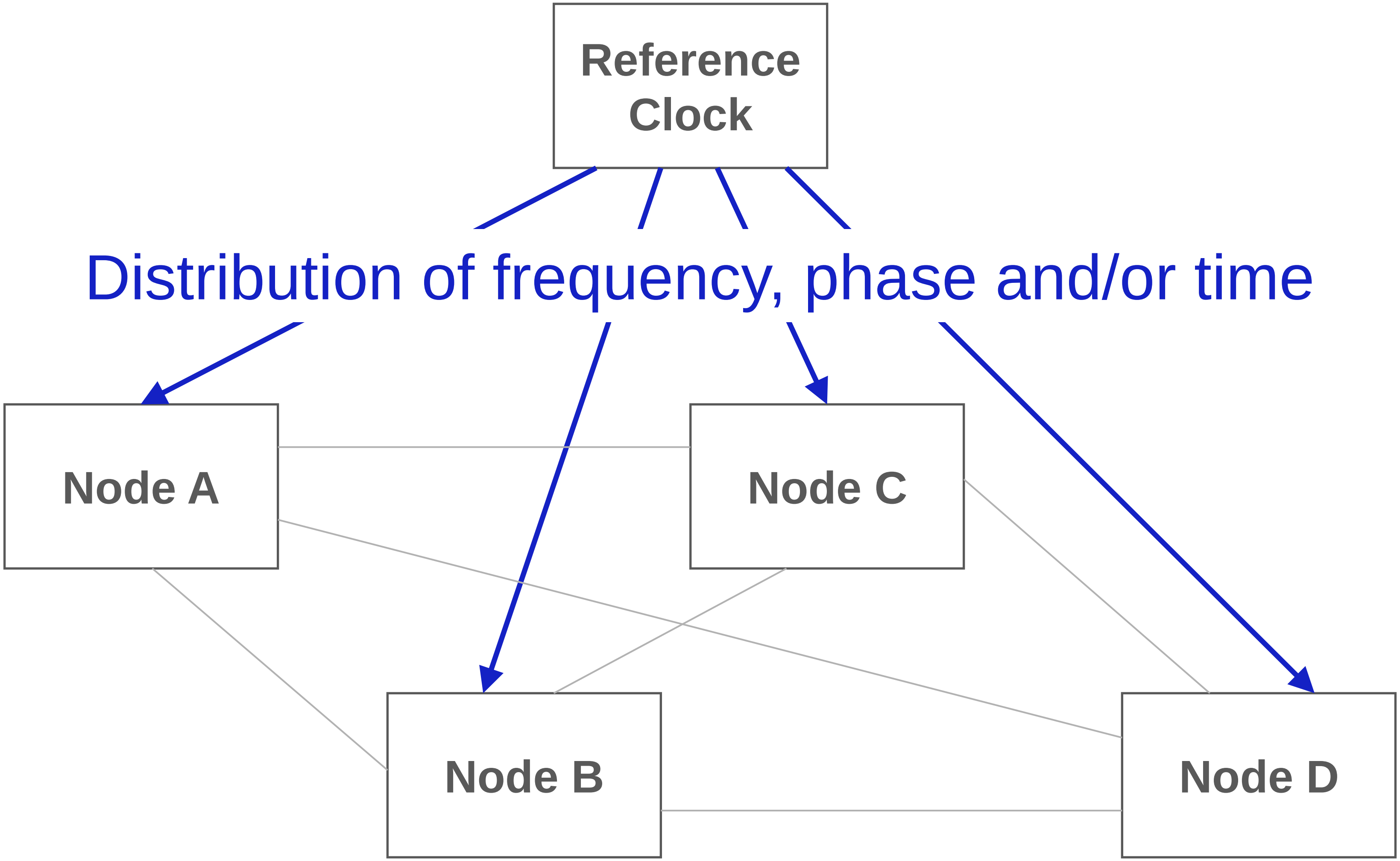
# Time Distribution using IEEE 1588 v2 (PTP)

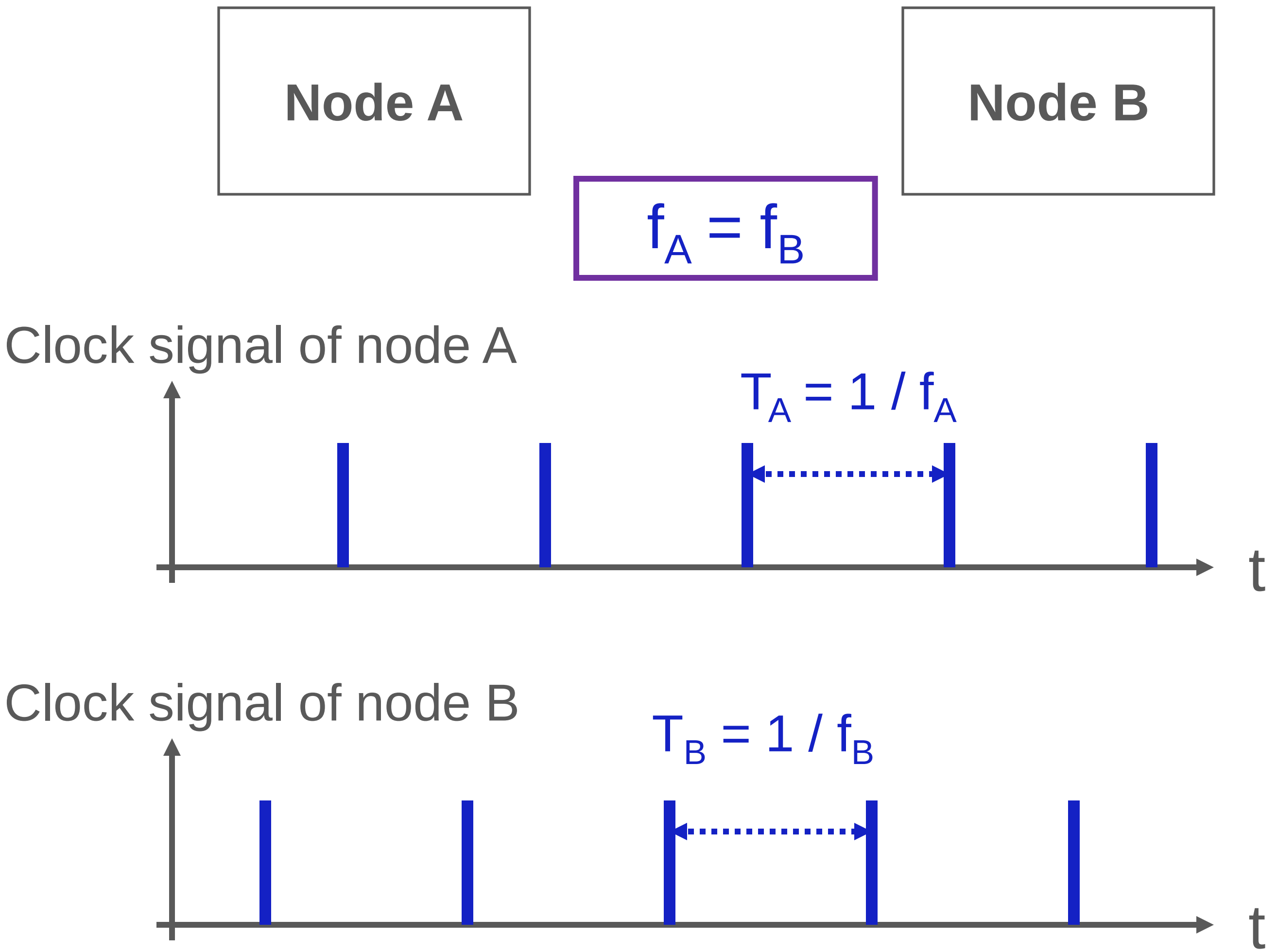
Oscilloquartz SA

# ASZINKRON ÀTVITELI HÀLÒZATOK SZINKRONIZÀCIÒS KÉRDÉSEI NAPJAINKBAN

# Network synchronization



# Frequency synchronization



# Az idö mértékegysége

**Általános Súly- és Mértékügyi Konferencia**

**(Conférence Générale des Poids et Mesures – CGPM)**

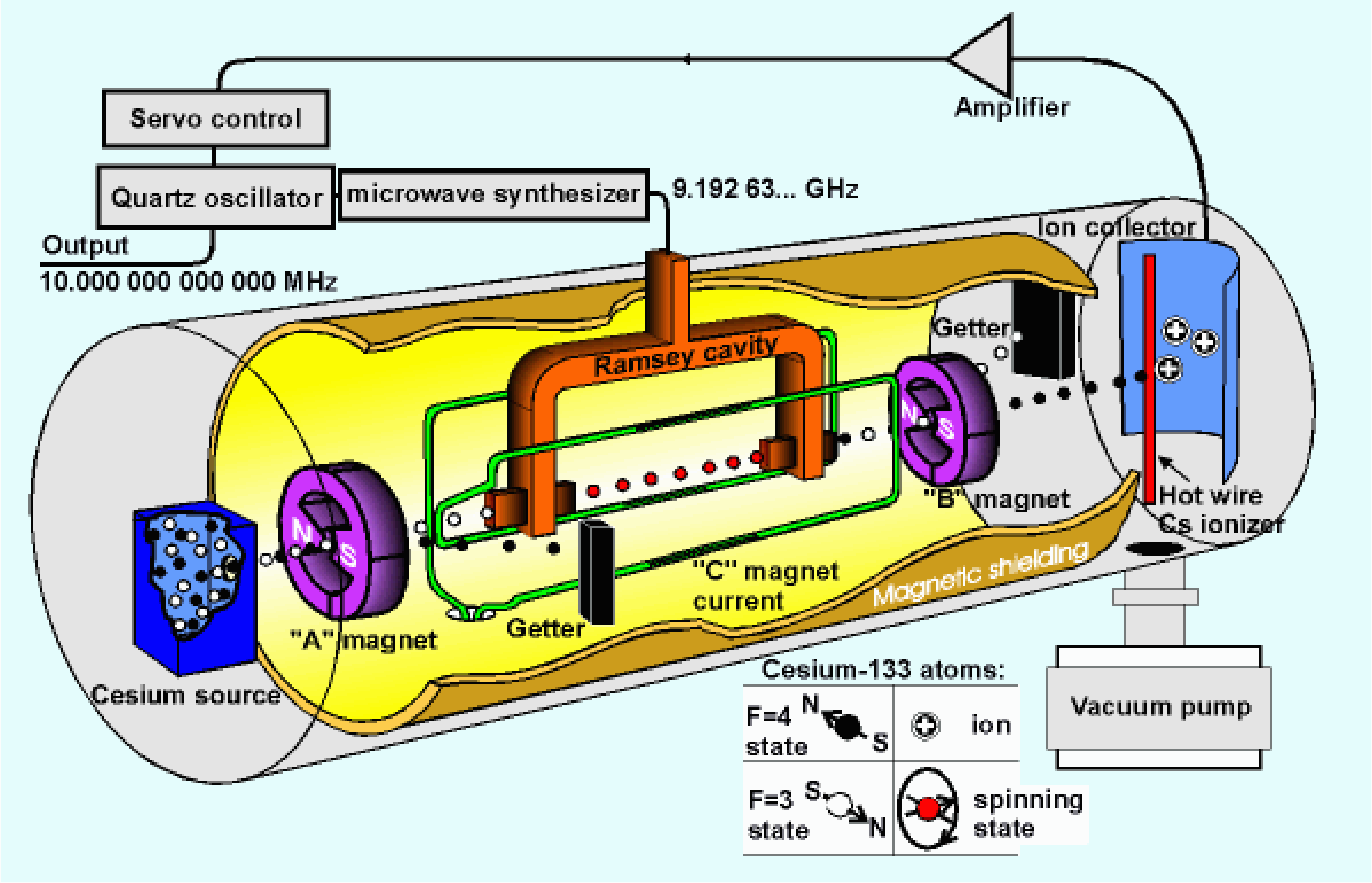
**1967-ben hozott döntése értelmében**

**A másodperc az alapállapotú cézium-133 atom két hiperfinom energiaszintje közötti átmenetnek megfelelő sugárzás**

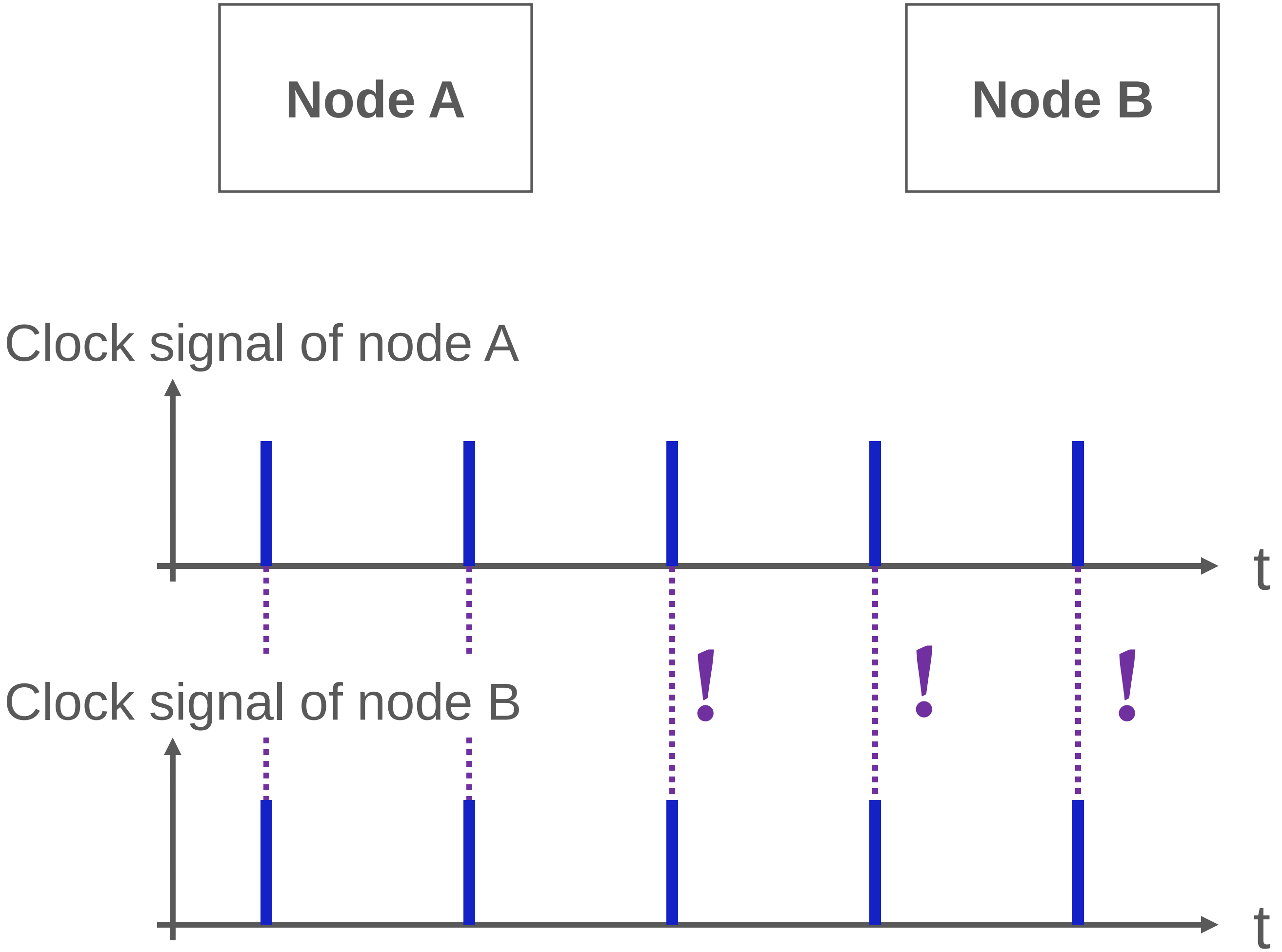
**9 192 631 770 periódusának időtartama.**

# Frequency source: **atomic Cesium clock (Cs)**
# Example: OSA 3230B cs Clock

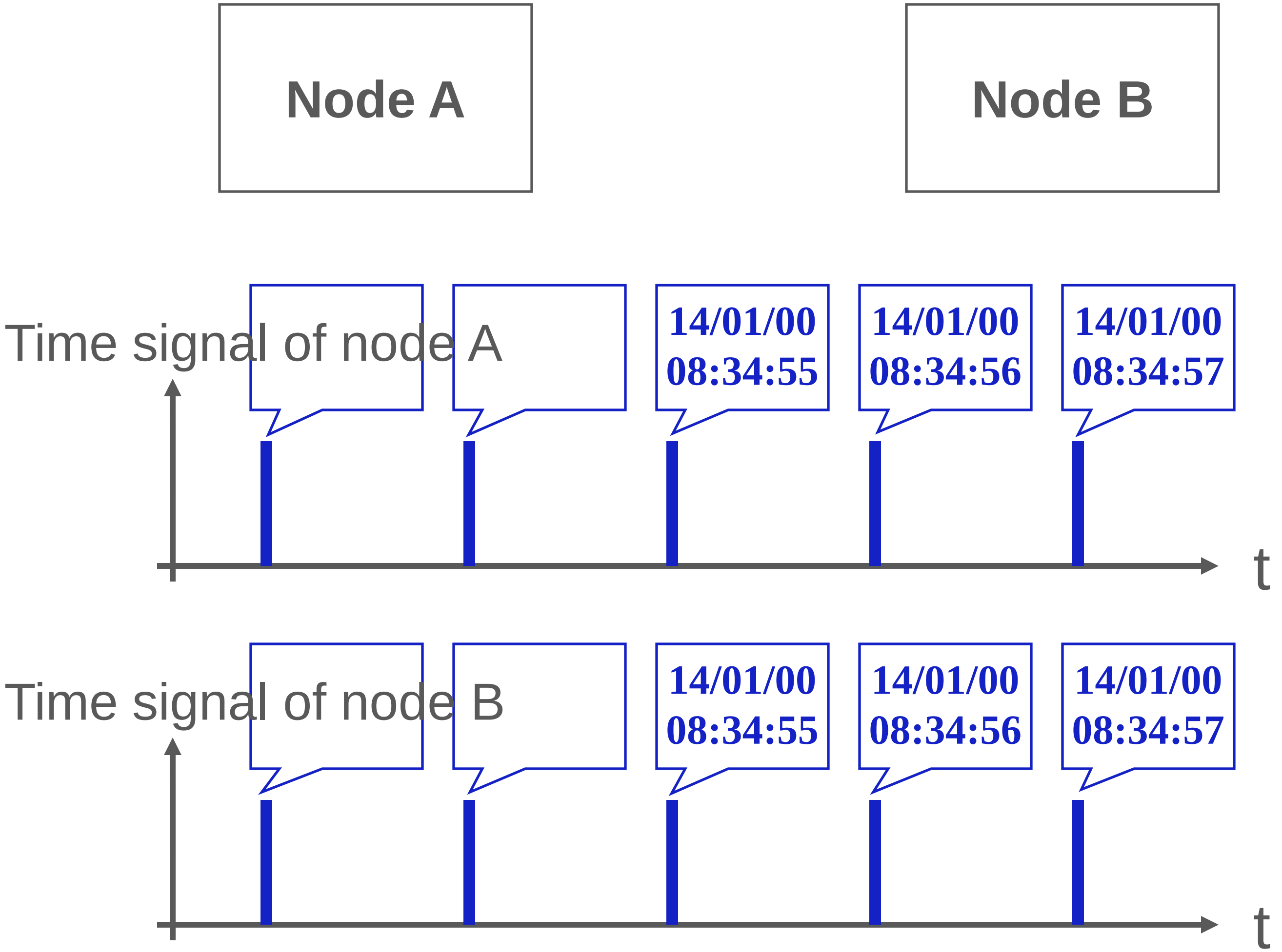
# Frequency source: **atomic Cesium clock (Cs)**
## Magnetic Cesium Beam Tube



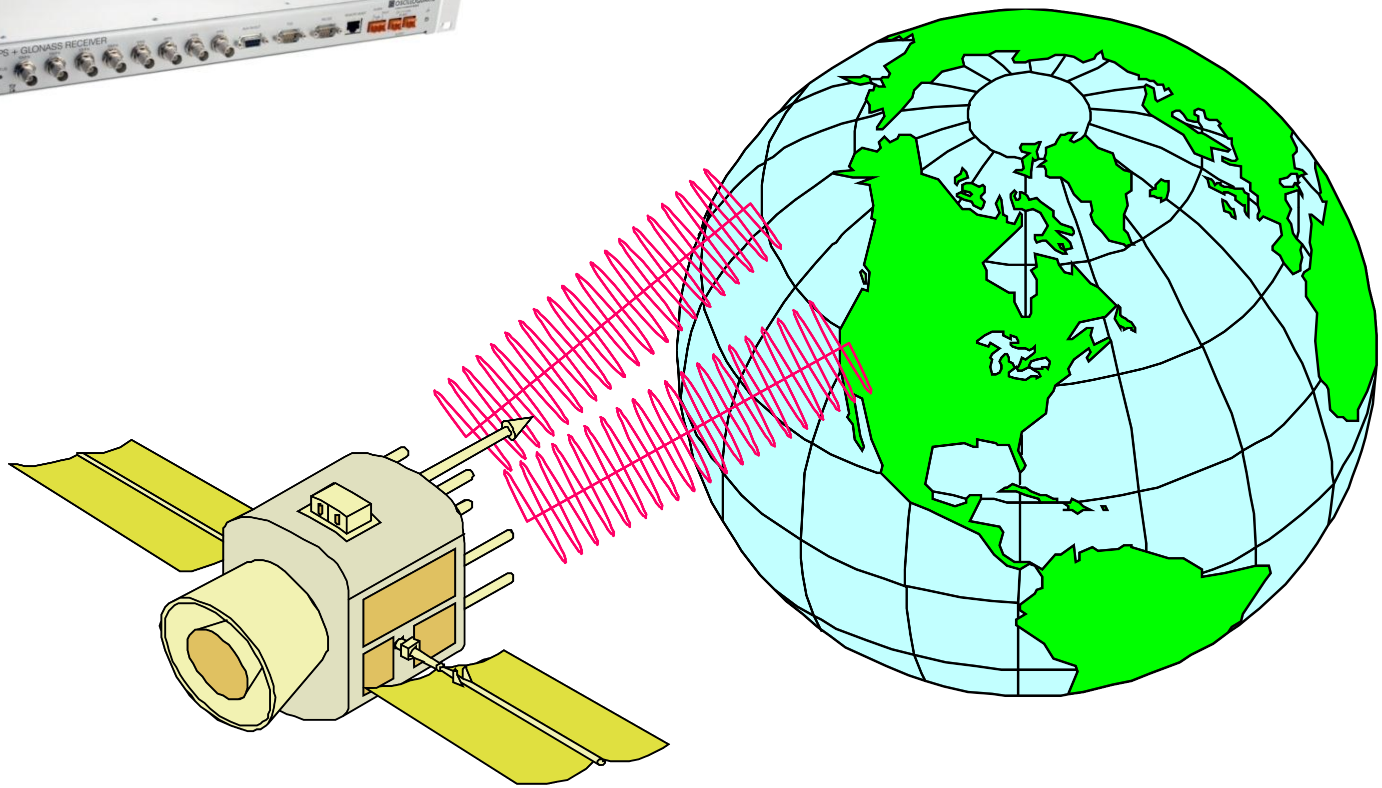
# Phase synchronization



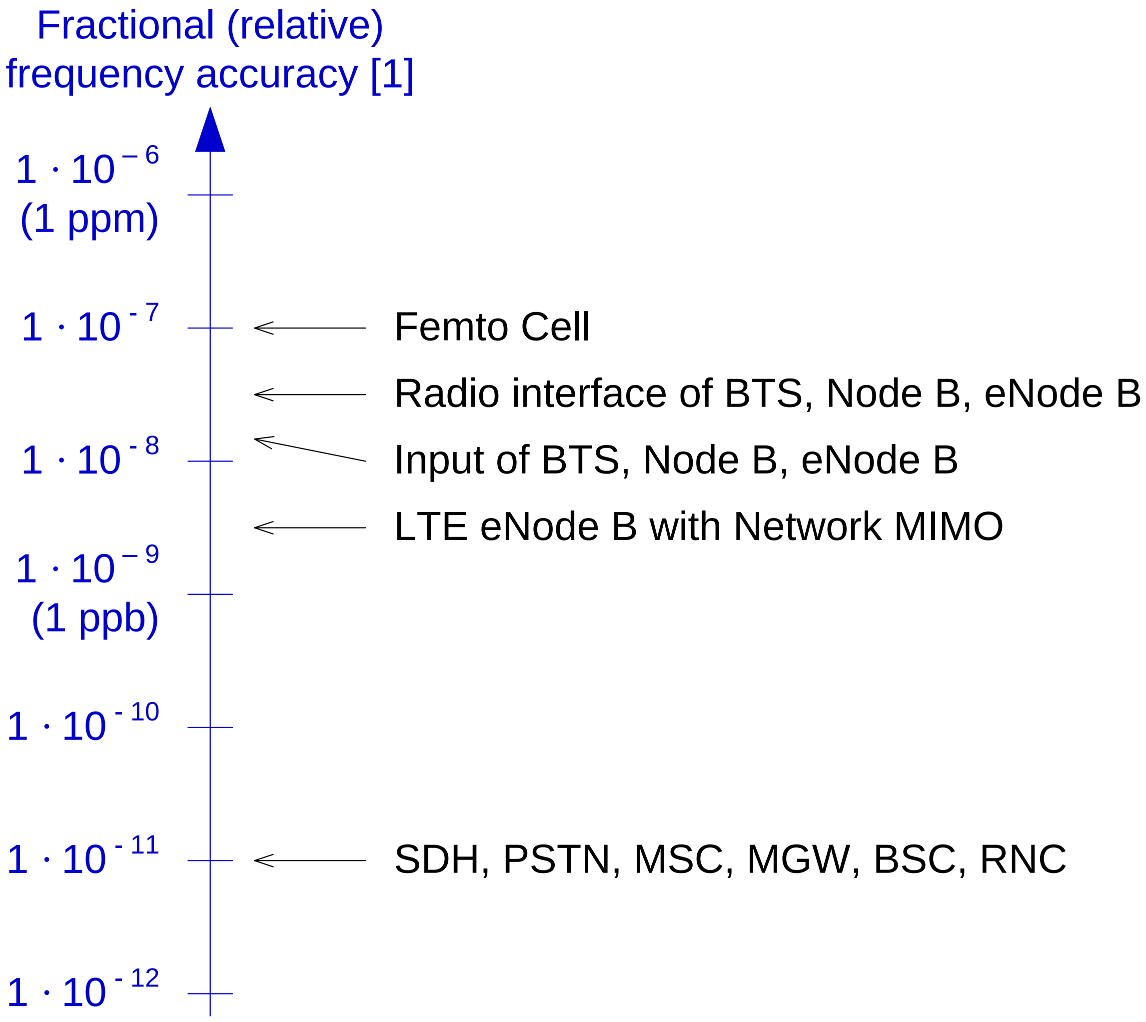
# Time synchronization (time-of-day)



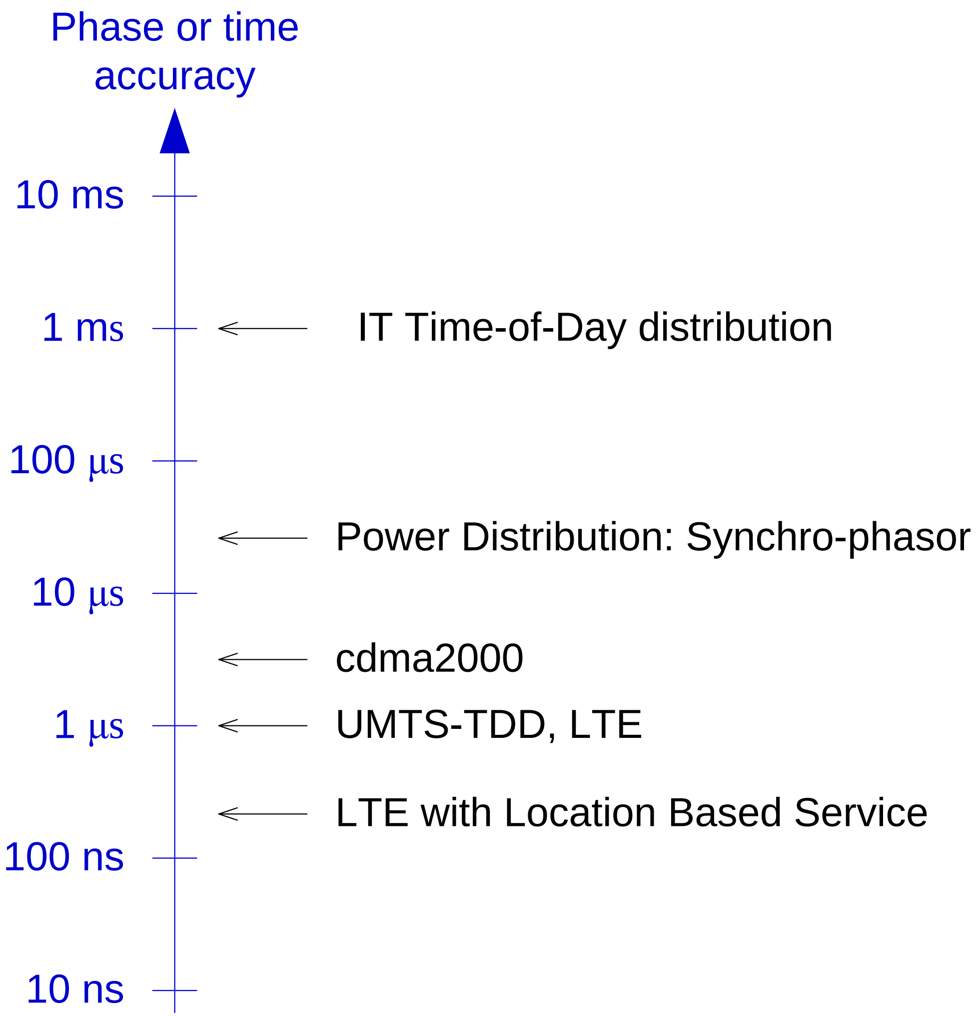
# Time source: Global Navigation Satellite System (GNSS)

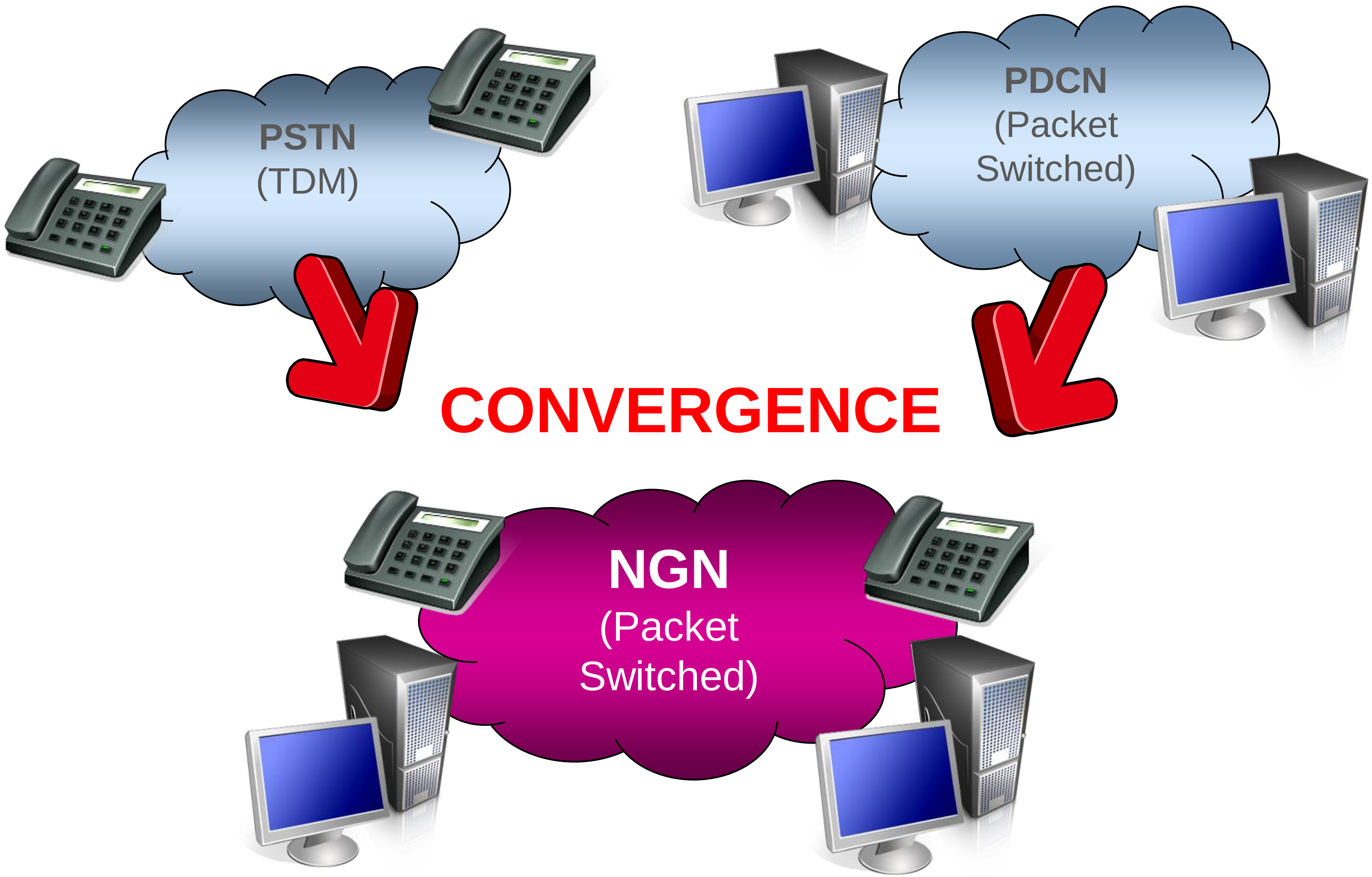
# Performance level: frequency



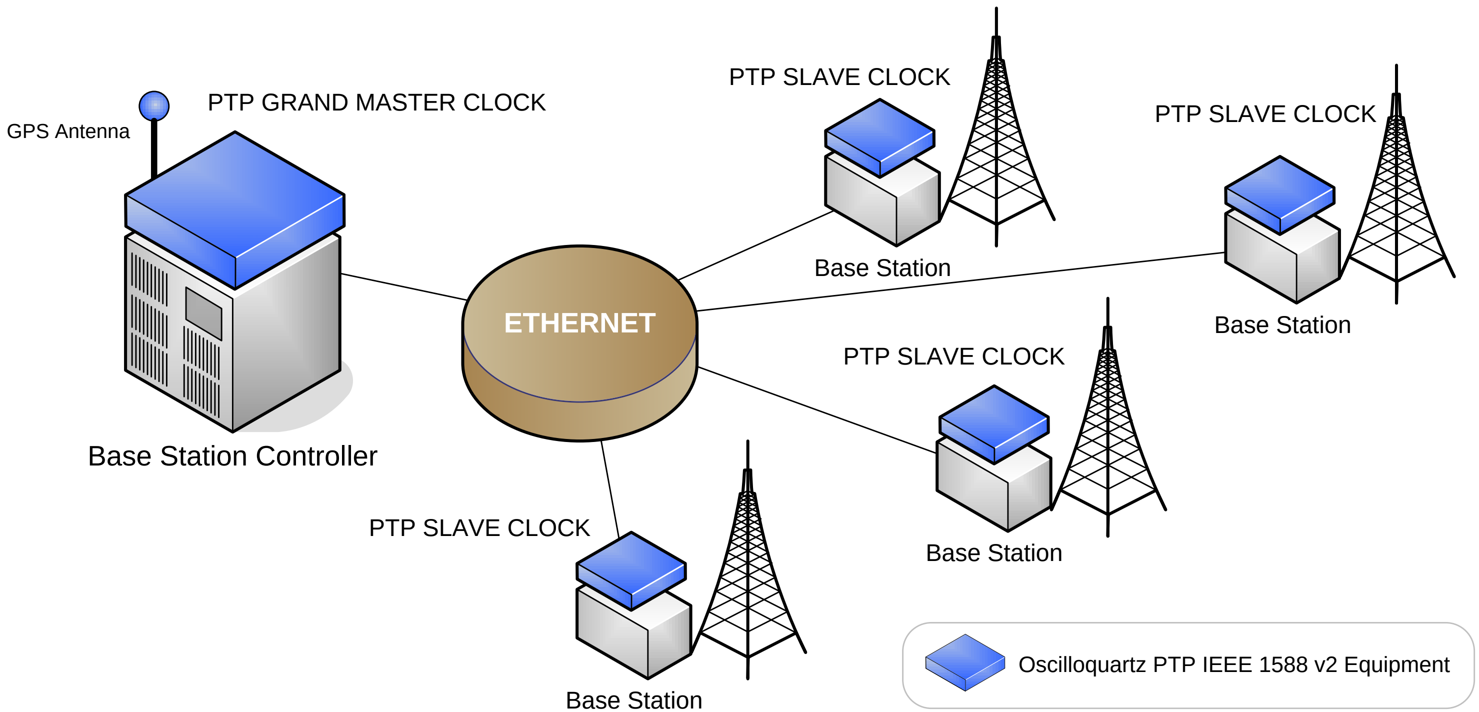
# Performance level: phase & time



# Network Convergence



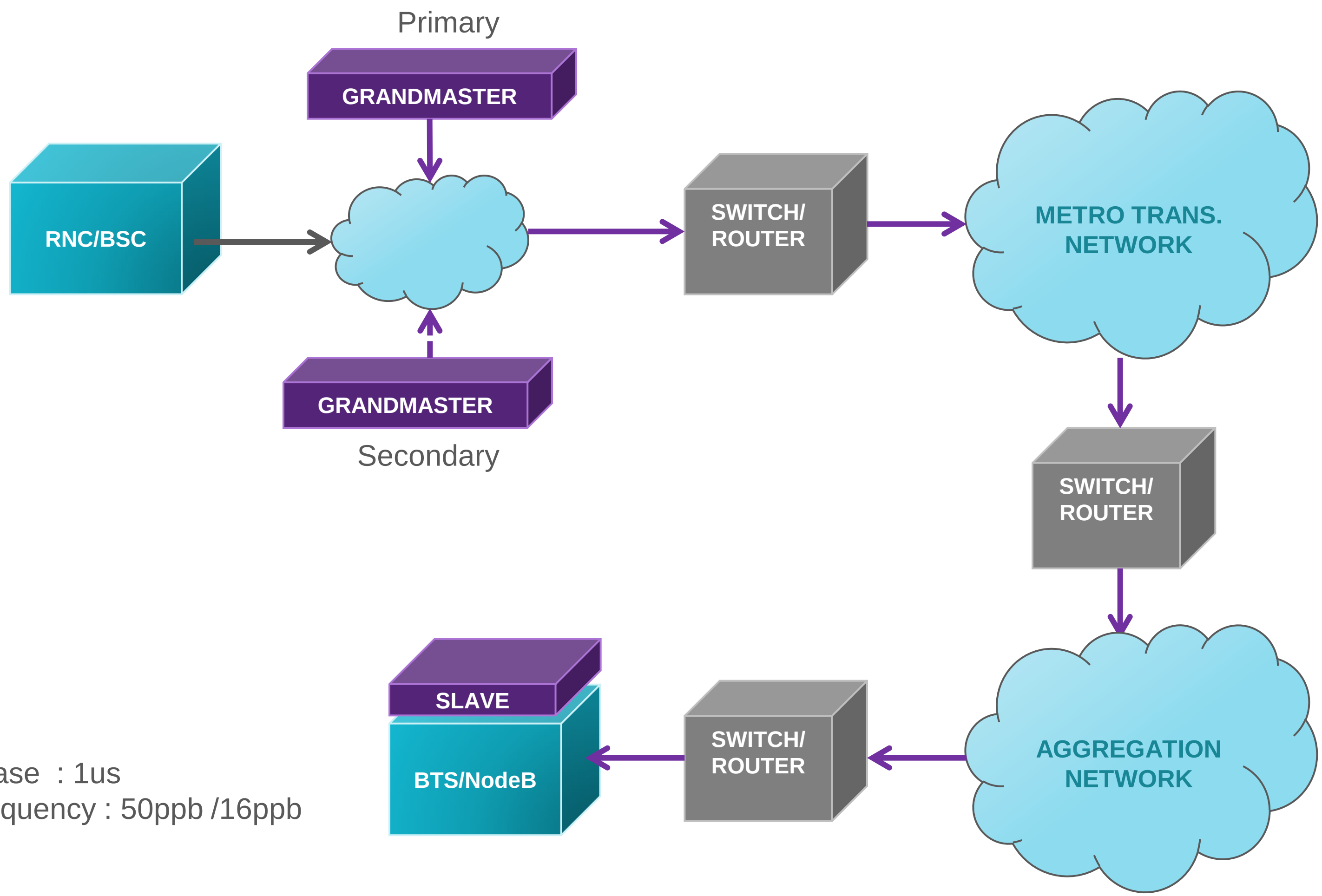
# Time Distribution via the Precision Time Protocol PTP (IEEE 1588 v2)



Chapter 1

# PTP PRINCIPLES

# Typical Backhaul Network




Phase : 1us
Frequency : 50ppb /16ppb

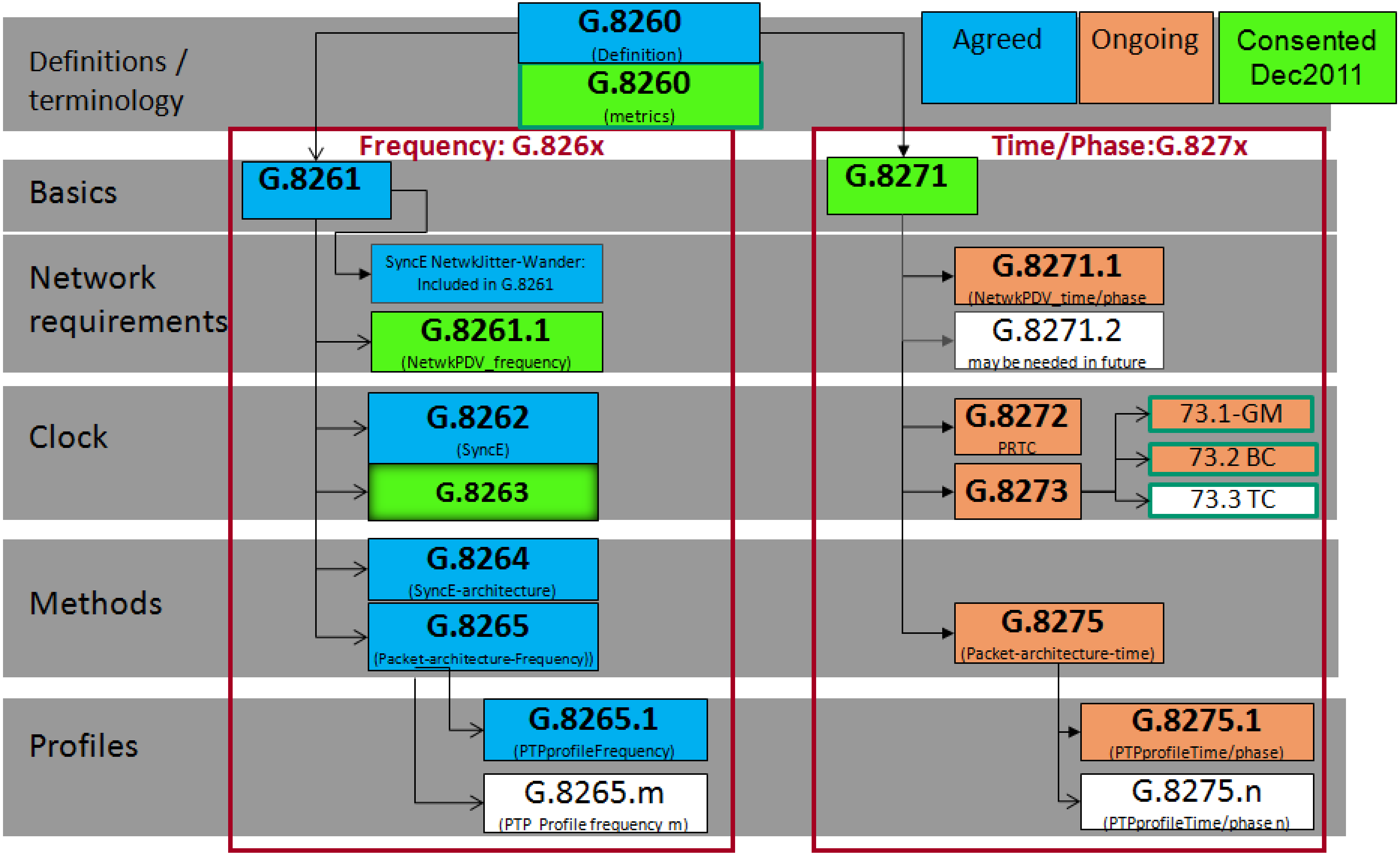
# IEEE standards

- IEEE 1588 (Precision Time Protocol) is standardized since 2002
- **Version 1** of the protocol is used for applications in:
  - Industries (e.g. Automation)
  - Test and measurement
  - Power networks
  - Military and Avionic
- **Version 2** is released since June 2008 and is made for applications in:
  - Telecom
  - Broadcasting
  - Power and Utilities

# What's new in PTP v2 ?

- PTPv2 meets accuracy for **telecom** applications
- High **refresh rates** up to 64 or 128 messages per second
- Correction field for **asymmetric** measurements
- **Multicast and Unicast** or Mixed are available
- Manual and Automatic **Master Clock selection** methods

# ITU-T standards



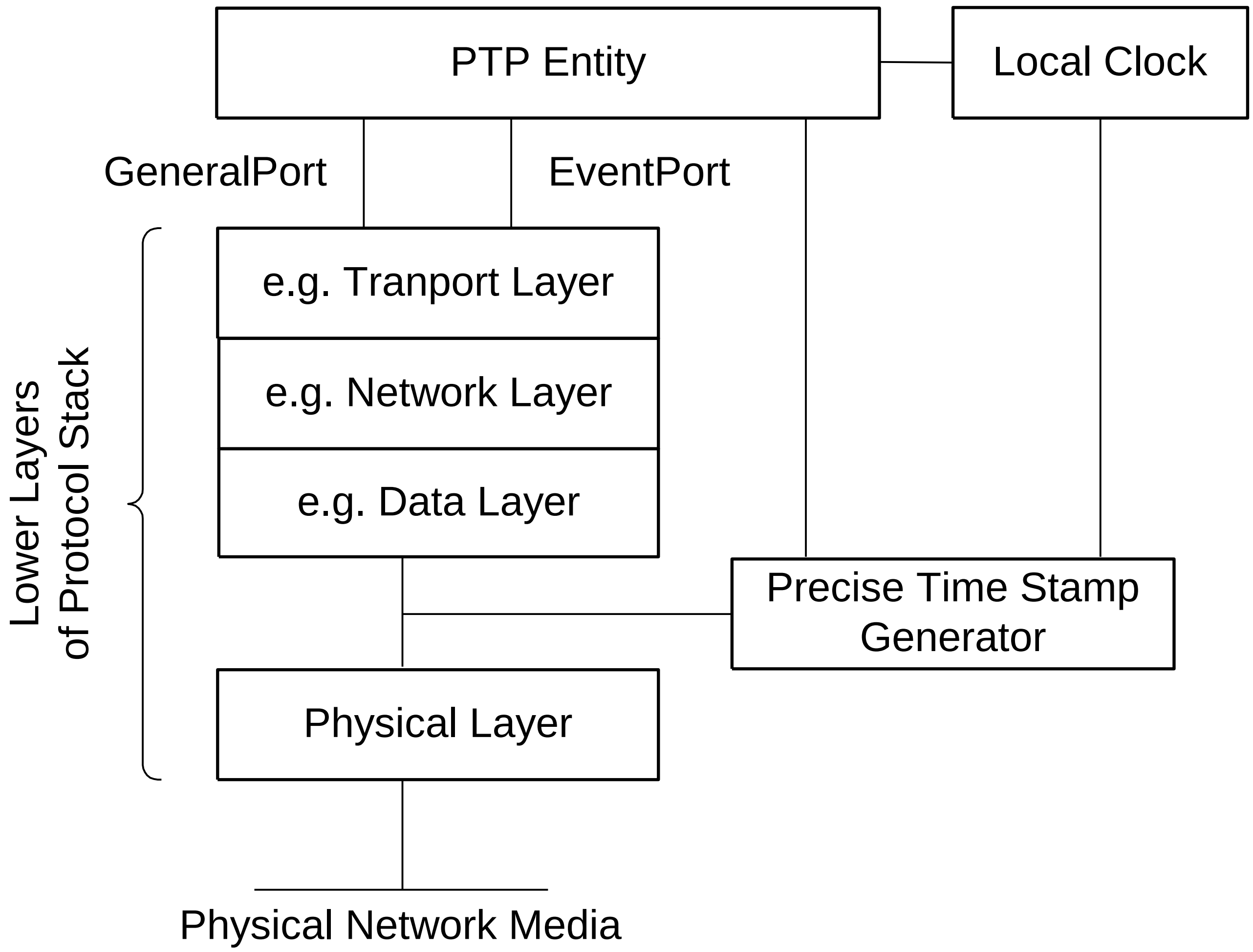
# Fact Sheet PTP v2

- PTP (Precise Time Protocol) is an IEEE standard:
  - IEEE 1588 v1: for LAN applications
  - IEEE 1588 v2: broader application space, incl. telecom
- Protocol for **sub-microsecond** synchronization of real-time clocks over frame and packet switched networks
- Uses 'Two-way Time Transfer' (TWTT) and 'Hardware Assistance'

# Fact Sheet PTP v2

- The main idea is to **mitigate the protocol stack delay** with appropriate electronic hardware and a modified TWTT protocol.
- A hardware « Precision **Time Stamp Generator** » measures the frame receive and transmit times at or close to the Physical Layer (Layer 1).
- The measured frame transmit times are communicated to the other end system with a second message.
- The **TWTT** calculation expoits the time values measured by the Precise Time Stamp Generator.
- The configuration of the clock hierarchy can be done manually or automaticaly using the **Best Master Clock** (BMC) algorithm.

# PTP Clock

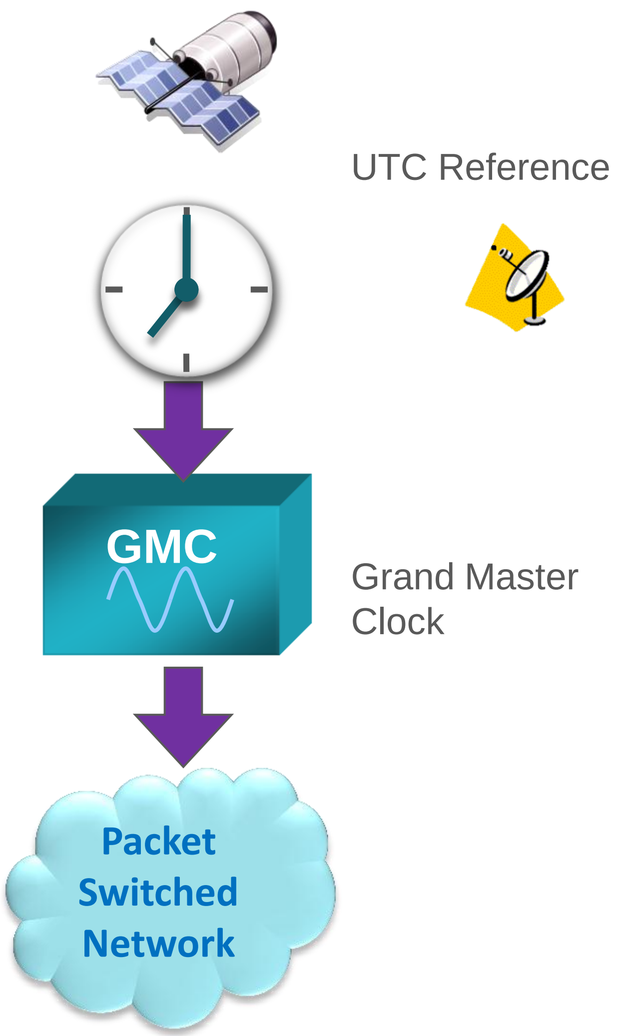

PTP Entity
Local Clock
GeneralPort
EventPort
e.g. Tranport Layer
e.g. Network Layer
e.g. Data Layer
Lower Layers
of Protocol Stack
Precise Time Stamp Generator
Physical Layer
Physical Network Media

# Elements of a PTP System

- Nodes
  - Ordinary clocks:
    - Communicate with other clocks over a single communication path
  - **Boundary** clocks (optional):
    - Communicate with multiple sets of clocks using distinct communication paths
  - Administrative nodes (optional):
    - For management purposes
- Communication paths
  - Network segments that allow direct communication between clocks

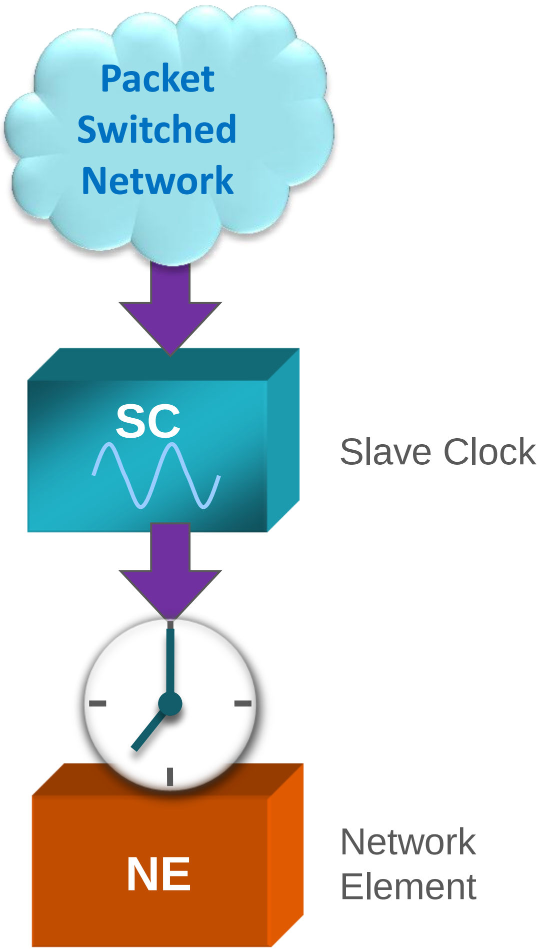
# Master Clocks

- The Primary Reference source of time of the network
- Typically synchronized to GPS
- Very stable and accurate
- High-speed PTP time stamp processor
- Min 100 Base-T line speed

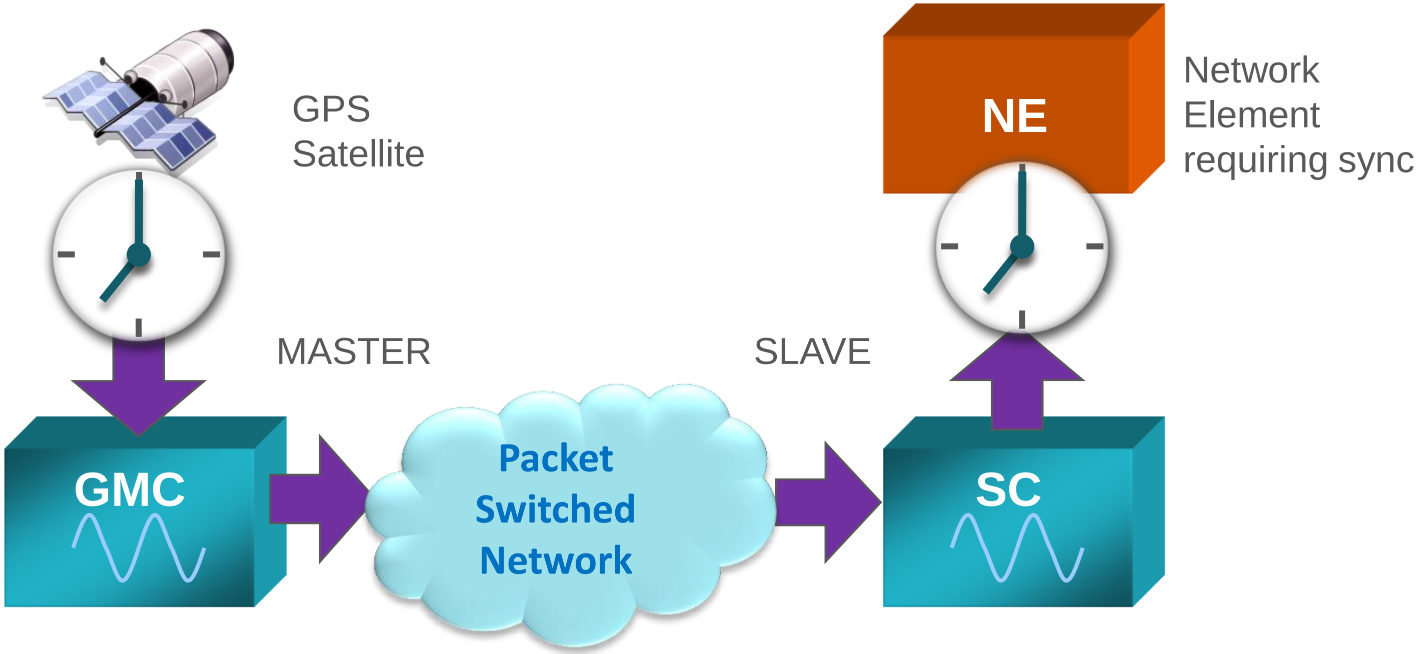


# Slave Clocks

- Are slaves to the path containing the best clock they can see
- Reduce Jittter and Latencies of packet transit introduced by Network switches and router
- Give time, phase and frequency to the Network Element

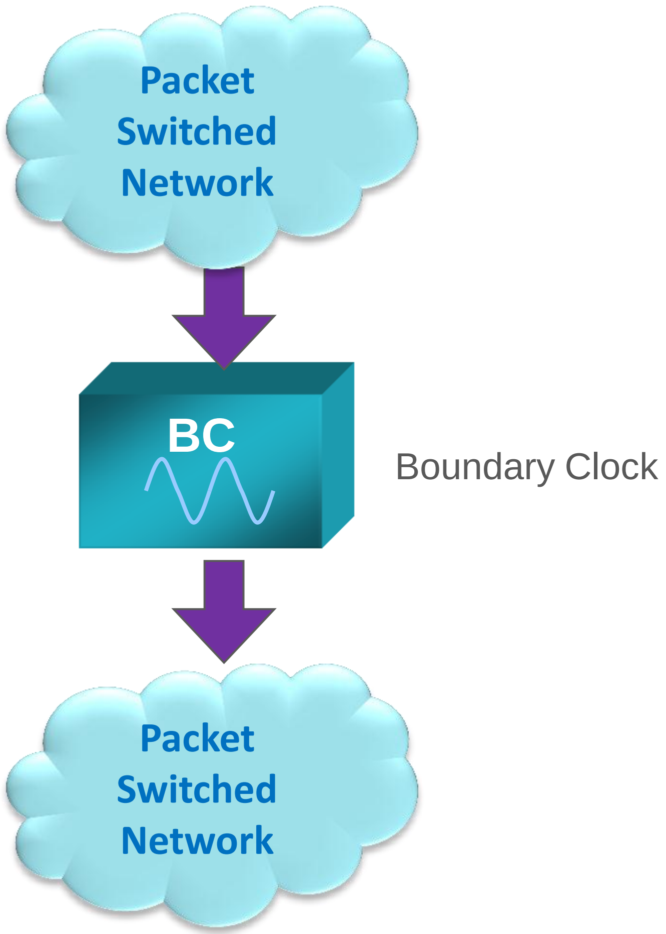


# The Simplest PTP Network

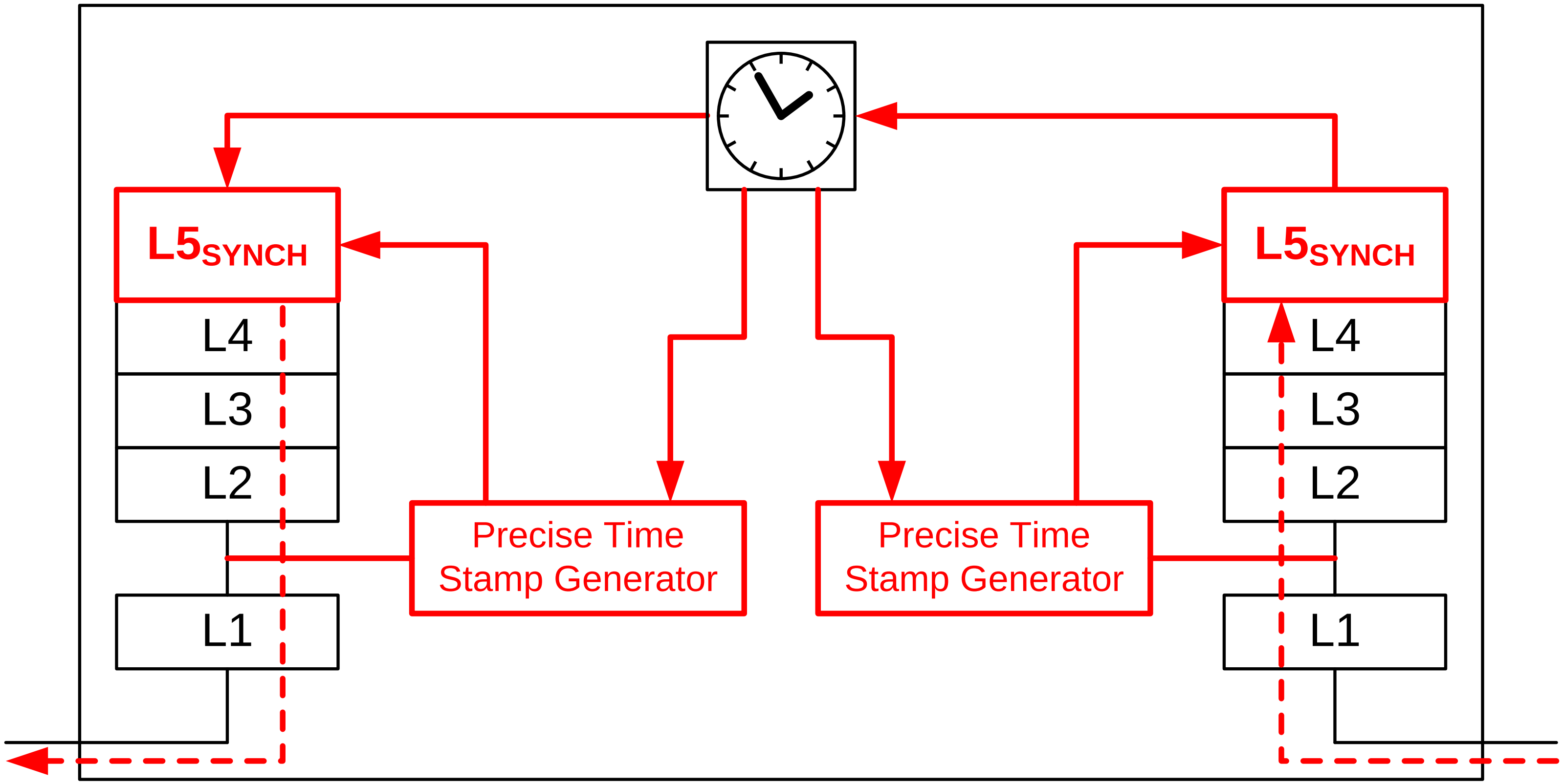


# Boundary Clocks

- Are slaves to the path containing the best clock they can see
- Are masters to the clocks on all other paths
- Serve to implement time distribution trees
- Are required…
  - …in gateways between different communication technologies
  - …in network element which block PTP messages
- Are recommended in network elements which insert significant delay fluctuations

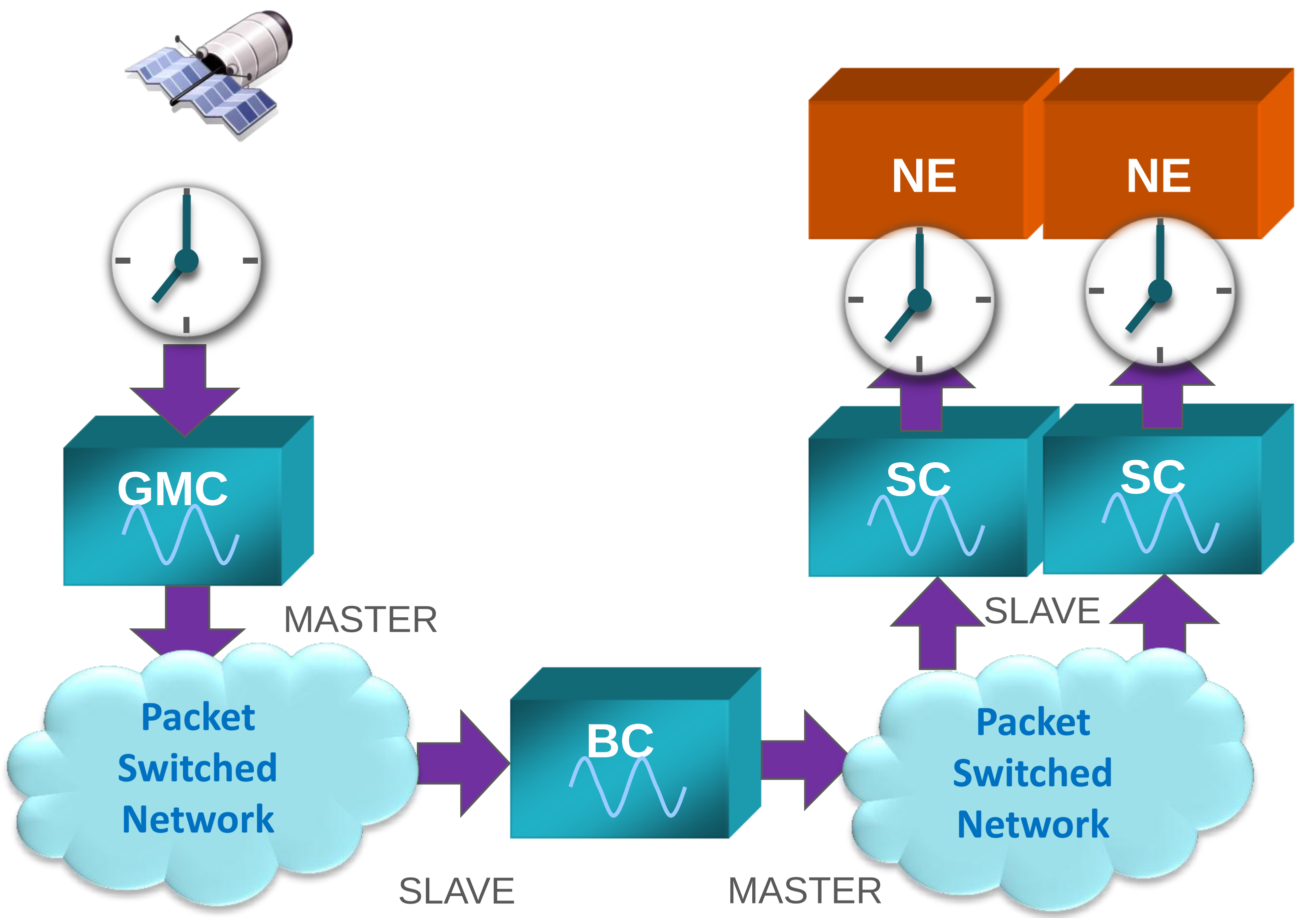


# Boundary Clocks Principle



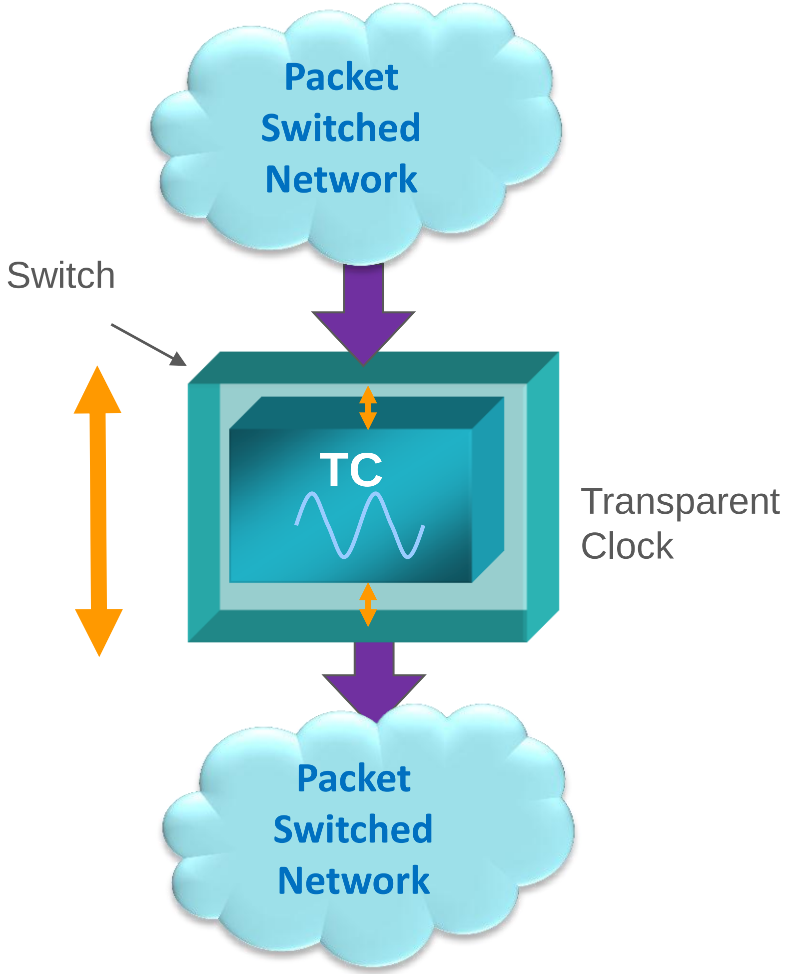

e.g. Ethernet Switch or IP Router

# PTP Network Principle with Boundary Clock

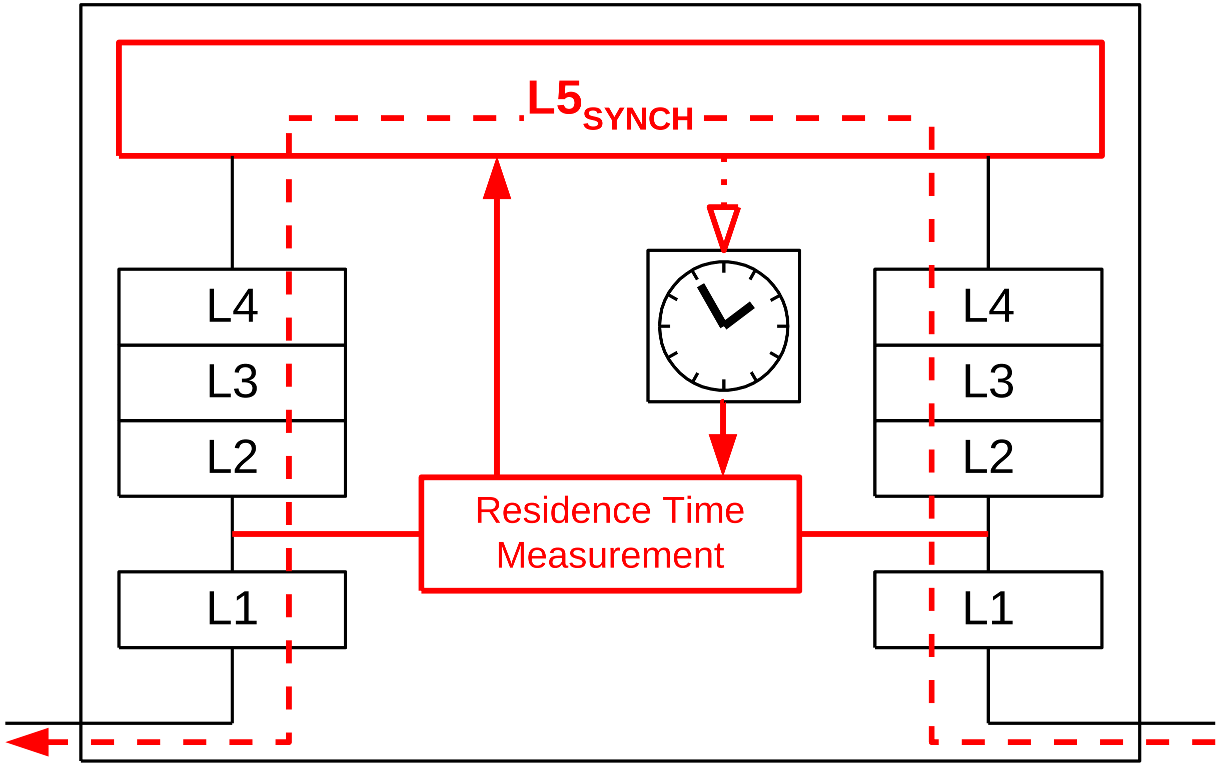


# End-to-end Transparent Clocks

- Are typically contained in switching equipment
- Measure the time elapsed between Switch input and Switch output
- Are recommended in network elements which insert significant delay fluctuations
- Not recommended by ITU-T



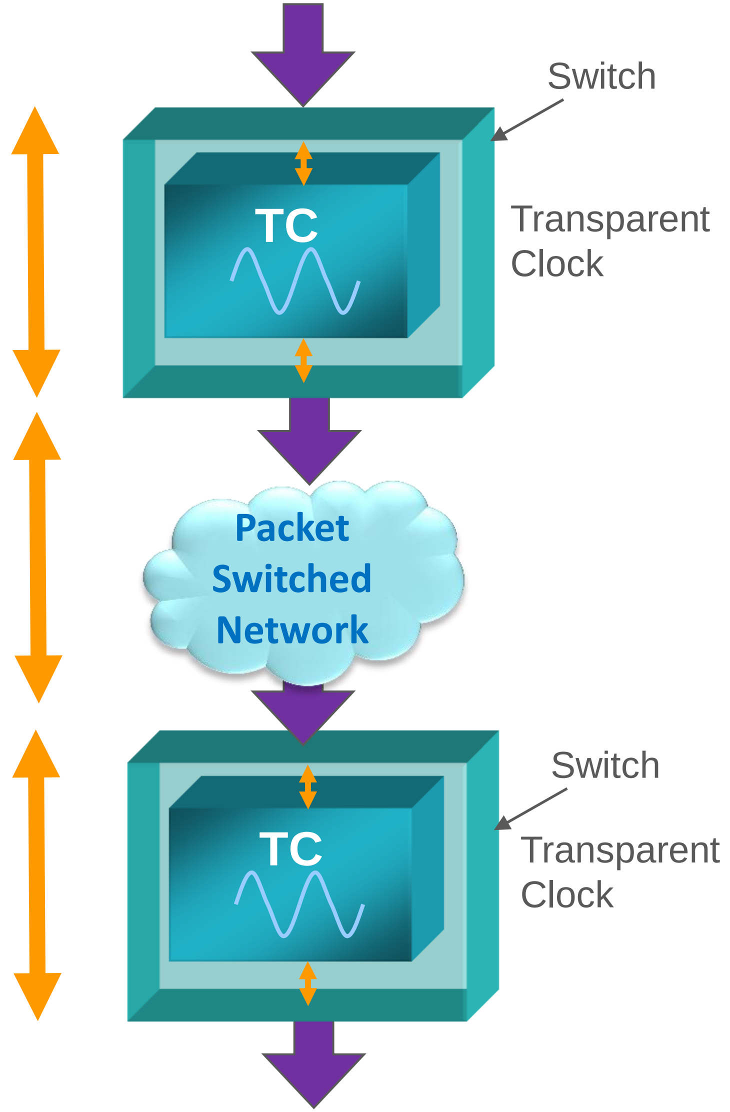
# Transparent Clock




e.g. Ethernet Switch or IP Router

# Peer-to-peer Transparent Clocks

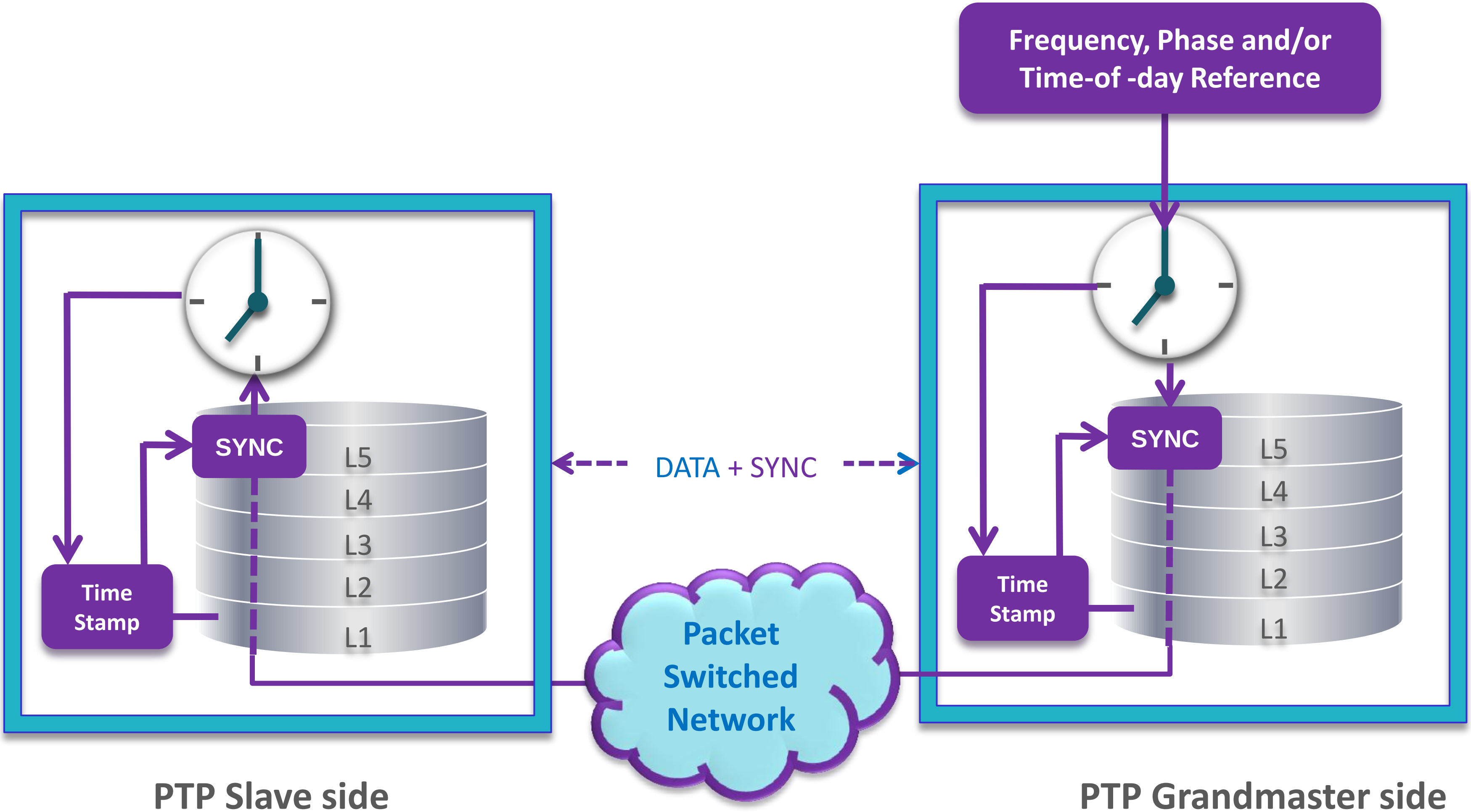
- Are typically contained in switching equipment
- Measure the time elapsed between Switch input and Switch output
- Measure time elapsed between two Transparent clocks
- Are recommended in network elements which insert significant delay fluctuations
- Not recommended by ITU-T



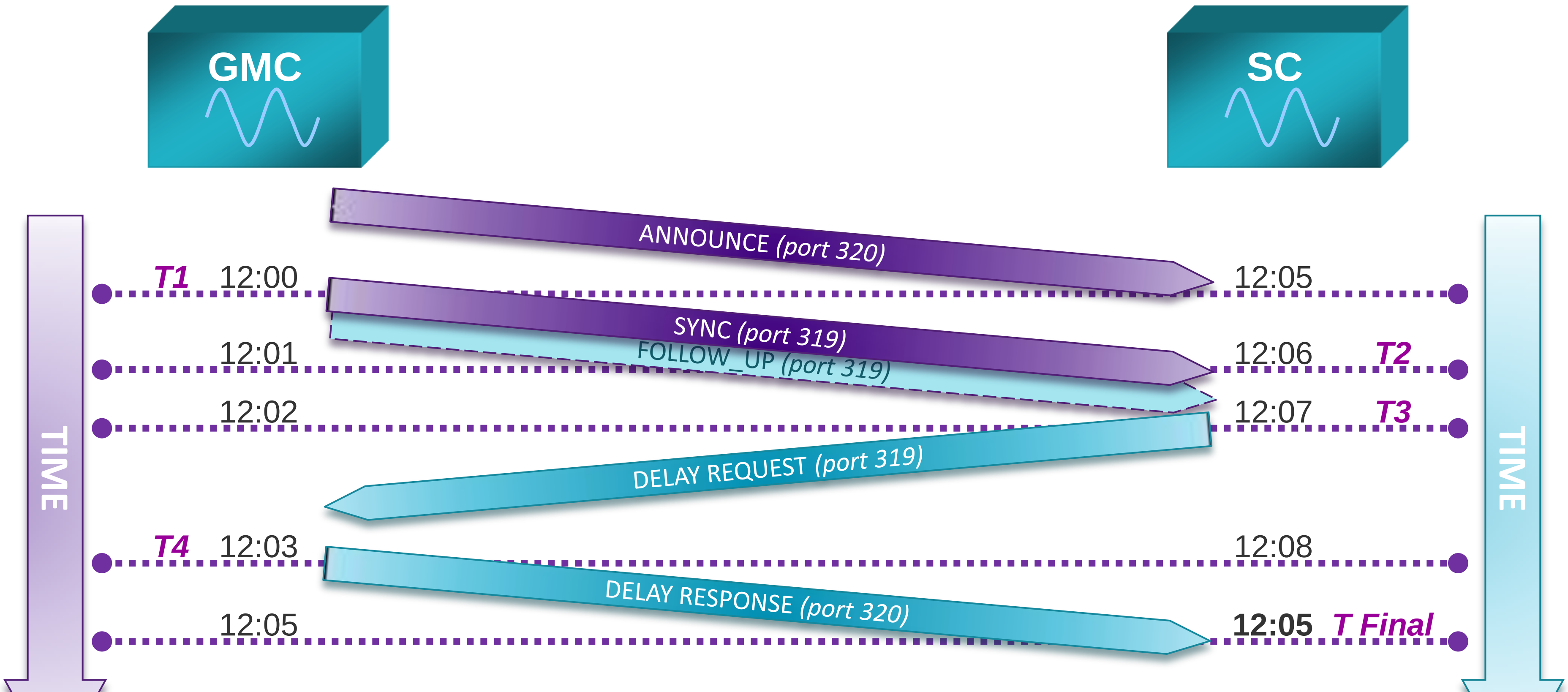
Chapter 2

# PTP COMMUNICATION

# Time Exchange between Master and Slave



# Two-Way Time Transfer (TWTT)




$$T\ Offset = \frac{(T2-T1) - (T4-T3)}{2} = \frac{(12{:}06-12{:}00) - (12{:}03-12{:}07)}{2} = \frac{6 - -4}{2} = 5$$

**Mean Propagation Delay = TSC – T Offset = 12:10 – 5 = 12:05**

# PTP V2 Messages

ANNOUNCE *(port 320)*

- Announce:
  - Entity the Master Clock
  - Conveys clock propeties
  - Typically sent every 2 sec.

SYNC *(port 319)*

- Sync messages:
  - Conveys Master Clock's time information (T1)

FOLLOW_UP *(port 319)*

- Follow_up:
  - Conveys Master Clock's time information (T1) in 2-step mode

DELAY REQUEST *(port 319)*

- Delay_Req messages:
  - Used to measure and correct transmission delay
  - Conveys estimate of transmit time

DELAY RESPONSE *(port 320)*

- Delay_Resp messages:
  - In response to a Delay_Req message
  - Used to measure and correct transmission delay
  - Conveys precise time stamp of Delay_Req message's receive time

# Master Selection Methods

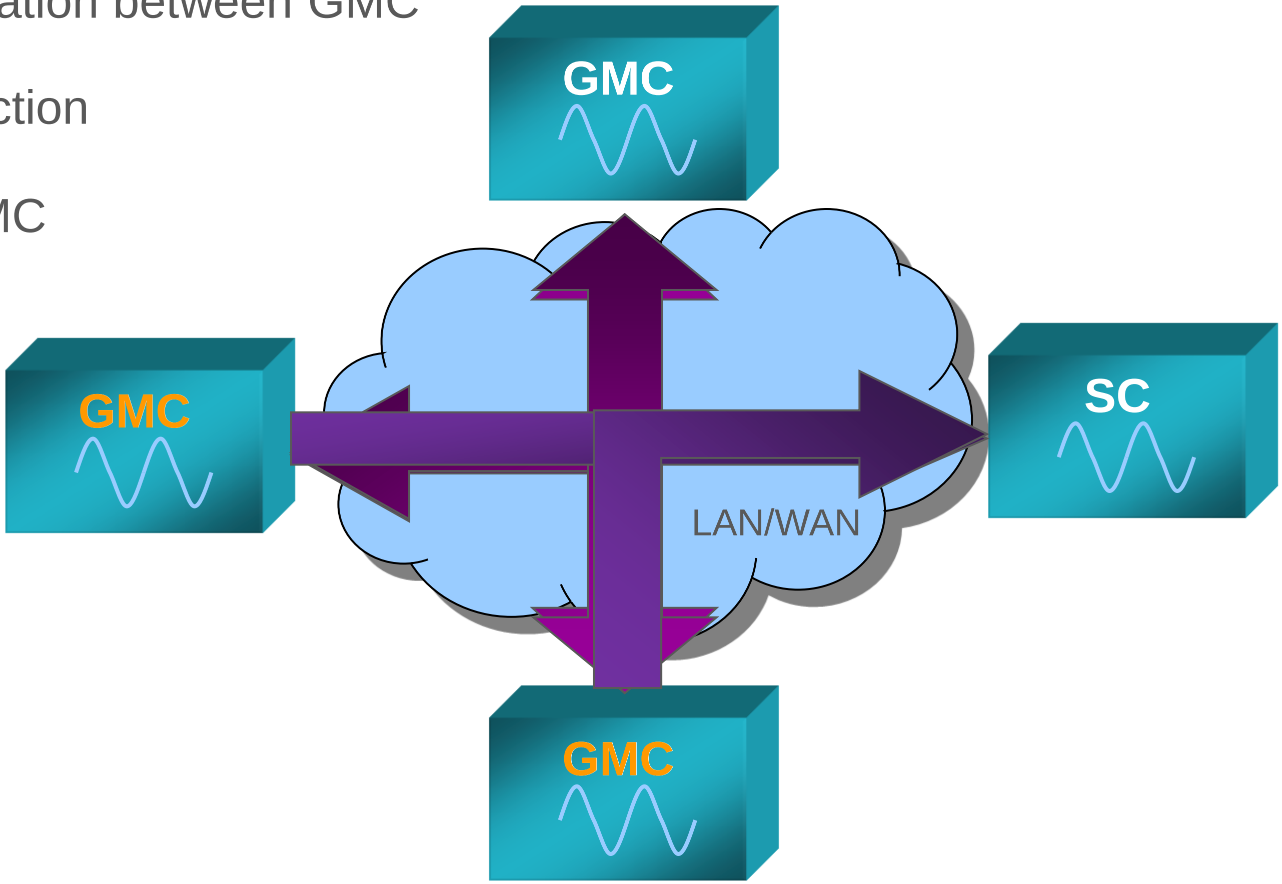
- Manual:
  - Configured via management system; static.
- Semi-automatic:
  - Acceptable master table:
    - Configure slave ports to accept only clocks from the table as masters
- Fully automatic:
  - Best Master Clock Algorithm (BMCA)

# Best Master Clock Selection

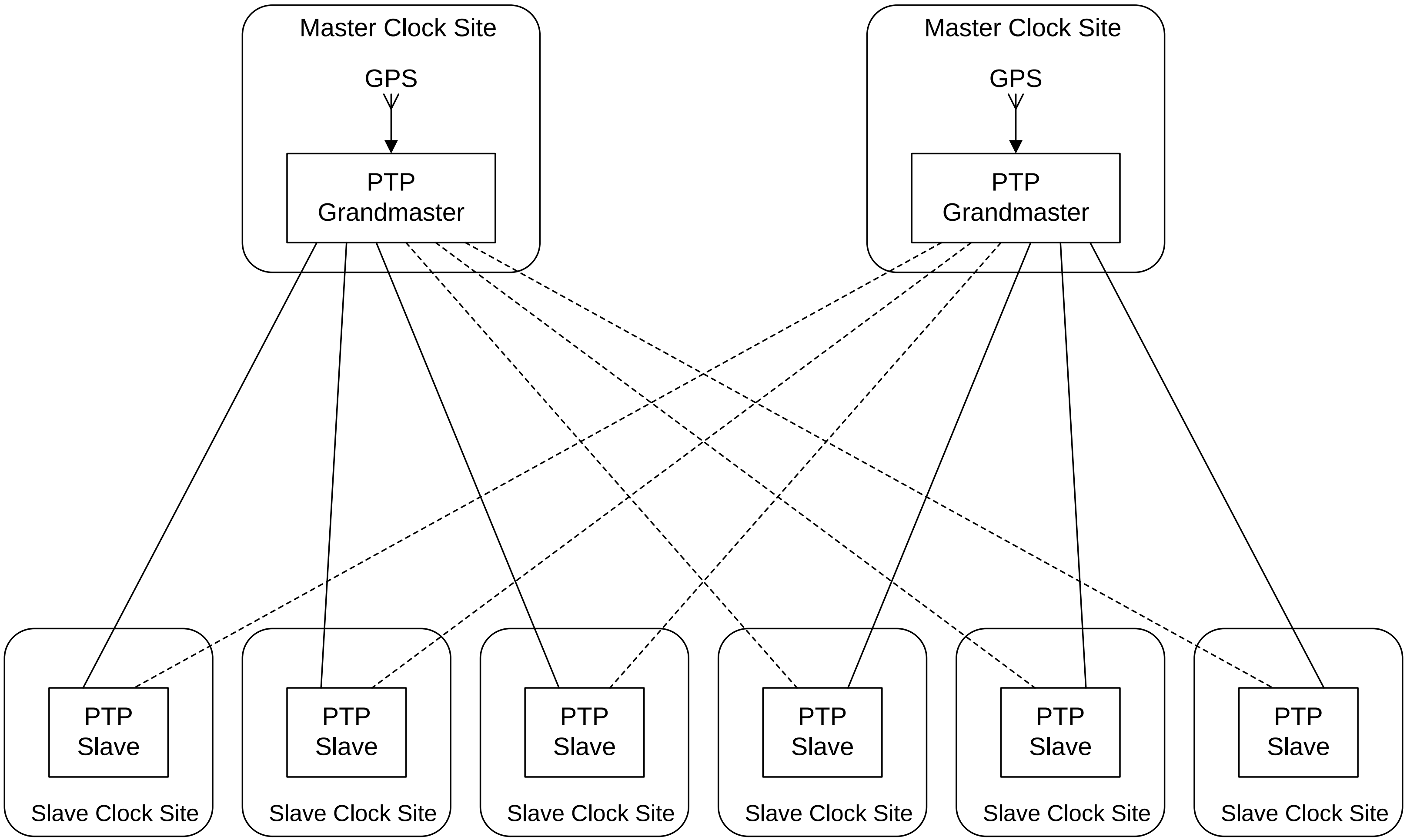
Communication between GMC

GMC Selection

Loss of GMC



# Acceptable Master Table - Redundancy

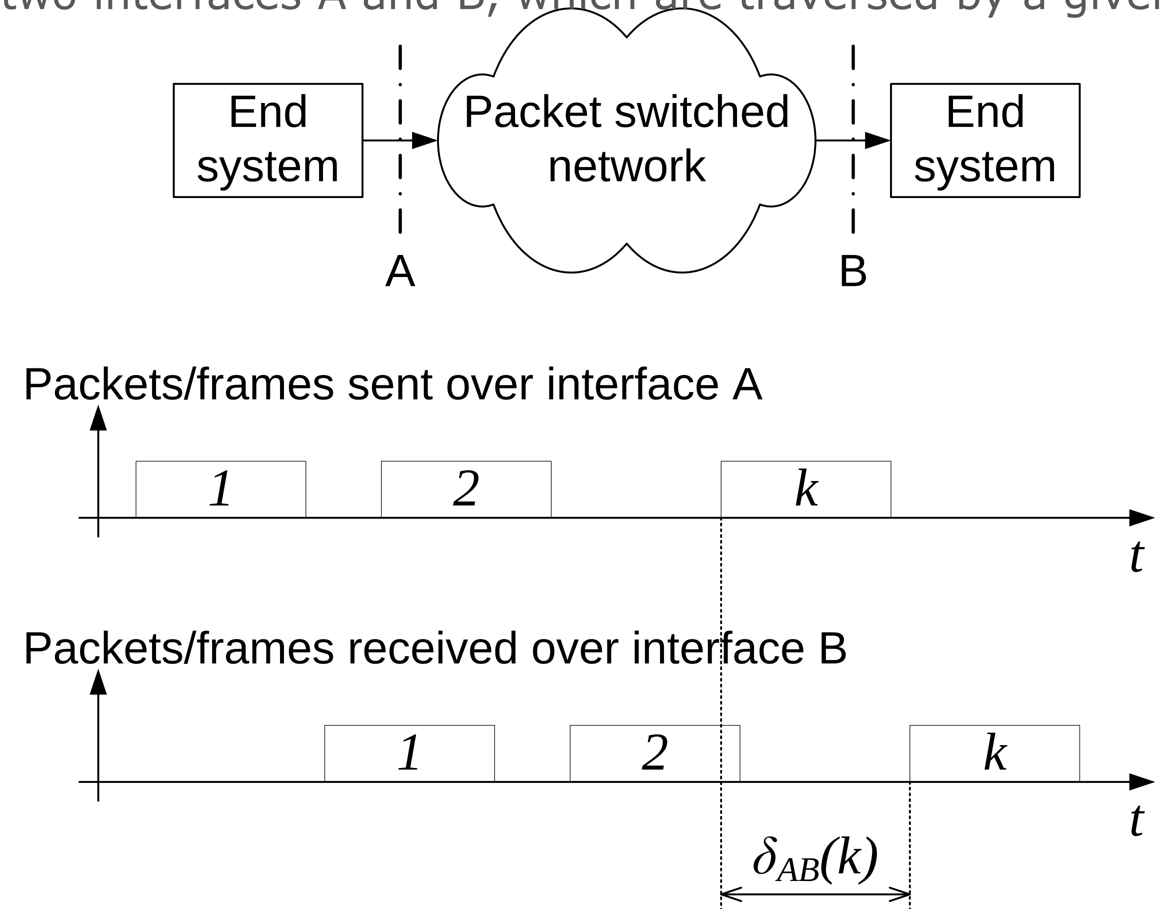


Chapter 3

# PTP PERFORMANCE

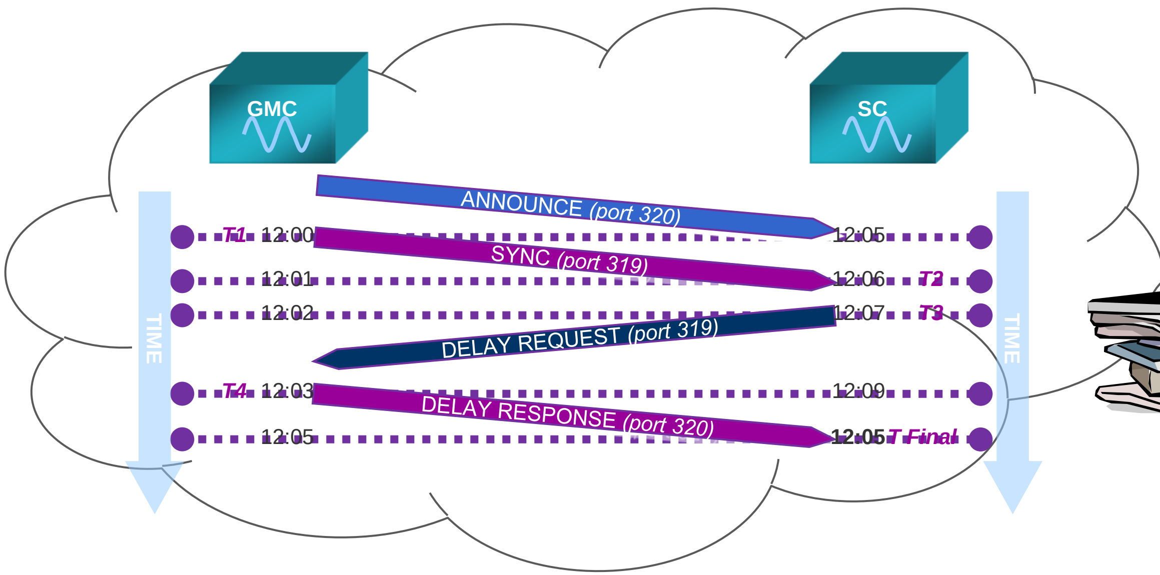
# Definition: Packet Delay δAB(k)

Consider two interfaces A and B, which are traversed by a given packet flow.



# TWTT (Two-Way Time Transfer ) is not perfect…

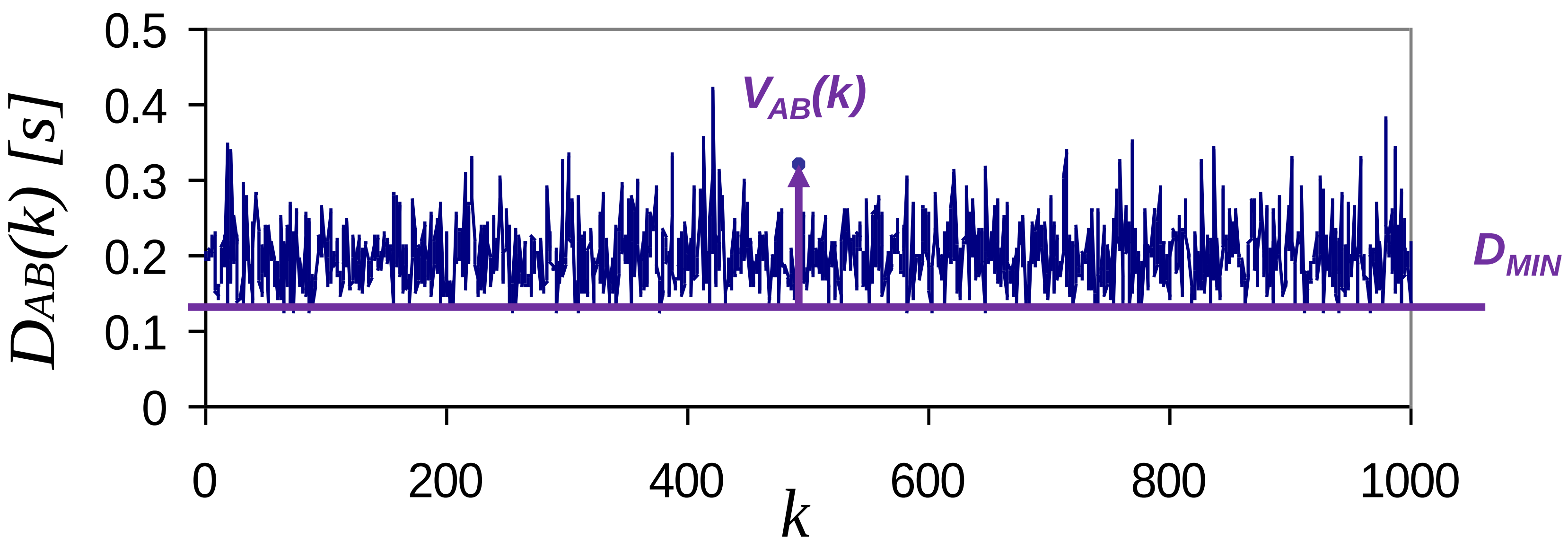
- Because of a packet delay asymmetry, the formula is affected by errors.
- In a packet network, the queuing part of the total packet delay is highly asymmetrical, except when there are very low traffic loads.

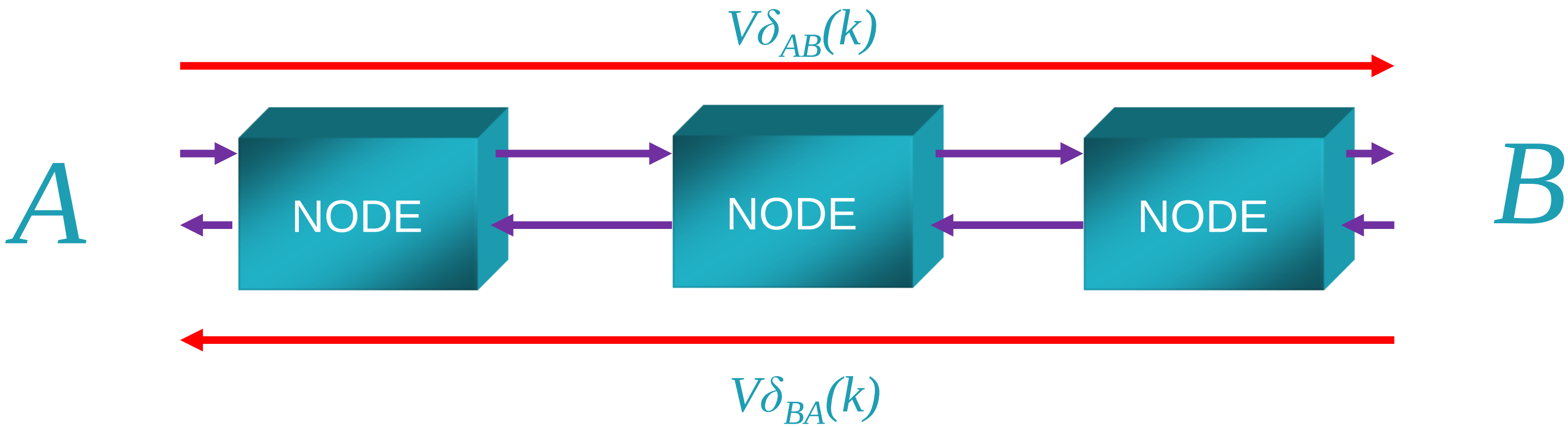



# Factors impacting performance

- Objective: ITU-T G.823 Network Limit for PDH synchronization interfaces
- Performance is impacted by …
  - Packet Delay Variation (PDV)
  - Packet Delay Asymmetry (PDA)
- PDV and PDA depend on …
  - the number of switching / routing nodes
  - the traffic load
  - QoS mechanisms

# Definition: PDV (Packet Delay Variation) VAB(k)



# Overview of Stand-Alone Products

- Compact 1U / 19″ rack-mountable units


  - PTP Grandmasters
    - OSA 5331 PTP Grandmaster – High Performance
  - PTP Slaves
    - OSA 5320 PTP Slave – Telecom
    - OSA 5320 PTP Slave – Broadcasting
    - OSA 5320 PTP Slave – Power & Utilities

# OSA 5331 PTP Grandmaster  Front Panel

# OSA 5331 PTP Grandmaster - Rear Panel

ToD Input (NMEA 0183)

ToD Output (NMEA 0183)

FE/GbE PTP Port

SFP PTP Port

Power supply B

GPS input

Alarm Relay

DC Power A

PPS Input

Local Mgmt

E1 / 2.048 MHz / T1 / 75 ohms output

E1 / T1 / 75 ohms input

Remote Mgmt

E1 / 2.048 MHz / T1 / 75 ohms output

10 / 2.048 MHz Input

10 MHz 50 ohms output

1PPS Output

Plug-in card

# TCC-PTP FOR OSA 5548C

# TCC-PTP (Time Code Card – PTP)

- Plug-in card for the OSA 5548C SSU/TSG
  - Enhances PTP v2 Grandmaster function
  - Fits into any Output card slot
  - OSA 5548C SSU-E60   : up to 6 TCC-PTP cards
  - OSA 5548C SSU-E200 : up to 20 TCC-PTP cards
    → PTP Hub

OSA 5548C SSU-E60

OSA 5548C SSU-E200

# OSA 5548C “PTP HUB”

CAPACITY (20 GM blades per shelf) in **Unicast or Multicast**

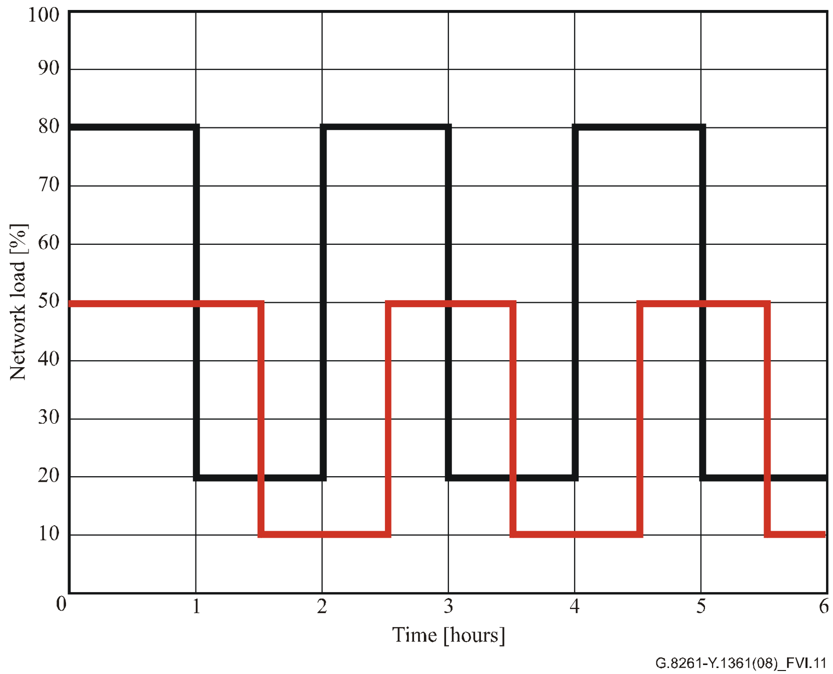
- with TCC-PTP GM
  - More than 2’500 slaves per shelf
- with TCC-PTP II GM *
  - More than 5’000 slaves per shelf

* Available in 2013

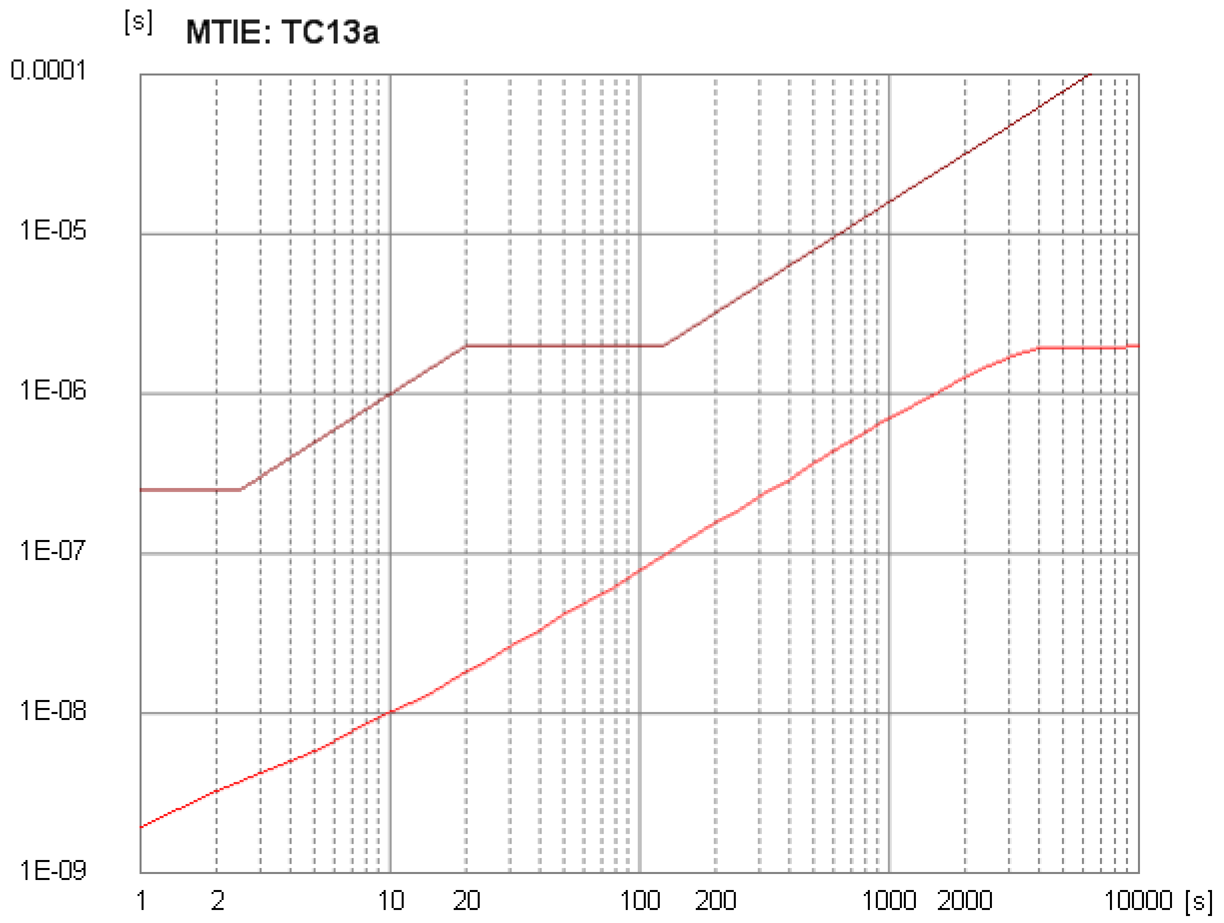
# TESTING

# Test Case 13 - Sudden large and persistent changes in network load

- Test Case 13 models sudden large and persistent changes in network load. It demonstrates stability on sudden large changes in network conditions, and wander performance in the presence of low frequency PDV.

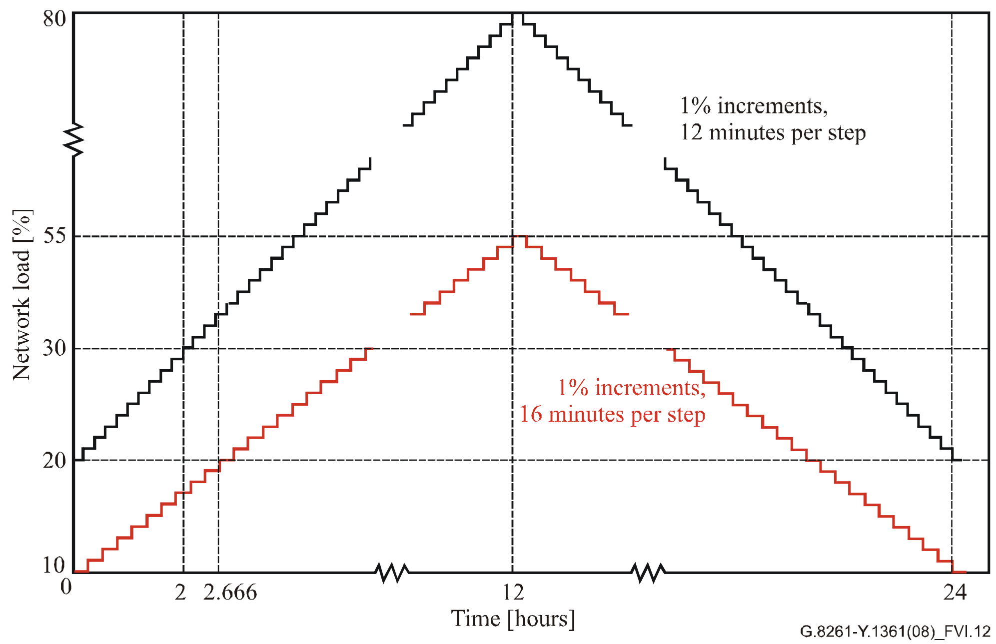


# Test case 13 - Results

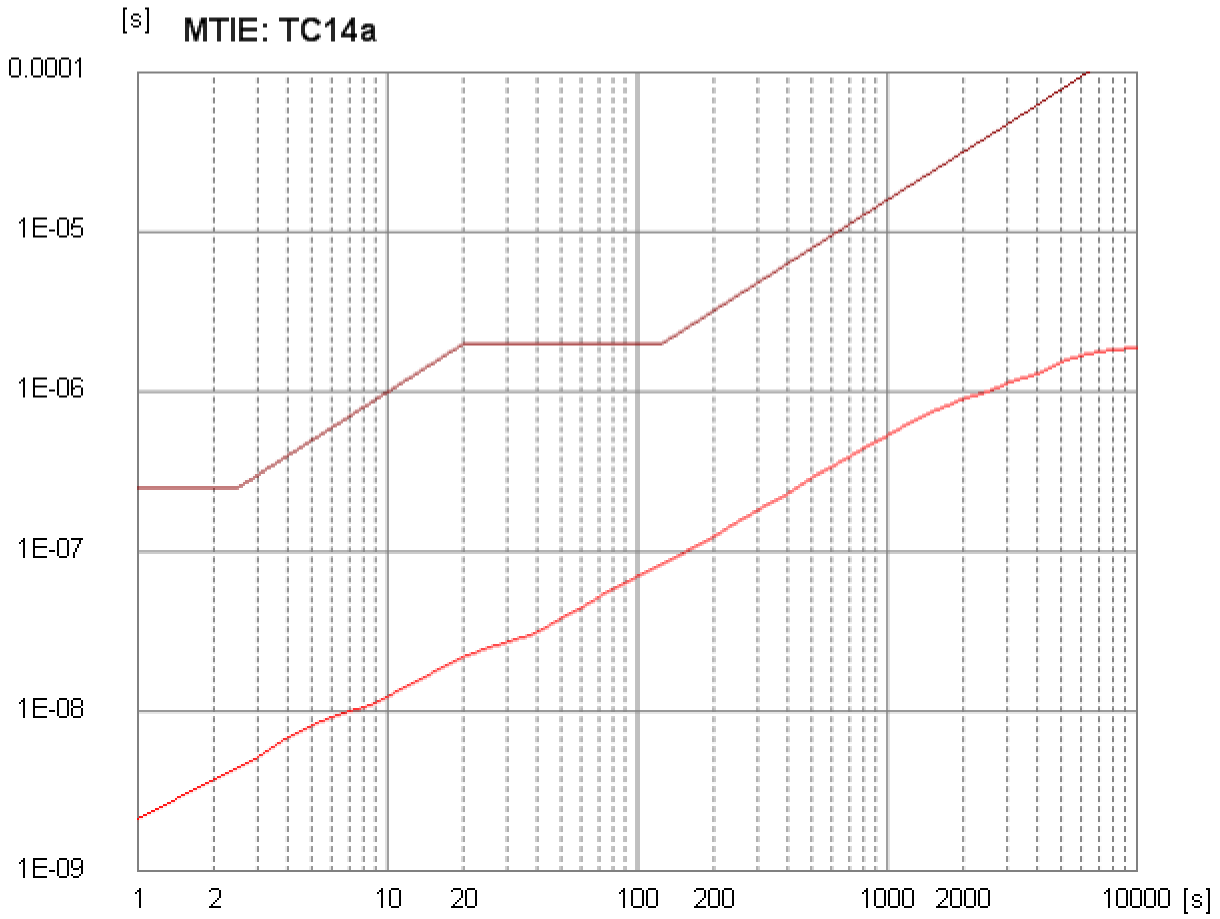


# Test Case 14 - Slow change in network load over an extremely long timescale

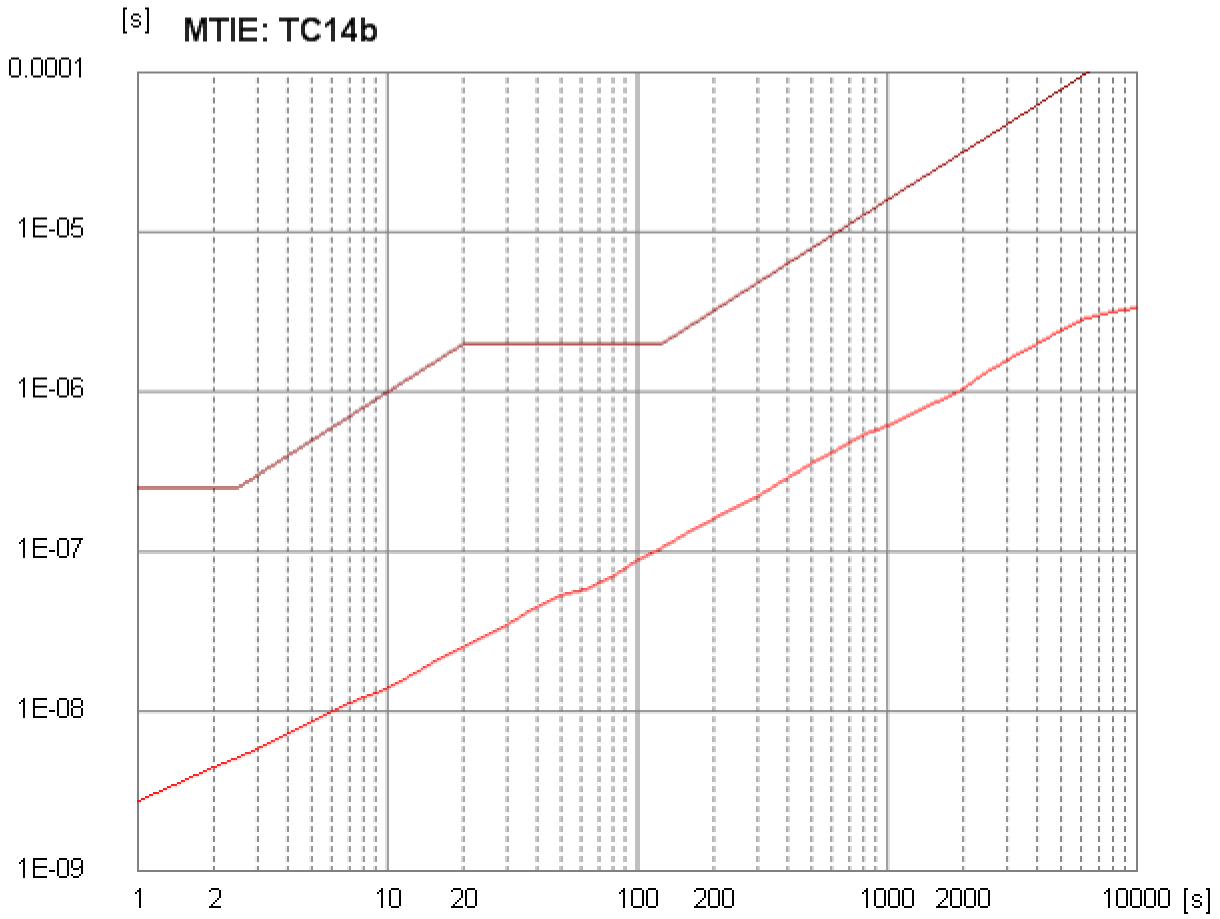
- Test Case 14 models the slow change in network load over an extremely long timescale. It demonstrates stability with very slow changes in network conditions, and wander performance in the presence of extremely low frequency PDV.



# Test case 14 – Results with Traffic model 1



# Test case 14 – Results with Traffic model 2



# Network Traffic Models

## Network Traffic Model 1
(majority of traffic is Voice)

- The access traffic is composed of conversational (voice), streaming (audio-video), interactive (http) and background (sms, e-mail):
  - 80% of the load must be minimum size packets
  - 15% of the load must be maximum size packets
  - 5% of the load must be medium size packets
  - Maximum size packets will occur in bursts lasting between 0.1 s and 3 s.

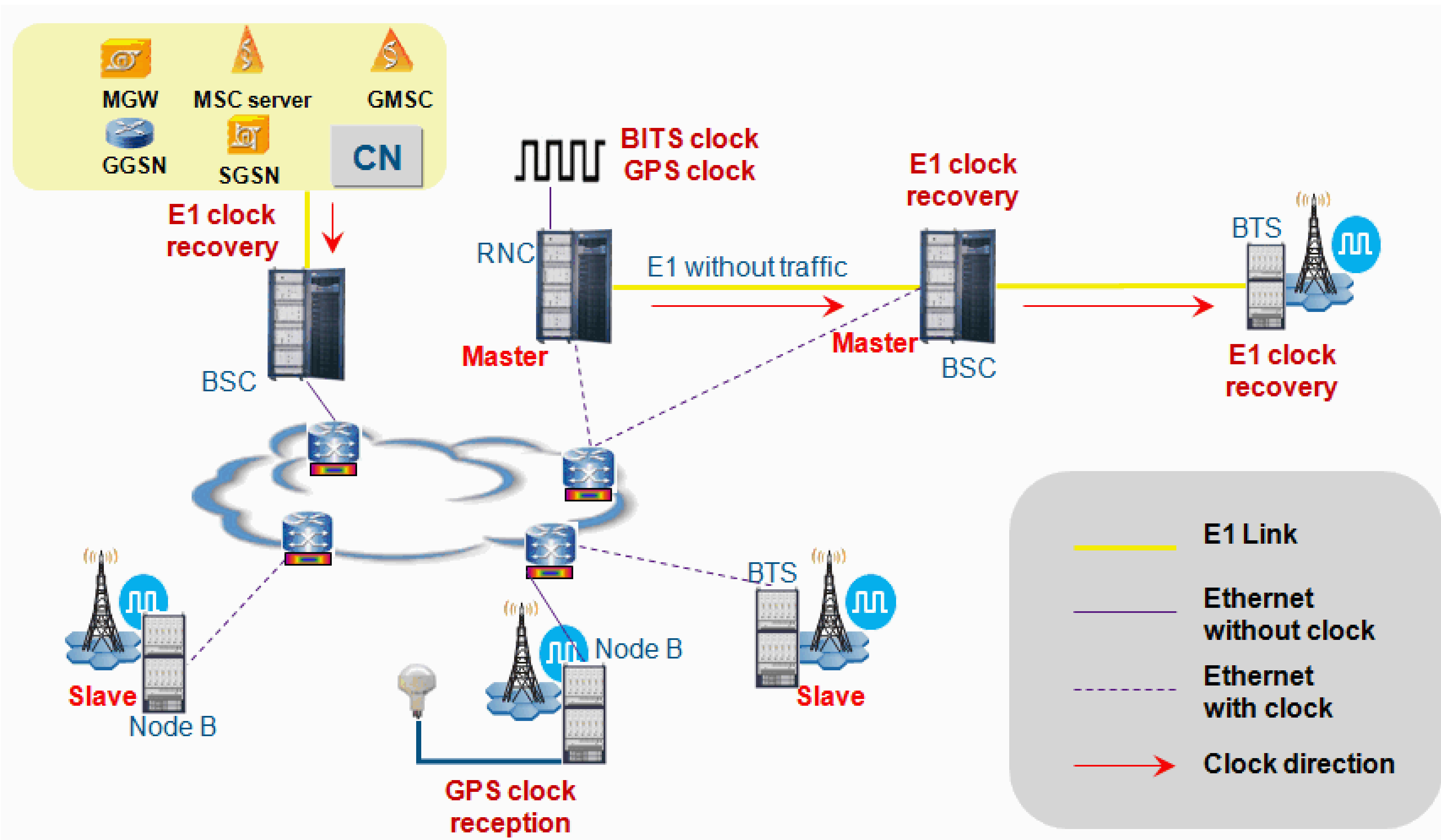
## Network Traffic Model 2
(majority of traffic is Data)

- 60% of the load should be based on packets of maximum size, and 40% on packets with a mix of minimum and medium size:
  - 60% of the load must be maximum size packets
  - 30% of the load must be minimum size packets
  - 10% of the load must be medium size packets
  - Maximum size packets will occur in bursts lasting between 0.1 s and 3 s.

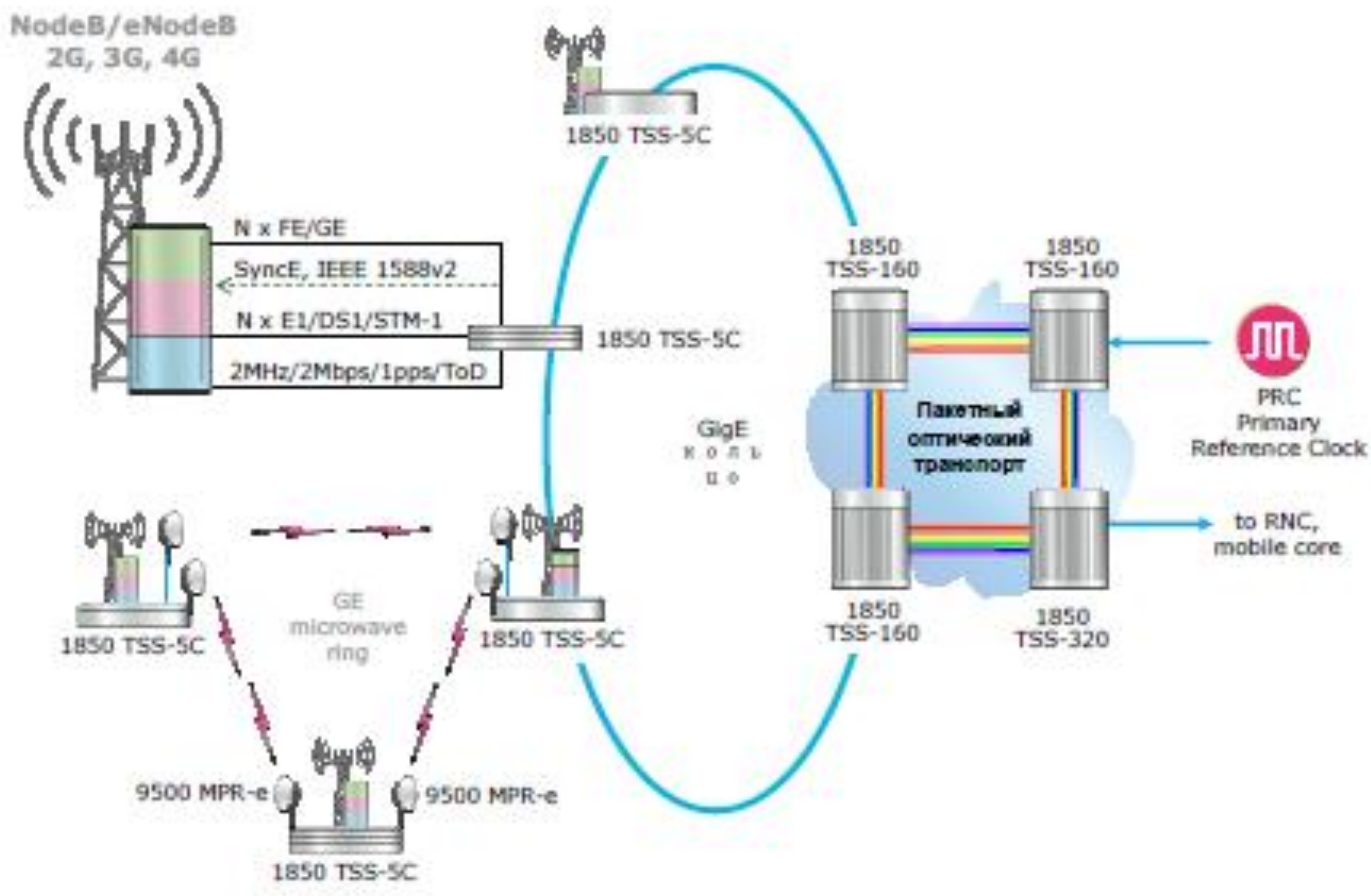
Chapter 5

# NETWORK EXAMPLES

# Egy élö példa



# Egy europai példa



# Köszönöm szives figyelmüket

Ha vannak kérdések
Nagyon szivesen àllok rendelkezésükre

- www.oscilloquartz.com