Synchronisation in Telecom Networks

ITSF / Jean-Loup Ferrant / November 16, 2006

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Network synchronisation history (1)

-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 (1988)

-Transport of synchronisation was done via 2 Mbit/s signals transported within the PDH hierarchy, quasi transparently

-The quality of these networks is guaranted by the control of wander that allows not to over/underflow buffers. These buffers were specified to allow 18 µs of wander without generation a slip

Network synchronisation history (2)

-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 with clocks are defined in G.811, G.812 and G.813.

-The respect of these recommendations avoids desynchronisation and allows the control of jitter and wander , prevents pointer justification and consequent wander on PDH tributaries

SDH networks have proven over last the 10 years their ability to provide excellent synchronisation network

Network synchronisation history (3)

-**GSM**, and later UMTS, generated new requirements for the synchronisation network.

Rather than Jitter and wander the frequency accuracy on the air ijnterface is the key requirement for synchronisation networks

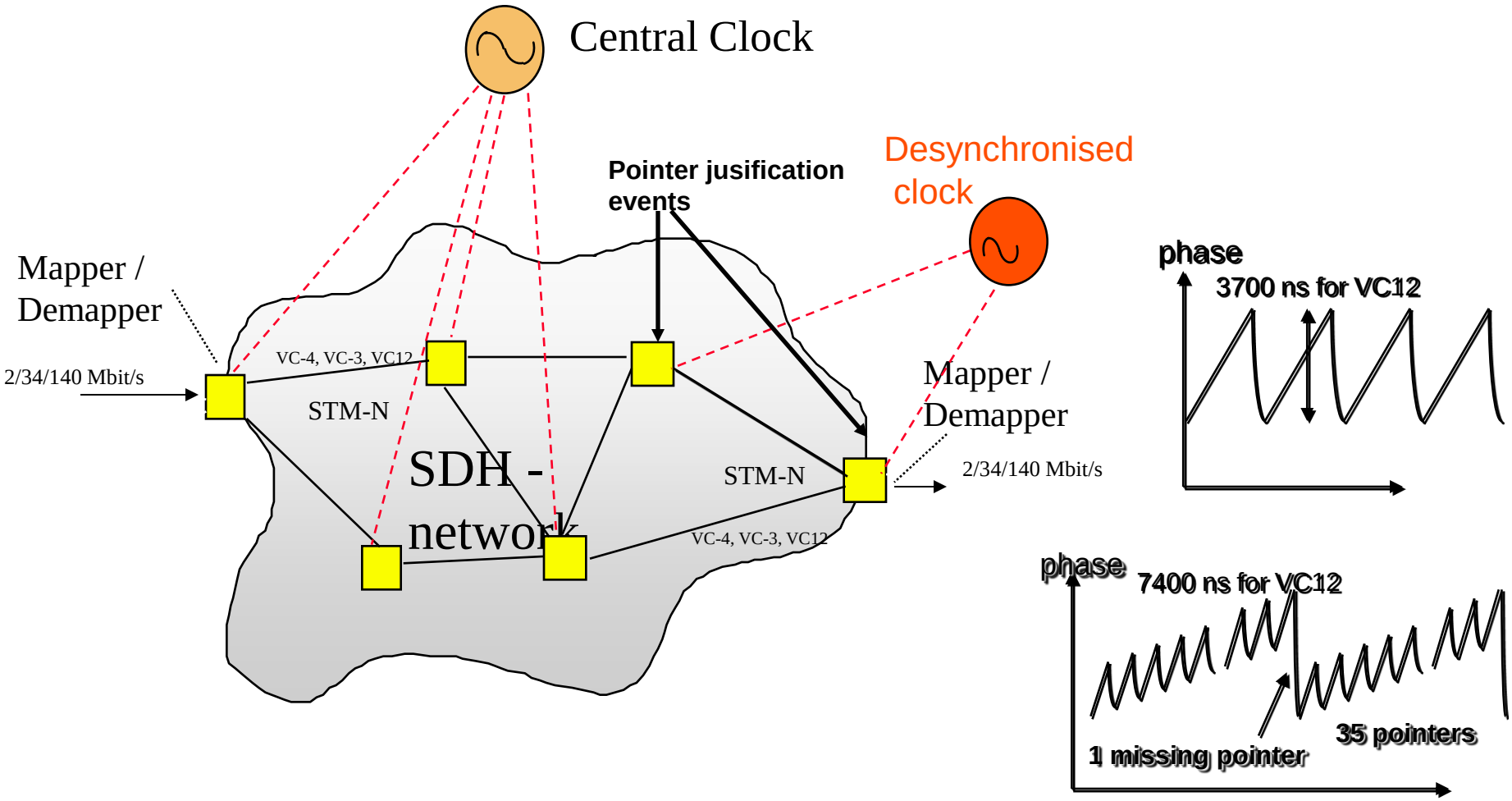
-**WDM** systems have been introduced

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

-**Packet networks** have been introduced in metro and access networks

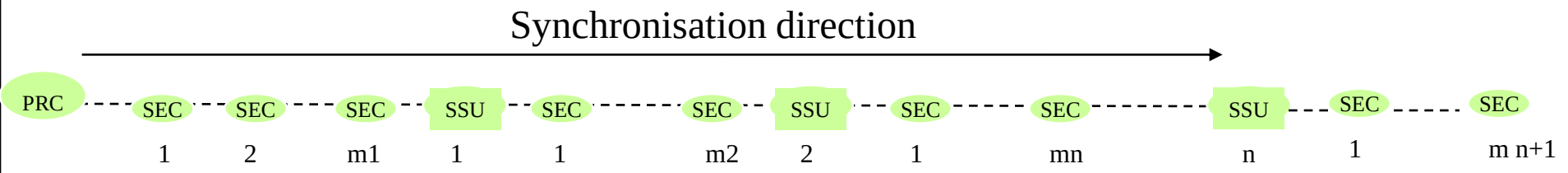
- New equipments, MSPP, combine TDM and Ethernet interfaces
- New standards specify the transport of TDM signals through packet networks
- New methods and protocols are proposed to transport synchronisation through packet networks

SDH
Mapping & PJE due to desynchronisation



SDH Network Synchronisation
Synchronisation reference chain

This reference chain has been specified in order to maintain jitter and wander within acceptable limits, as specified in G.825

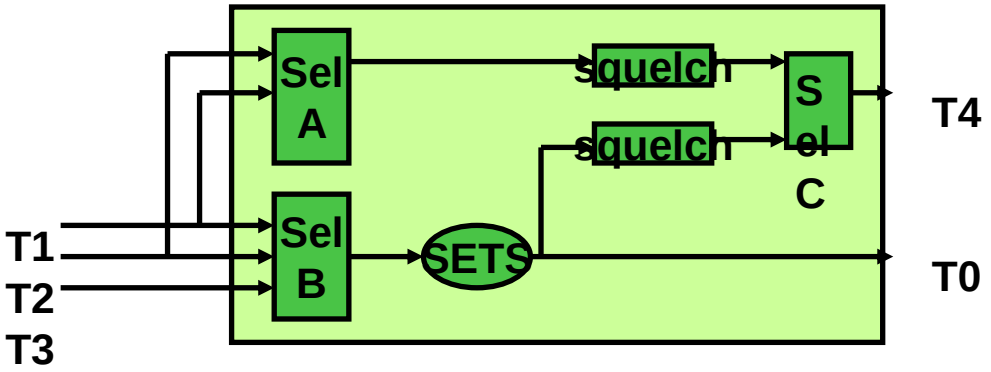


Maximum numbers according to G.803:

- maximum number of SEC's between 2 SSUs: $m1, m2, \ldots mn+1 \leq 20$
- maximum number of SSU's in a chain: $n \leq 10$
- maximum number of SEC's in a chain: 60

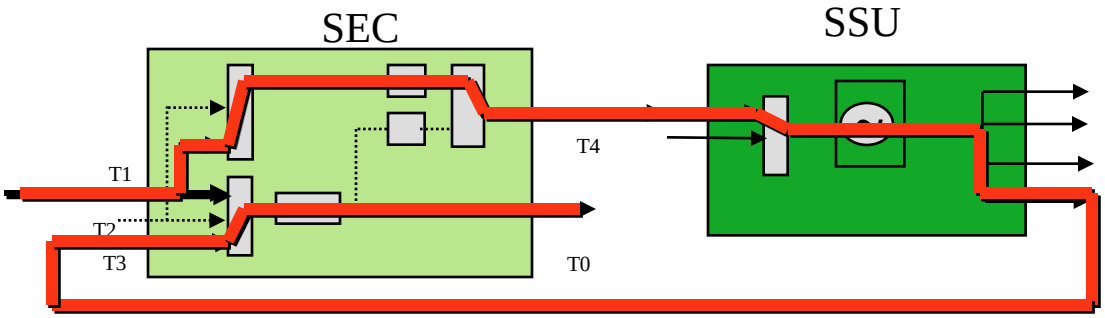
SEC (SDH Equipment Clock) and SSU

T3 : 2MHz(2 Mbit/s) input sync. Signals
T4 : 2MHz (2 Mbit/s) output sync. Signals
T1 : 2 Mhz derived from STM-N
T2 : 2 MHz derived from 2 Mbit/s
T0 : 2 MHz station clock



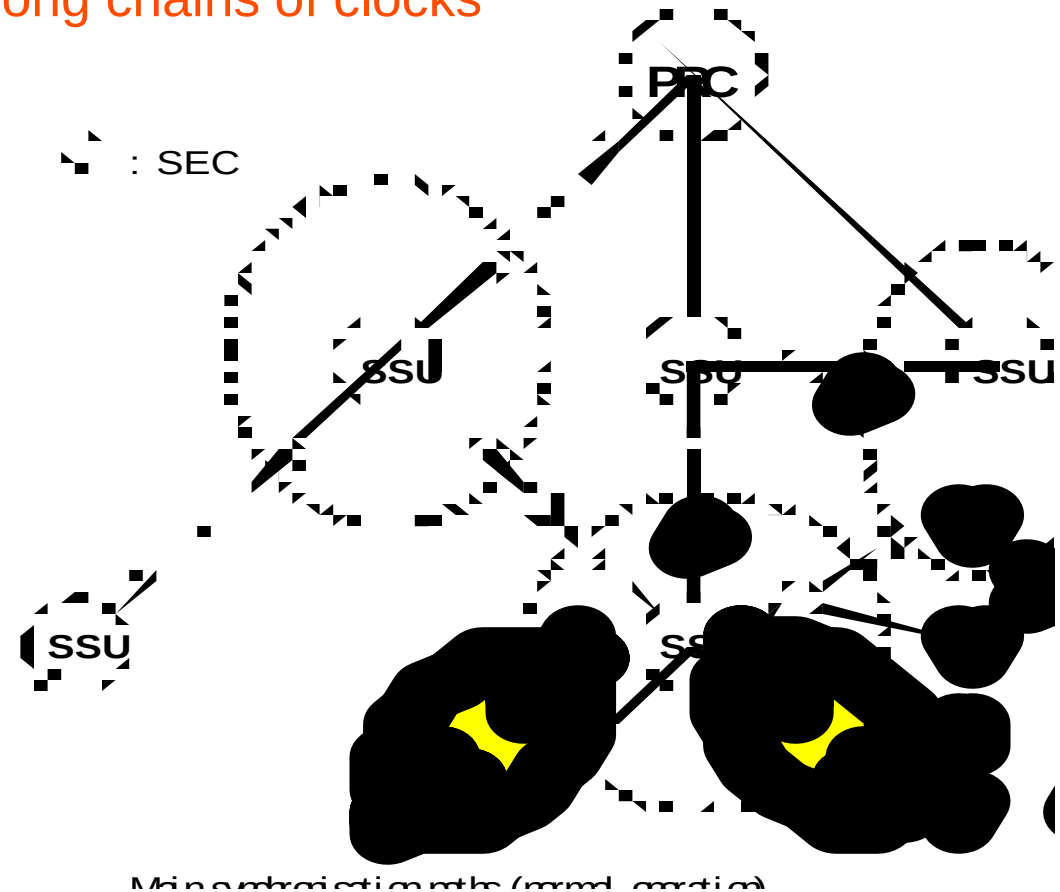
SETS: SDH Equipment Timing Source

Using the T1-T4 link allows to synchronize the SEC from the SSU without any risk of timing loop



Hierarchical Master-slave solutions

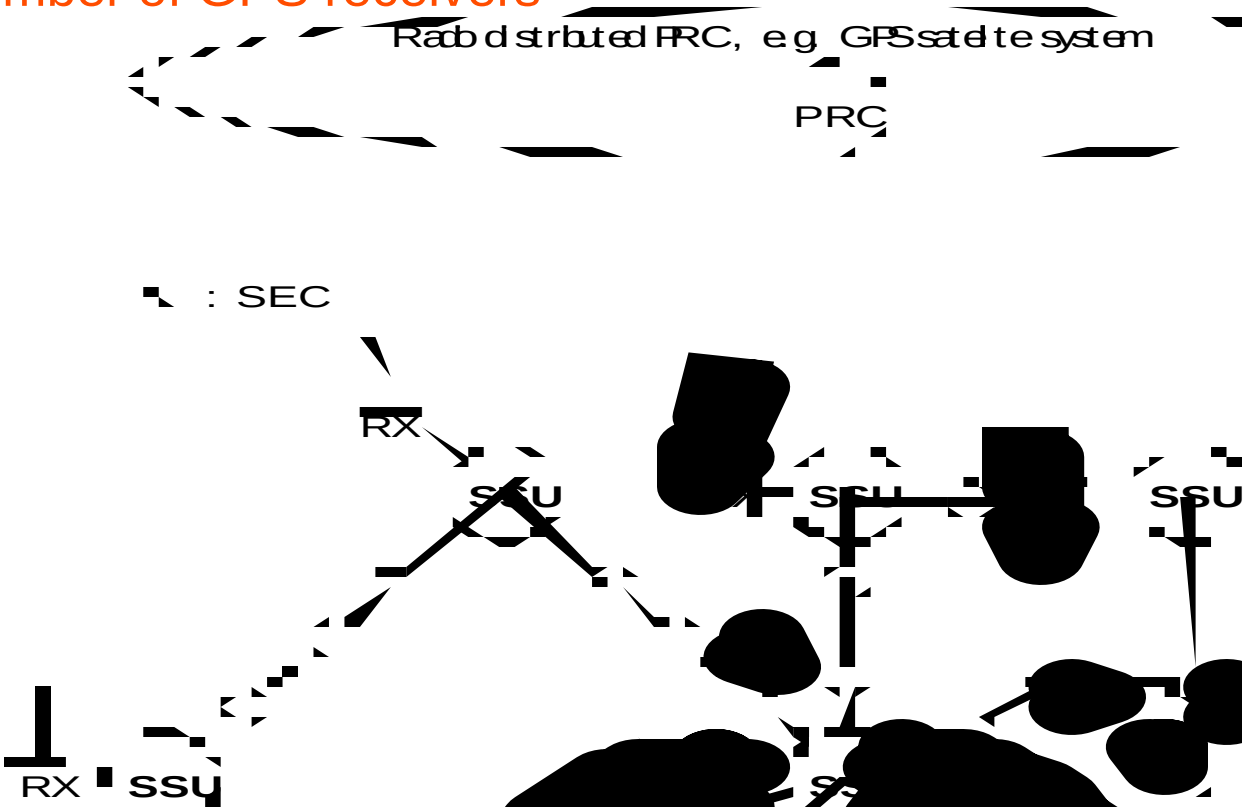
- Easy and robust architecture, no timing loop
- May lead to long chains of clocks



Distributed architecture

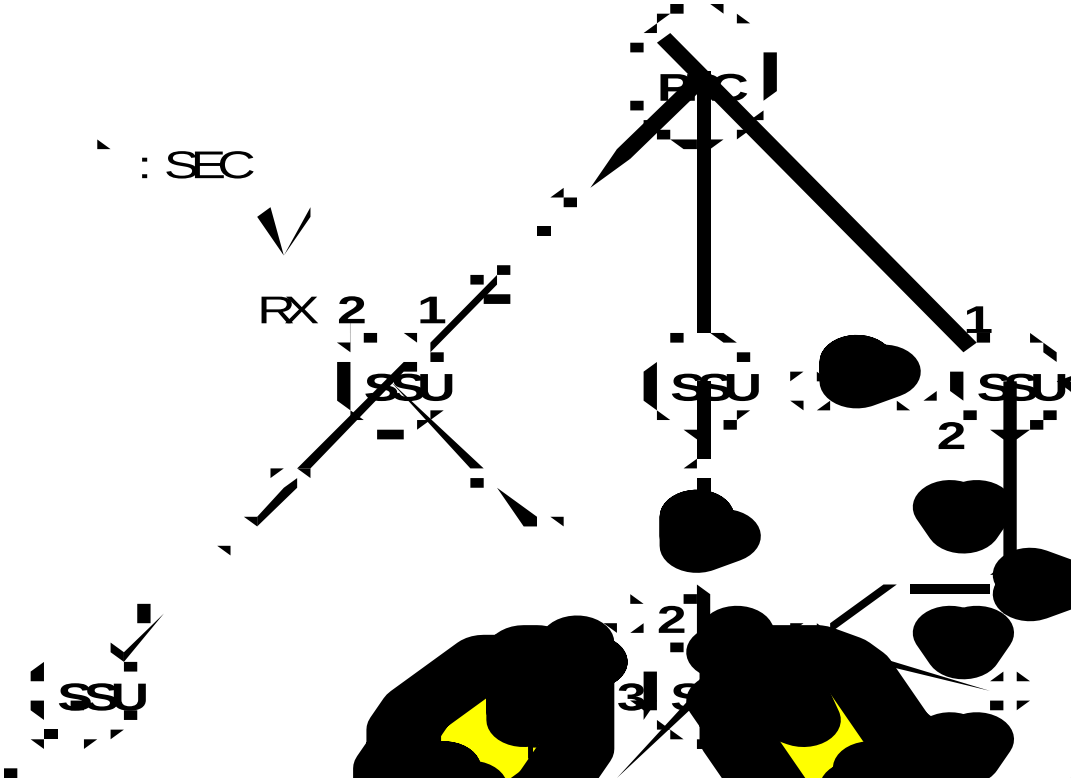
Example with use of GPS receivers

- Short chain of clocks
- High number of GPS receivers



Hybrid solutions

Each of the 2 architectures, centralised and distributed has its own drawbacks, and most operators are optimising their synchronization network with a mix of both architectures.



SSM and synchronisation protection

SSM purpose

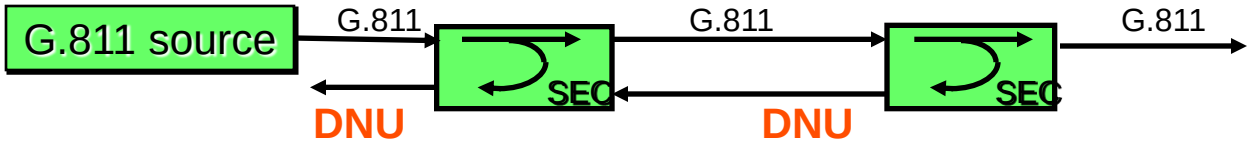
- Provide timing traceability
- Indicate the Quality Level of the source of synchronization

SSM definition

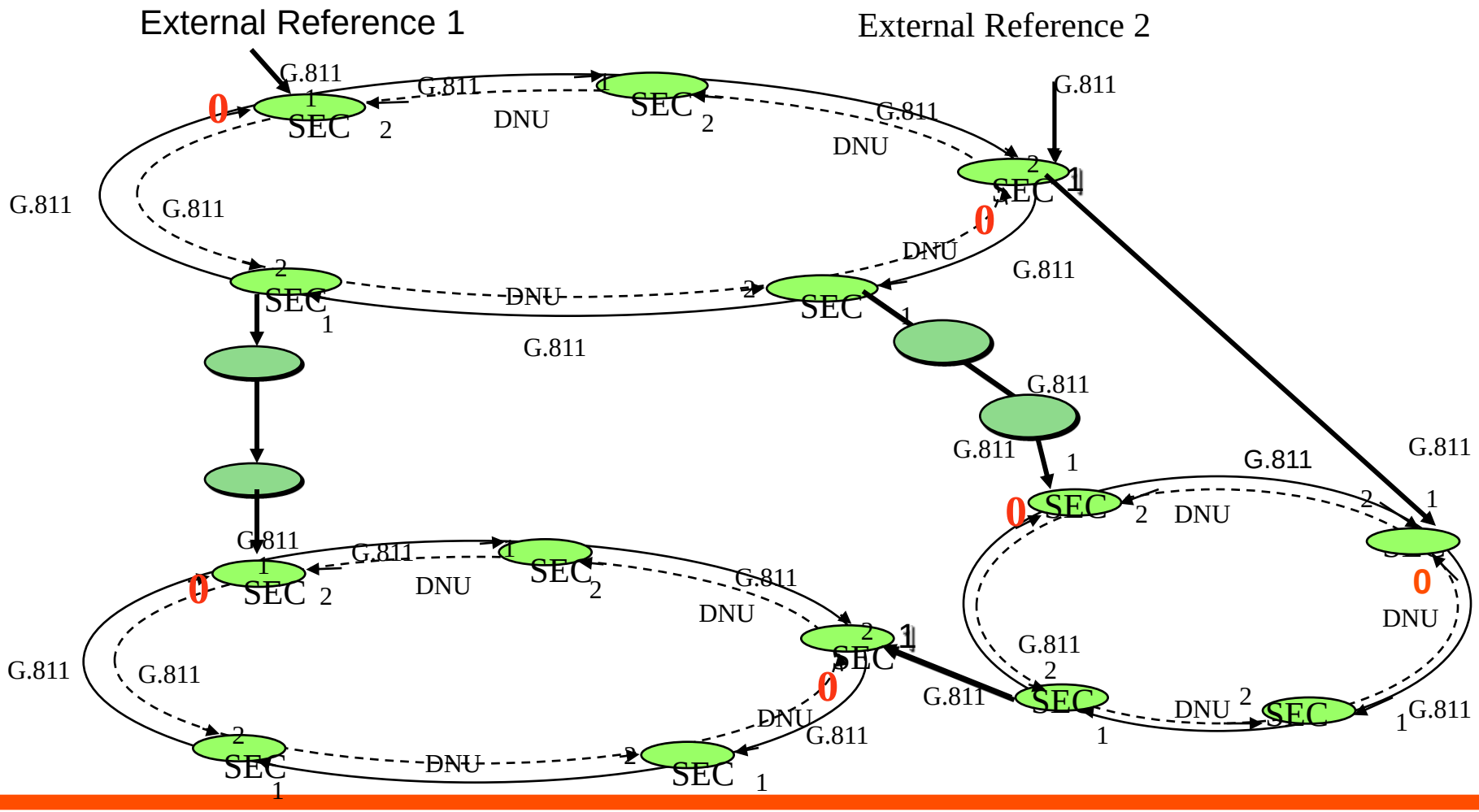
- A 4 bit code located in S1 byte of STM-N frame

SSM application

- Generates a DNU code to prevent timing loop
  - In linear chains and rings and combination of them
  - In meshed networks with some restrictions
- Provide desynchronisation detection



Generalisation of SSM



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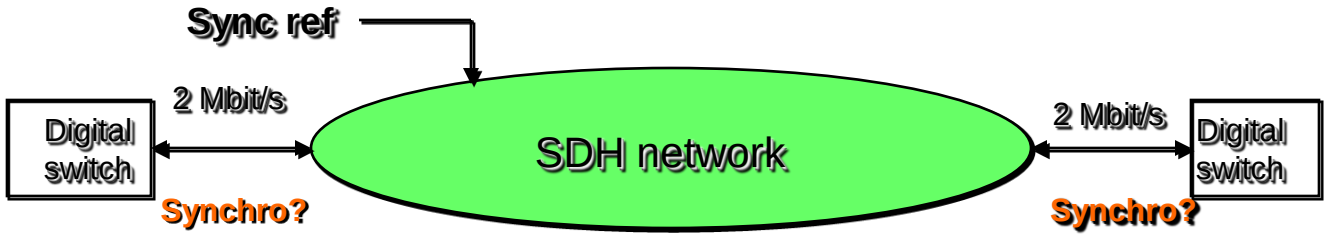
Synchronisation of the E1 layer in SDH

- When SDH is the sync layer
  - E1 is floating within the SDH frame through an asynchronous mapping
  - E1 is inappropriate to transport synchronization due to VC12 PJE

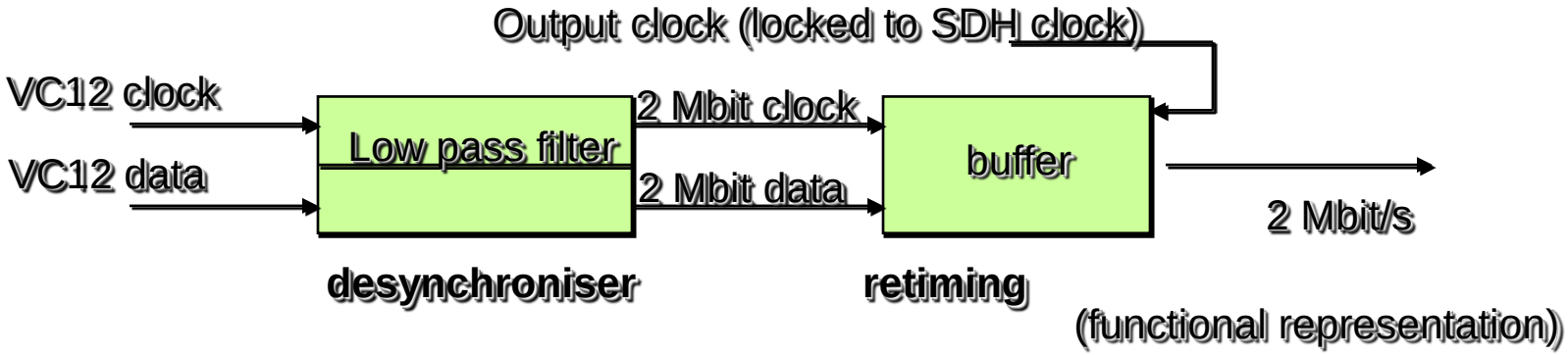


- Solutions
  - Provide a 2 Mhz/2 Mbit rom an SSU if the digital switch has a synchronisation port
  - Implement a retiming function with the 2 Mbit/s desynchroniser

Synchronisation of the E1 layer: SDH NE retiming

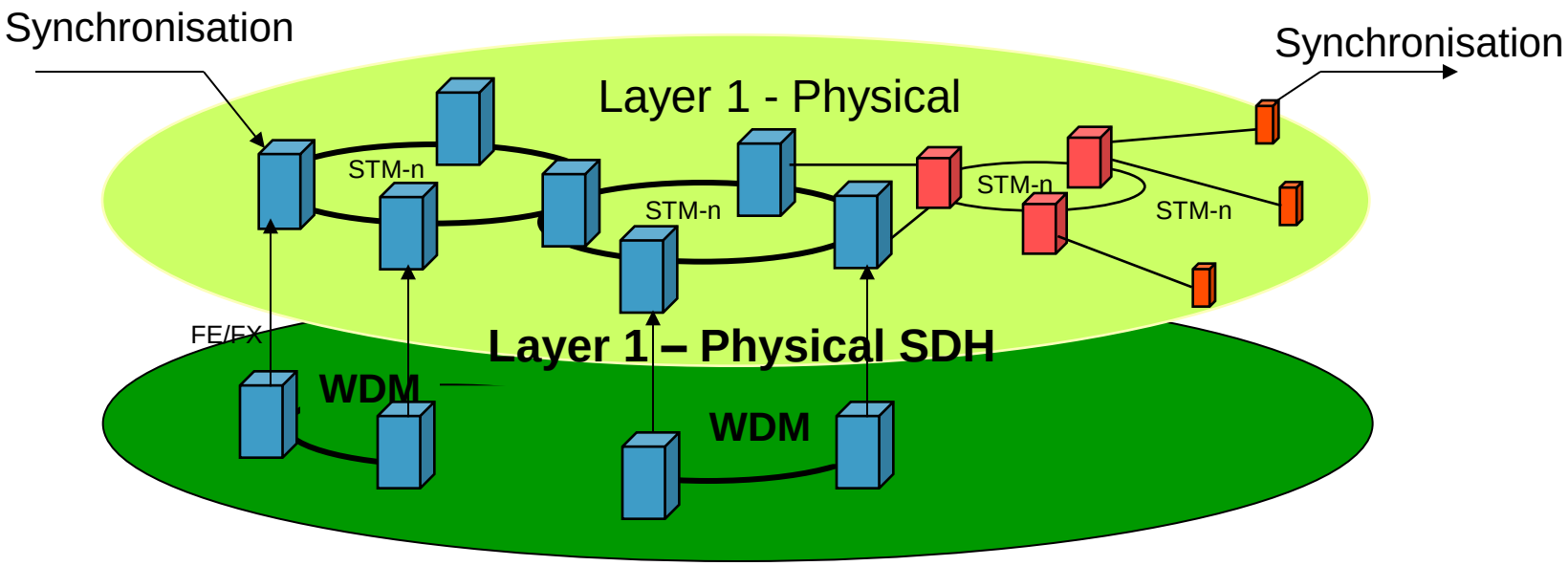
The retiming function is basically a buffer in which a 2 Mbit/s signal is entered with its own clock and which is extracted with the SDH clock of the SDH NE. Note that retiming is also implemented in some SSUs.

- This allows to deliver a network synchronization quality to the 2 Mbit/s and get rid of phase jumps caused by VC12 PJE
- This must be used only on synchronized 2 Mbit/s, otherwise bits will be periodically lost in the buffer



Optical networks

WDM system have been specified to be transparent to client timing
SDH synchronisation network are not jeopardized by WDM, OTN



Synchronisation choices for OTN

OTN is plesiochronous

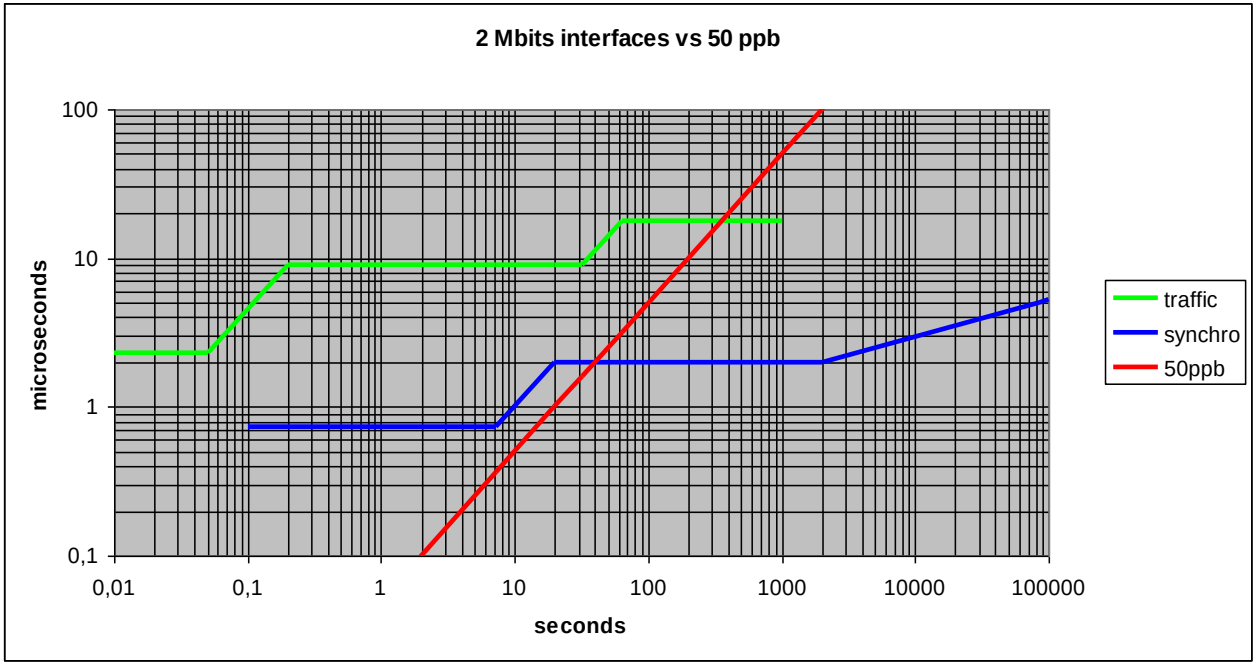
ITU has stated that there is no need for OTN to carry synchronisation, since there is already one network layer that does it, SDH.

- OTN is transparent to CBR client timing, jitter and wander are specified in G.8251
- Each OTN NE has its own free-running clock within ±20 ppm
- OTN is a plesiochronous network
- G.709 specifies justification scheme to adapt client and G.709 frame rate
- All client signal can be within ±20 ppm, even with multiplex function

When OTN does not transport SDH client, it couldnot transport timing, but this might change using new synchronisation methods transported on packet networks

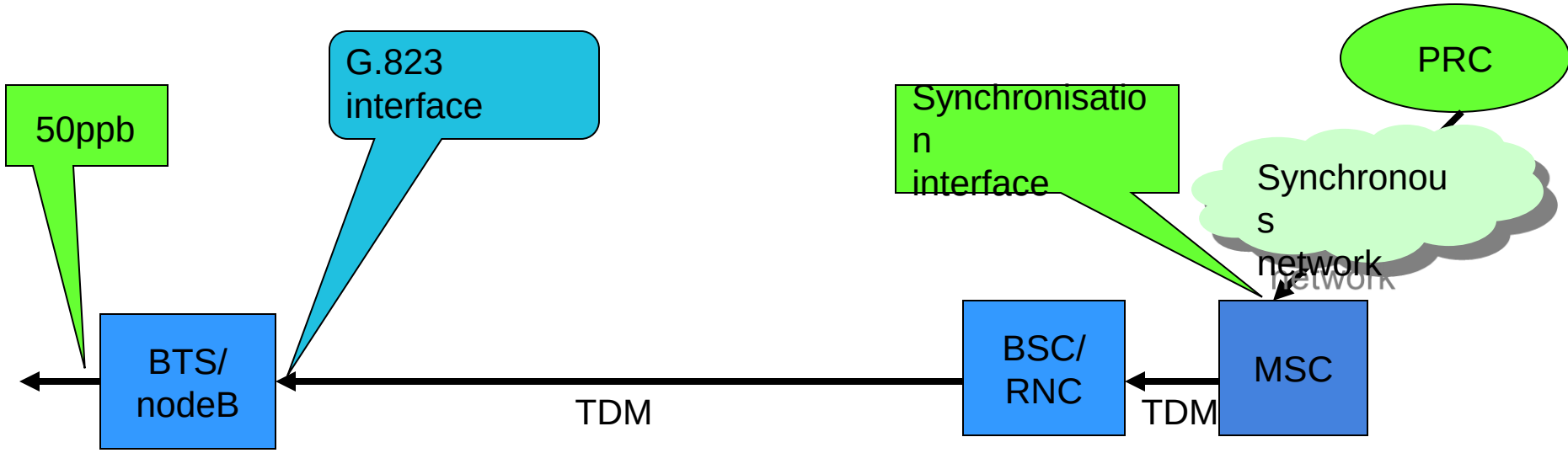
Mobile requirements

In mobile applications, the most important requirement is that the frequency accuracy on the air interface remains within 50 ppb (red line) in order to provide handover when a mobile moves from one cell to another one.



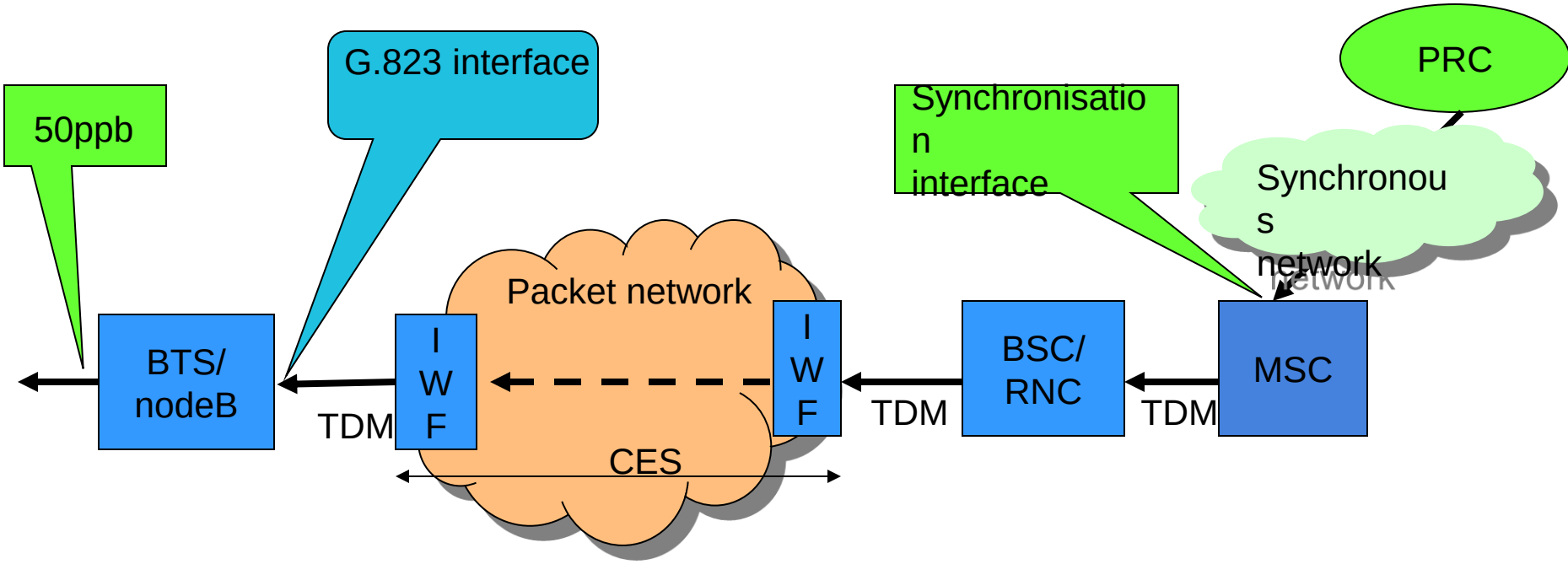
Requires low clock bandwidth implementation in BTS/ nodeB

Mobile Backhauling: Typical TDM Architecture



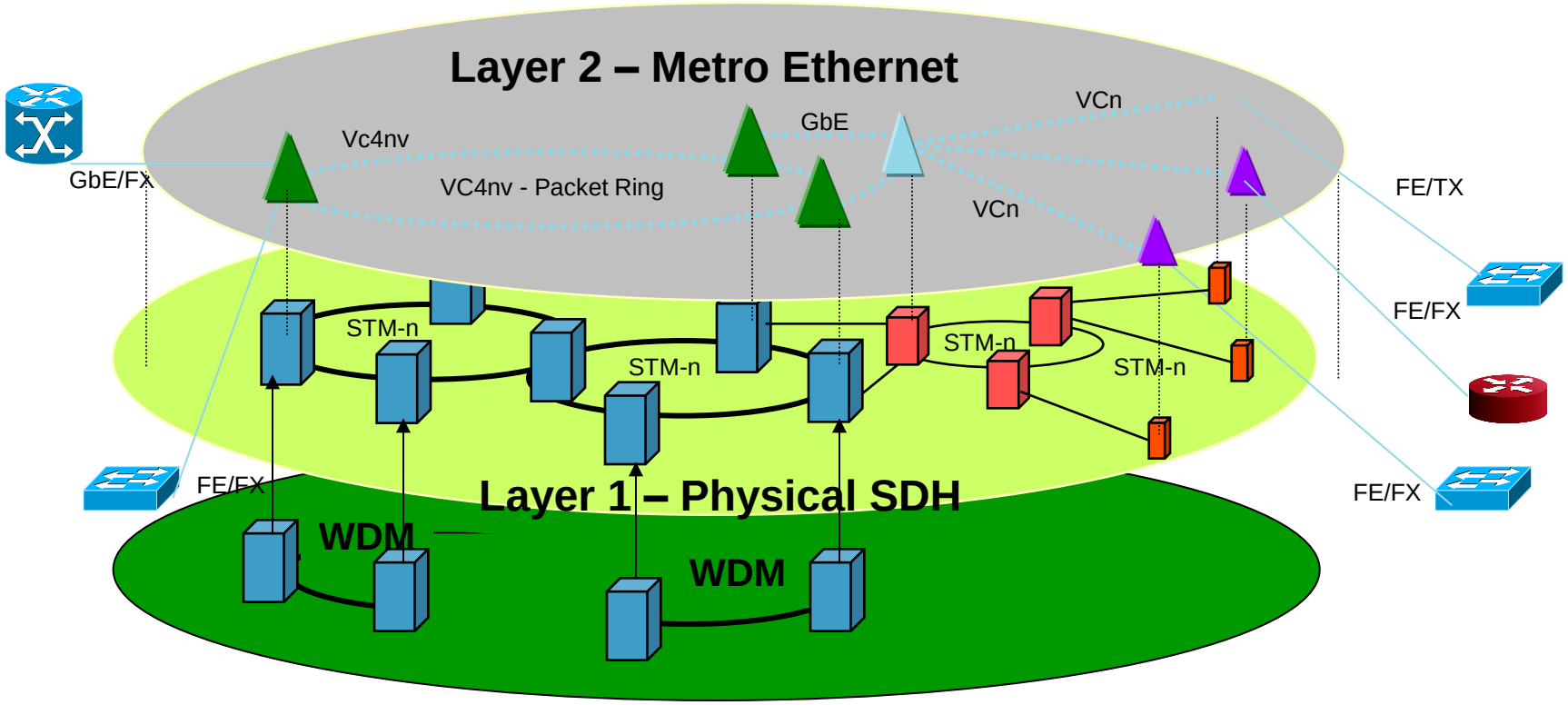
- **BTS/nodeB locked to a PRC:**
- **TDM generated in a MSC that is locked to a PRC via a synchronisation interface (E1, 2 MHz, STM-N)**
  - **BTS/nodeB synchronized on TDM**
  - **BSC synchronized on MSC by the TDM traffic signal**

Mobile Backhauling, example with CES



- **BTS/nodeB locked to a PRC:**
- **TDM generated in a MSC that is locked to a PRC via a synchronisation interface (E1, 2 MHz, STM-N)**
  - **BSC synchronized on MSC by the TDM traffic signal**
  - **BTS/nodeB synchronized on TDM recovered from CES packets**

New technologies in transport networks



Packet networks and synchronisation

1st phase: pseudowire

CES: for transport of TDM

- Adaptive Method
- Differential Method

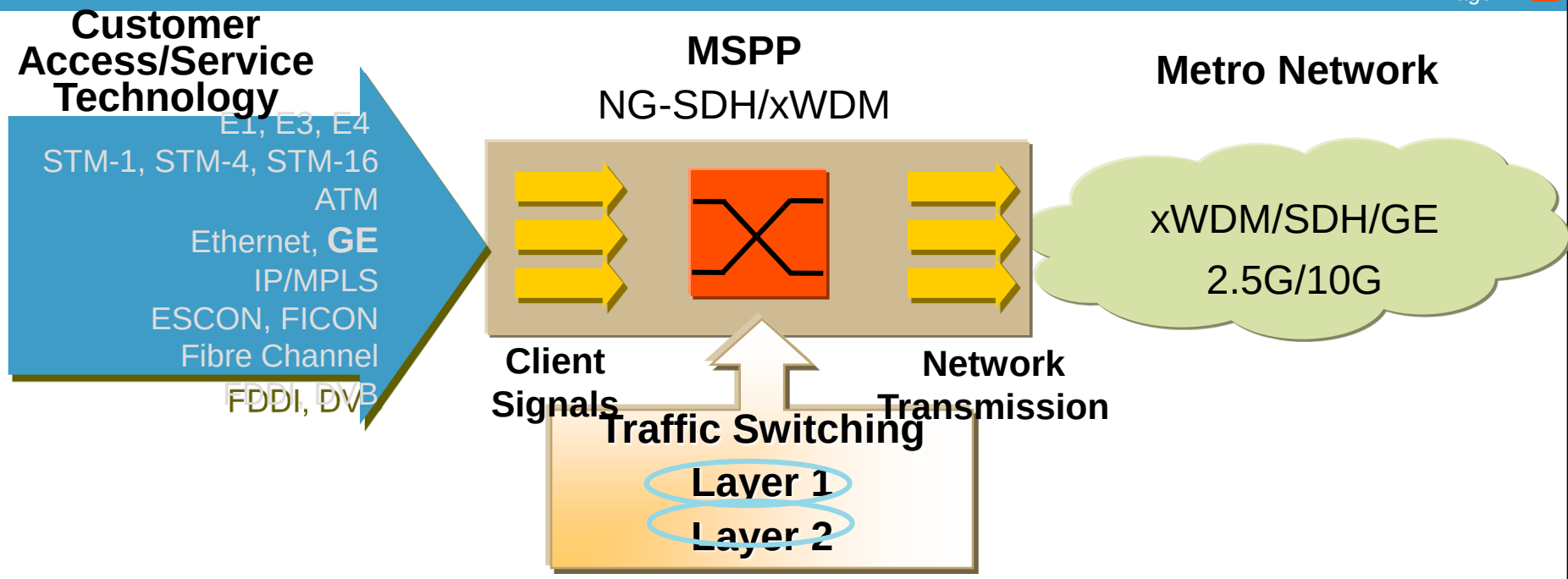
2nd phase: packet networks

Time Protocols

- Precision Time Protocol (IEEE1588)
- Network Time Protocol (NTP)
- Real Time Protocol (RTP)

Synchronous Ethernet

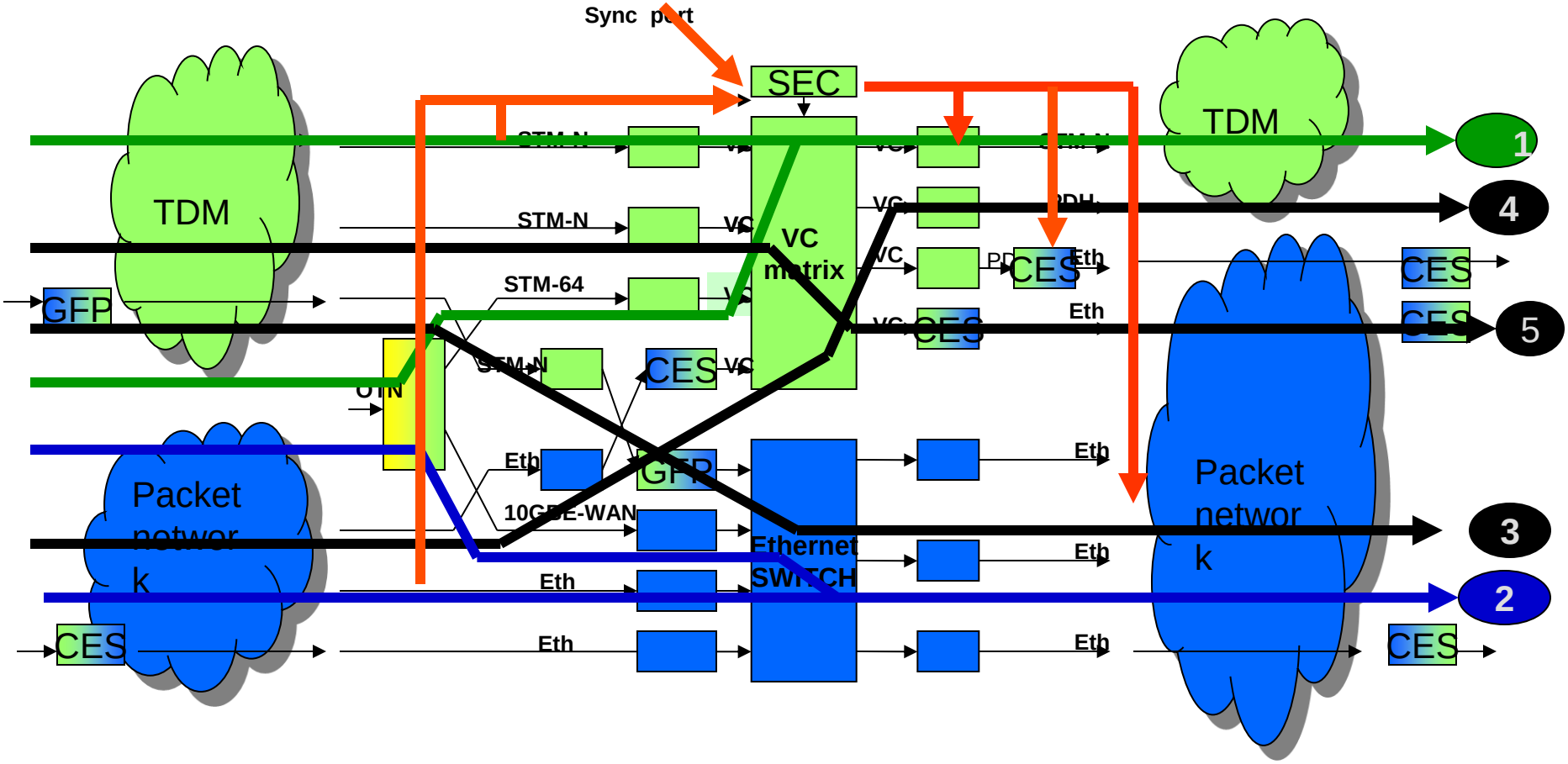
Multi-service provisioning platform (MSPP)



MSPP clock can be synchronised by STM-N, Sync Eth or external synchronisation ports

The clock can be used to synchronise STM-N, sync Eth ports and CES when a clock is needed.

TDM-PSN connexion



Candidate techniques for PSN

	Pro	Con
CES Pseudowire Adaptive	- No specific requirement on intermediate equipments	Medium quality as PDV sensitive
CES Pseudowire Differential	-No specific requirement on intermediate equipments -Good performance	- Need network ref clock at both end points
Synchronous Ethernet	-Excellent quality, similar to SDH -No influence of payload	- all switches of the link need to process the sync Eth feature
IEEE1588™ V2 Applicable to Telecom (Expected approval early 2007)	- good performance - Possibility to bypass some switches not processing 1588 (	-full performance achieved only if all switches are IEEE1588
NTP/RTP	- suits several packet network applications such as VOIP	-Current accuracy too low for TDM applications

Conclusion

Introduction of packet networks creates a similar situation as that one that occured when SDH was introduced in PDH networks, corruption of the existing synchronisation network by a new layer.

VC pointer were the SDH problem and PDV is the packet network problem.

There has been one solution to solve the issue with SDH, the transport of timing STM-N signals.

Many solutions are currently presented to solve the issue with packet networks.

Many presentations will describe these solutions during the next 2 days.

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