Net.Time φ 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

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ALBEDO a **Global** manufacturer of **Testers** & **Timing** appliances

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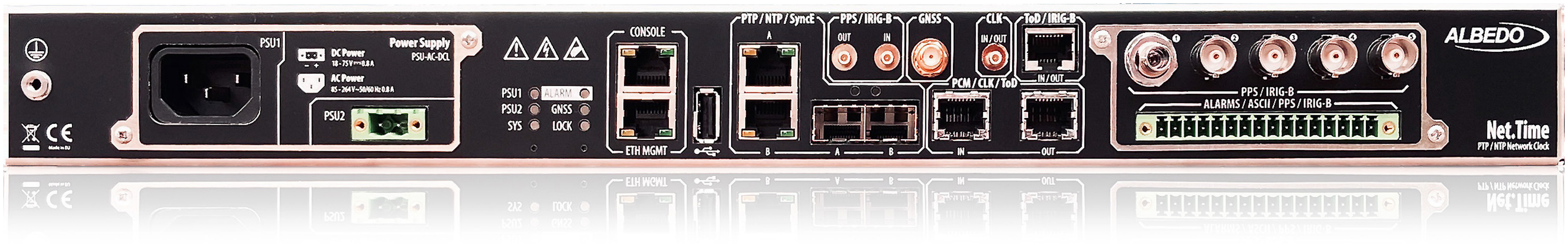
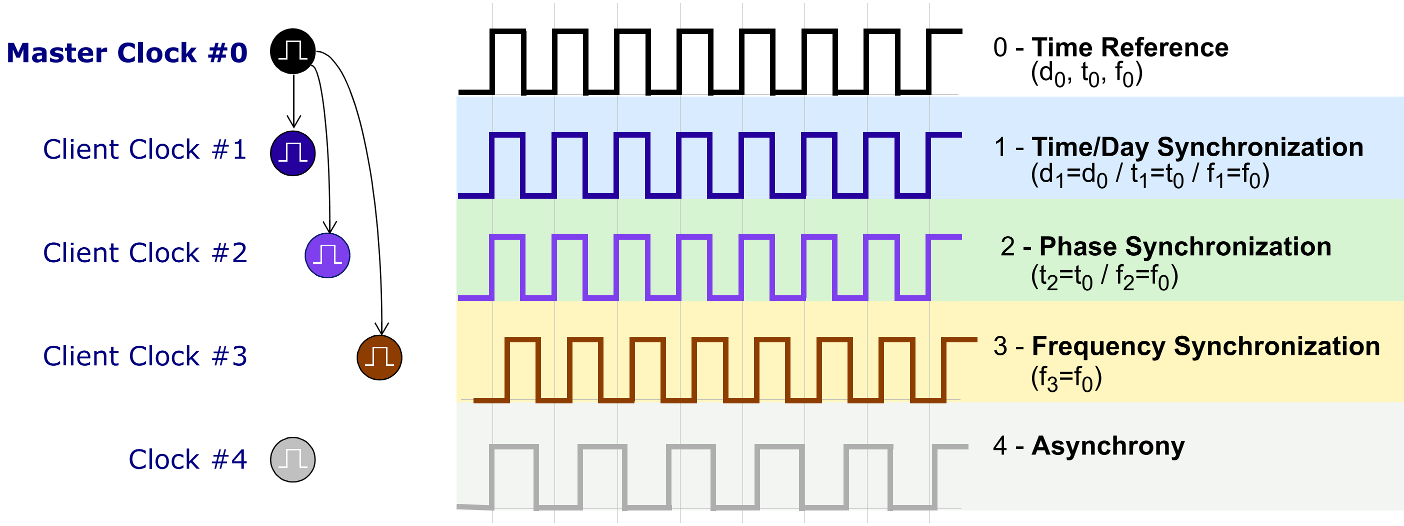
Net.Time φ a substation clock



Net.Time φ is a PTP/NTP over PRP clock designed to facilitate the integration of conventional substations with the new IEC 61850 standards by offering a wide variety of reference inputs and outputs. It can be equipped with a Rubidium oscillator, the best option for time quality especially in hold-over. It is powerful as it supports up to 22 simultaneous outputs, and very flexible because it can be disciplined with multiple back-up inputs.

About **Synchronization**

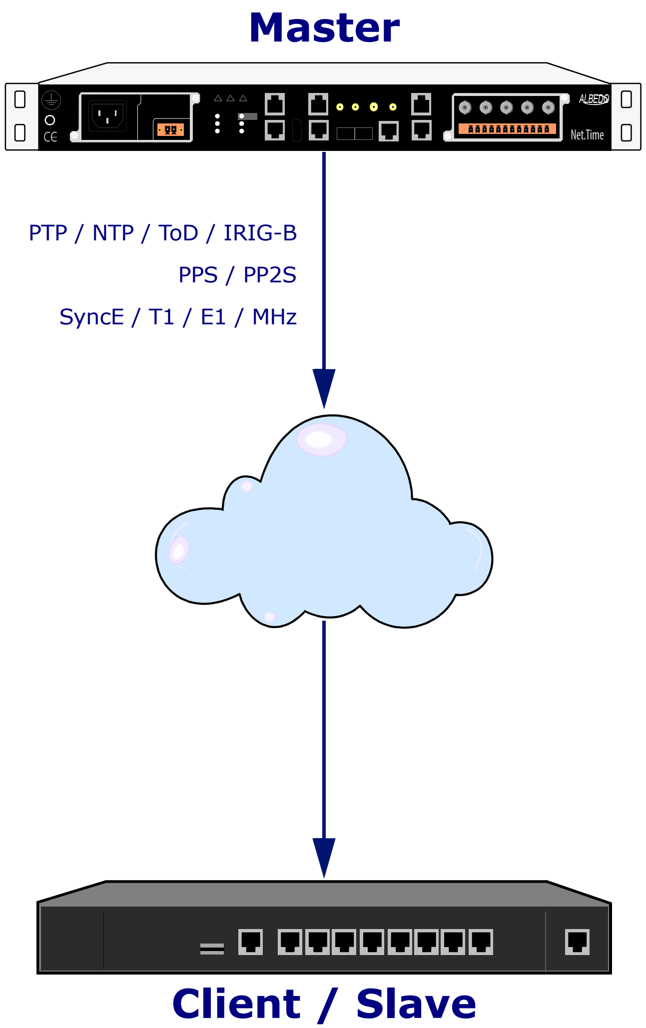


Synchronization aims to discipline clocks in a network to a common time reference.

- **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 φ Synchronization signals



Net.Time φ 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
- DCF77

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

- PPS
- PP2S

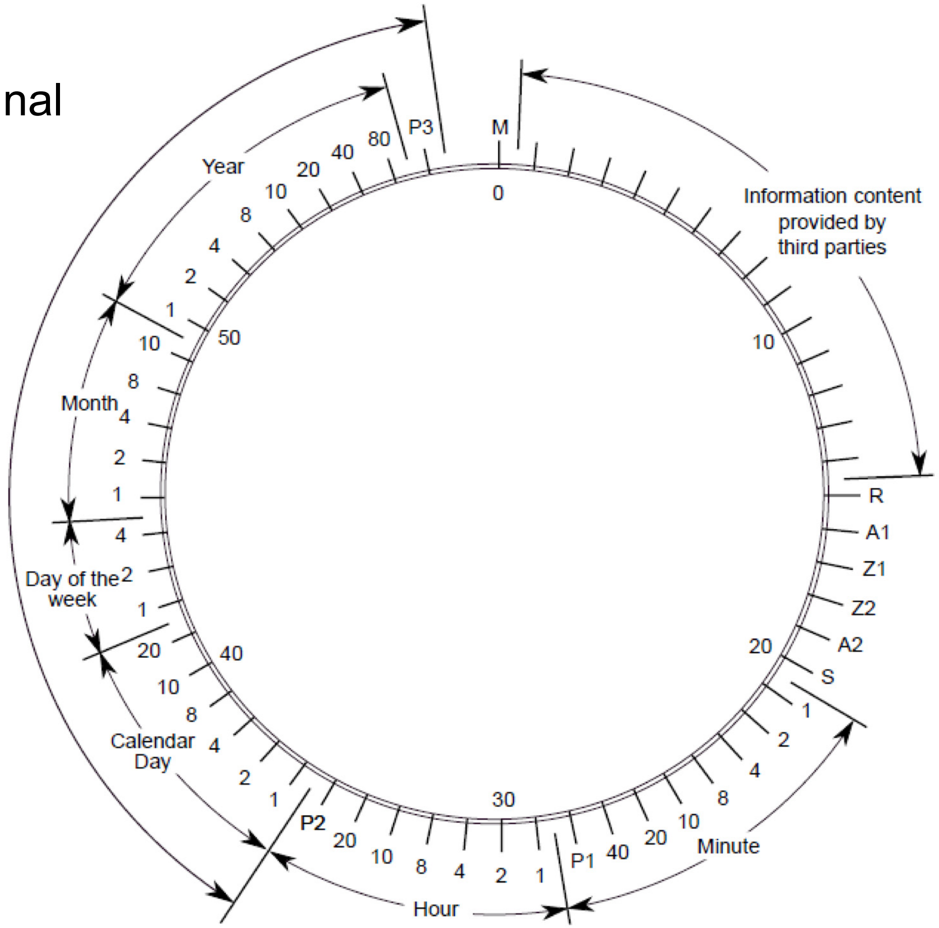
Frequency Synchronization: can only provide frequency:

- T1
- E1
- SyncE
- MHz

DCF77 signal

Originally DCF77 is a German long-wave time signal and standard-frequency radio station that carries an amplitude-modulated data signal repeated every minute.

- M: Start
- R: service request to the DCF77 system
- A1: forthcoming change CET to/from CEST
- Z1, Z2: time zone indication
- A2: Leap second warning bit
- Pi: parity bits
- S: Start of time information minute, hour, day, week day, months, year



A lot of substations generate the DCF77 signal synchronized with GNSS (or the time reference used in the node). The accuracy of DCF77 is good enough for SCADA and wall clocks and is still used.

IRIG-B signals

IRIG - Xabc

Rate
- A: 1000 PPS
- **> IRIG-B: 100 PPS <**
- D: 1 PPM
- E: 10 PPS
- G: 10000 PPS
- H: 1 PPS

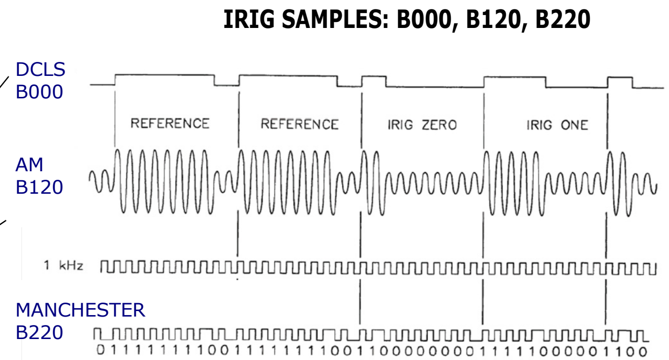
Coding
- 0: BCD, CF, SBS
- 1: BCD, CF
- 2: BCD
- 3: BCD, SBS
- 4, 5, 6, 7: others

Carrier
- 0: No carrier (DCLS)
- 1: 100 Hz
- 2: 1 kHz
- 3: 10 kHz
- 4: 100 kHz
- 5: 1 MHz

Modulation
- 0: Unmodulated DCLS
- 1: AM (Amplitude Modulated)
- 2: Manchester Modulated

BCD
0000 = 0
0001 = 1
0010 = 2
0011 = 3
0100 = 4
0101 = 5
0110 = 6
0111 = 7
1000 = 8
1001 = 9

BCD - Binary Coded Decimal, coding of time (HH,MM,SS,DDD)
SBS - Straight Binary Second of day (0....86400)
CF - Control Functions depending on the user application



IRIG-B sends a timing signal at 100 pulse/sec rate including Year, Day, Hour, Min, Sec data with an update rate of one second direct or over a Carrier:

Unmodulated DCLS IRIG-B offers several transmission alternatives

- 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

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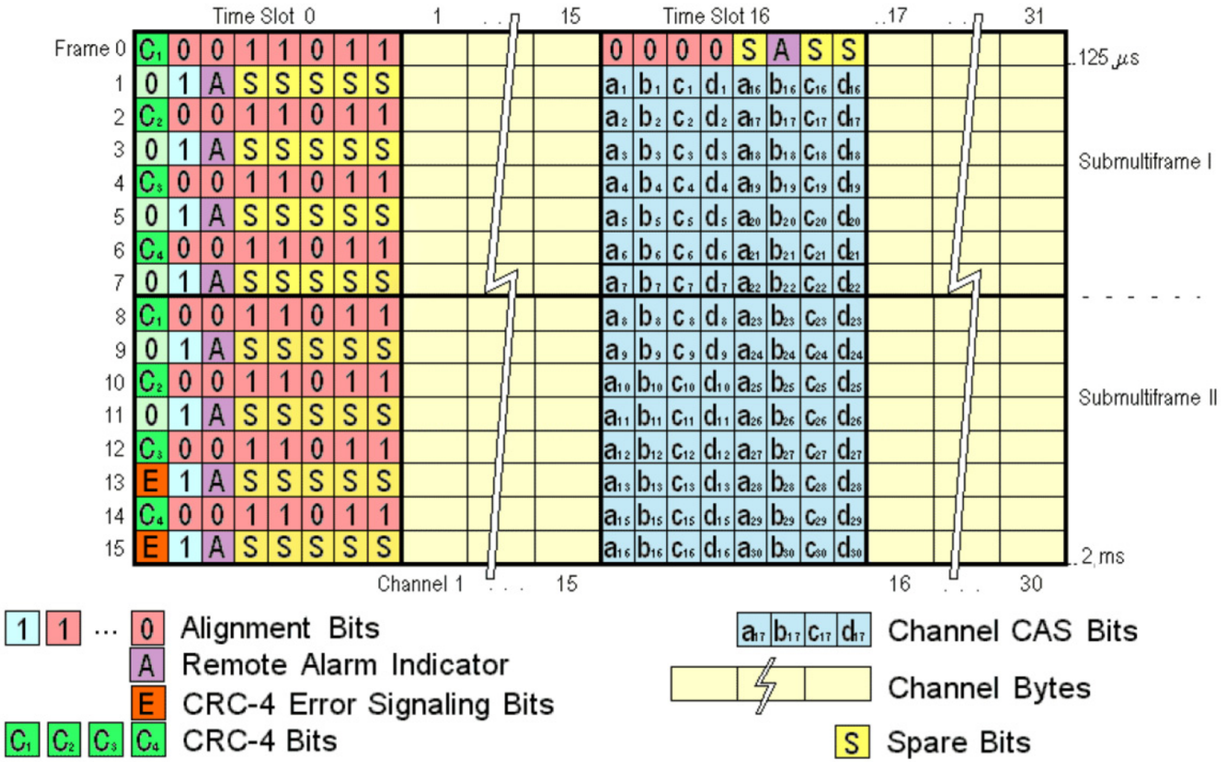
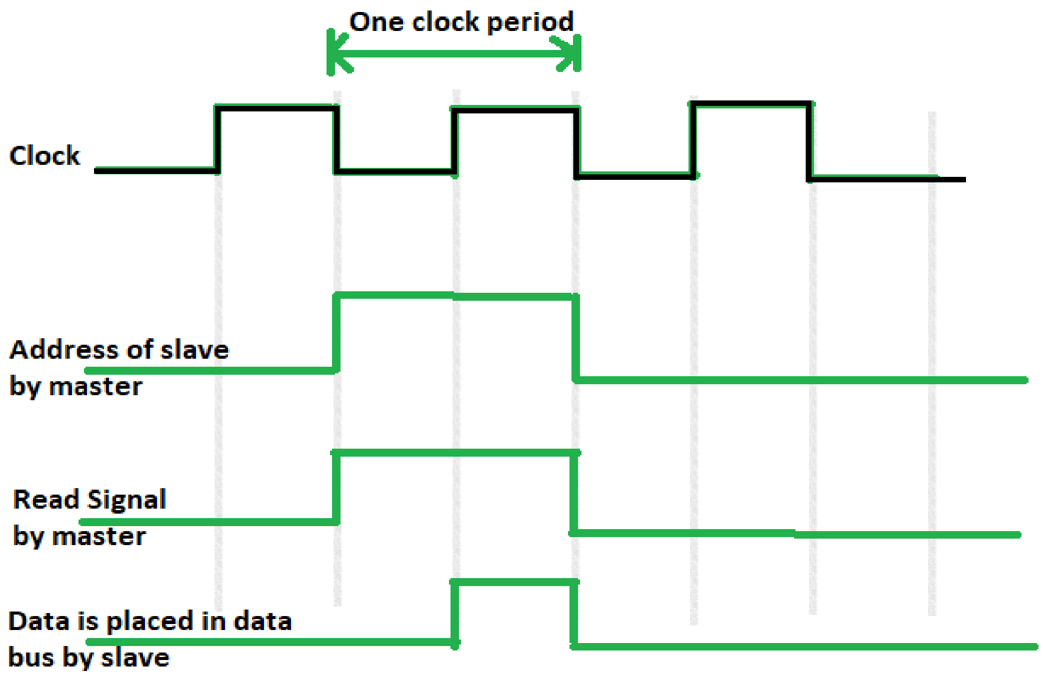
T1/E1 signals



- The T-carrier is a hardware specification for carrying multiple time-division multiplexed (TDM) telecommunications channels over a single four-wire transmission circuit. It was developed by AT&T at Bell Laboratories ca. 1957 and first employed by 1962 for long-haul pulse-code modulation (PCM) digital voice transmission with the D1 channel bank.
- The E-carrier is a member of the series of carrier systems developed for digital transmission of many simultaneous telephone calls by time-division multiplexing. The European Conference of Postal and Telecommunications Administrations (CEPT) originally standardized the E-carrier system.

Mbit/s & **MHz** signals



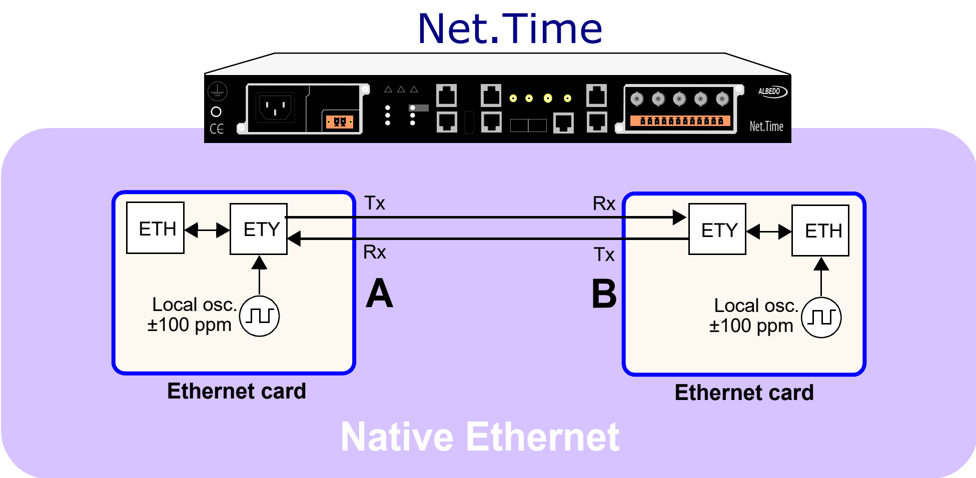
Often known as BITS (Building Integrated Timing Supply) describe a building-centric timing system, the BITS system efficiently manages the number of timing interfaces within a structure providing external timing connections typically deployed as T1 or E1 frequencies but also can refer to MHz and then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

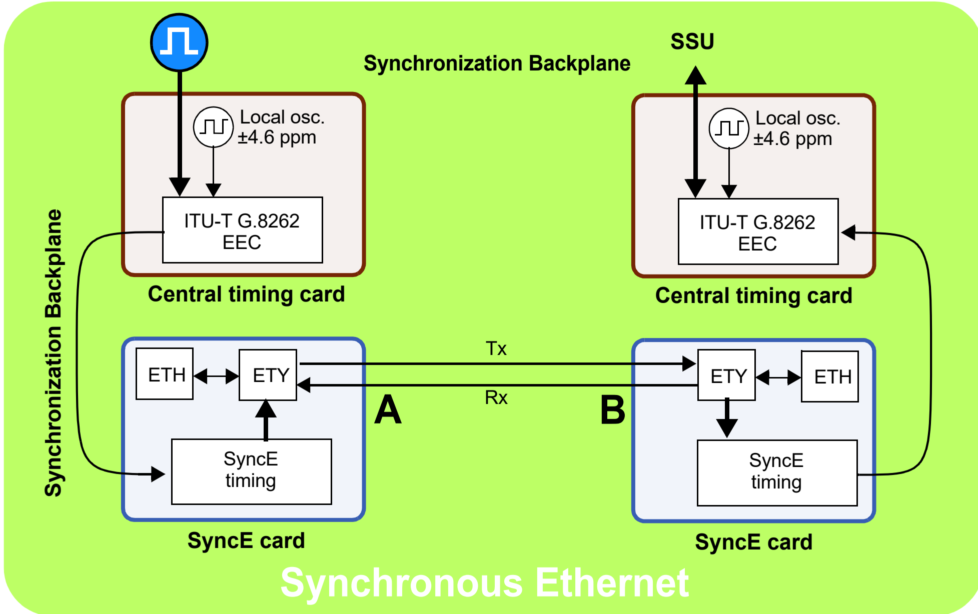
There are several signals suitable for transporting synchronization:

- 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.

SyncE (Synchronous Ethernet)





SyncE is not part of the IEC 61850 but is required in the Power Grid and implemented by Net.Time

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

NTP server

Network Time Protocol support)

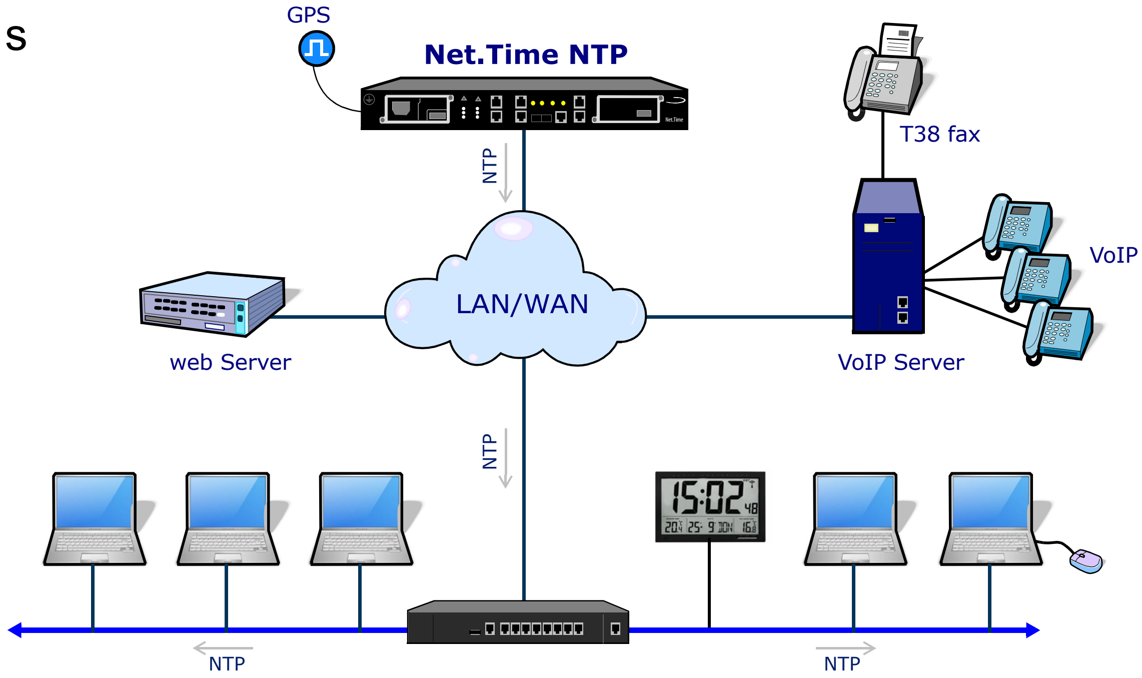
- Port A: NTP server @ 1000 transactions / s
- Port B: NTP client and time ref.

NTP versions

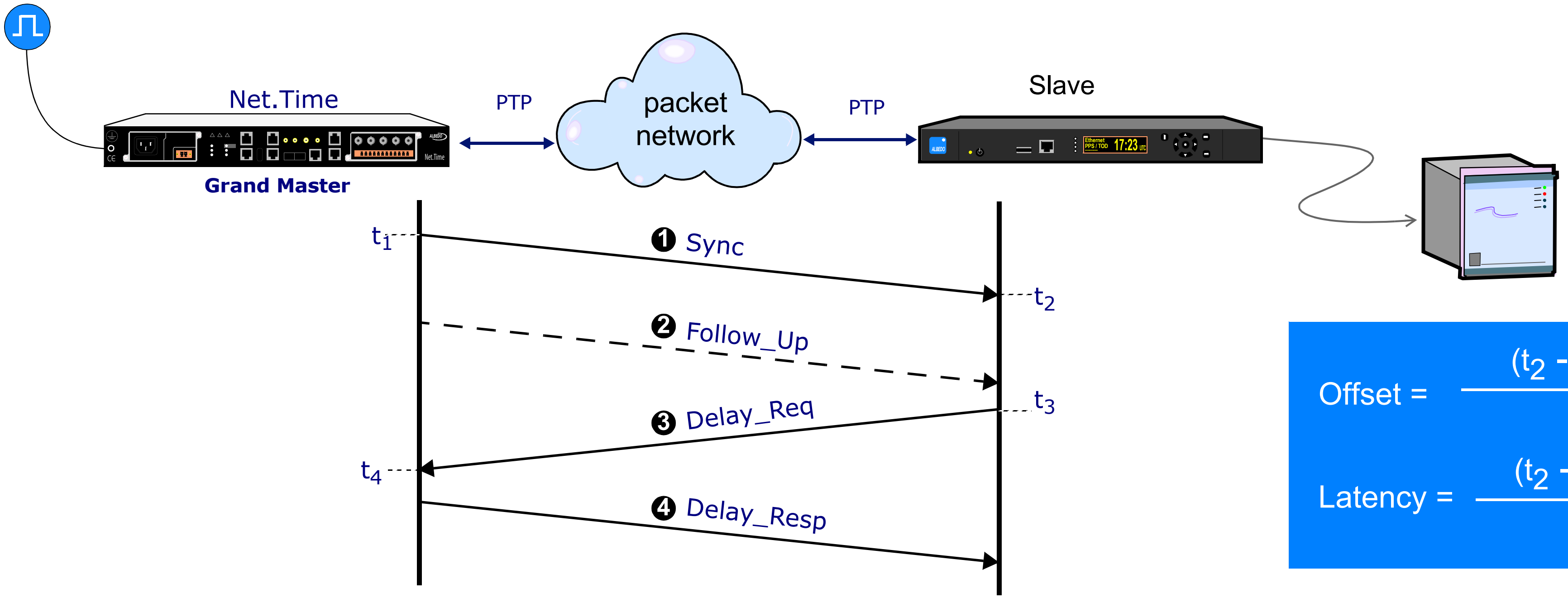
- NTPv3 (RFC 1305) server & client
- NTPv4 (RFC 5905) server & client
- SNTPv3 (RFC 1769) server

Configuration

- Maximum/ Minimum polling interval



PTP - Precision Time Protocol (IEEE 1588)



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

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

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.

Timing **Evolution**

(1960)

IRIG-B

- Bulk metering
- Simple
- Robust

10 us

(1990)

NTP

- SCADA
- Even recorder
- Security
- Personal Data

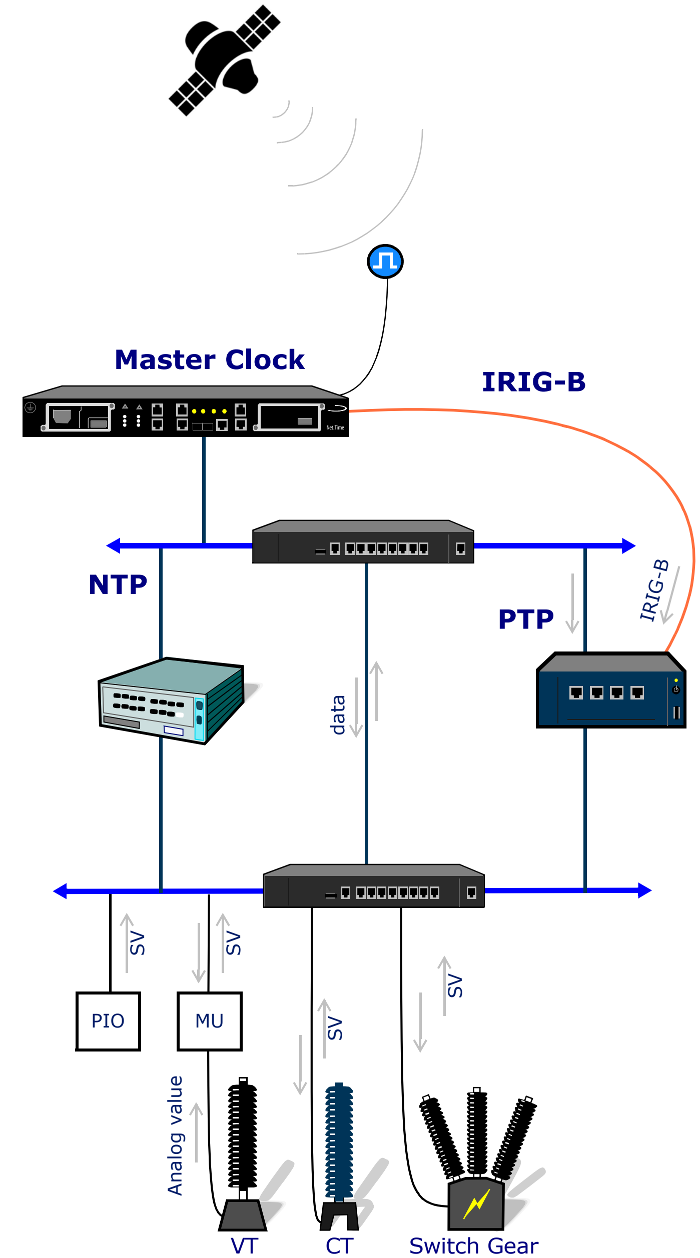
1 ms

(2020)

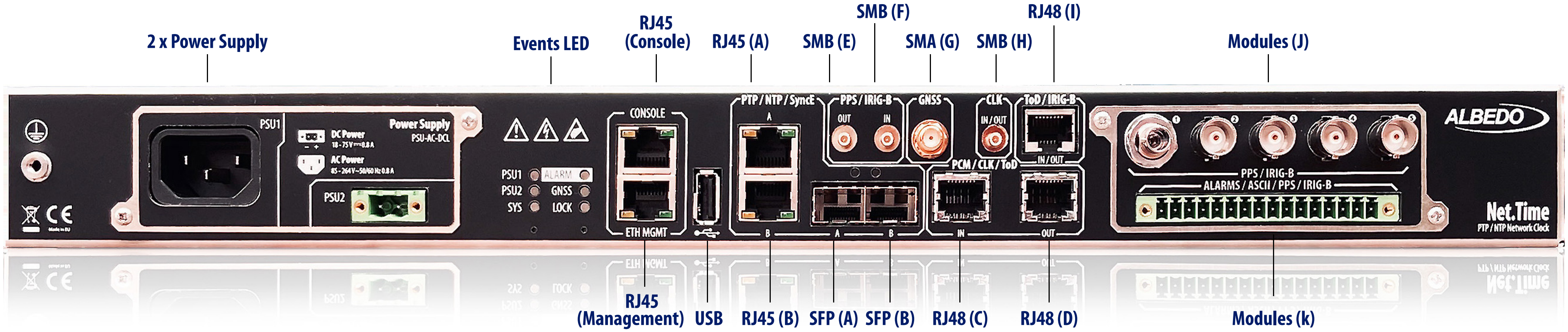
PTP

- Substations
- IED
- SV
- Teleprotection

100 ns



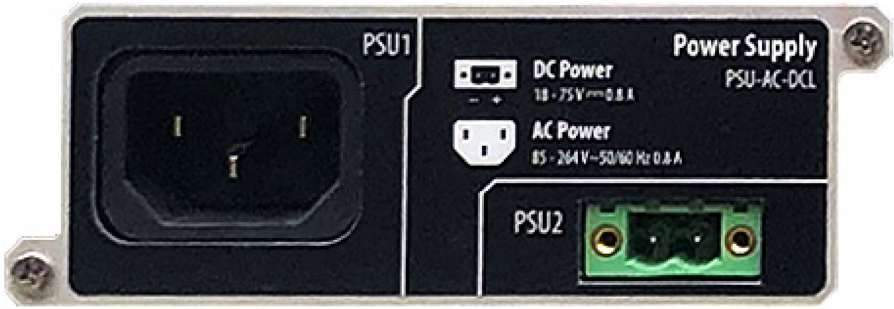
Power Grid have a combination of all them



from **10Mb/s** up to **1Gb/s**

- 19” / ETSI/1U/201 mm rack mount
- Fanless operation
- Weight: 1.9 kg / 4.2 lb
- Redundant power supply
- 6 x LEDs
- USB: Software and firmware upgrade
- Storage temperature: -40 ~ +85ºC
- Operating: -25 ~ +75ºC (10 ~ 95% RH non condensing)
- Slot for 5 x Optional Modules

Power Supply redundancy



Multiple combinations

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

Options

- AC: 100 ~ 240 Vac, 50- 60 Hz (IEC 60320 C13/C14)
- DC: 18 ~ 75 Vdc (2-pin 5.1 mm)
- AC/DC: 85 - 264 VAC or 10 - 370 VDC (2-pin 5.1 mm)

Rubidium or OCXO

Internal Oscillator

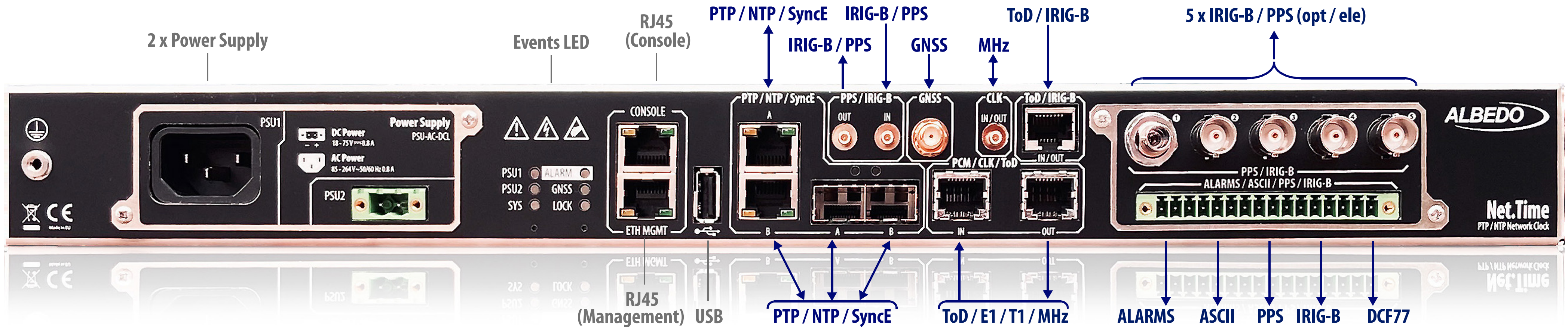
- Rubidium better than ±5.0 e-11
- OCXO better than ±0.1 ppm
- Internal time reference better than ±2.0 ppm

Hold-over

- Rubidium: 1µs / 24 hours
- OCXO: 10µs / 12 hours

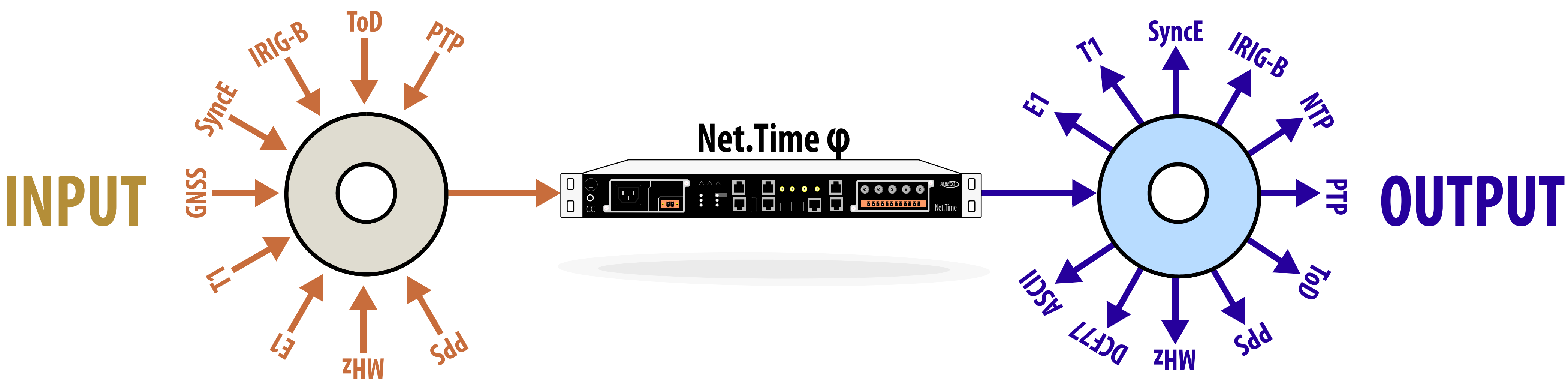
best **accuracy** in market

Timing **interfaces**



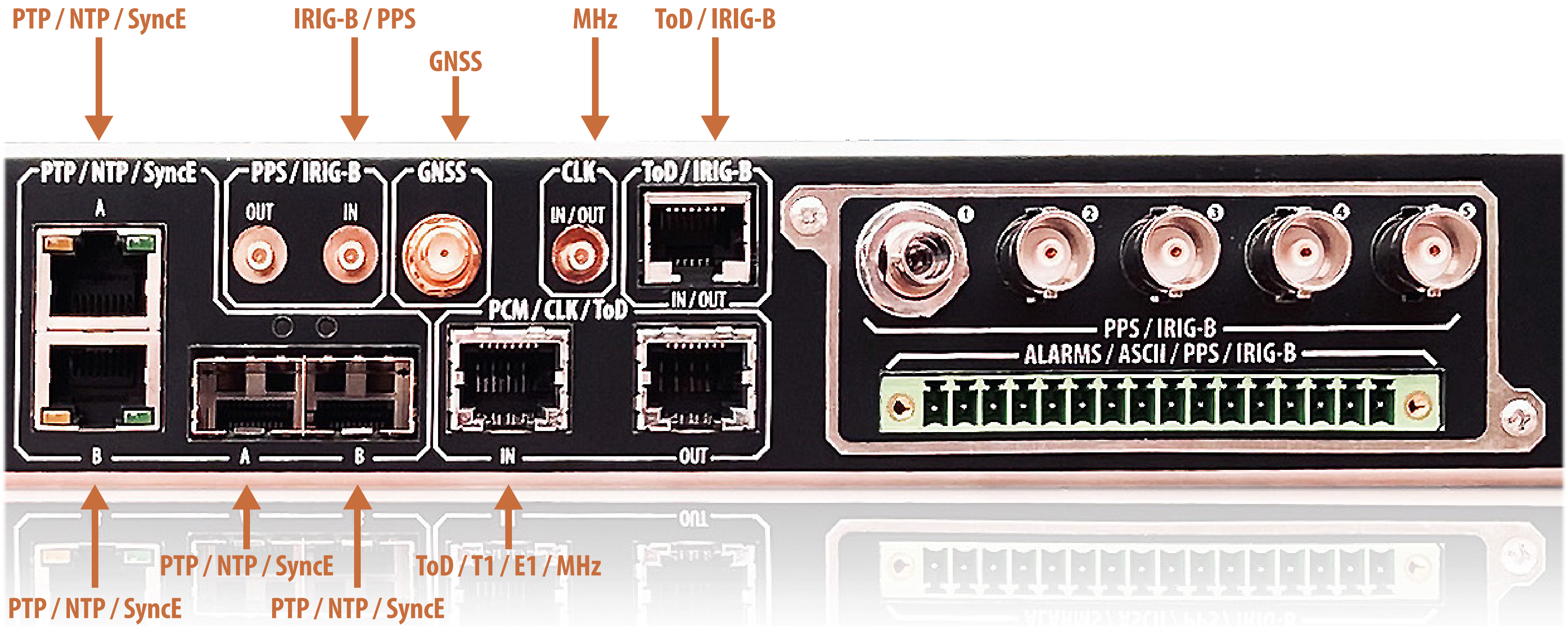
	GNSS	PTP	NTP	ToD	IRIGB	PPS	PP2S	SyncE	T1/E1	MHz	ASCII	DCF77	Alarm
RJ45 (A)		out	out					in/out					
RJ45 (B)		in	in					in/out					
SPF (A)		out	out					in/out					
SPF (B)		in	in					in/out					
SMB (E)					out	out	out						
SMB (F)					in	in	in						
SMB (H)										in/out	in/out		in/out
SMA (G)	in												
RJ48 (I)				in/out	in/out								
RJ48 (C)				in					in	in	in		in
RJ48 (D)				out					out	out	out	out	out
BNC/ST (J)					out	out	out				out		out
Socket (K)					out	out	out				out		out

Universal Time Protocol **Translator**



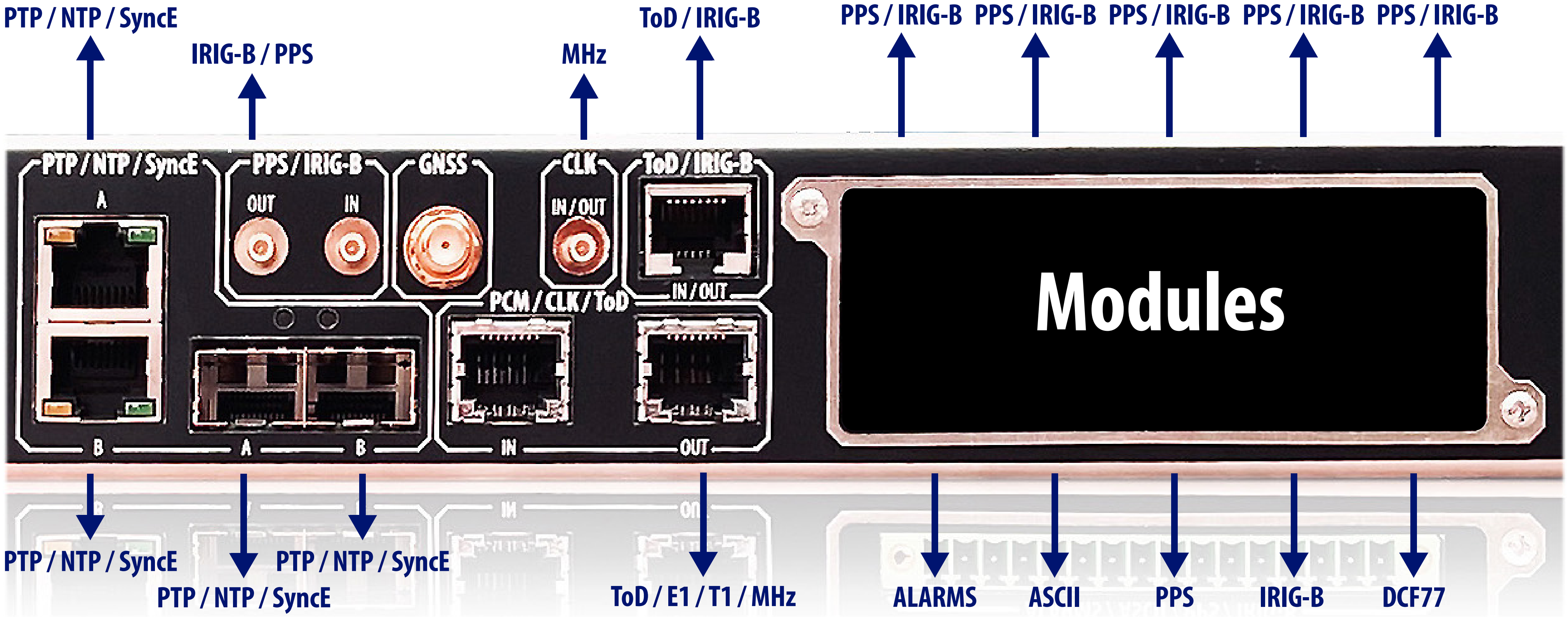
	Input Signals							
Output Signals	GNSS	PTP	ToD	IRIG-B	PPS	SyncE	T1/E1	MHz
PTP	yes	yes	yes	yes	yes	yes	yes	yes
NTP	yes	yes	yes	yes	yes	yes	yes	yes
ToD	yes	yes	yes	yes	yes	yes	yes	yes
IRIG-B	yes	yes	yes	yes	yes	yes	yes	yes
PPS	yes	yes	yes	yes	yes	yes	yes	yes
SyncE	yes	yes	yes	yes	yes	yes	yes	yes
E1/T1	yes	yes	yes	yes	yes	yes	yes	yes
DCF77	yes	yes	yes	yes	yes	yes	yes	yes
MHz	yes	yes	yes	yes	yes	yes	yes	yes

Input references



up to **10 different** time **references**

Output signals



up to **22 simultaneous** Outputs

T1/E1 to PTP, NTP, SyncE, T1/E1 & MHz

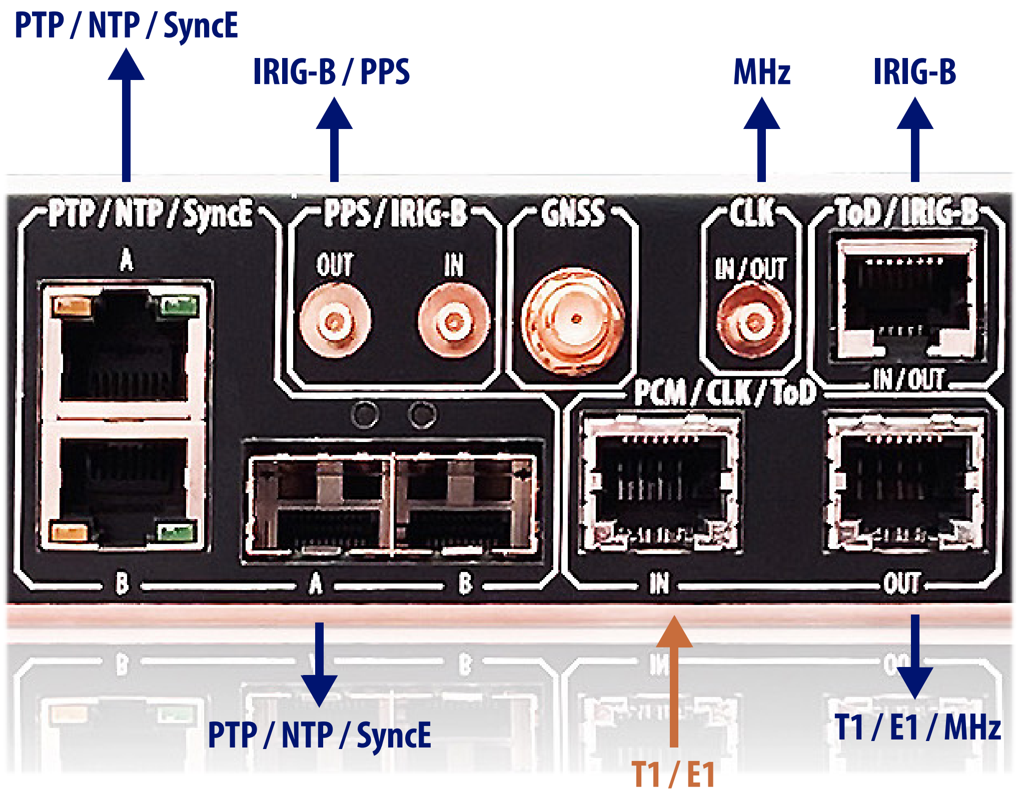
E1/T1 are only a Frequency references therefore can only discipline Frequency signals.

Rates

- 1544 Mb/s
- 2048 Mb/s

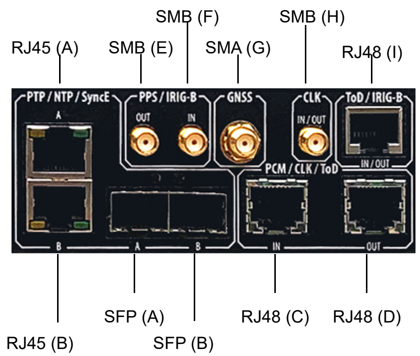
Can discipline

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



any **input** to **output**

	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



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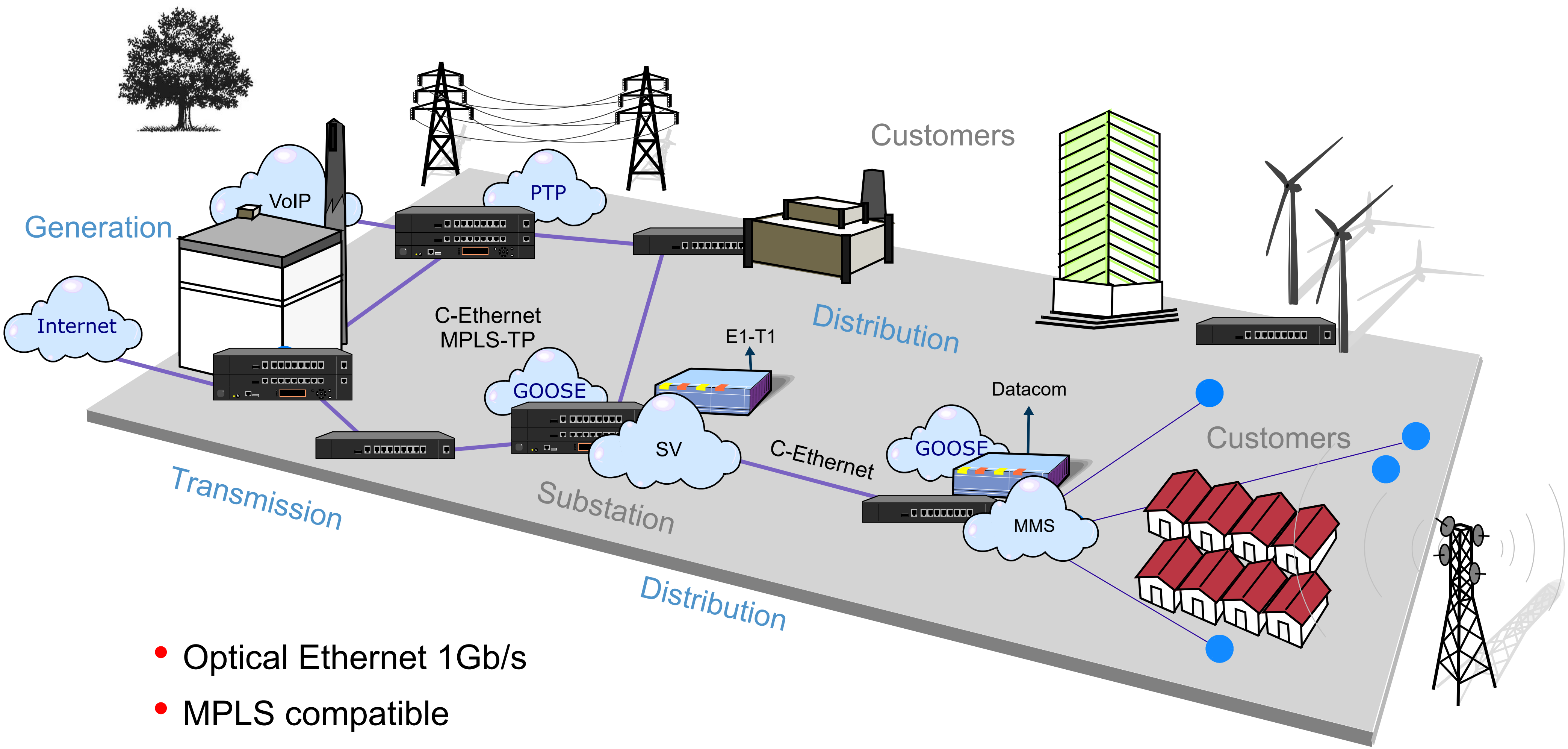
5 x **Modules**

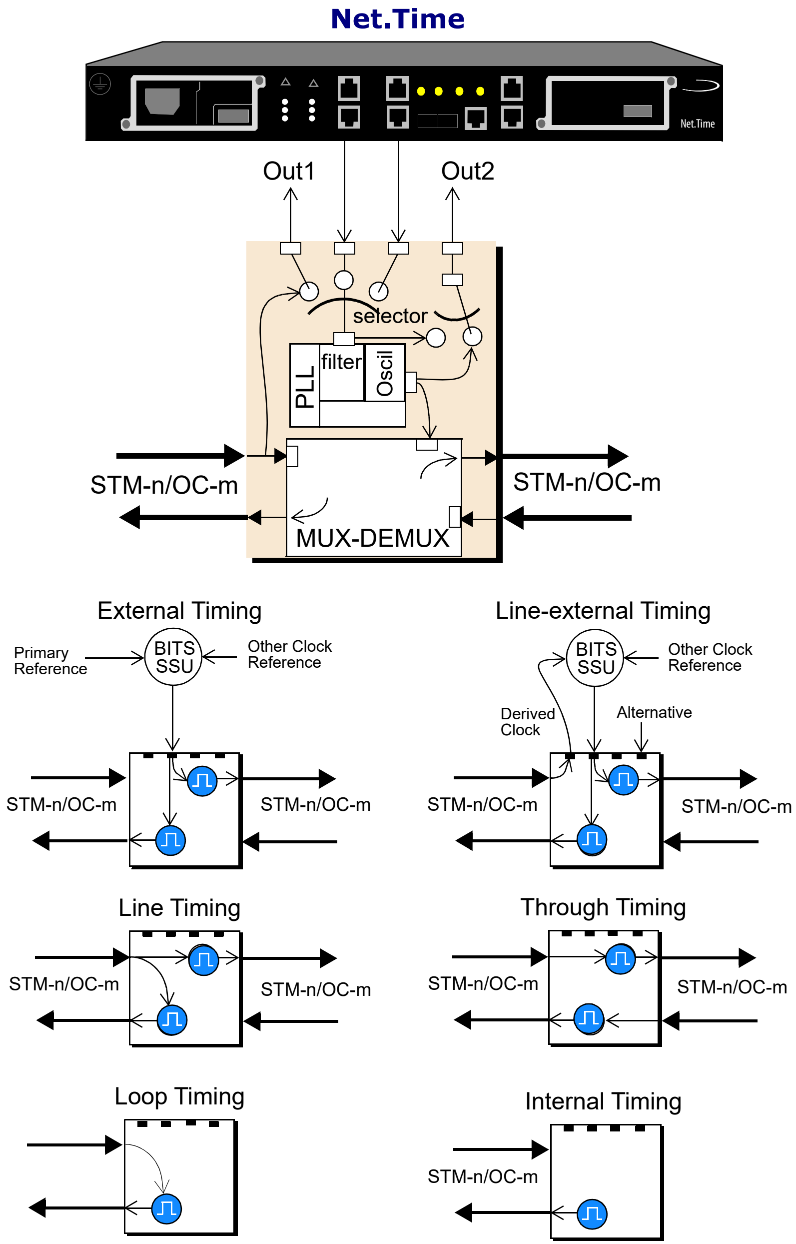

Modules
RIC-50
IRIG-B / PPS
RIC-50
PPS / IRIG-B
IRIG / DCF
PPS / IRIG-B
IRIG-B / DCF
RIC-52
IRIG-B / PPS
RIC-52
ToD / ASCII / IRIG-B
PPS
IRIG-B
IRIG / DCF
PPS / IRIG-B
IRIG-B / DCF
RIC-54
IRIG-B / PPS
RIC-54
PS / IRIG-B
IRIG / DCF
ALARMS / ASCII / PPS / IRIG-B
ALARMS / ASCII / PPS / IRIG-B
RIC-82
IRIG-B / PPS
RIC-82
PPS / IRIG-B
ALARMS / ASCII / PPS / IRIG-B
ALARMS / ASCII / PPS / IRIG-B
RIC-84
IRIG-B / PPS
RIC-84
PPS / IRIG-B
ALARMS / ASCII / PPS / IRIG-B
ALARMS / ASCII / PPS / IRIG-B

Net.Time in the **WAN**



- Optical Ethernet 1Gb/s
- MPLS compatible
- PTP Telecom / Power profiles

Frequency for SONET/SDH



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

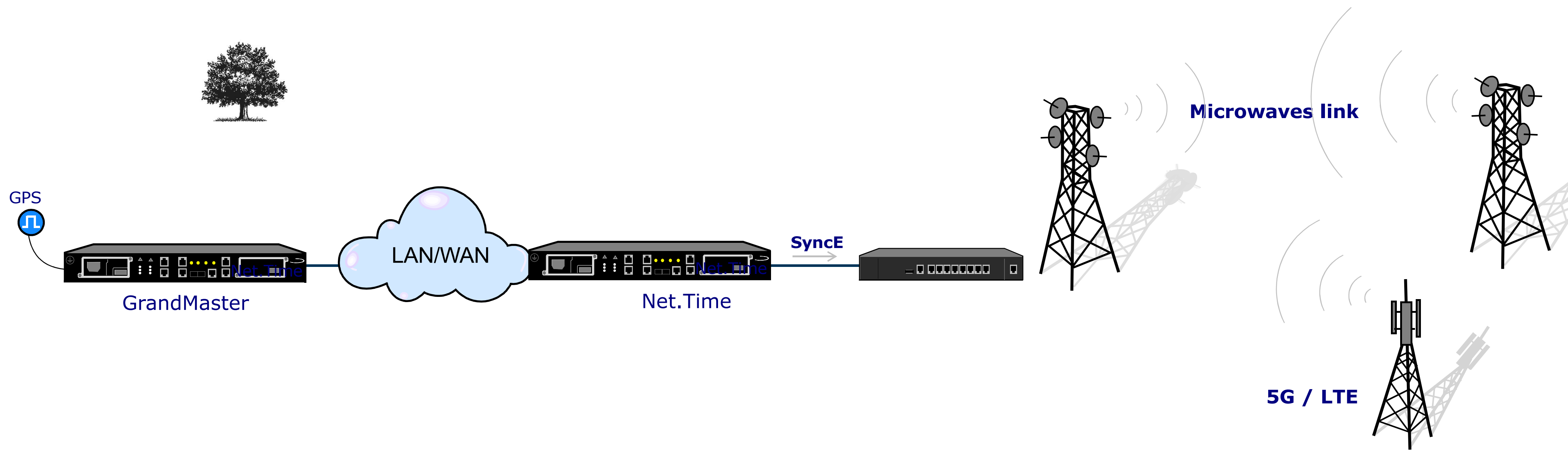
1 - External timing: The NE obtains its signal from a BITS or stand-alone synchronization equipment (SASE). This is a typical way to synchronize, and the NE usually also has an extra reference signal for emergency situations.

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.

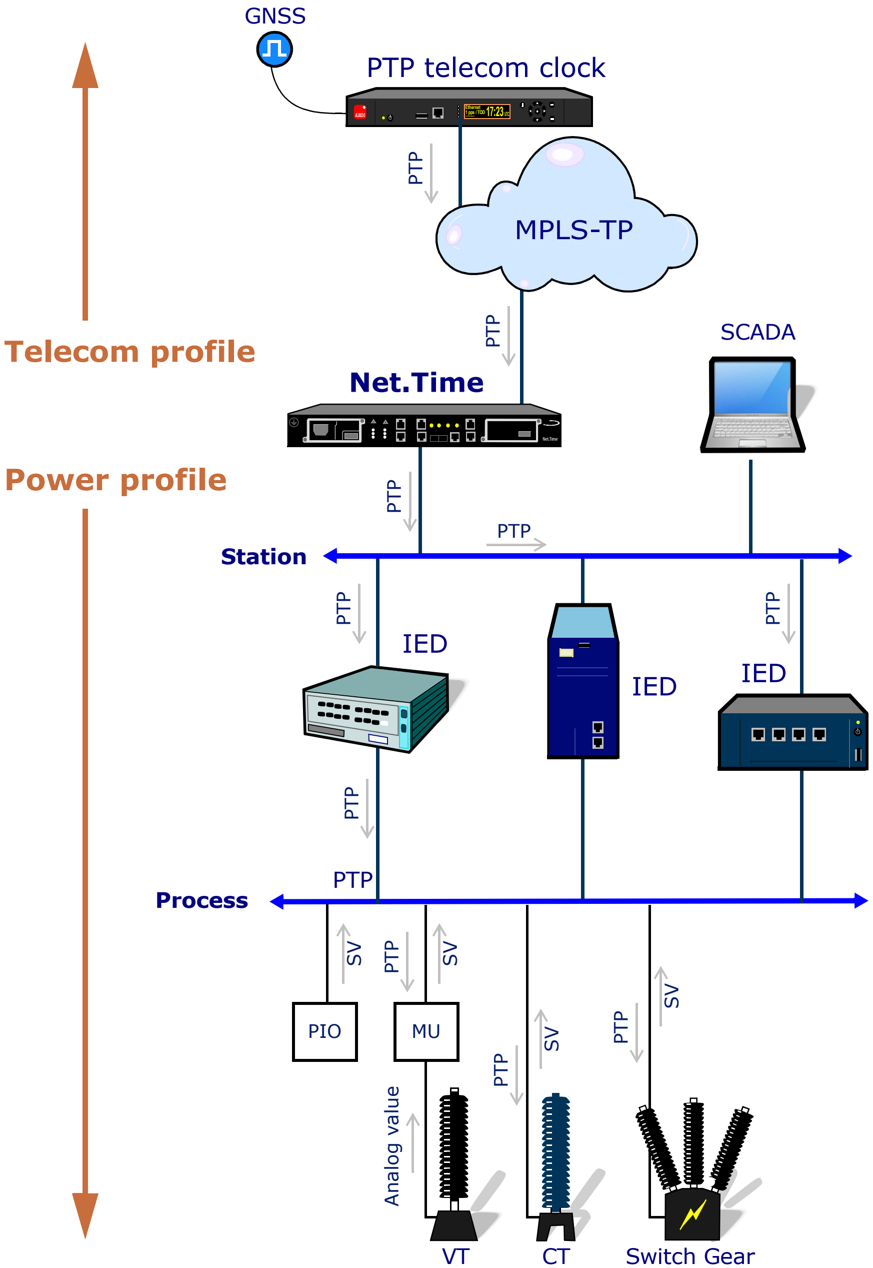
Wireless & SyncE



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
- QL 16 bits compatible

PTP Profiles translation



Net.Time supports the following PTP profiles

- Default
- Telecom
- Power
- Utility

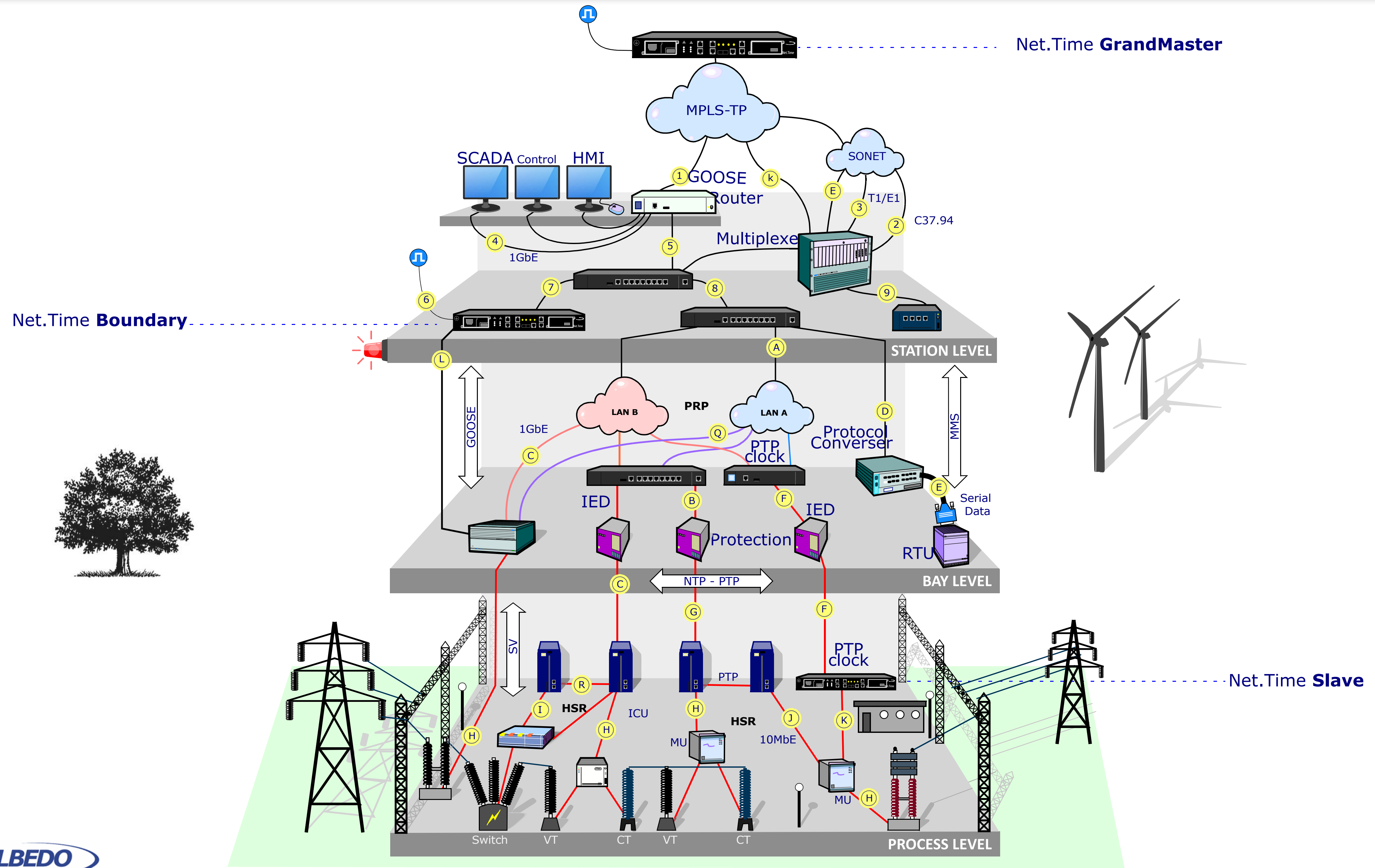
Then it is possible to interconnect networks using different synchronization profiles:

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

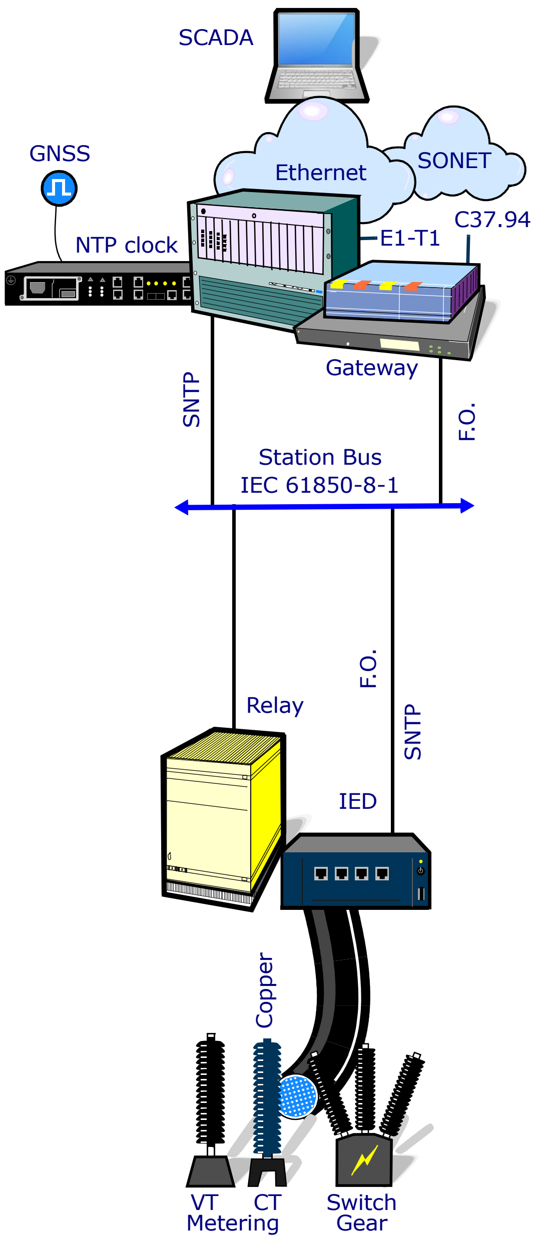
No need for PTP profile translator

Net.Time is a Profile translator

Substation **Timing**



Migration to **IEC 61850**

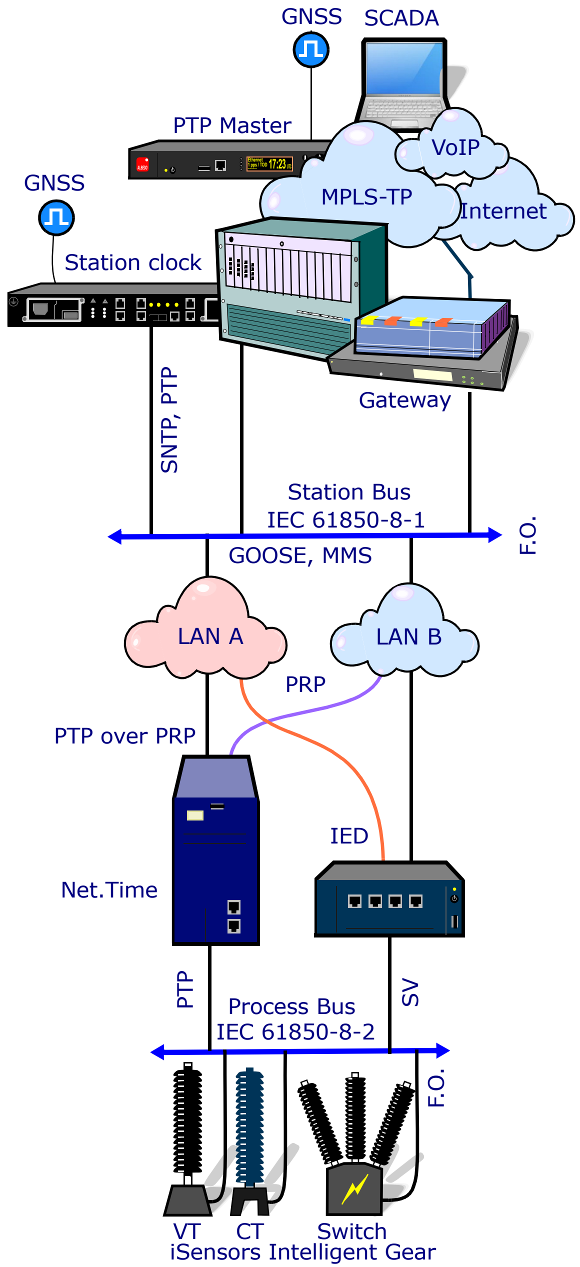


Conventional Substation

- IRIG-B
- PPS
- T1/E1

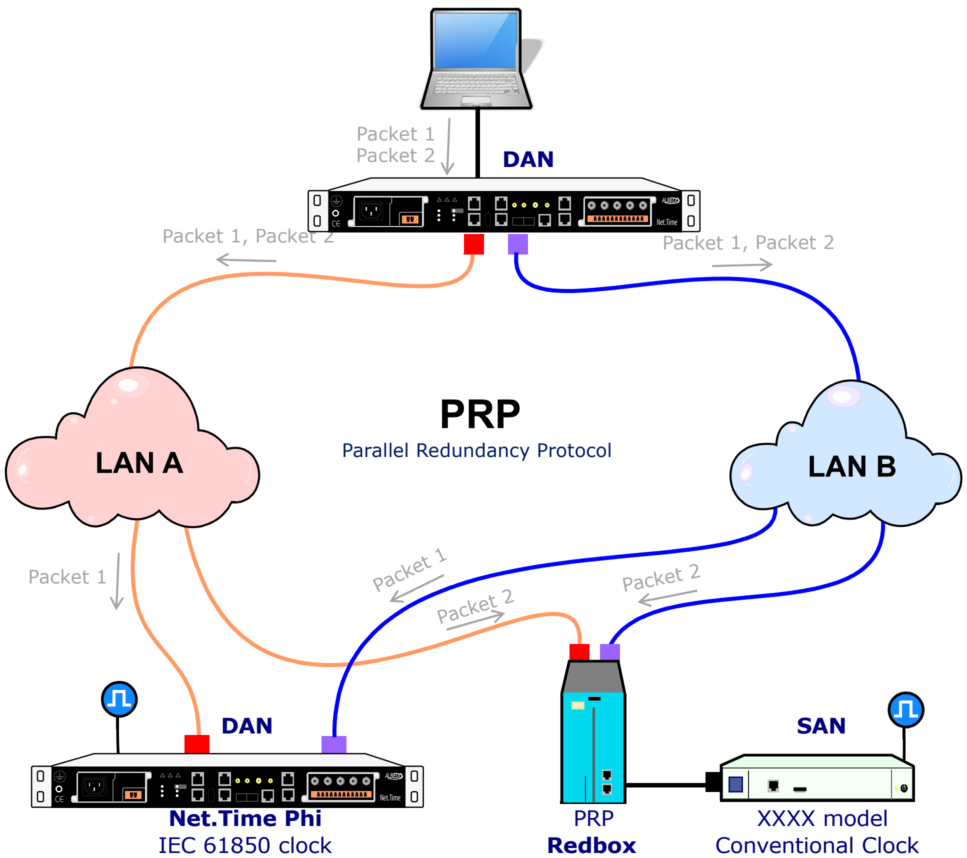
IEC 61850 substation

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



Conventional migration **IEC 61850**

DAN (double) - SAN (single)



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.

The latency of both networks should be similar, if they were very disparate packets would always arrive first through the same network and wait for the second.

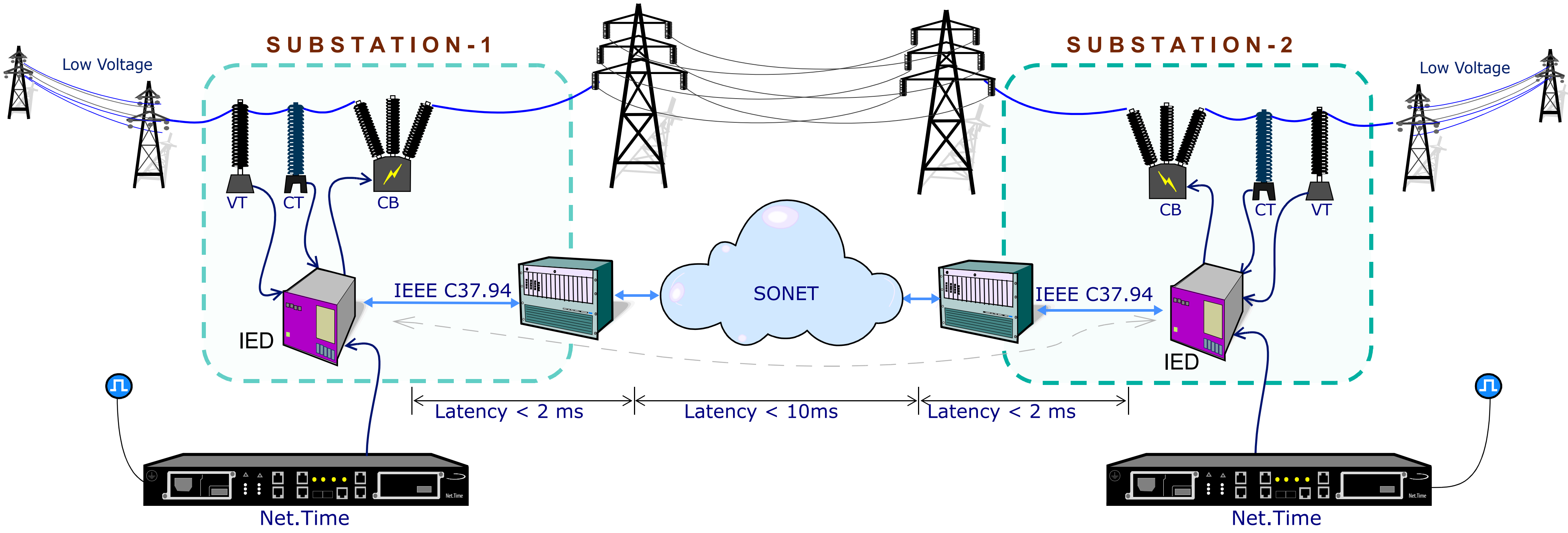
We can find two types of devices:

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

PRP is encapsulated in IP/MAC then it can use conventional networks so LAN A and LAN B can transport any traffic, PRP and non-PRP, and this a nice advantage compared with HSR.

PRP with zero-time recovery for PTP and NTP

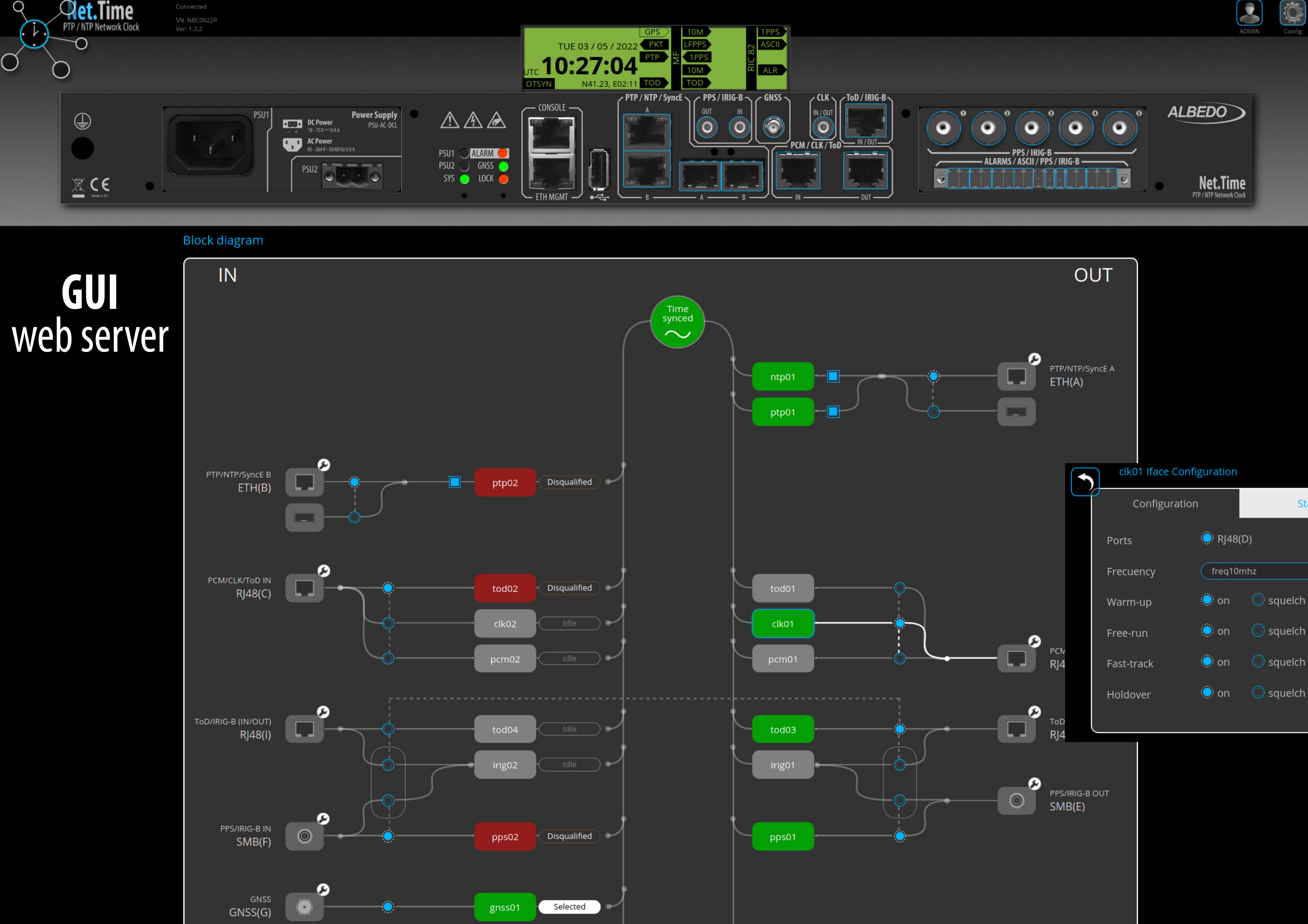
Phase for C37.94 Teleprotection



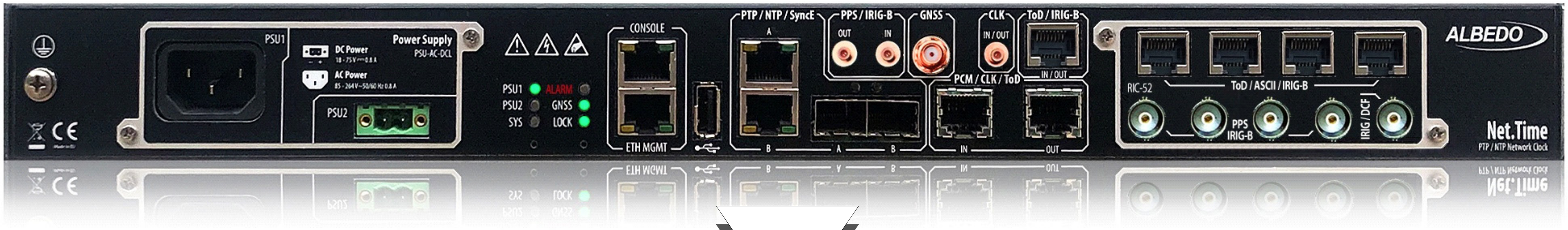
Teleprotection is based on the comparative of electrics parameters a both sides of the lines under protection, therefore any strategy requires perfect synchronization of all the elements. Phase synchronization is required to prevent overloads and facilitate reconnection.

Differential Protection requires permanent Synchronization

GUI web server



WAN



Substation

That's all

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the Path to Excellence