Synchronization in telecom networks

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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.

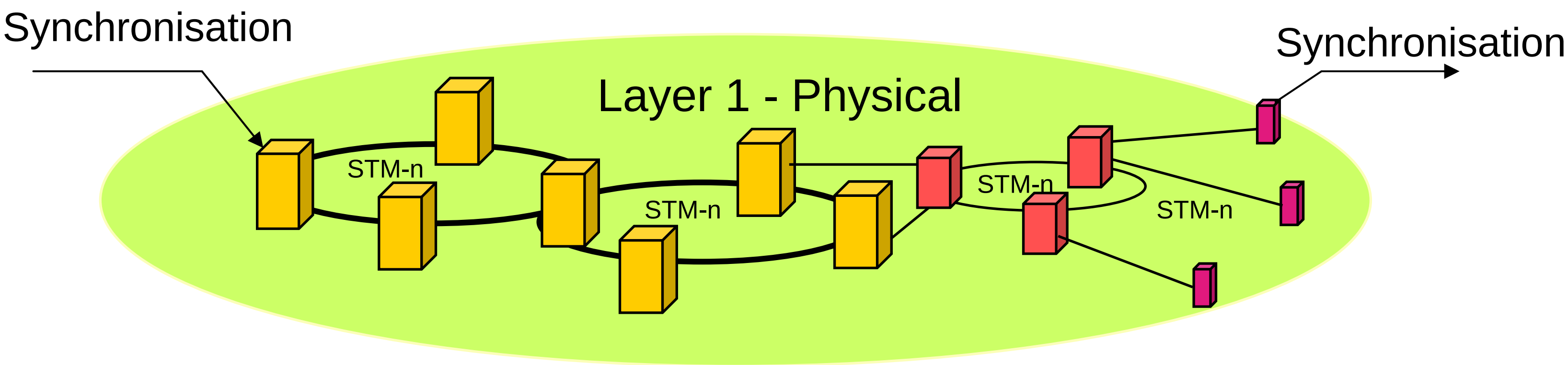
-STM-N was chosen and specified to transport network synchronisation.

-G.803 defines the hierarchical architecture of synchronisation network with clocks are defined in G.811, G.812 and G.813.

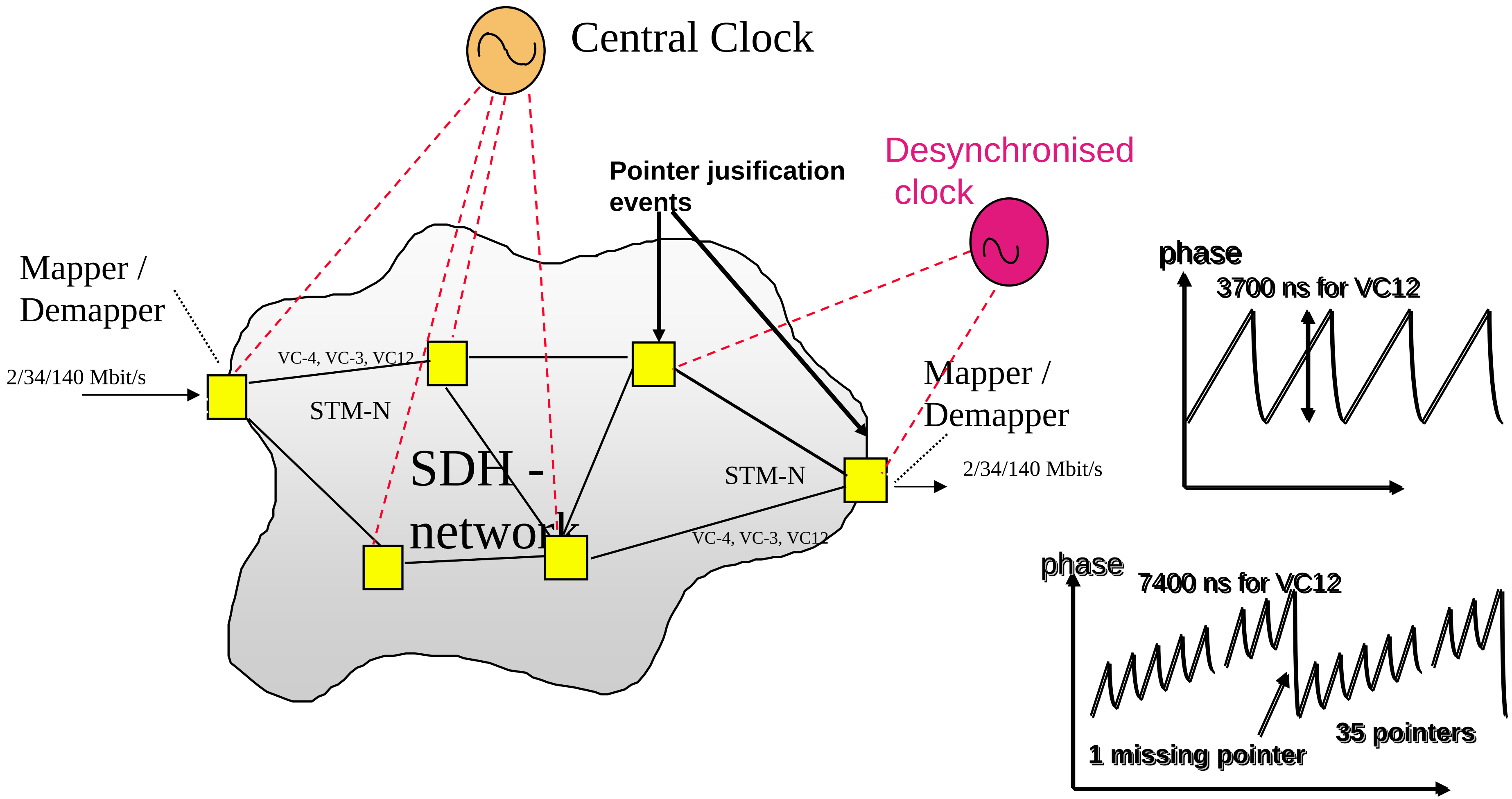
-The respect of these recommendations avoids desynchronisation and allows the control of jitter and wander , prevents pointer justification and consequent wander on PDH tributaries

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

SDH networks



SDH could corrupt the old 2 Mbit/s synchronization network



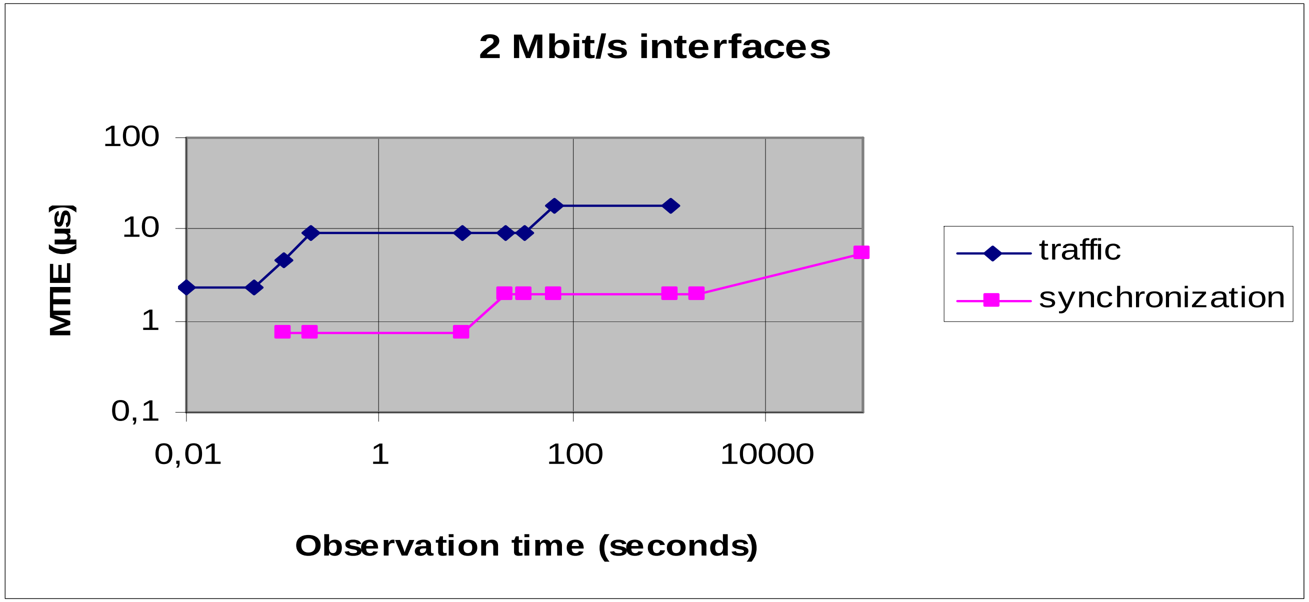
2 Mbit/s interfaces

Traffic interface

- It is specified to limit the wander at the input of PSTN switches below 18µs
- This interface is available on a 2 Mbit/s extracted from an SDH VC12

Synchronization interface

- It has much better performance, this is the only interface specified in synchronization networks
- This interface is available at the output of SDH SECs



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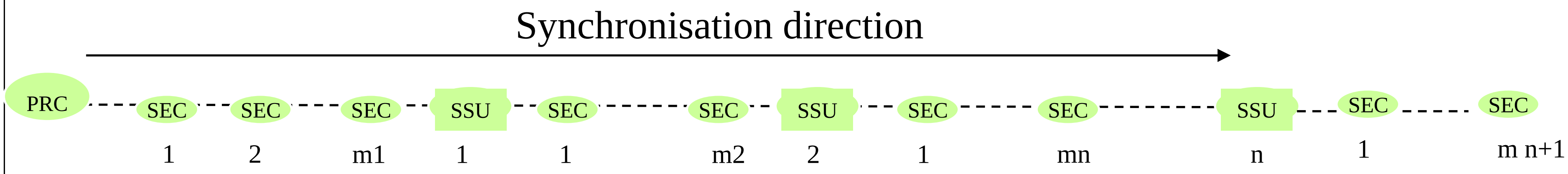
SDH Network Synchronisation
Synchronisation reference chain

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

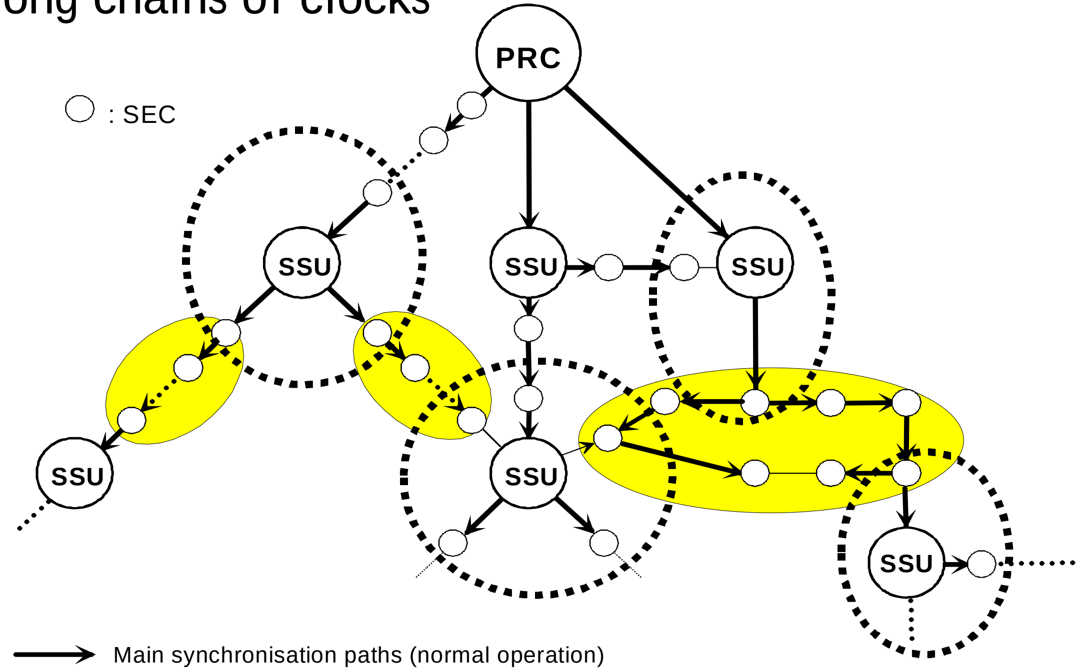


<u>Maximum numbers according to G.803:</u>

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

Hierarchical Master-slave solutions

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



Main synchronisation paths (normal operation)
Under failure situations the direction indicated by the arrow may be reversed

Standby synchronisation paths
Paths without arrows may be used in either direction, depending on the failure situation

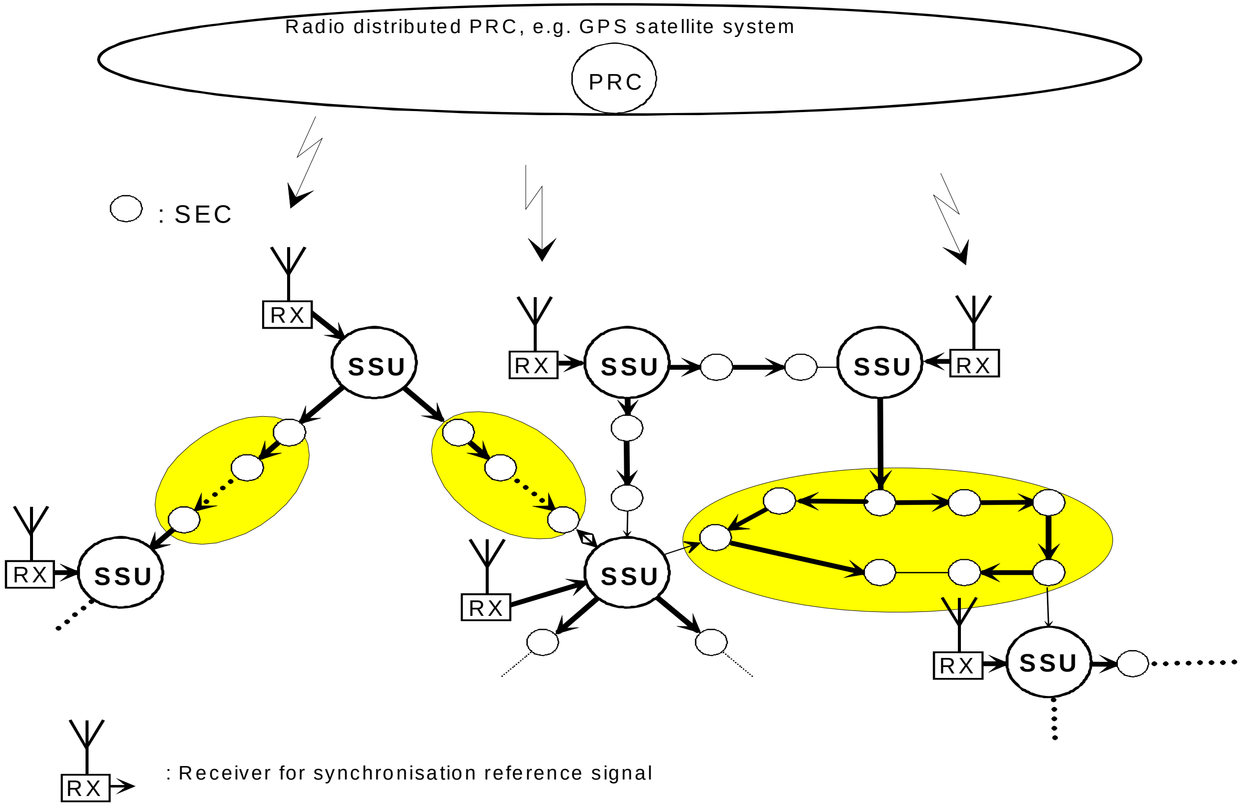
:Network nodes, areas of intra-node synchronisation distribution (examples)

:Transport network, areas of inter-node synchronisation distribution (examples)

Distributed architecture

Example with use of GPS receivers

- Short chain of clocks
- High number of GPS receivers



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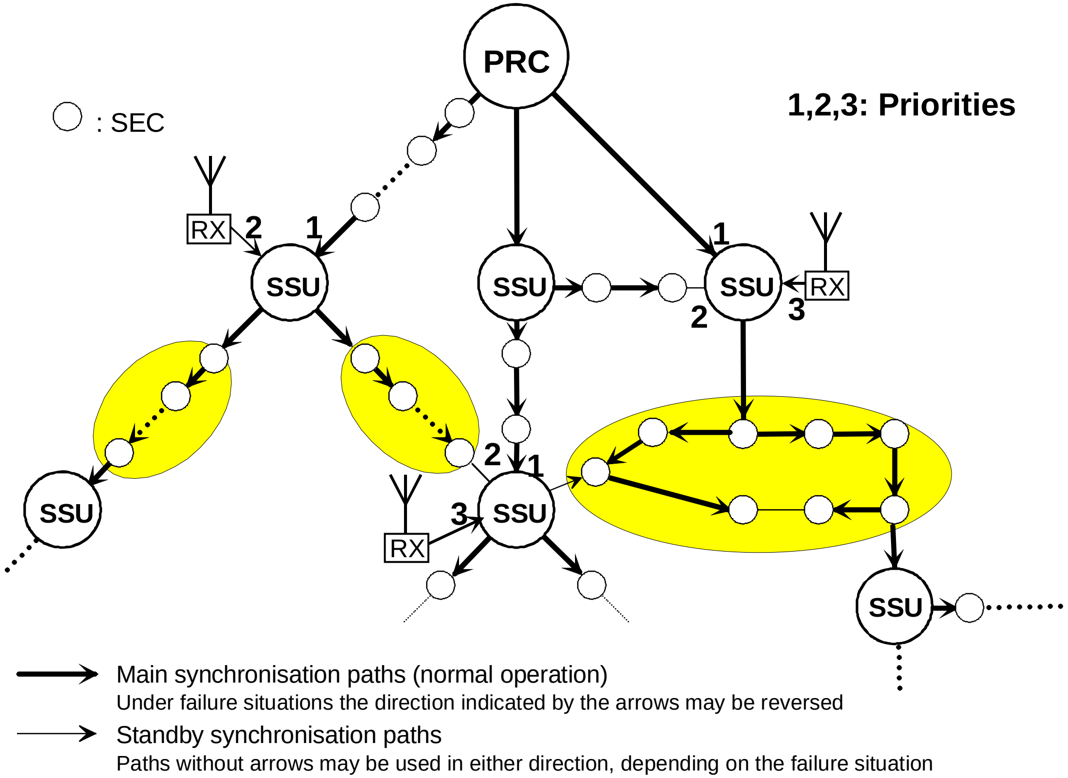
Hybrid solutions

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.



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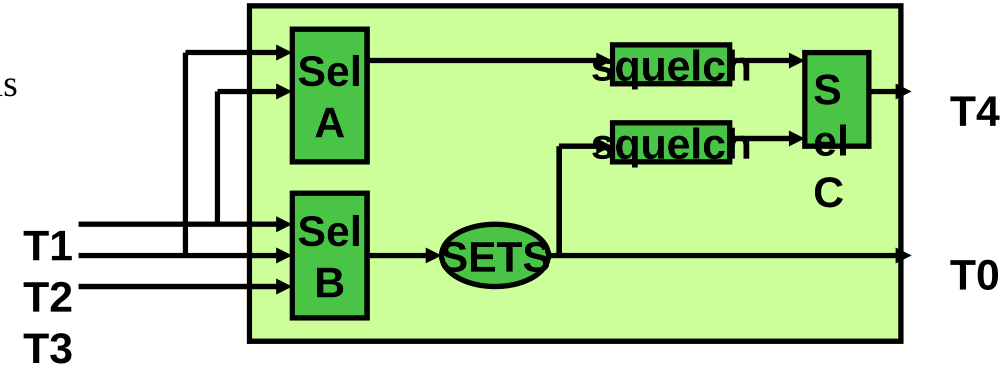
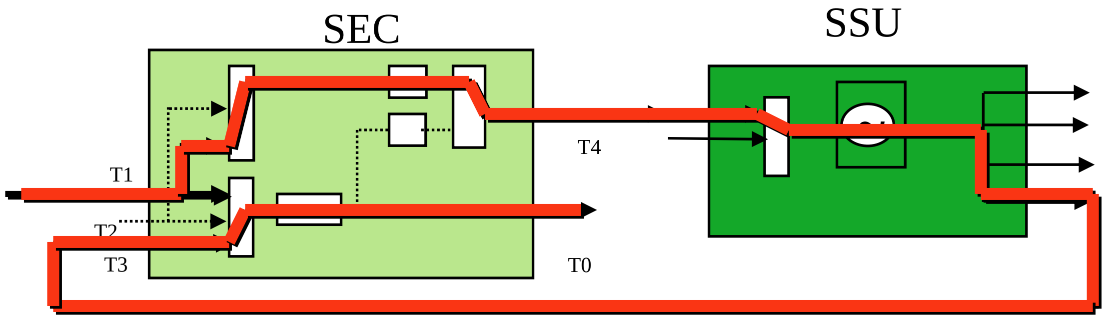
SEC (SDH Equipment Clock) and SSU

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



SSM and synchronisation protection

SSM purpose

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

SSM definition

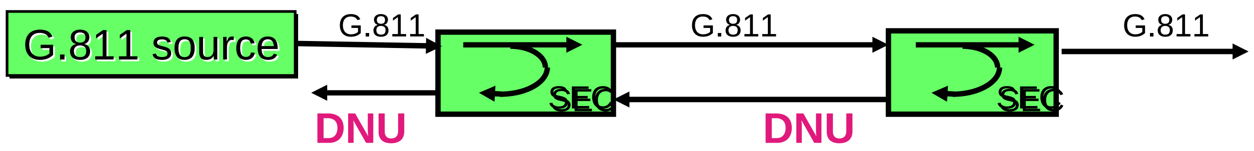
- A 4 bit code located in S1 byte of STM-N frame

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

Restriction

- SSM algorithm has been standardized only at the SEC level
- It has not yet been defined at the SSU level , for general application



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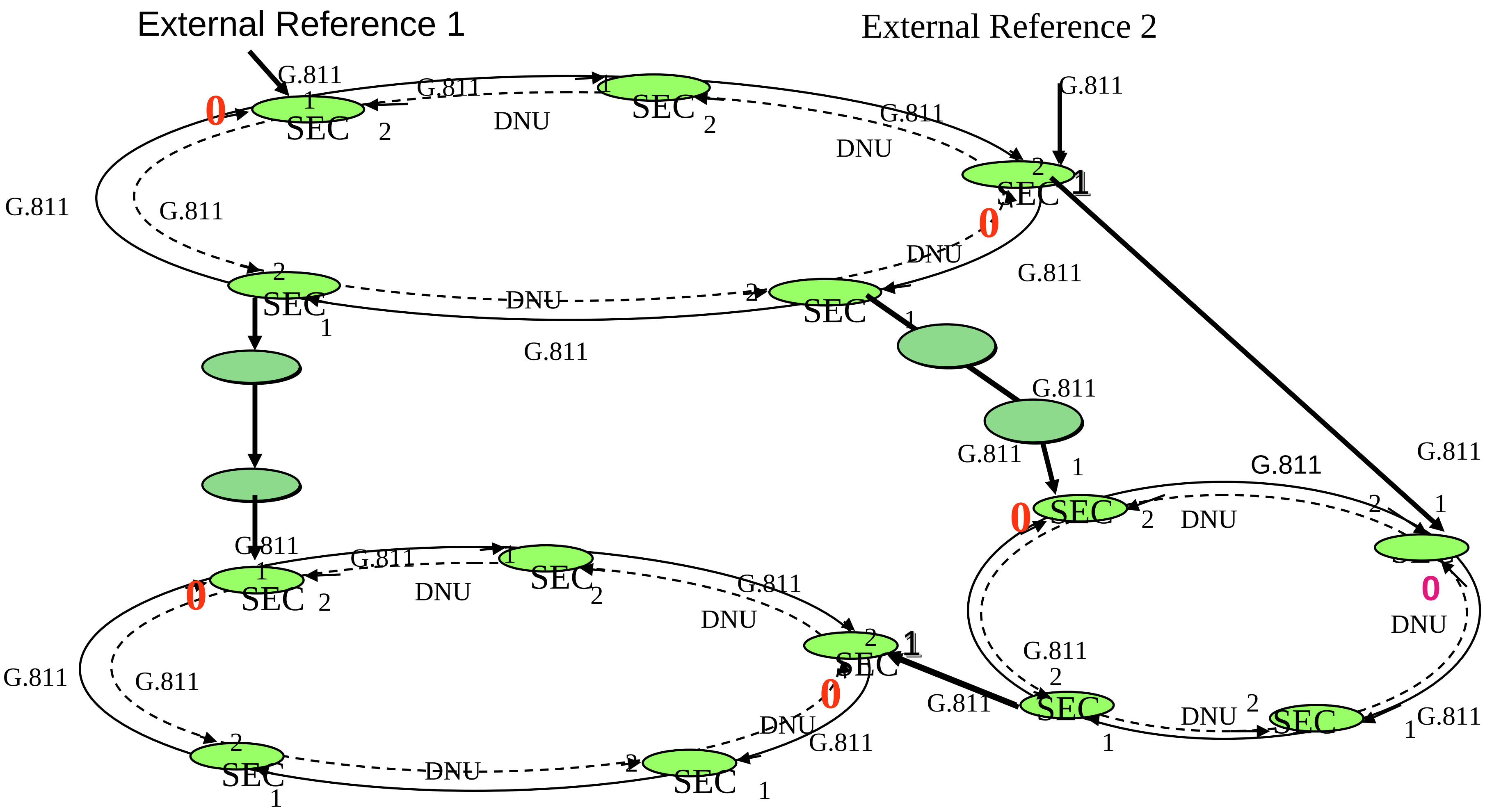
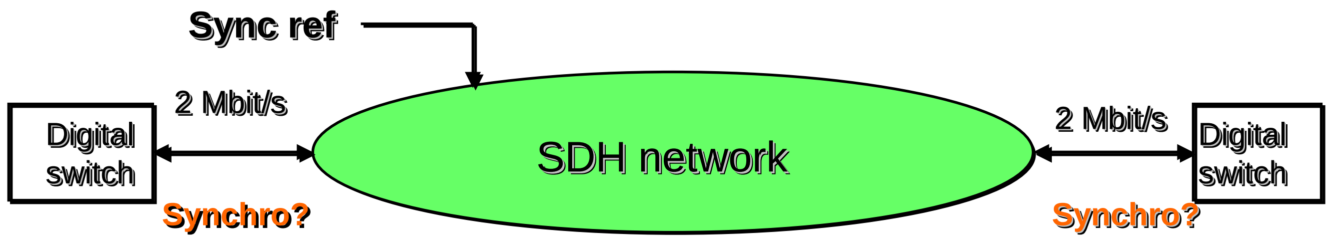
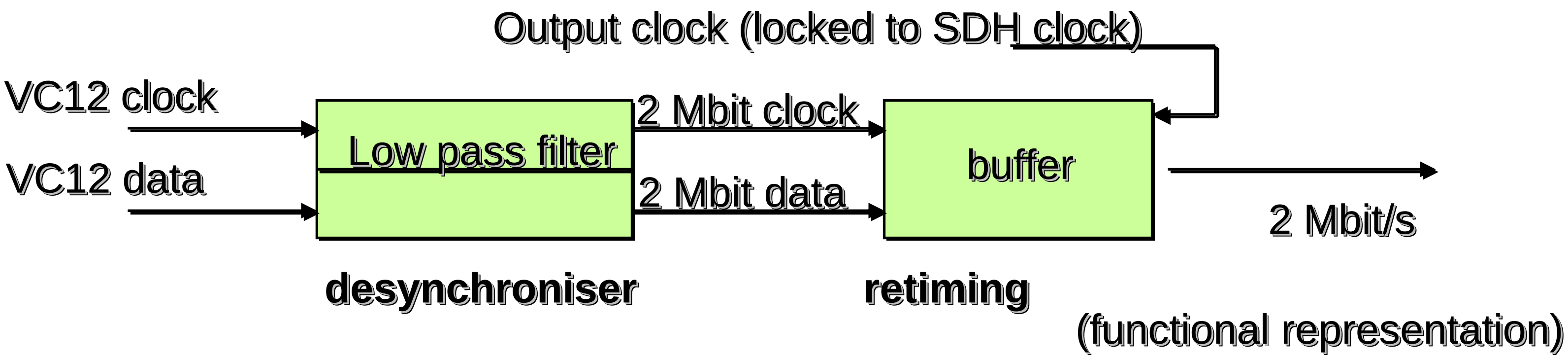
Generalisation of SSM



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



- **Solutions**
  - Provide a 2 Mhz/2 Mbit rom an SSU if possible
  - Implement a retiming function with the 2 Mbit/s desynchroniser



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Other network synchronization items

WDM systems have been introduced

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

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

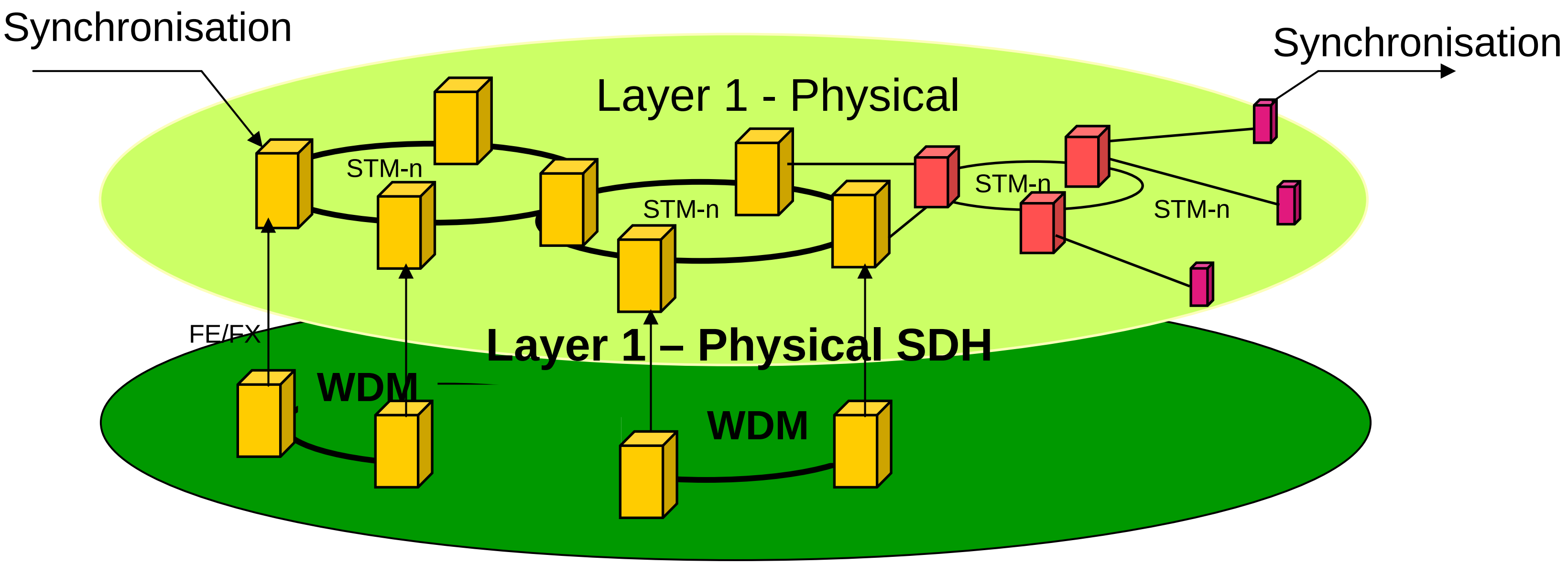
- Rather than Jitter and wander, the frequency accuracy on the air interface is the key requirement for synchronisation networks

Access

- NTR Network Time Reference has been defined to transport timing through DSL systems, ADSL and SHDSL

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

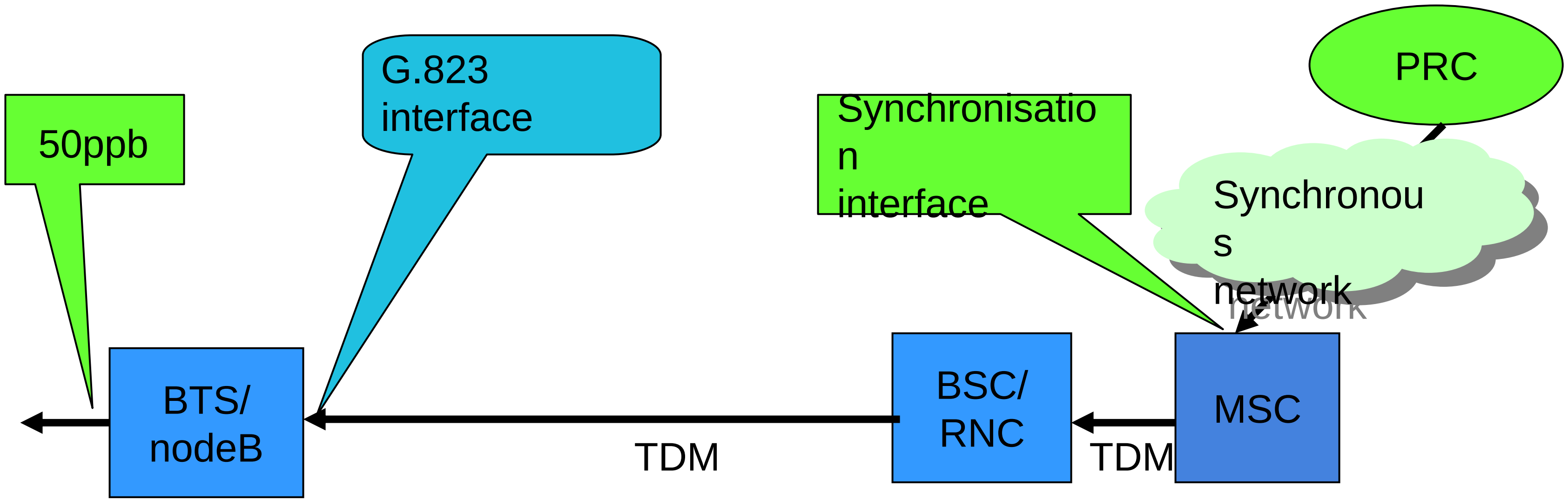
ITU has stated that there is no need for OTN to carry synchronisation, since there is already one network layer that does it, SDH.

- 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

- Care should be taken that some mappings might not be transparent to timing transported over Ethernet.

Mobile Backhauling: Typical TDM Architecture

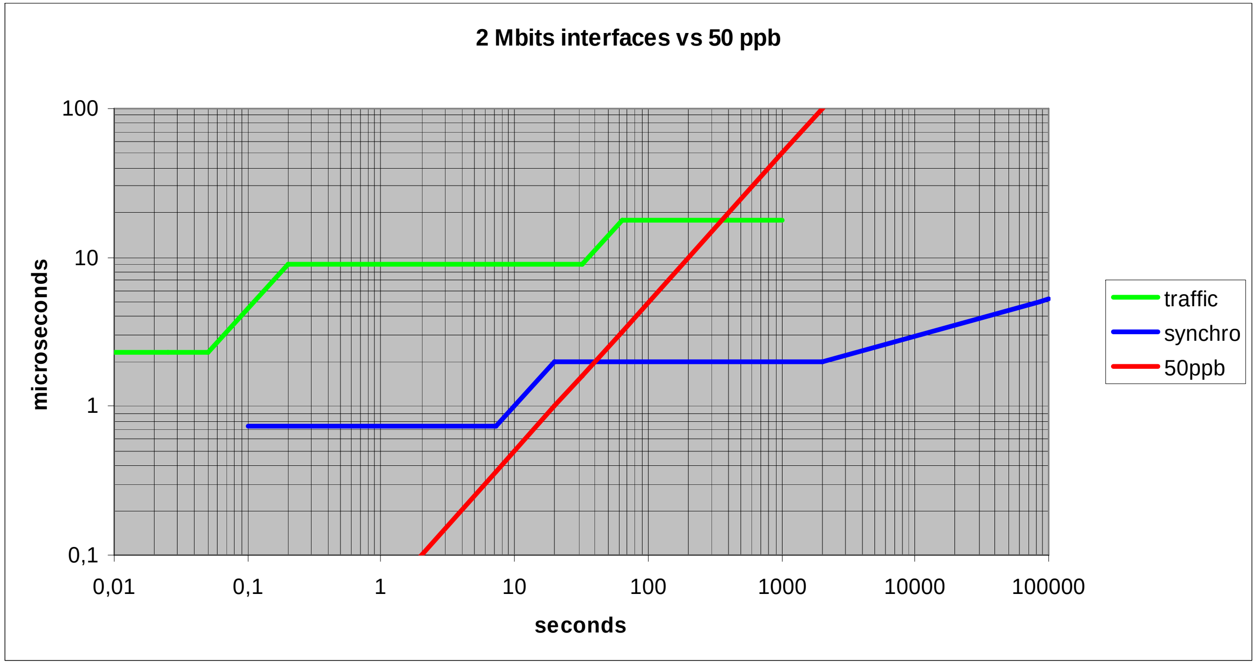


BTS/nodeB locked to a PRC:
TDM generated in a MSC that is locked to a PRC via a synchronisation interface (E1, 2 MHz, STM-N)

- **BTS/nodeB synchronized on TDM**
- **BSC synchronized on MSC by the TDM traffic signal**

Mobile 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.



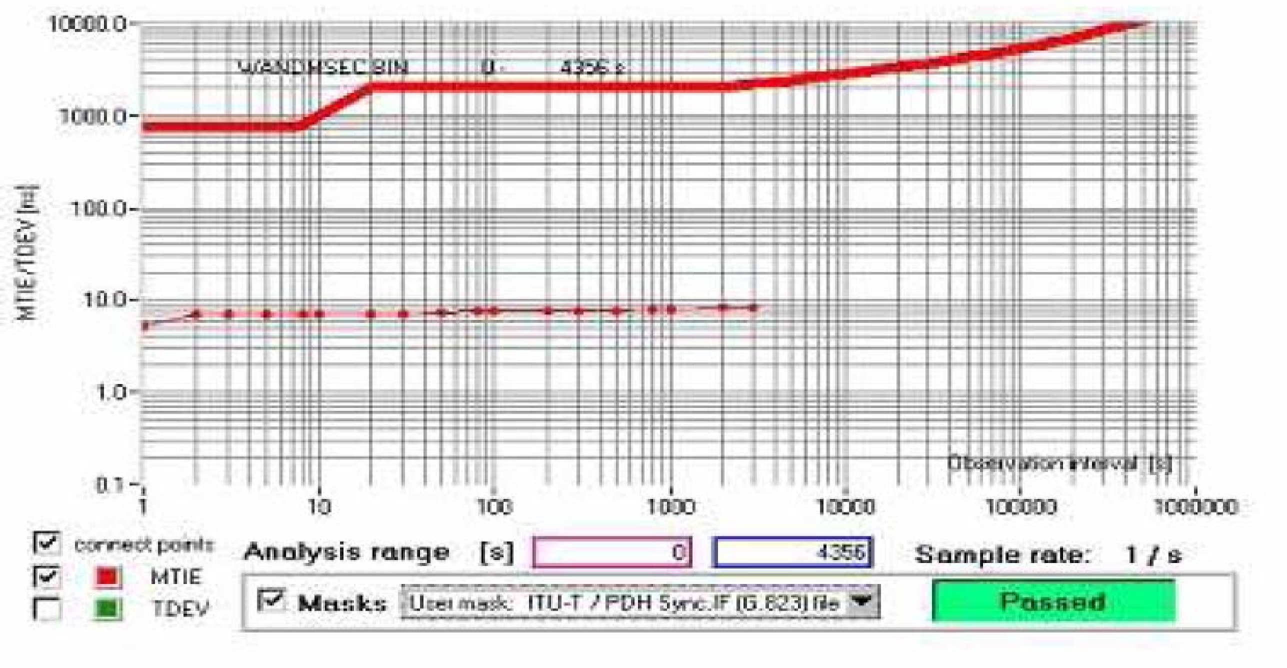
Requires low clock bandwidth implementation in BTS/ nodeB

Synchronization in access networks: NTR Network Timing Reference

NTR is a method that transmits an 8kHz timing marker through the ADSL system has been defined by ITU for DSL products.

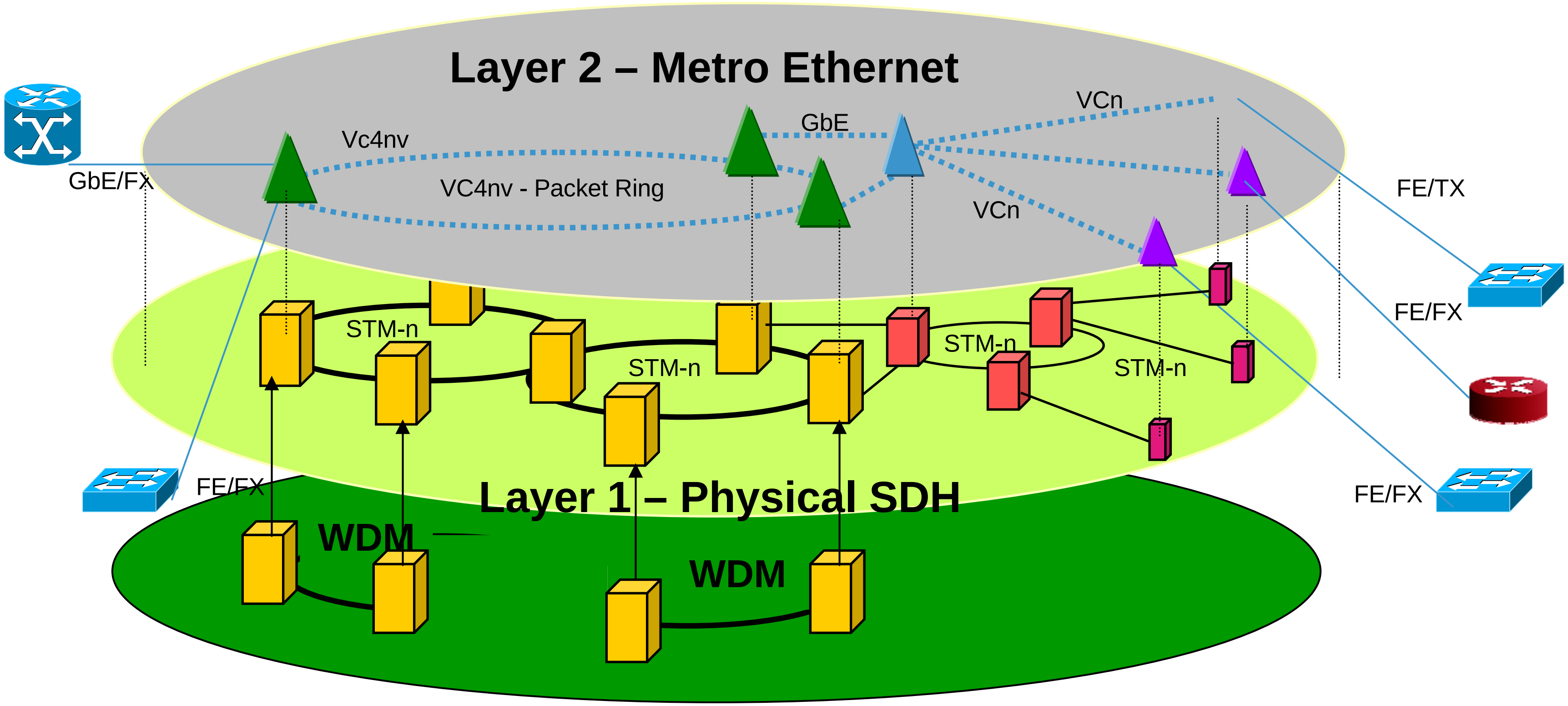
It can be implemented on ADSL and SHDSL systems

As an example, the attached figure show the quality of a clock recovered from a SHDSL system synchronized from a GPS.



Packet networks

Main issue: PDV might corrupt timing transport



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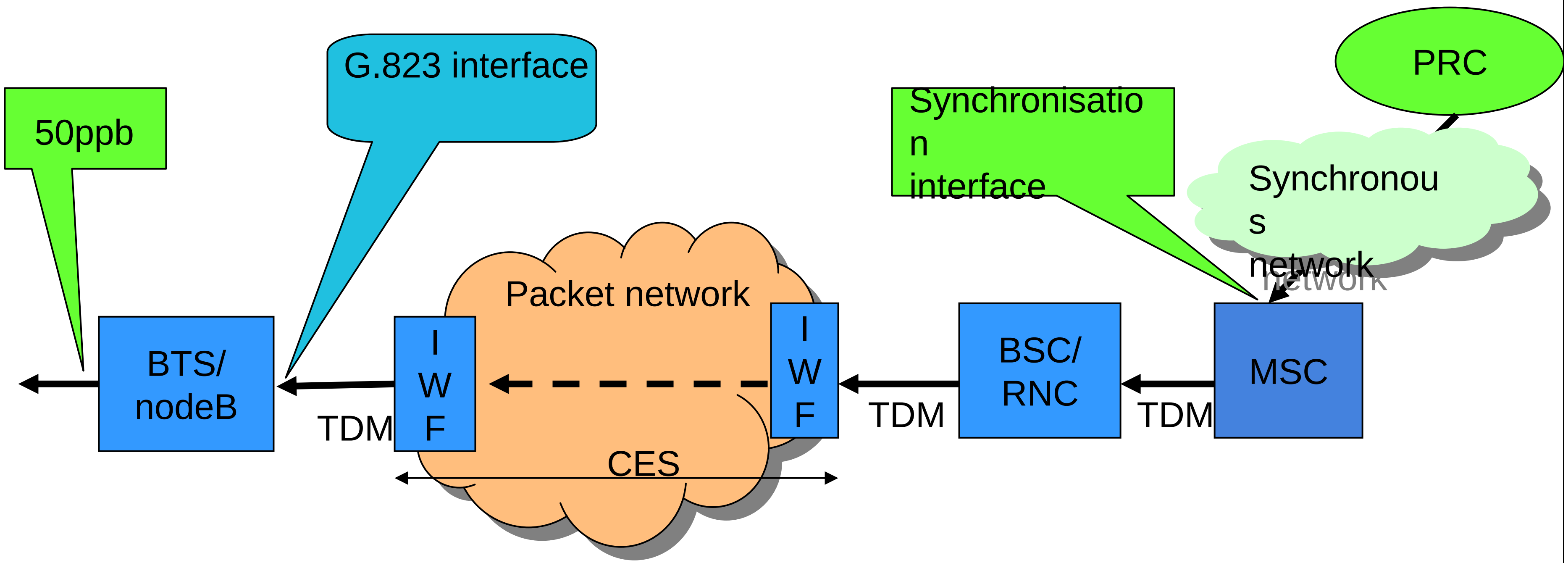
Mobile Backhauling, example with CES



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**

Packet networks and synchronisation

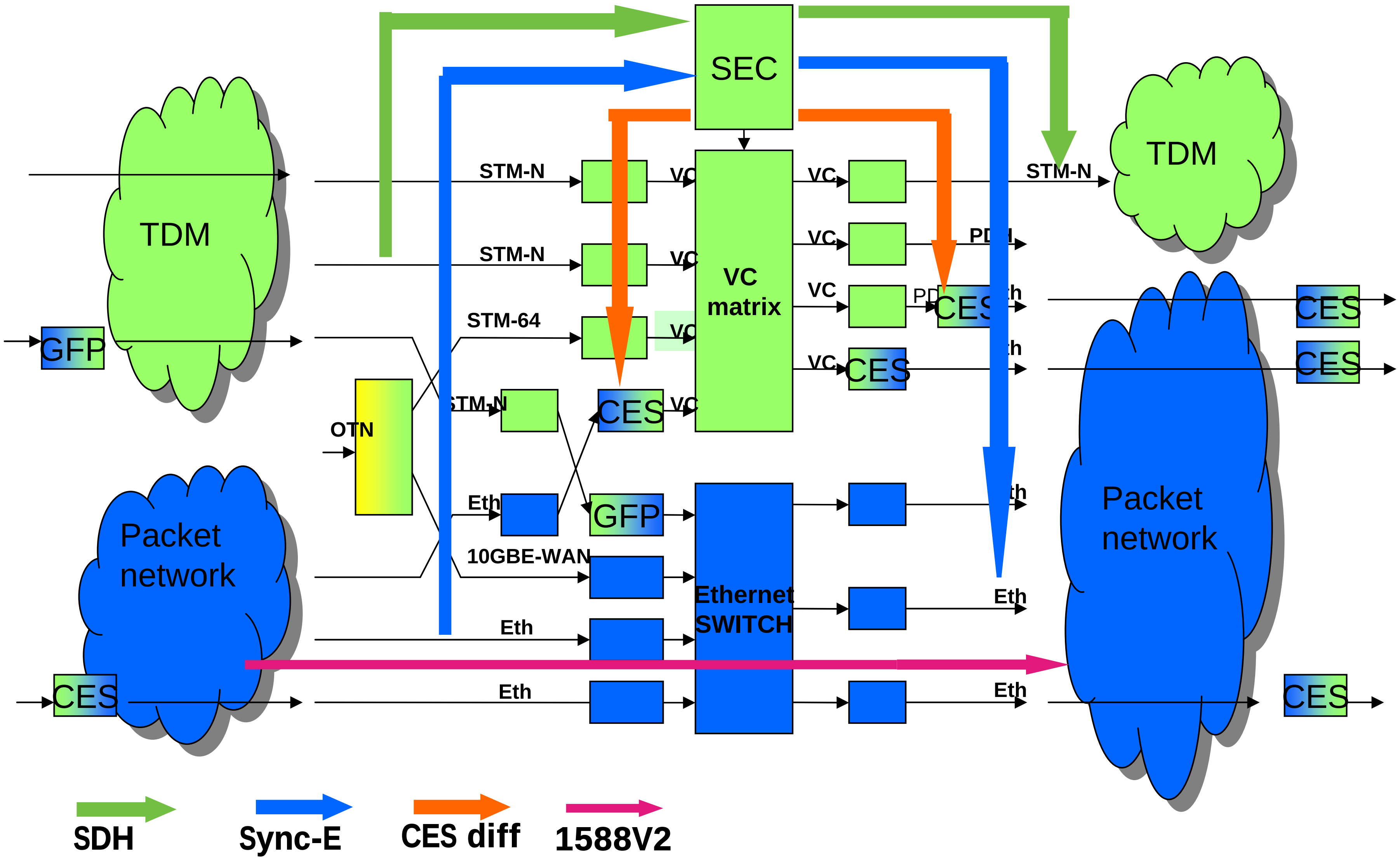
Transport of TDM payload

- CES, Pseudowire
  - Adaptive Method, sensitive to PDV
  - Differential Method, requires a network reference clock at both ends

Transport of reference timing (time, phase,frequency)

- **Time Protocols**
  - Precision Time Protocol (IEEE1588) V2
    - Several clocks: boundary, and transparents clocks
  - Network Time Protocol (NTP)
- **Synchronous Ethernet**
  - It has been specified this year by ITU-Tto transport frequency
  - It has same performance as SDH and interwork with SDH
  - It requires that all NEs in the chain process are Synchronous Ethernet

Multi-service provisioning platform (MSPP)
An hybrid SDH-Synchronous Ethernet equipment



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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 switches not processing 1588	-full performance achieved only if all switches are IEEE1588
NTP	- suits several packet network applications	-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, 1 byte, was the SDH problem
- PDV,x ms, is the packet network problem.

Synchronous ethernet and 1588 V2 will be complementary methods to bring synchronization in packet networks www.alcatel-lucent.com