is from user C (in incoming times slot C) to user G (in outgoing time slot G)
A classical **Digital Switch** is made up of two functional elements:

1. **A Time Switch** called “T”.
2. **A Space-Switch** called “S”.

The architecture of a digital switch is described in sequences of T's and S's.

For example, the 4ESS is a **TSSSST** switch.

Where, the **input stage** is a time switch, followed by **four space switches** in sequence and the **last stage** is a time stage.
• Another example, the Northern Telecom DMS-100 is a TSTS switch that is folded back on itself.

• Many of the new switches or enhanced versions of the switches just mentioned have very large capacities (e.g., 100,000 lines) and are simply TST or STS switches.
Lucent 5ESS TSSSST Switch
Northern Telecom DMS-100 Line Card Drawer showing line cards
Time Switch

• Time-Division Switch or simply, **Time-Switch** is a **Time-Slot Interchanger (TSI)**.

• We know that **E1** consists of **32 time-slots** in **125 µs**, with time slot duration of **3.906 µs**, and each **time-slot** contain **8-bits**.

• **TSI** involves moving the data contained in each **time-slot** from the incoming bit stream at the **switch inlet ports**, to an outgoing bit stream at the **switch outlet ports**, but with a different **time-slot** arrangement in accordance with the destination of each **time-slot**.
• To accomplish this, at least one time-slot must be stored in memory (Write) and then called out of memory in a changed position (Read).

• The operations must be controlled in some manner, and some of these control actions must be kept in memory together with the software managing such actions.

• Typical control functions are time-slot “idle” or “busy”.
• The three basic functional blocks of a time switch are:
  1. Memory for speech.
  2. Memory for control.
  3. Time-slot counter or processor.
• There are two choices in handling the time switch:
  1. Sequential write, random read
  2. Random write, sequential read.
Time-slot interchange: time switch (T). Sequential write, random read.
Time-switch, time-slot interchange (T). Random write, sequential read.
• **With sequential write**, the **time-slots** are written into the speech memory as they appear in the incoming bit stream.

• **With random write**, the incoming **time-slots** are written into memory in the order of appearance in the outgoing bit stream (the desired output order).

• The writing of incoming **time-slots** into the speech memory can be controlled by a simple **time-slot** counter and can be sequential (e.g., in the order in which they appear in the incoming bit stream).
• If the **readout** of the speech memory is controlled by the **control memory**, 
• In this case the **readout is random** where the **time-slots** are read out in the desired output order. 
• If the **write** is of the speech memory is controlled by the **control memory**, 

• In this case, the writing process is random.
• The memory has as many cells as there are time-slots (e.g. E1 = 32 time-slots, DS1 = 24 time-slots).
• This time switch, works well for a single multiplexed inlet – outlet switch, which we denote by single inlet – outlet trunk.
• How can we increase a switch’s capacity?
• Enter the space switch (S). (see the figure in the next slide)
• For example, time-slot $B_1$ on the $B$ trunk is moved to the $Z$ trunk into time-slot $Z_1$, and time-slot $C_n$ is moved to trunk $W$ into time-slot $W_n$.
• However, we see that there is no change in time-slot position.
Space switch connects time slots in a spatial configuration.
Space Switch

- Figure in the next slide illustrates a typical time-division space switch.
- It consists of a **Cross-Point Matrix** made up of **Logic Gates** that allow the switching of **time-slots** in the **spatial domain**.
- These **PCM time-slot bit streams** are organized by the switch into a pattern determined by the required network connectivity.
Time-division space switch cross-point array showing enabling gates.
• The matrix consists of a number of input horizontals and a number of output verticals with a Logic Gate at each cross-point.

• The array, as shown in the figure, has \( M \) input horizontals and \( N \) output verticals, and we call it an \( M \times N \) array.
• If \( M = N \), the switch is Non-blocking.
• If \( M > N \), the switch Concentrates;
• If \( N > M \), the switch Expands.
• For a given time-slot, the appropriate Logic Gate is enabled and the time-slot passes from the input horizontal to the desired output vertical.