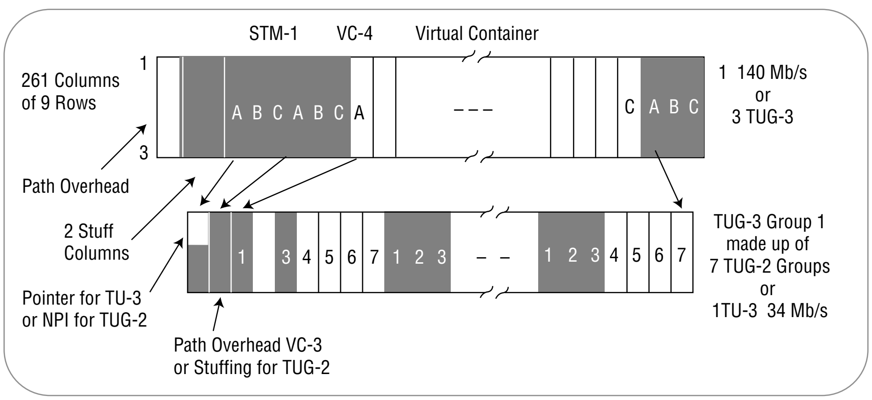
SDH Tributary Multiplexing

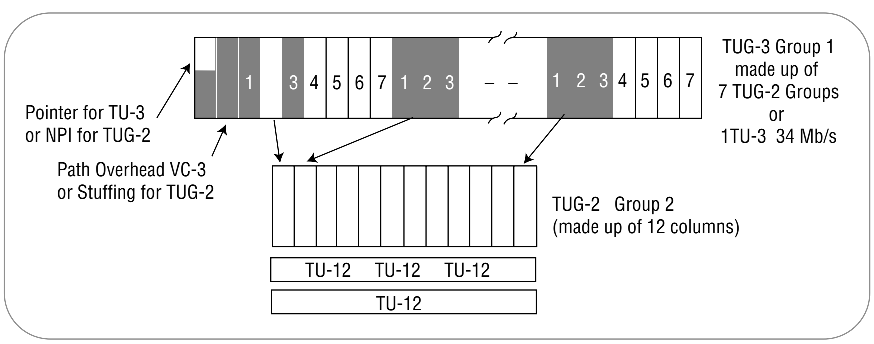
In order to accommodate mixes of different TU types within a VC-4, the TUs are grouped together (refer to the previous SDH Multiplexing Hierarchy diagram – Figure 12). A VC-4 that is carrying Tributary Units is divided into three TUG-3, each of which may contain seven TUG-2s or a single TU-3. There can be a mix of the different TU Groups. For example, the first TUG-3 could contain twelve TU-12 and three TU-2, making a total of seven TUG-2 groups. The TU groups have no overhead or pointers; they are just a way of multiplexing and organizing the different TUs within the VC-4 of a STM-1.

The columns in a TU Group are not consecutive within the VC; they are byte-interleaved column-by-column with respect to the other TU groups (see Figure 13).

This figure also shows several columns allocated for fixed stuffing. NPI (Null Pointer Indicators) are used to indicate when a TUG-2 structure is being carried, rather than a TU-3 with its associated TU-3 pointer.



▶ ***Figure 13.*** *SDH tributary structure showing TUG-3 multiplexing in VC-4.*



▶ ***Figure 14.*** *Tributary unit structures.*

Tributary Unit Group

The first TUG-2 Group within a TUG-3, called Group 1, is found in every seventh column, skipping columns 1 and 2 of the TUG-3, and starting with column 3.

The Tributary Unit columns within a group are not placed in consecutive columns within that group (Figure 14). The columns of the individual TUs within the TU Group are byte-interleaved as well.

Tributary Units are optimized in different sizes to accommodate different signals. Each size of TU is known as a "type" of TU. A 36-byte structure, or 4 columns by 9 rows, could accommodate the 2.048 Mbit/s signal. This particular TU is simply designated a TU-12. In this case the four columns provide a signal rate of 2.304 Mbit/s, allowing capacity for overhead. Other signals require TUs of different sizes.

With each TU Group using 12 columns of the VC-4, note that the number of columns in each of the different Lower-Order TU types are all factors of 12. As a result, a TU group could contain one of the following combinations:

- Three TU-12s (with four columns per TU-12)
- One TU-2 (with twelve columns per TU-2)

TU Multiframe

In the floating TU mode, four consecutive 125-microsecond frames of the VC-4 are combined into one 500-microsecond structure, called a TU Multiframe. In other words, the 500-microsecond multiframe is overwritten on, and aligned to the 125-microsecond VC-4s. The occurrence of the TU Multiframe and its phase is indicated in the VC-N Path Overhead, by the Multiframe Indicator byte (H4). A value XXXXXX00 in the Multiframe Indicator byte indicates that the next STM frame contains the first frame in the TU Multiframe; a value XXXXXX01 in the Multiframe Indicator byte indicates that the next VC-4 contains the second frame in the TU Multiframe, and so on. (Only the last two bits of the H4 byte have a value of 0 or 1 assigned; the first six bits are unassigned and this is denoted by the X.)

The Tributary Units also contain payload pointers to allow for flexible and dynamic alignment of the VC. In this case, the TU pointer value indicates the offset from the TU to the first byte of the VC. TU pointers allow AU and TU payloads to differ in phase with respect to each other and the network while still allowing AUs and TUs to be synchronously multiplexed.

The TU Multiframe overhead consists of four bytes: V1, V2, V3, and V4 (see Figure 15). Each of these four bytes, V1 to V4, is located in the first byte of the respective TU frame in the TU Multiframe. The payload pointers V1 and V2 indicate the start of the payload within the multiframe and V3 provides a 64 kbit/s channel for a payload pointer movement opportunity. The V4 byte is reserved. The remaining bytes in the TU Multiframe define the TU container capacity which carries the Virtual Container, and the Path Overhead. The container capacity differs for the different TU types because their size varies according to the number of columns in each type.

The container capacity for each type of TU is shown in Table 11.

TU Payload Pointer

The TU Payload Pointer allows dynamic alignment of the lower-order VC-M within the TU Multiframe in much the same fashion as described for the higher-order VC-N. The alignment of any one lower-order VC-M is independent of the other VC-Ms; in other words, all VCs within an STM can float independently of each other.

This payload pointer, which is located in positions V1 and V2 of the TU Multiframe, is made up of two 8-bit bytes, and it can be viewed as one word. The value of the pointer is a binary number found in bits 7 to 16 of V1 and V2. This value indicates the offset in bytes from the end of the pointer (byte V2) to the first byte of the VC; the V3 and V4 bytes are not counted. The range of the offset differs for each TU type (see Table 12).

That is, the value of the pointer for a TU-12 has a range of 0 to 140. For example, if the TU Payload Pointer has a value of 0, then the VC-M begins in the byte adjacent to the V2 byte; if the TU Payload Pointer has a value of 35, then the VC-M begins in the byte adjacent to the V3 byte. The V5 byte is the first byte of the VC-M in the first multiframe.

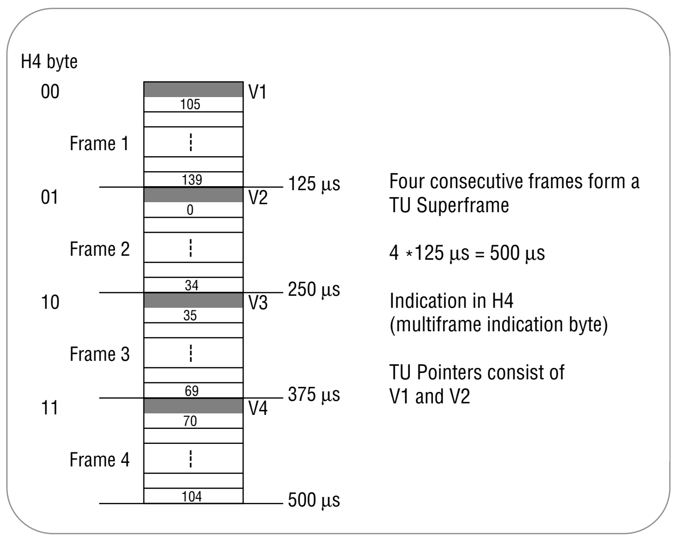
Table 11. TU Container Capacity

TU Type	TU Capacity Calculation *	TU Pointer	TU Container Capacity
TU-11	3 x 9 x 4	4 bytes	104 bytes
TU-12	4 x 9 x 4	4 bytes	140 bytes
TU-2	12 x 9 x 4	4 bytes	428 bytes

* Columns x rows x frames

Table 12. TU Container Pointer Values

TU Type	Total TU bytes	V1 to V4	Pointer Value Range
TU-11	108	4	104
TU-12	144	4	140
TU-2	432	4	428



▶ ***Figure 15.*** *TU multiframe structure.*