Deployments with Multiple Synchronization References

Selection, Monitoring & Fault Management

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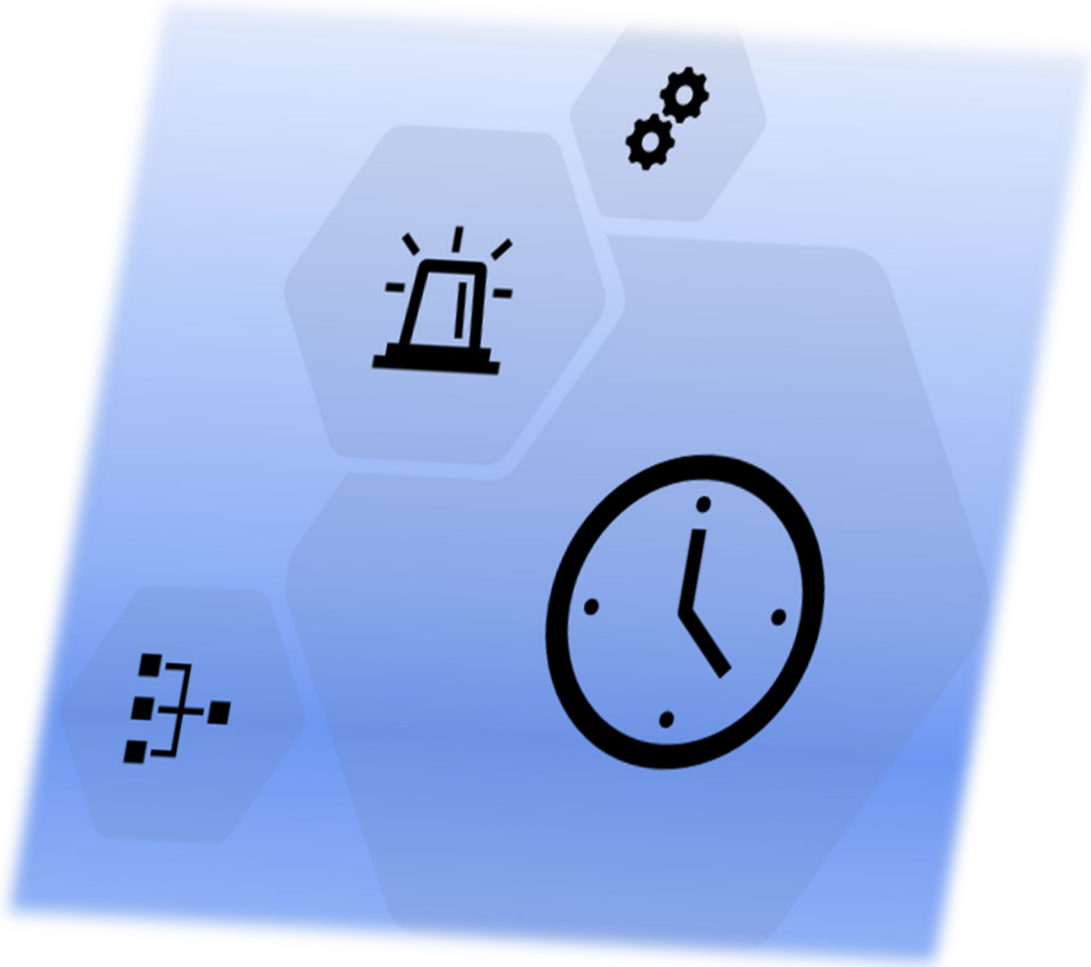
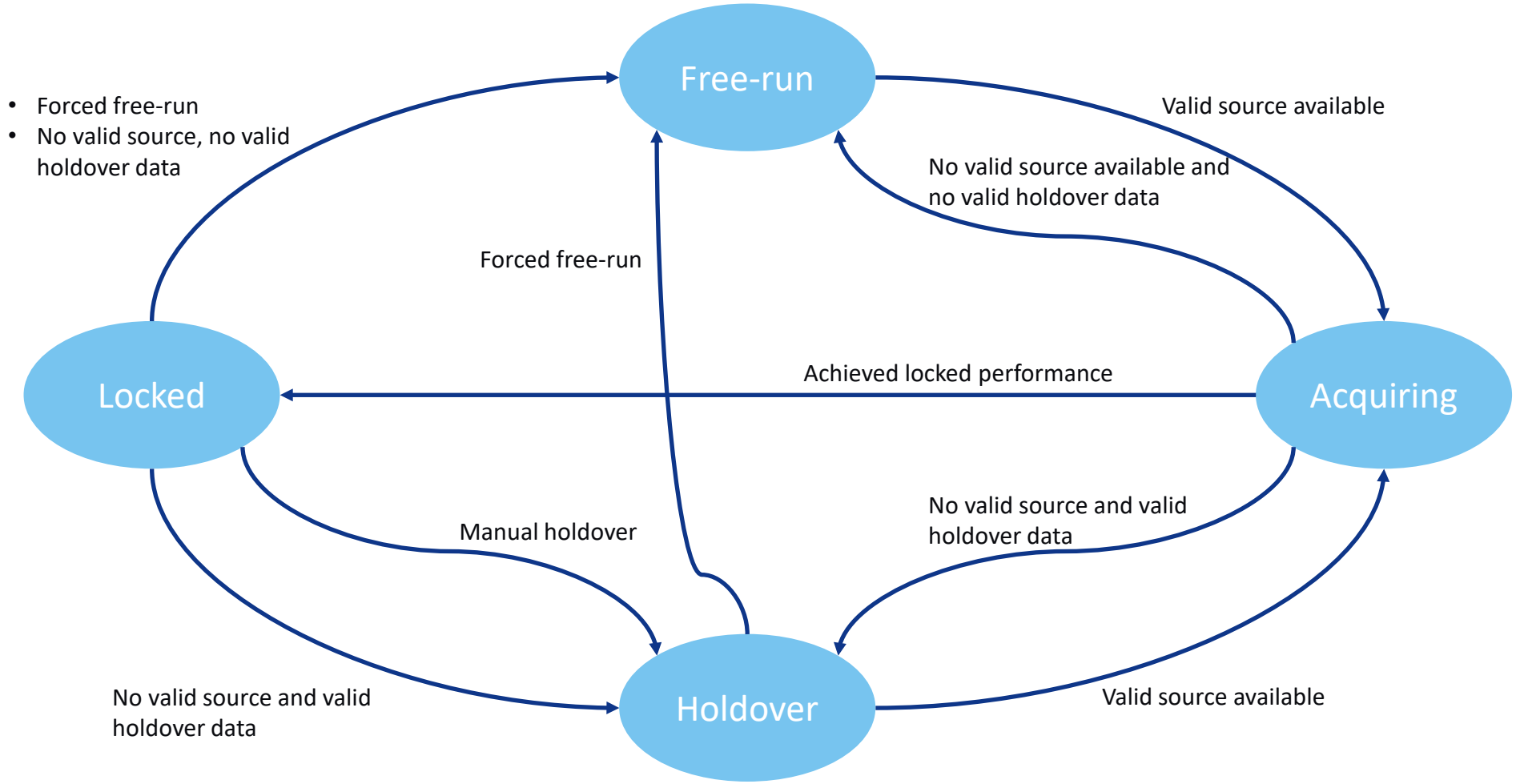
Outline

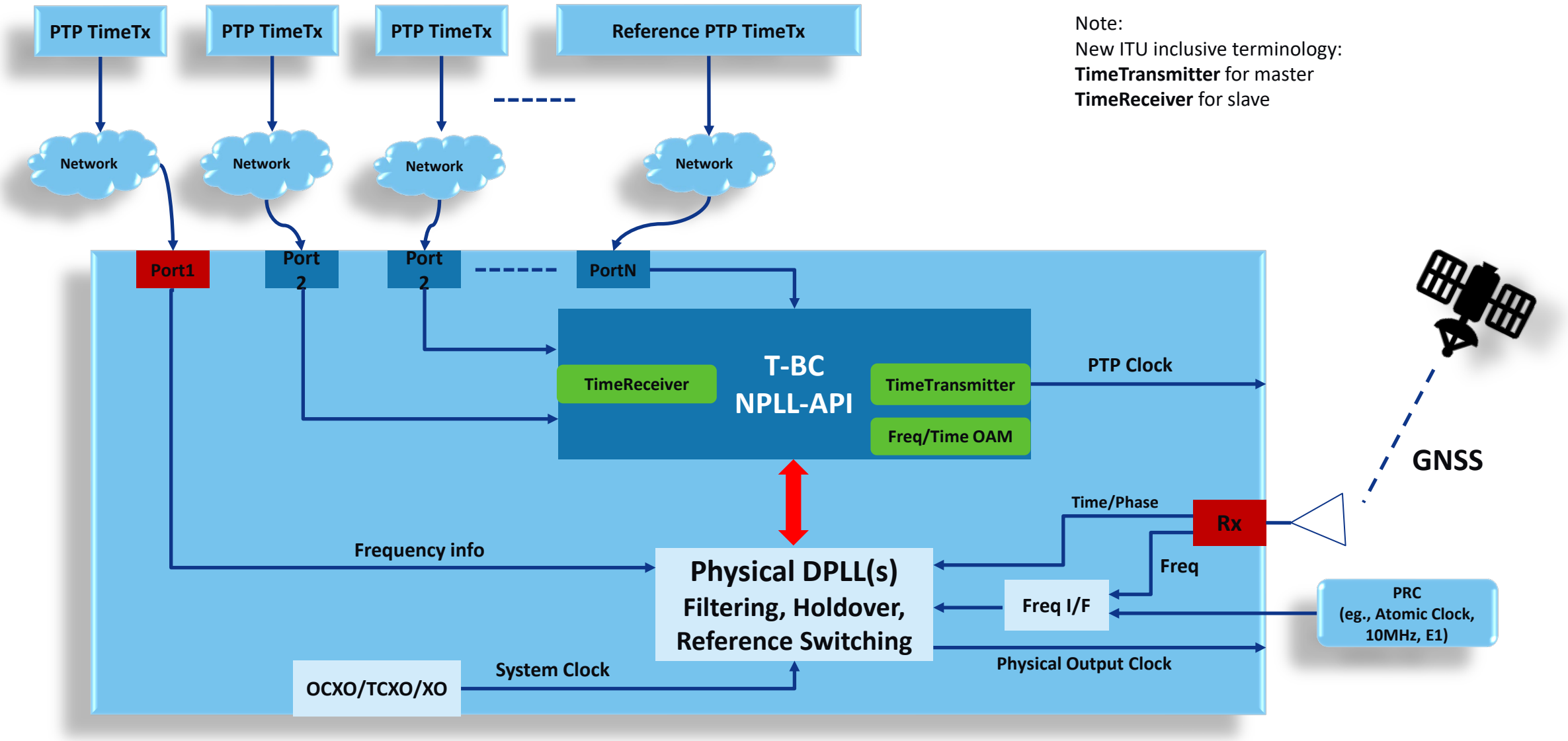
- **Clock States**
- **Fault Management**
- **Multi-reference T-BC**
- **Frequency Monitoring Alarms**
- **Phase Monitoring Alarms**
- **Monitoring Process**
  - Standby
  - Association
  - Performance
  - Switching



Clock State Diagram G.781.1



Multi-Reference T-BC



Note:
New ITU inclusive terminology:
TimeTransmitter for master
TimeReceiver for slave

Fault Management (G.7721, G.Sup68)

- **Equipment synchronization FCAPS functions (Fault, Configuration, Accounting, Performance and Security)**
- **"Fault management includes the detection, isolation and correction of abnormal operation of the synchronization network and elements. " [G.7721]**
- **Alarms:**

Physical layer Frequency	Packet Layer Time/Freq
Loss of timing inputs (dLTI) Reference Loss	Loss of PTP message
Clock unlock	Time unlock
Source performance degradation	Time/Phase Offset
SSM level degradation	TOD (or PTP) input degradation
loss of SSM	loss of PPS+TOD

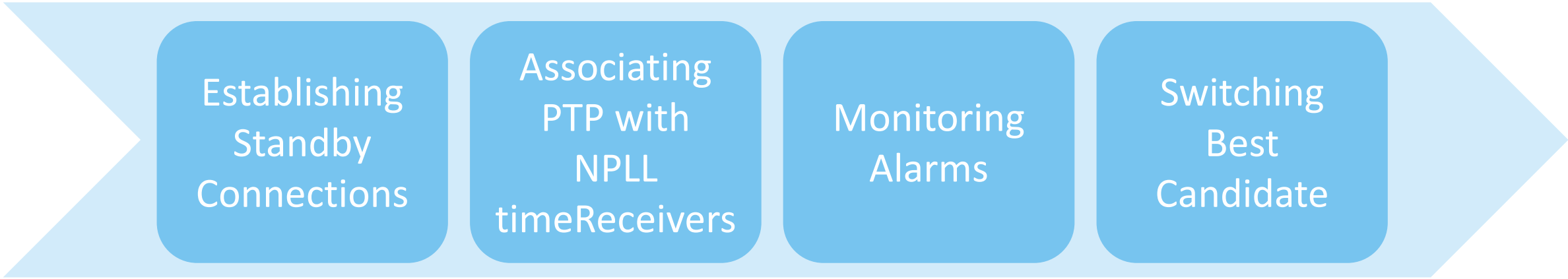
Frequency Monitoring (G.Sup68)

Classification	Alarm level	Alarm description	
		Physical Layer	Over Packet
Alarm	Critical alarm	Frequency reference source loss	Frequency reference source loss
		Clock unlock	PTP clock unlock
		Clock hardware failure	Port failure
	Major alarms	SSM message loss	Announce message loss
		Frequency offset of current reference source is over the limit	Sync message loss
		SSM quality level degradation	PTP packet timing signal unusable
		Clock pull-in or hold-in	Frequency offset of current reference source is over the limit
		Clock power-cycle (during period)	Clock-class degradation of current frequency reference source
	Minor alarms	Frequency offset of reference source listed in priority list is over the limit	Frequency offset of reference source listed in priority list is over the limit
		Clock oscillator frequency drift notice	Frequency offset by PTP detection is over the limit
Event	Event	Frequency reference source switch	Frequency reference source switch
		Frequency synchronization status switch	Frequency synchronization status switch

Time Monitoring (G.Sup68)

Classification	Alarm level	Alarm description
Alarm	Critical alarm	1PPS+TOD input loss
		PTP physical link failure (network outage)
		Time unlock (phase lock)
	Major alarms	TOD input degradation
		PTP input degradation
		Announce message loss
		Sync or Delay_Resp message loss
	Minor alarms	Time offset accumulation is over the limit
		Measured time error by reference comparison is over the limit
		Measured time error based on passive port is over the limit
		Measured time error based on PTP message is over the limit
Event	Event	Local timeReceiver port switch
		GM clock switch
		Time synchronization status switch

Multi-Port Monitoring Process



Standby PTP Connections for G.8265.1

- Uses a unicast negotiated model for frequency sync
- The PEC-S itself treats each individual PTP connection (port) as a separate PTP clock
- The PTP stream requests full-timing-service (Announce, Sync & Delay_Resp). The reference selection engine, based on ITU-T G.781, selects the best PTP clock. The other PTP clocks are in standby

Standby PTP Connections for G.8275.2

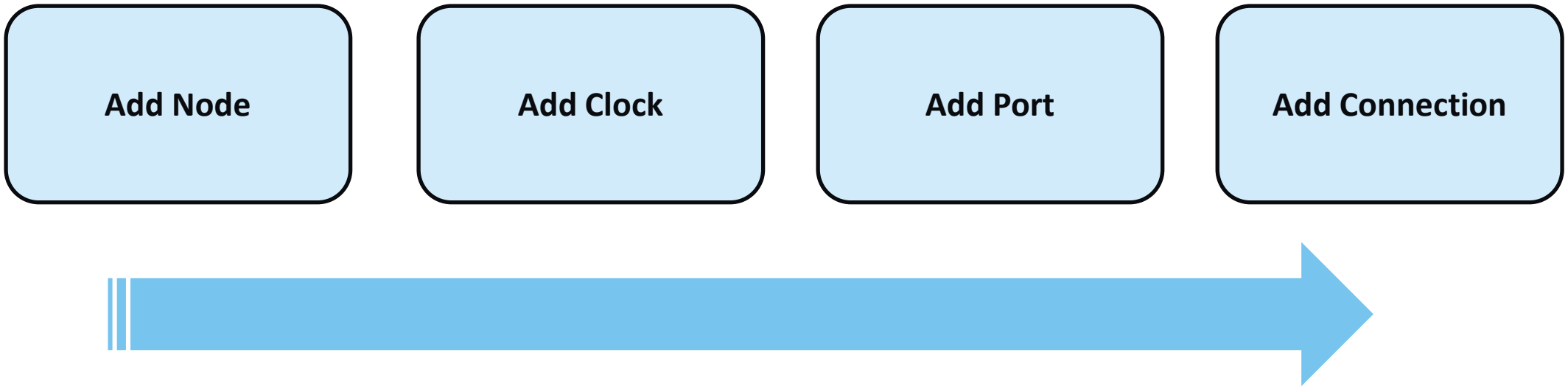
This profile uses a unicast negotiated model for phase/time synchronization with partial timing support

- **Operation without Local GNSS**
  - Any PTP port that is not in the timeReceiver state is allowed to request full timing service (Announce, Sync & Delay_Resp) from its neighbor using the PTP port's unicast table
  - The ABTCA selects the PTP connection from the PTP port in the timeReceiver state as active. The other PTP connections associated with each PTP port are in standby
- **Operation with Local GNSS**
  - The T-BC-P or T-TSC-P instantiates a single PTP clock with multiple PTP ports.
  - One PTP port will be instantiated for the GNSS input
  - The ABTCA, the virtual PTP port associated with the GNSS input will enter the timeReceiver state, while the other PTP ports will enter PASSIVE standby state

Standby PTP Connections for G.8275.1

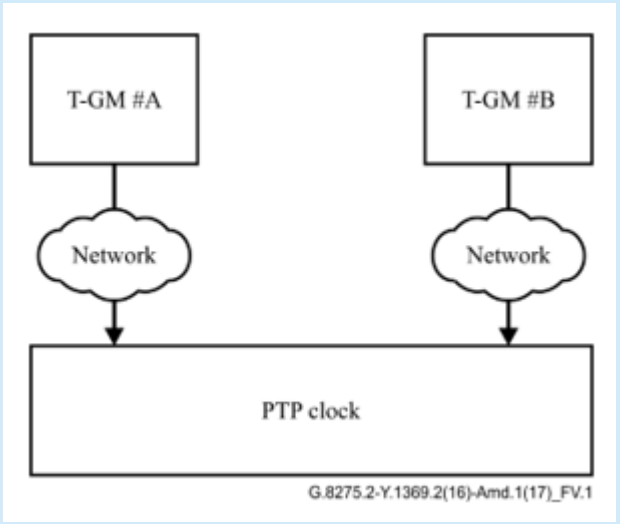
- Operates with a multicast model for phase/time synchronization with full timing support
- The T-BC or T-TSC instantiates a single PTP clock with multiple PTP ports.
- A PTP port that is not in the timeReceiver state is allowed to request timing information (Delay_Resp) from its neighbor
- A PTP port that is not in the TimeTransmitter state may send timing information (Announce, Sync & Delay_Resp) to its neighbor provided the alternate timeTransmitter flag is TRUE
- ABTCA, one PTP port will enter the timeReceiver state, while the other PTP ports will enter PASSIVE or TimeTransmitter state

Solution Architecture

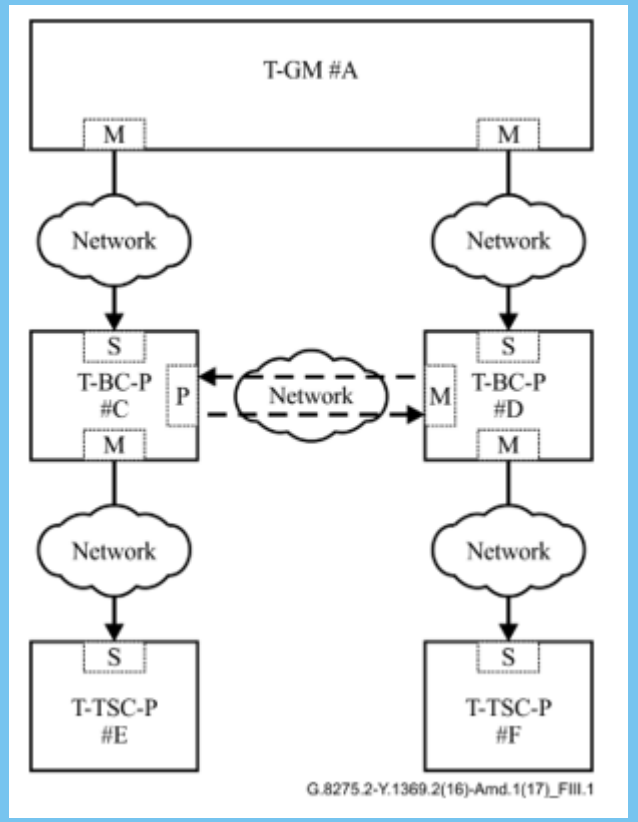


- NPLL Device. One for each hardware PLL
  - In PACKET or Frequency-assistance mode selects one NPLL timeReceiver
  - In ELECTRICAL mode selects the virtual PTP port
- NPLL timeReceiver(s)
  - Is active if selected by the NPLL device
  - Is standby/monitoring if not selected by the NPLL device

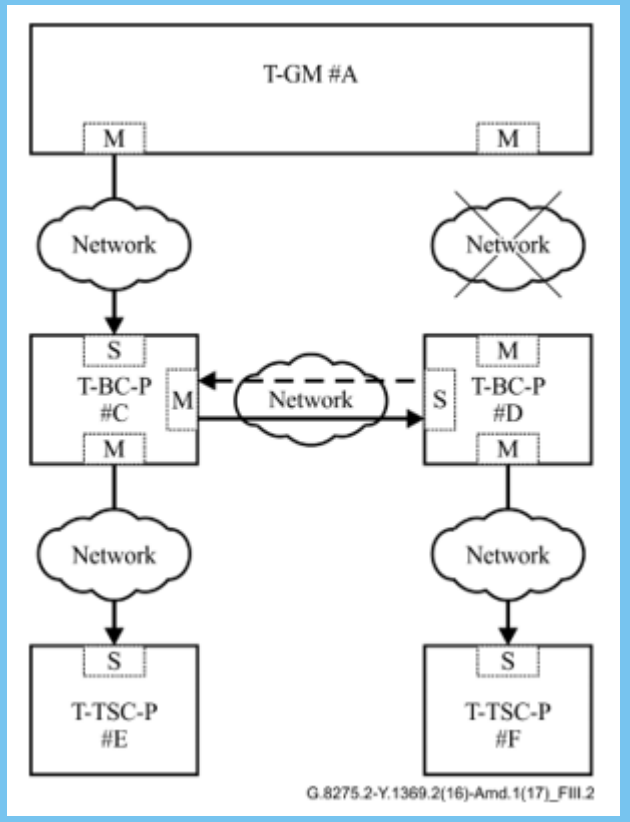
Example G.8275.2 Appendix III, V



BTCA Cycling



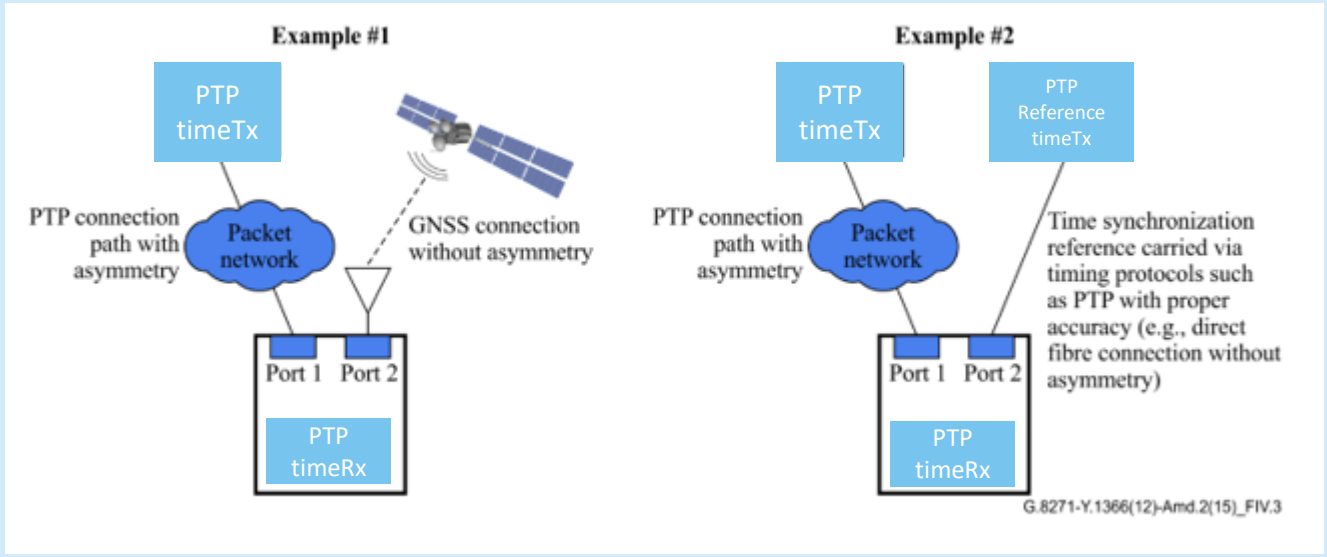
Before Failure



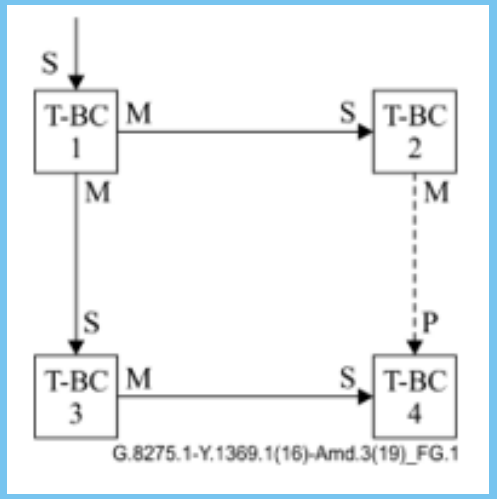
After Failure

S: TimeReceiver, M: TimerTransmitter

Examples from G.8275.1 (A.XII and Anex G)



Alternate timeTransmitter monitoring using peer PTP port



Time monitoring with passive PTP port

Note that:
S: TimeReceiver, M: TimerTransmitter

Associating PTP Connections with NPLL TimeReceivers

- **ITU-T G.8265.1**
  - On a PEC-S, each PTP clock is associated 1:1 with an NPLL timeReceiver
- **ITU-T G.8275.2**
  - On a T-BC-P or T-TSC-P/T-TSC-A, each PTP port is associated 1:1 with an NPLL timeReceiver. A virtual PTP port is not associated with a NPLL timeReceiver
- **ITU-T G.8275.1**
  - On a T-BC or T-TSC typically only one NPLL timeReceiver is associated with the PTP clock. The PTP port in the timeReceiver state currently receives timing information (Sync, Delay_Resp), therefore there is nothing to monitor on the other PTP ports

TimeReceiver Reporting

- **Following the standard alarms mentioned earlier, active and monitoring timeReceivers will report on clock quality and state and issue associated alarms.**
- **Examples:**
  - Phase offset value
  - Frequency stability value
  - FREQ_LOCK state
  - PHASE_LOCK state
  - SSM Loss

Switching Operation

1. Given the ability to monitor multi-PTP connections
2. Choice for automatic detection of initial Phase and/or Frequency offsets
3. Choice to manually applying Phase and Frequency offsets
4. Switch to standby timeReceiver B from A
5. Follow the same process to switch to timeReceiver C, D, etc.

Acronyms

- ABTCA Alternate Best TimeTransmitter Clock Algorithm
- API Application Programming Interface
- NPLL Network Phase Locked Loop
- BC Boundary Clock
- GNSS Global Navigation Satellite System
- PEC-S Packet-based Equipment Clock - TimeReceiver
- PTP Precision Time Protocol (IEEE 1588)
- T-TSC-A Assisted Partial Support Telecom Time TimeReceiver Clock
- T-TSC-P Partial Support Telecom Time TimeReceiver Clock
- SSM Synchronization Status Message
- SyncE Synchronous Ethernet
- ToD Time of Day

Standards References

- ITU-T G.7721 *Management requirement and information model for synchronization*
- ITU-T G.Sup68 *Synchronization OAM requirements*
- ITU-T G.8265.1 *Precision time protocol telecom profile for frequency synchronization*
- ITU-T G.8275.1 *Precision time protocol telecom profile for phase/time synchronization with full timing support from the network*
- ITU-T G.8275.1 *Annex G Monitoring*
- ITU-T G.8275.1 *Appendix XII Monitoring*
- ITU-T G.8275.1 *Annex K Monitoring*
- ITU-T G.8275.2 *Precision time protocol telecom profile for phase/time synchronization with partial timing support from the network*
- ITU-T G.8275.2 Appendix III Monitoring
- ITU-T G.8275.2 Appendix V BTCA cycling
- ITU-T G.8275 *Architecture and requirements for packet-based time and phase distribution*
- ITU-T G.8275 Annex E

Thank You

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