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The ~~Revolution~~ Evolution of the IEEE 1588 Standard

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Agenda

- Backward compatibility
- New Optional features
  - Modular transparent clock
  - Profile Isolation
  - Interdomain interactions
  - High accuracy features
  - Security
  - Monitoring

Backward Compatibility

"The working group shall ensure that the resulting draft has the highest degree of backward compatibility possible with the previous edition of IEEE 1588…"

--- From the Bylaws of the IEEE 1588 Working Group

What Backward compatibility means

- New edition device will not break 2008 edition network
- New features are optional
- Old features work as before

Year	Version number	Backward compatible
2002	1	N/A
2008	2	No
2018	2.1	Yes, with v2

PTP Message Common Header

Table 18—Common message header

Bits								Octets	Offset
7	6	5	4	3	2	1	0		
transportSpecific				messageType				1	0
reserved				versionPTP				1	1
messageLength								2	2
domainNumber								1	4
reserved								1	5
flagField								2	6
correctionField								8	8
reserved								4	16
sourcePortIdentity								10	20
sequenceId								2	30
controlField								1	32
logMessageInterval								1	33

2008 edition

Table 26—Common PTP message header

Bits								Octets	Offset
7	6	5	4	3	2	1	0		
majorSdoId				messageType				1	0
minorVersionPTP				versionPTP				1	1
messageLength								2	2
domainNumber								1	4
minorSdoId								1	5
flagField								2	6
correctionField								8	8
messageTypeSpecific								4	16
sourcePortIdentity								10	20
sequenceId								2	30
reserved								1	32
logMessageInterval								1	33

New edition

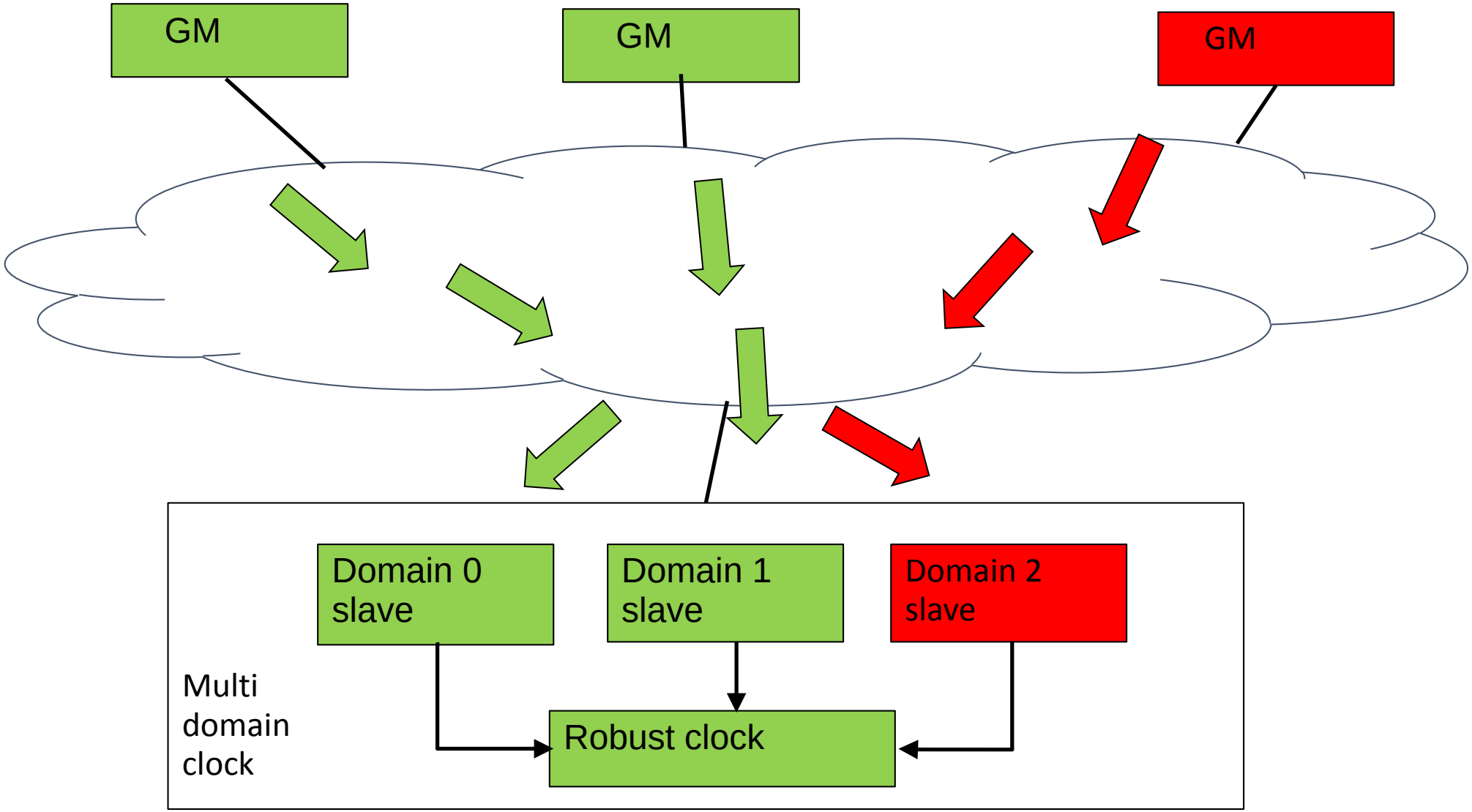
Modular Transparent Clocks

- Modular transparent clocks
  - Blade architecture switches/routers
  - SFP modules convert ordinary switches or routers to TCs
- Egress TC ports can update either correction field when Follow_Up present
- Both ingress or egress TC ports can change stepness
  - Create Follow_Up to accompany Sync
  - Combine correction fields in Sync, and drop Follow_Up (New!)
- twoStepFlag indicates message semantics only
  - TRUE means Follow_Up coming
  - FALSE means no Follow_Up
  - Regardless of TC port properties

Profile Isolation

- SdoId = Standardization development organization identity
  - 12 bits in common message header
  - Given out by IEEE Registration Authority
  - Any legitimate standards group could get one
    - 0x00 indicates standard, non-isolated PTP
    - 0x100 indicates IEEE 802
    - 0xFFD, 0xFFE are for experimental use
    - ITU, IEC, SMPTE, IETF, etc.. could each get one
    - Meinberg, University of Illinois, etc.. could not
- Domain
  - Domain 4, SdoId = 0x300, is a different domain than Domain 4, SdoId = 0x301
  - Profile can dictate how the domain numbers associated with that organizations SdoID are used
  - Domain 0-15 for profile 1, domain 6-31 for profile 2, etc.

Interactions among domains

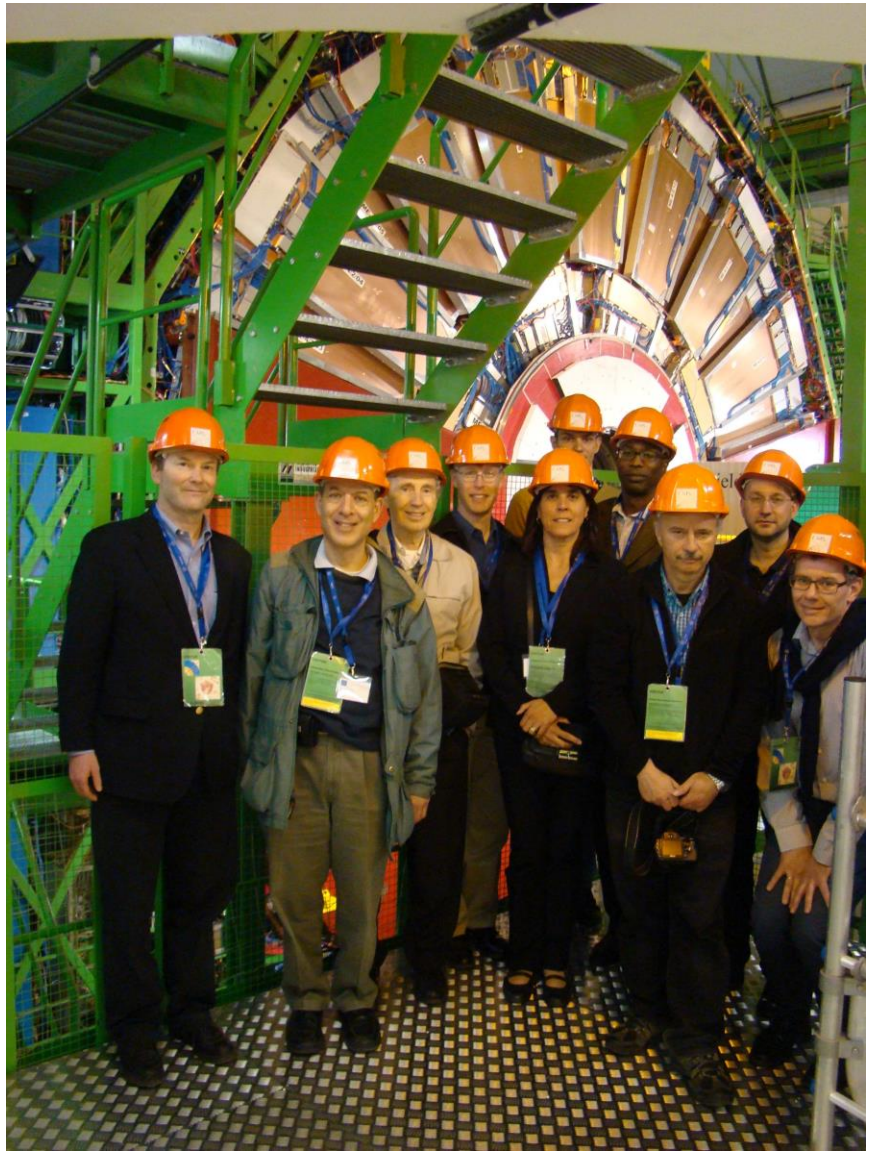


Interactions among domains

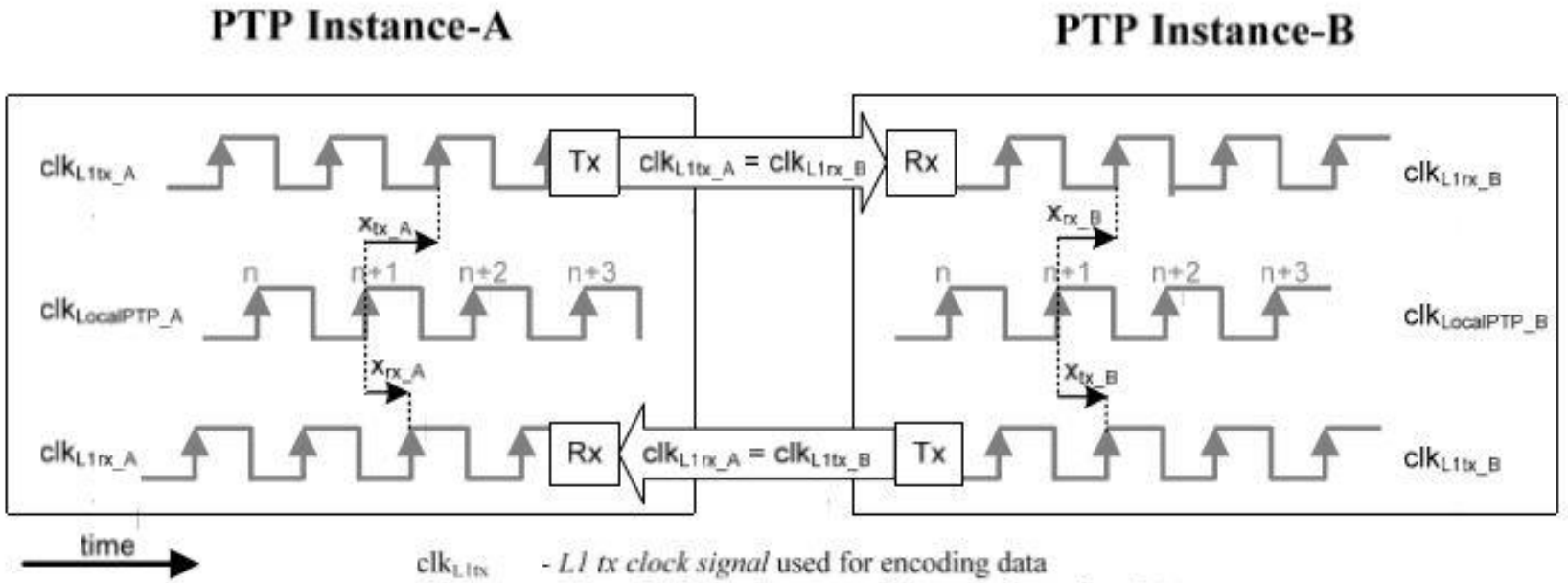
- Independent domains fed from a single timing source
- Multipath PTP
- Time transfer between domains via non PTP mechanism
  - IRIG-B, 1PPS, Backplane
  - Interdomain timing metadata adapter
  - Timing transfers but not protocol (Each domain has own BMCA)
- Common Mean Link Delay service (new!)
  - Peer delay networks with multiple domains
  - Link delay usually domain independent
  - Measure once use measurement in all domains
  - Especially useful for nodes with many ports

High Accuracy PTP

- Based on work at CERN
  - White Rabbit extensions to PTP
  - Lead scientist Maciej Lipinski
  - Achieved sub-ns phase synchronization
- Manually configured port states
  - All ports either configured or BMCA, no mixing
- Layer 1 Syntonization
- Asymmetry calibration



High Accuracy PTP



clk_{L1tx} - *L1 tx clock signal* used for encoding data
clk_{L1rx} - *L1 rx clock signal* recovered from the incoming data
$clk_{LocalPTP}$ - *signal from Local PTP Clock* used by PTP *time counter*
x_{rx} - phase offset between $clk_{LocalPTP}$ and clk_{L1rx}
x_{tx} - phase offset between $clk_{LocalPTP}$ and clk_{L1tx}

Figure 65—Link reference model.

Asymmetry errors removed through calibration of phase differences among various clocks

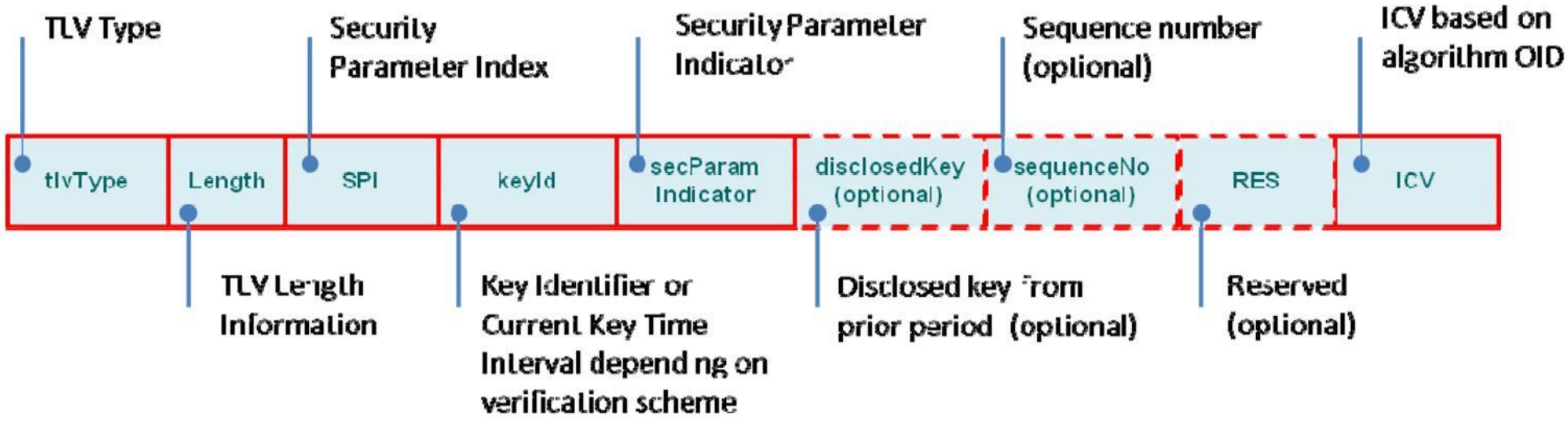
- Calibration is relative to “Golden Calibrator”
- Scaling to large networks unsolved problem
- Layer-1 Syntonization keeps phase errors quasi-static so they can be calibrated

Security

Four Prongs

1. Recommendations for transport of PTP over IPsec and MACsec
2. Security TLV
   - Can be attached to any PTP message
   - Friendly to GDOI and TESLA based key exchange mechanisms
   - Key exchange details outside scope of IEEE 1588
3. Recommendations for use of redundancy in network architecture
   - For example, multi-master PTP, multipath PTP
   - Necessary but not sufficient to defeat delay attacks
4. Recommendations on the use of monitoring

Security TLV



Performance Metrics for Monitoring

- Complete implementation
  - 24 our average of each metric
  - 24 hours worth of 15 minute averages of each metric
  - 37 metrics defined
  - Partial or no implementation allowed
- Based of fundamental statistics for each quantity
  - Average, minimum, maximum, standard deviation
  - Or counters
- Examples
  - averageOffsetFromMaster
  - minMeanPathDelay (delay request-response only)
  - maxMeanLinkDelay (peer delay only)
  - SyncRx (counter)

Even more optional features

- Slave timing measurement TLV for monitoring
  - Pass timestamps to GM or monitoring node to verify timing
- Special ports
  - Interfacing PTP with transport mechanism which has built in timing
  - WiFi
  - EPON
- Mixed multicast/unicast operation
  - Sync, Announce are multicast
  - Delay Request, Delay Response are unicast
  - Cut down on “noise” in multicast address
- Not addressed in this edition: standards MIB, YANG

Summary

- Backward compatibility maintained
  - PTPv2 and PTPv2.1 devices can work together
- Features for robustness and accuracy
  - Profile Isolation
  - Interdomain interactions
  - Security TLV
  - Standard metrics
  - Slave port monitoring
- Features for Accuracy
  - Manual port configuration
  - Calibration
  - Layer-1 syntonization
- Features for flexibility
  - Modular TCs
  - Special ports
  - Mixed multicast/unicast

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Thank you for your attention

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