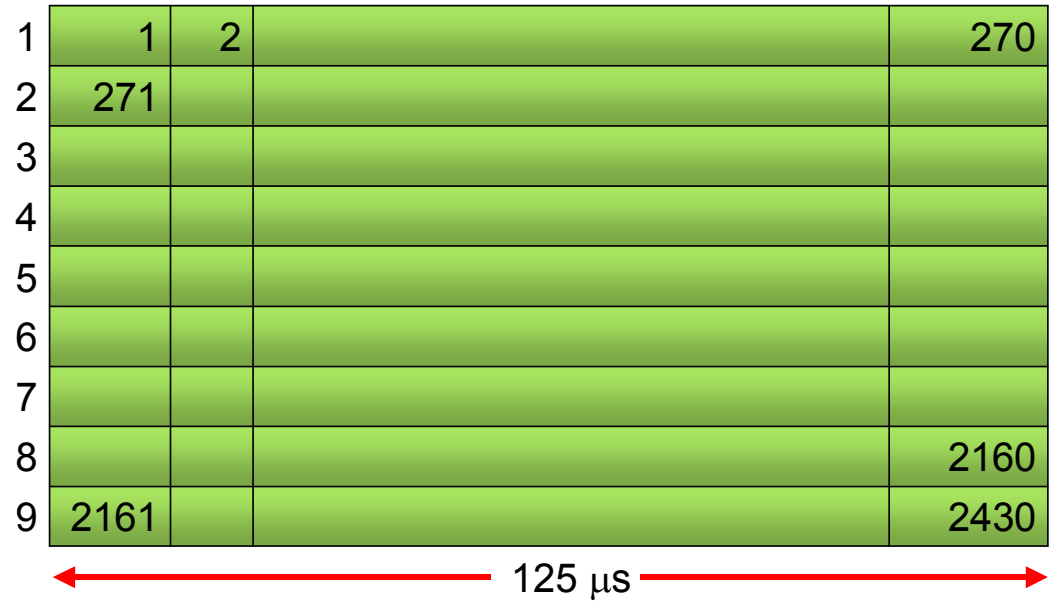
SDH structure

- Basic Structure
  - In 125 μs, 2430 words, each word represent 8 bits which is equivalent to a sample. Hence for 1 second there are 155.52 Mb.
  - Uses word (byte) interleaving. Hence easy to manage.
  - In order to analyze the structure these 2430 words are organized in 9 rows with 270 columns as follows:

Basic Structure



Structure for 2 Mbps and 34 Mbps

2.048 Mbps

1	1	2	3	4
2	5	..	..	..
3	..	..	..	..
4	..	..	..	..
5	..	..	..	..
6	..	..	..	..
7	..	..	..	..
8	..	..	..	32
9	33	34	35	36

125 μs => 36 x 8

1s => 2304 kb

Spare bits = 0.256 (12.5%)

34.368 Mbps

1	2	..	..	..	83	84
85	..	..	..	..	..	..
..	..	..	..	..	..	..
..	..	..	..	..	..	..
..	..	..	..	..	..	..
..	..	..	..	..	..	..
..	..	..	..	..	..	..
..	..	..	..	..	..	..
..	..	..	..	..	755	756

125 μs => 756 x 8

1s => 48.384 kb

Spare bits = 14.02 (40%)

Further reviewed on slide # 15

Spare bits = Path Overhead + justification

For 34 Mbps structure 21 Nos. 2.048 Mbps can be placed

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Observations

- **For 34 Mbps in PDH 2.048 Mbps, 16 streams can be multiplexed**
- **In SDH 21 Nos. can be multiplexed, WHY?**
- **For PDH, CEPT 34.368 Mbps and PDH American equipment is 44.736 Mbps, Hence 84 columns are used for 44.736 Mbps American system, SDH stream stems from American SONET.**
  (CEPT – Committee of European Post & Telecommunication)
- **Hence it has been designated for American 44.736 Mbps, though we are using it for CEPT 34Mbps. That's why there are many spare bits if we use it for 34Mbps directly on STM1.**

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Structure of 34 Mbps when formed from 2Mbps

(Actual 34.368Mbps)

1	1	2	..	..	..	83	84
2	85	..	..	..	..	..	..
3	..	..	..	..	..	..	..
4	..	..	..	..	..	..	..
5	..	..	..	..	..	..	..
6	..	..	..	..	..	..	..
7	..	..	..	..	..	..	..
8	..	..	..	..	..	..	
9		..	..	..	..	755	756
	1	2	..	..	..	..	84

For 125μs => 756 x 8 bits

1 s =>48384

Spare bits for POH + Justification= 9.3444 (6.7%)

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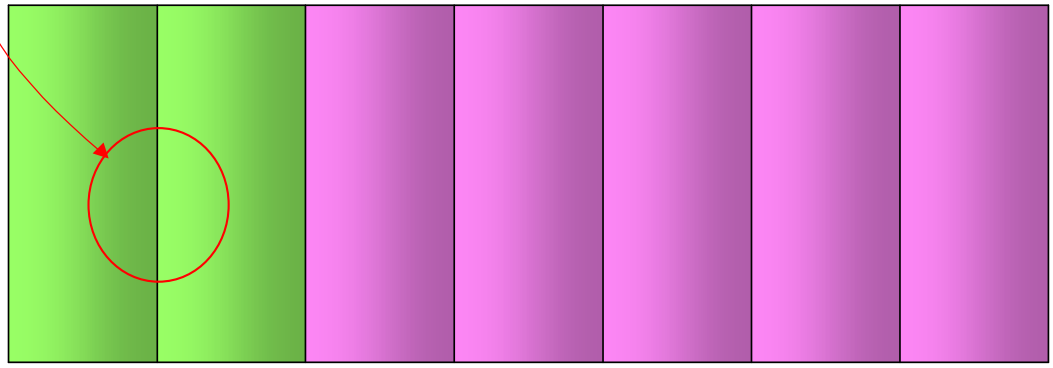
Structure of 34Mbps in STM1 when formed from 34 Mbps itself

- Every basic tributary has to accommodate for each POH + Justification
- Hence for 34 direct to be placed, it needs two more columns to accommodate POH + Justification



If we fill with 21 Nos. of 2.048 Mbps, these first two columns are spare

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Structure of 140 Mbps in STM1 when formed from 34Mbps

(Actual 139.264 Mbps)

1	1	2	..	..	..	257	258
2	259	..	..	..	..	..	..
3	..	..	..	..	..	..	..
4	..	..	..	..	..	..	..
5	..	..	..	..	..	..	..
6	..	..	..	..	..	..	..
7	..	..	..	..	..	..	..
8	..	..	..	..	..	..	1464
9	1465	..	..	..	..	2321	2322
	1	2	..	..	..	..	258

For 125μs => 2322 x 8 bits

1 s => 148.605

Spare bits for POH + Justification= 9.3444 (6.7%)

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Observations

- For 140 Mbps is PDH (CEPT) there are 4 Nos. 34 Mbps streams. But in SDH only 3 Nos 34 Mbps can be accommodated
- 63 Nos 2.048 Mbps can be accommodated in SDH.
- No equipment for PDH 140 Mbps (America)

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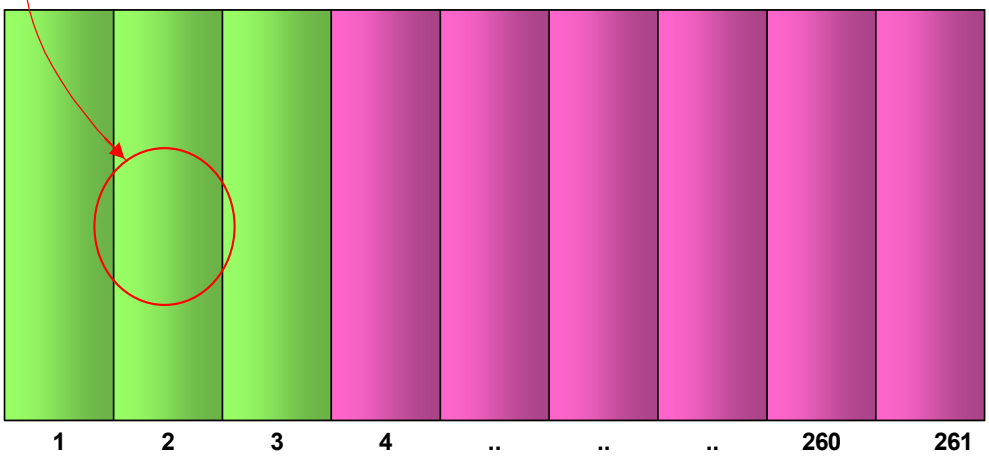
Structure of 140Mbps in STM1 when formed from 140Mbps itself

- Similar reasoning as for 34 Mbps, in order to direct 140 Mbps into SDH, One might think that 3 columns are used for POH and Justification, but it is not. Why?



If we fill with 3 of 34 Mbps, these first 3 columns are spare

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Bytes Allocated for Justification and Matching the speed variations input tributaries

- When we consider TU12, 12.5% bits are available for matching the variations as well as for justification.
- For similar variations TU3 40.0% bits are available
- But or similar variations in TU4, if we use 258 columns 6.7% bits are available, which is not enough when we consider the bit speed. Hence 2 more columns are kept for the treatment of variations in 140Mbps as well as justification (to be adjusted). Hence there is a deviation from the previous thinking and 260 columns are allocated for 140 Mbps instead of 258 columns. One more column is allocated for POH and for the Pointer first 9 bytes of the 4th Row is allocated.

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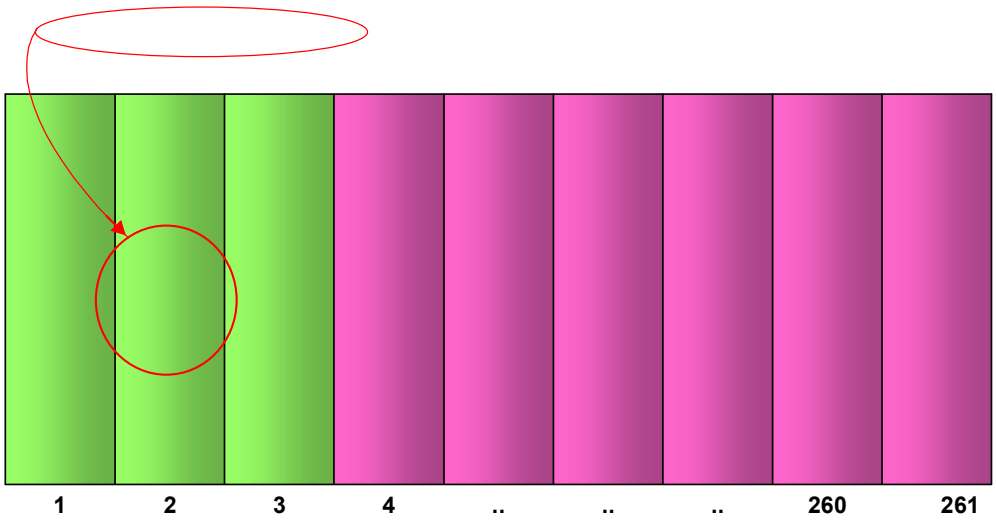
Structure of 140Mbps in STM1 when formed from 140Mbps itself

- **Additional 3 columns are**



If we fill with 3 of 34 Mbps, these first 3 columns are spare

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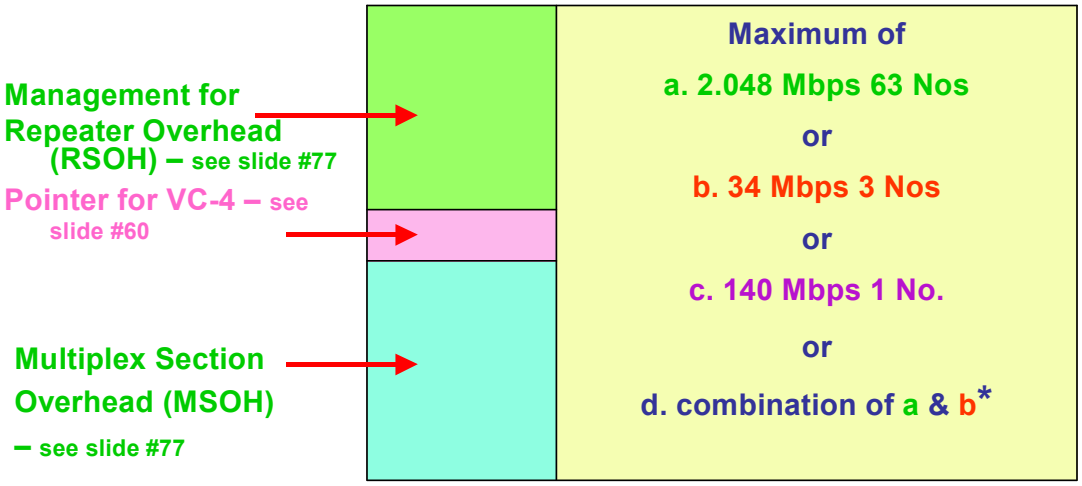
Accommodation of Bit Rates for SDH



* if,

- 1 No of 34 Mbps then a maximum of 42 Nos. of 2 Mbps

or

- 2 Nos of 34 Mbps then a maximum of 21 Nos. of 2 Mbps

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Building blocks of STM1

- 2 Mbps is the lowest speed for European system to be connected to STM1
- Then 34 Mbps and 140 Mbps systems can be connected
- 8 Mbps cannot be connected to STM1
- STM1 can be made either from 140 Mbps or a combination of 2Mbps and 34 Mbps. Hence the basic building block has been designed to accommodate the above thinking
- TU is the basic building block of SDH, from PDH for 2 Mbps or 34 Mbps
  - TU12 = 2 Mbps
  - TU3 = 34 Mbps
- Intermediate multiplexing point has been created to accommodate American systems.

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PDH

There are 3 standards in the world: CEPT. North America and Japan. SDH can combine all these 3 systems except CEPT 8.448Mbps and Japan 32.064Mbps and 97.728 Mbps

* - these bit rates are not directly accommodated in SDH

CEPT Mbps	North America Mbps	Japan Mbps
2.048	1.544	1.544
8.448*	6.312	6.312
34.368	44.376	32.064*
139.264		97.728*

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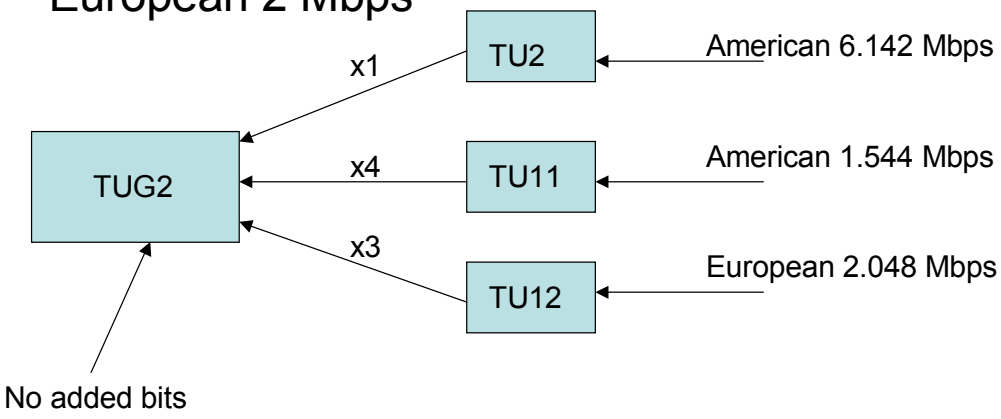
Unification of Lower Tributaries of US & CEPT

- For example, TUG2 to accommodate American 6 Mbps and 1.5 Mbps with European 2 Mbps



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- **Also intermediate multiplexing point has been introduced in addition to mixing of European and American systems to accommodate lower speed tributaries**
- **Ex: TUG3**
- **While TUG3 can accommodate European 34 Mbps and American 44Mbps, it can accommodate 7 of TUG 2**

- **See next slide**

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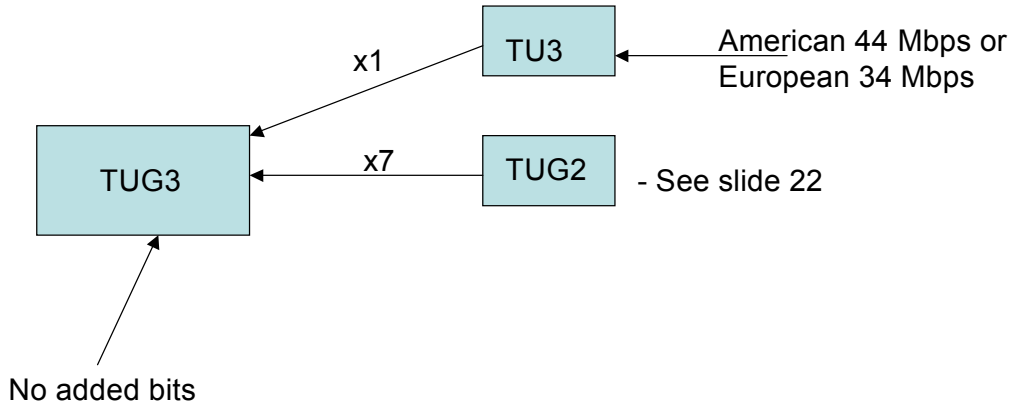
Unification of Higher Tributaries of US & CEPT



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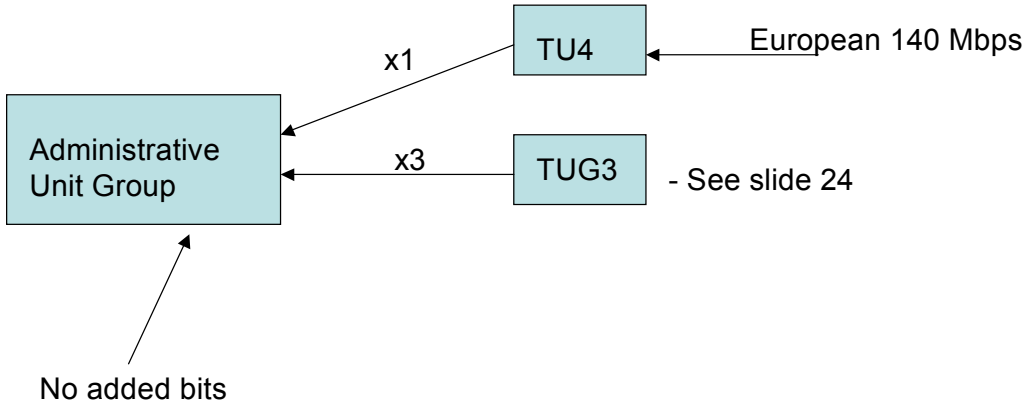
- Highest multiplexing point has been introduced to accommodate European 140 Mbps and to accommodate lower bit speed tributaries



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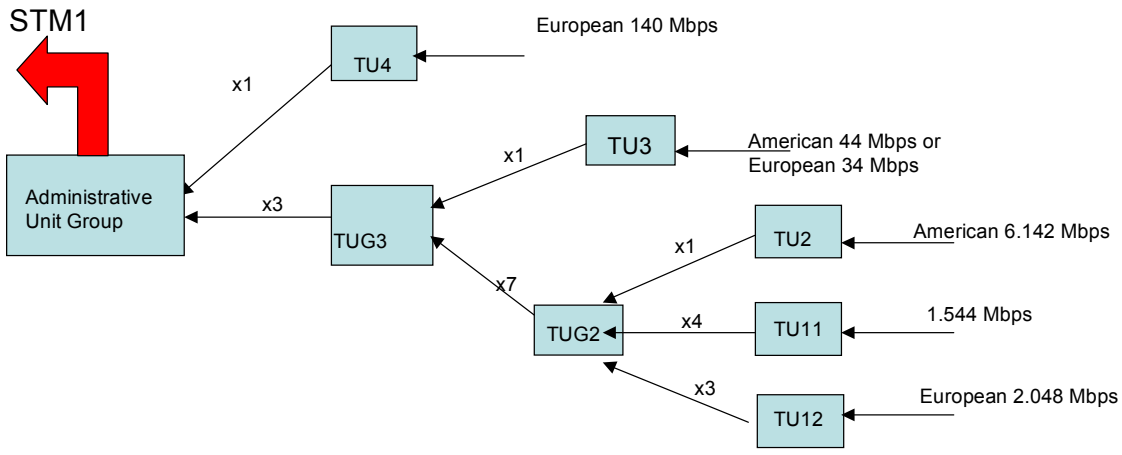
Summary of Multiplexing up to STM1



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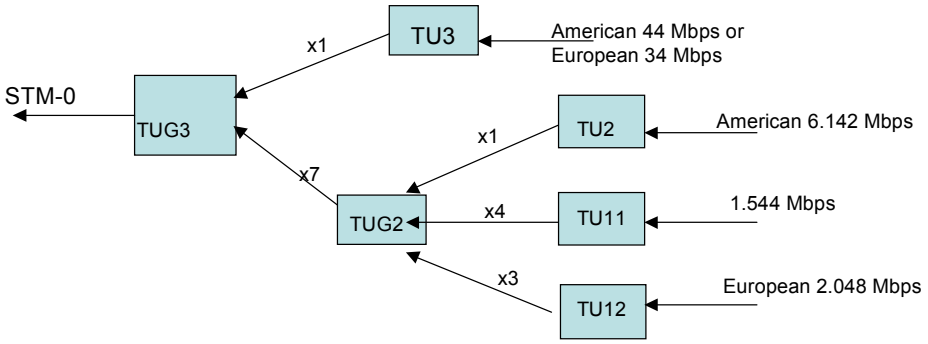
Adaptation of STM in Satellites

- Instead of 155.52 Mbps a lower bit rate 51.84 Mbps is adopted for satellite communication.



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Higher Order STM

- Unlike PDH, in SDH when it goes to higher order no additional bits are inserted at higher order multiplexing points. The following gives the details of higher order STMs.

	Bit rate (Mbps)	Approximate bit rates	Calculation of higher order bit rates	No. of voice channels	Bit period
STM1	**155.52**			**1,890**	**6.4ns**
STM4	**622.08**		**=155.52 x 4**	**7,560**	**1.6ns**
STM16	**2488.32**	**~2.5Gbps**	**=622.08 x 4**	**30,240**	**400ps**
STM64	**9953.28**	**~10Gbps**	**=2488.32 x 4**	**120,960**	**100ps**

Note: Conventional CEPT PCM of 30 channels is assumed.

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Interface Between PDH and SDH

- For explanation CEPT system is used. Same concept applies for other systems.
- PDH tributary will be converted to a virtual container by adding Path Overhead (POH) bits, so that each tributary the originating and destination nodes can be identified.
- This Virtual Container (VC) will be added a Pointer. Hence, made as a Tributary Unit (TU). The pointer thus added will provide the justification of PDH tributary with respect to the SDH tributary.
- The pointer will help at the demultiplexing point to demultiplex to the correct phase of the original PDH signal.

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What is Justification

- Imagine 2 compartments of a train. It is connected with a pair of buffers and flexible chain.
- If the first moving compartment going faster the next. The chain will pull the next compartment. This is equivalent to 'Positive Justification.'
- If the first compartment is moving slower than the next the buffers will collide and slow down the next one. This is equivalent to 'Negative Justification'.
- In this example, the first moving compartment is analogous to higher order tributary and the next is equivalent to primary tributary.

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Effects of Justification

- Assume secondary tributary speed f_s
- Assume primary tributary speed f_p
- If $f_s > f_p$, Positive Justification, the effect will be to read one information bit of primary as two information bits of secondary. Hence, in secondary one bit has to be inhibited.
- If $f_s < f_p$, Negative Justification, the effect will be to lose one information bit of primary in the secondary. Hence, in secondary one bit has to be introduced.
- If $f_s = f_p$, Zero Justification, the ideal situation but difficult to realize in practice.
- In SDH, all the above 3 justifications will be achieved by introduction of a pointer in addition to the information and path overhead bits.

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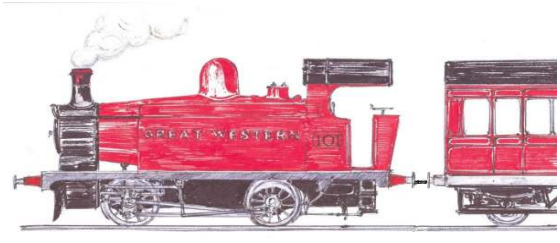
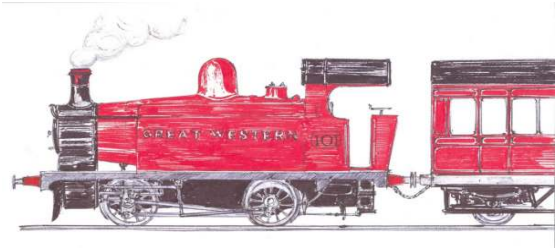
Train Analogy

Buffer – chain coupling mechanism



- Positive Justification
- Tension in the chain



- Negative Justification
- Compression in the buffer

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Formation of Tributary Units

- In SDH, the basic PDH tributary (whether 2Mbps, 34Mbps or 140Mbps) will be carried in any order of STM as a respective tributary unit of TU-12, TU-3 or AU-4.
- The basic PDH will be treated at the entrance as a container of bits. This container will be added certain overhead bits to match to the STM bit period of 6.7ns. This is called a container (C-12, C-3 or C-4).
- These containers are then added with management-bits-like path overhead. POH plays vital role in operation, administration and maintenance of original PDH tributaries up to the transportation to the required destination of the same. The basic functions of POH includes error detection and transmission path verification. So that this container can be treated as a Virtual Container (VC). Hence this will become VC-12, VC-3 or VC-4.
- This virtual container will be further added with Justification Bits or called as a Pointer to indicated the phase differences between the PDH tributaries with respect to the STM1.
- The STM1 will have a separate pointer to be used when it is multiplexed further to a higher order SDH.

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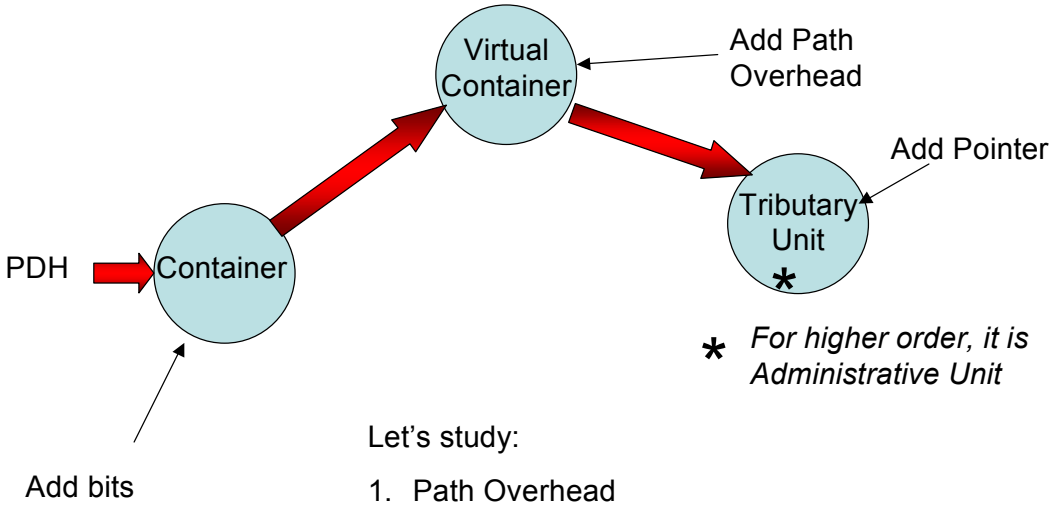
Summary of Tributary Unit Formation



Let's study:

1. Path Overhead
2. Pointer

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