The Impact of Recent advances in Optical Networking on Synchronisation

ITSF / jean-Loup Ferrant / October 2005

-**introduction: synchronisation history**

-DWDM, CWDM

-OTN

-10 GBE

-MSPP

-Conclusion

Network synchronisation history

-PSTN and PDH

-Switches needed synchronisation in order to comply with slip generation specified in G.822

-Switches used to be synchronised from G.812 clocks (old 1988 version)

-Transport of synchronisation was done via 2 Mbit/s signals transported within the PDH hierarchy, in a quasi –transparent way

-SDH

-With SDH, 2 Mbit/s signals transported via VC12 were not anymore suitable for network synchronisation due to the phase transients of VC12 pointer justification.

-STM-N was chosen and specified to transport network synchronisation.

-G.803 defines the hierarchical architecture of synchronisation network .

-Clocks are defined in G.811, G.812 and G.813.

Network synchronisation history (2)

New technologies have been developped during the last years.

-WDM systems have been introduced to transmit several signals on a single fibre

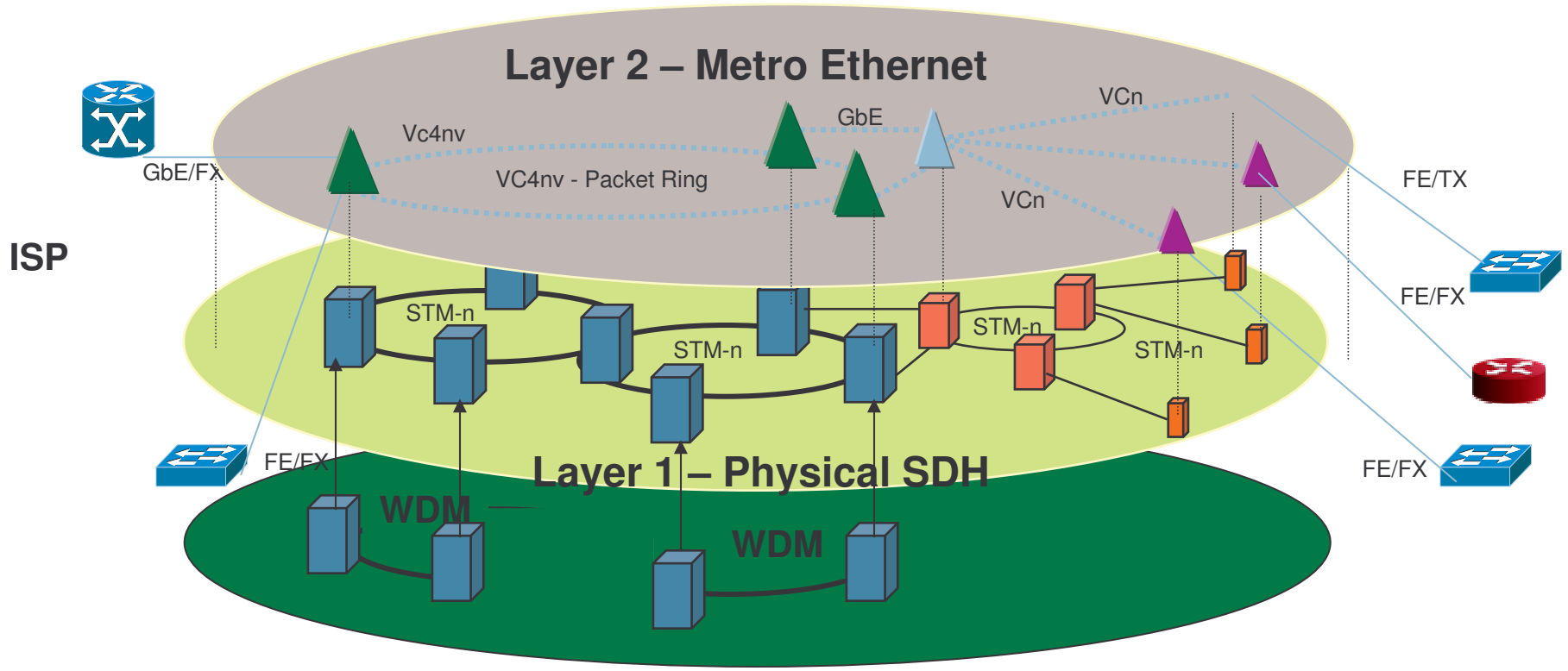
- Pre OTN point-to point WDM systems with proprietary implementation
- OTN systems based on G.709

-Data became a major client for transport systems

- 1G and 10G ethernet .
- MSPP

Transport networks have evolved to adapt to these changes.

New technologies in transport networks



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DWDM, CWDM (1)

-**DWDM are point-to-point systems**.

-Client signals are mapped in a proprietary frame transported on a wavelength

-Frame is designed so that mapping minimizes the noise generation

-wavelengths are multiplexed on one fiber.

-Some DWDM systems add a FEC in order to increase the length of spans.

-2 types of regenerators

- Optical amplifiers: no effect on the signal timing
- 3R regenerators:

clock is regenerated, some jitter is added on the timing.

The maximum number of regenerators, bounded by the J&W tolerance, is not specified as it depends on the implementation (usefull simulations in the annex of G.8251).

DWDM, CWDM (2)

DWDM versus CWDM

-They only differ by the accuracy of the wavelength frequency and the number of them.

-No difference for synchronisation

-The above presentation is then valid for both technologies.

Conclusion

These systems are almost transparent to the timing of the client signal and do not add specific constraints on the synchronisation network.

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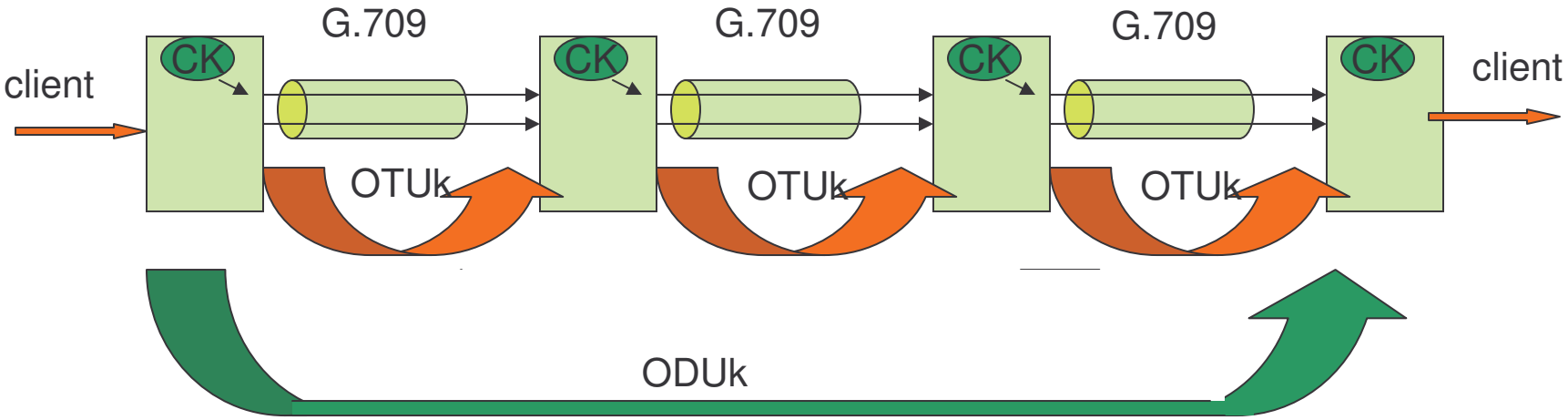
OTN

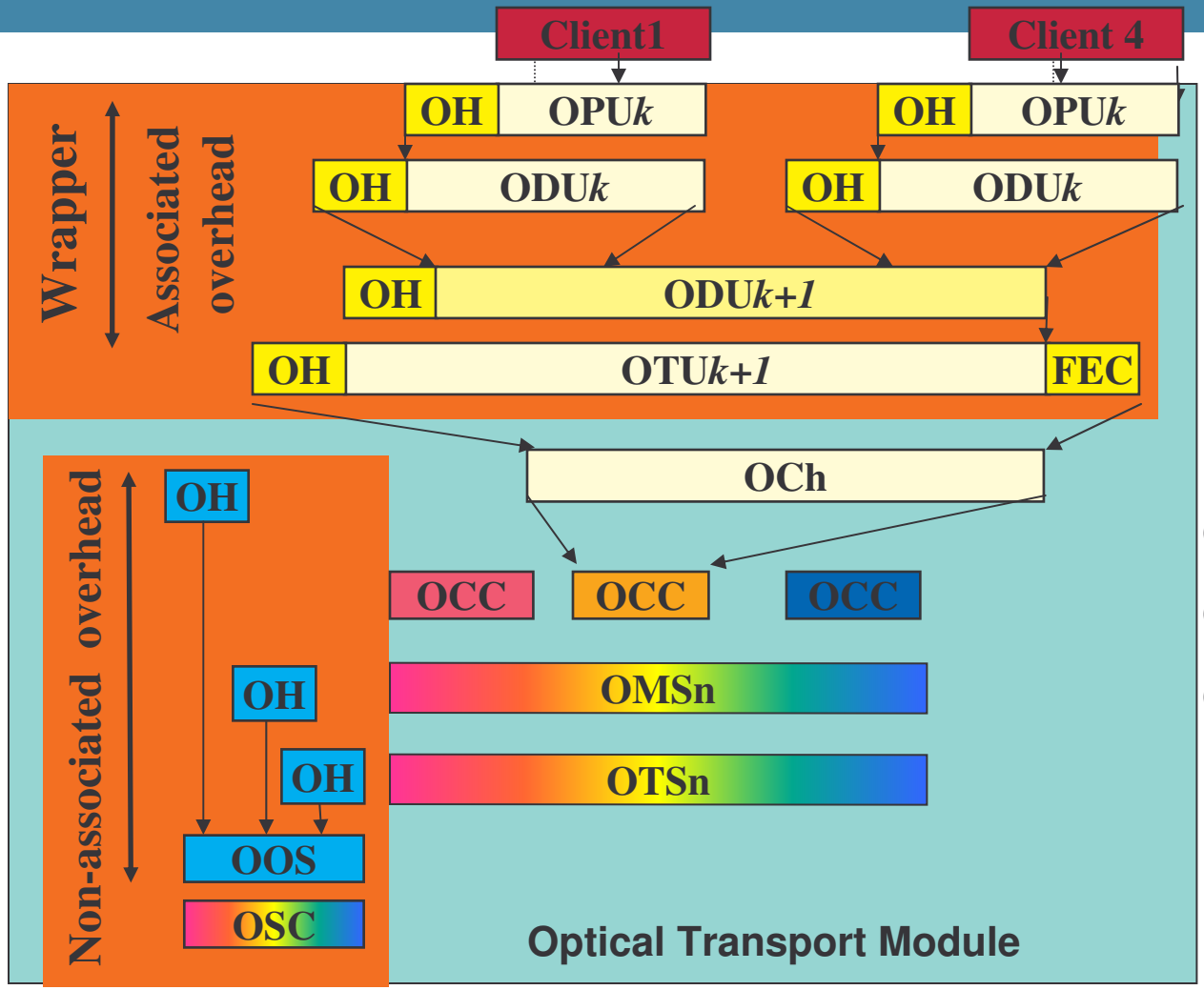
-The main difference between OTN and WDM is that OTN is a network application and not a point-to-point one as WDM.

-OTN is mapping client signals into ODU transported by G.709 frames.



(By analogy with SDH: OTUk / AU and ODUk/VC)

The OTN with ODU multiplexing



OCh Payload Unit

OCH Data Unit *k*

OCh Data Unit *k+1*

OCh Transport Unit

Optical Channel

Optical Channel Carrier

Optical Multiplex Section

Optical Transmission Section

OTM Overhead Signal

Optical Supervisory Channel

OTM0 Physical Section

Synchronisation choices

- **OTN is plesiochronous**

ITU has stated that there is no need for OTN to carry synchronisation, since there is already one network layer that does it, SDH.

- OTN must be transparent to CBR client timing
- Each OTN NE has its own free-running clock
- OTN is a plesiochronous network
- G.709 specifies justification scheme to adapt client and G.709 frame rate

Drawback: when OTN does not transport SDH client, it cannot transport timing.

-2 types of client mappings: synchronous or asynchronous

- synchronous mapping:(not very common, incompatible with ODU multiplex))
  - The client timing is recovered to generate the WDM frame rate.
  - The WDM frame is synchronous to the client
- Asynchronous mapping:
  - The WDM system has its own clock independant of the client one.
  - The WDM frame has a justification process.

Synchronisation choices (2)

-**OTN allows ODU multiplexing**

Using justification method

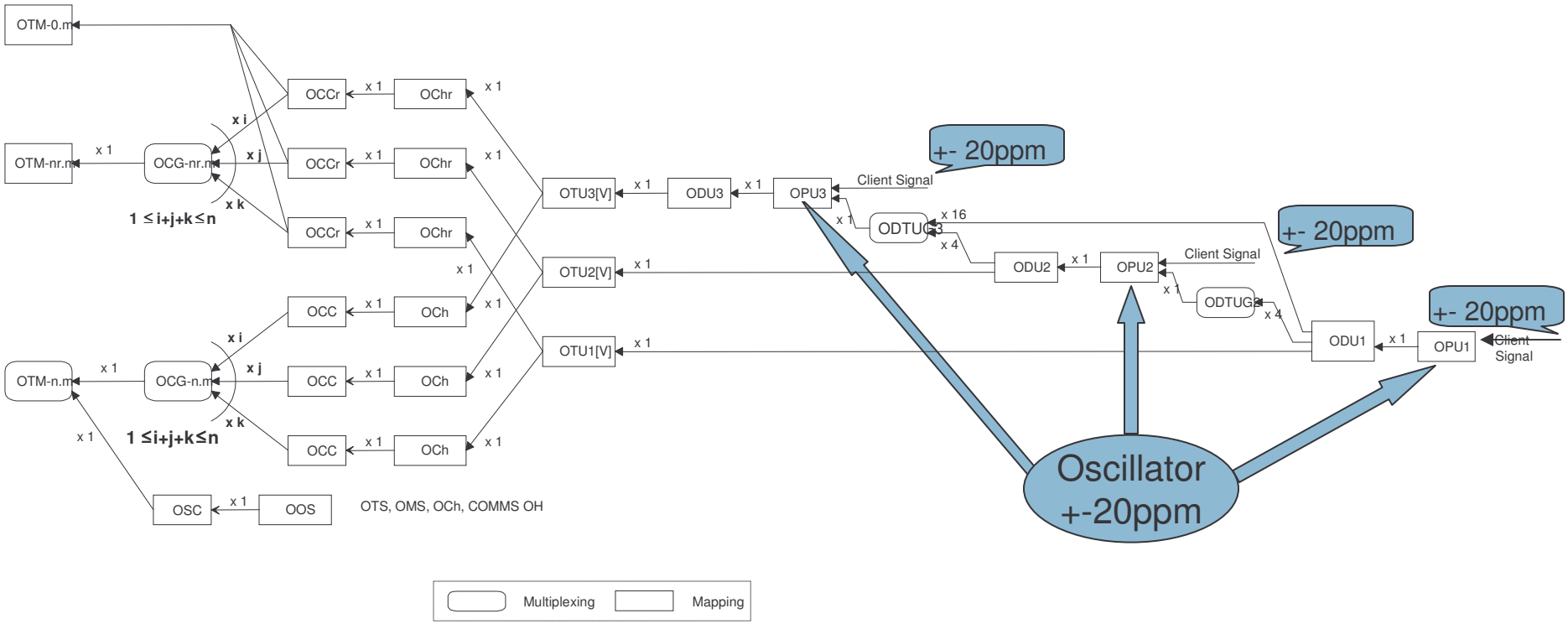
4 ODU1 may be multiplexed into 1 ODU2

4 ODU2 may be multiplexed into 1 ODU3

16 ODU1 may be multiplexed into 1 ODU3

This allows insertion/extraction of ODUs in equipments (ADM)

G.709 multiplexing scheme



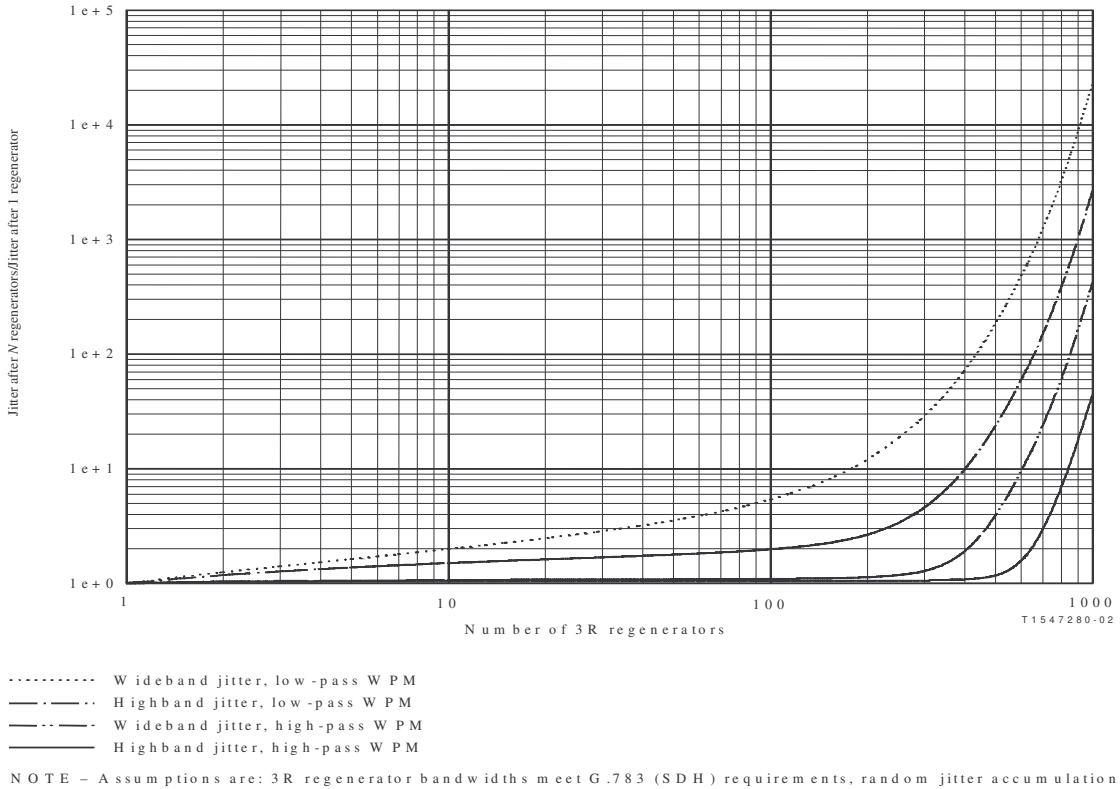
G.8251 Jitter and wander within OTN

OTN timing issues have been specified in G.8251which specifies

- jitter and wander at client interfaces
  - Compliant with client jitter specification
    - eg G.825 for STM-N
  - ±20 ppm accuracy allowed to clients
- 4 Clocks for the different functions in OTN
  - 3R regenerator, mapping synchronous or asynchronous, and demapping
  - All of them specified with ±20 ppm accuracy
- Jitter and wander accumulation in OTN
  - Speified in G.8251

Jitter accumulation in 3R regenerators

-G.8251 presents results of jitter accumulation in OTN islands due to 3R regenerators. A maximum number of 50 3R regenerators per OTN island has been agreed

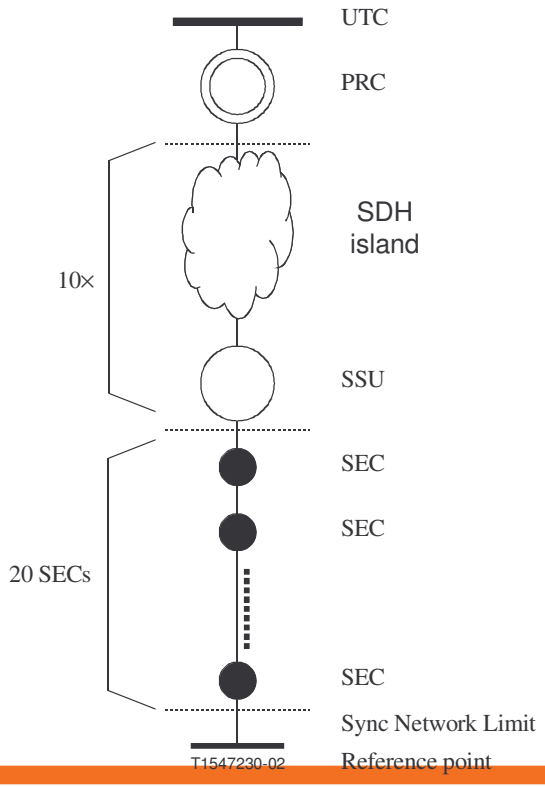


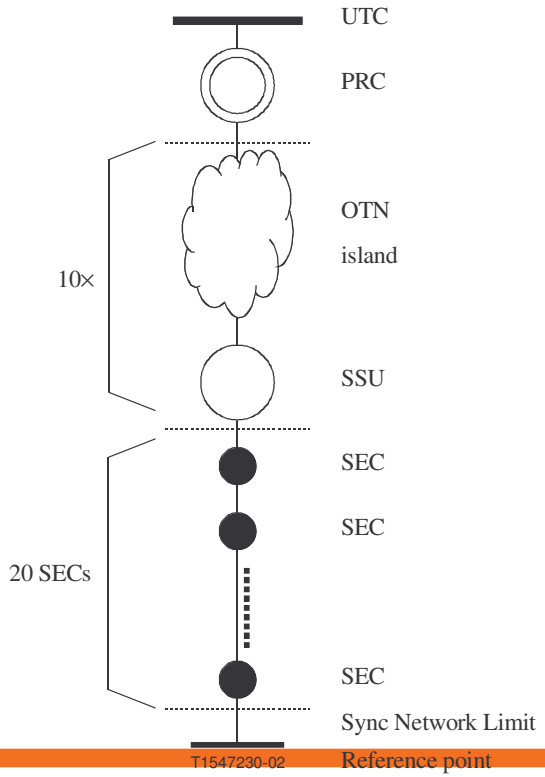
NOTE – Assumptions are: 3R regenerator bandwidths meet G.783 (SDH) requirements, random jitter accumulation, no WFM in VCO (high-pass) noise cases. Log-log plot.

Impact of OTN on SDH HRM

G.8251 states that each SDH island of the G.803 reference model can be replaced by an OTN island.

An OTN island may be up to 1 mapping NE plus 9 ODUk multiplexing OTN NEs





WDM and OTN

WDM and OTN do not raise severe synchronisation issues in networks. Jitter and wander accumulation allows implementation of large networks.

The only synchronisation issue is raised when OTN does not transport SDH and when the client need synchronisation.

GPS/ Galileo was the only solution.

Synchronisation of Ethernet might be the right answer since the main non-SDH client of OTN is 10GBE.

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10G Ethernet

-Ethernet is plesiochronous with a 100 ppm rate accuracy. This is valid for 10 Mbit/s, 100 Mbit/s and 1Gbits.

-For 10Gbit/s, IEEE 10GBE task-force decided to specify 2 accuracies:

- 100 ppm or all 10GBE types with the exception of WAN
- 20 ppm for 10GBE WAN
  - in order to allow mapping of 10GBE WAN into G.709 frames.
  - This is also consistent with SONET specification since 10GBE WAN uses the OC192 frame.
  - Although built with a STM64 (OC192) frame, 10GBE-WAN is plesiochronous

10G Ethernet timing

Two issues are raised by 10GBE

- Most 10GBE interfaces are LAN type.
- 10GBE- LAN cannot be mapped transparently into OTN.
  - Discussion are ongoing in ITU-T to find an alternative, but difficult to achieve

- 10GBE-WAN is plesiochronous
  - When 10GBE WAN is the only payload of an OTN system, there is no possibility to transport synchronisation through the system
  - A solution will be to synchronise 10GBE.

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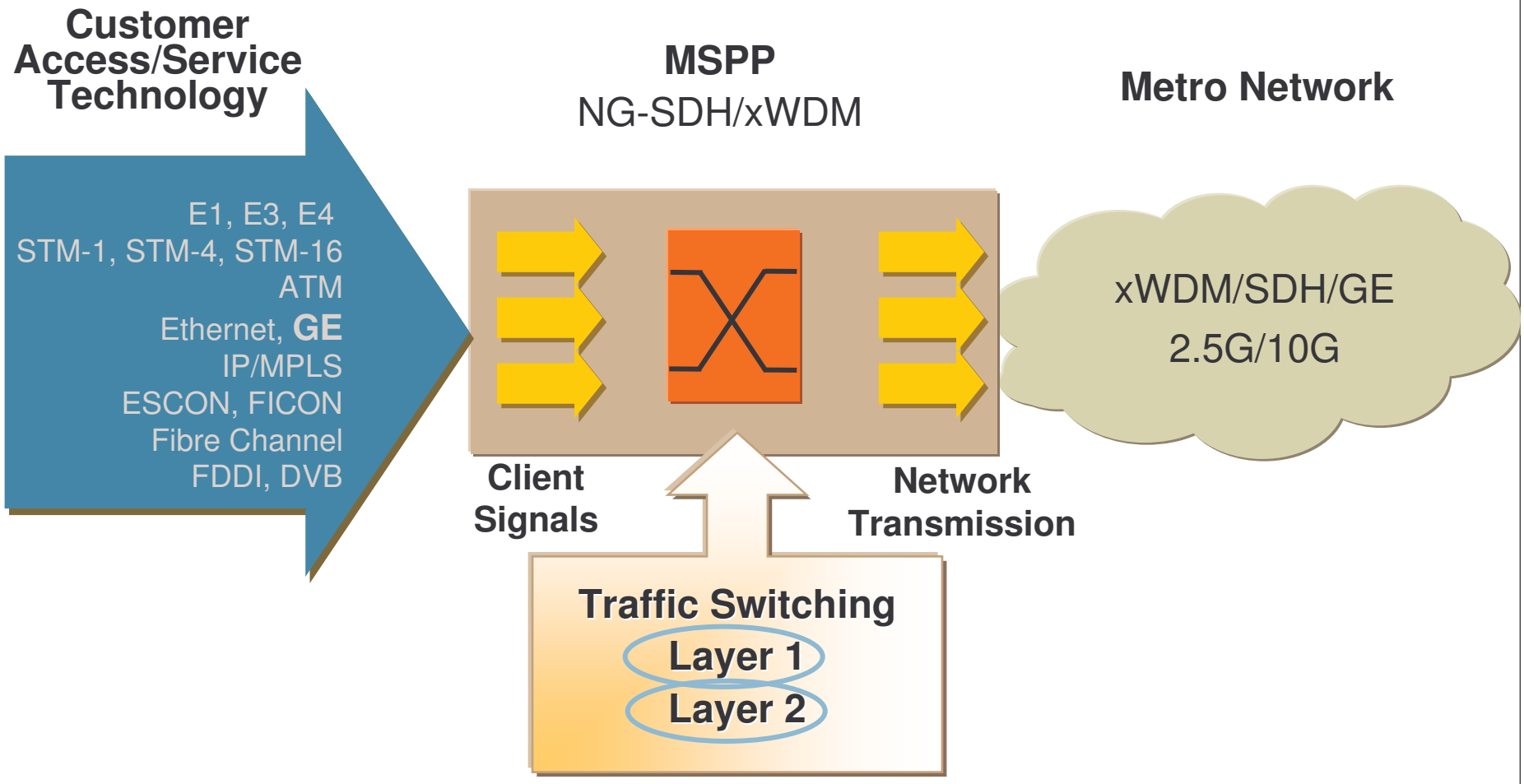
Multi-service provisioning platform (MSPP)



Synchronisation in MSPP

MSPP have STM-N ports, they are SDH NEs

They can be synchronised by STM-N or external synchronisation ports

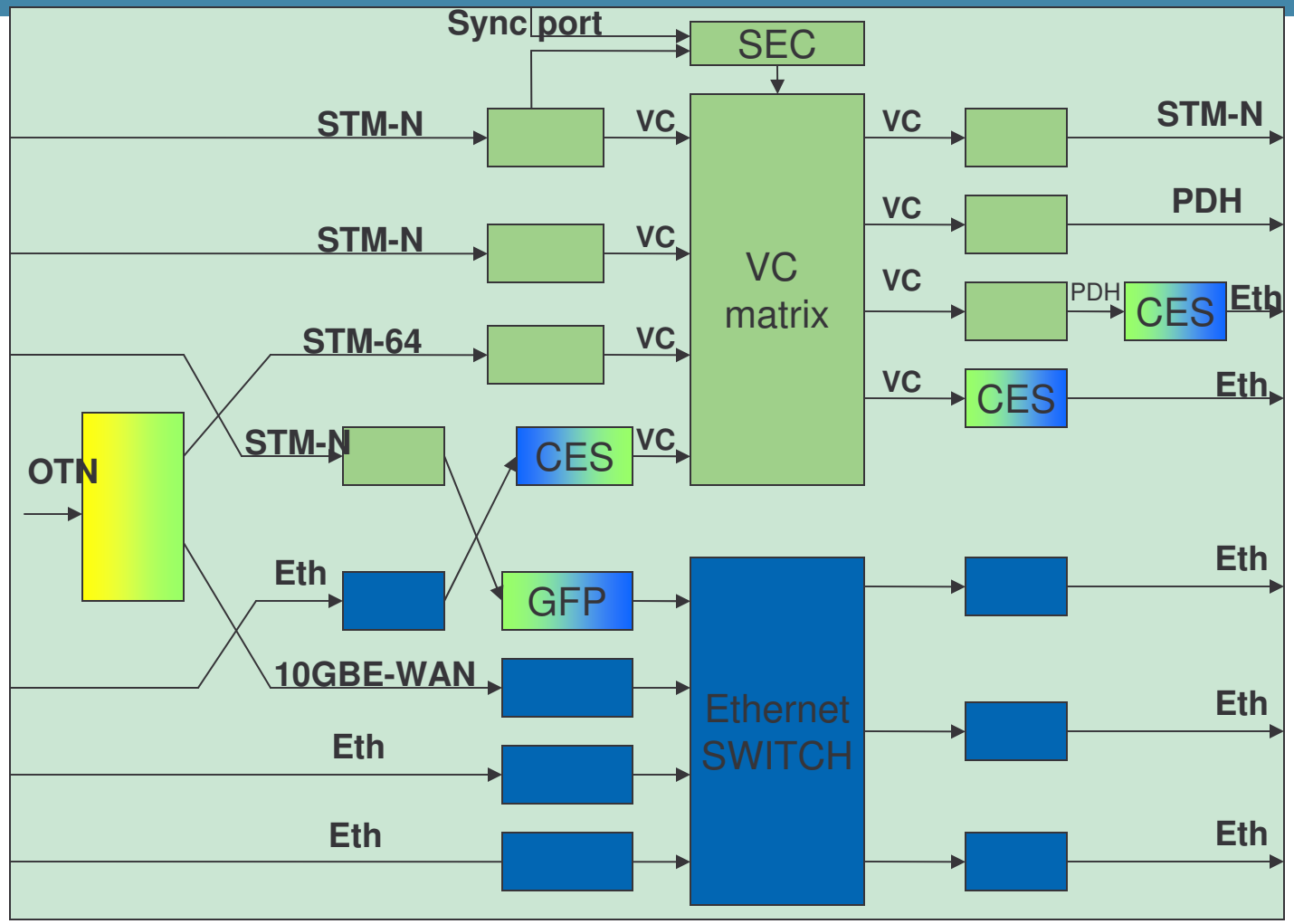
They have an internal SDH clock that can be used to synchronise STM-N ports.

Data ports are terminating asynchronous frames, inserting and extracting packets.

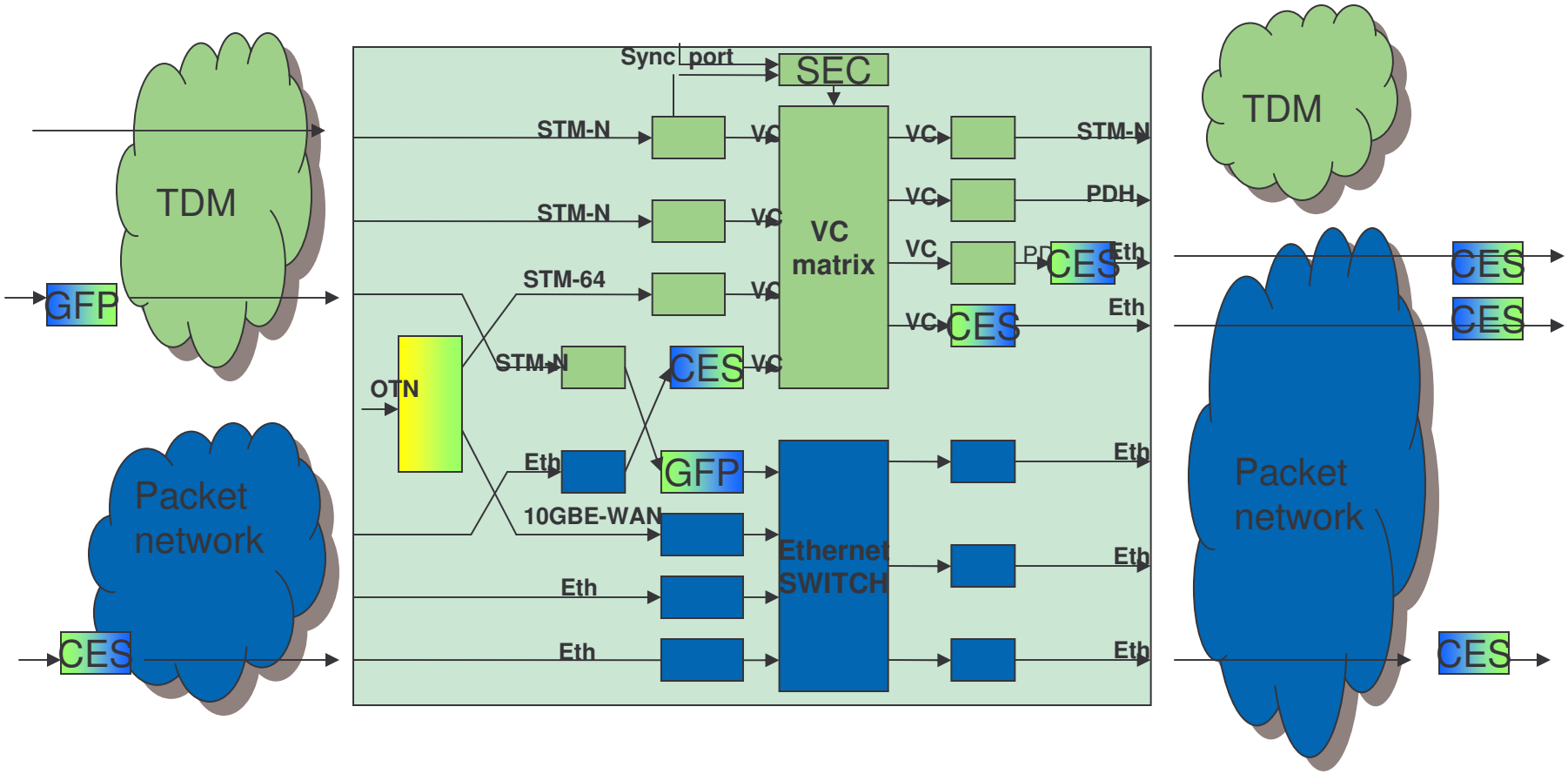
Links between SDH and data can be done via CES or GFP

- CES may transport PDH or SDH VC's through packet networks
- GFP, Generic Framing Procedure, allows transport of data signals into SDH or OTN

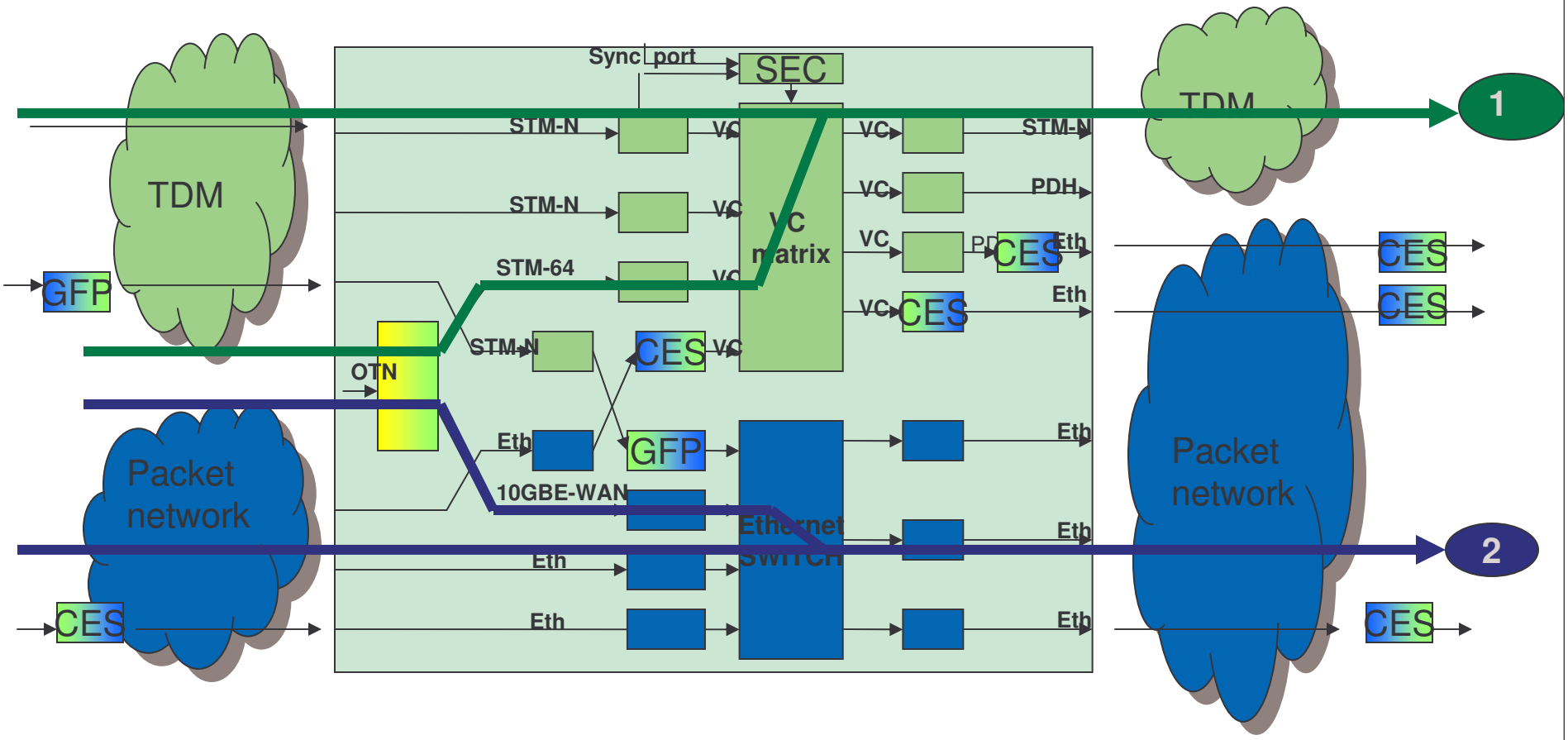
Functions that can be inside MSPP



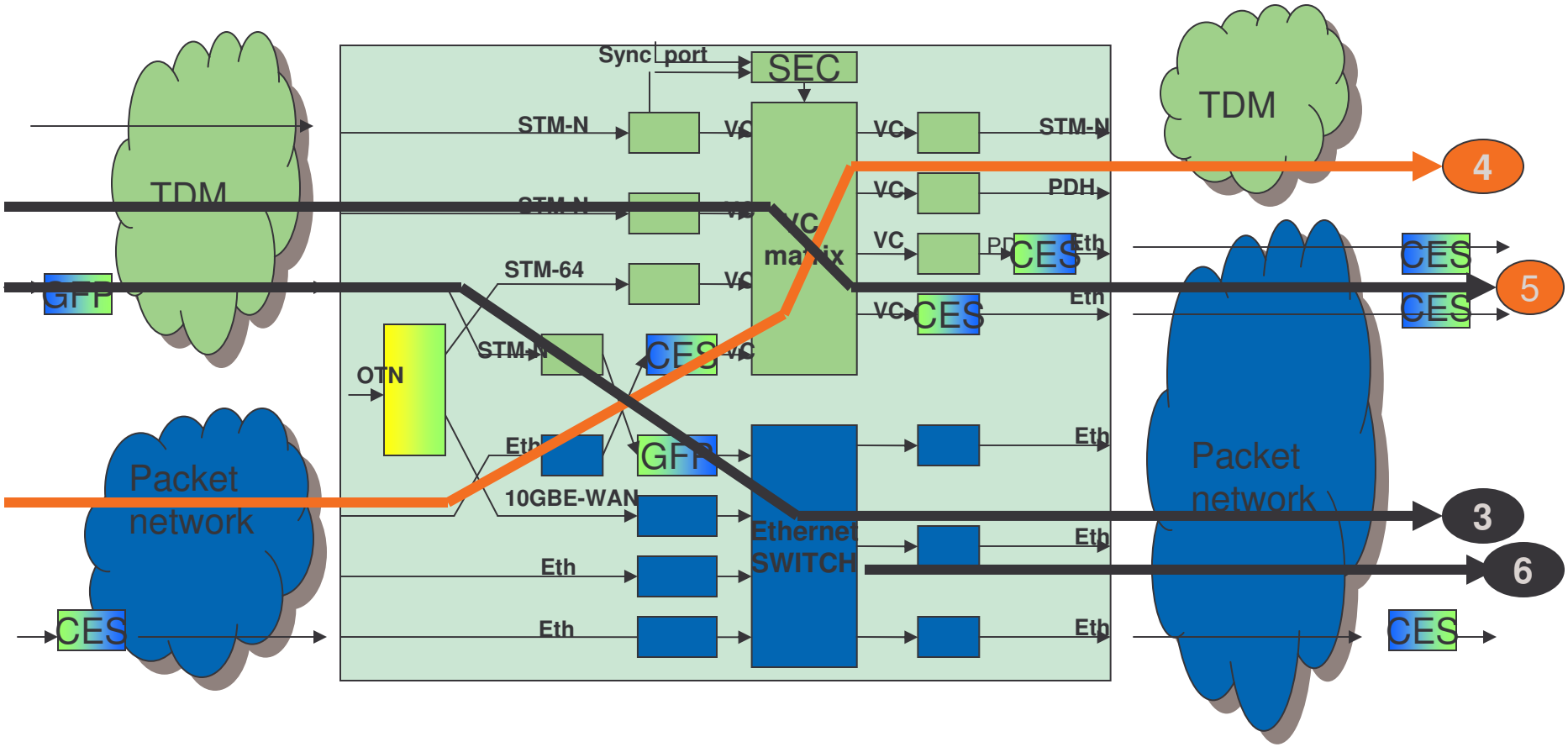
MSPP in an hybrid network



TDM and packet connections



TDM-PSN connexion



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Conclusion

New transport technologies, WDM, OTN and MSPP do not raise new synchronisation issues.

The only synchronisation issue is raised by the introduction of plesiochronous data signals in transport networks, that may prevent transport of synchronisation where it is needed.

CES may be a solution for applications with no more than x Eth switches.

Other methods are under investigation is standards, for example: 1588 for telecom networks, TDMoIP, etc

A more general solution will be the synchronisation of Ethernet signals in transport networks, this assumes:

- A clock must be defined for transport Ethernet equipments
- Eth chip vendors provide access to the received clock
- All NEs must be equipped with a clock
- A traceability indicator must be defined and implemented

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