Topic 4: Local Networks and Digital Switching

Lesson A_4: PCM Switching and the Digital Network

Contents

Objectives:

1. To demonstrate a mastery of the concepts and terminology related to local networks and switching practice in such a way as to benefit from planned practical exposure
2. To describe and explain the time division switching function within a pulse code modulated network.

Lesson A_4 Outline

5.0 Digital Switching and Networks

In this section we study time division switching in which a common wire path is available to many simultaneous users separated by time slots. The digital information will be either Pulse Code Modulated (PCM) or Delta Modulated (DM). Our approach will be to briefly describe PCM and apply it to switching using various generic switch architectures while explaining functional operations. We follow this treatment of PCM switching by examining digital networks and their topology, network timing and synchronisation, and conclude by discussing network degradation mechanisms and performance.

5.1. Elements of PCM Switching

From our brushing acquaintance with analogue switching [3], it makes sense to talk about the advantages of digital switching. Time-division switching presents the following economic advantages:

- It requires fewer equivalent cross-points for any given number of lines and trunks than the space-division methods just described.
- It has comparatively tiny switches.
- It has more common circuit modules.
- It makes it possible to achieve full availability within economic limits.

Its technical advantages include:

- It regenerates the signal and in the process cleans it up.
- It is noise immune.
- It enhances the advantages of SPC by being entirely digital.
- It uses binary message formats compatible with both switching and computers.
- The digital exchange is free from insertion loss associated with switches.
- It benefits from the tendency of digital systems to come down in price.

Its technical disadvantages are:

- Even a well-designed digital switch tends to worsen the system's error performance.
- It requires switch and network synchronisation as well as reduction of wander and jitter, all complicating factors.

Time division switching (T) and space division switching (S) form the two main parts of a digital switch. The operators normally combine the two elements in a variety of ways as sequences, e.g. folded TSTS (DMS-100), TSSSST (AT&T No. 4 ESS) and SSTSS (AT&T No. 3 EAX). The topic examines the networks based on the time and space switch.

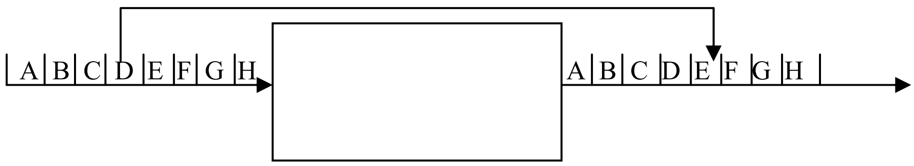

Figure 5.1.1 A simplified time-division switch showing user D (incoming time slot D) connecting to user E (outgoing time slot E)

The elementary function of a time switch is to interchange TDM time slots. We will learn later under the signalling topics that a time slot in PCM consists of 8 bits. A simple frame lasts 125 μs in transmission (the actual transfer of the bit sequence from the transmitter into the medium in contrast with propagation). In the European CEPT 30+2 system the frame has 32 time slots while in the North American DS1 system it has 24. In either case, then, each time slot lasts 125/32 = 3.906 μs and 125/24 = 5.208 μs, respectively. A time switch maps a time slot in the incoming bit stream into a desired outgoing time slot to connect two users assigned the respective time slots as shown in **Fig. 5.1.1**. The switch uses memory registers (buffer) to store a tagged incoming slot and to read it out in a new sequence position. As shown in **Fig. 5.1.2**, the time switch consists of three building blocks (architectural):

- Memory for speech (by traffic time slots)
- Memory for control
- Time slot counter (processor).

The time switch (T) writes the incoming time slots into memory either in sequence as they

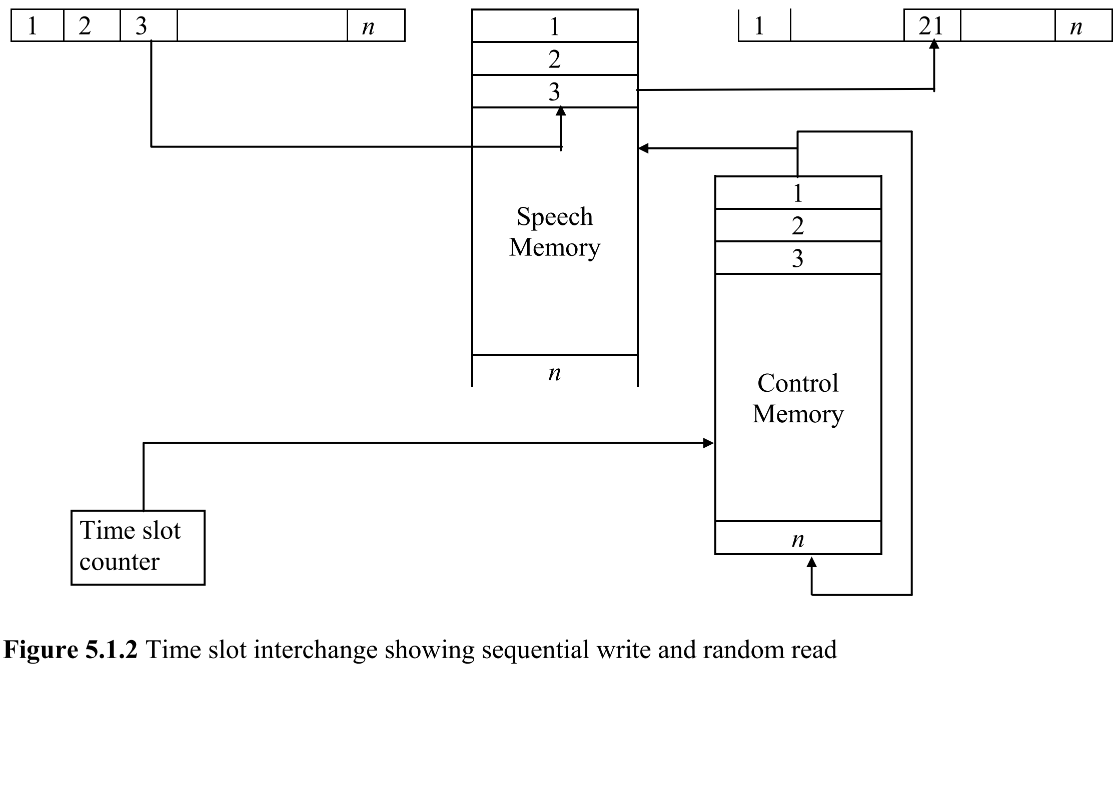

Figure 5.1.2 Time slot interchange showing sequential write and random read

arrive or randomly. Random write can be combined with sequential read to put them in the proper order for the outgoing stream. **Fig. 5.1.2** shows the combination of sequential write with random read to accomplish the same goal. In each case the time slot counter controls the process. This switch arrangement requires as many switching cells as there are time slots.

We can use a space switch (S) for a multiple port switch such as a tandem switch for handling trunk calls. The space switch will move incoming slots from any single frame into any of the *n* outgoing ports without changing their respective input slot numbers or positions at the destination. A typical space switch has a cross-point matrix of logic gates switching in a pattern specific to the given network connection plan. The inputs are horizontal while the outputs are vertical and each intersection consists of a logic gate. If the switch has *m* horizontals and *n* verticals, it is an $M \times N$ array. If $M = N$, the switch is non-blocking. $M > N$ implies that it concentrates, while $M < N$ means it expands. Unequal inlets and outlets tend to be the norm at local exchanges that require either concentration or expansion, otherwise tandem switches are non-blocking, as a rule.

The digital switch is a combination of either T and S switches in any order or S switches only. Small digital switch implementations favour STS combination because its architecture is simpler than TST. However, as implementations become larger, expansion favours the TST approach since time expansion is cheaper than space expansion. Where control requirements are paramount, choose STS but where expansion potential and modularity prevail, then choose TST. For instance the AT&T No. 4 ESS is a large switch with a TSSSST architecture that can terminate 107 520 trunks with a blocking probability of 0.5% and channel occupancy of 0.7. For an in-depth feel of a particular implementation, read Chapter 10, Section 4 of [2].

Currently, the PTC is struggling to implement the absolutely necessary digitisation of the public switched telephone network (PSTN). The vision is that of an all-digital network with fibre optics cabling together with microwave trunks and international satellite links. Historically, unless you have been cleared to work within the PTC, you would not easily come across literature on the details of the implementation. Hence we can only discuss the North American and European networks, which have been open to the public for a long time. In the near future, privatisation will most likely make it possible for us to write textbooks explaining the various networks currently under implementation in Zimbabwe.

5.2. The Digital Switching Network [2, 4]

The changeover to the integrated services digital network (ISDN) will not be absolute in that much of the existing routes will remain intact but perhaps increased in size and number as traffic intensity grows and new traffic combinations come in. There will be more competition under the Communications Bill, in addition to optical fibre links and mobile telecommunications growth. The approach to accomplishing universal access is the focus of current global implementations. The local loop has become more important than ever. Ideas for its enhancement include optical fibre to expand the available bandwidth for multimedia applications and wireless local loops to increase subscriber density without the cost of additional cabling. As you might be aware, it is hoped that by year 2000, the Mutare-Harare-Bulawayo-Beitbridge route will be an all-optical fibre link or backbone. Let us then examine the design issues involved in the subscriber loop as well as other design issues relating to an all-digital network as envisioned for the near future.

The list of major issues includes:

- Enhancement in the profile of available services in digital networks
- Network performance and related requirements
- Synchronisation and timing
- The international interface using either DS1 or CEPT 30+2
- Signalling using ITU-T SSN No. 7

- Maintenance

Summary

In this lesson we studied time division switching in which a common wire path is available to many simultaneous users separated by time slots. The digital information was either Pulse Code Modulated (PCM) or Delta Modulated (DM). Our approach was to briefly describe PCM and apply it to switching using various generic switch architectures while explaining functional operations. We followed this treatment of PCM switching by examining digital networks and their topology, network timing and synchronisation, and concluded by discussing network degradation mechanisms and performance in a converged world.

***************** End Topic 4 Lesson A_4 of A_6 *****************

References

[1] *Local Area Networks,* International Telecommunications Union, Geneva, 1968.
[2] Roger L. Freeman; *Telecommunication System Engineering, 2/e*; Wiley, 1989.
[3] T3221A04 Appendix A – Conventional Switching
[4] John L. Fike; *Understanding Telephone Electronics*; Texas Instruments Inc., 1983.