Synchronous Digital Hierarchy (SDH)

- **Agenda**

Introduction
SDH advantages
Bit Rates
Standard Frame representation
Frame structure
Transport overhead
SDH Multiplexing
Concatenation
Justification
Architecture
SDH Equipment
Network topologies
Network protection
Quality standards

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Synchronous Digital Hierarchy (SDH)

- Introduction

SONET(Synchronous Optical Network) or SDH(Synchronous Digital Hierarchy) as it's known in Europe, is a set of standards for interfacing Operating Telephone Company(OTC) optical networks.

They are a set of global standards for interfacing equipment from different vendors(One of the few where telephony is concerned).

SONET is the protocol for North America and Japan while SDH is the definition for Europe. The differences between SONET and SDH are slight.

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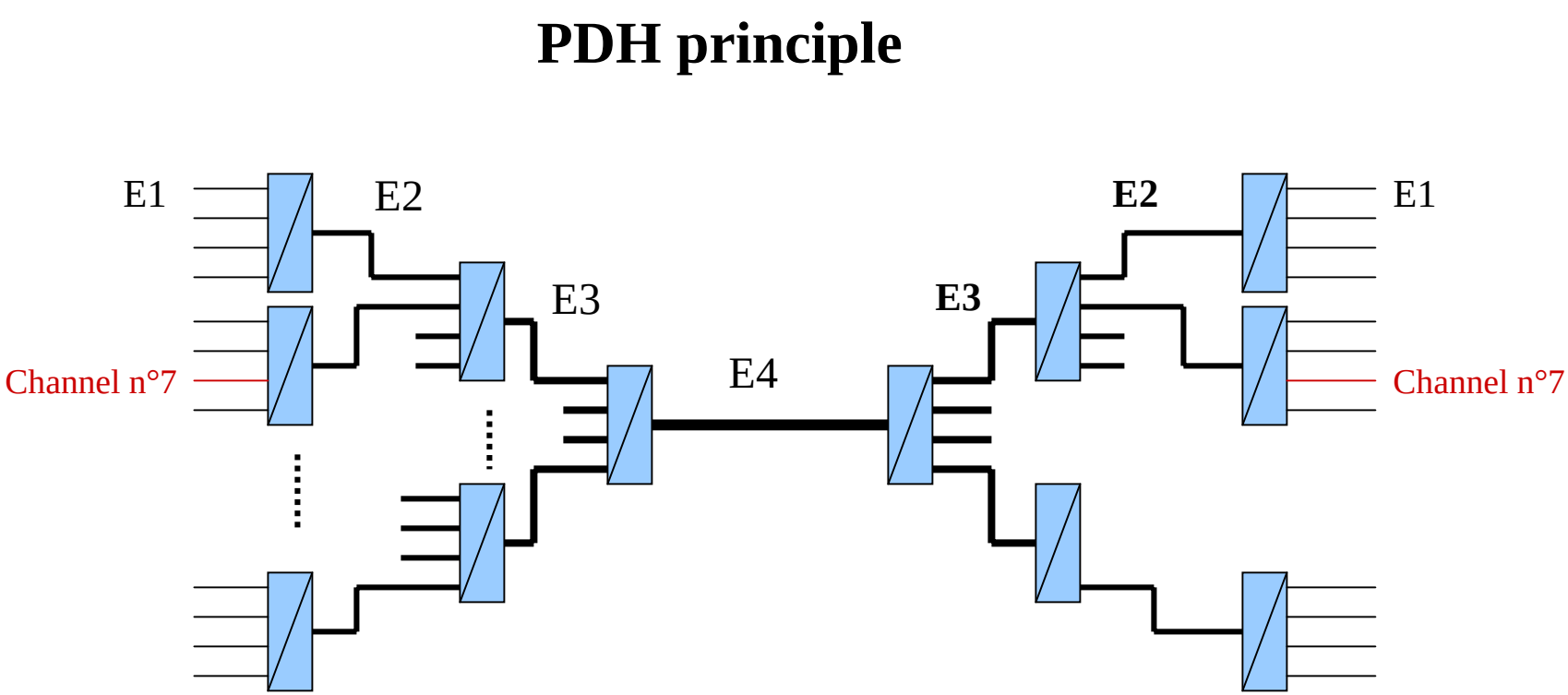
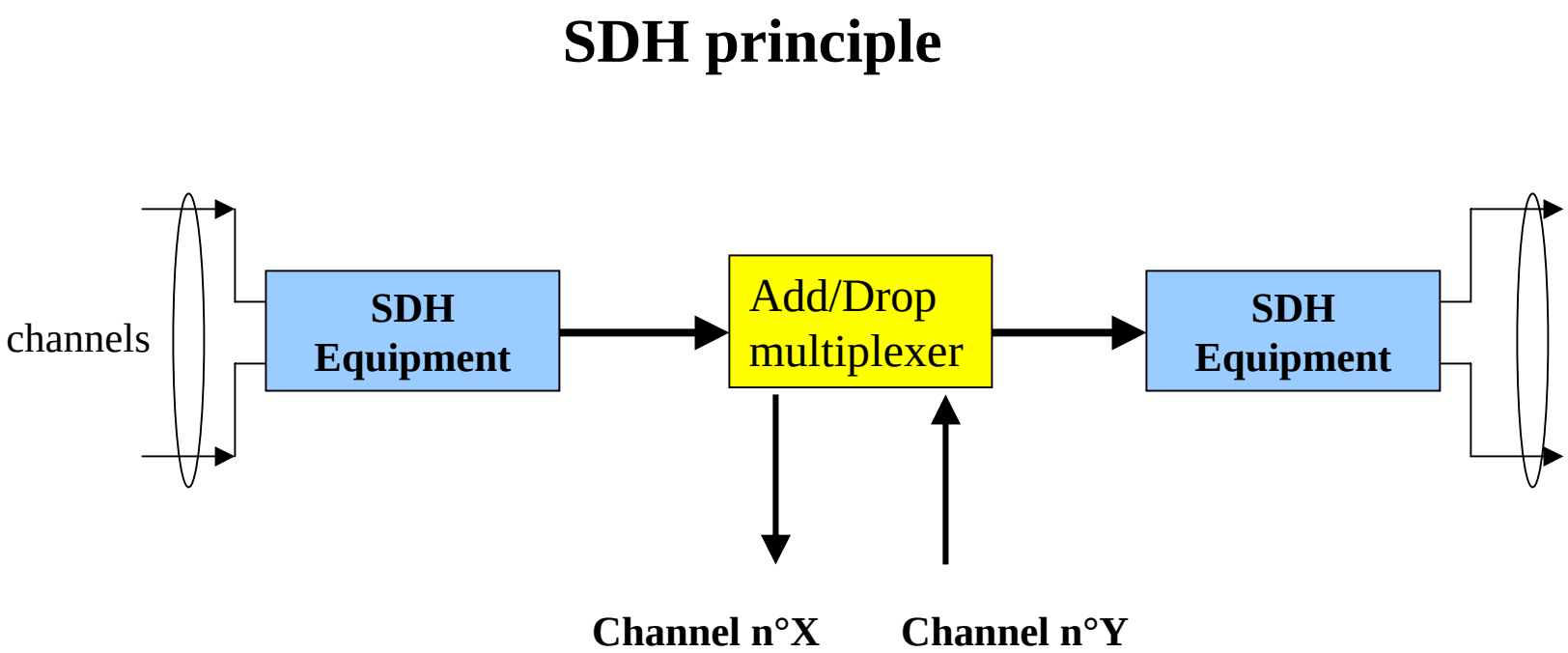
Synchronous Digital Hierarchy (SDH)

- SDH Advantages versus PDH



Synchronous Digital Hierarchy (SDH)

- SDH Advantages versus PDH



Synchronous Digital Hierarchy (SDH)

- SDH Advantages versus PDH

SDH is based on the principal of direct synchronous multiplexing.

Essentially, separate, slower signals can be multiplexed directly onto higher speed SDH signals without intermediate stages of multiplexing.

SDH is more flexible than PDH and provides advanced network management and maintenance features.

Can be used in the three traditional telecommunications areas: long-haul networks, local networks and loop carriers. It can also be used to carry CATV video traffic.

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Bit Rates

Optical Level	Electrical Level	Line Rate (Mbps)	SDH Equivalent
OC-1	**STS-1**	**51.84**	**---**
OC-3	STS-3	155.520	STM-1
OC-9	**STS-9**	**466.56**	**STM-3**
OC-12	STS-12	622.080	STM-4
OC-18	**STS-18**	**933.120**	**STM-6**
OC-24	**STS-24**	**1244.160**	**STM-8**
OC-36	**STS-36**	**1866.240**	**STM-13**
OC-48	STS-48	2488.320	STM-16
OC-96	**STS-92**	**4976.640**	**STM-32**
OC-192	STS-192	9953.280	STM-64

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Synchronous Digital Hierarchy (SDH)

- Bit Rates

International organization defined standardized bit rates :

155, 520 Mbit/s	→	STM1
622, 080 Mbit/s	→	STM4
2,488 Gbit/s	→	STM16
9,953 Gbit/s	→	STM64

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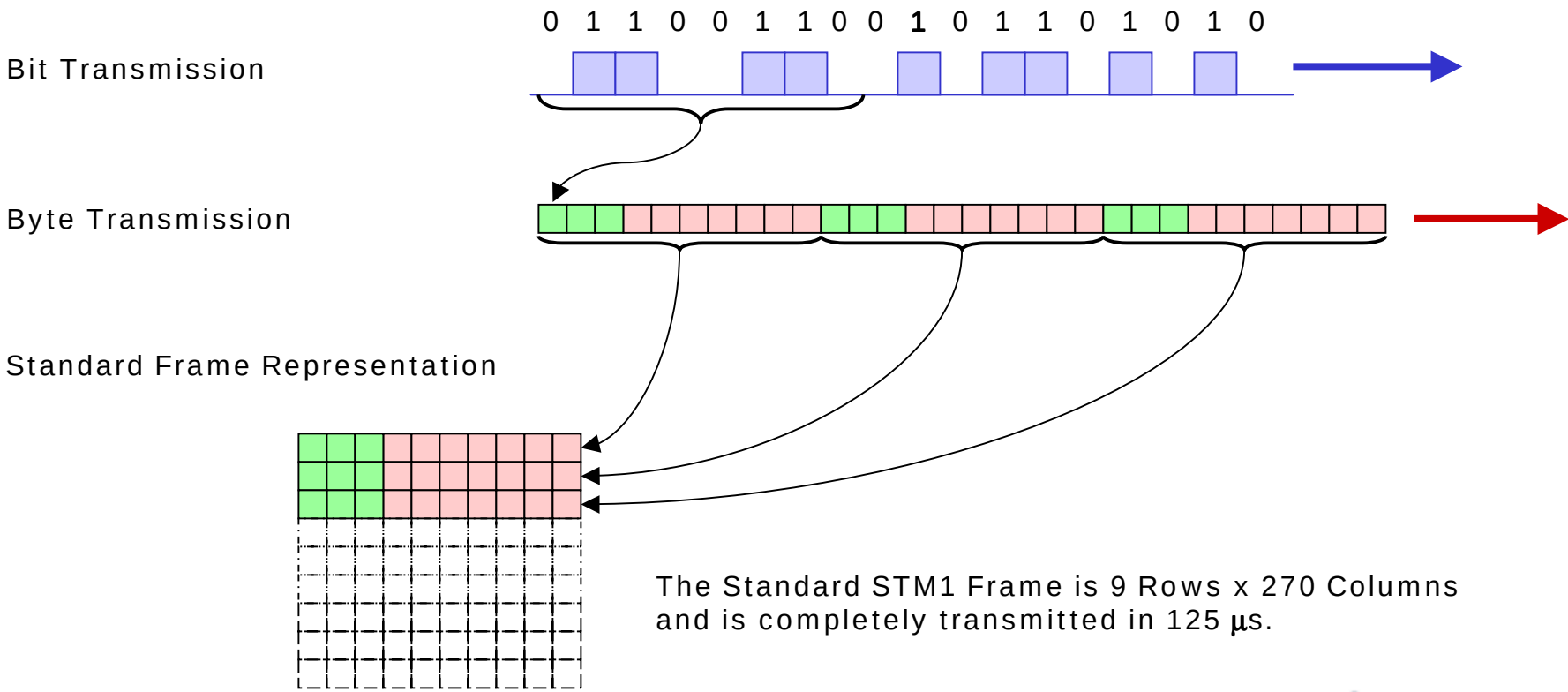
Synchronous Digital Hierarchy (SDH)

- SDH : Standard Frame Representation

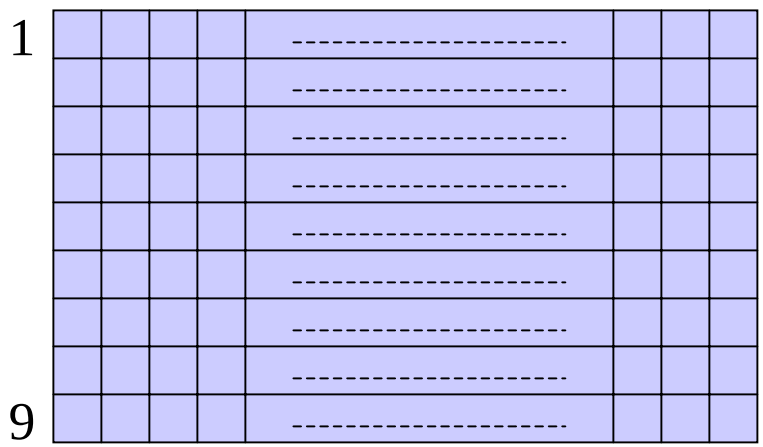


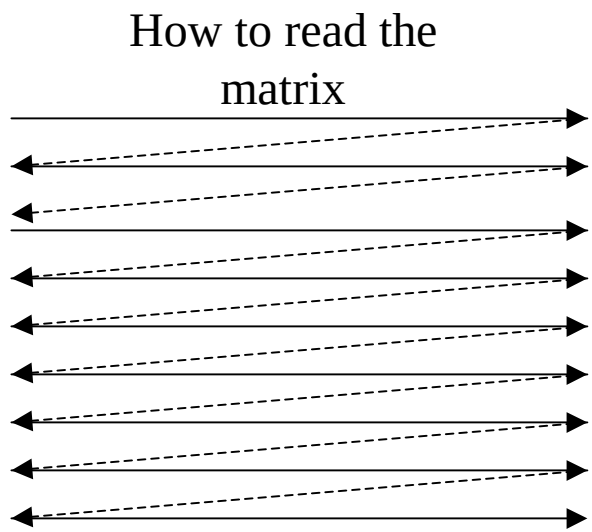
The Standard STM1 Frame is 9 Rows x 270 Columns and is completely transmitted in 125 µs.

Synchronous Digital Hierarchy (SDH)

- SDH : Standard Frame Representation

Everywhere in the world, the standard SDH frame representation is a : **MATRIX with 9 rows**





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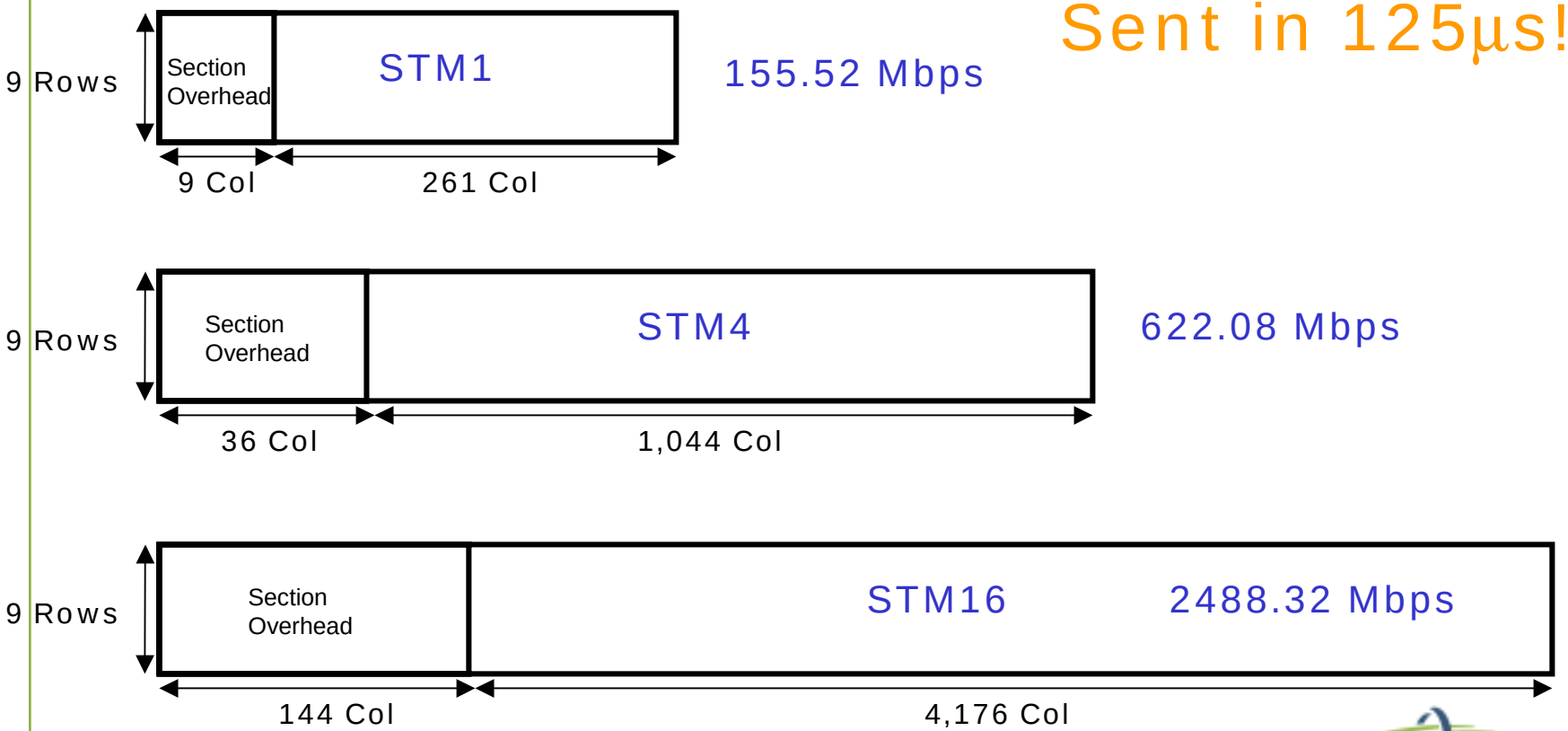
Synchronous Digital Hierarchy (SDH)

- SDH frame structure

Each Frame is Sent in 125µs!



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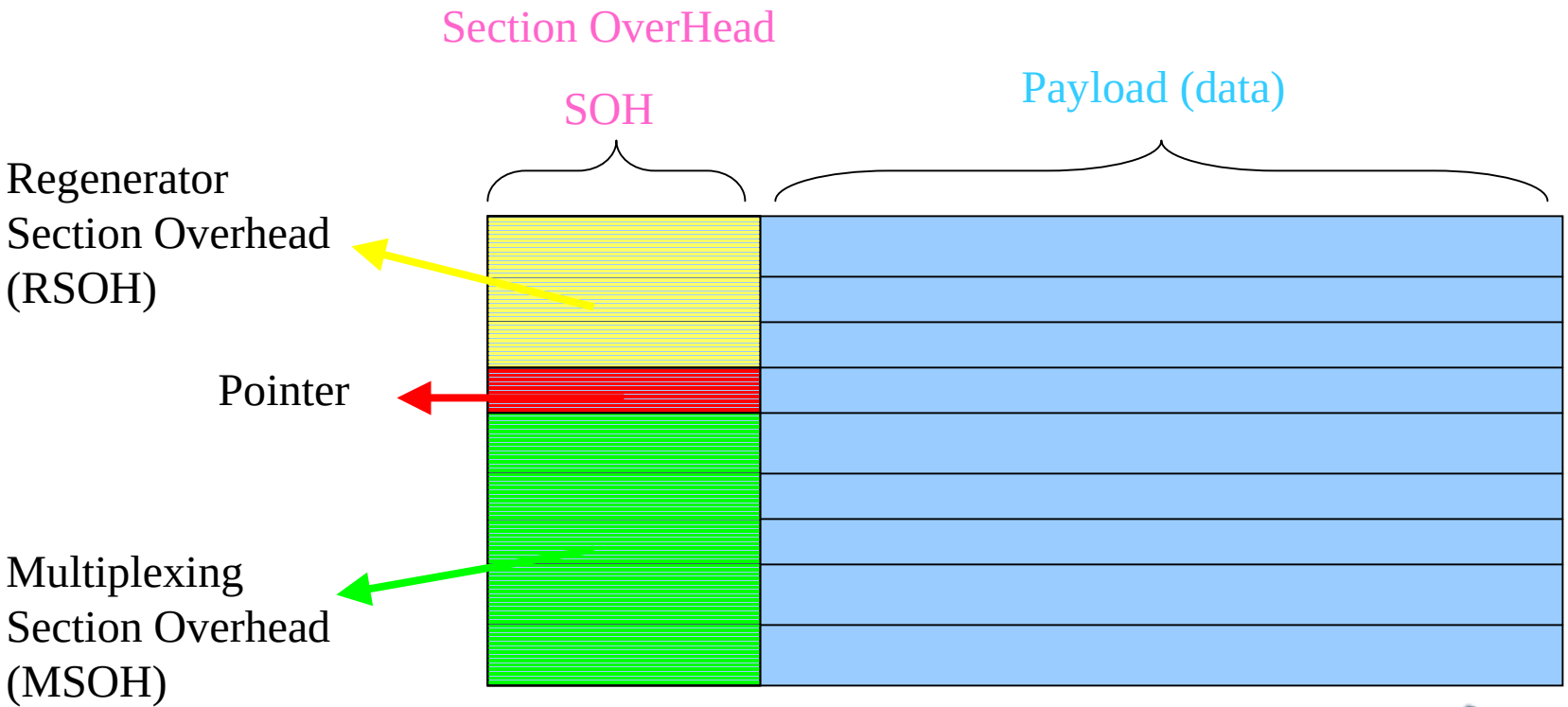
Synchronous Digital Hierarchy (SDH)

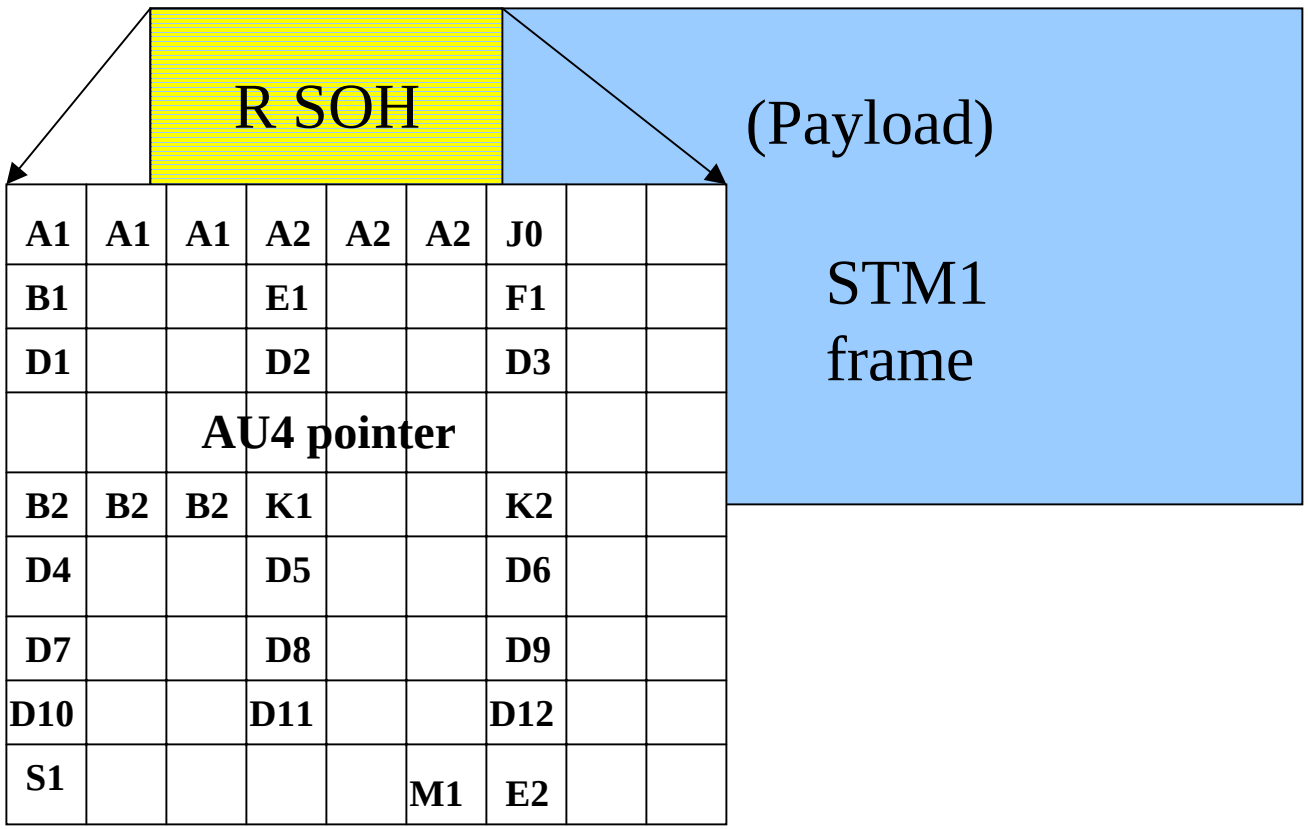
- SDH frame structure

  All SDH frames have the same structure :



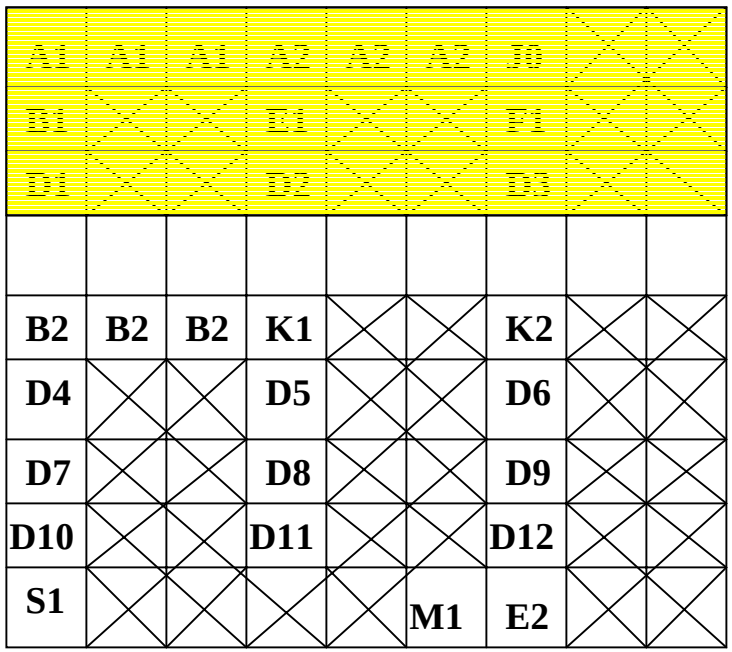
Synchronous Digital Hierarchy (SDH)

- Transport Overhead : SOH



Synchronous Digital Hierarchy (SDH)

- Transport Overhead : SOH



A1 and A2 : frame alignment word

B1 : Regenerator setion error monitoring

J0 : STM1 identifier (16 bytes word)

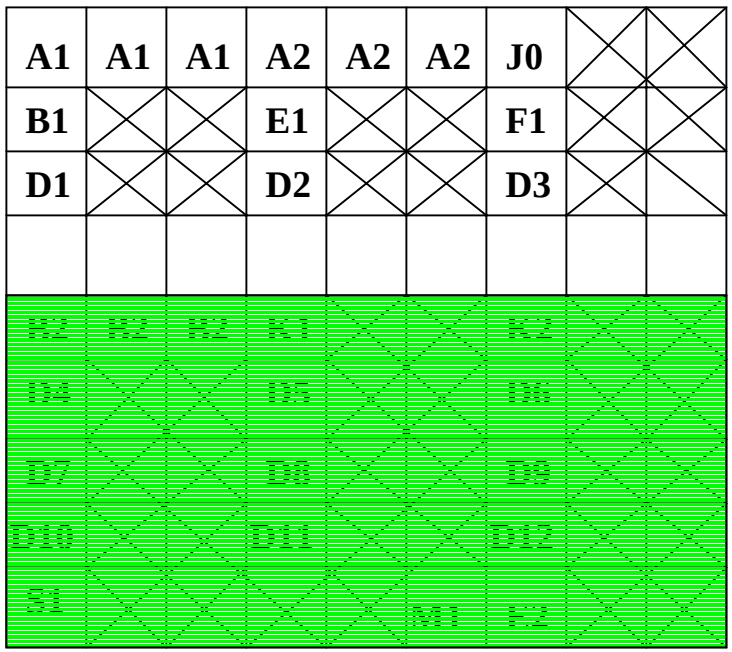
E1 : Service channel (transport a 64 Kbit/s channel)

F1 : user channel. May be used for network exploitation

D1-D3 : Data communication Channel at 192 Kbit/s.

Synchronous Digital Hierarchy (SDH)

- Transport Overhead : SOH



B2 : Multiplexing section error monitoring

K1 and K2 : Automatic protection switching signalling

D4-D12 : Data communication Channel at 576 Kbit/s.

S1 : bytes of synchronization status

M1 : Binary code for number of errored blocks

E2 : service channel at 64 Kbit/s

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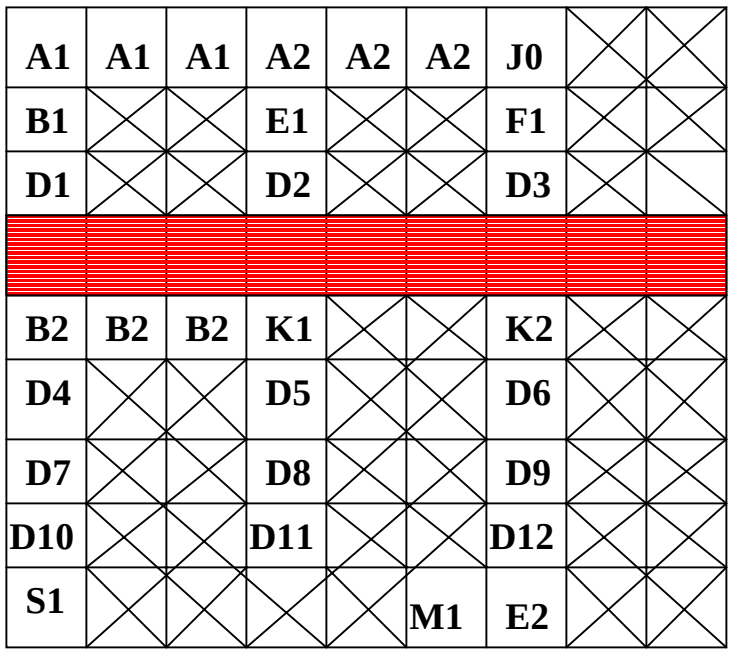
Synchronous Digital Hierarchy (SDH)

- Transport Overhead : AU 4 pointer



The secret to making SDH work is the payload pointer. The tributaries coming into a multiplexer may have been created with a clock running at a different speed. They are not necessarily aligned with each other or with the clock in the multiplexer. To resolve this problem, remember that this is a SYNCHRONOUS network, the SDH multiplexer finds the beginning of a frame for each tributary.

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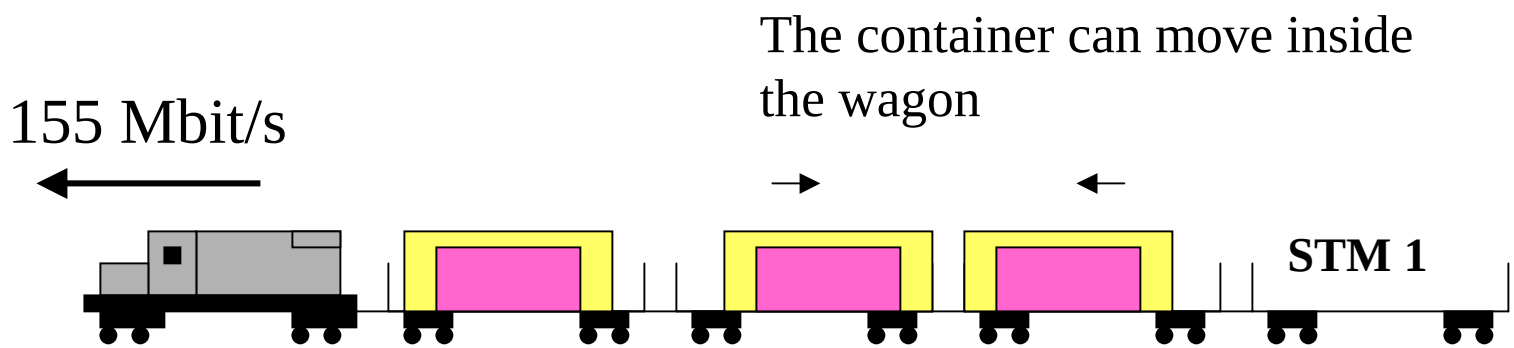
Synchronous Digital Hierarchy (SDH)

- Transport Overhead : AU4 pointer

  In order to illustrate the pointer working, have a look on the following picture :



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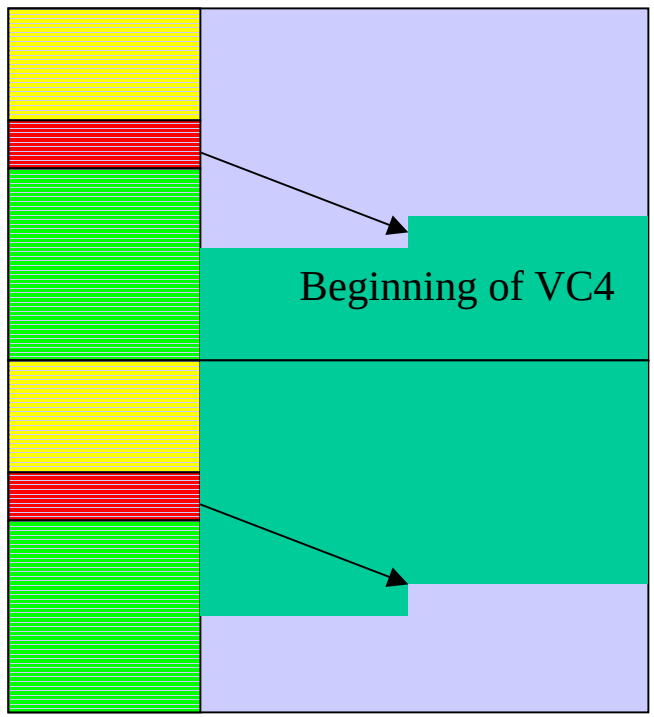
Synchronous Digital Hierarchy (SDH)

- Transport Overhead : AU4 pointer

You have exactly the same phenomenon in SDH :



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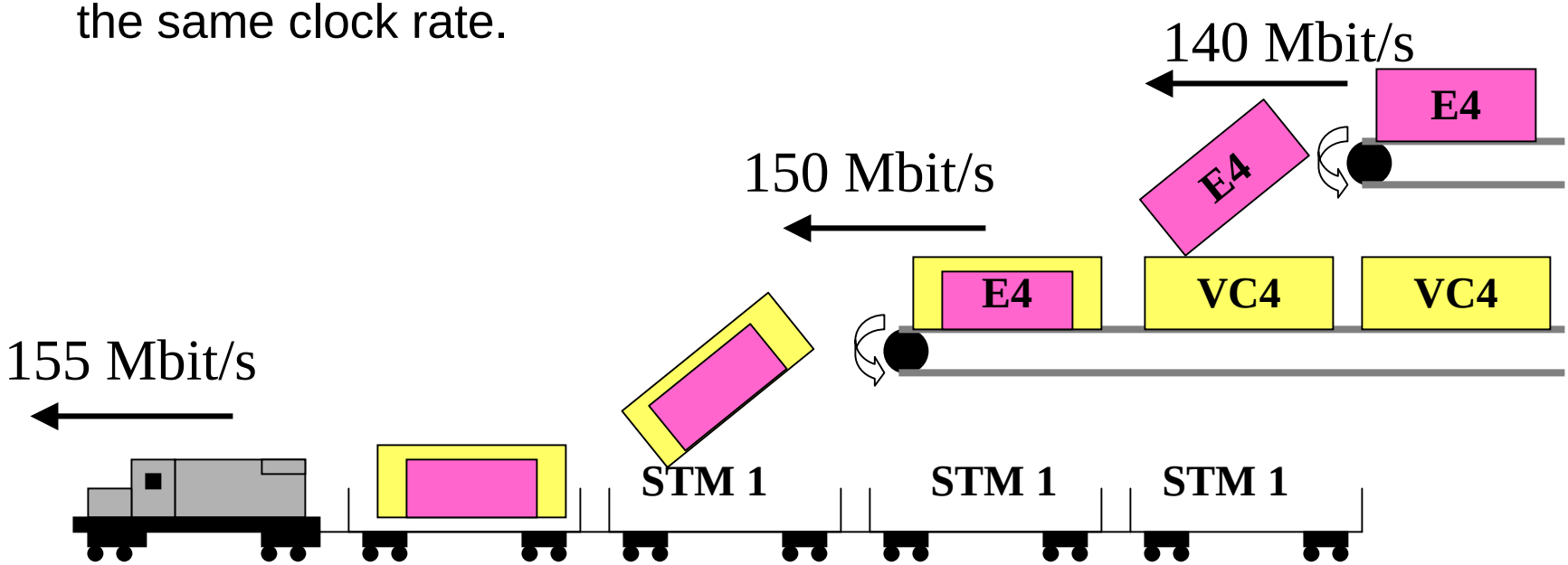
Synchronous Digital Hierarchy (SDH)

- SDH Multiplexing

SDH is a new way of multiplexing slow signals onto a faster signal. It has mechanisms for dealing with tributaries that are not running at the same clock rate.

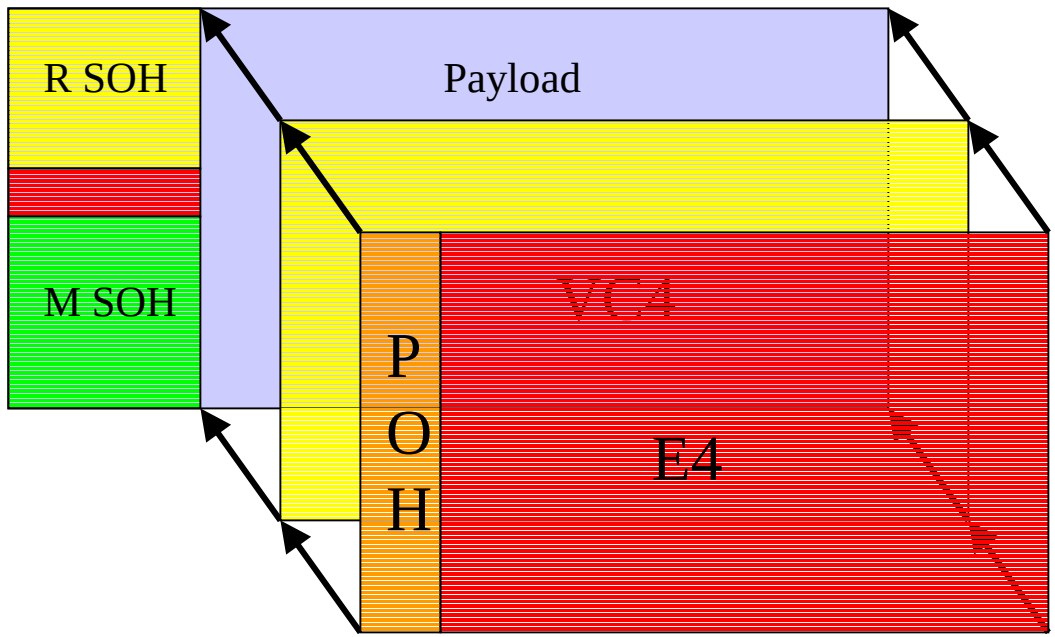


Synchronous Digital Hierarchy (SDH)

- SDH Multiplexing

  Translation of the previous picture in SDH language :

STM1 frame



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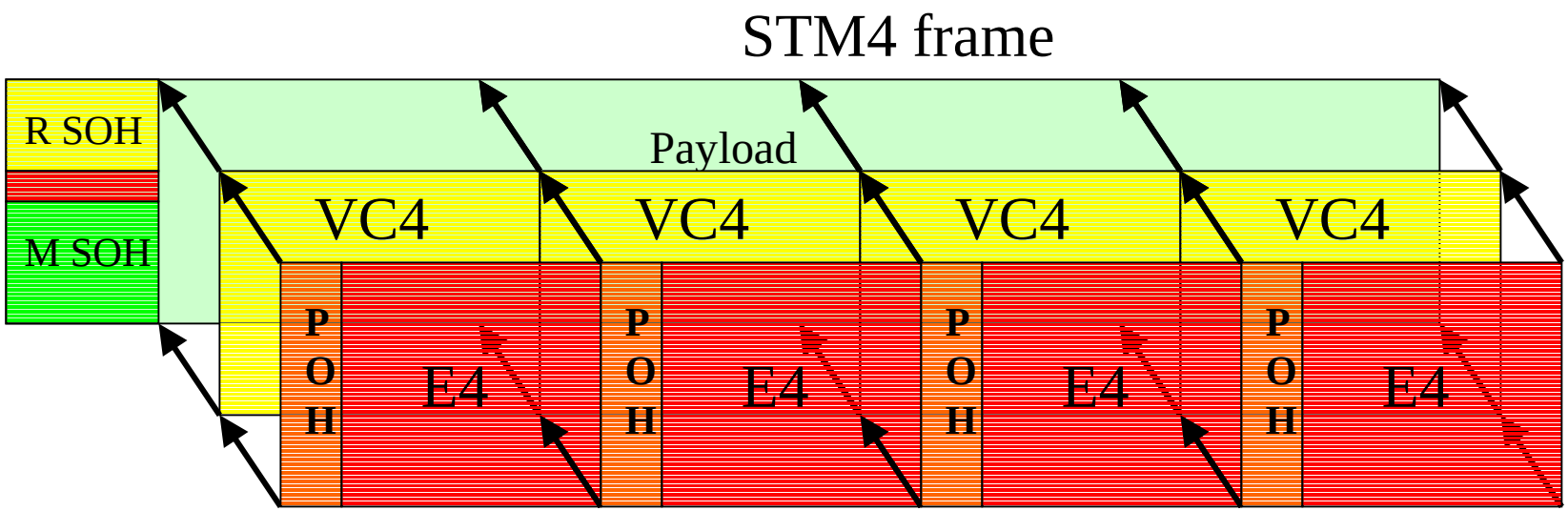
Synchronous Digital Hierarchy (SDH)

- SDH Multiplexing



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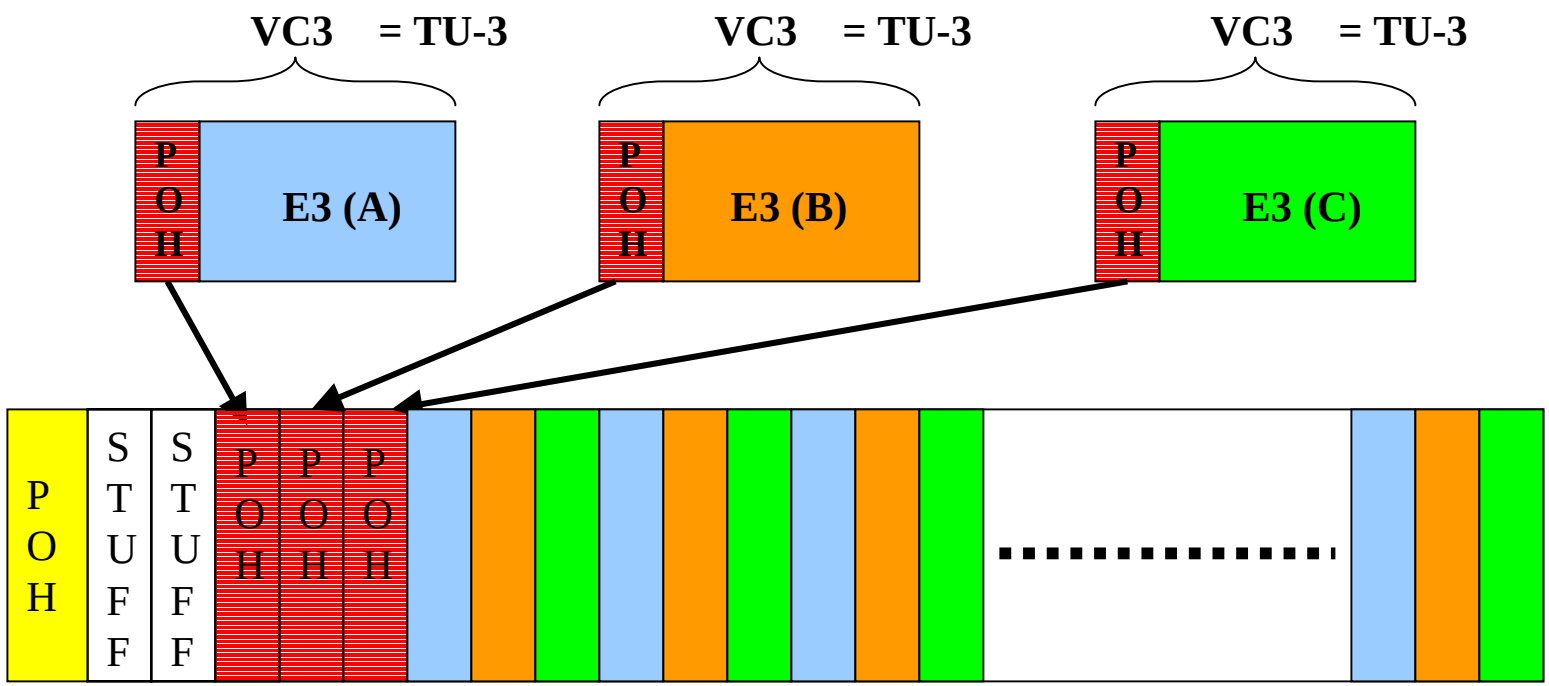
Synchronous Digital Hierarchy (SDH)

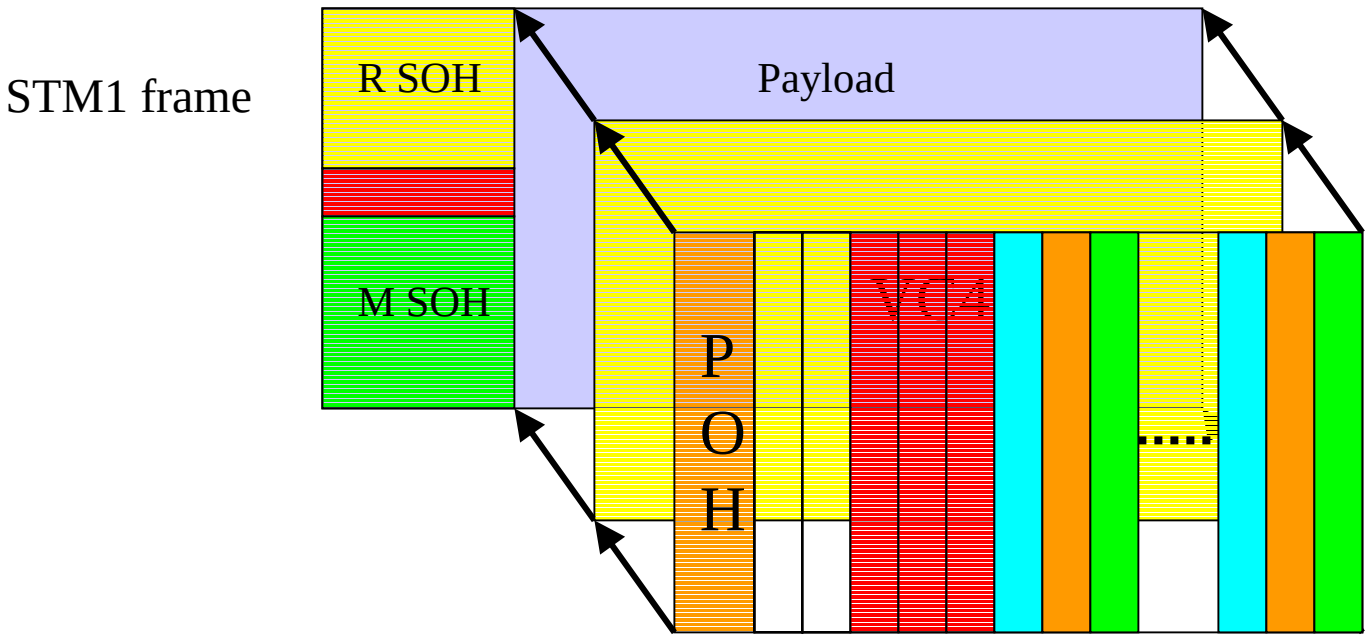
- SDH Multiplexing : another example (E3=>STM1)

  You can map 3 E3 (34 Mbit/s) onto one STM1.



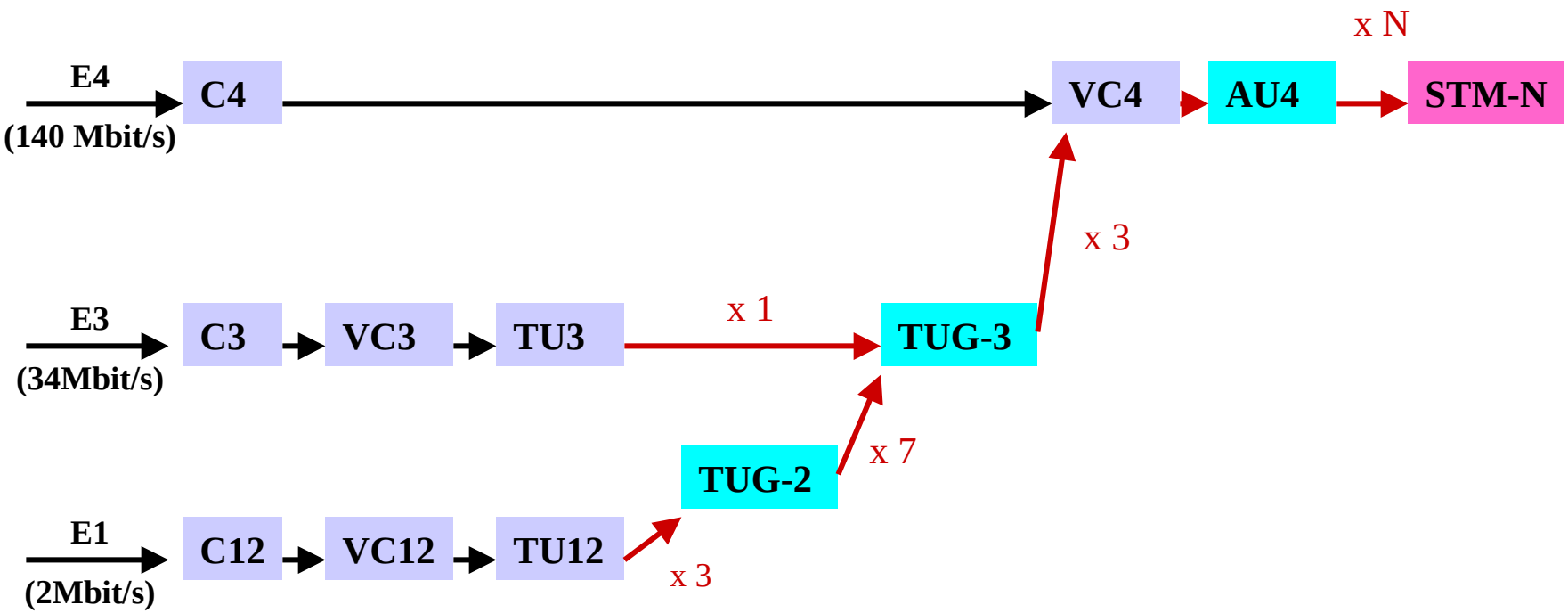
Synchronous Digital Hierarchy (SDH)

- SDH Multiplexing : another example (E3=>STM1)



Synchronous Digital Hierarchy (SDH)

- The SDH Multiplexing map



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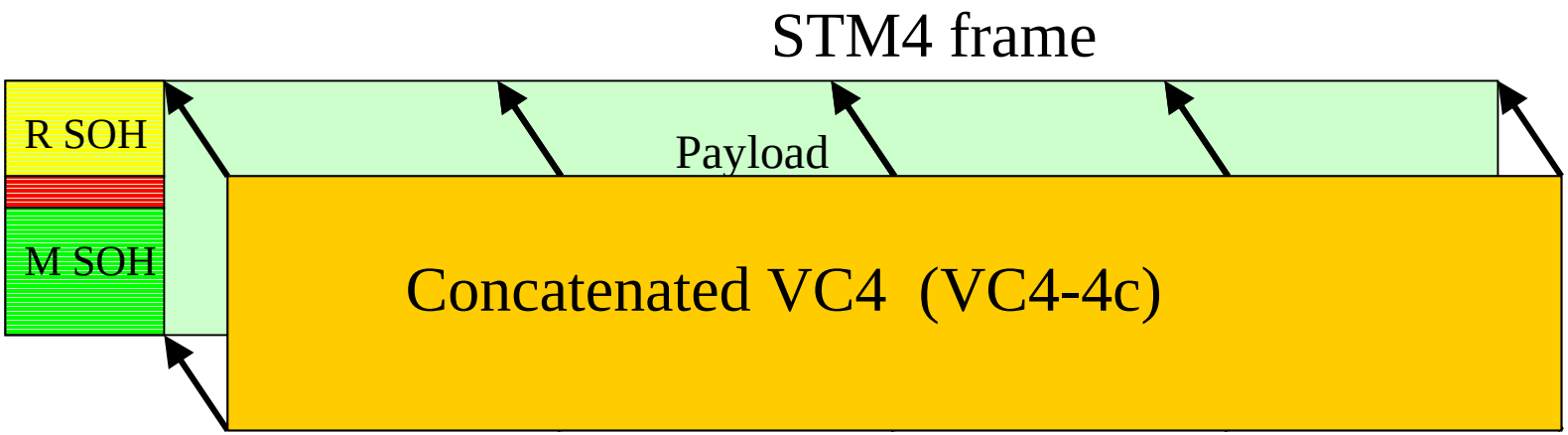
Synchronous Digital Hierarchy (SDH)

- What is the « concatenation » ?



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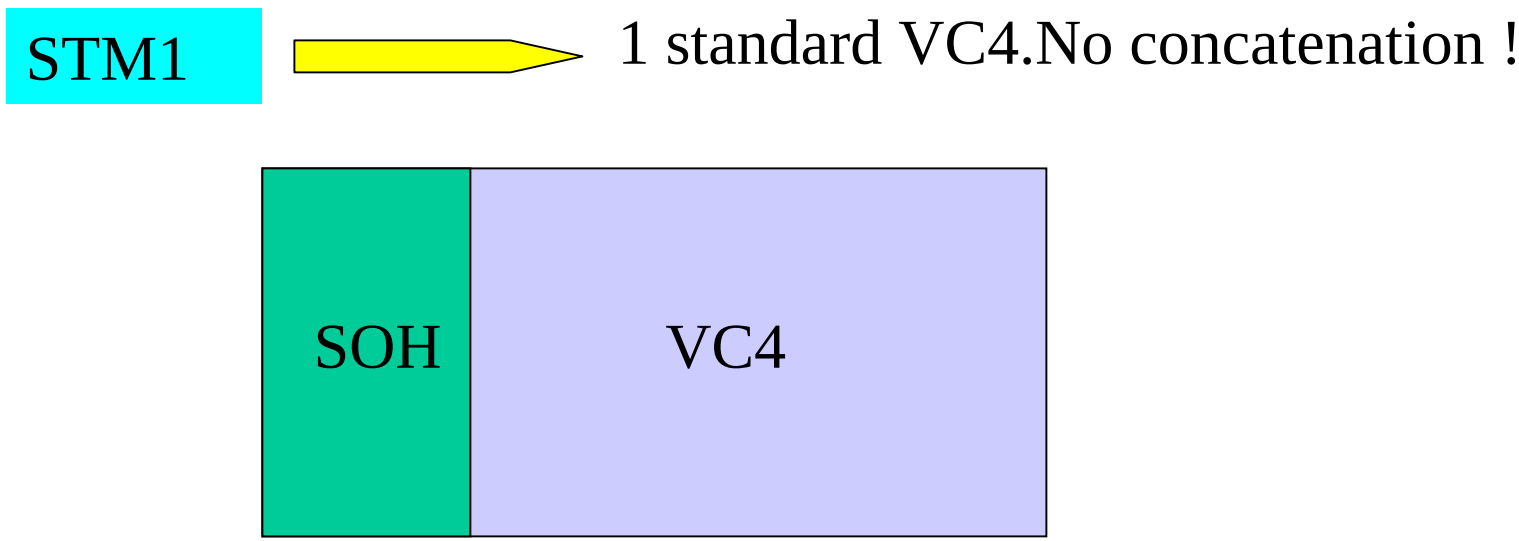
Synchronous Digital Hierarchy (SDH)

- What are the different « concatenation » possibilities?



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Synchronous Digital Hierarchy (SDH)

- What are the different « concatenation » possibilities?

STM4 → 4 standard VC4
1 concatenated VC4-4c

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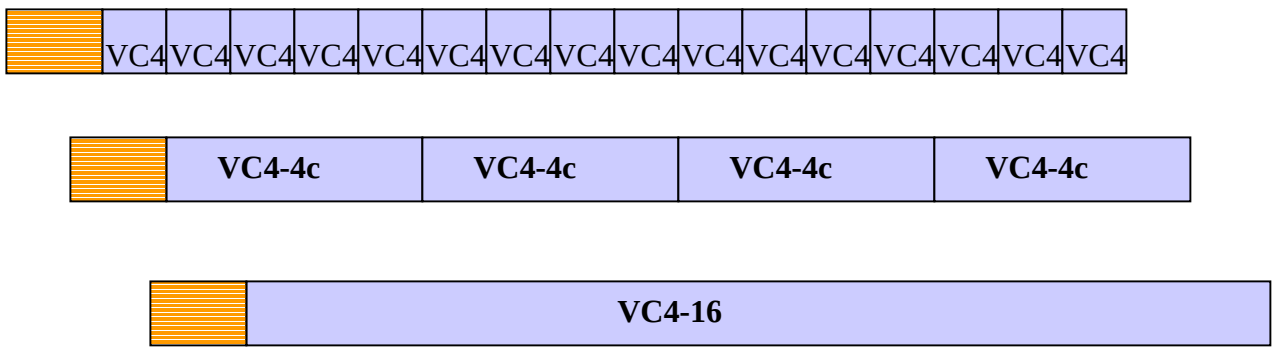
Synchronous Digital Hierarchy (SDH)

- What are the different « concatenation » possibilities?

STM16 → 16 standard VC4
4 concatenated VC4-4c
1 concatenated VC4-16c



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Synchronous Digital Hierarchy (SDH)

- What are the different « concatenation » possibilities?

STM64 → 64 standard VC4
16 concatenated VC4-4c
4 concatenated VC4-16c
1 concatenated VC4-64c

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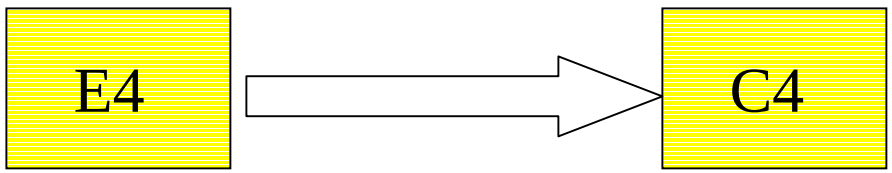
Synchronous Digital Hierarchy (SDH)

- What is the « Justification » ?



In theorie, the E4 speed should be the same than the C4 speed.

But in pratical, the E4 speed can be a little bit faster or slower than the theorical speed.

If you want to adapt the speed variation, you need a special system called « justification » each time you want to map a tributary.

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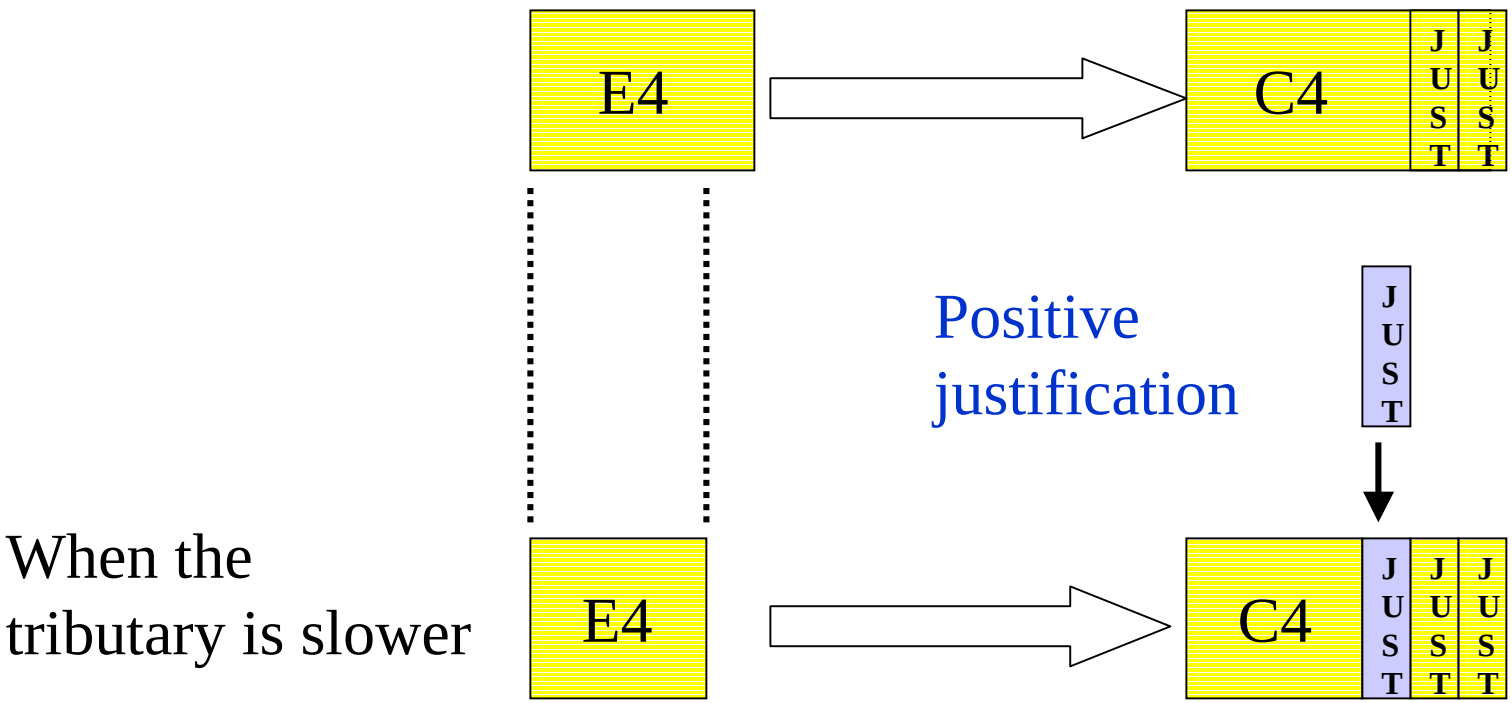
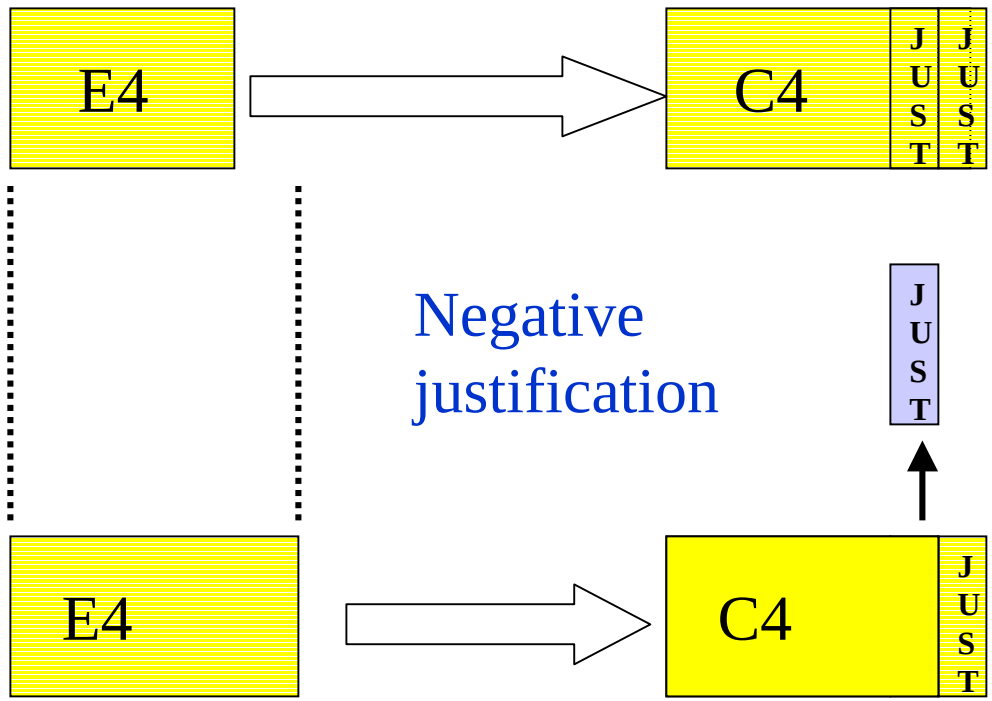
Synchronous Digital Hierarchy (SDH)

- What is the « Justification » ?



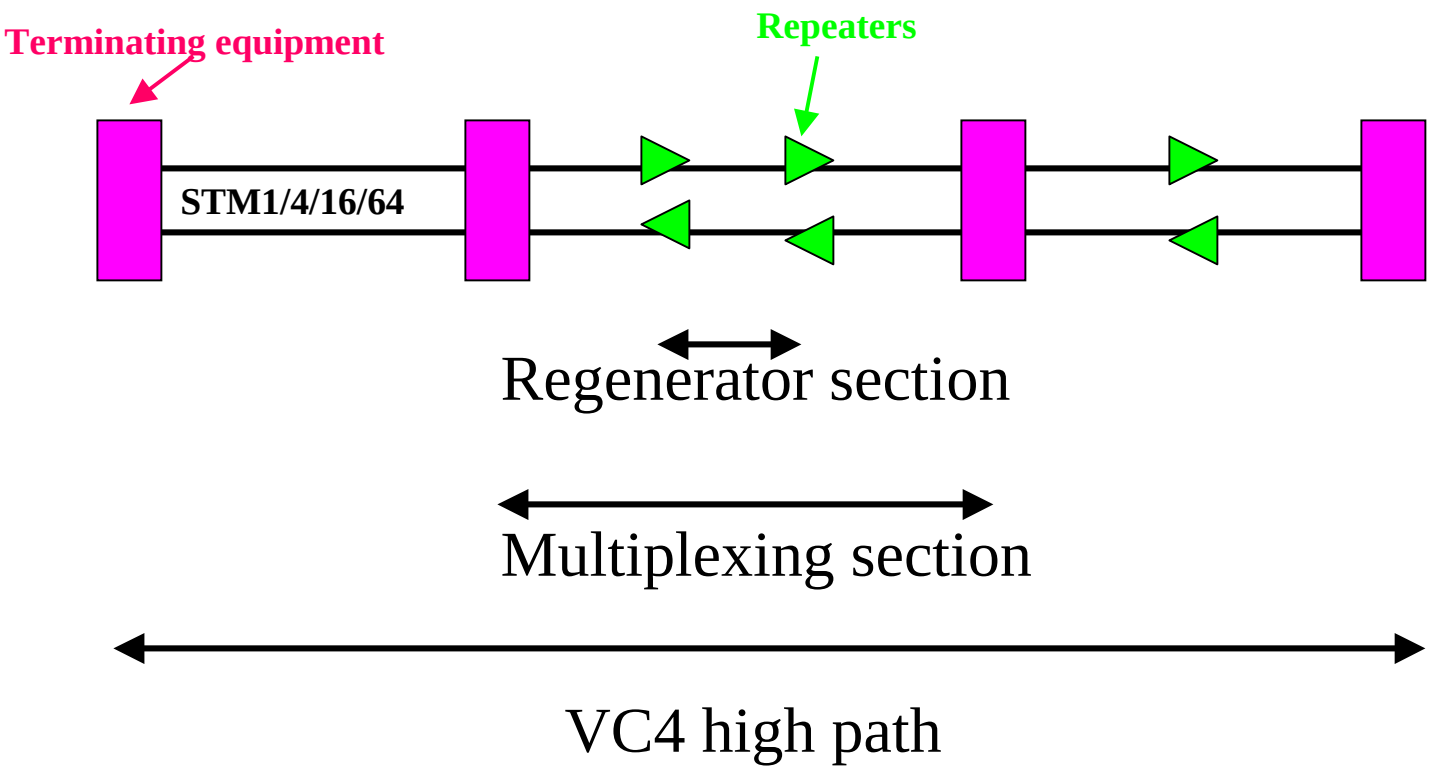
Synchronous Digital Hierarchy (SDH)

- What is the « Justification » ?



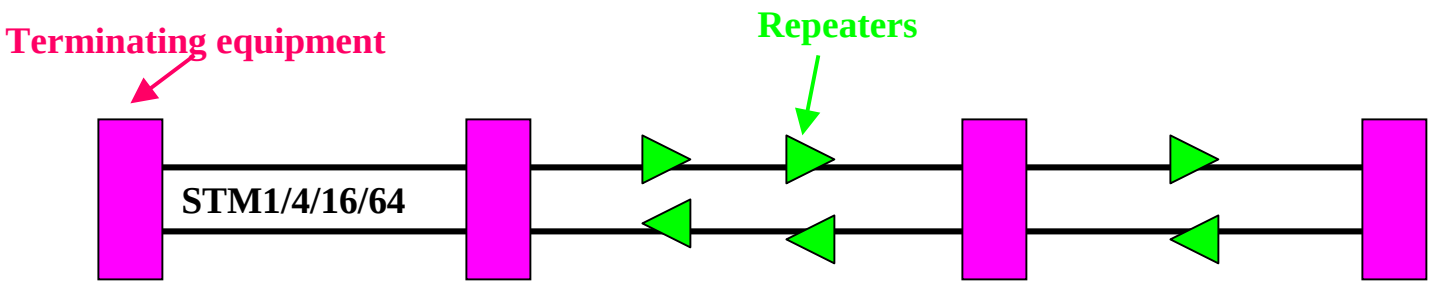
Synchronous Digital Hierarchy (SDH)

- SDH architecture basics



Synchronous Digital Hierarchy (SDH)

- SDH architecture basics : Regenerator section



Regenerator section is the basic segment of SDH network.

It is the smallest entity which can managed by the system.

Each repeater monitors defects such as Loss Of Signal, Loss Of Frame, B1 errored blocks ...

By passing through a repeater, the R-SOH is fully recalculated.

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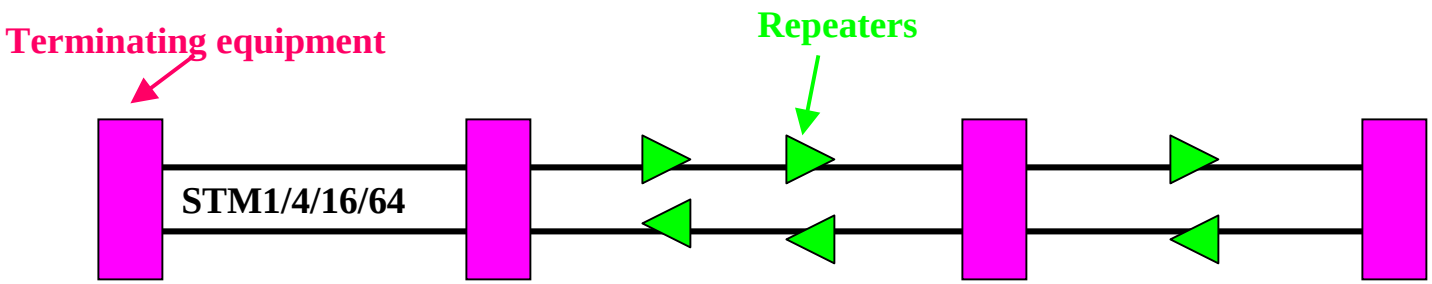
Synchronous Digital Hierarchy (SDH)

- SDH architecture basics : Multiplexing section



The multiplexing section is the entity delimitated by 2 equipment which process the payload of an STM-N.

Detects defects and errored blocks and generated special alarm in the forward and backward direction.

Manage the Automatic Protection Switching wtih K1 and K2 bytes.

Regenerated a complete SOH.

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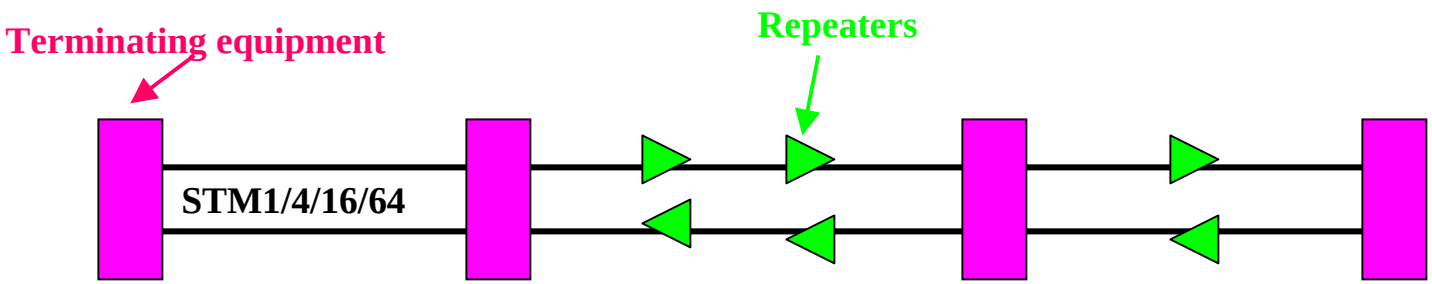
Synchronous Digital Hierarchy (SDH)

- SDH architecture basics : VC4 high path



The VC4 High Path is an entity which transport a C4 container from end to another end of a network.

A VC4 can be affected to one customer.

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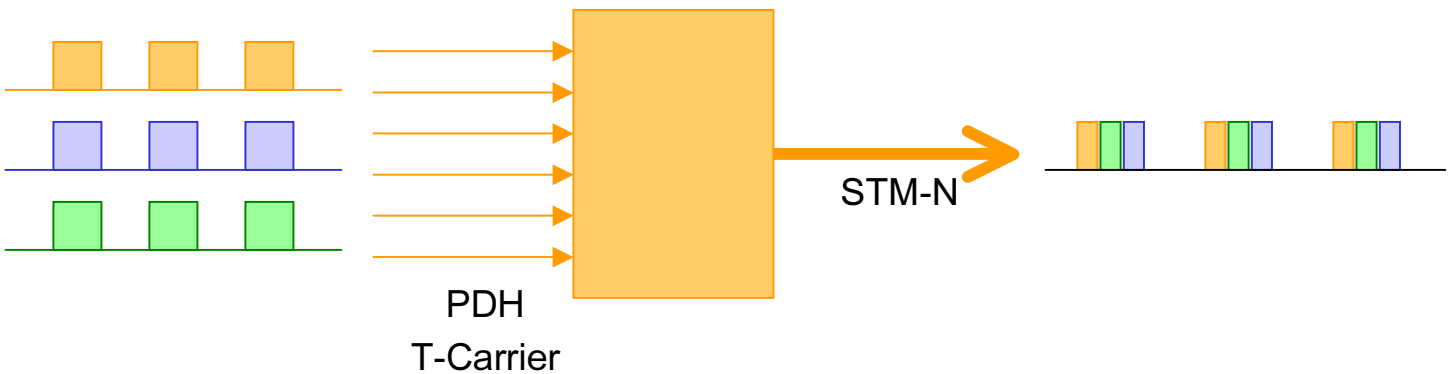
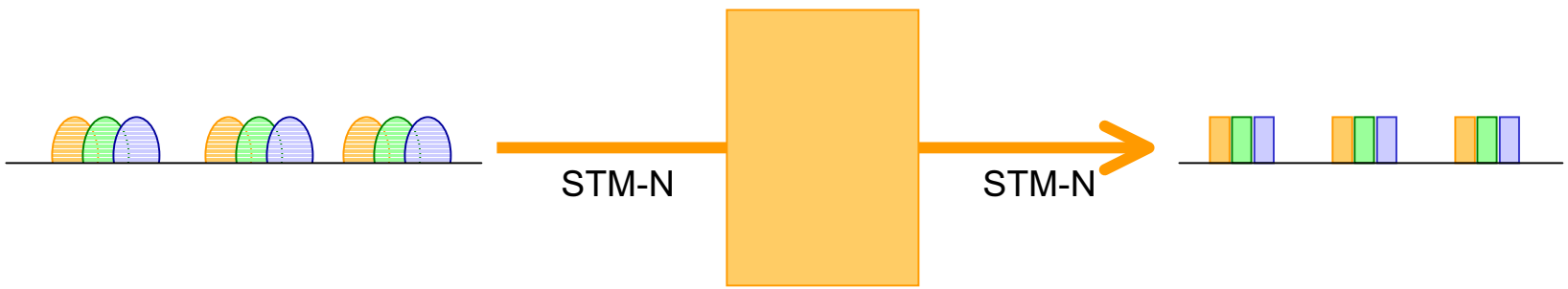
Synchronous Digital Hierarchy (SDH)

- SDH equipments : Terminal Multiplexer
  - » *Input:* Low Bit Rate and PDH/T-Carrier Tributaries
  - » *Output:* High Bit Rate SDH Signals



Synchronous Digital Hierarchy (SDH)

- SDH equipments : Regenerator
  - *Input:* STM-N Synchronous Signal
  - *Output:* STM-N Synchronous Signal
  - Reconditions Transmission To Minimize Jitter, Dispersion, Etc.



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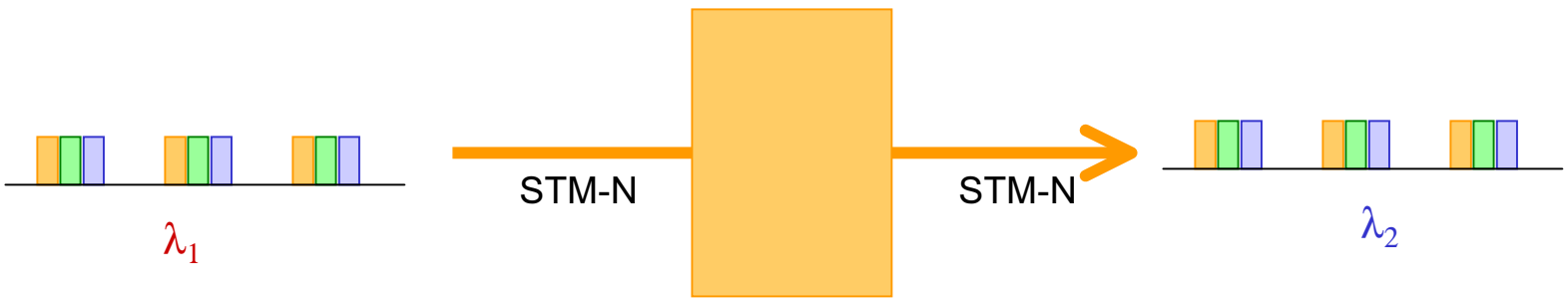
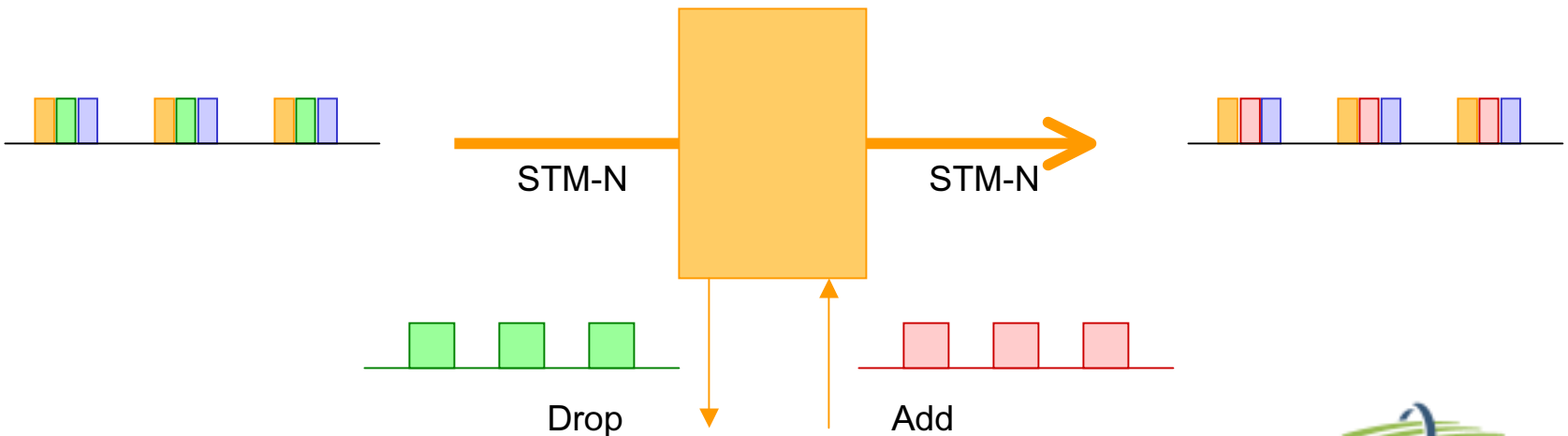
Synchronous Digital Hierarchy (SDH)

- SDH equipments : Transponder (λ Converter)
  - *Input:* STM-N Synchronous Signal at λ_1
  - *Output:* STM-N Synchronous Signal at λ_2
  - Changes the Wavelength of the Transmission Signal



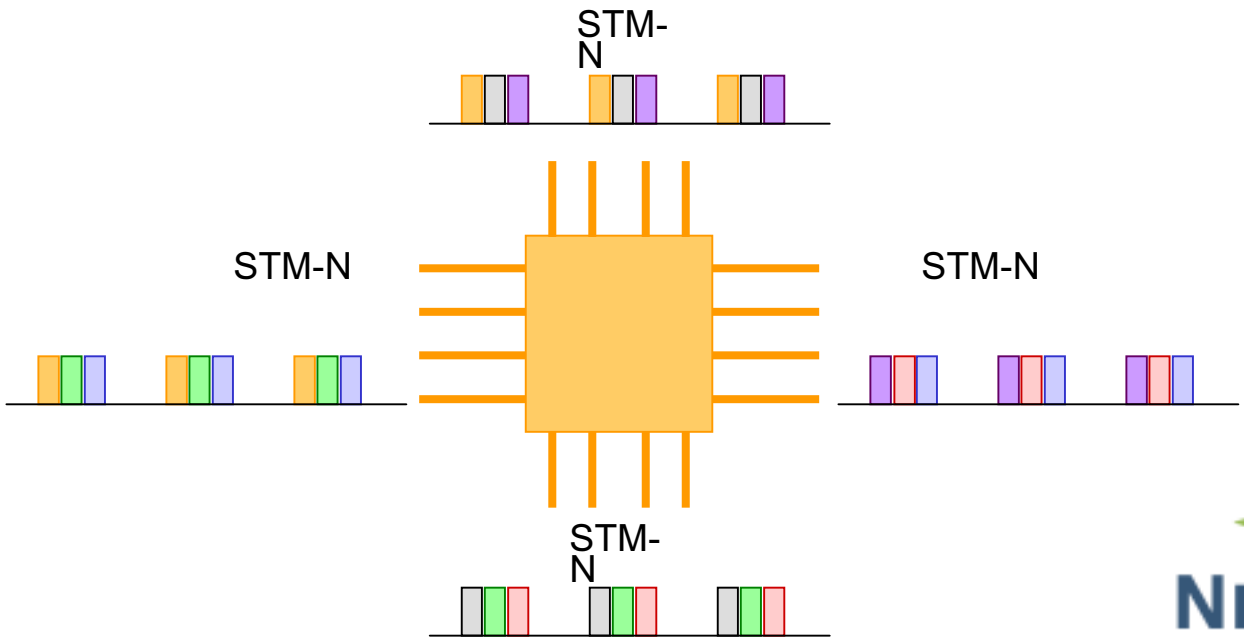
Synchronous Digital Hierarchy (SDH)

- SDH equipments : Add/Drop Multiplexer
  - » *Input:* STM-N Synchronous Signal
  - » *Output:* STM-N Synchronous Signal
  - » Allows the Extraction and Injection of Synchronous Tributaries



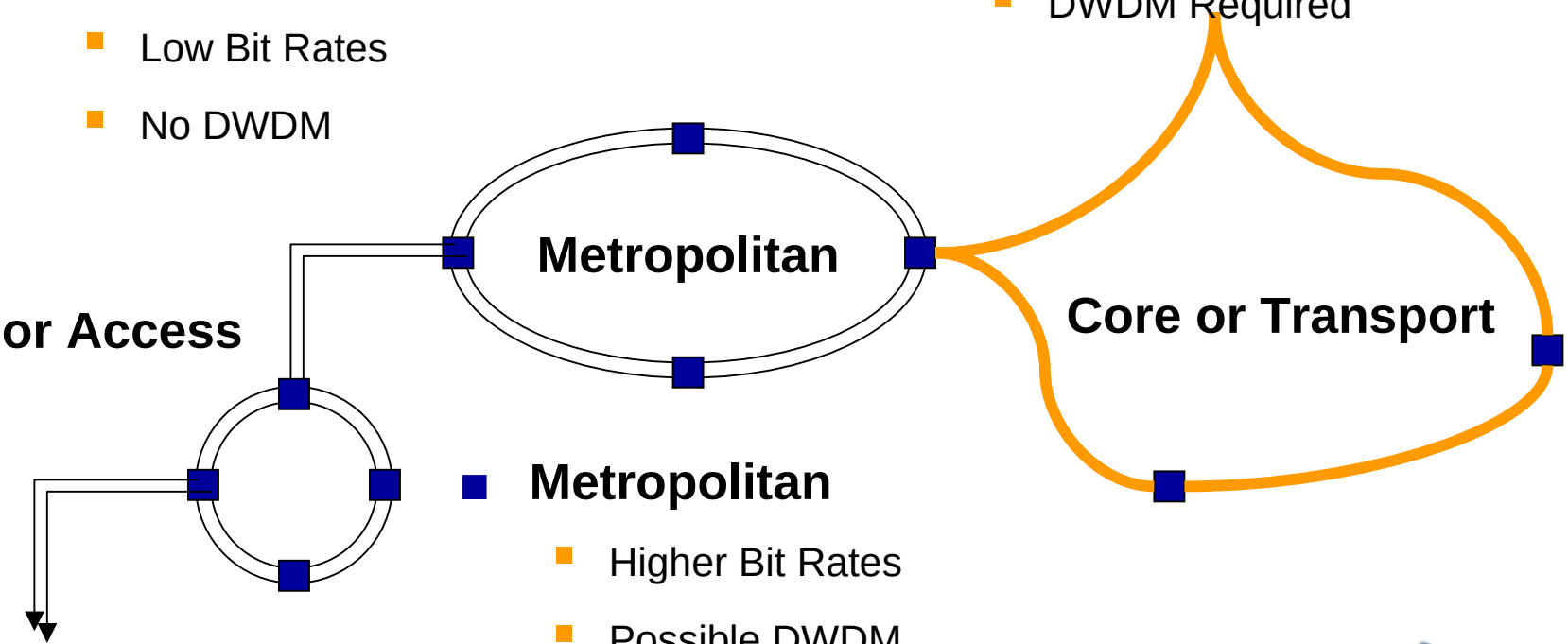
Synchronous Digital Hierarchy (SDH)

- SDH equipments : Digital Cross Connect
  - *Input:* Many STM-N Optical Signals
  - *Output:* Many STM-N Optical Signals
  - Allows Routing of STM-N Signals at High Data Rates



Synchronous Digital Hierarchy (SDH)

- **Core or Transport**
  - Very High Bit Rates
  - DWDM Required
- **Local or Access:**
  - Low Bit Rates
  - No DWDM

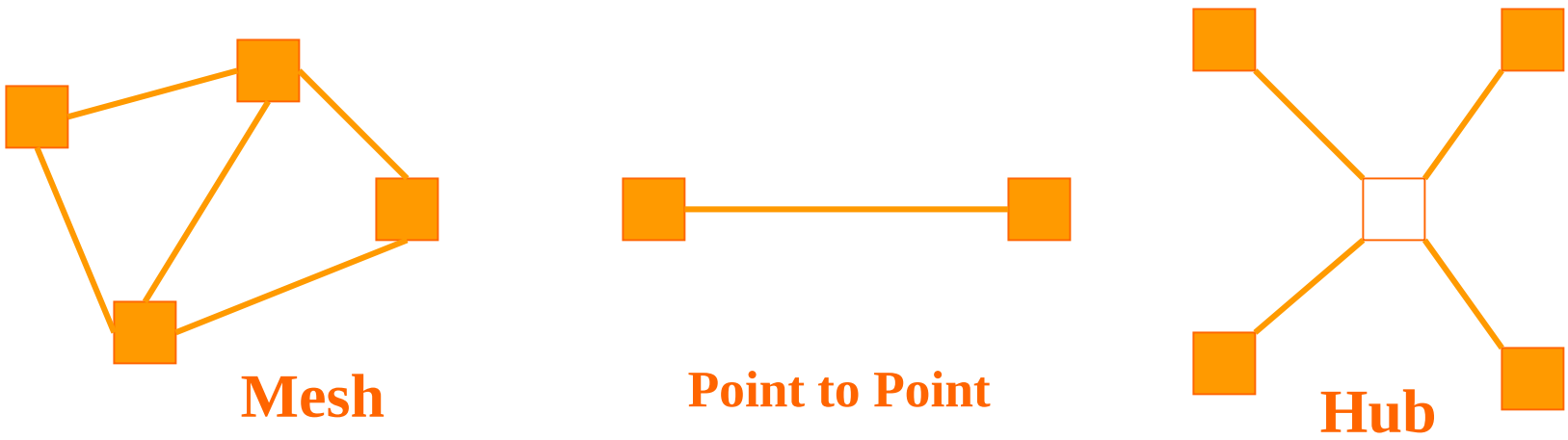


- **Metropolitan**
  - Higher Bit Rates
  - Possible DWDM

Synchronous Digital Hierarchy (SDH)

- Network Topology

Traditional networks make use of Point to Point, Mesh and Hub (i.e Star) arrangements :



but SDH allows these to be used in a much more comprehensive way.

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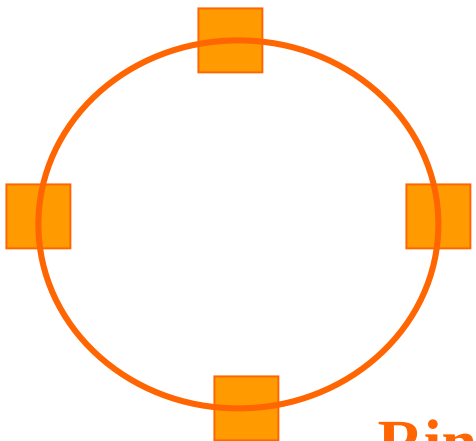
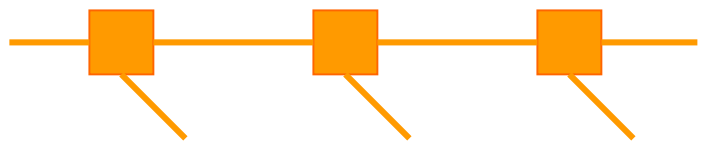
Synchronous Digital Hierarchy (SDH)

- Network Topology

SDH enables the previous arrangements to be combinated with Rings and Chains of ADMs (Add/Drop Multiplexer) :



Ring



Chain

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Synchronous Digital Hierarchy (SDH)

- Network Topology

Point to Point

- » Large Capacity (with DWDM)
- » Few Links
- » Example: Intercontinental Submarine Links

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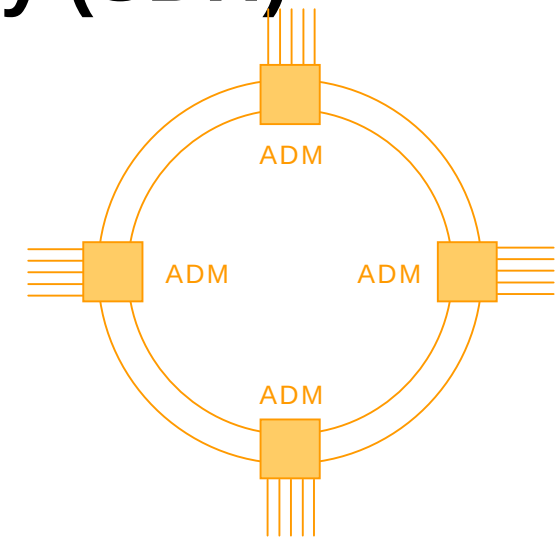
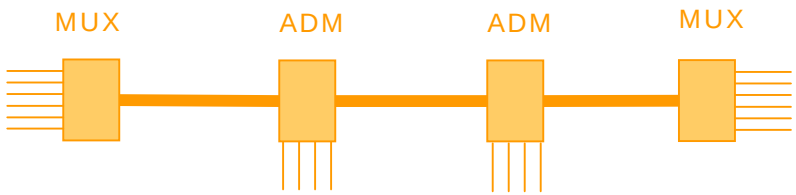
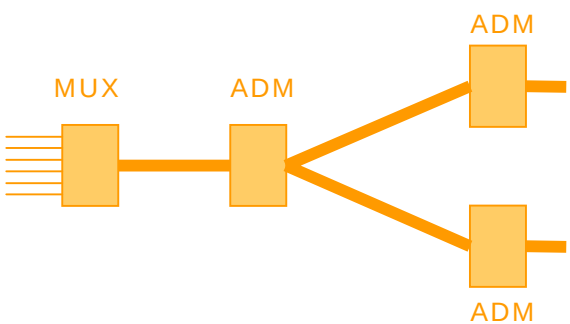
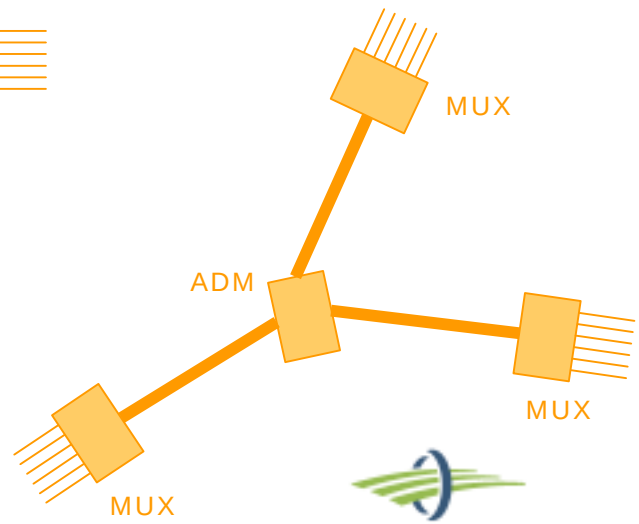
Synchronous Digital Hierarchy (SDH)

- Network Topology
  - Ring, Bus, Tree and Star
    - » Differing Capacity
    - » Many Links
    - » Example: Access Networks









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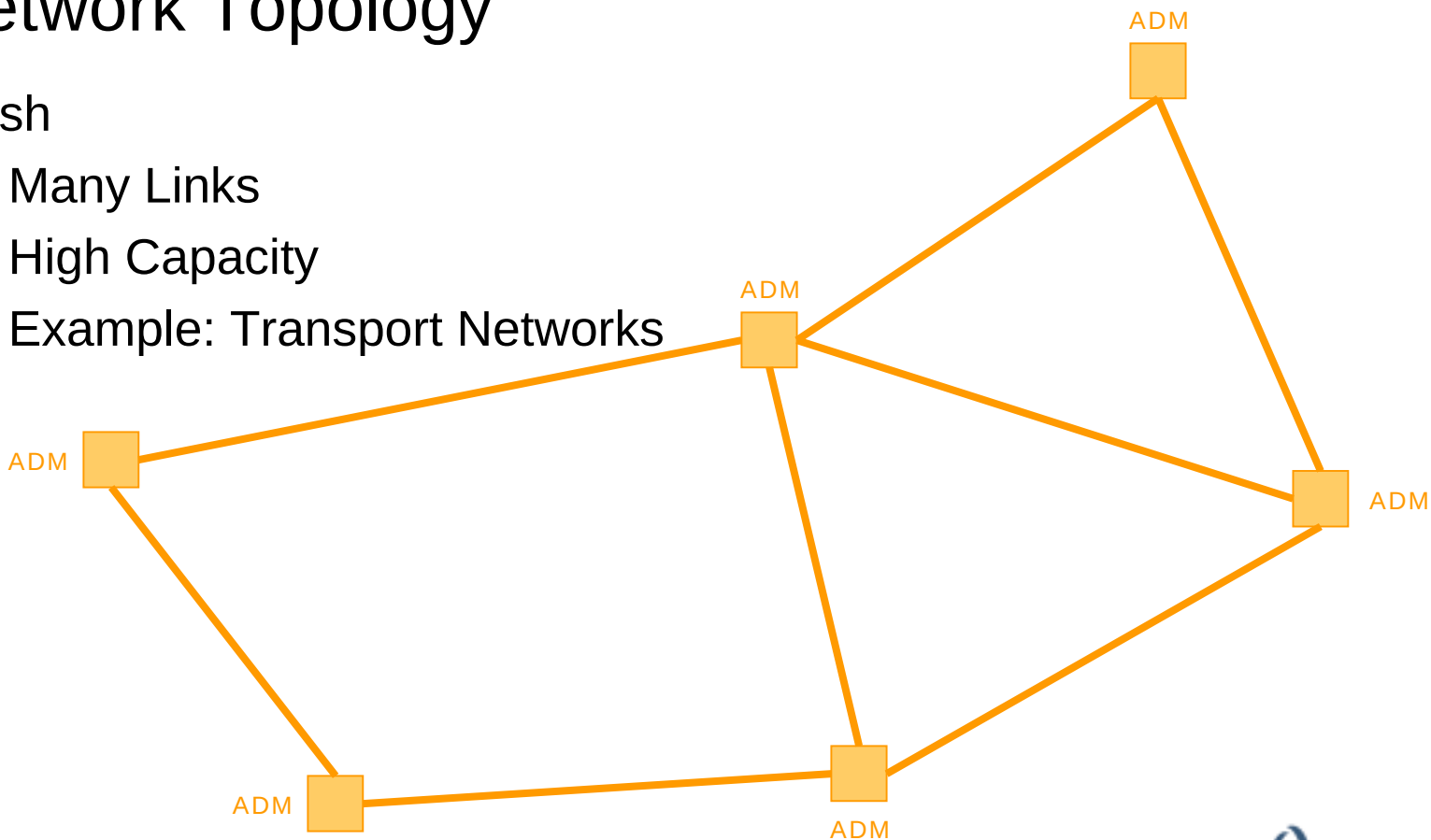
Synchronous Digital Hierarchy (SDH)

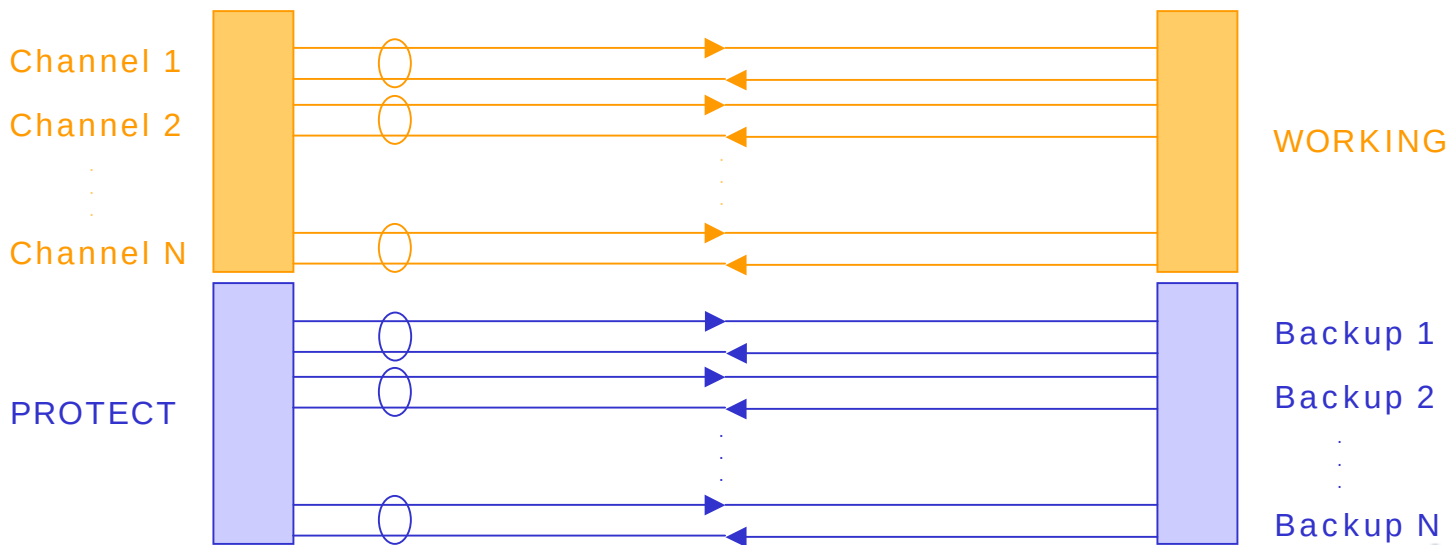
- Network Topology
- Mesh
  - » Many Links
  - » High Capacity
  - » Example: Transport Networks



Synchronous Digital Hierarchy (SDH)

- **Network protection :**
- 1+1 Protection
  - » Most Redundant
  - » Most Expensive

Each Bidirectional SDH Channel (2 Fibers) has a dedicated backup channel (2 Fibers).

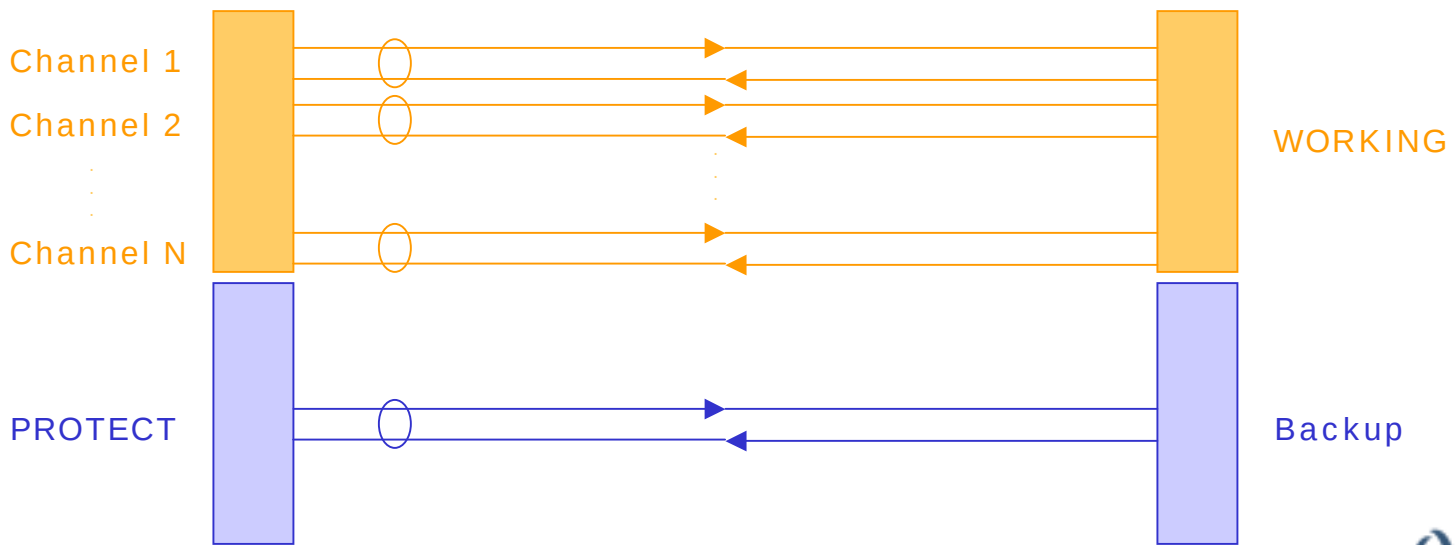


Synchronous Digital Hierarchy (SDH)

- **Network protection :**

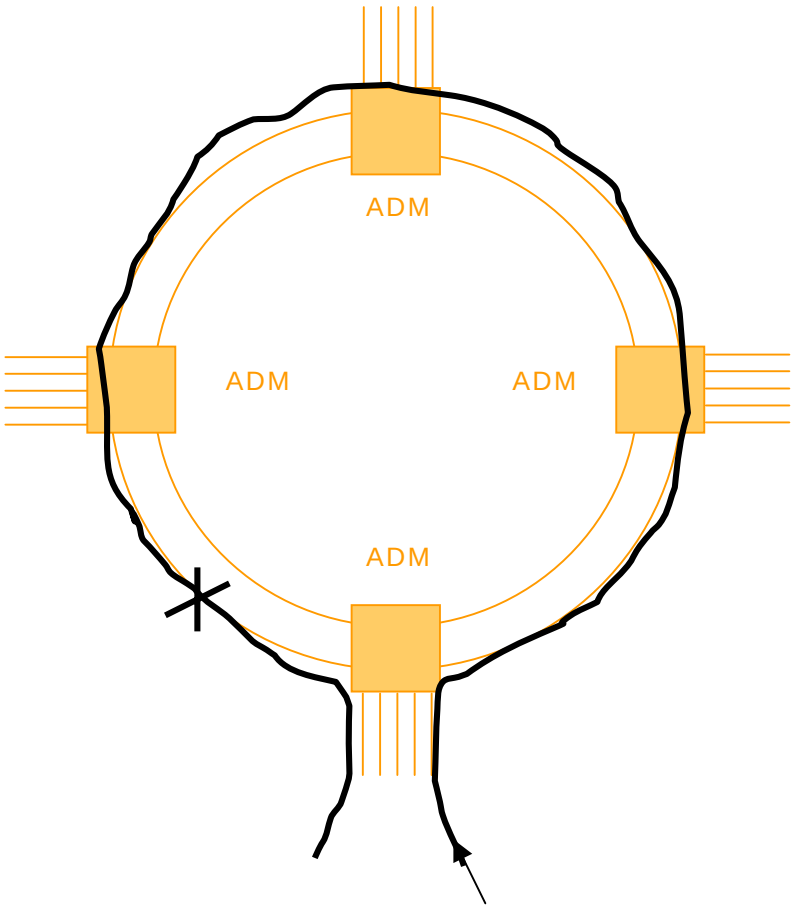
- 1:N Protection
  - » Least Redundant
  - » Most Efficient

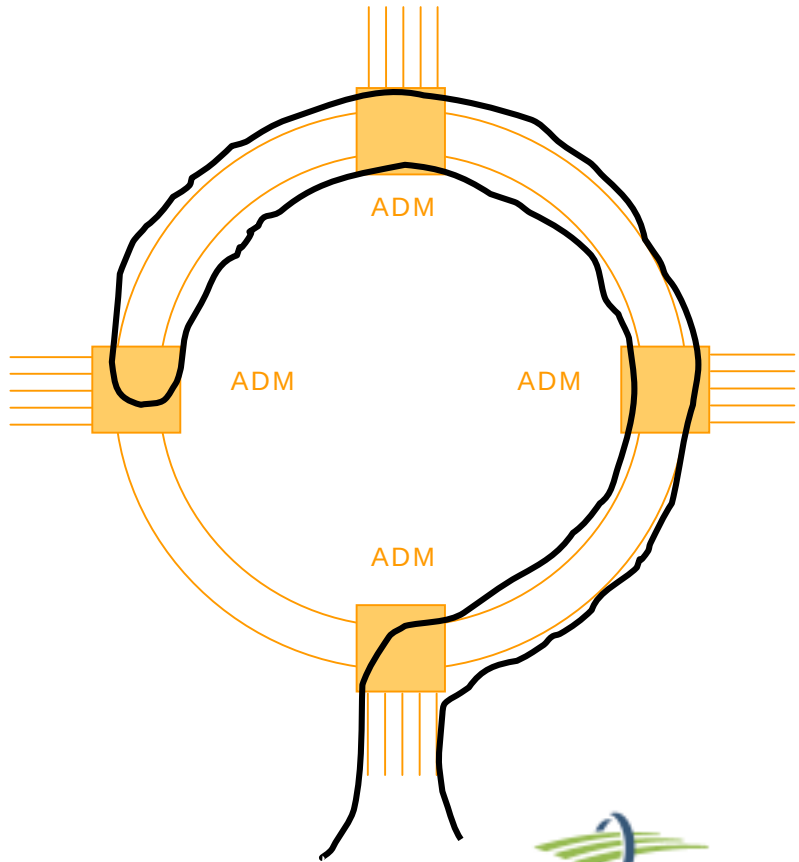
Every Bidirectional SDH Channel (2 Fibers) shares a dedicated backup channel (2 Fibers).



Synchronous Digital Hierarchy (SDH)

- **Network protection : ring protection**





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Synchronous Digital Hierarchy (SDH)

- **Network protection :**

During an Automatic Protection Switching, the network loses traffic (= the operator loses money!!!).

That ’s the reason why it ’s very important for an operator to check the correct working of APS.

The main parameter is the switch duration. The recommendation give 50 ms (max) to recover a correct signal.

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Synchronous Digital Hierarchy (SDH)

- Quality standard
  - **ITU-T G.826 –** Quality parameters, objectives and calculations for bit rates at or above the primary rate
  - **ITU-T G.821 –** Error performance of a digital connection operating below the primary rate
  - **ITU-T M.2100 –** Performance limits for system turn-up and maintenance
  - **ITU-T G.783 –** Recommendation for automatic protection switching and standardized pointer movements

It Is Important To Know That We Are Compliant With These Standards

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Synchronous Digital Hierarchy (SDH)

- Quality parameters
  - **Errored Seconds (ES) –** Seconds during which there is at least one error per block or frame
  - **Severely Errored Seconds (SES) –** Length of time during which a major alarm (LOS, LOF, AIS, Etc.) is recorded or when 30% of the frames received in one second contain errors
  - **Unavailability –** Length of time where SONET equipment is not available (beginning after 10 consecutive SES)

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Synchronous Digital Hierarchy (SDH)

- **THANK YOU !**

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