

# Net.Time applications



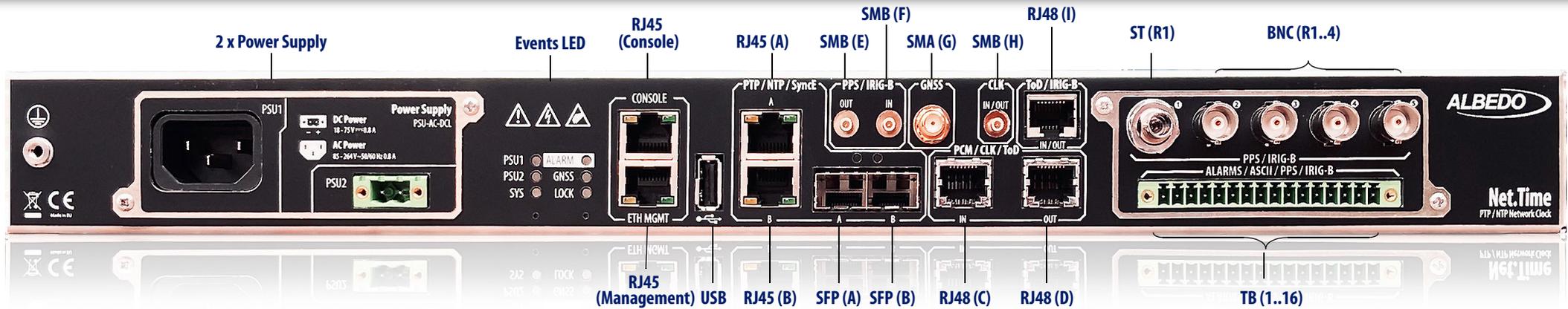
*Net.Time is a Grandmaster and Boundary clock that supports PTP and NTP over PRP and multiple input/output options such as IRIG-B, 1PPS, ToD and SyncE to satisfy all timing needs of power utility, enterprise and telecom applications*

*Just in Time*



# ALBEDO a Global manufacturer of Testers & Timing appliances

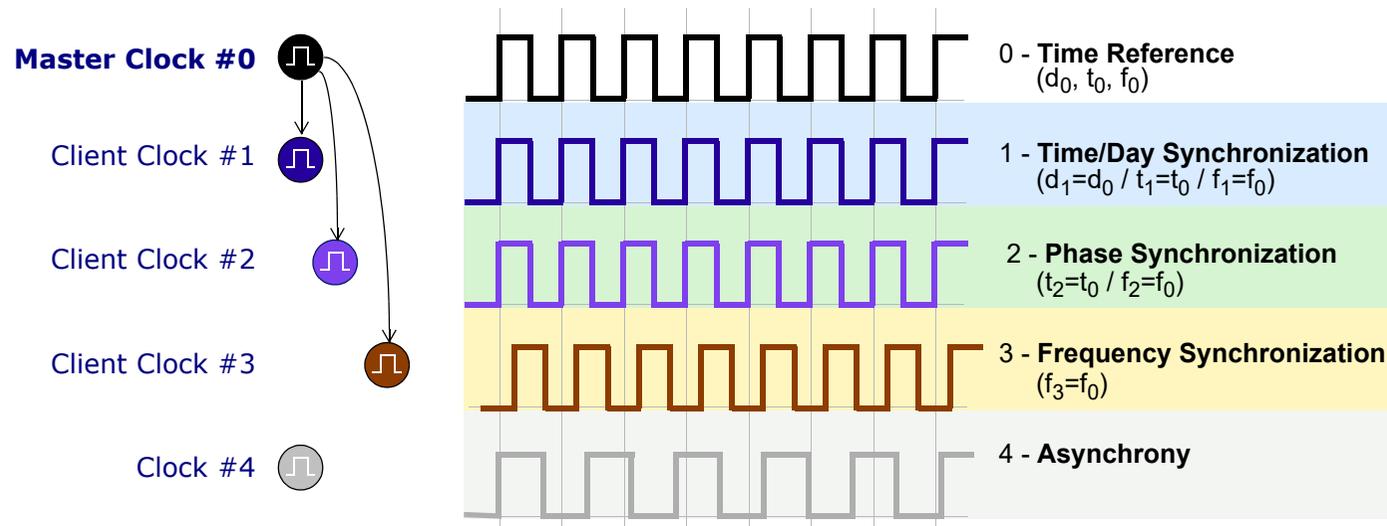




Net.Time is a boundary clock designed to simplify migration to PTP protocol from previous generation architectures. Net.Time offers seamless translation while offering a high variety of clock reference inputs and outputs that may be used as primary or backup references, monitoring and synchronization.

	GNSS	PTP	NTP	ToD	IRIG-B	PPS	PP2S	SyncE	T1/E1	MHz	ASCII	Alarm
RJ45 (A)		out	out					in/out				
RJ45 (B)		in	in					in/out				
SFP (A)		out	out					in/out				
SFP (B)		in	in					in/out				
SMB (E)					out	out	out					
SMB (F)					in	in	in					
SMB (H)										in/out		
SMA (G)	in											
RJ48 (I)				in/out	in/out							
RJ48 (C)				in					in	in		
RJ48 (D)				out					out	out		
ST (R1)					out	out						
BNC (R1..4)					out	out						
TB(1..16)					out	out					out	out

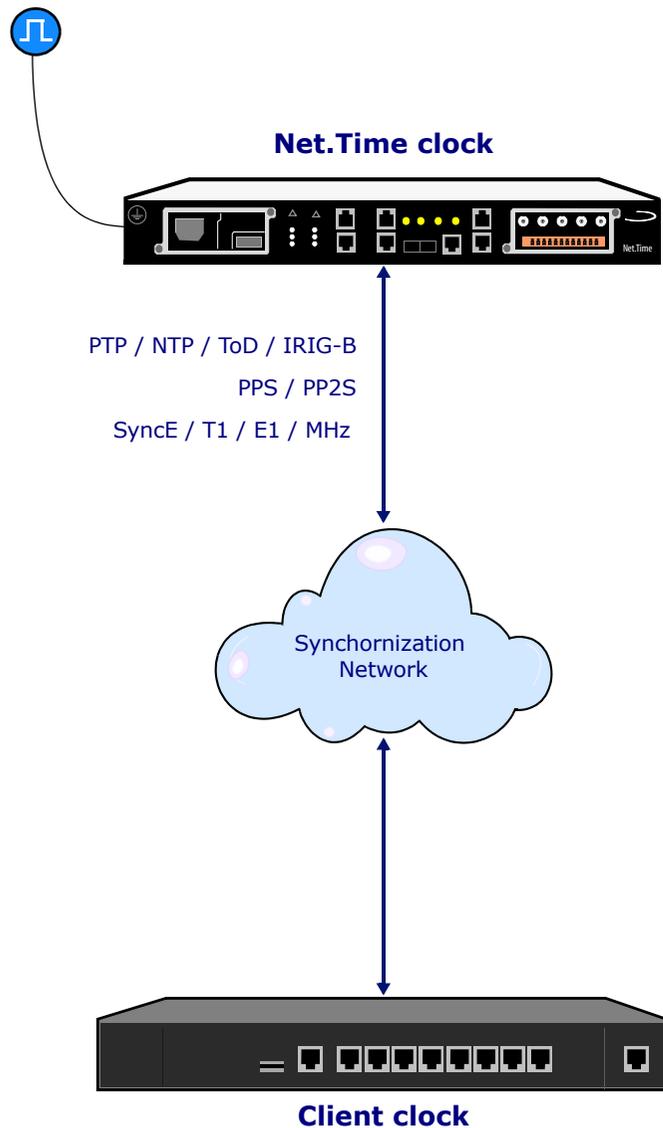
# About Synchronization



Synchronization aims to discipline clocks in a network to a common time reference.

- **Master Clock #0** is the time reference defined by a Day ( $d_0$ ), Phase ( $p_0$ ) and Frequency ( $f_0$ )
- **Client Clock #1** is disciplined to the Master on Day ( $d_0$ ), Phase ( $p_0$ ) and Frequency ( $f_0$ )
- **Client Clock #2** is disciplined to the Master only on Phase ( $p_0$ ) and Frequency ( $f_0$ )
- **Client Clock #3** is disciplined to the Master only on Frequency ( $f_0$ )
- **Clock #4** is not disciplined at all

Even when initially set accurately, real clocks will differ after some amount of time due to clock drift, caused by clocks counting time at slightly different rates.



Net.Time can synchronize by means of several signals that can be grouped according the following hierarchy.

**Time/Day Synchronization** which is the most comprehensive as provide day, phase & frequency:

- PTP
- NTP
- ToD
- IRIG-B

**Phase or Time Synchronization:** can only provide phase and frequency:

- PPS
- PP2S

**Frequency Synchronization:** can only provide frequency:

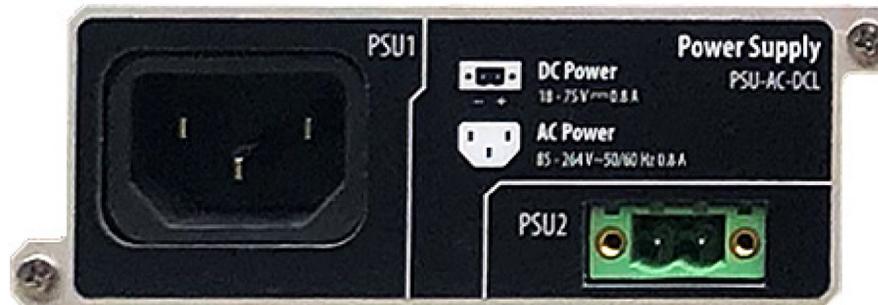
- T1
- E1
- SyncE
- MHz

## Platform

- 19" / ETSI/1U/201 mm rack mount
- Fanless operation
- Weight: 3.4 kg / 8.7 lb
- Redundant power supply
- LEDs
- USB: Software and firmware upgrade
- Storage: -20 ~ +85°C
- Operating temp.: -10 ~ +65°C
- Operating humidity: 10 ~ 90%

## Net.Time 1U -19'





## Multiple combinations

- Single: AC / DC / DCAC
- Double: AC+AC, AC+DC, DC+DC, AC+DCAC, AC+DCAC, DCAC+DCAC

## Options

- AC: 85 ~ 264 VAC (IEC 60320 C13/C14)
- DC: 18 ~ 75 VDC (2-pin 5.1 mm)
- DCAC: 85 ~ 264 VAC (2-pin 5.1 mm)
- DCAC: 100 ~ 370 VDC (2-pin 5.1 mm)



### Internal Oscillator

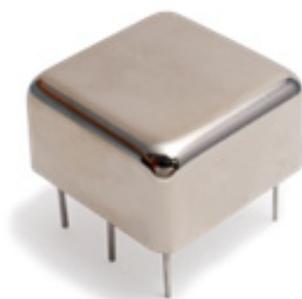
- Rubidium better than  $\pm 5.0 \text{ e-11}$
- OCXO better than  $\pm 0.1 \text{ ppm}$
- Internal time reference better than  $\pm 2.0 \text{ ppm}$

### Rubidium features

- GNSS Locked
- Time/Phase Accuracy to UTC:  $\pm 20 \text{ ns}$  at  $1\sigma$  after 24 hours lock
- Frequency Accuracy:  $1 \text{ e-11}$  (averaged over one week)

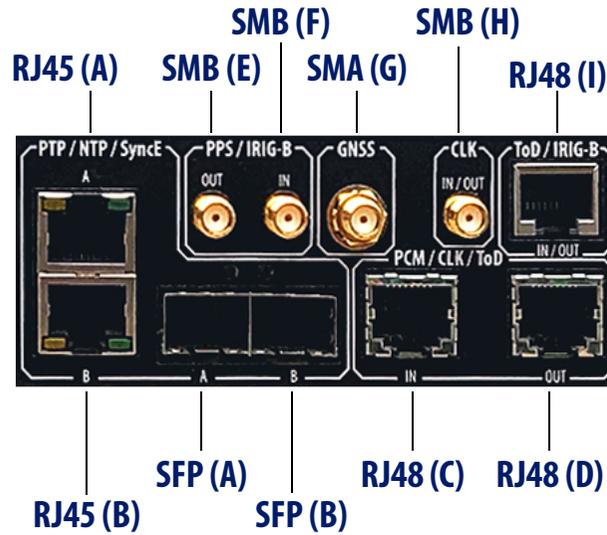
### Hold-over

- Output freq. accuracy (after 24 h. locked):  $1.5 \text{ e-11} / 24\text{h}$
- Output time accuracy (after 24 h. locked):  $\pm 100 \text{ ns} / 2\text{h}$   $\pm 1.0 \mu\text{s} / 24 \text{ h}$



### Freerun

- Output freq. accuracy (7.5 minutes warm up):  $\pm 1 \text{ e-9}$
- Output freq. accuracy on shipment (24 h warm up):  $\pm 5.0 \text{ e-11}$
- Aging (1 day, 24 hours warm up):  $\pm 0.5 \text{ e-11}$

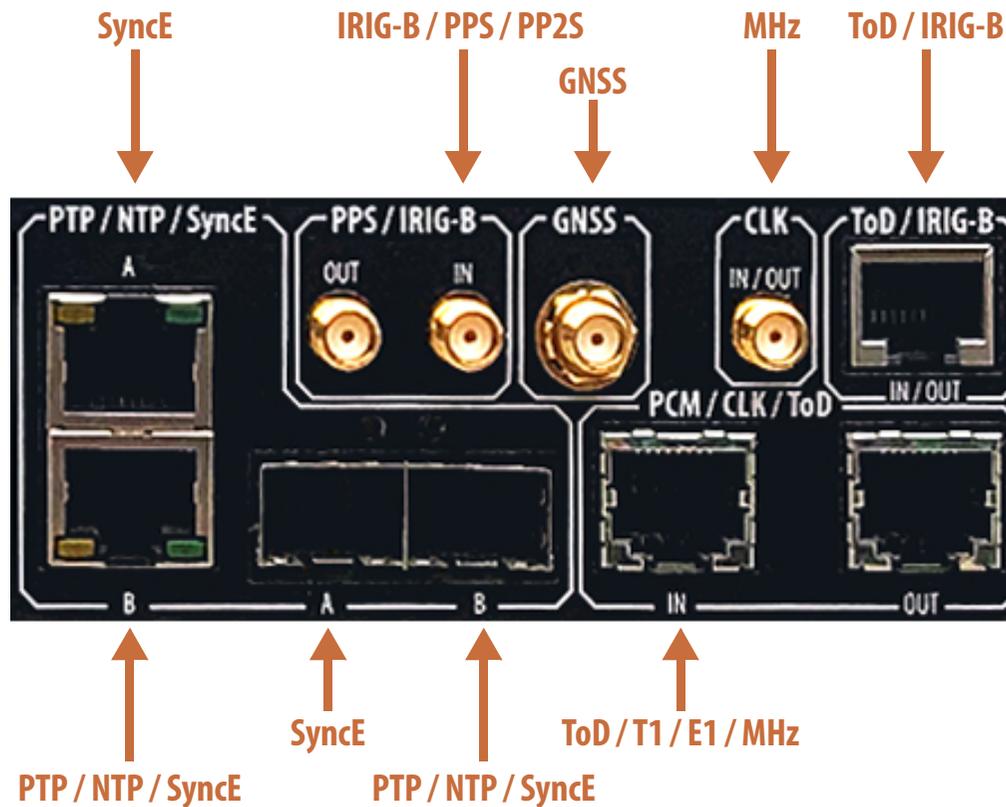


Multiple time references are possible in Net.Time from GPS to IRIG-B

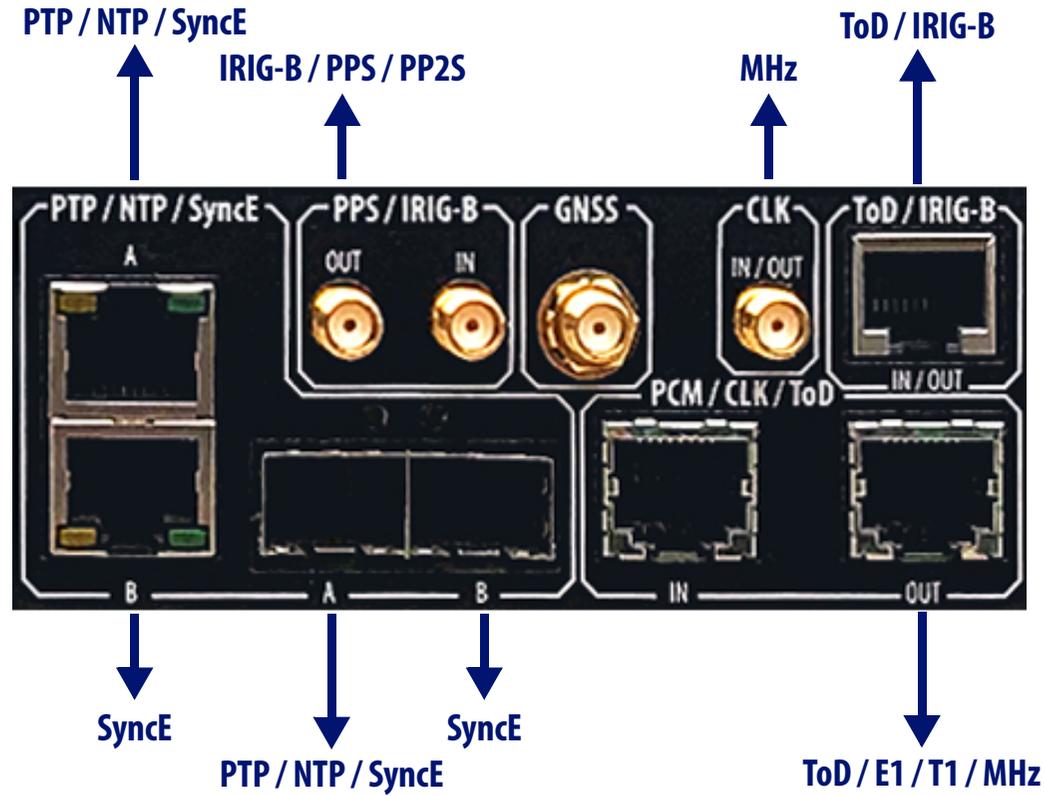
	GNSS	PTP	NTP	ToD	IRIG-B	PPS	PP2S	SyncE	T1/E1	MHz
RJ45 (A)		out	out					in/out		
RJ45 (B)		in	in					in/out		
SFP (A)		out	out					in/out		
SFP (B)		in	in					in/out		
SMB (E)					out	out	out			
SMB (F)					in	in	in			
SMB (H)										in/out
SMA (G)	in									
RJ48 (I)				in/out	in/out					
RJ48 (C)				in					in	in
RJ48 (D)				out					out	out

Can be defined the sequence of alternatives in case of the main time reference failure.

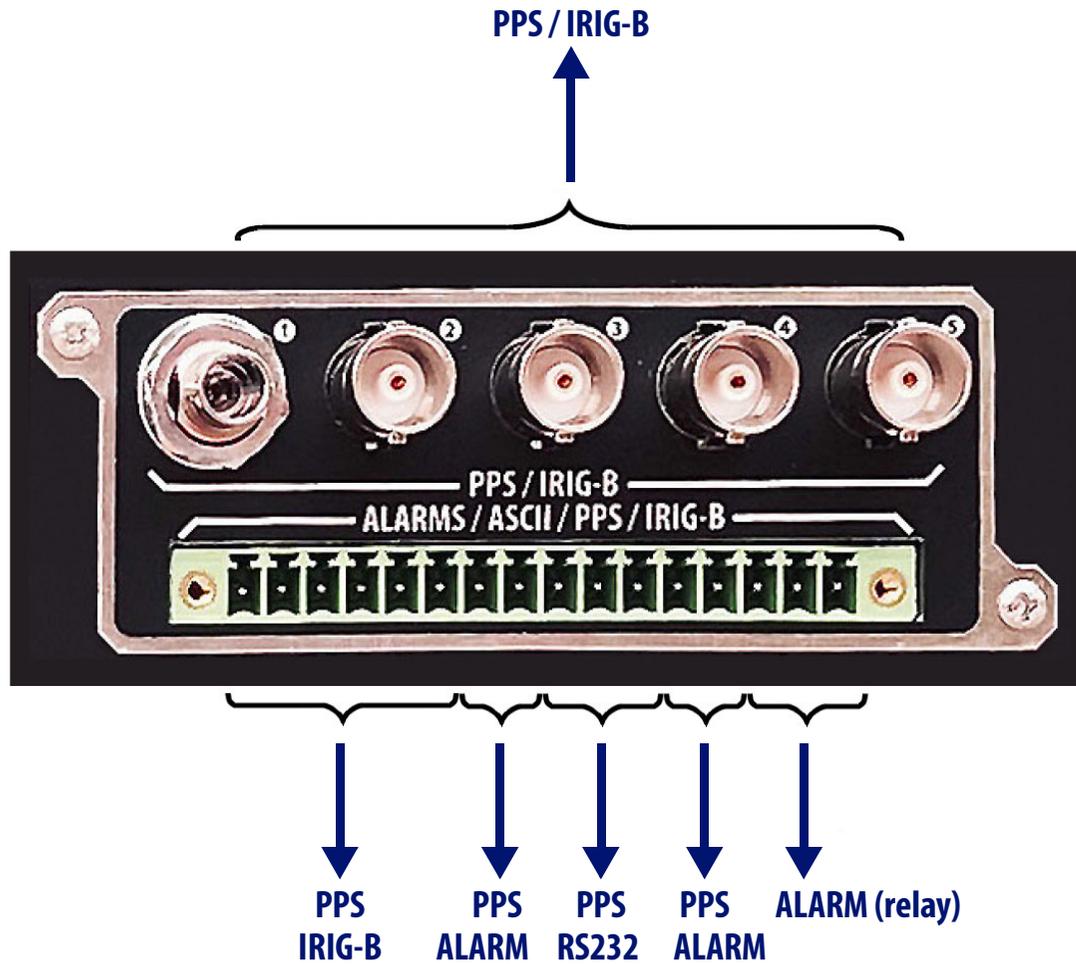
# Input references



Can be defined the sequence of alternatives in case of the main time reference failure.

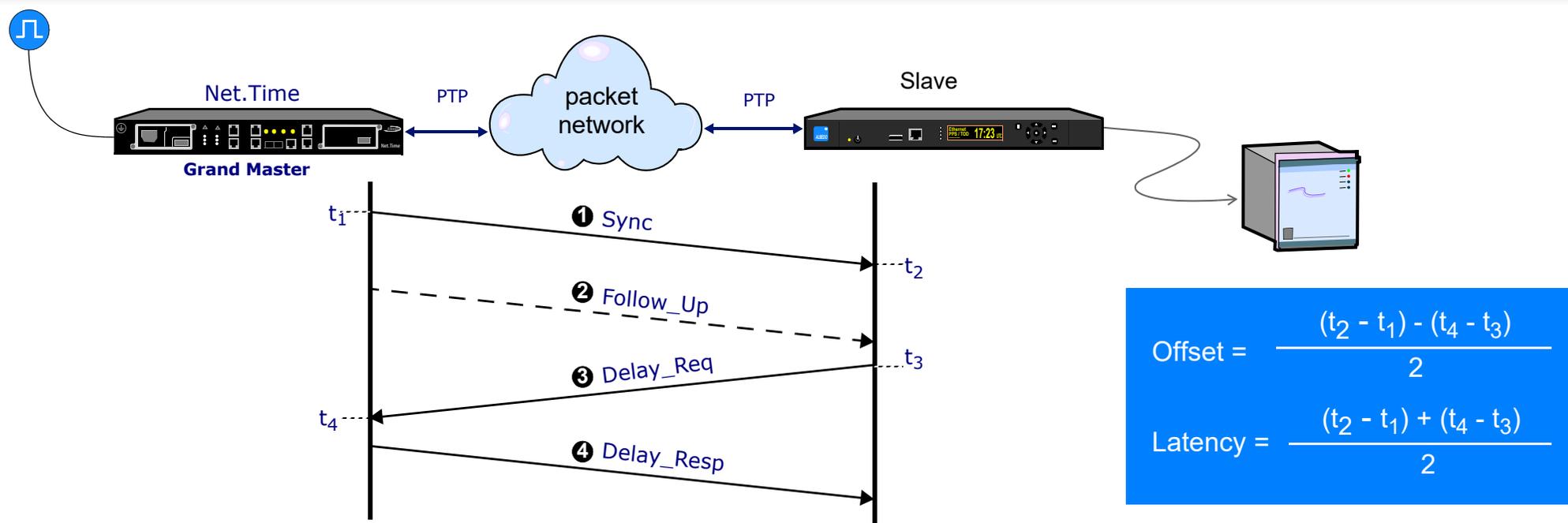


Can be defined the sequence of alternatives in case of the main time reference failure.



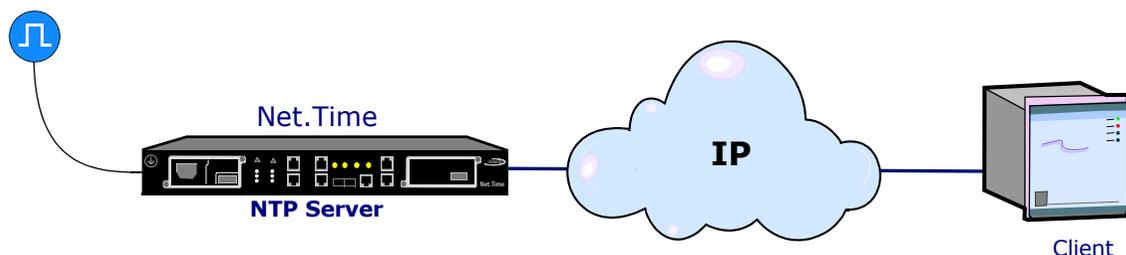
Several configurable modules are available .

	IRIGB	PPS	ASCII	Alarm
ST (R1)	out	out		
BNC (R1..4)	out	out		
TB(1..16)	out	out	out	out

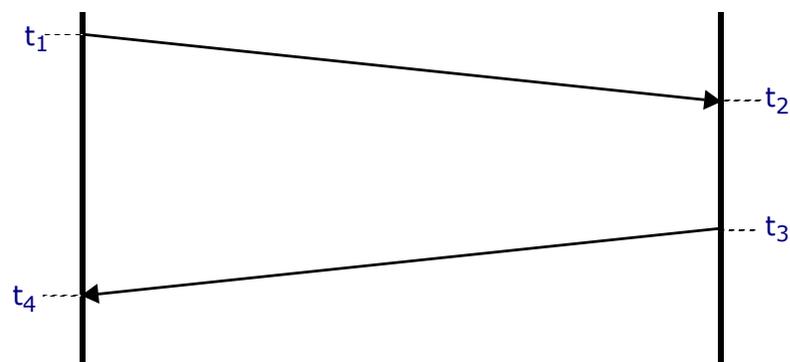
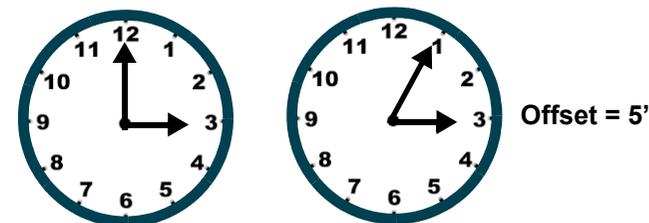


It is a cost-efficient solution and can be applied on the basis of the existing Ethernet network in a substation. PTP (IEEE 1588) applies master/slave time synchronization mechanisms and supports hardware time stamps. The basic parameters of Latency / Offset are computed from the  $t_{1...4}$  stamps.

- Grandmaster sends a series of messages with date and time to client-clocks
- Client-clocks compensate the delays and get synchronized with the Master
- Frequency is then recovered with a precise time-of-d
- PTP prevents error accumulation in cascaded topologies, fault tolerance and enhances the flexibility and PTP can use an existing Ethernet reducing cabling costs and requires just a few resources.



Offset: difference between clocks

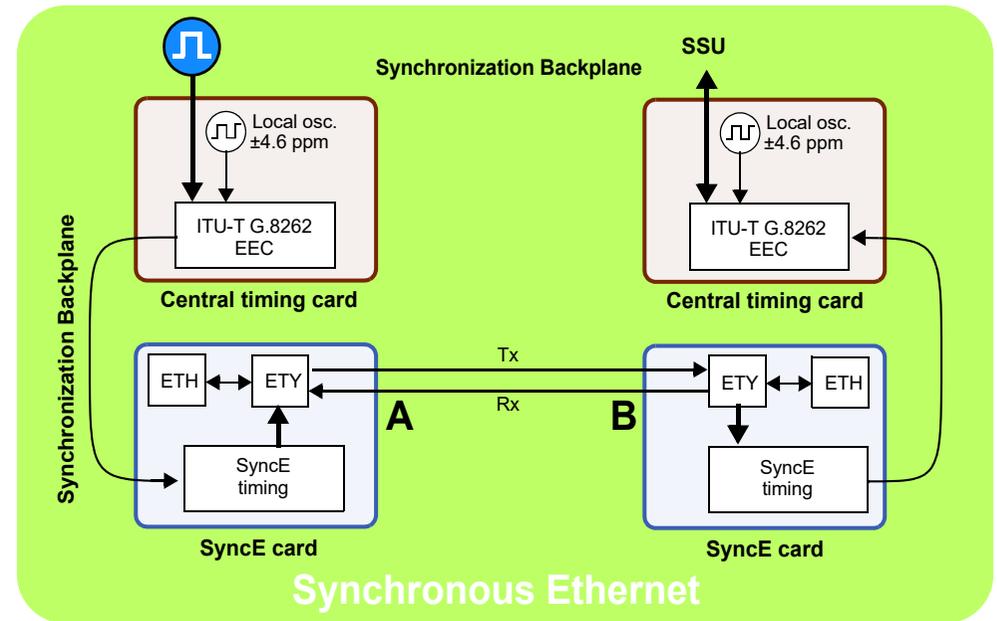
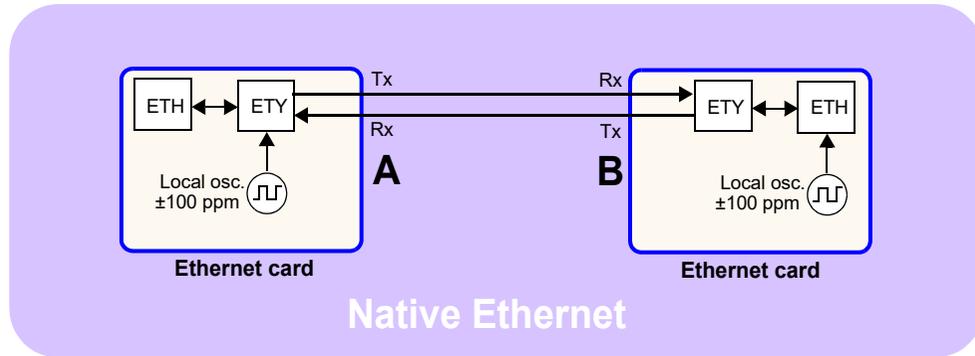


$$\text{Offset} = \frac{(t_2 - t_1) + (t_3 - t_4)}{2}$$

$$\text{Round Trip Delay} = (t_2 - t_1) + (t_4 - t_3)$$

NTP can provide a miliseconds range of precision which is good enough for most of enterprise applications.

- Network Time Protocol (NTP) is an Internet protocol for synchronizing the clocks of computer systems over packet network with variable latency.
- The clock frequency is then adjusted to reduce the offset gradually, creating
- Precision 1 - 10 ms. in Internet, (0,5 - 1 ms for LAN ideal conditions)



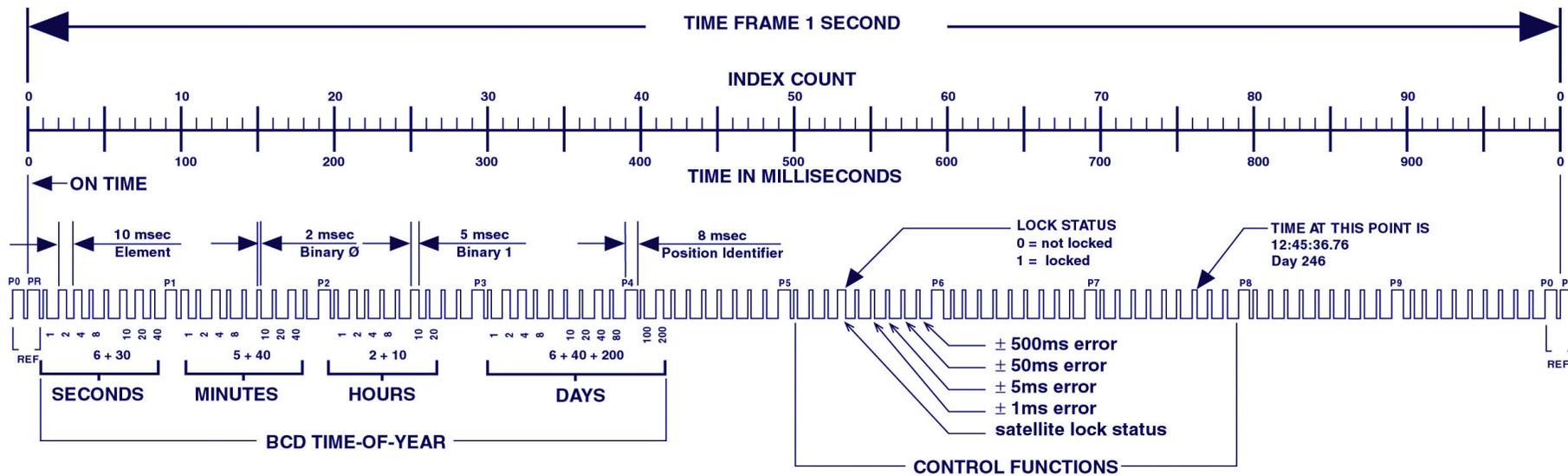
SyncE is not part of the IEC 61850 but is being used in the Power industry

**1. PHY Ethernet**

- Rx gets synchronized using the input line [Tx (port B) >>> Rx (port A)]
- BUT there is no time relation between the Rx and Tx of the same Port

**2. SyncE PHY (physical layer)**

- Rx gets synchronized using the recovered clock
- Tx uses a traceable reference clock



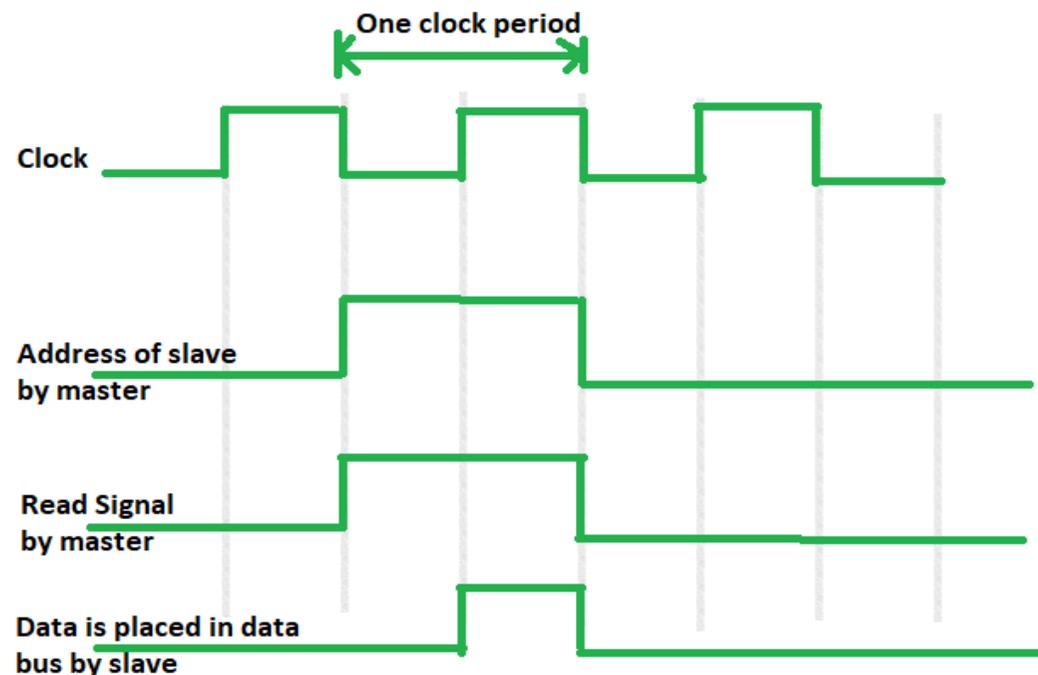
Developed for the US Army (1960) still is widely used:

- Consists of 100 bits generated every second, 74 bits of which contain time information
- Various time, date, time changes and time quality information of the time signal
- IEEE-1344 extension included year data information

## Unmodulated IRIG-B transmission

- TTL-level signal over coaxial cable or shielded twisted-pair cable
- Multi-point distribution using 24 Vdc for signal and control power
- RS-485 differential signal over shielded twisted-pair cable
- RS-232 signal over shielded cable (short distances only)
- Optical fiber





Often known as BITS (Building Integrated Timing Supply) describe a building-centric timing system, the BITS system efficiently manages the number of timing interfaces within a structure providing external timing connections typically deployed as T1 or E1 frequencies but also can refer to MHz and then distributing timing to all circuits that require it.

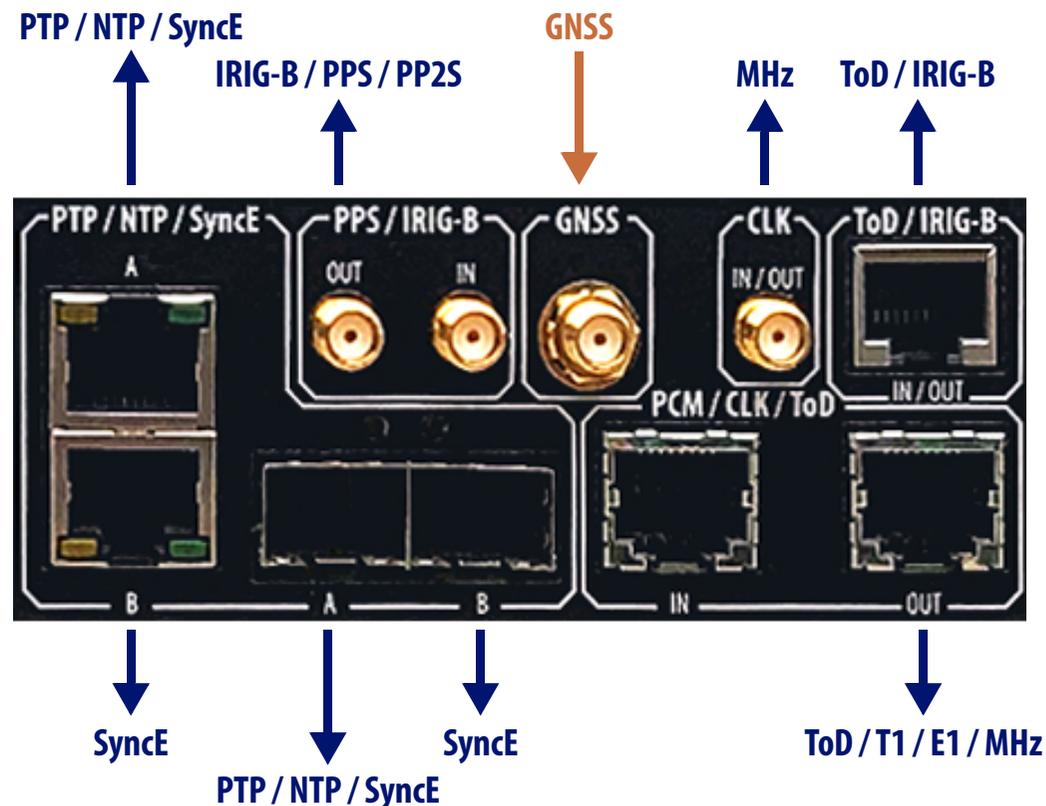
There are several signals suitable for transporting synchronization:

- Analog, of 1,544 and 2,048 kHz
- Digital, of 1,544 and 2,048 kbit/s

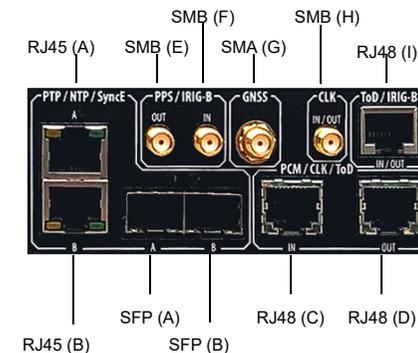
In both cases it is extremely important for the clock signal to be continuous.

## Features

- Built-in GNSS receiver
- Single and Multiple constellation
- Fixed position mode for GNSS references
- Automatic setting of UTC-to-TAI offset
- 4 ~ 5 VDC output
- Cable delay compensation
- Automatic antenna detection



	GNSS	PTP	NTP	ToD	IRIG-B	PPS	PP2S	SyncE	T1/E1	MHz
RJ45 (A)		out	out					in/out		
RJ45 (B)		in	in					in/out		
SPF (A)		out	out					in/out		
SPF (B)		in	in					in/out		
SMB (E)					out	out	out			
SMB (F)					in	in	in			
SMB (H)									in/out	
SMA (G)	in									
RJ48 (I)				in/out	in/out					
RJ48 (C)				in					in	in
RJ48 (D)				out					out	out

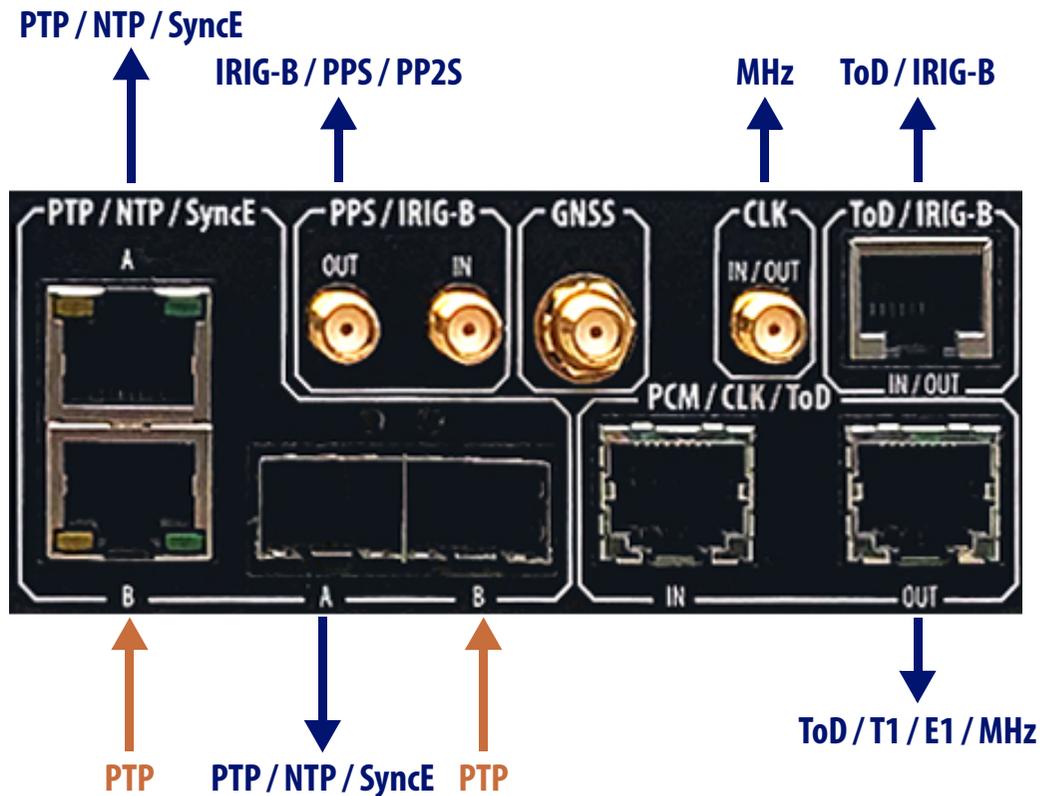


## Ports

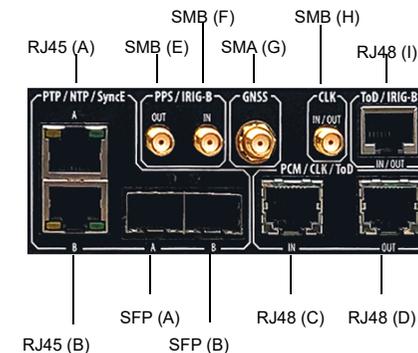
- Port A: PTP master
- Port B: PTP slave
- 256 clients @ 128 packets/sec

## Profiles

- Default profiles
- Telecom frequency profile
- Telecom phase and time profile
- PTS / APTS profile
- Utility Profile



	GNSS	PTP	NTP	ToD	IRIG-B	PPS	PP2S	SyncE	T1/E1	MHz
RJ45 (A)		out	out						in/out	
RJ45 (B)		in	in						in/out	
SPF (A)		out	out						in/out	
SPF (B)		in	in						in/out	
SMB (E)					out	out	out			
SMB (F)					in	in	in			
SMB (H)										in/out
SMA (G)	in									
RJ48 (I)				in/out	in/out					
RJ48 (C)				in					in	in
RJ48 (D)				out					out	out

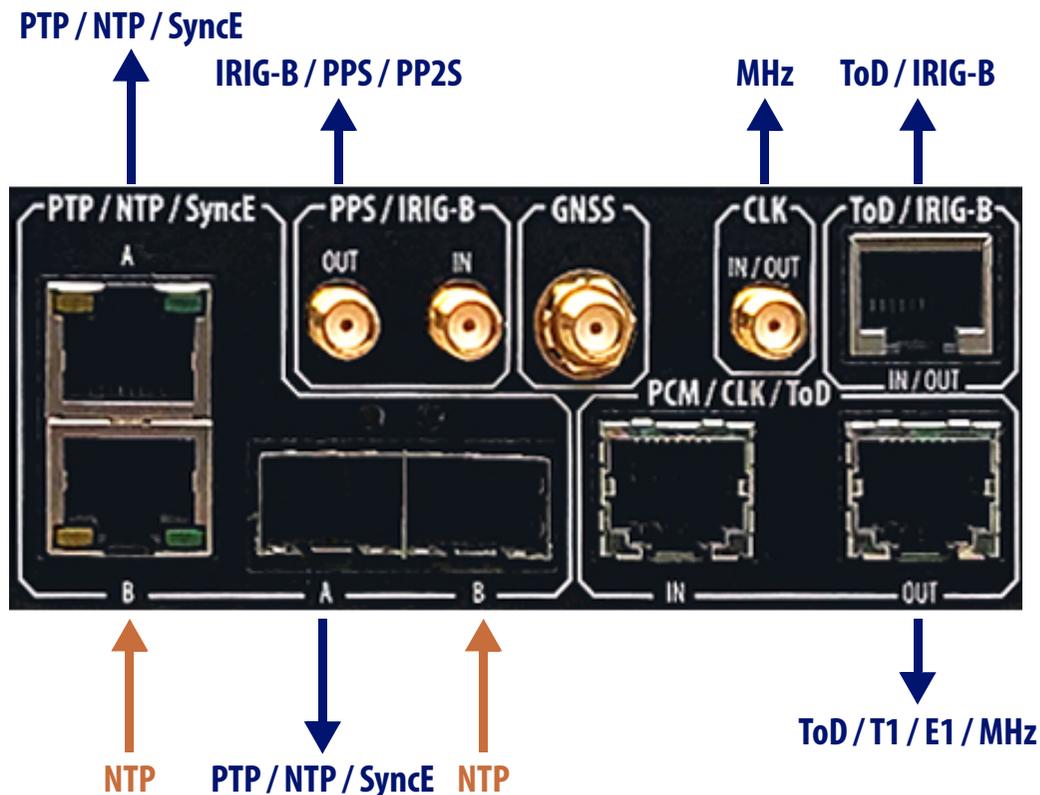


## Ports

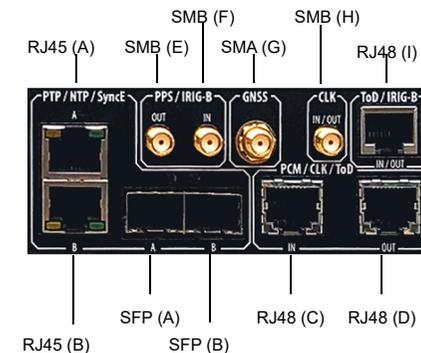
- Port A: NTP master
- Port B: 1000 transactions per second

## NTP versions

- NTPv3 (RFC 1305) master and slave
- NTPv4 (RFC 5905) master and slave
- SNTPv3 (RFC 1769) master

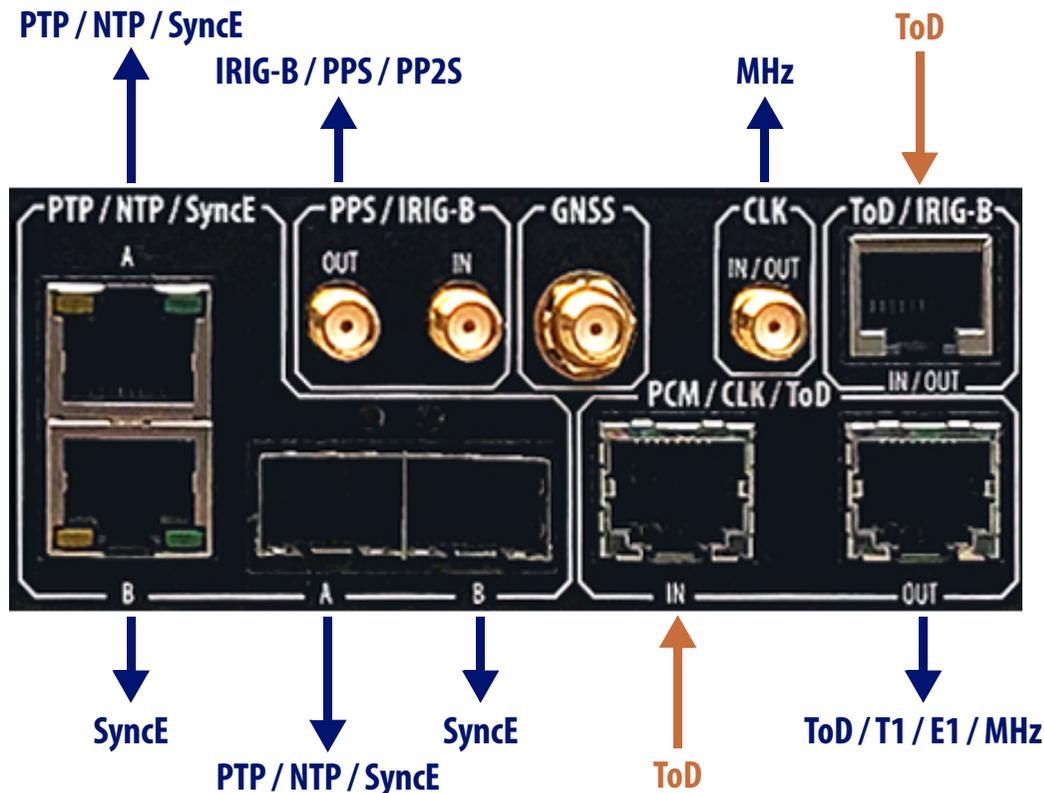


	GNSS	PTP	NTP	ToD	IRIGB	PPS	PP2S	SyncE	T1/E1	MHz
RJ45 (A)		out	out						in/out	
RJ45 (B)		in	in						in/out	
SPF (A)		out	out						in/out	
SPF (B)		in	in						in/out	
SMB (E)					out	out	out			
SMB (F)					in	in	in			
SMB (H)										in/out
SMA (G)	in									
RJ48 (I)				in/out	in/out					
RJ48 (C)				in					in	in
RJ48 (D)				out					out	out

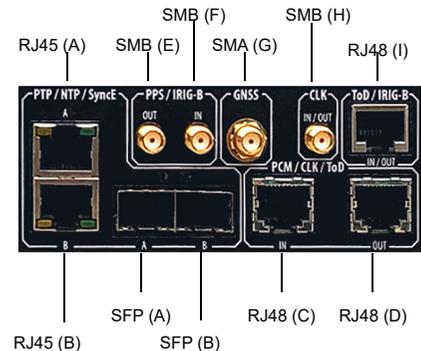


## ToD formats supported

- ITU-T G.8271
- China Mobile
- NMEA



	GNSS	PTP	NTP	ToD	IRIG-B	PPS	PP2S	SyncE	T1/E1	MHz
RJ45 (A)		out	out						in/out	
RJ45 (B)		in	in						in/out	
SPF (A)		out	out						in/out	
SPF (B)		in	in						in/out	
SMB (E)					out	out	out			
SMB (F)					in	in	in			
SMB (H)										in/out
SMA (G)	in									
RJ48 (I)				in/out	in/out					
RJ48 (C)				in					in	in
RJ48 (D)				out					out	out

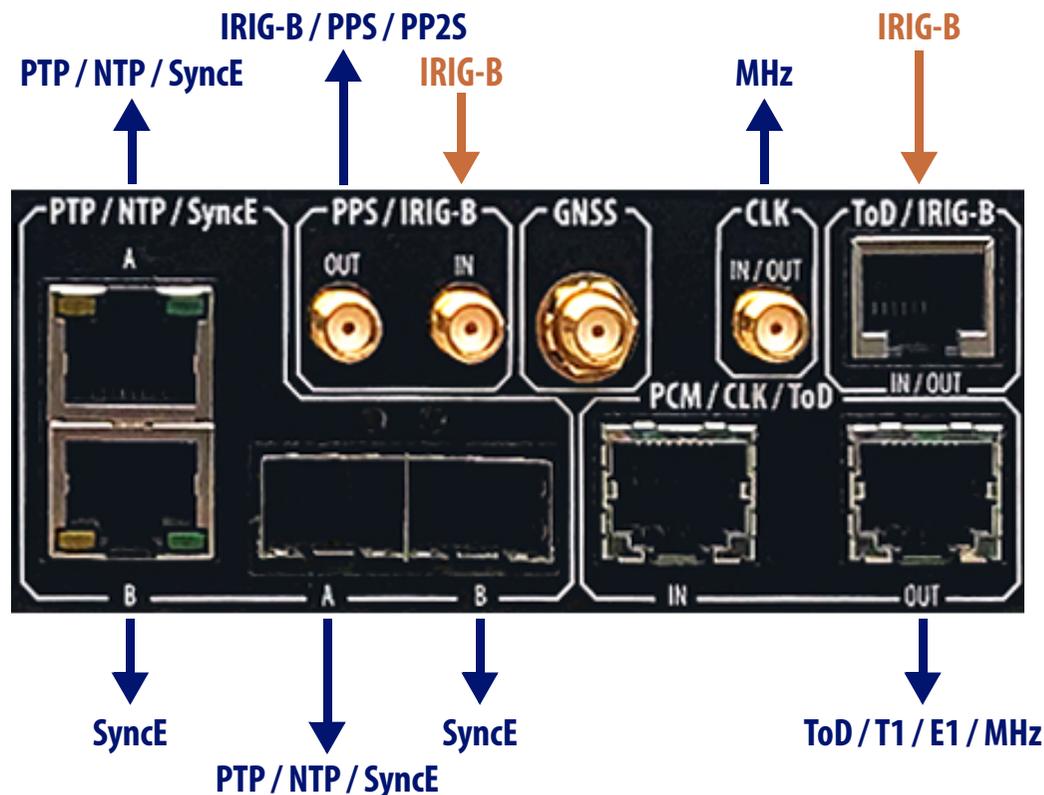


## IRIG-B formats supported

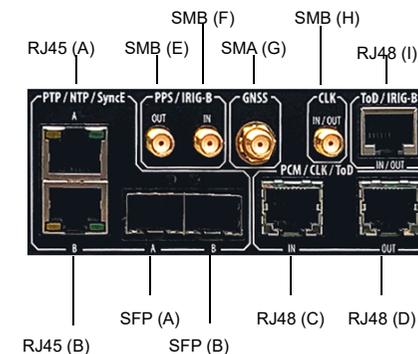
- B00X
- B12X
- B13X
- B14X
- B15X
- B22X

## IRIG-B at the interface

- 5 ~ 10 Vpp
- AC/DC coupling
- Termination 50 W / 600 W / High Z



	GNSS	PTP	NTP	ToD	IRIGB	PPS	PP2S	SyncE	T1/E1	MHz
RJ45 (A)		out	out						in/out	
RJ45 (B)		in	in						in/out	
SPF (A)		out	out						in/out	
SPF (B)		in	in						in/out	
SMB (E)					out	out	out			
SMB (F)					in	in	in			
SMB (H)										in/out
SMA (G)	in									
RJ48 (I)				in/out	in/out					
RJ48 (C)				in					in	in
RJ48 (D)				out					out	out

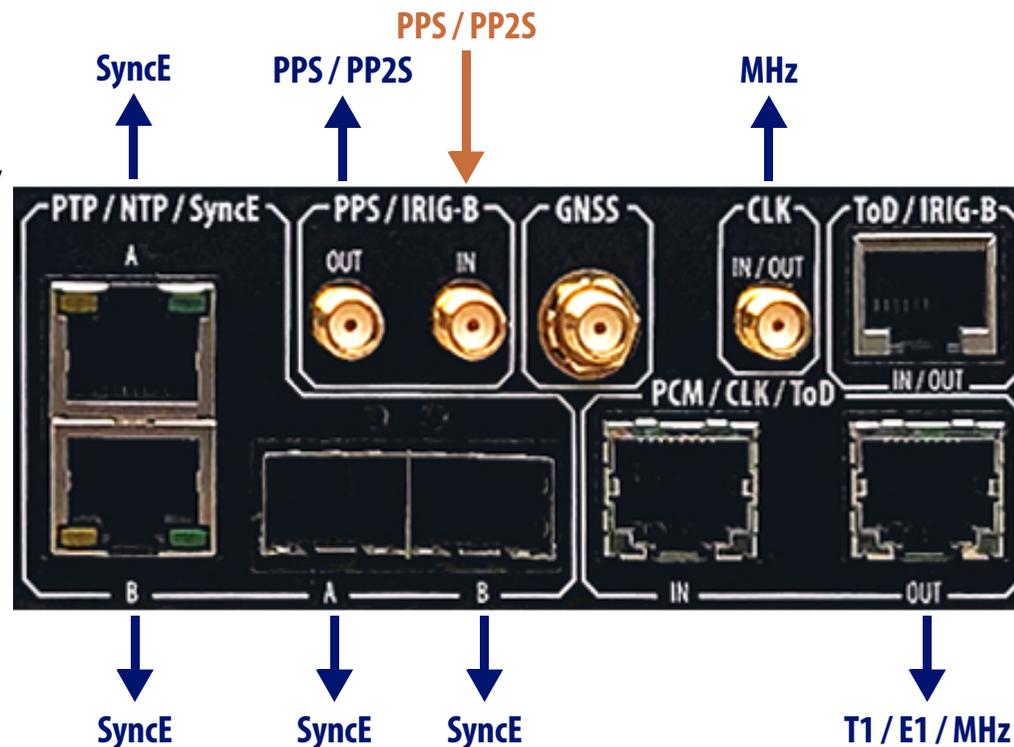


PPS does not have Day information then it can only be reference for Phase and Frequency signals.

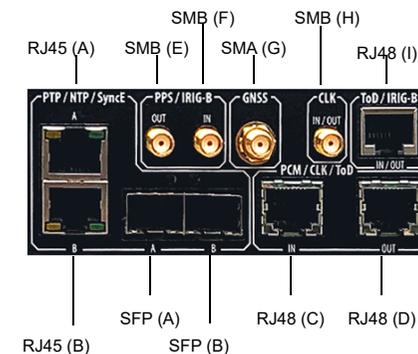
- 1 PPS and 1 PP2S
- Unbalanced SMB 50 W ITU-T G.8271

Can discipline

- 1 PPS and 1 PP2S
- T1/E1
- MHz: 10, 5, 2.048 and 1.544



	GNSS	PTP	NTP	ToD	IRIG-B	PPS	PP2S	SyncE	T1/E1	MHz
RJ45 (A)		out	out						in/out	
RJ45 (B)		in	in						in/out	
SPF (A)		out	out						in/out	
SPF (B)		in	in						in/out	
SMB (E)					out	out	out			
SMB (F)					in	in	in			
SMB (H)										in/out
SMA (G)	in									
RJ48 (I)				in/out	in/out					
RJ48 (C)				in					in	in
RJ48 (D)				out					out	out



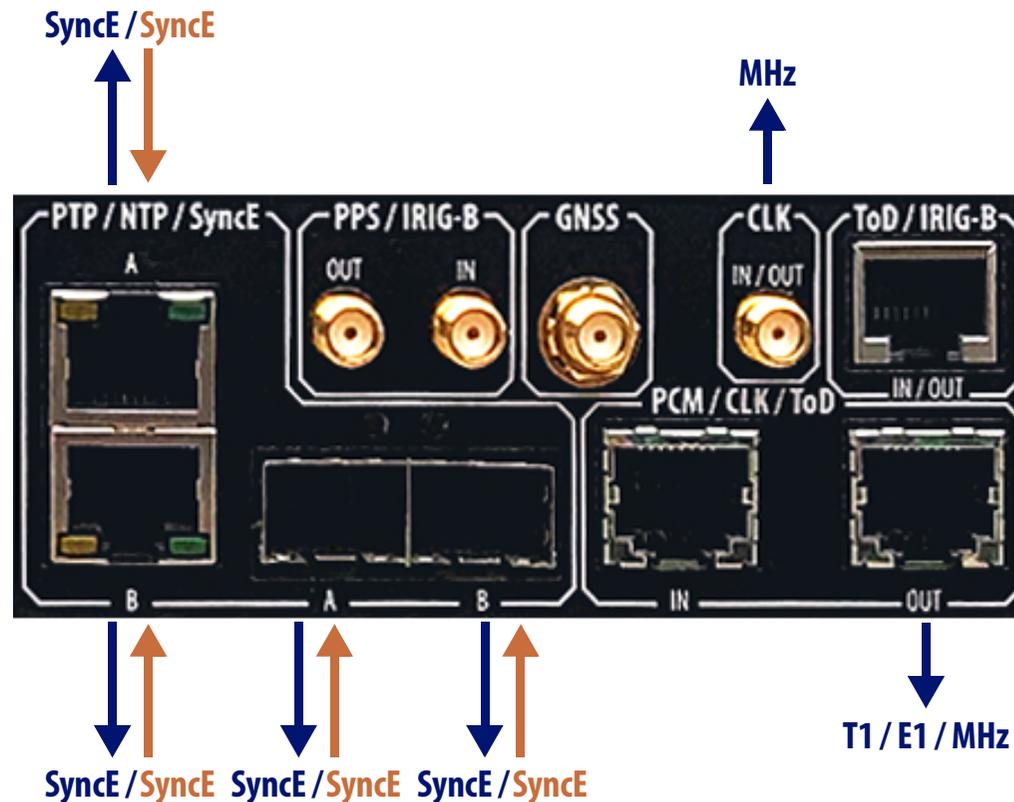
SyncE is only a Frequency reference therefore can only discipline Frequency signals.

### SyncE features

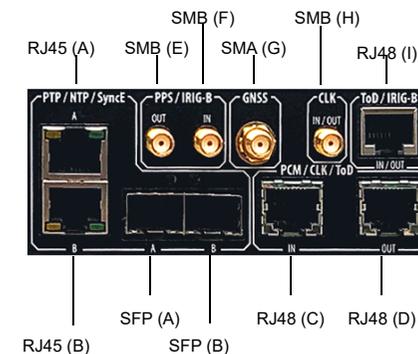
- Built-in GNSS receiver
- Single and Multiple constellation
- Fixed position mode for GNSS references
- Automatic setting of UTC-to-TAI offset
- 4 ~ 5 VDC output
- Cable delay compensation
- Automatic antenna detection

Can discipline

- SyncE
- T1/E1
- MHz: 10, 5, 2.048 and 1.544 MHz



	GNSS	PTP	NTP	ToD	IRIGB	PPS	PP2S	SyncE	T1/E1	MHz
RJ45 (A)		out	out						in/out	
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SPF (A)		out	out						in/out	
SPF (B)		in	in						in/out	
SMB (E)					out	out	out			
SMB (F)					in	in	in			
SMB (H)										in/out
SMA (G)	in									
RJ48 (I)				in/out	in/out					
RJ48 (C)				in					in	in
RJ48 (D)				out					out	out



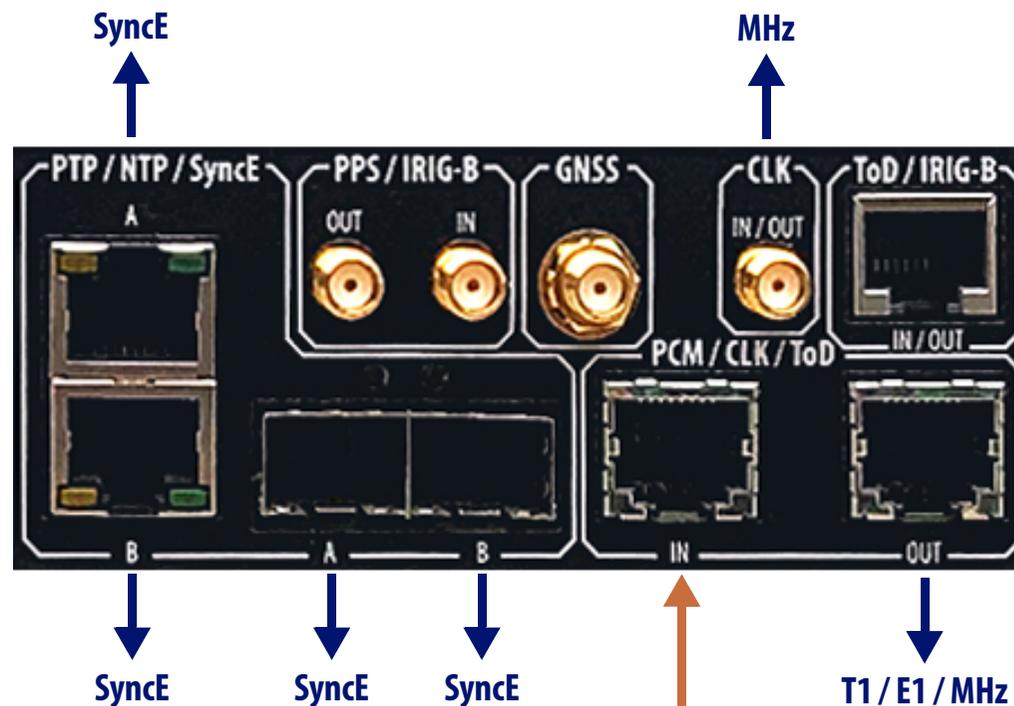
E1/T1 are only a Frequency references therefore can only discipline Frequency signals.

### Rates

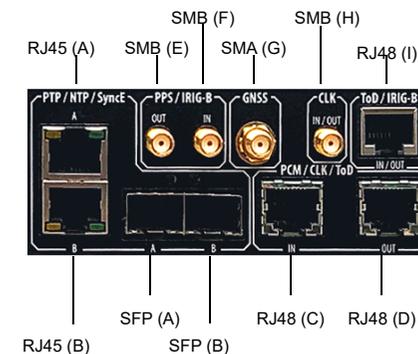
- 1544 Mb/s
- 2048 Mb/s

Can discipline

- SyncE
- T1/E1
- MHz: 10, 5, 2.048 and 1.544 MHz



	GNSS	PTP	NTP	ToD	IRIG-B	PPS	PP2S	SyncE	T1/E1	MHz
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RJ45 (B)		in	in						in/out	
SPF (A)		out	out						in/out	
SPF (B)		in	in						in/out	
SMB (E)					out	out	out			
SMB (F)					in	in	in			
SMB (H)										in/out
SMA (G)	in									
RJ48 (I)				in/out	in/out					
RJ48 (C)				in					in	in
RJ48 (D)				out					out	out



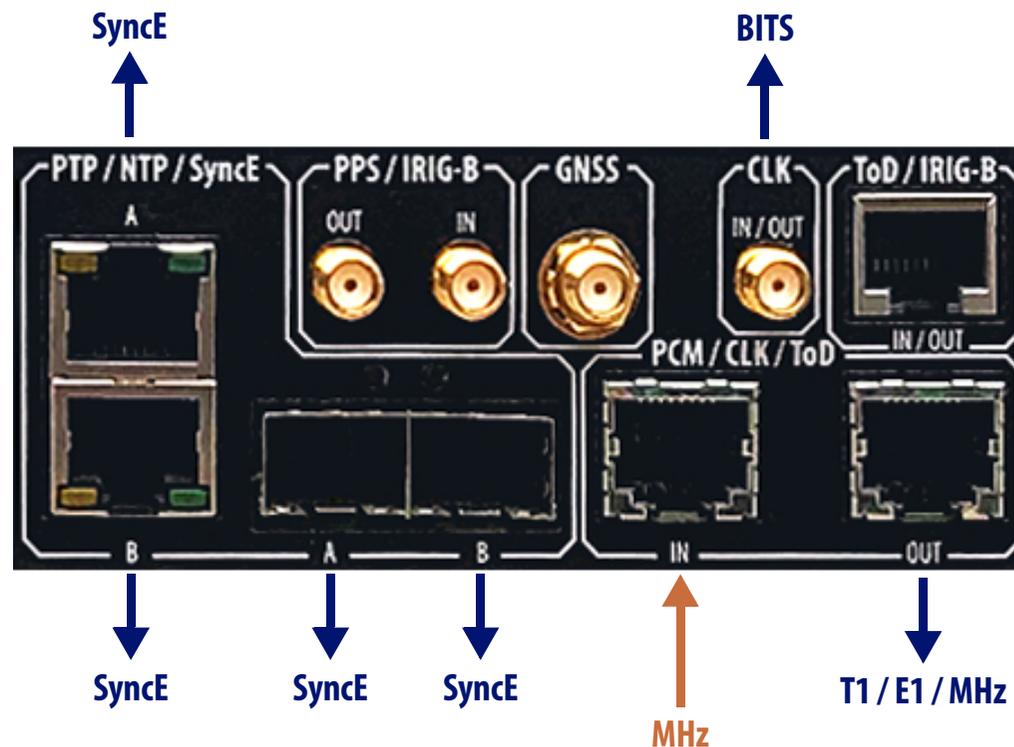
E1/T1 are only a Frequency references therefore can only discipline Frequency signals.

### Rates

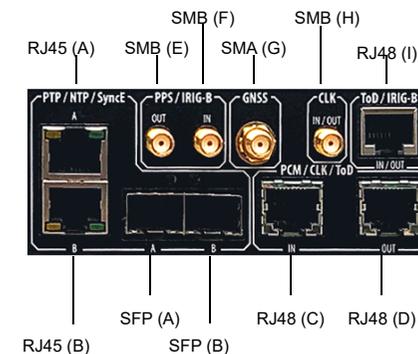
- 1544 kHz
- 2048 kHz
- 5 MHz
- 10 MHz

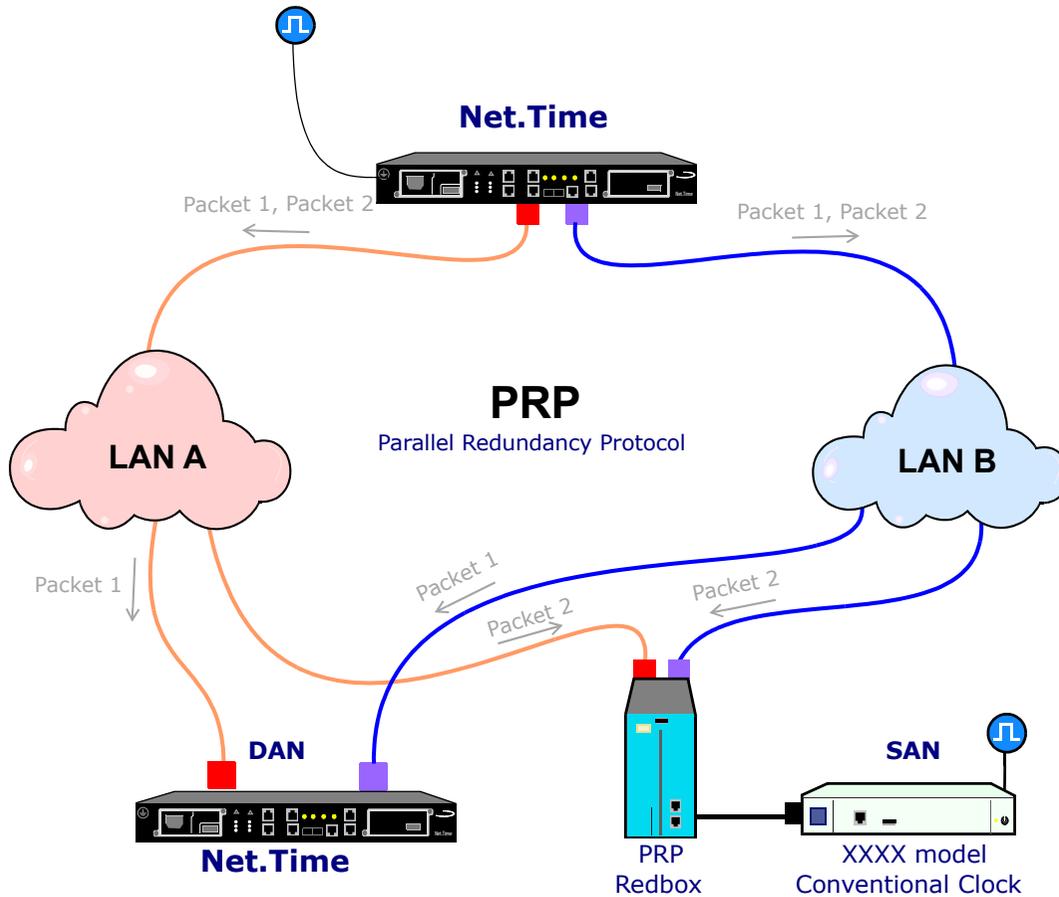
Can discipline

- SyncE
- T1/E1
- MHz: 10, 5, 2.048 and 1.544 MHz



	GNSS	PTP	NTP	ToD	IRIG-B	PPS	PP2S	SyncE	T1/E1	MHz
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RJ45 (B)		in	in						in/out	
SPF (A)		out	out						in/out	
SPF (B)		in	in						in/out	
SMB (E)					out	out	out			
SMB (F)					in	in	in			
SMB (H)										in/out
SMA (G)	in									
RJ48 (I)				in/out	in/out					
RJ48 (C)				in					in	in
RJ48 (D)				out					out	out



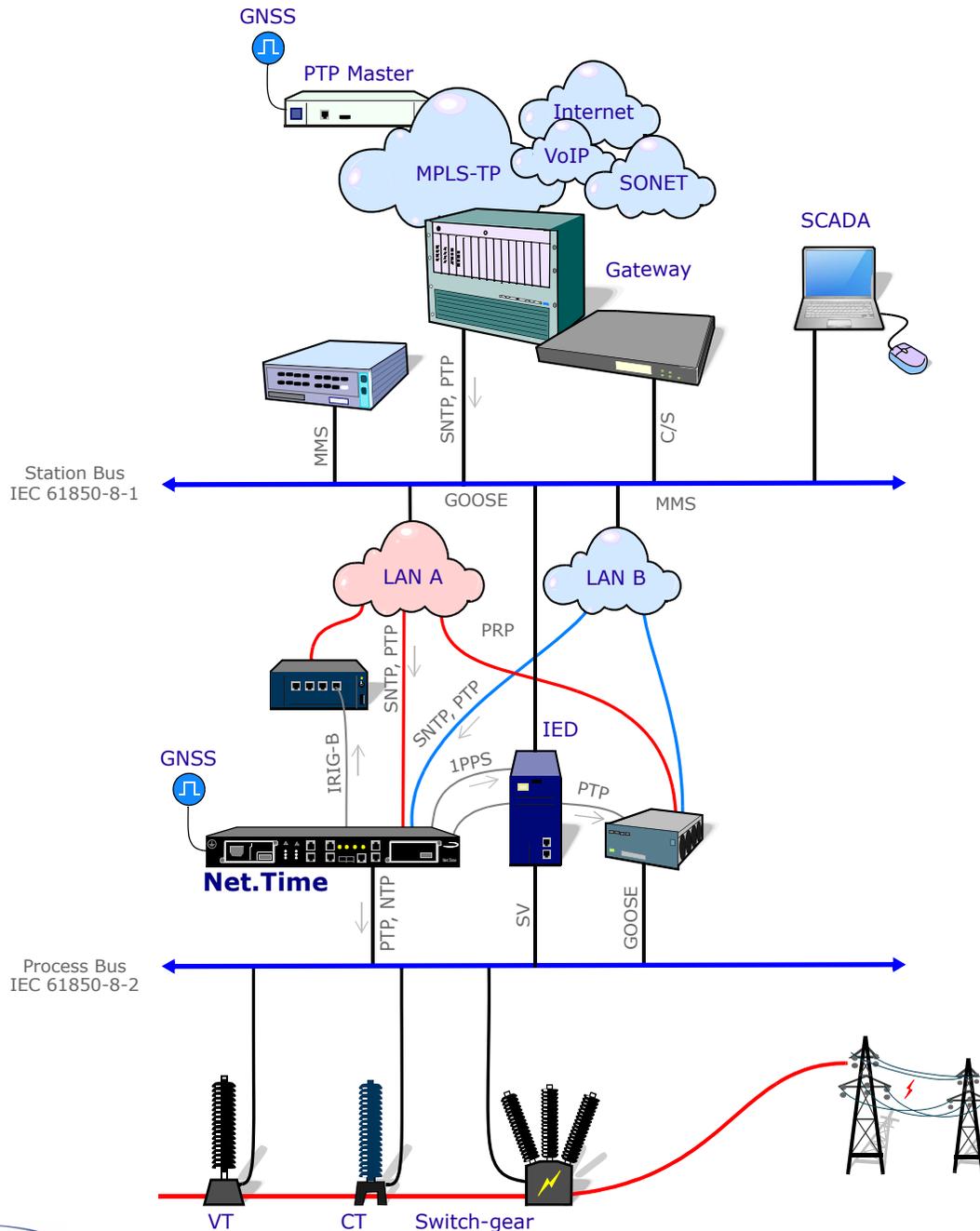


PRP is based on the use of two independent networks. The sender **must send each packet twice** (to LAN A and LAN B) through two separate ports. There are two types of devices:

- **DAN** (Double Attached Node) if has PRP support is integrated, can be attached directly
- **SAN** (Single Attached Node) conventional device without PRP support a Redundancy Box (redbox) is required to be connected.

### PRP in Net.Time

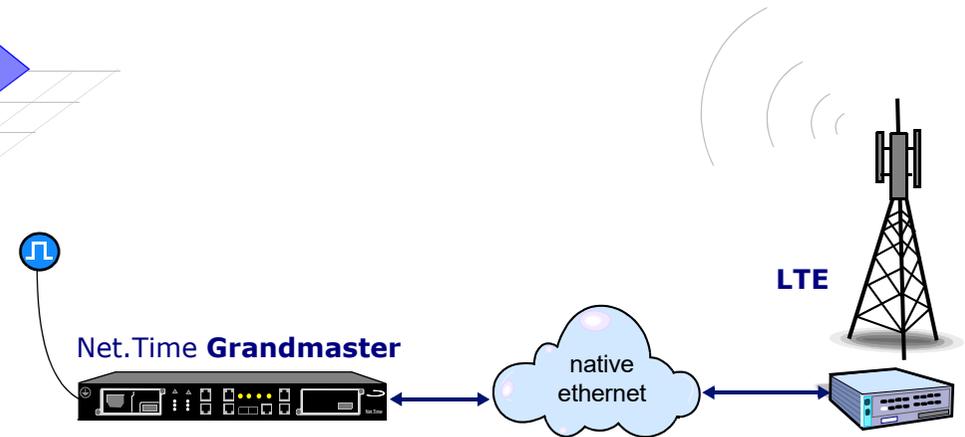
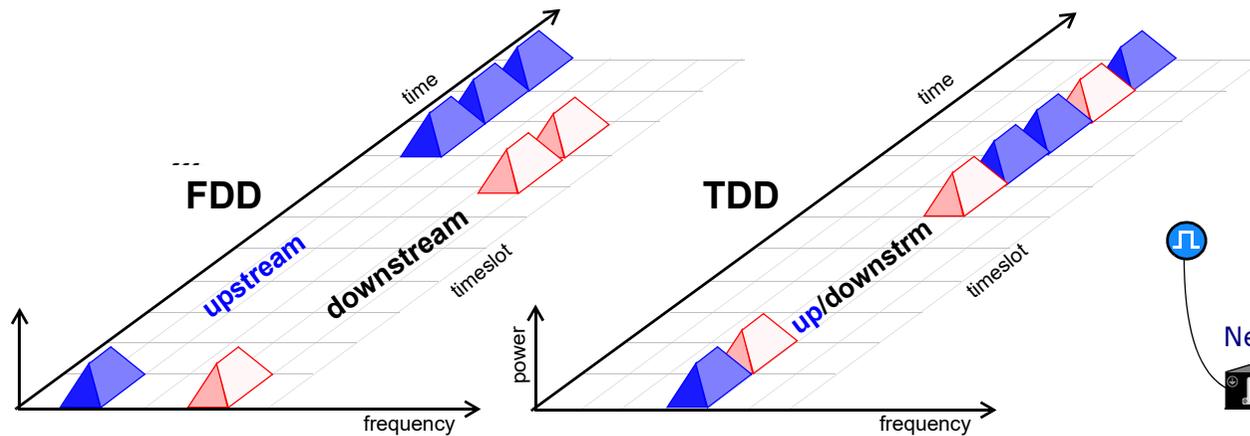
- PRP extension for IEEE 1588 / IEC 61588
- Link Redundancy Entity (LRE) IEC 62439-3
- Generation of RCT trailers
- Duplicate discard mode
- PRP supervision frame generation / decoding



Network redundancy is crucial for maintaining **high network availability**, and many redundancy technologies can provide millisecond-level recovery. However, some mission-critical and time-sensitive applications **cannot tolerate even a millisecond** of network interruption without severely affecting operations or jeopardizing the safety of on-site personnel.

Parallel Redundancy Protocol (**PRP**) provide **seamless fail-over** from a single point of failure. PRP realizes active network redundancy by packet duplication over two independent networks that operate in parallel.

Based on these two seamless redundancy protocols, a redundancy box (**Redbox**) can quickly activate non-HSR or non-PRP devices connected to HSR or PRP networks with zero switch-over time.



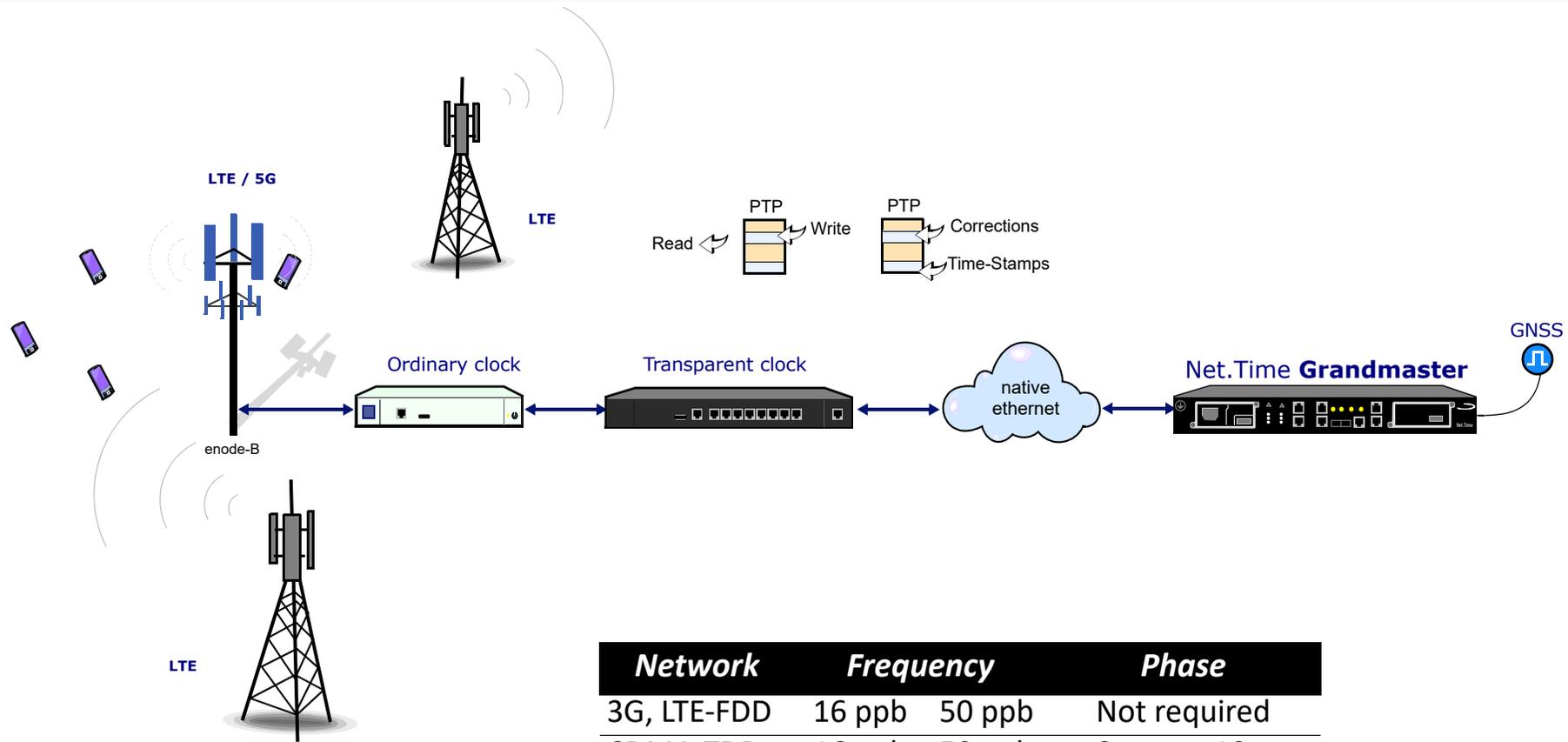
## Time synchronization with Net.Time

In 5G duplexing upstream and downstream use separate frequencies, in TDD upstream and downstream share the same frequency. FDD requires only syntonization while TDD is more and efficient on the use of the available bandwidth but requires Frequency and Phase Synchronization which is also know as Time synchronization.

LTE-FDD (Frequency Division Duplex) timing requirements were similar to GSM and 3G. Only required a frequency reference. However new 5G networks are very demanding on frequency and phase requirement, particularly those architectures that consider small cells, where the frequency reutilization is a key factor of performance.

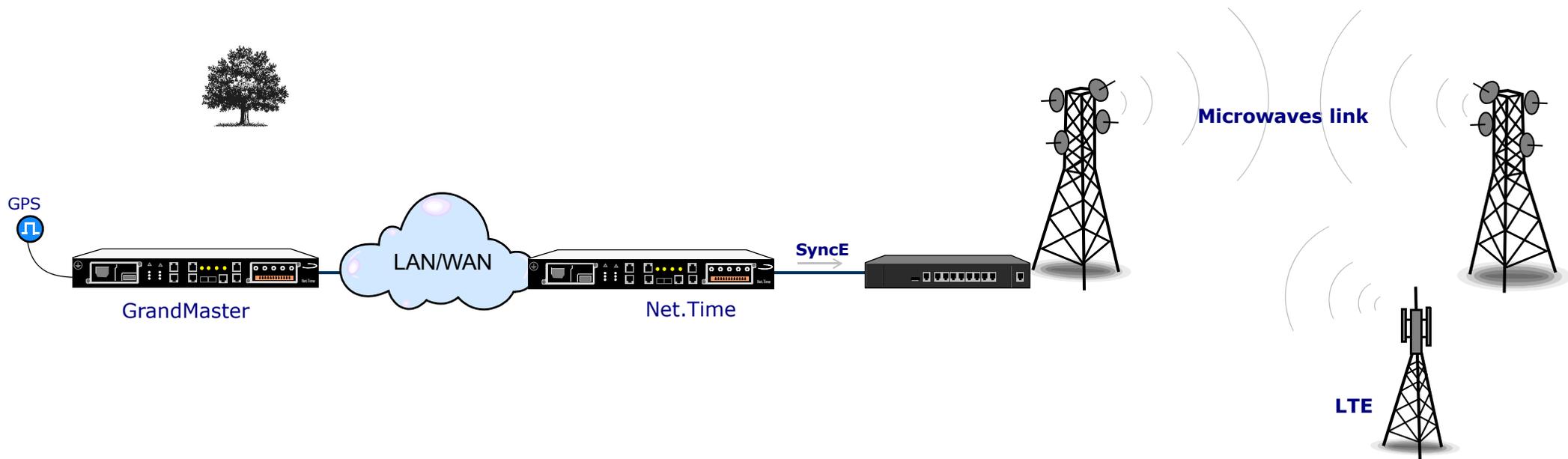
Net.Time signals:

- PTP, NTP, IRIG-B, ToD
- Providing Day+Phase+Frequency



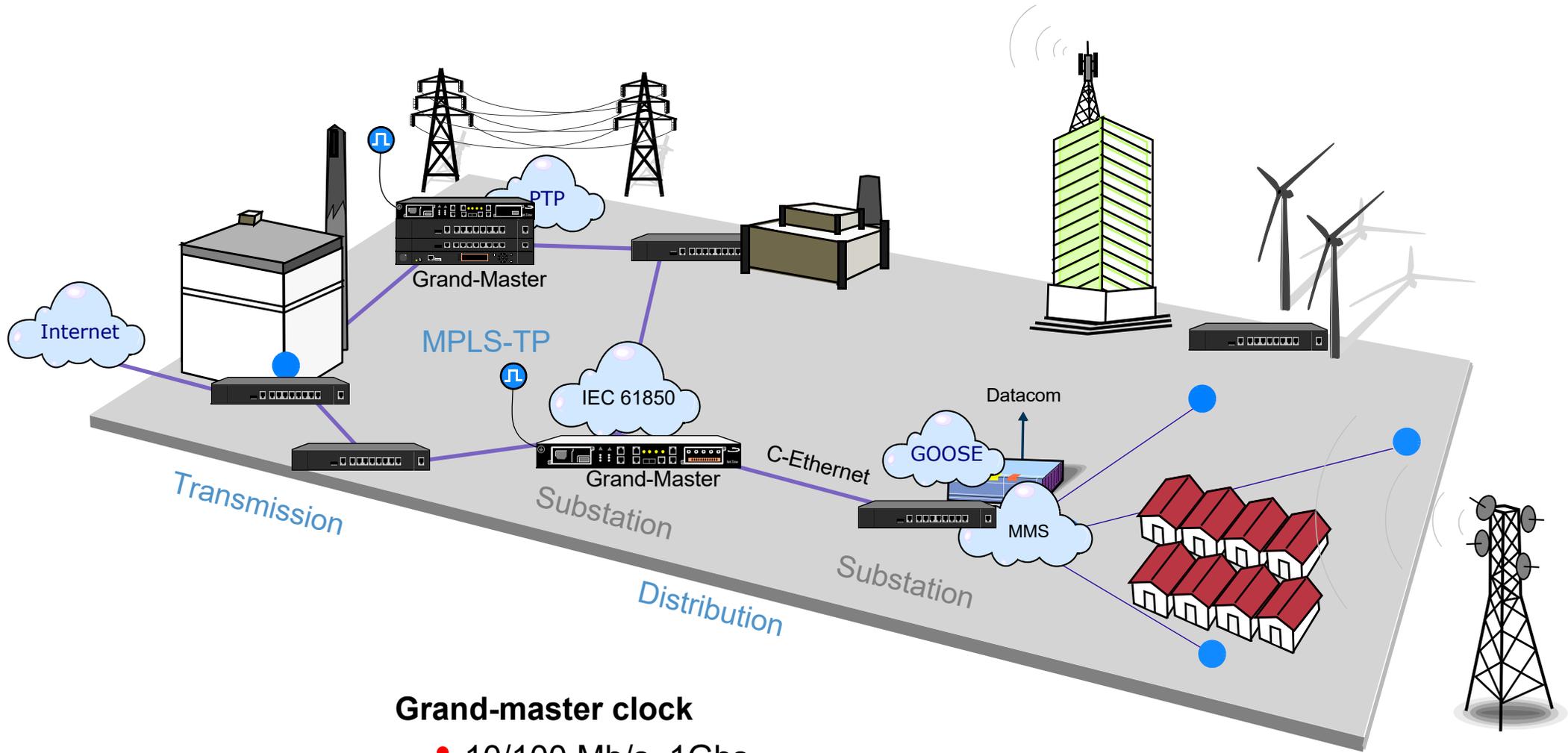
Network	Frequency	Phase
3G, LTE-FDD	16 ppb 50 ppb	Not required
CDMA-TDD	16 ppb 50 ppb	$\pm 3 \mu s$ to $\pm 10 \mu s$
LTE-TDD	16 ppb 50 ppb	$\pm 1 \mu s$ to $\pm 5 \mu s$
5G	16 ppb 50 ppb	$\pm 0.5 \mu s$ to $\pm 5 \mu s$

Frequency & Phase requirements of wireless networks.



Net.Time supports Synchronous Ethernet over a copper and optical connections. This allows operators to utilize cables on SFP ports and still meet timing and synchronization requirements for demanding applications like LTE in mobile networks and microwaves links.

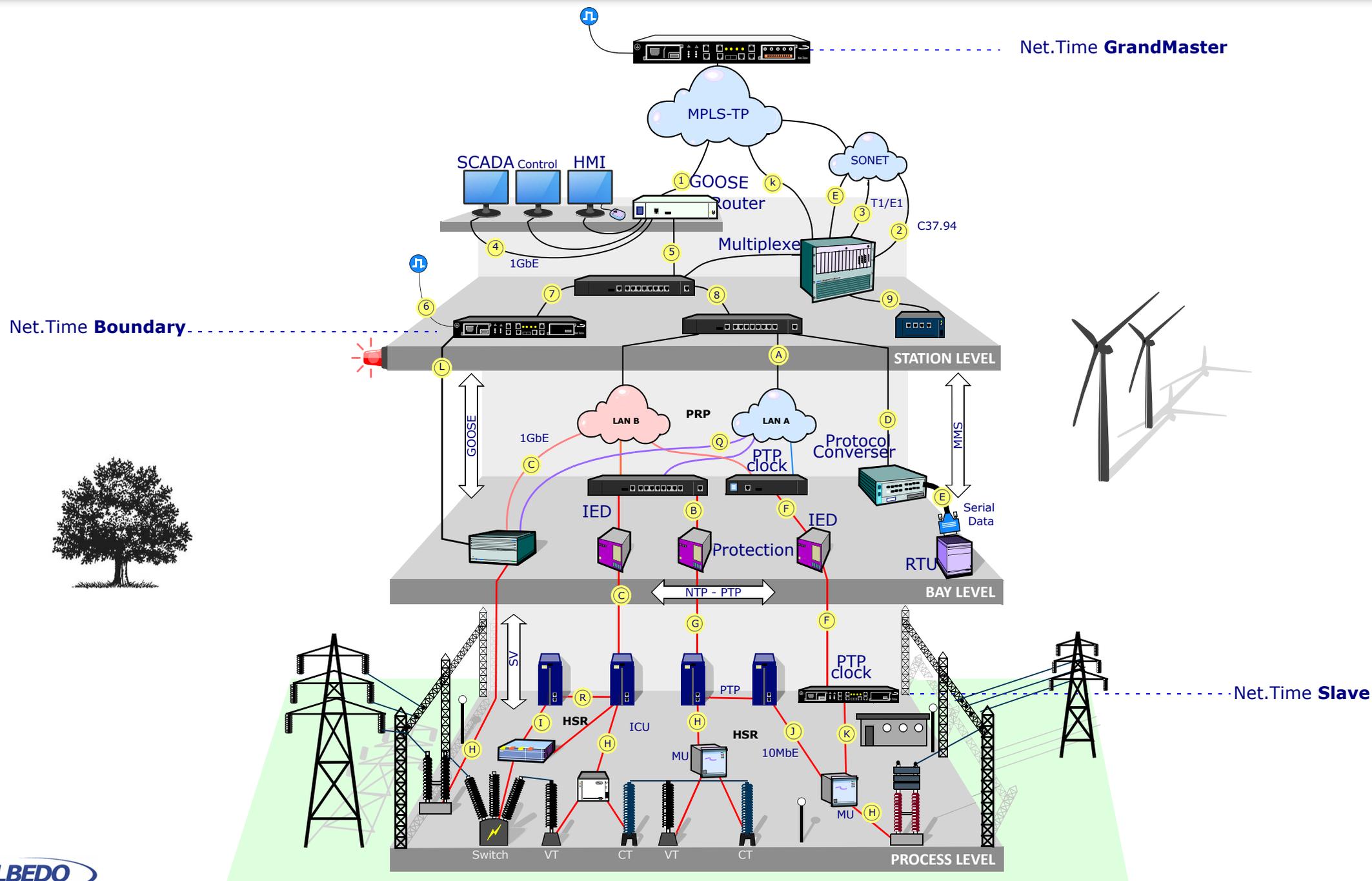
- Interfaces: RJ45 and SFP
- SyncE input/output
- Full ESMC / SSM support as per ITU-T G.8264 and G.781
- Heart-beat and event SSM messages
- QL to be transported by the SSM

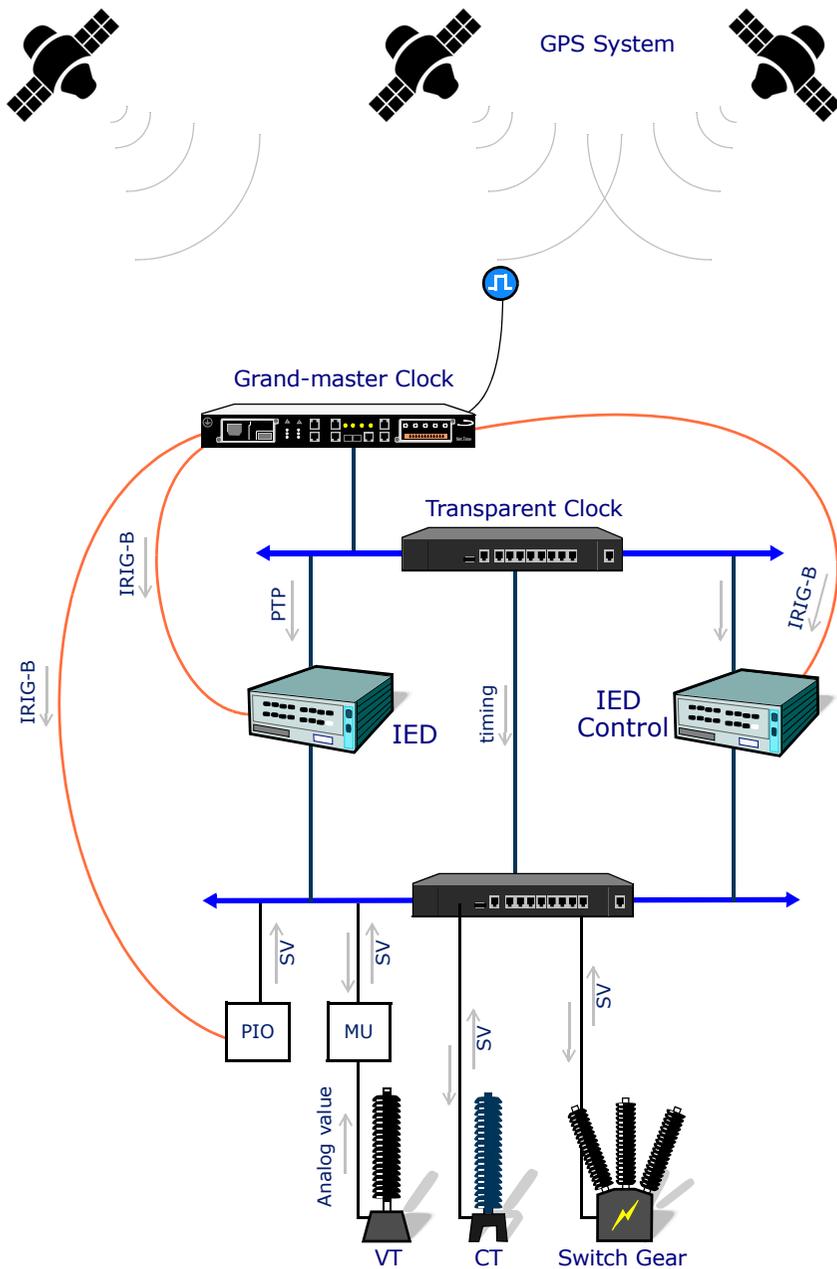


### Grand-master clock

- 10/100 Mb/s, 1Gbs
- Stand-alone GNSS clock
- Boundary clock

# Grandmaster / Boundary / Slave

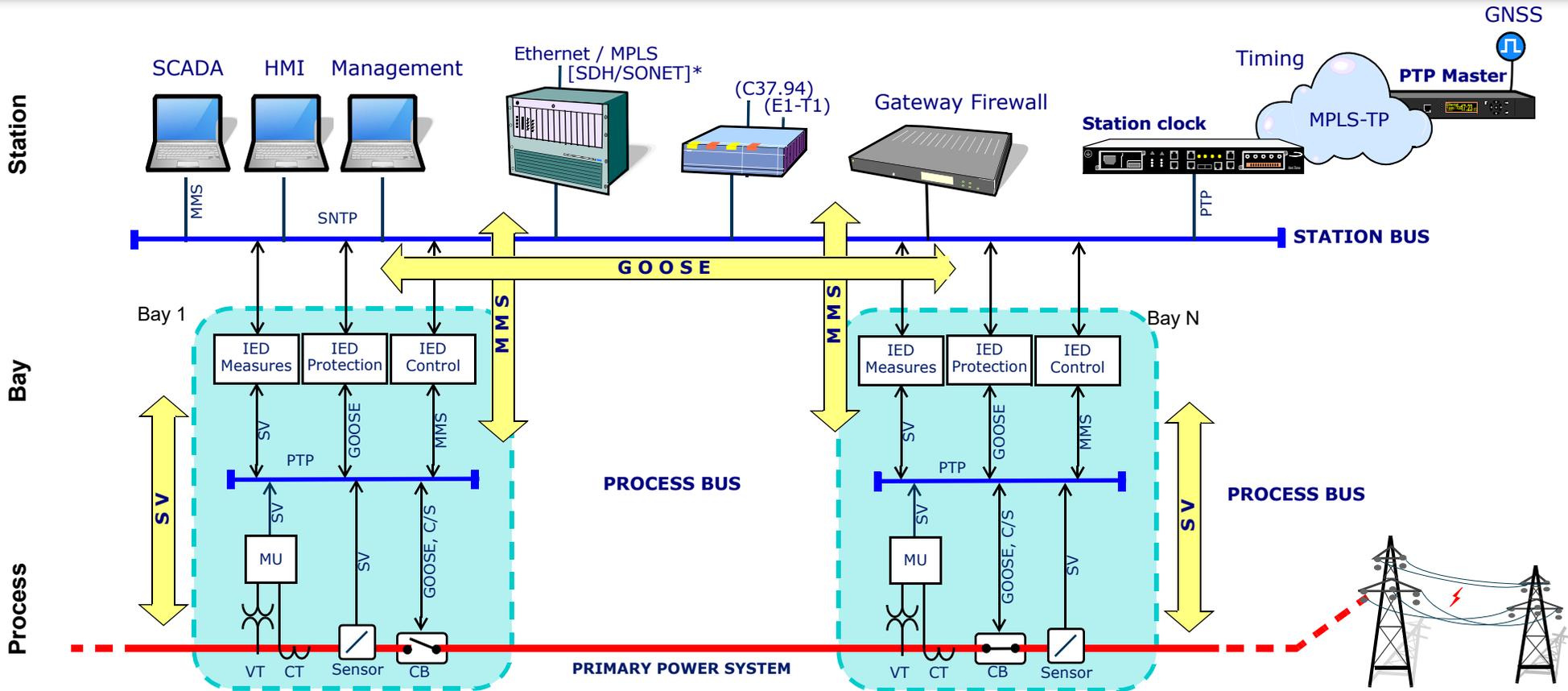




Many Utilities acquire timing from GNSS and the station clock converts signal into a 1-pps or IRIG-B code, which are then distributed by dedicated links to all the IEDs in a substation. However, important to say that this system has some **weaknesses** (\*) being **vulnerable** to human and natural disruptions that may perturb normal operations by raising false alarms, delaying actions, and lowering system efficiency.

GPS is a good back-up, nevertheless modern substations should avoid the use of GPS as primary time reference for critical applications because time integrity cannot be assured. The alternative is PTP because it also provides frequency and phase timing and it has the required security to deliver synchronization in a reliable way for applications such as automation, wide-area monitoring, protection, and real-time control.

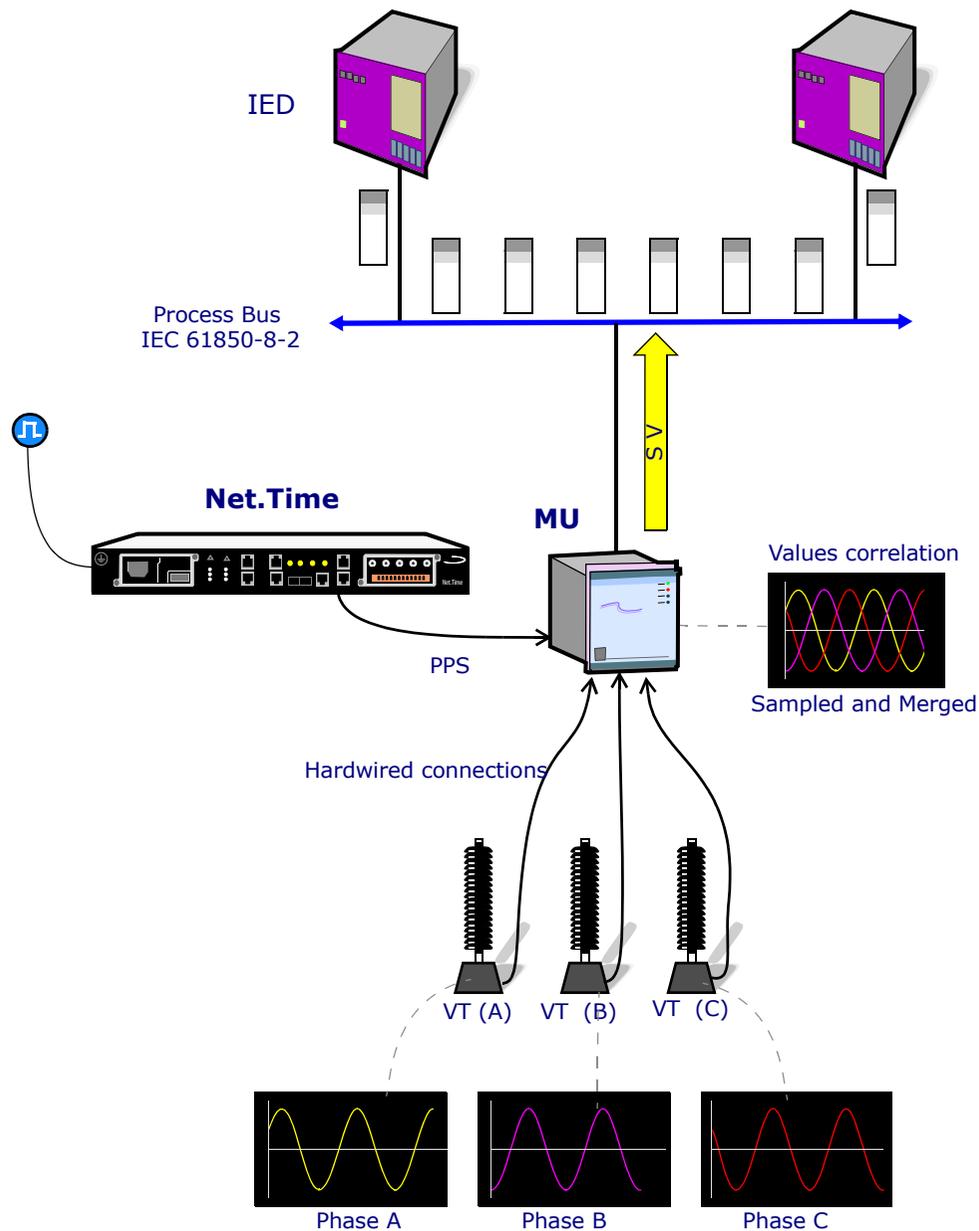
(\*) Problems are produced by interferences and installation faults cause significant concerns about the reliability of satellite timing. Common issues include storms, satellite decommissioning, poor antenna installations, receiver failures, terrestrial or spacial interferences, and malicious spoofing that may send false timing to receivers that in some extreme cases, this could cause operational problems for the electric grid.



IEDs require accurate synchronization, unfortunately SNTP does not satisfy the needs of all applications.

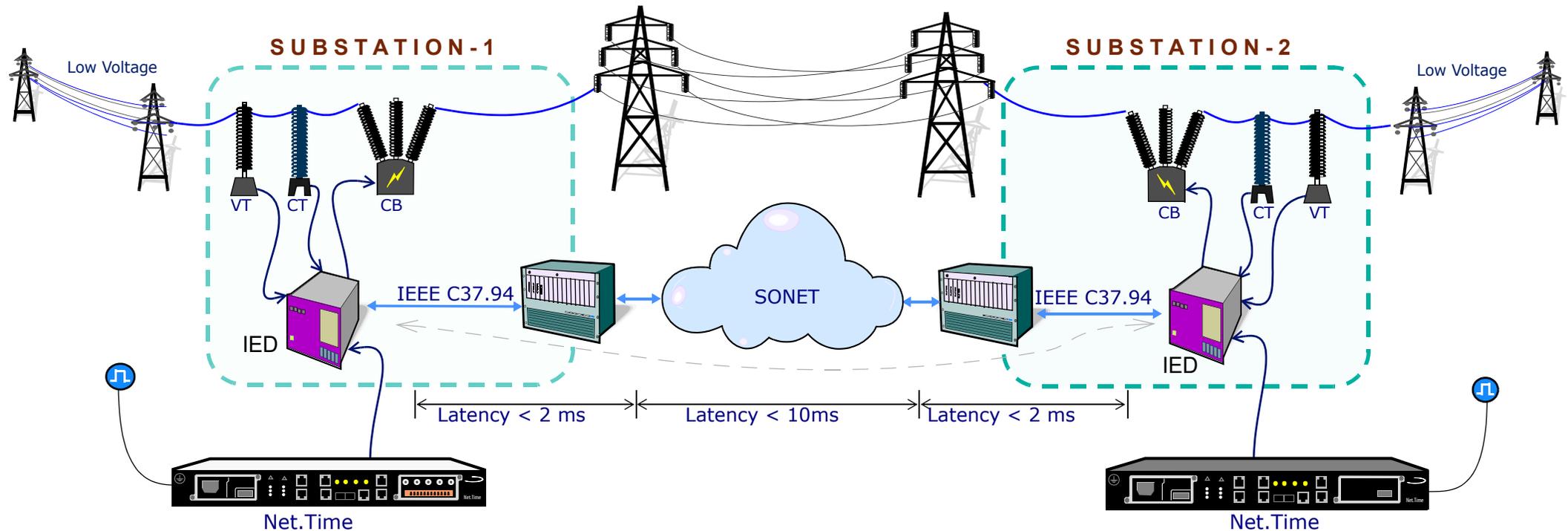
Precision Time Protocol (IEEE 1588) with **Power Profile** defined in IEEE C37.238 address the requirements of the power industry in terms of accuracy, continuous operation (24/7) and deterministic failure behavior.

Application	Accuracy	Timing
PMU	1 $\mu$ s	Absolute
Protection	1 $\mu$ s	Relative
SV	1 $\mu$ s	Relative
SCADA	1 ms	Absolute



Merging Units (MU) require **Phase Synchronization**. MU digitize analog measurements of current / voltage.

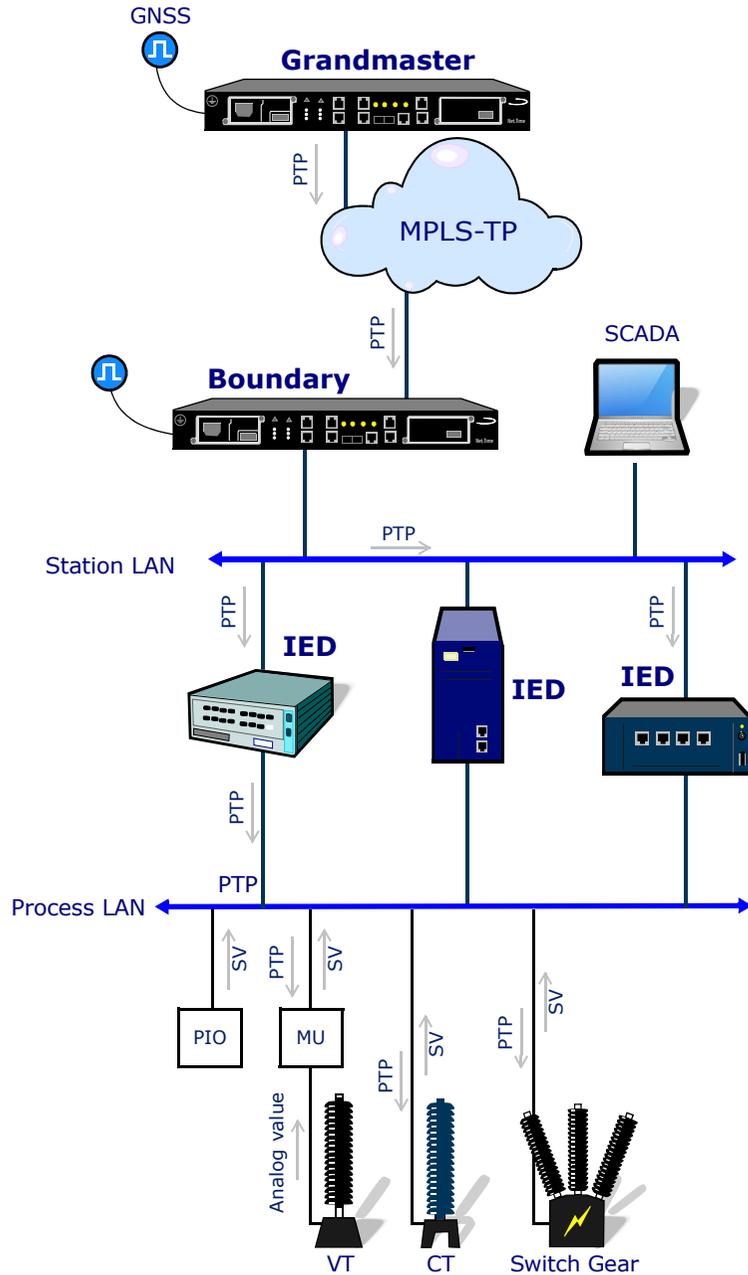
- MUs combine and perform time correlation of voltages and currents of the three phases of a line.
- Connections from CT / VT to MU are usually hardwired.
- The data is published in the form of sampled values (SV) that can be used directly by bay IEC and controllers and/or protection relays that support this protocol.



Tele-protection: protection schemes aided by tele-communications

Tele-protection relays on communicate between substations to isolate faults of the electrical plant. The reliability of the links is critical and must be resilient to the effects encountered in high voltage areas such as high frequency induction and ground potential rise.

Phase synchronization is required to prevent overloads and facilitate reconnections.

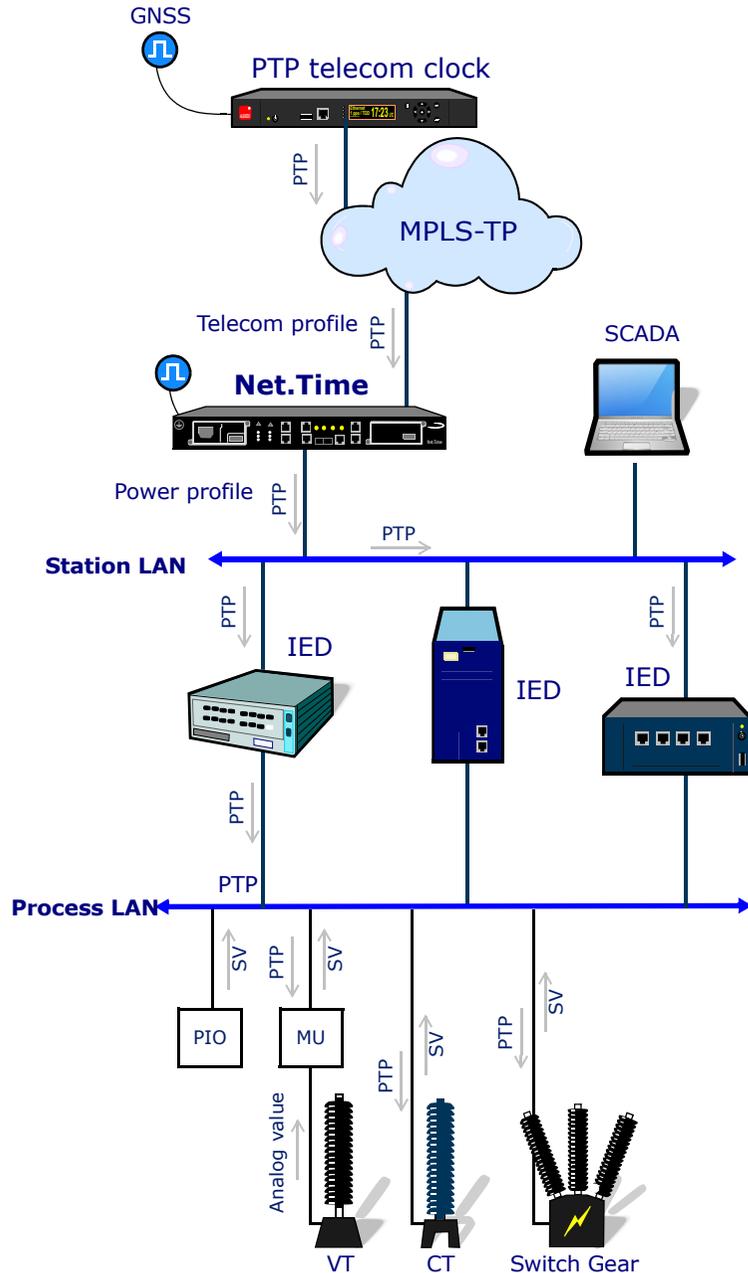


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PMU	1 $\mu$ s	Absolute
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SCADA	1 ms	Absolute

**Phasor Measurement Units (PMU)** are not part of the IEC 61580 but the C37.1188 standard. PMUs are deployed across the grid for analyzing the quality of the power service by measuring magnitudes such as phase angle, line voltage and current waveforms in real-time. Values are collected at 30 to 120 samples/s, time-stamped with UTC and sent to data servers. Information is processed comparing many different points to know the situation, to load balance and to prevent faults. Synchrophasors have indeed timing needs due to high-frequency reporting, the wide geographic distribution and the large number of PMUs.



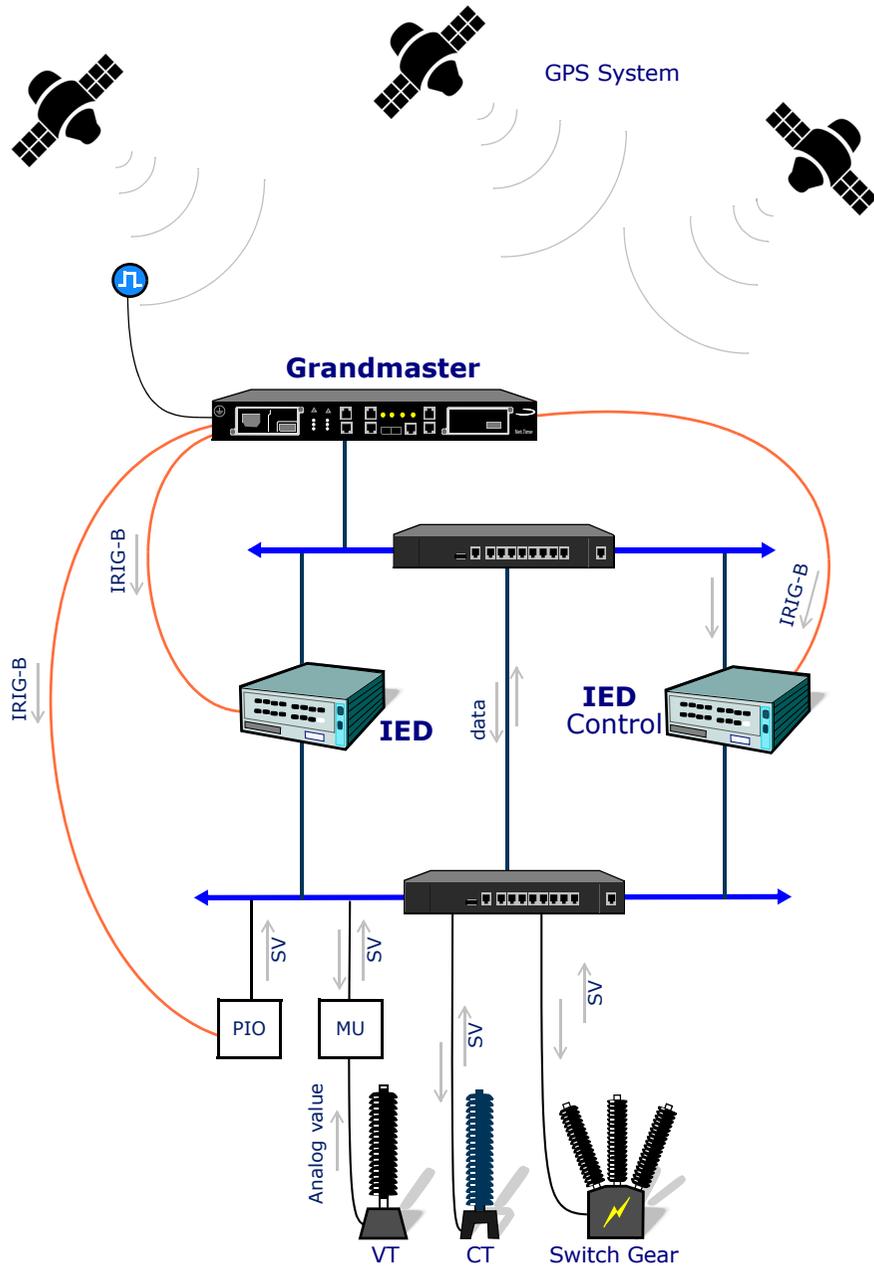
Net.Time supports the following PTP profiles

- Default
- Telecom
- Power
- Utility

Then it is possible to interconnect networks using different synchronization profiles:

- Telecom to Power
- Telecom to Utility
- Power to Telecom
- Power to Utility
- Utility to Telecom

ADVANTAGE: no need for protocol translator



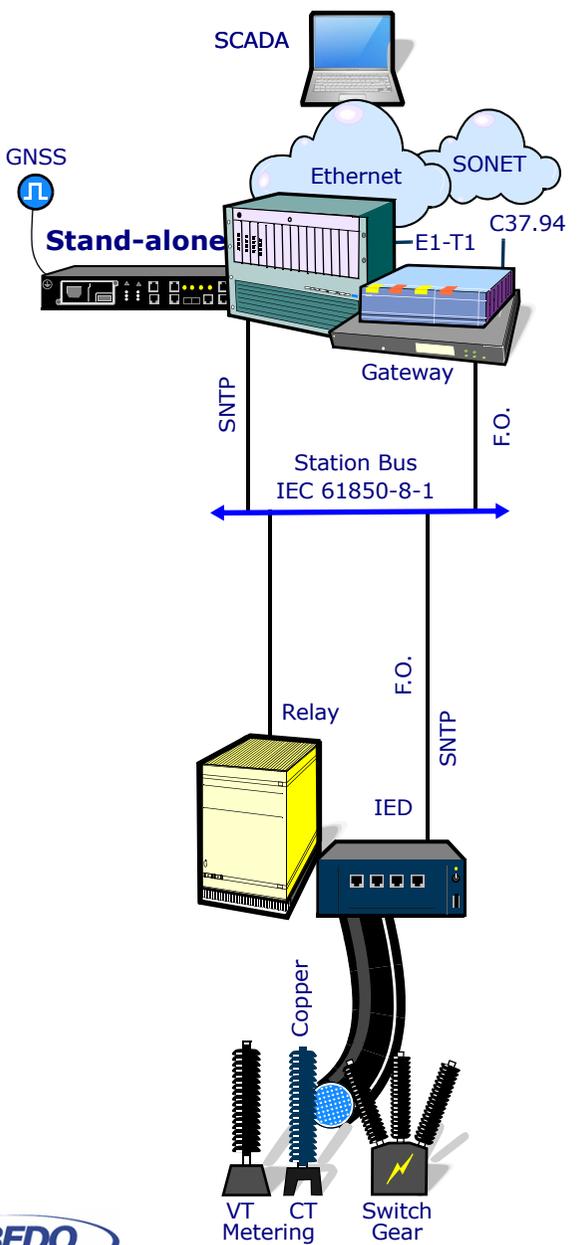
A veteran on duty

Developed for the US Army (1960) is still widely used in the power and in the aerospace industries:

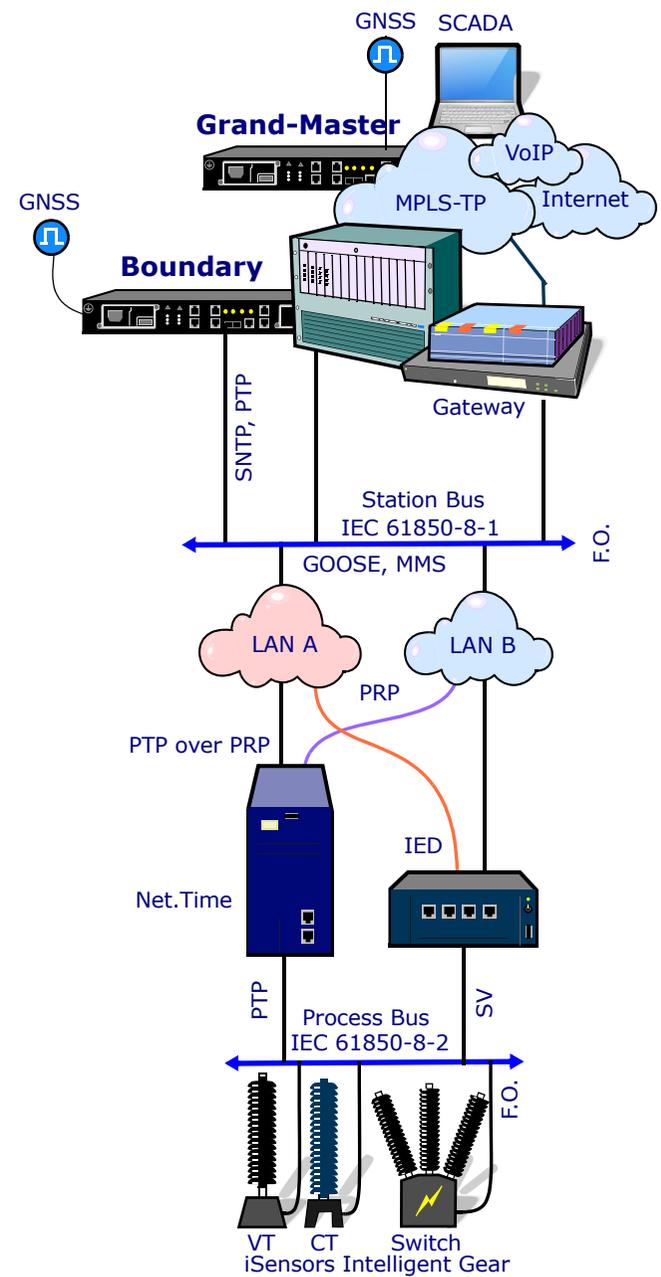
- Consists of 100 bits generated every second, 74 bits of which contain time information
- Various time, date, time changes and time quality information of the time signal
- IEEE-1344 extension included year data information

Net.Time supports IRIG-B as a synchronization signal and as a time reference as well.

### Conventional Substation



### IEC 61850 Substation

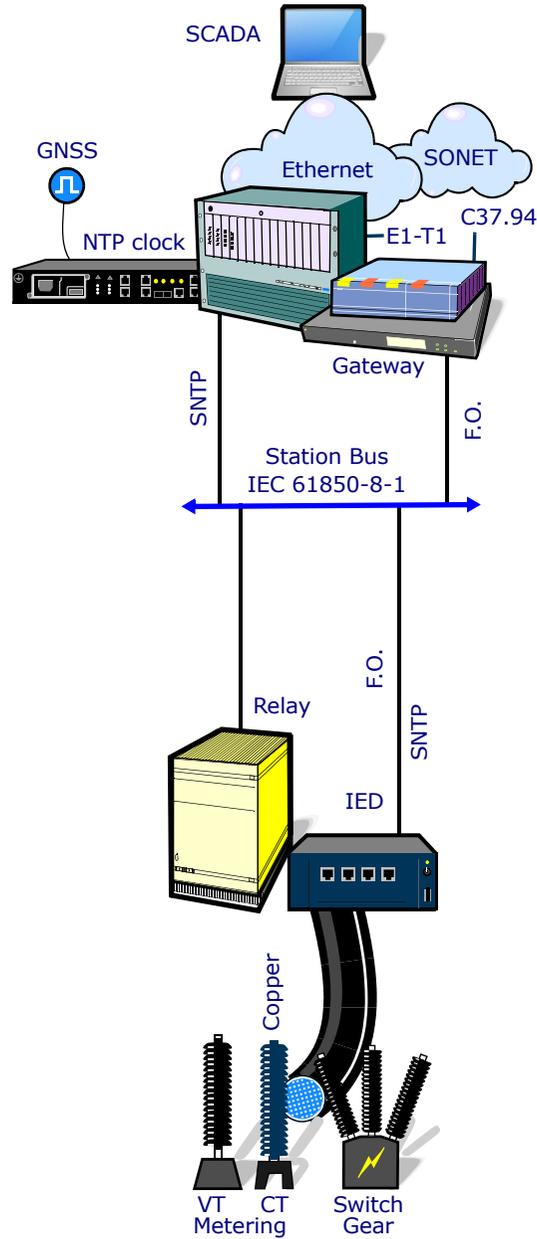


### Conventional clock

- 10/100 Mb/s, 1Gbs
- Stand-alone GNSS clock
- Boundary clock
- PTP, NTP, IRIG interfaces

### IEC 61850 clock

- 1/10Gb/s
- Double port

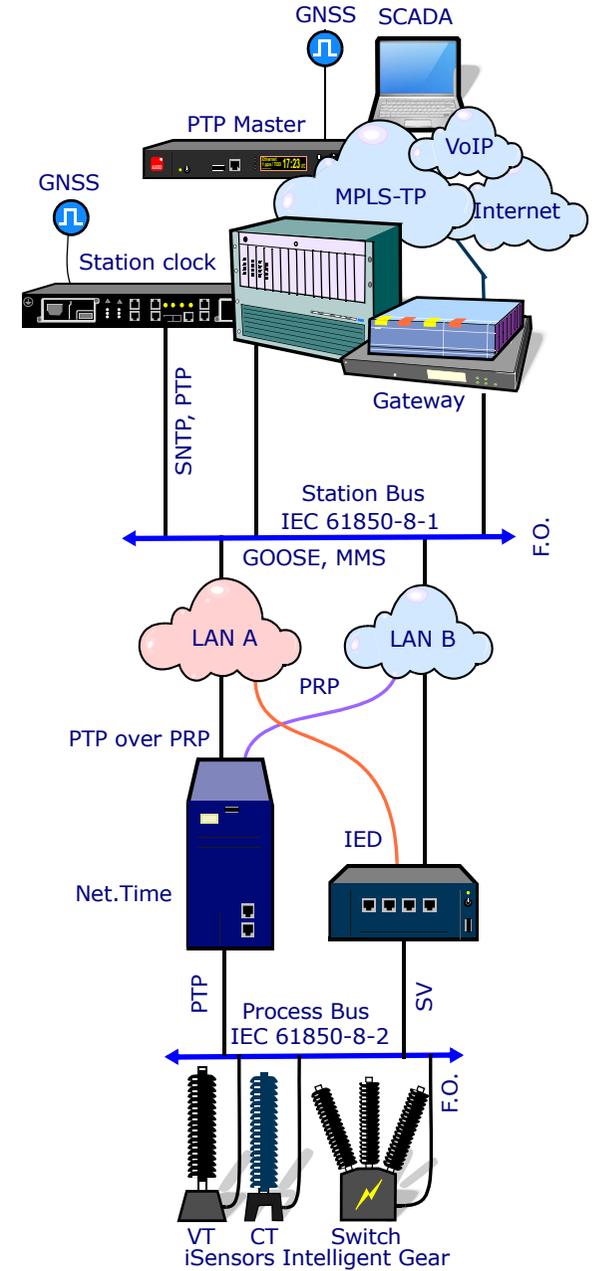


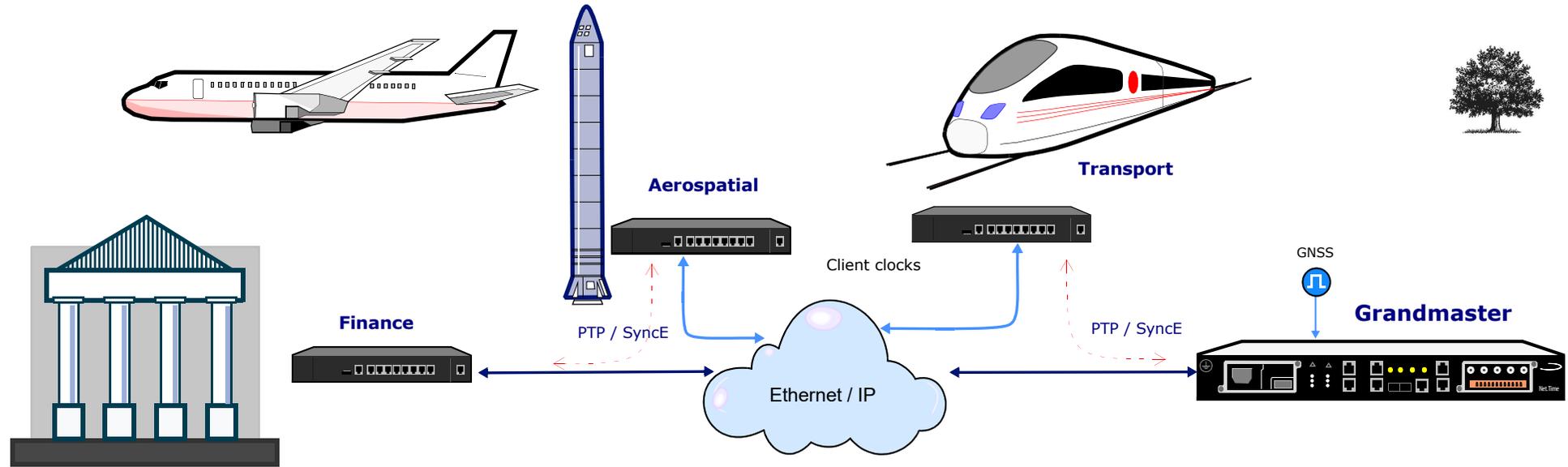
## Conventional Substation

- IRIG-B
- PPS
- T1/E1

## IEC 61850 substation

- PTP
- PRP
- SyncE
- NTP
- IRIG-B
- PPS
- T1/E1





### NTP clock

- NTP v2
- NTP v3

### PTP

- Customized profiles

### PPS

### IRIG-B

- Several options

### BITS

- E1/T1

### MHz

- Several options

## Network Time Protocol support)

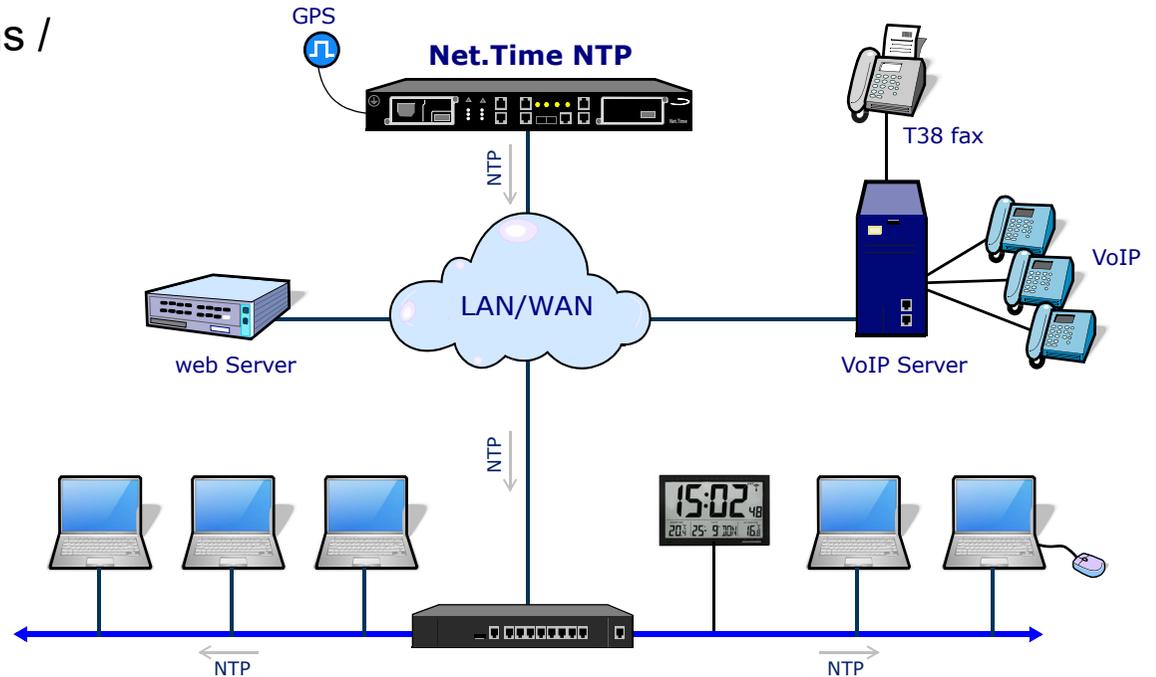
- Port A: NTP server @ 1000 transactions / sec.
- Port B: NTP client and time ref.

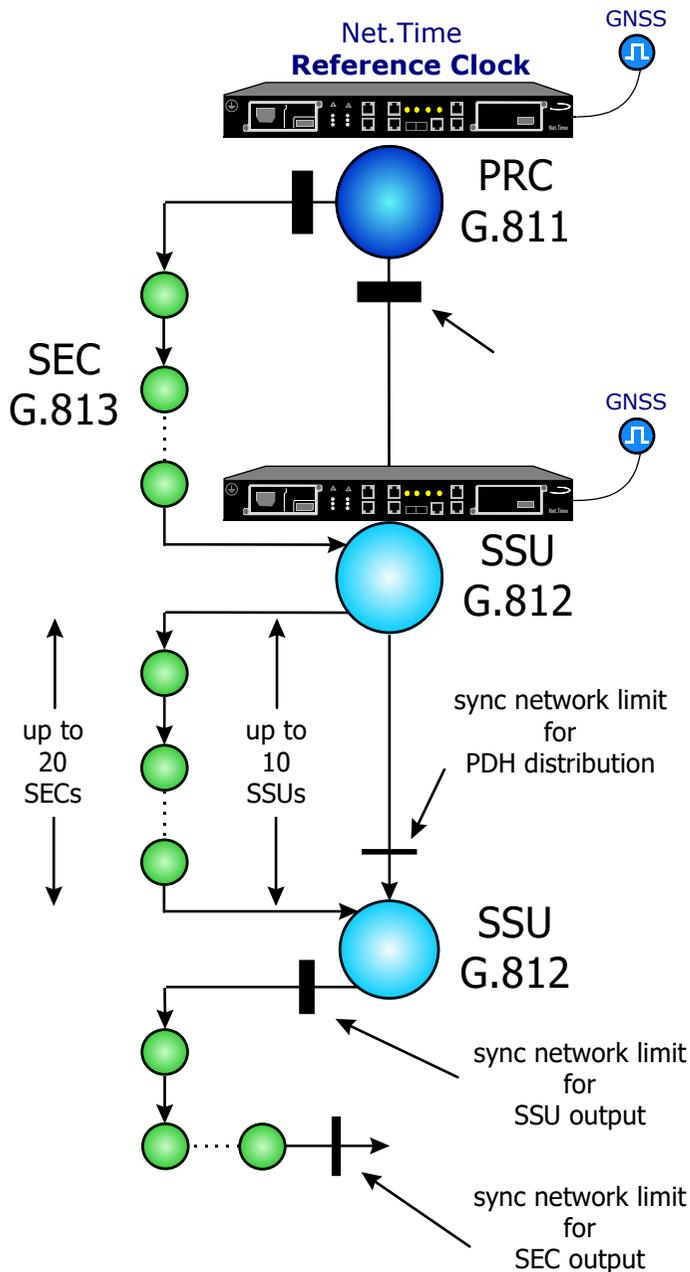
## NTP versions

- NTPv3 (RFC 1305) server & client
- NTPv4 (RFC 5905) server & client
- SNTPv3 (RFC 1769) server

## Configuration

- Maximum/ Minimum polling interval



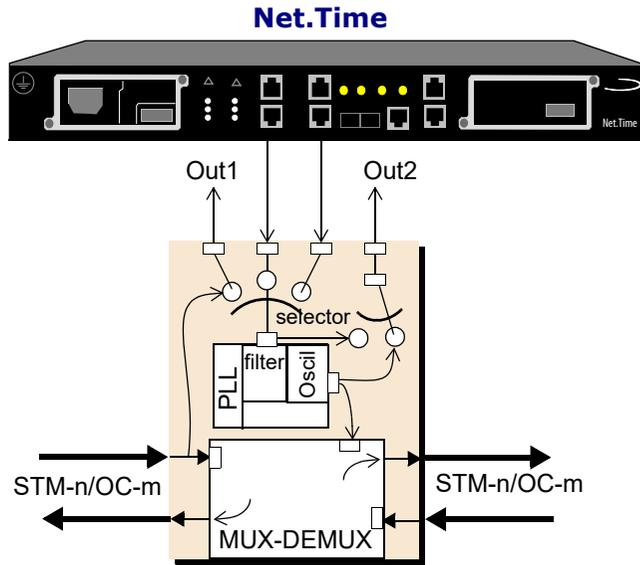


Net.Time configured as PRC is equipped with Rubidium oscillator providing timing to the SSU that can be a Net.Time with OCXO oscillator.

SSUs receive the signal (typically T1/E1 or BITS) and filter them to avoid degradation. In the event of a loss of timing signal SSU become primary clock and must continue working:

- High-quality transit SSUs used as reference for other SSUs
- Local SSU last link to synchronize network elements

A number of standards (ITU-T G.803, G.822, G.823, G.825, G.783, G.810, G.811, G.812, G.813, G.958, O.171, etc.) define the clock quality, functionality and limits of the synchronization tree to maintain the quality of the signals.



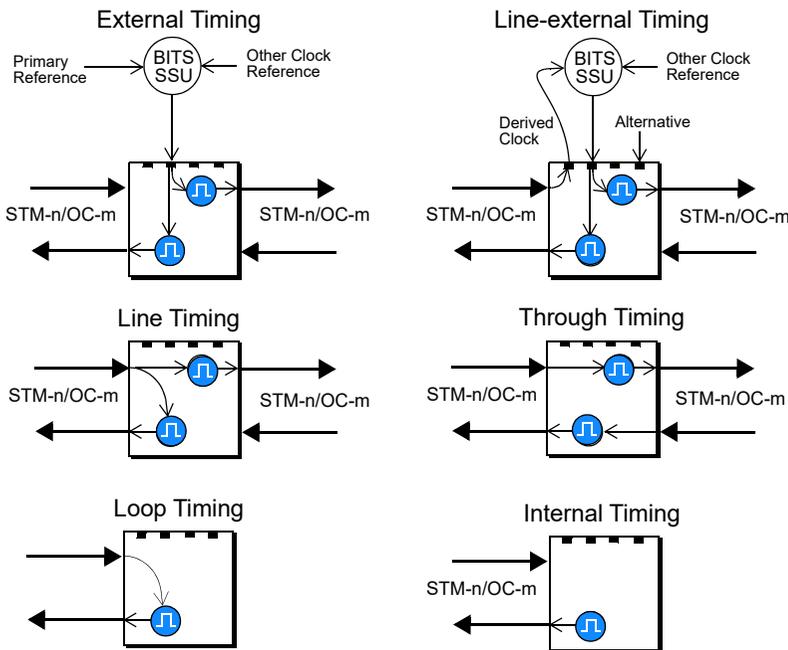
In SDH/SONET there are four ways to synchronize ADM and digital cross connects (DXC):

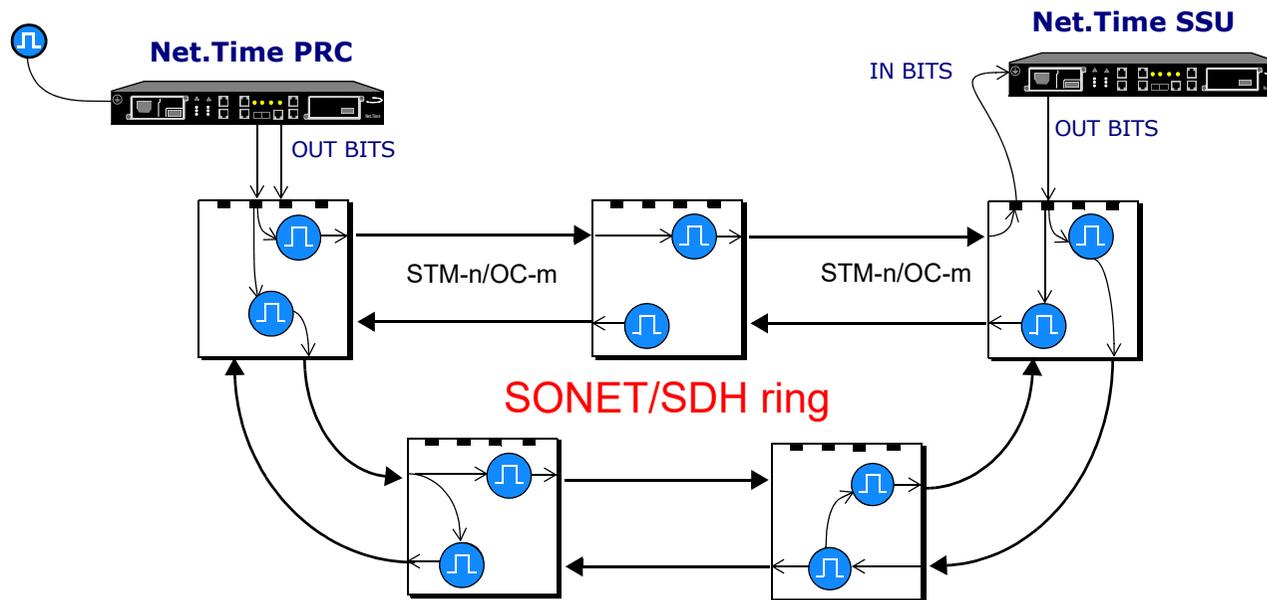
**1 - External timing:** The NE obtains its signal from a BITS or stand-alone synchronization equipment (SASE). This is a typical way to synchronize, and the NE usually also has an extra reference signal for emergency situations.

**2 - Line timing:** The NE obtains its clock by deriving it from one of the STM-n/OC-m input signals. This is used very much in ADM, when no BITS or SASE clock is available. There is also a special case, known as loop timing, where only one STM-n/OC-m interface is available.

**3 - Through timing:** This mode is typical for those ADMs that have two bidirectional STM-n/OC-m interfaces, where the Tx outputs of one interface are synchronized with the Rx inputs of the opposite interface.

**4 - Internal timing:** In this mode, the internal clock of the NE is used to synchronize the STM-n/OC-m outputs. It may be a temporary holdover stage after losing the synchronization signal, or it may be a simple line configuration where no other clock is available.





Often known as Building Integrated Timing Supply (BITS) there are several signals suitable for transporting synchronization:

- Sinusoidal: 1,544 and 2,048 kHz
- Digital: 1,544 and 2,048 kbit/s (T1 and E1)

In both cases it is extremely important for the clock signal to be continuous.

That's all



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