



# **Jitter and Wander Testing in High-Speed Telecom Networks**

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ITSF 2006

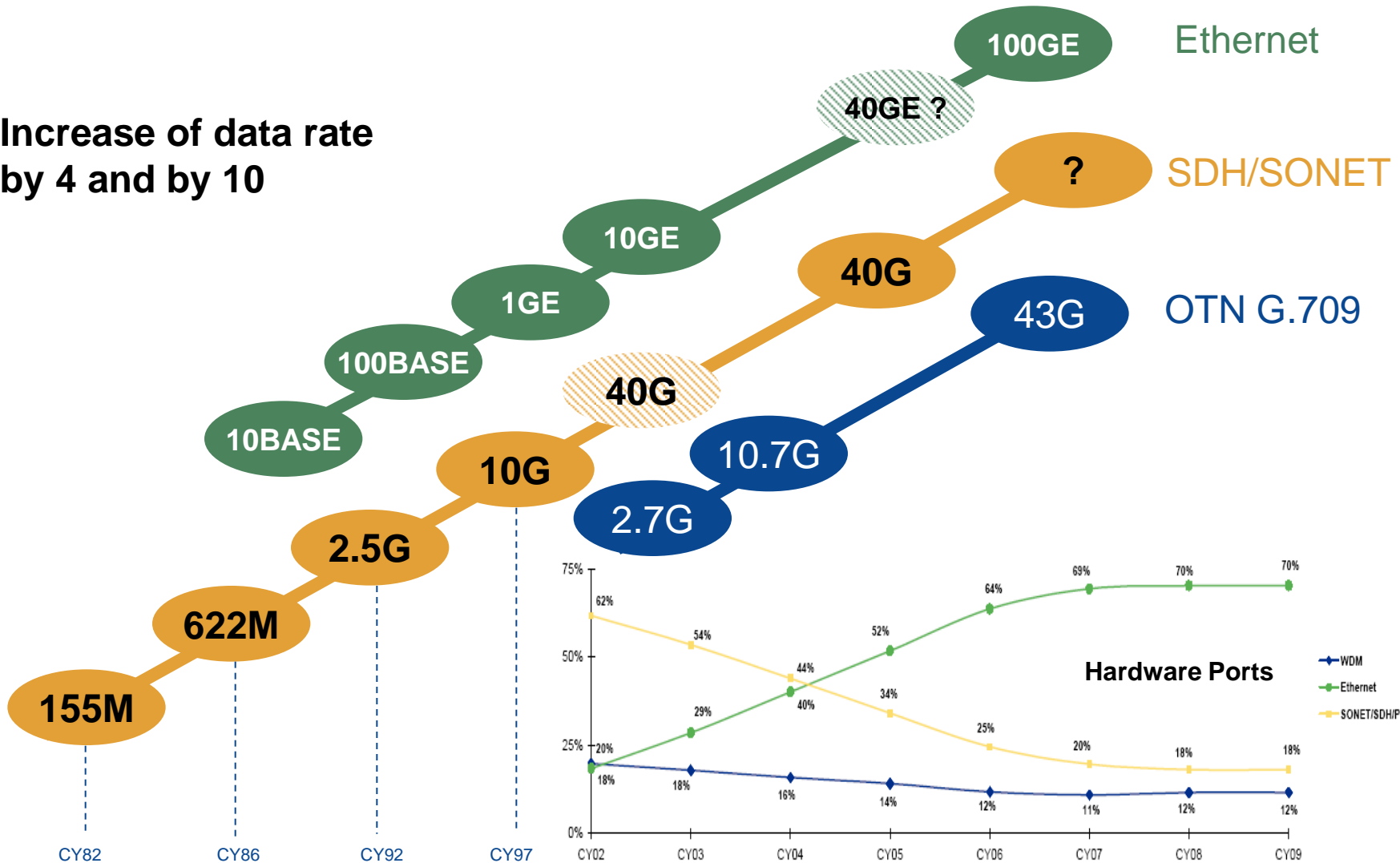


## Agenda

- **Network evolution**
- Jitter and wander aspects
- Application scenarios
- Case study
- Conclusion

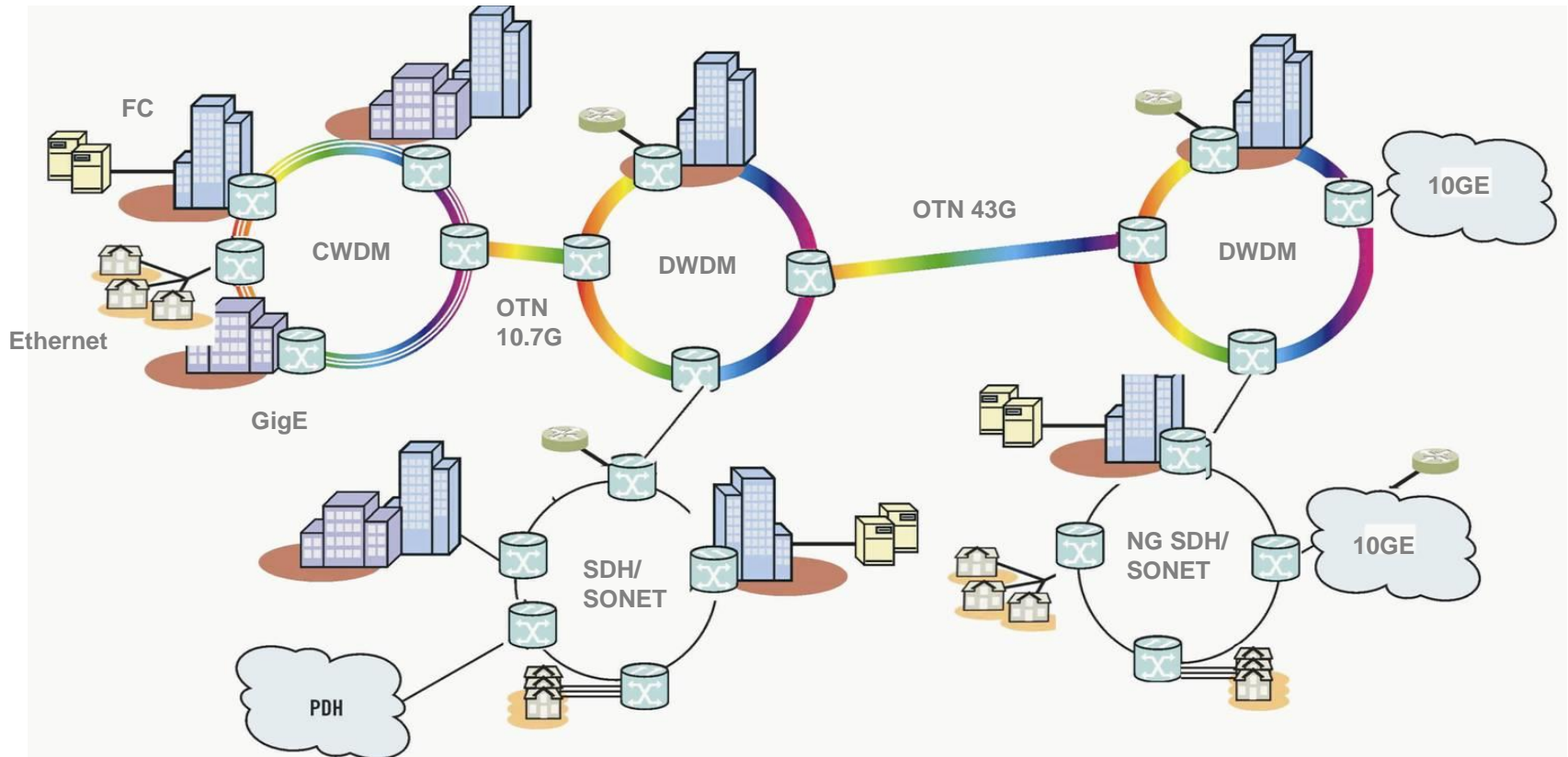
# Evolution of optical transport data rates

Increase of data rate  
by 4 and by 10



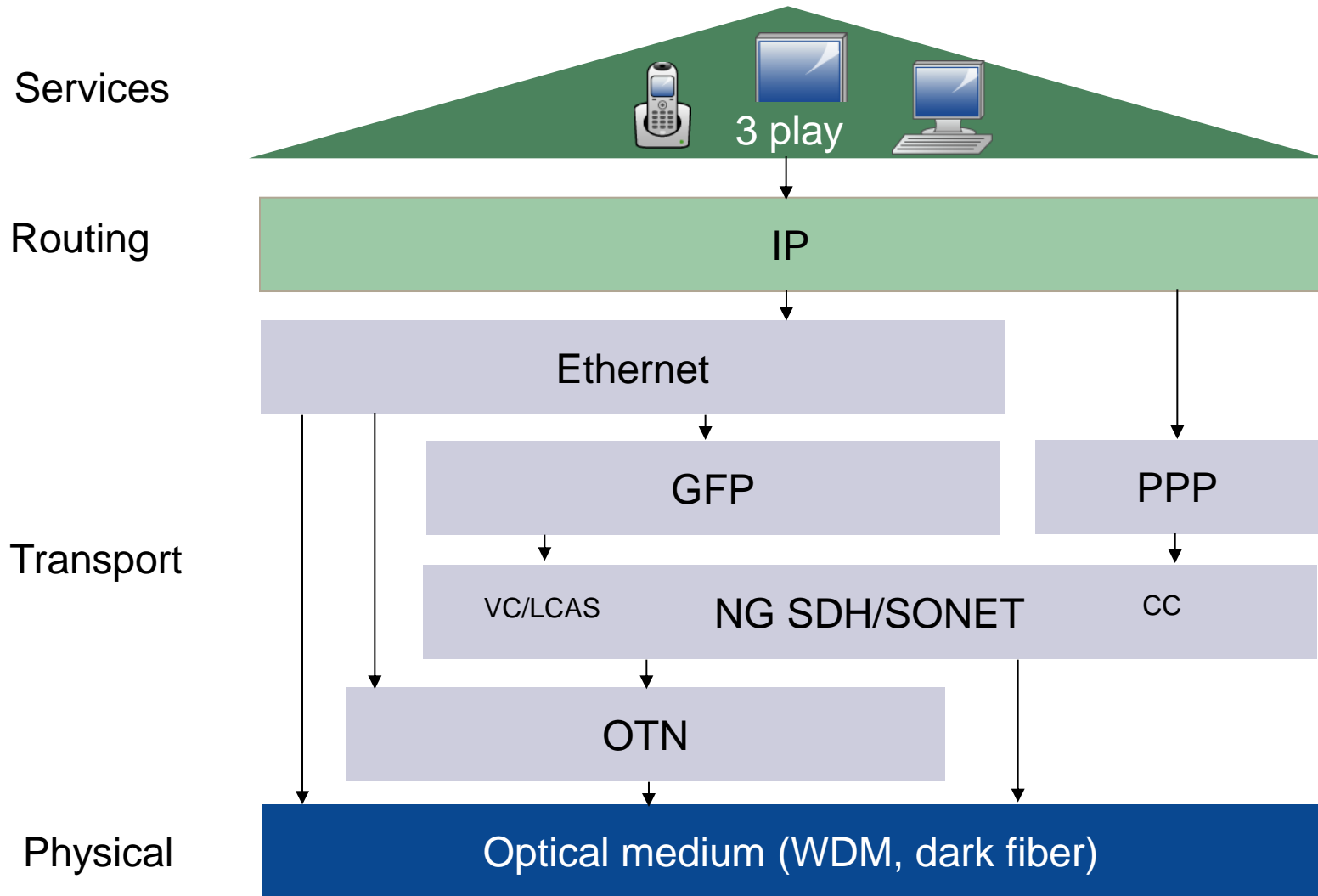
Source: Infonetics Research, February 2006

# Combining TDM and packet switched networks

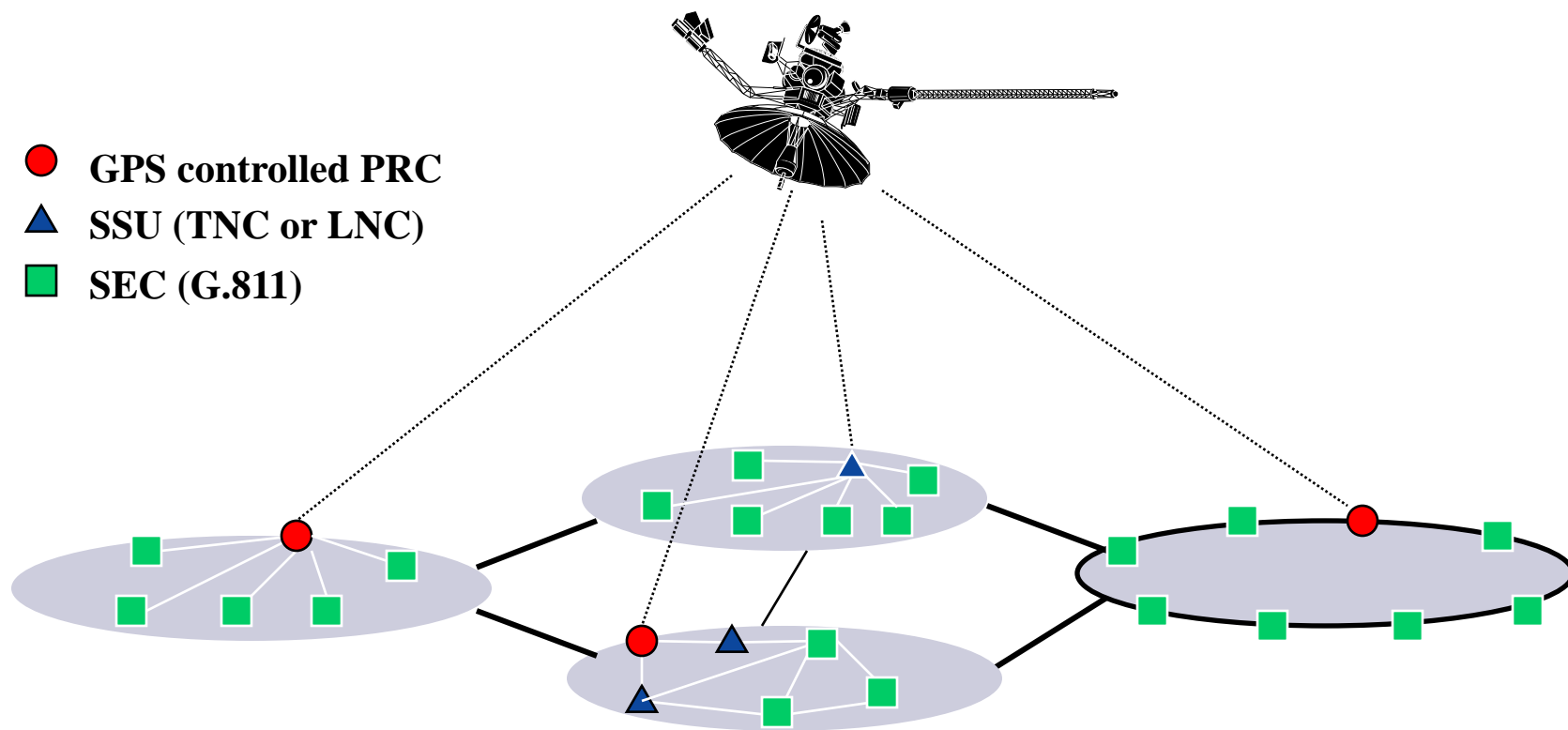


**High-speed service 10GE:**  
WAN (9.9G), WAN OTN (10.7G), LAN (10.3G), LAN OTN (11.1G)

# Transport of IP over optical medium



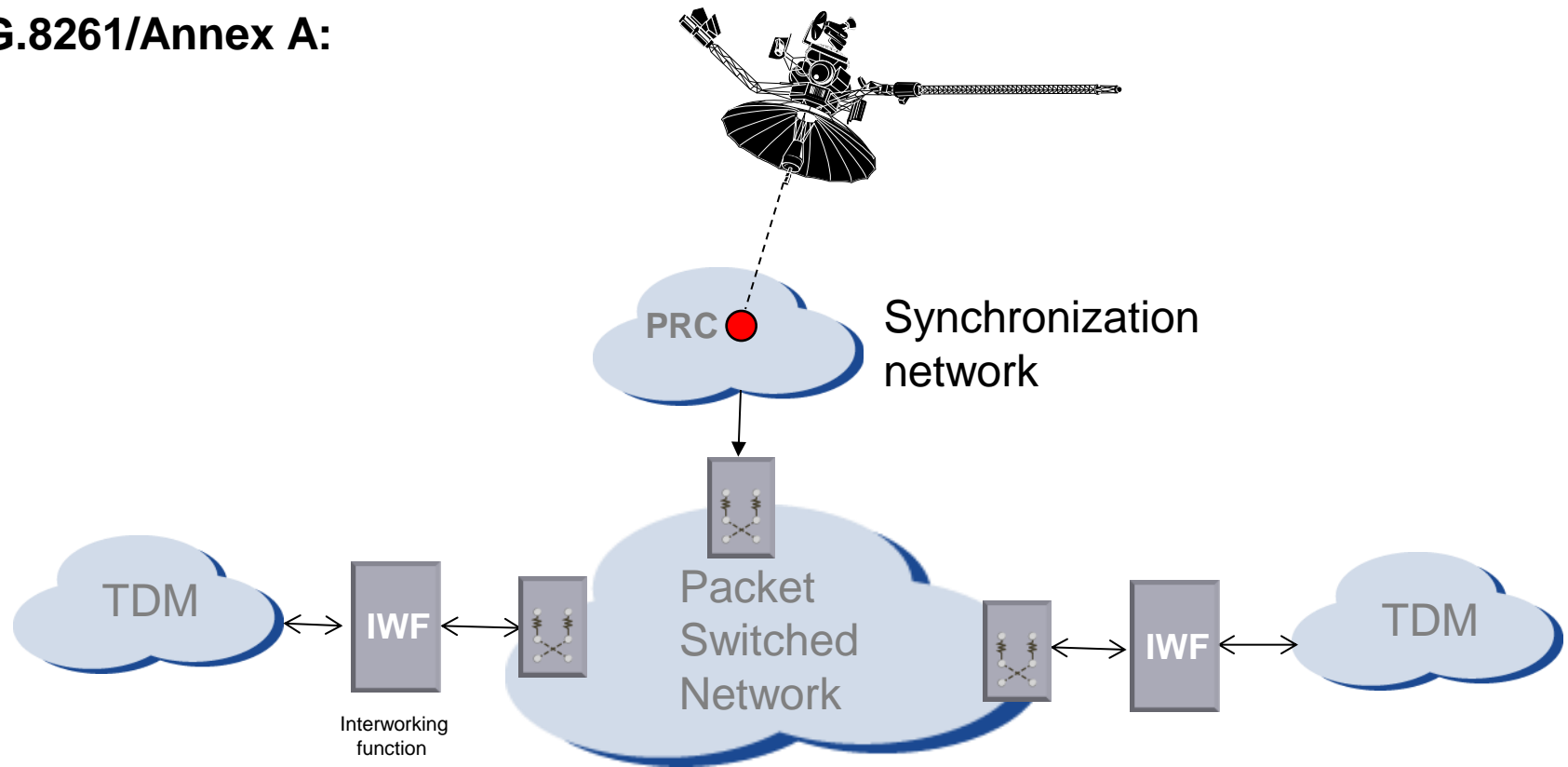
# SDH network synchronization – well implemented



- OTN is not required to transport synchronization
- OTN allows the transport of synchronization via SDH client connections

# Timing distribution via Ethernet – an example

## G.8261/Annex A:



- Timing is distributed from PRC to IWF across the packet switched network
- Ethernet switches are part of the synchronization network

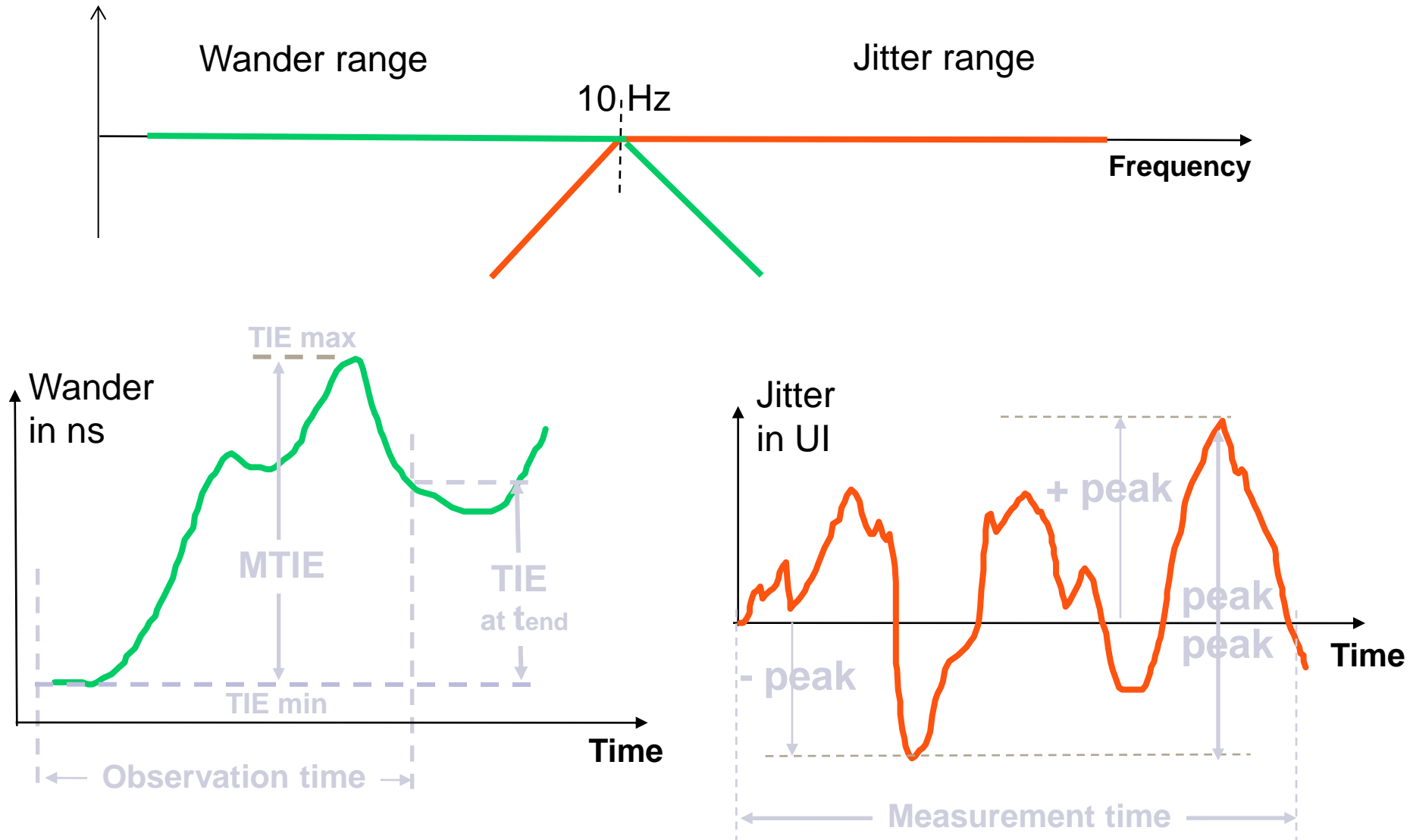


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# Difference between jitter and wander



# ITU-T Recommendations for OTN/SDH/PDH

## Jitter/wander generation, tolerance and transfer



<b>G.810</b>	Definitions and terminology
<b>G.811</b>	Primary Reference Clocks (PRC)
<b>G.812</b>	Synchronisation Supply Unit (SSU)
<b>G.813</b>	SDH Equipment Slave Clocks (SEC)
<b>G.823</b>	PDH Network Interfaces (2 Mb/s)
<b>G.824</b>	PDH Network Interfaces (1.5 Mb/s)
<b>G.825</b>	SDH Network Interfaces
<b>G.8251</b>	OTN Network Interfaces
<b>G.783</b>	SDH Equipment Functional Blocks

# Rec. for synchronization over packet networks

ITU-T G.8261

Timing and synchronization in packet networks

TDM over packets needs to be compliant to existing TDM timing standards



physical layer (layer 1)  
vs.  
in-band (layer 2)

*How to transport the timing information*

IEEE 1588

Precision Clock Synchronization Protocol

Precision Time Protocol (PTP) is able to synchronize distributed clocks with an accuracy of less than one microsecond

IETF RFC1305

Network time protocol (NTP) – accuracy in ms

*poor precision*

IETF RFC2030

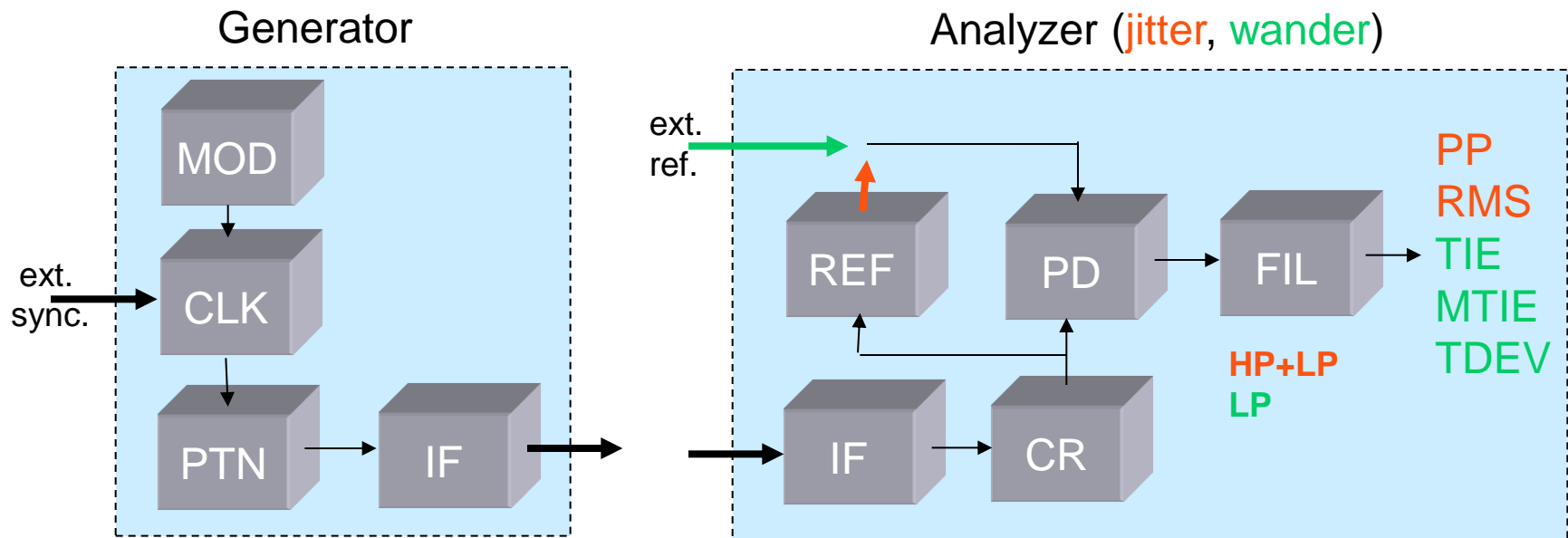
Simple network time protocol (SNTP) – accuracy in s

# ITU-T Recommendations for test equipment

**O.171** Jitter and wander measuring equipment for PDH

**O.172** Jitter and wander measuring equipment for SDH

**O.173** Jitter measuring equipment for OTN

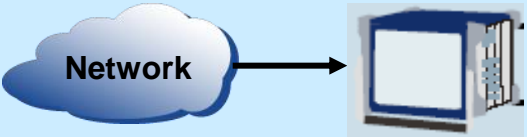
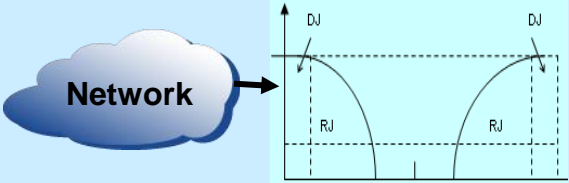
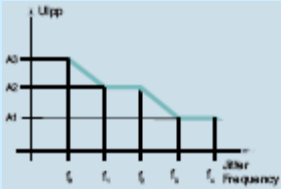
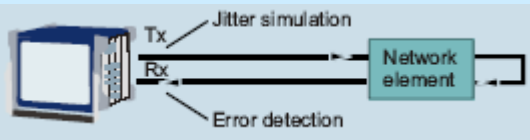
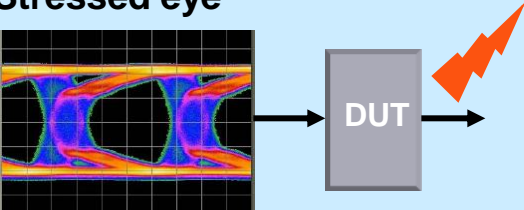
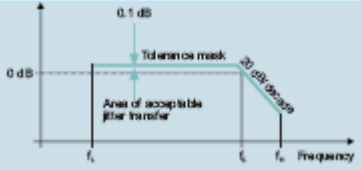
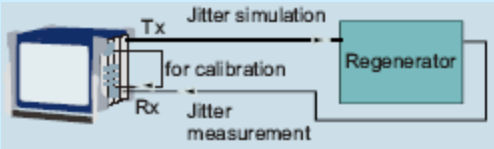




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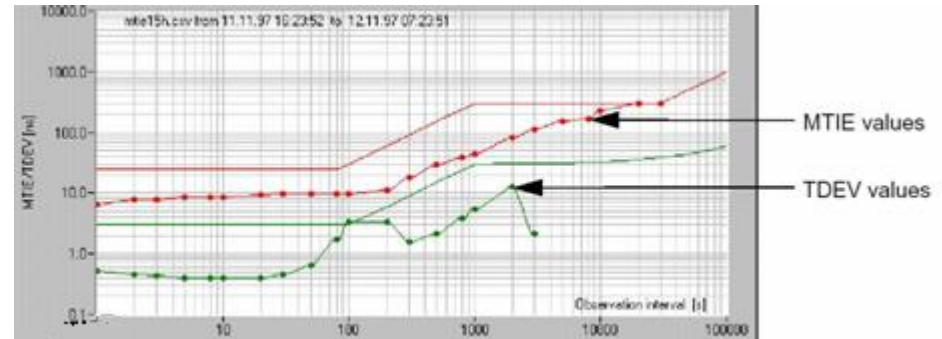
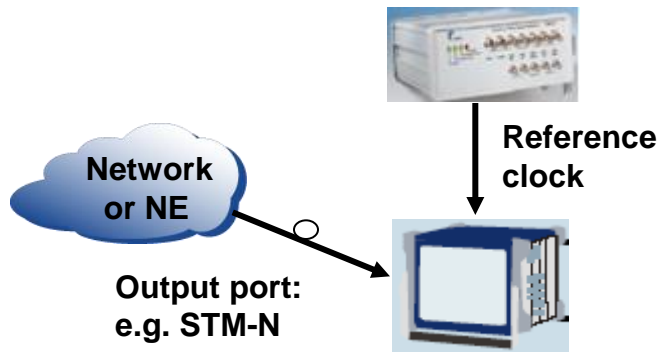
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# Jitter and wander applications

Jitter/wander	SDH/SONET/PDH OTN (wander not required)	Ethernet
<b>Generation</b>		<b>BERT scan (Bathtub curve)</b> 
<b>Tolerance</b> 		<b>Stressed eye</b> 
<b>Transfer</b> 		<b>not applicable</b>

# Requirements for wander test equipment

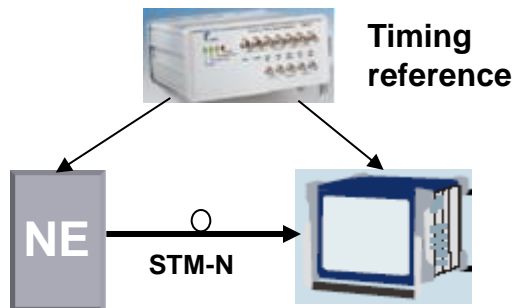
- Generation of wander amplitudes/frequencies
- Analysis of TIE, MTIE, TDEV, frequency offset and drift rate
- Built-in masks that comply with ITU-T, Telcordia, ETSI and ANSI
- Sample rates 1/ s, 30/ s, 60/ s, 1000/ s
- Reference input for clock 1.5/ 2/ 5/ 10MHz and data 1.5/ 2Mbps



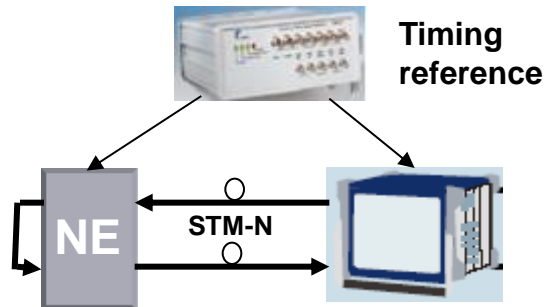
# Commissioning test configurations

- Tests on network element (NE) level prior to installation
- Tests on synchronisation interfaces after installation

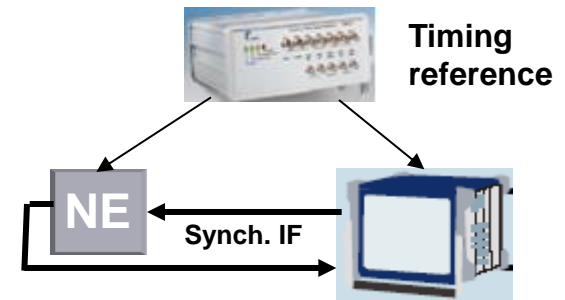
Wander generation



Wander tolerance



Wander transfer

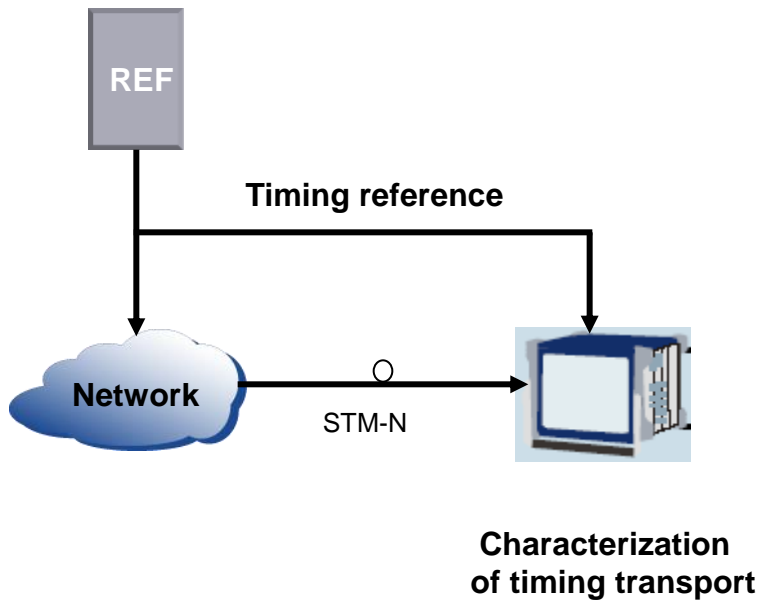




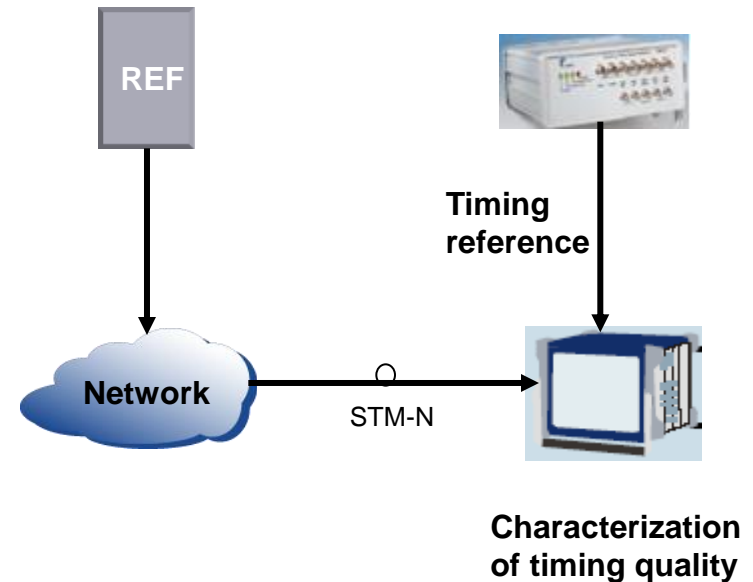
# Acceptance test configurations

- Tests on interfaces handing over timing between telecom networks
- Tests on reference clock sources

## Synchronized configuration

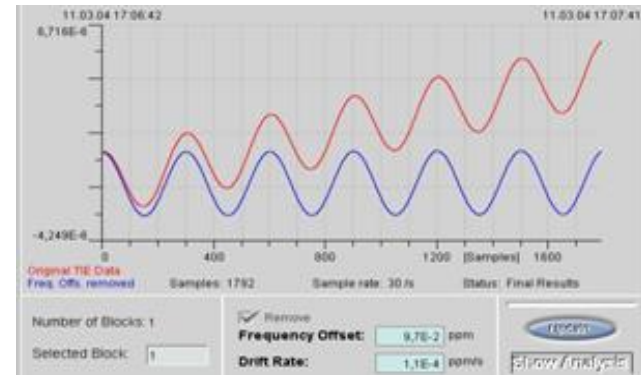
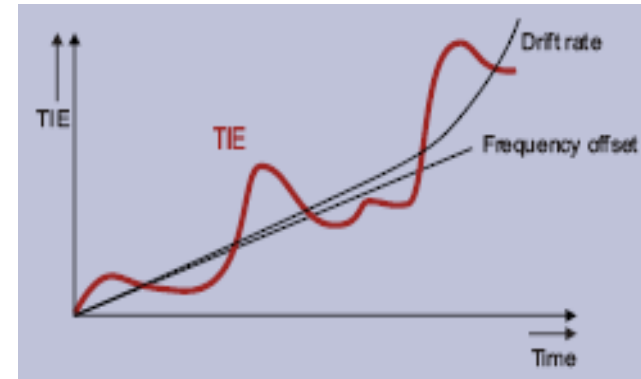
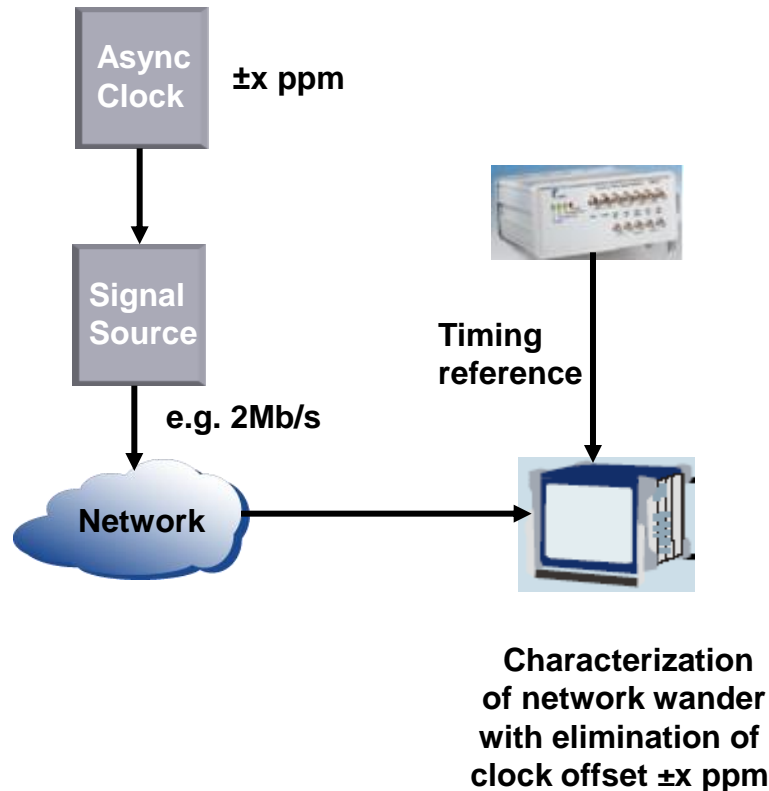


## Non-synchronized configuration



# Test configuration for asynchronous signals

Maximum relative time interval error (MRTIE)

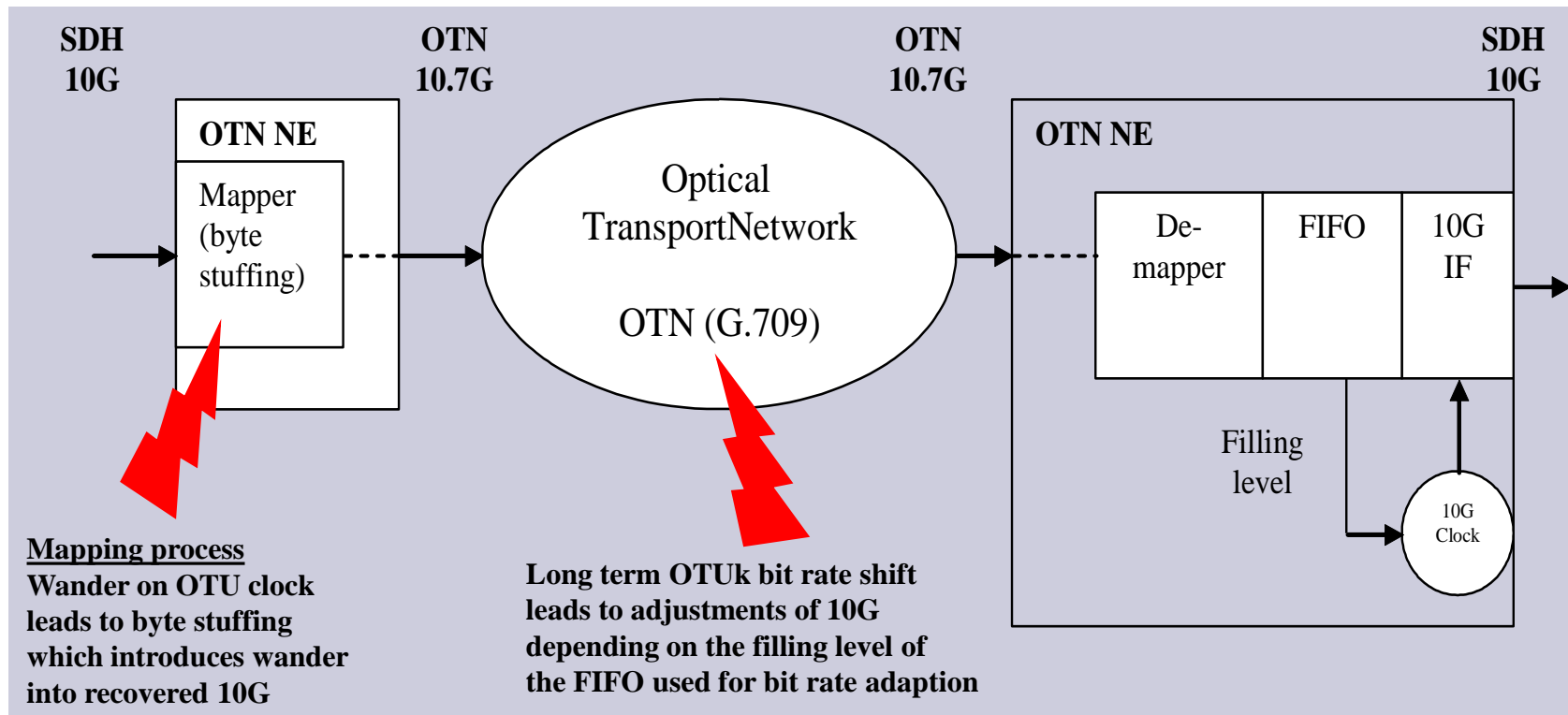


**TIE with frequency offset**

**Offset corrected TIE**

# Wander on OTN network elements

- The OTN physical layer is not required to transport network synchronization
- There is no need for specification of network wander limits (ITU-T G.8251)
- Our recommendation: Wander measurement at OTU interfaces to ensure proper operation at SDH interfaces

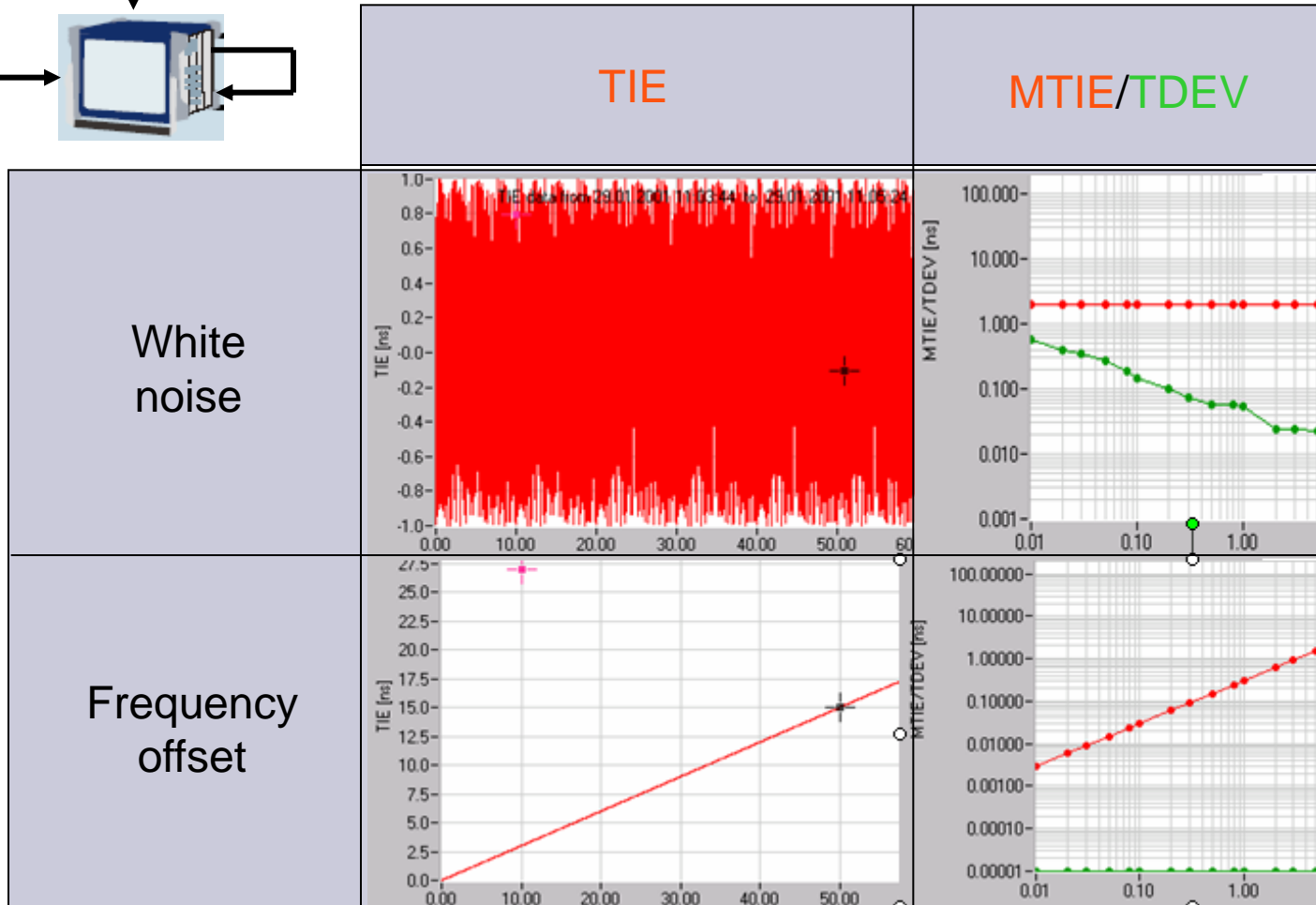
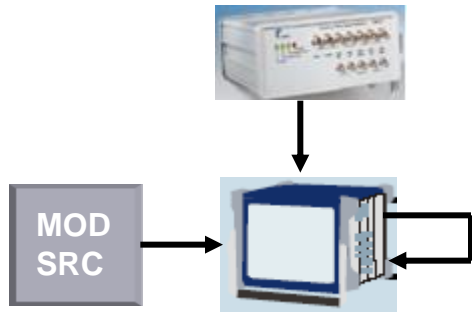




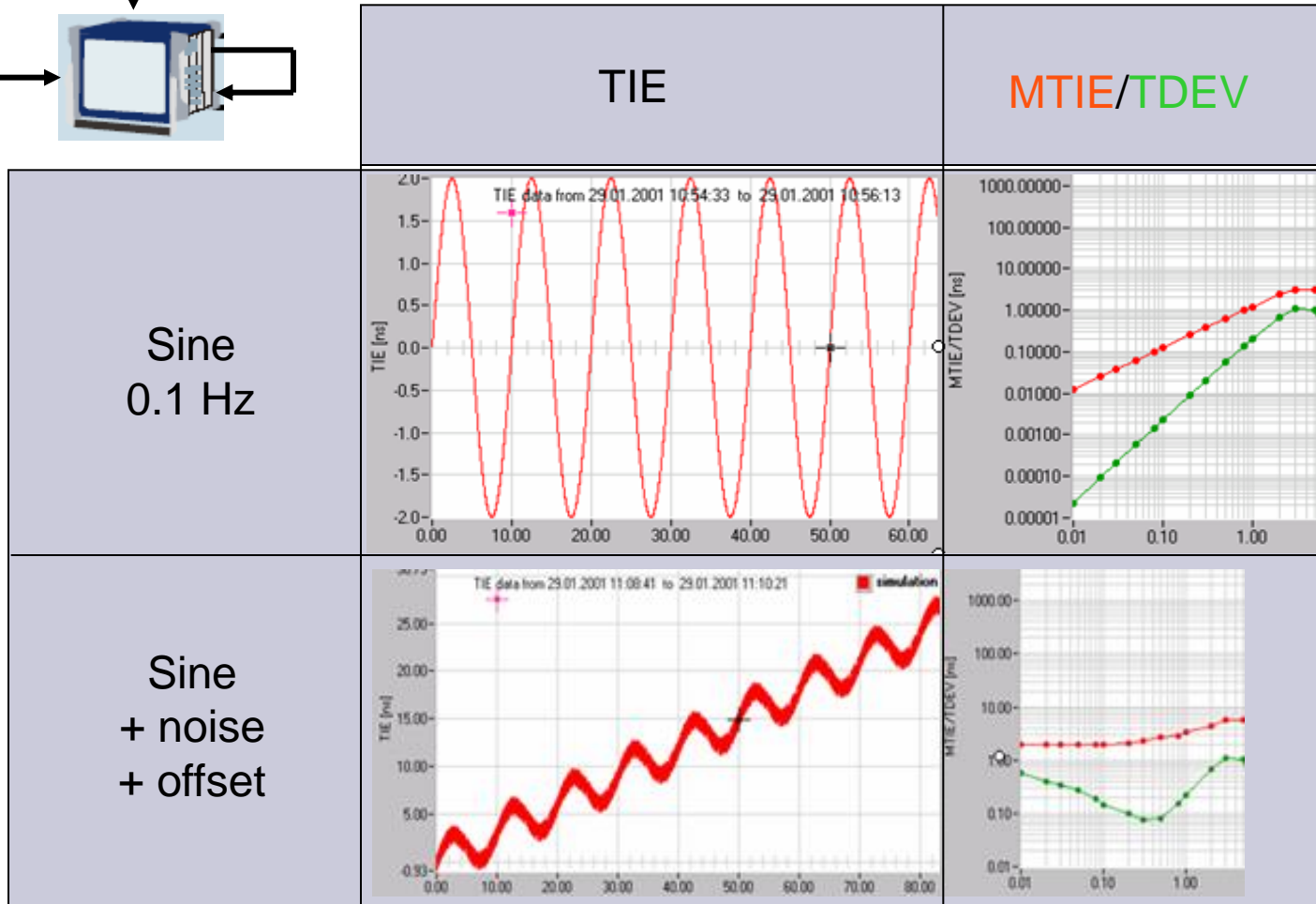
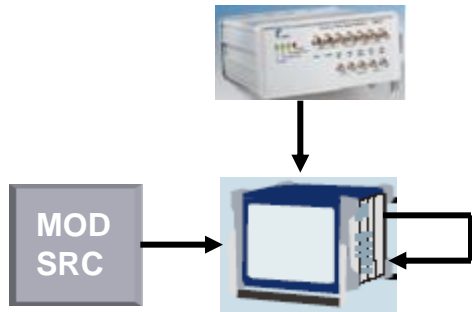
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# Examples for wander analysis



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# Conclusion



- Carriers try to converge new and legacy services on to a single platform, a packet switched network such as metro Ethernet. This will allow them to reduce both capital and operating costs.
- Synchronization is essential to enable real-time and high-speed transmission for telecom networks.
- As telecom networks migrate to packet networks, the debate is about how the „synchronization” is passed from one network node to another.
- Several standard bodies are working on that topic.
- Carriers need to evaluate and decide whether “in-band” or “physical layer” is the preferred technique to transport the timing information.



**Thank you  
for your attention**



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