Comparison of On-path Support to Other Methods for Precision Timing Protocol

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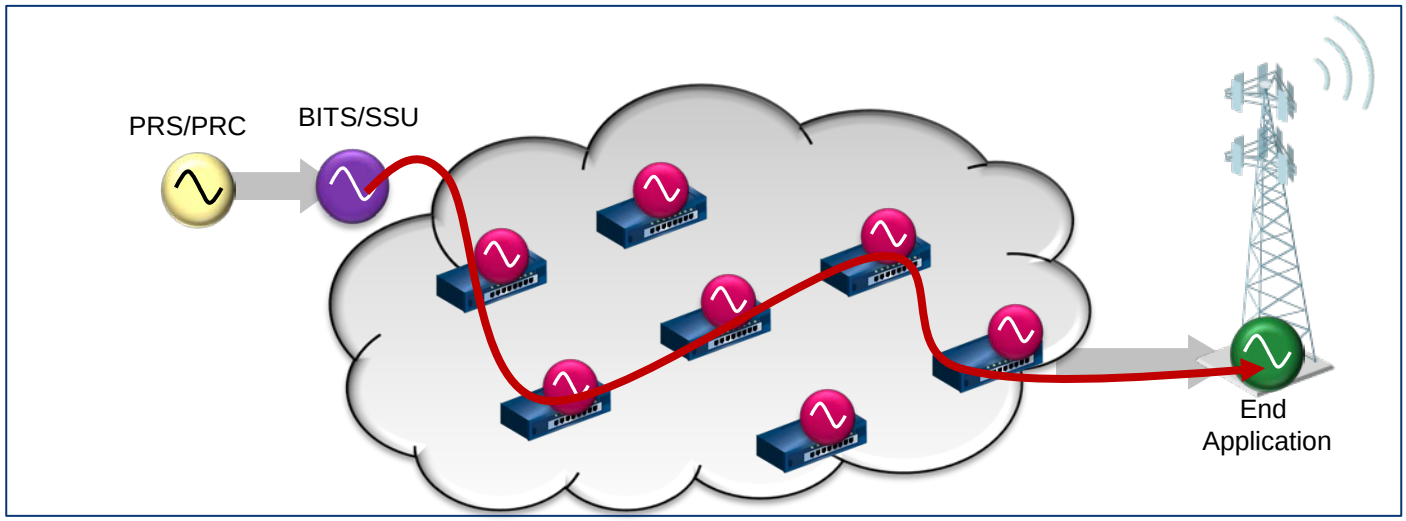
Introduction

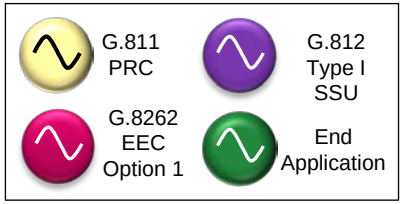
- Delivery of Frequency via Synchronous Ethernet
- Methods for delivering phase
  - Phase over Unaware networks
  - Phase over Partially aware network
  - Phase over Aware networks
- Comparison of results using different methods

Use case – SyncE for frequency distribution

- Fully approved in ITU-T G.8262
- Advantages
  - Synchronous Ethernet extends the SONET/SDH timing model to Ethernet
  - Meets all existing frequency requirements via the bit rate of the Ethernet physical layer
    - Independent of packets and loading
- Disadvantages
  - Need to upgrade Ethernet equipment in the Ethernet packet chain to support SyncE
  - Need unbroken chain of SyncE equipment from frequency source to end application
    - May use SONET or PDH to add timing to Ethernet at some intermediate point in the network (i.e. at egress from SONET over packet network to Ethernet network)

SyncE Syntonization





Transition from Frequency to Frequency and Phase

Terminology: Aware networks

- Aware
  - Addition of Boundary clock at each node in the network
    - According to ITU model current under study
  - Split up the network in to smaller pieces
  - Needed for end-to-end time of day performance

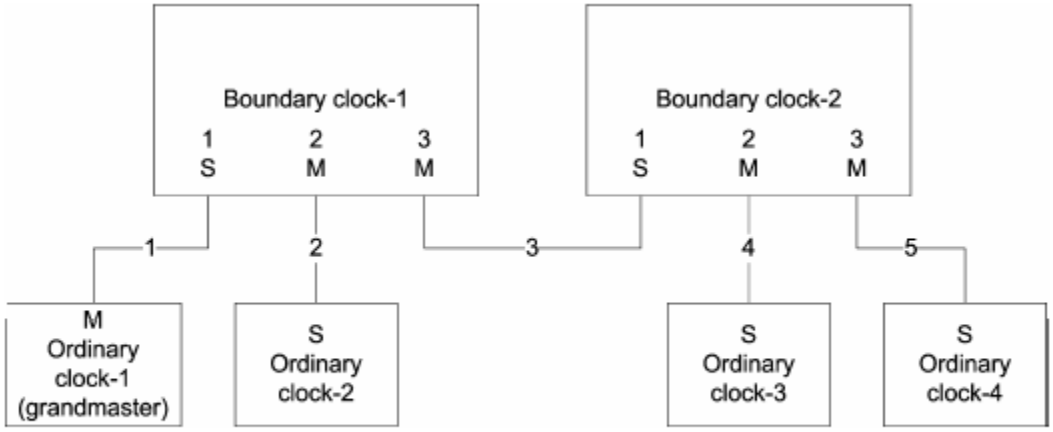


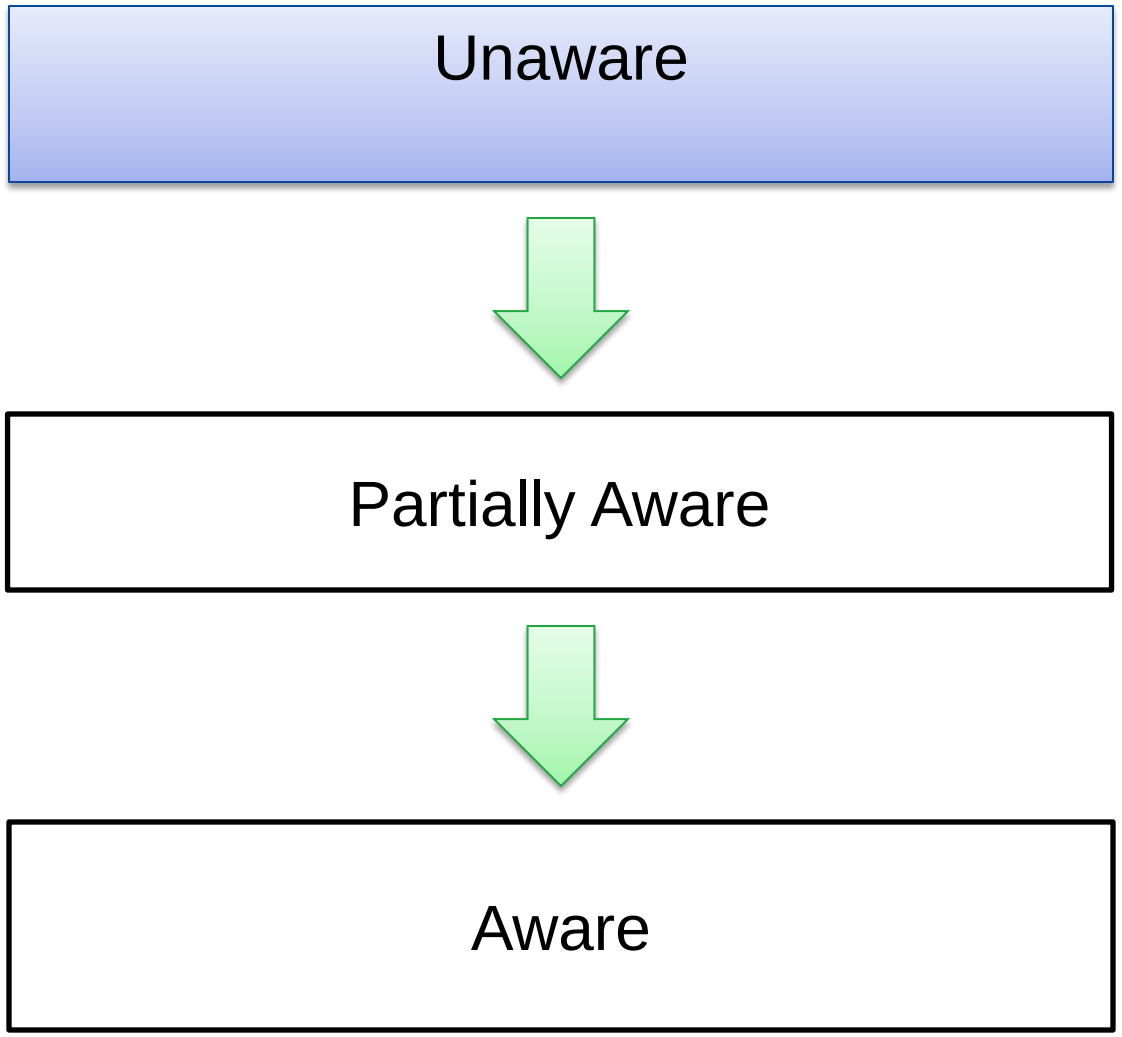
Figure 10—Simple master–slave clock hierarchy

From IEEE Std 1588-2008 page 32

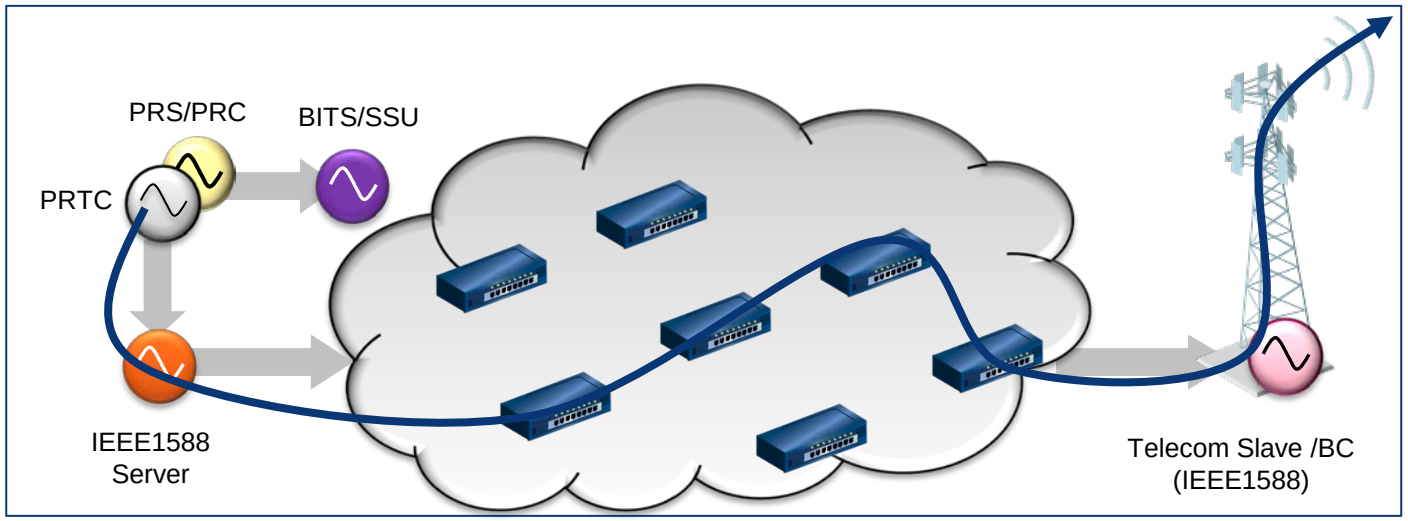
Terminology: Network Types

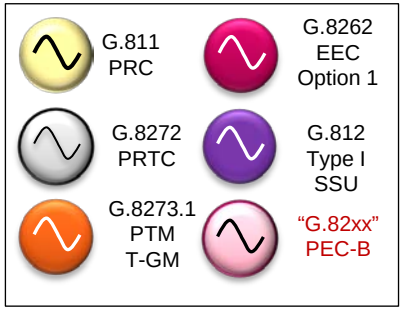
- Unaware networks
  - No processing of the PTP packets at intermediate nodes by Boundary Clocks
- Partially Aware
  - Some Boundary Clocks in the network but not at every node
  - May be needed for existing networks during transition
  - May allow phase transfer without upgrading all network elements in network
- Aware Networks
  - All nodes in the network have Boundary Clocks

Network Types

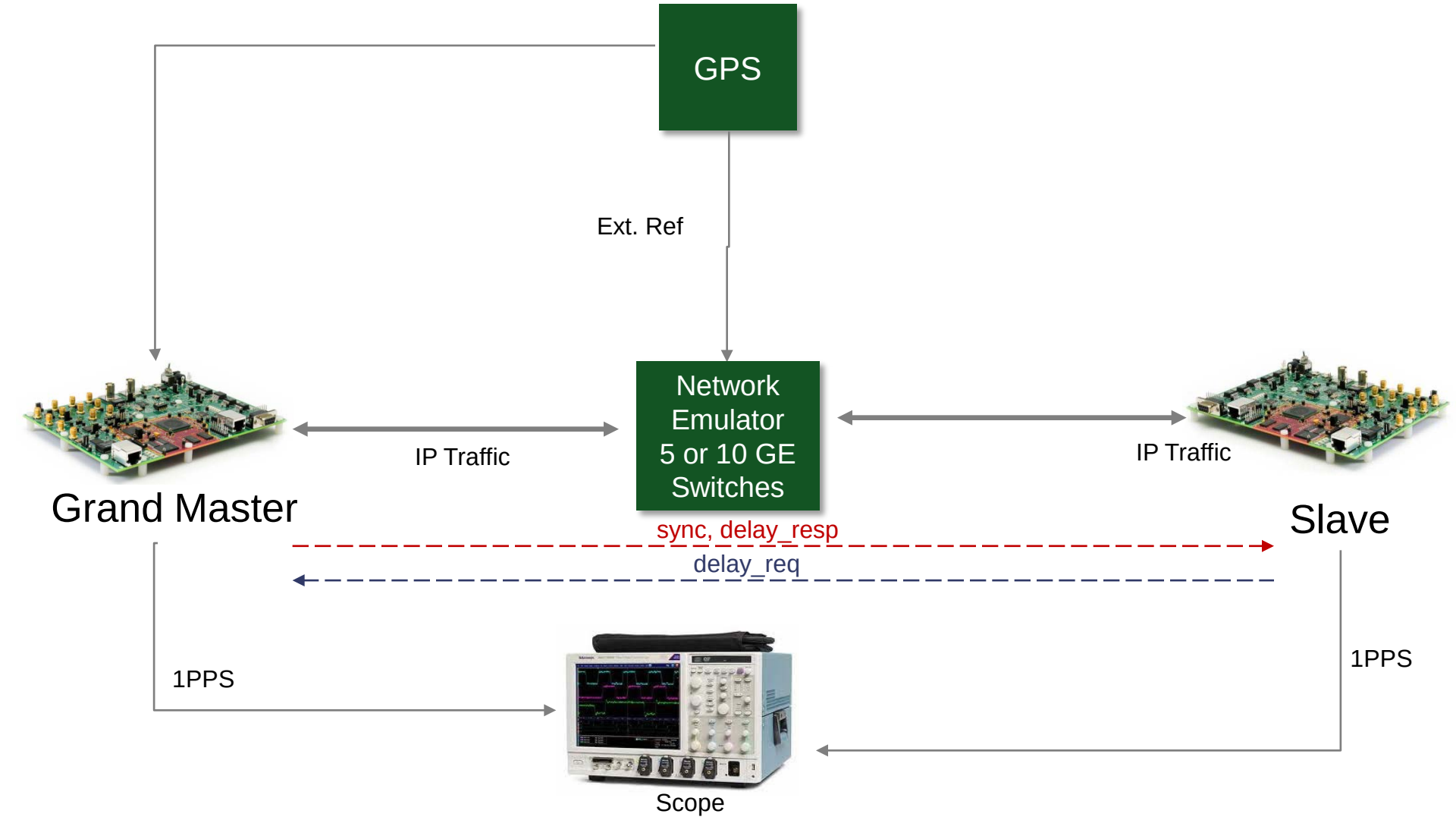


Unaware
No On-Path Support





Test Setup



Results – 5 switch network

- 5 Gigabit Ethernet switch network
- Passed frequency mask for DS1 and E1 network

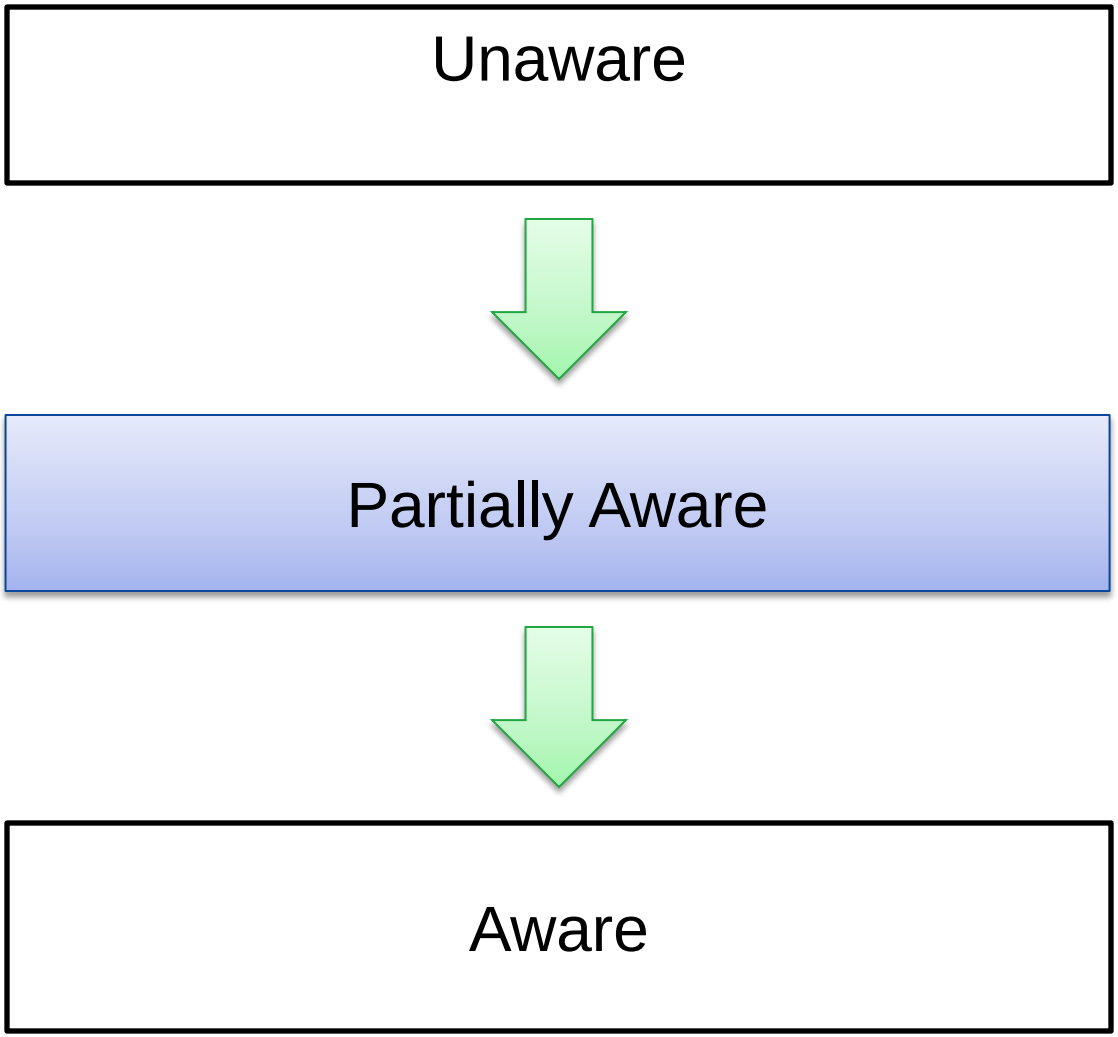
Test Case	Traffic Model	Phase (30 min from start-up)		
		Minimum [ns]	Maximum [ns]	Absolute [ns]
TC12 - Static	TM2	-92	5	92
TC13 – Square (50min from start)	TM2	-220	90	220
TC13 – Square (70min from start)	TM2	-180	102	180
TC14 - Ramp	TM2	-140	30	140
TC15 - Outage 10 & 100 s.	TM2	-62	25	62
TC16 - Cong. 10 & 100 s.	TM2	-52	-5	52
TC17 – Re-route 3 Sw 200us.	TM2	-65	63	65

Results – 10 switch network

- 10 Gigabit Ethernet switch network
- Passed frequency mask for DS1 and E1 network

Test Case	Traffic Model	Phase (30 min from start-up)		
		Minimum [ns]	Maximum [ns]	Absolute [ns]
TC12 - Static	TM2	-220	+150	220
TC13 – Square (50min from start)	TM2	-200	+285	285
TC13 – Square (70min from start)	TM2	-330	+280	330
TC14 - Ramp	TM2	165	+265	265
TC15 - Outage 10 & 100 s.	TM2	165	+232	232
TC16 - Cong. 10 & 100 s.	TM2	115	+260	260
TC17 – Re-route 3 Sw 200us.	TM2	190	+285	285

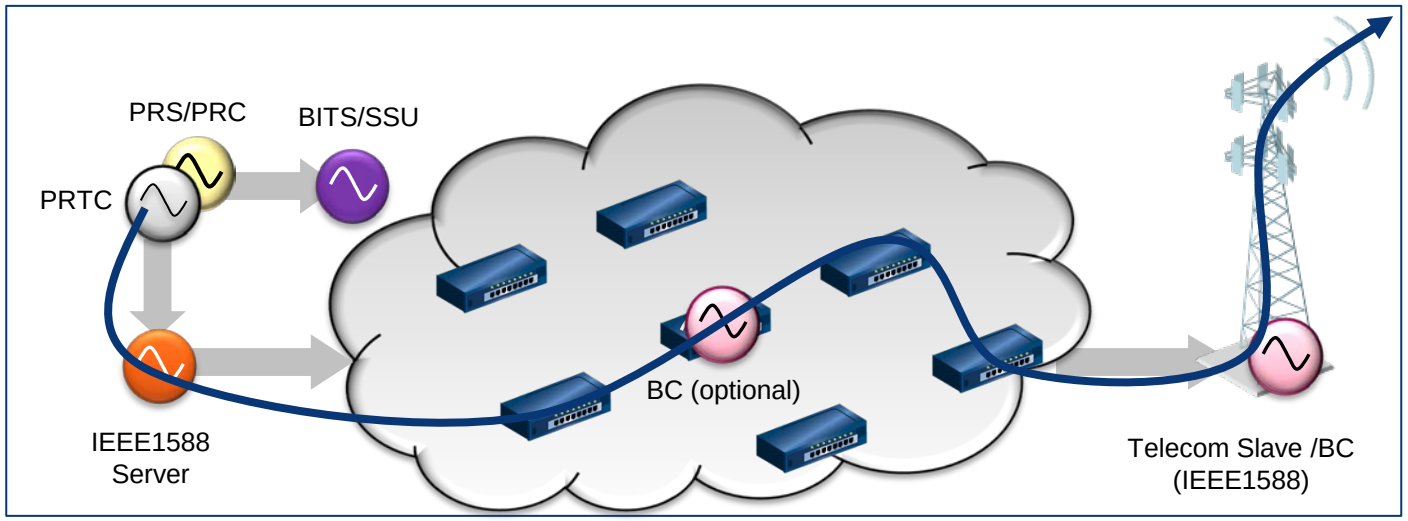
Network Types

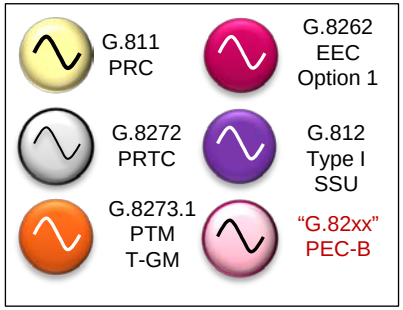


Use case
Phase over Partially aware networks

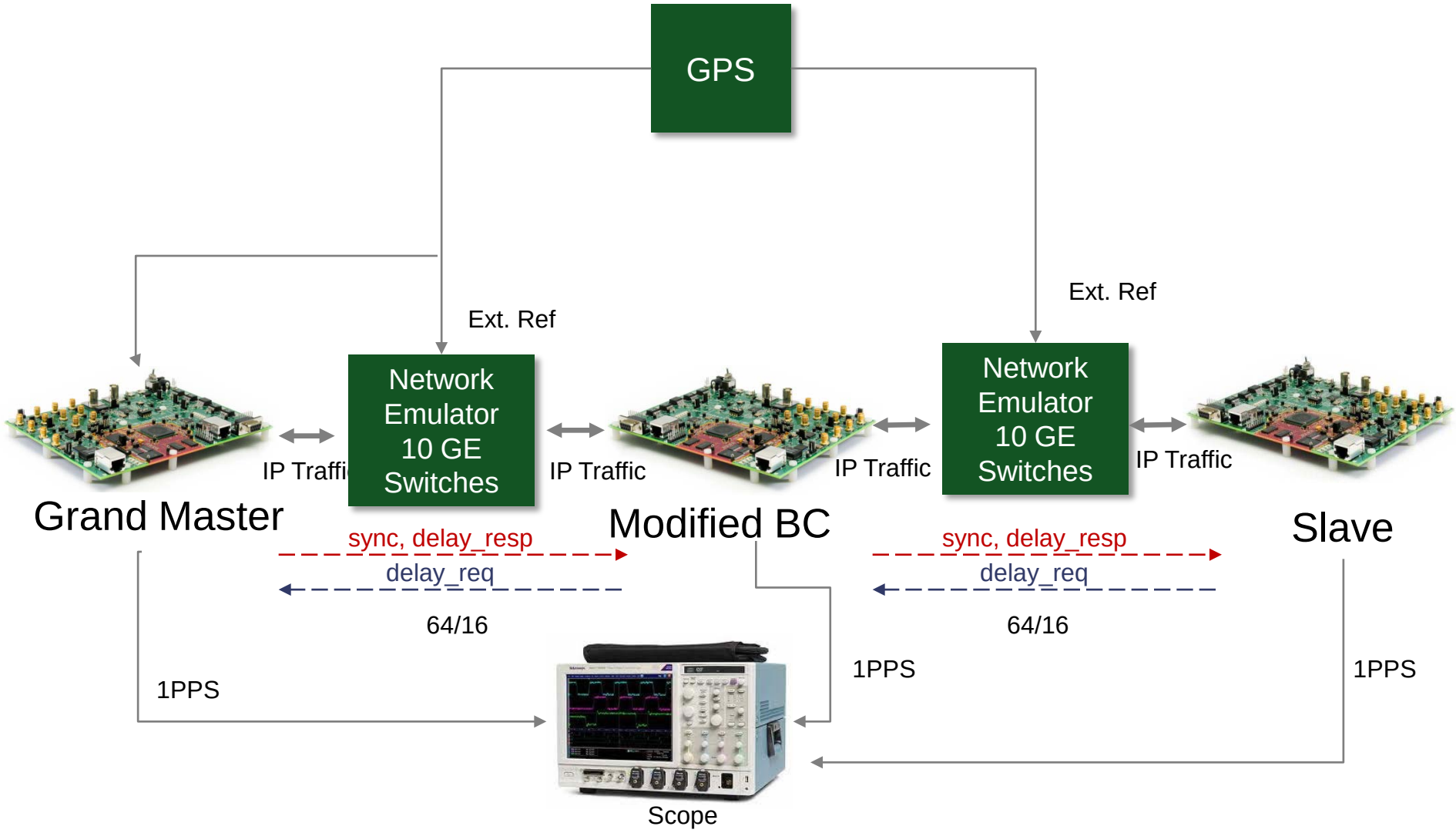
- Currently under study in standards
- Too many network types and configurations
- Need unaware phase profile
- May be possible in a managed network
  - Single carrier with careful engineering of link utilization and routing

Partially Aware Network
Partial On-Path Support without SyncE Syntonization





Test Setup



Results - Frequency

- Passed frequency mask for DS1 and E1 network

Test Case	Traffic Model	ITU-T G.8261 PEC Deployment Case 2		G.824 DS1	G.824 Traffic (TDEV)
		G.824 Traffic	CES		
BC: TC12 – TC17	TM2	✓	✓	✓	✓
Slave: TC12 – TC17	TM2	✓	✓	✓	✓

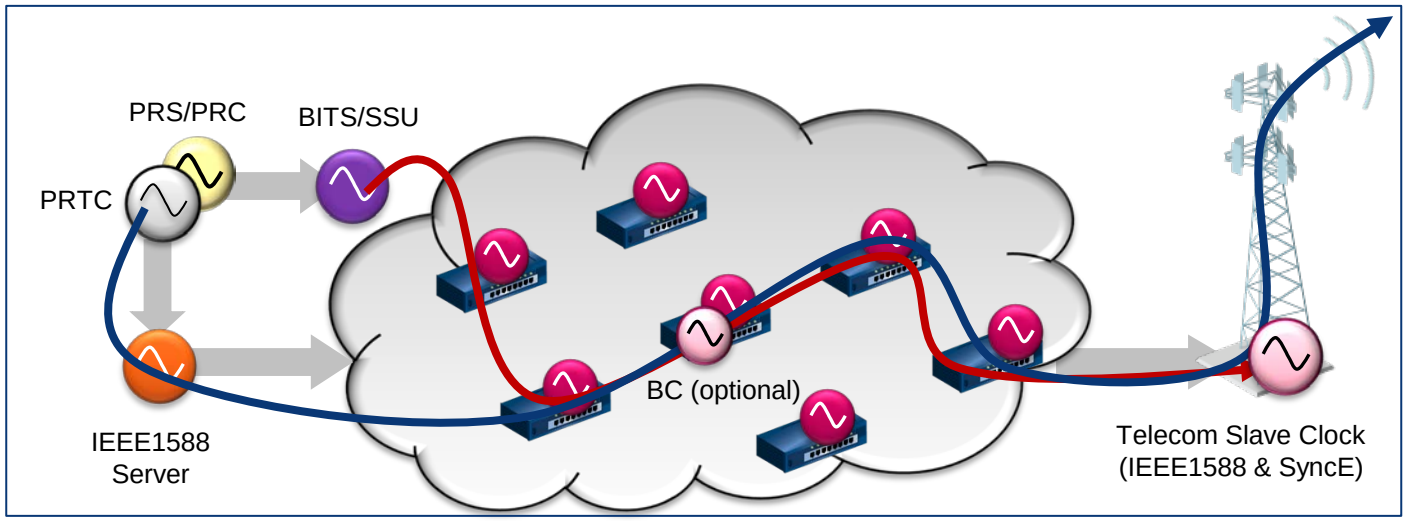
Test Case	Traffic Model	ITU-T G.8261 PEC Deployment Case 2		ITU-T PEC Deployment Case 1 / EEC Option 1 / ITU-T G.823 SEC	
		G.823 Traffic	CES	MTIE	TDEV
BC: TC12 – TC17	TM2	✓	✓	✓	✓
Slave: TC12 – TC17	TM2	✓	✓	✓	✓

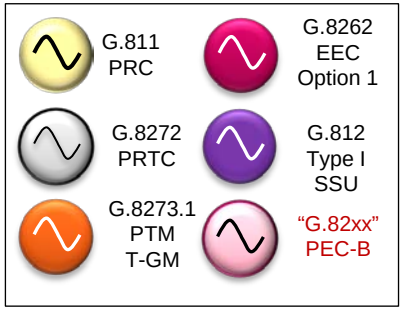
Results - Phase

- Passed phase mask of 1 microsecond over the 20 switch network
- Network: 10 GE switches – modified BC – 10 GE switches
- Used combined PDV file with 7 test cases

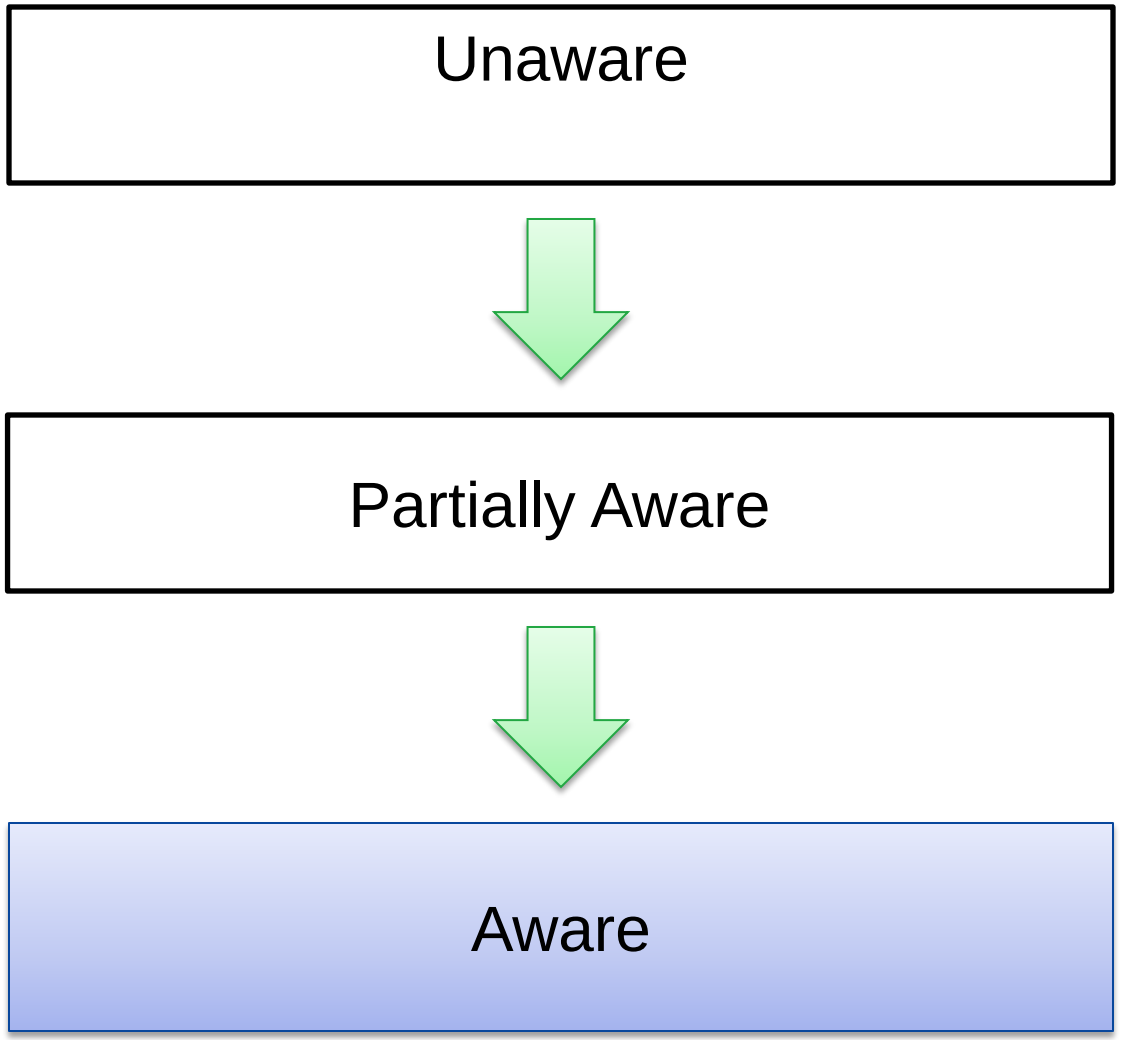
Test Case	Traffic Model	Phase		
		Min	Max	Abs
BC: TC12 – TC17	TM2	-550 ns	334 ns	550 ns
Slave: TC12 – TC17*	TM2	-939 ns	297 ns	939 ns

Partially Aware Network
Partial On-Path Support with SyncE Syntonization

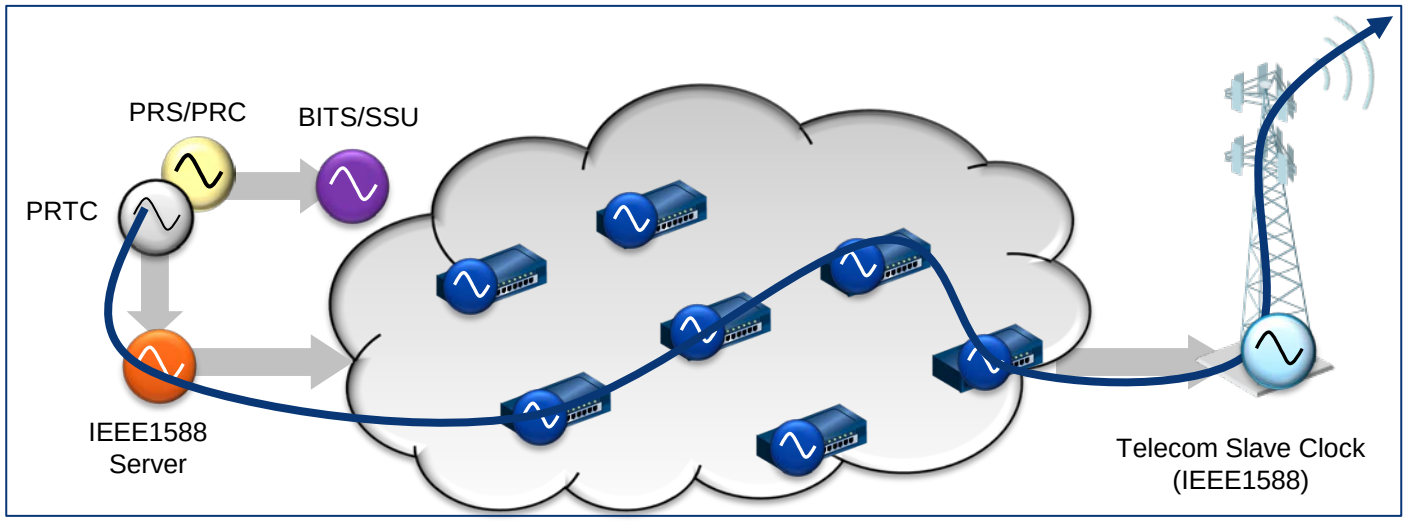


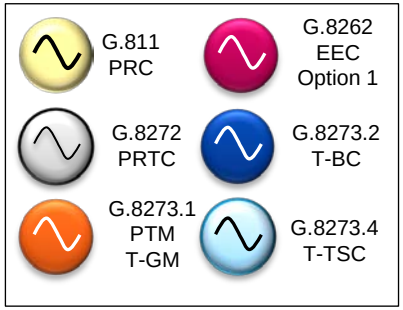


Network Types



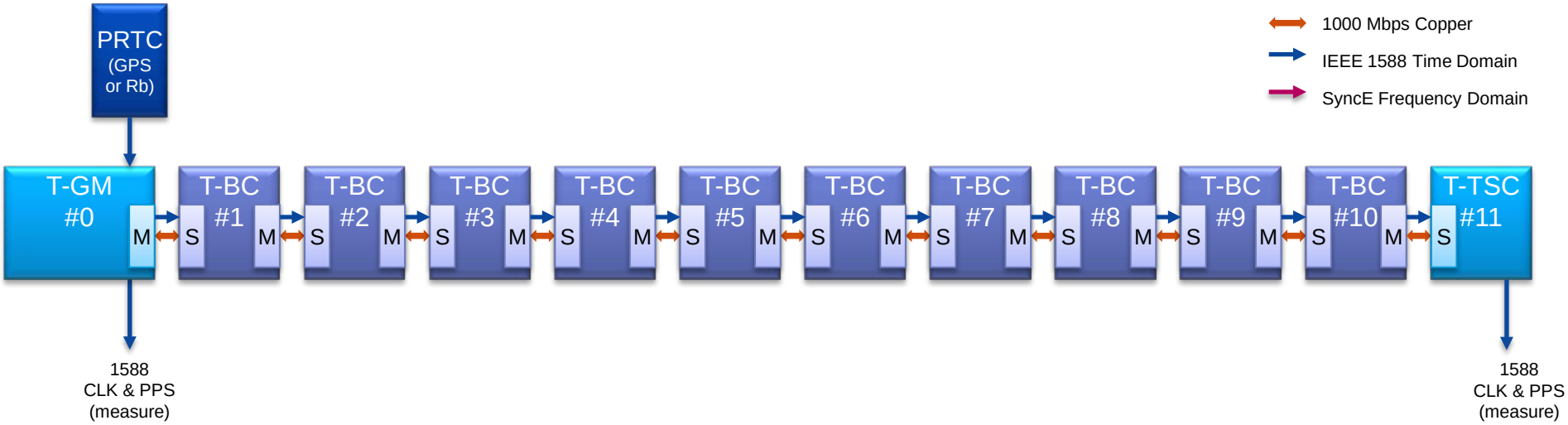
Aware Network
Full On-Path Support without SyncE Syntonization



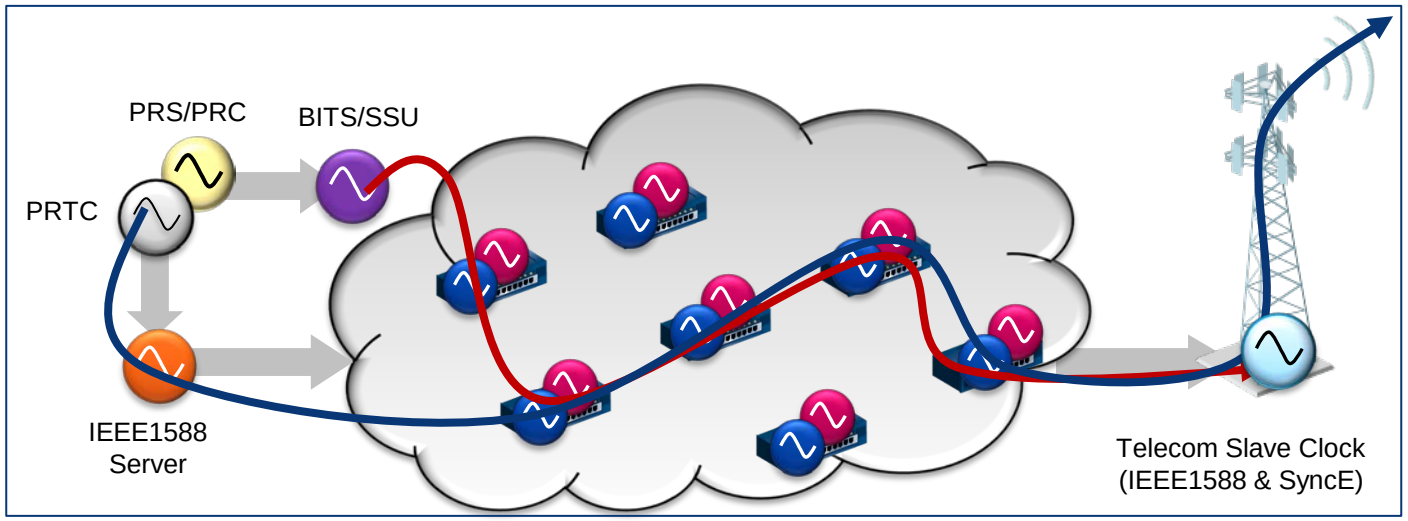


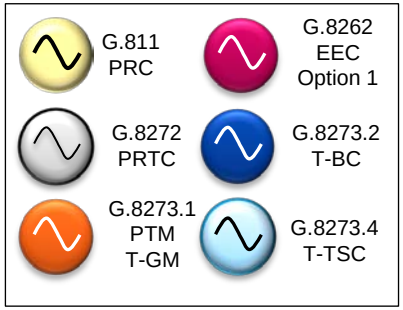
Test Setup

- Master, 10 Boundary Clock nodes, Slave
- Expect phase alignment of 150-200 ns
  - Based on noise accumulation along the chain at 16/16



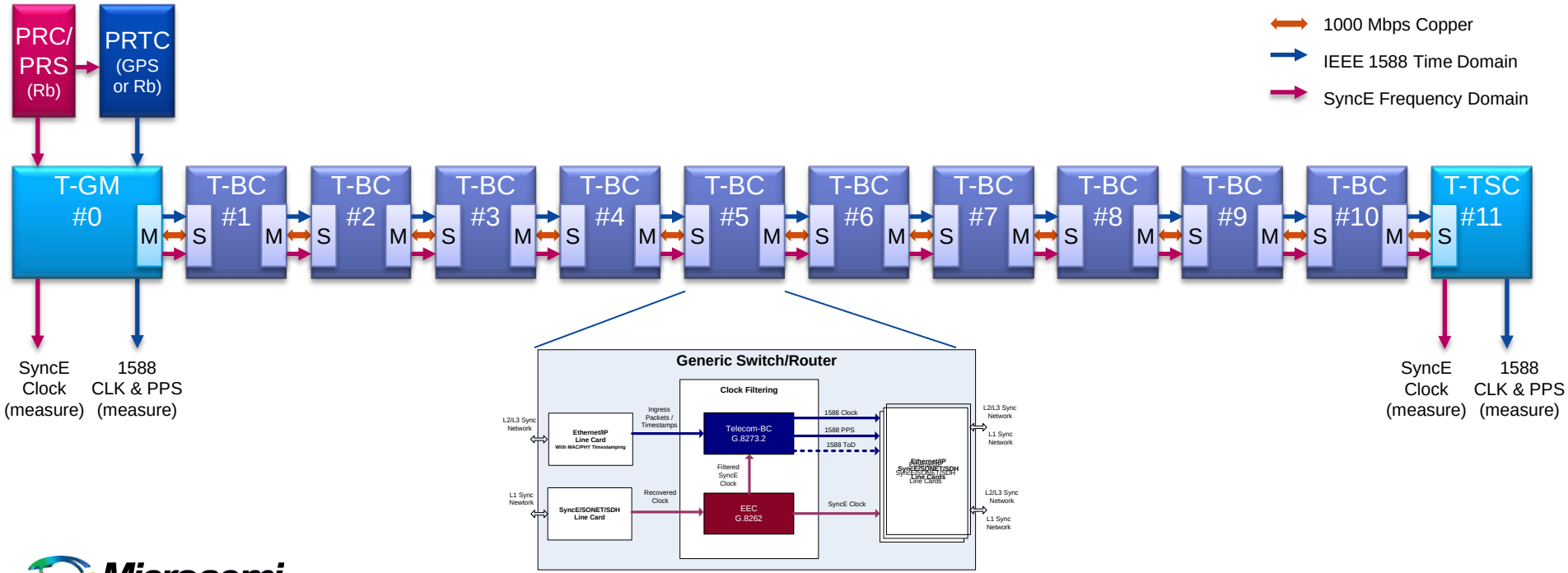
Aware Network
Full On-Path Support with SyncE Syntonization





Test Setup/Results

- Master, 10 Boundary Clock nodes, Slave
  - SyncE distribution reference chain
- Phase (at slave)
  - FFO < +/- 3 ppb
  - MTIE < 30 ns
  - Time Error < 70 ns
    - Note: Packet rate of 16/16



Summary

- Phase transfer results for various networks as shown in this presentation
- The use of aware network with SyncE support give the best performance
- The use of SyncE provides improvement in the partially aware case
- SyncE and IEEE-1588 together gives the best performance

Phase transfer (ns)	Partially Aware	Aware
No SyncE Support	Good	Better
With SyncE Support	Good	Best