Module
12
Synchronous Digital Hierarchy

Lesson

39

Synchronous Digital Hierarchy

12.1.1 INTRODUCTION

As end-users (particularly business users) become ever more dependent on effective communications, there has been an explosion in the demand for sophisticated telecom services. Services such as videoconferencing, remote database access, and multimedia file transfer require a flexible network with the availability (on demand) of virtually unlimited bandwidth. The complexity of the current network, based on plesiochronous transmission systems, means that network operators are unable to meet this demand.

The current plesiochronous digital hierarchy (PDH) evolved in response to the demand for plain voice telephony (sometimes called POTS - plain Old Telephone Service) and as such is not ideally suited to the efficient delivery and management of high bandwidth connections. Synchronous transmission systems address the shortcomings of the PDH. Using essentially the same fiber, a synchronous network is able to significantly increase available bandwidth while reducing the amount of equipment in the network. In addition, the provision within the SDH for sophisticated network management introduces significantly more flexibility into the network.

Deployment of synchronous transmission systems will be straightforward due to their ability to work with existing plesiochronous systems. The SDH defines a structure which enables plesiochronous signals to be combined together and encapsulated within a standard SDH signal. This protects network operators' investment in plesiochronous equipment, and enables them to deploy synchronous equipment in a manner suited to the particular needs of their network.

As synchronous equipment becomes established within the network, the full benefits it brings will become apparent. The network operator will experience significant cost savings associated with the reduced amount of hardware in the network, and the increased efficiency and reliability of the network will lead to savings resulting from a reduction in maintenanace and operations. Another result of increased reliability will be a reduction in the need to hold spare equipment.

The sophisticated network management capabilities of a symchronous network will give a vast improvement in the control of transmission networks. Improved network restoration and reconfiguration capabilites will result in better availability, and faster provisioning of services. SDH offers network operators a future-proof network solution. It has been designed to support future services such as Metropolitan Area Networks (MANs), Broadband ISDN, and personal Communications networks.

12.1.2 SDH DATA RATES

SDH defines a number of "Containers", each corresponding to an existing plesiochronous rate. Information from a plesiochronous signal is mapped into the relevant container. The way in which this is done is similar to the bit stuffing procedure carried out in a conventional PDH multiplexer. For SDH systems, the 155.52 Mb/s Synchronous Transport Module Level-l (STM-l) is the fundamental building block. Again, lower rate payloads are mapped into an STM-l, and higher rate signals are generated by synchronously multiplexing N STM-l signals to form the STM-N signal. Insofar as the transport overhead of an STM-N is N times the transport overhead of an STM-l, the transmission rate is N x 155.52Mb/s. As currently defined (ITU-T Recommendation G.707), the SDH transmission rates correspond to N = 1,4, and 16. (Although not currently recommended, other rates for intermediate and higher values of N could be similarly generated. In particular, work is now progressing to standardize OC-192 and STM-64 signals)

12.1.3 SDH FRAME FORMATS

SDH frames are conveniently depicted as rectangular octet-based units transmitted every 125 µs(8000 frames/s).

As shown in the Figure, the STM-1 frame format is 9 rows of 270 bytes(1 byte =8 b), or 2430 b/frame, corresponding to an aggregate rate of 155.52 Mb/s. Each octet equates to 64 kb/s, and an octet column of nine rows is 576 kb/s. Transmission occurs from upper left to lower right, as if reading words on a page. The first nine byte-columns of the basic frame are set aside for Section Overhead (SOH); the remaining 261 are for payload mapping. Further, the overhead portion is subdivided into three areas: the first, occupying rows 1-3, is known as Regenerator Section Overhead (RSOH); the second, occupying row 4, contains Administrative Unit (AU) pointers to identify the position of floating payloads; and rows 5-9 are identified as Multiplex Section Overhead (MSOH).In addition to the SOH, a column of Path Overhead (POH) resides within the Information Payload, and can, in fact, spill across two consecutive frames.

Briefly, SDH SOH supports transport capabilities such as framing, error monitoring, and management operations channels (orderwire, monitoring, and control of automatic protection switching, data communication channels, and an unspecified user channel). POH supports performance monitoring, status, signal labeling, a tracing function, and a user channel. This latter overhead is added and dismantled at or near service origination /termination points, and is not processed at intermediary nodes.

12.1.4 SDH MULTIPLEXING STRUCTURES

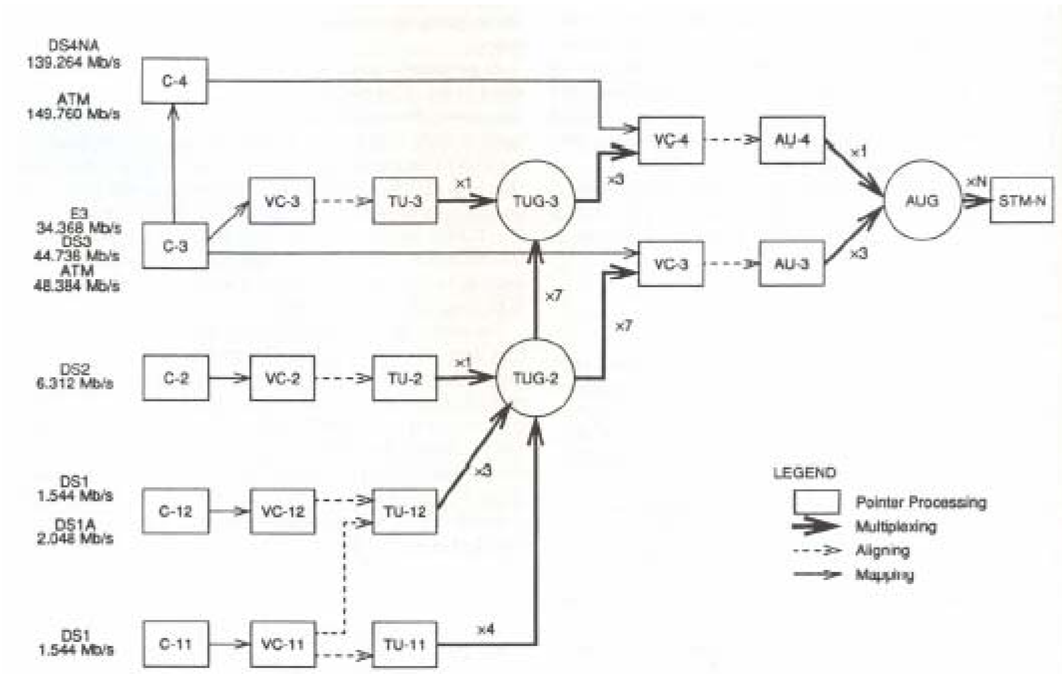

Fig. 4. SDH multiplexing structure.

SDH permits different mappings of the same payload and requires four hierarchical levels in forming the payload of an STM-l. As shown in figure below Plesiochronous signals are first mapped into one of five Containers (C) suitable to their individual bandwidth needs. Adding POH then results in a Virtual Container (VC). Here, two types of VCs are defined: higher order VCs (i.e., VC-3 and -4) and lower order VCs (i.e., VC-2, -3, -II, and -12), with VC-3 treated as either higher or lower order. The higher order VCs are mapped to either Administrative Unit Level-3 (AU-3) or AU-4; lower order VCs are mapped to higher order VCs, with Tributary Unit (TU) pointers to locate them. At this point, one AU-4 or three AU-3s are mapped or multiplexed (respectively) to form the Administrative Unit Group (AUG)

"SPE of an STM-I." Byte-interleaved multiplexing of N STM-ls creates an STM-N. As a final observation, the SDH multiplexing plan carries with it the notion of viewing one or more TUs as a Tributary Unit Group (TUG): no special overhead is associated with a TUG; it exists to facilitate network planning or traffic routing; hence, it becomes the responsibility of SDH network management to properly administer its path. SDH signals are transported optically, electrically, via terrestrial microwave radio, or satellite.

12.1.5 SYNCHRONIZATION

Synchronization is a key aspect of SDH, and is an underlying basis to the facile hierarchical multiplexing and demultiplexing that the transmission format permits. Synchronization is, first and foremost, predicated on the availability of a strata of clocks which are traceable to one or more extremely precise references, from which local clock is directly available at carrier central offices or loop timed from the signal carried on fiber trunks terminating on NEs.

Even under optimum conditions, however, clock transients, facility interruptions, environmental factors, or NEs themselves can give rise to instantaneous frequency deviations. As a result, the incoming bit rate can depart slightly from the outgoing bit rate, which, over a short interval, can give rise to accumulated phase differences which cause buffer overflows.

SDH accommodates this by using pointers to offset the phase accumulation due to frequency deviations. The phase difference is accumulated in a buffer until a level is reached indicating that adjustment is necessary. At that point, an information byte is either written to the payload or the buffer is inhibited for one byte interval prior to writing the payload. This is accomplished via pointers in the SDH/SONET overhead which identify the location of the information payload, and incrementing or decrementing that payload. For example, if the incoming signal rate is greater than the outgoing rate, the buffer will overflow, the payload is shifted one byte to the left by virtue of decrementing the pointer value, and the previous payload is reduced by one byte of information.

G.709 defines different combinations of virtual containers which can be used to fill up the payload area of an STM - 1 frame. The process of loading containers and attaching overhead is repeated at several levels in the SDH, resulting in the "nesting" of smaller VCs within larger ones. This process is repeated until the largest size of VC (a VC - 4 in Europe) is filled, and this is then loaded into the payload of the STM - 1 frame. When the payload area of the STM - 1 frame is full, some more control information bytes are added to the frame to form the "Section Overhead". The section overhead bytes are so-called because they remain with the payload for the fiber section between two synchronous multiplexers. Their purpose is to provide communication channels for functions such as OA&M; facilities, alignment and a number of other functions.

12.1.6 EMERGING ITU-T RECOMMENDATIONS FOR SDH

Following the work carried out in the U.S. on SONET, discussions, which would later lead to the definition of the Synchronous Digital Hierarchy (SDH), were initiated in 1986 under CCITT SG XVIII. They resulted, in 1988, in the approval of the G.707, G.708,and G.709 Recommendations. These documents contain the specifications of the basic principles of SDH. The hierarchical bit rates, multiplexing principles, and multiplex elements are defined there. Studies on SDH multiplexing have been pursued since 1988, and the initial content of G.708 and G.709 has evolved. Their second version was approved in 1990. Since the beginning of the current study period, their maintenance has been under the province of ITU-T SG 15.

The G.707, G.708, and G.709 Recommendations define a worldwide Network Node Interface (NNI) having the following advantages.

- It allows simple inter-working between hierarchies based on 1.5 and 2 Mb/s.
- The interface is applicable to any kind of equipment that may be found in a transmission network (multiplexer, cross-connect, line system).
- The principles can be applied to any physical medium (optical fiber, radio relay).
- It takes into account the current PDH hierarchy while being fully open to future applications.

Objective Questions

39.01

Subjective Questions

39.11

Level 2 Questions

39.21