Traditional Synchronization Standards Overview

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AGENDA

- **Telecom Synchronization**
- **International Telecommunication Union (ITU-T)**
- **North America**
- **Quality Metrics**
- **Synchronous and Converged Network Model**
- **ITU, Study Group 15, Question 13 – Future Work**
- **Summary**

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Telecom Synchronization

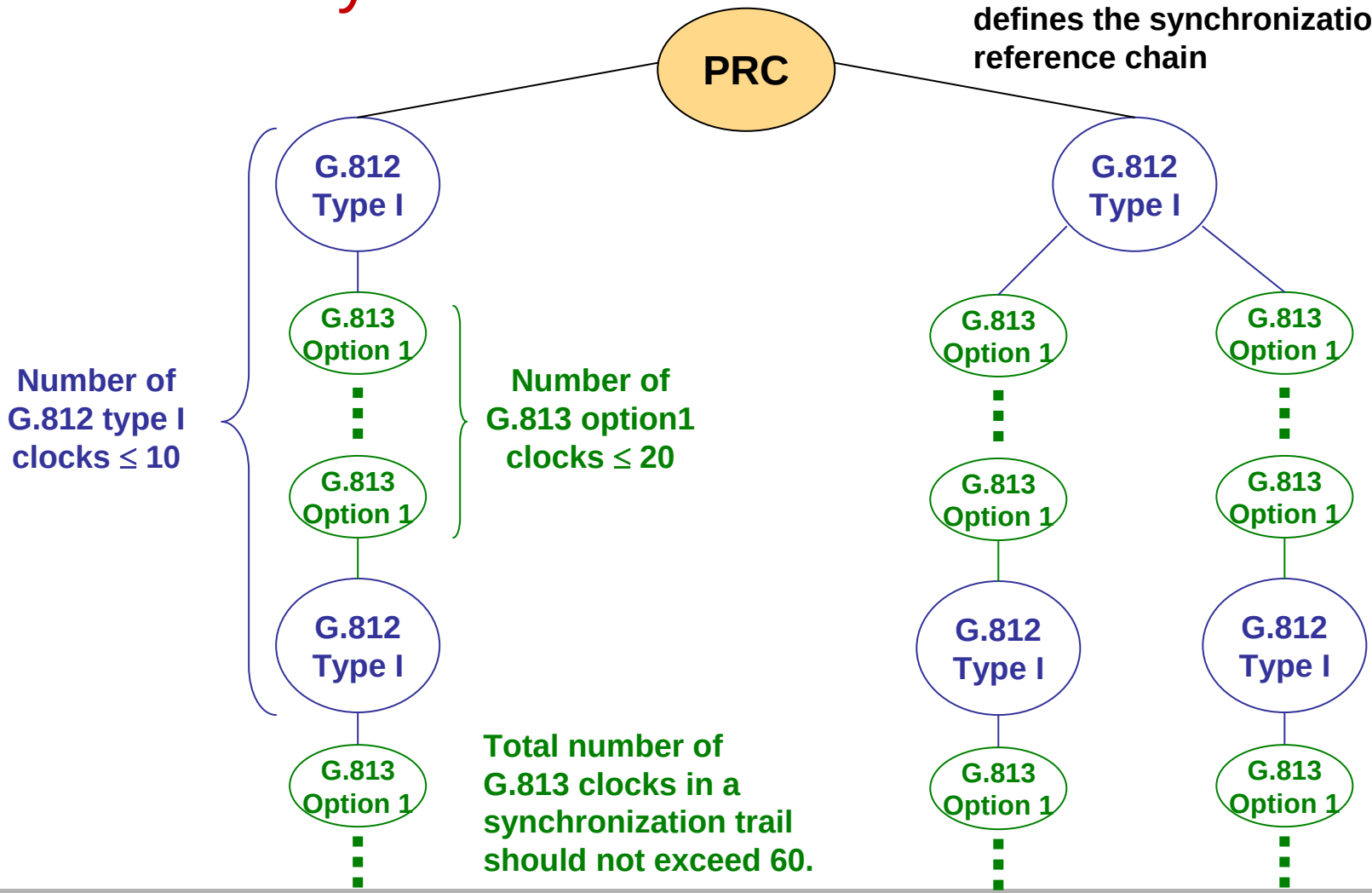
- **Clock quality levels (Stratum for North America and Types and Options for the International Telecommunication Union – ITU) are defined by the industry standards organizations to maintain clock quality in the network**
- **Time-sensitive services need synchronization**
- **Synchronization is important to avoid overflow or underflow of slip buffers, bit errors and other adverse effects**
  - **ITU-T Recommendation G.822 provides criteria for controlled slip rate**

ITU Recommendations

- **G.781 – Synchronization layer functions**
- **G.783 – Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks**
- **G.810 – Definition and Terminology of Synchronous Networks**
- **G.811 – Timing Characteristics of Primary Reference Clocks**
- **G.812 – Timing requirements of slave clocks suitable for use as node clocks in synchronization networks**
- **G.813 – Timing characteristics of SDH equipment slave clocks (SEC)**
- **G.822 – Controlled Slip Rate Objectives on an international digital connection**
- **G.823 – The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy**
- **G.824 – The control of jitter and wander within digital networks which are based on the 1544 kbit/s hierarchy**
- **G.825 – The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH)**

ITU-T SDH Timing Distribution Hierarchy

ITU-T Recommendation G.803 defines the synchronization reference chain



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Synchronous Status Messages (SSM)

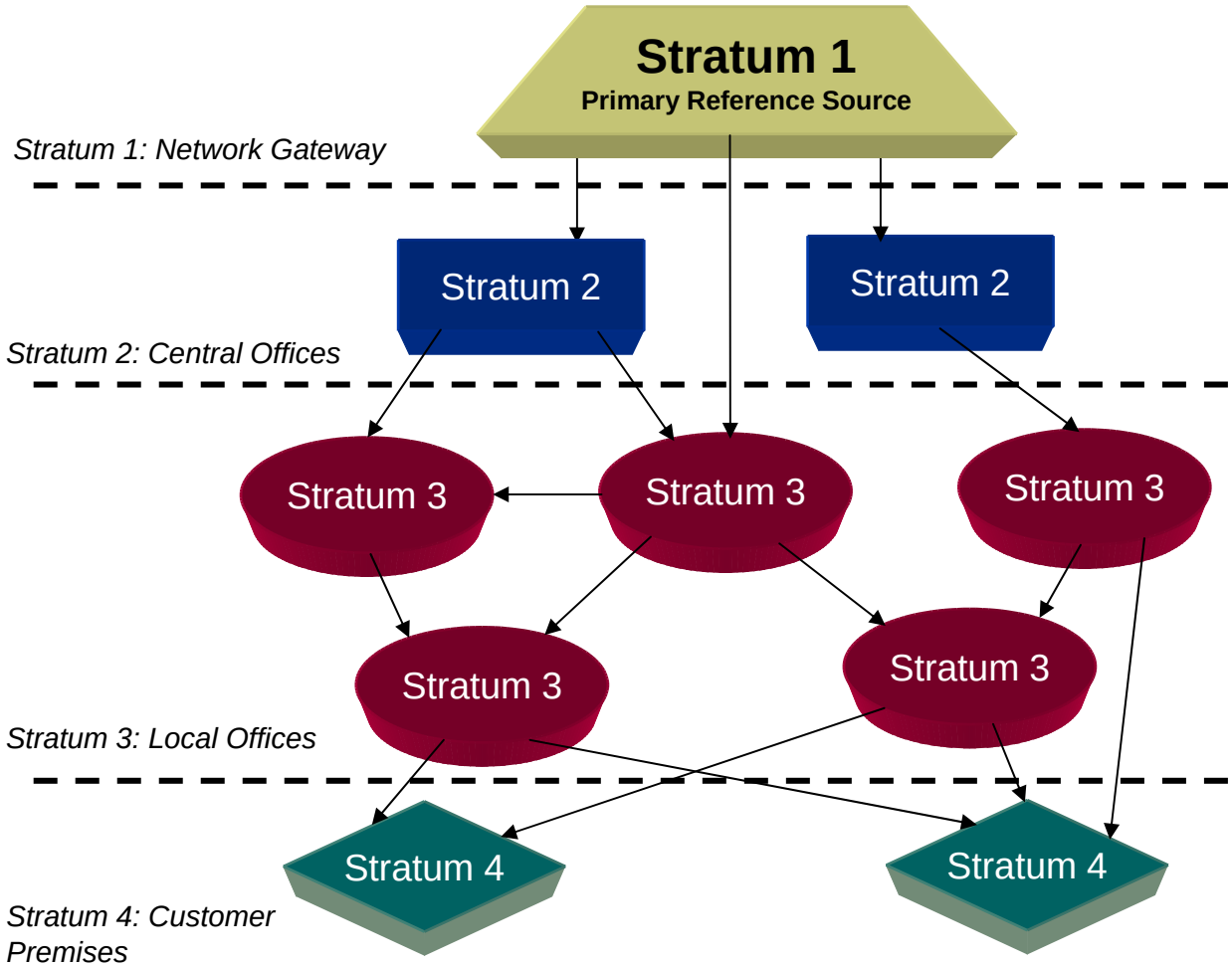
- **It is used to transport Quality Identifier**
- **SSM selection algorithm is described in G.781**
- **SSM defined in ITU-T G.707 is as follows:**

S1 bits (b5-b8)	SDH synchronization quality level description
0000	Quality unknown (Existing Synchronization Network)
0001	Reserved
0010	ITU-T Rec. G.811
0011	Reserved
0100	SSU-A
0101-0111	Reserved
1000	SSU-B
1001-1010	Reserved
1011	ITU-T Rec. G.813 Option I (SEC)
1100-1110	Reserved
1111	Do not use for synchronization (Note)

North America

- **ANSI T1.101 – Synchronization interface standard**
- **Telcordia/Bellcore GR-253-CORE – SONET transport systems: common generic criteria**
- **Telcordia/Bellcore GR-1244-CORE – Clocks for the synchronized network: common generic criteria**

North America Timing Distribution Hierarchy



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Quality Metrics

- **Free run accuracy – Maximum long-term (20 yrs) deviation from the nominal frequency when the clock output no longer reflects the influence of a connected external reference, or transition.**
- **Holdover stability – Maximum rate of change of the clock frequency with respect to time when the clock has lost its controlling reference input and is using stored data, acquired while in locked operation, to control its output.**
- **Pull-in / Hold-in range – The largest offset between a slave clock's reference frequency and a specified nominal frequency, within which the slave clock will achieve locked mode**
- **Wander – The long-term variations of the significant instants of a digital signal from their ideal position in time (where long-term implies that these variations are of frequency less than 10 Hz).**
- **Phase Transients – Perturbations in phase of limited duration. During clock rearrangement operations (e.g. reference switching), the output of the clock should meet the TIE requirement**

Clock Level

North America Stratum Level	ITU-T Clock Level	Free-run Accuracy	Holdover Stability	Pull-in/ Hold-in range	Wander Filtering	Phase Transient (Re-arrangement)
1 (PRS)	**PRC (G.811)**	+/- $1x10^{-11}$	N/A	N/A	N/A	N/A
2	**Type II (G.812)**	+/- 0.016 ppm	+/- $1x10^{-10}$ /day	0.016 ppm	0.001Hz	MTIE < 150ns
Not Defined	**Type I (G.812)**	N/D	+/- $2.7x10^{-9}$ /day	0.01 ppm	0.003Hz	MTIE < 1μs
3E	**Type III (G.812)**	+/- 4.6 ppm	+/- $1.2x10^{-8}$ /day	4.6 ppm	0.001Hz	MTIE < 150ns Phase slope 885ns/s
3	**Type IV (G.812)**	+/- 4.6 ppm	+/- $3.9x10^{-7}$ /day	4.6 ppm	3Hz 0.1Hz (SONET)	MTIE < 1μs Phase slope 61us/s Objective: MTIE < 150n Phase slope 885ns/s
Not Defined	**Option I (G.813)**	+/- 4.6 ppm	+/- $2x10^{-6}$ /day	4.6 ppm	1 – 10Hz	MTIE < 1μs
SMC	**Option 2 (G.813)**	+/- 20 ppm	+/- $4.6x10^{-6}$ /day	20 ppm	0.1Hz	MTIE < 1μs Objective mask 150ns Phase slope 885ns/s
4	**4**	+/- 32 ppm	N/A	32 ppm	No	No Requirement

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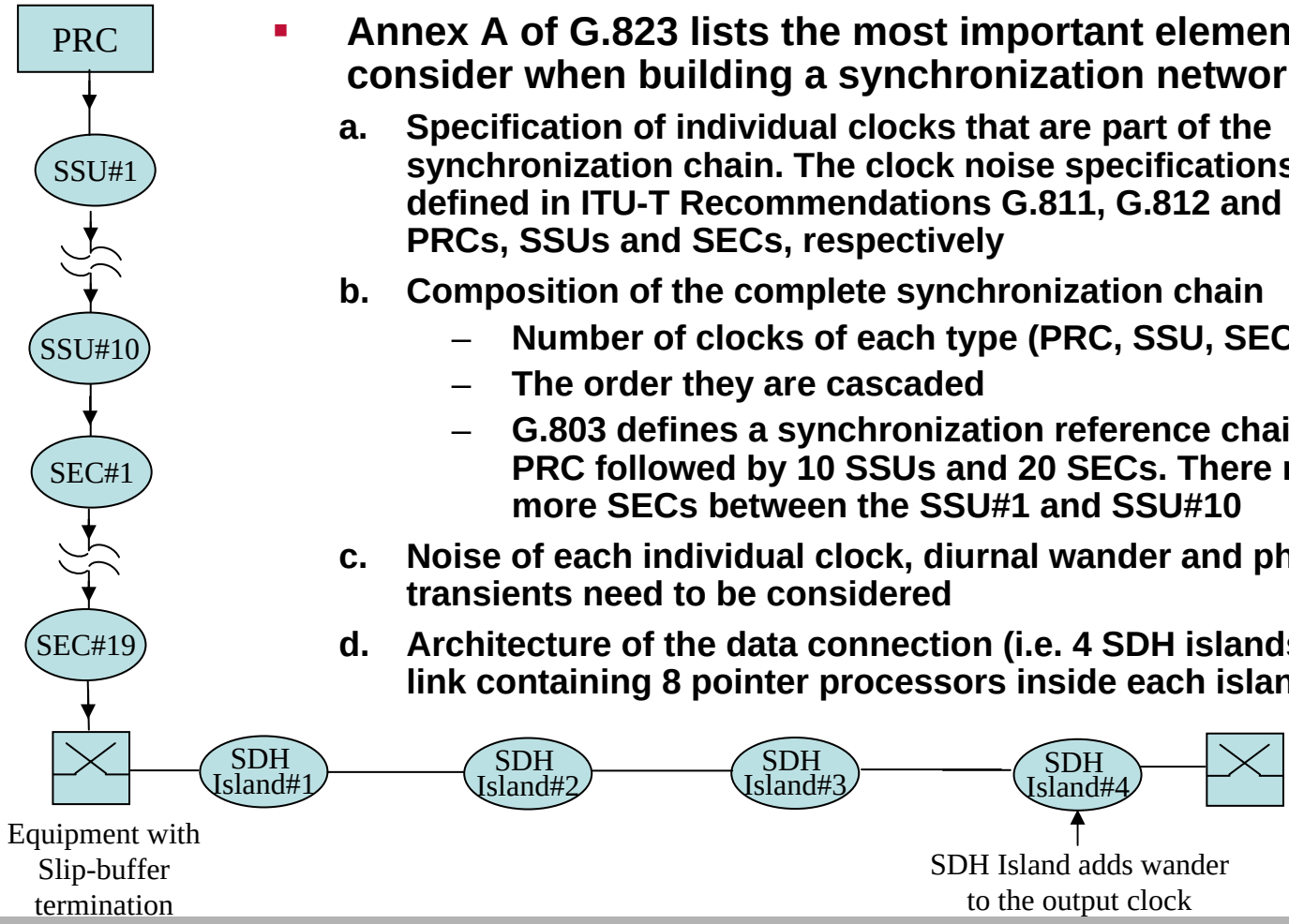
Synchronous Network Model



- **Annex A of G.823 lists the most important elements to consider when building a synchronization network**
  - **a. Specification of individual clocks that are part of the synchronization chain. The clock noise specifications are defined in ITU-T Recommendations G.811, G.812 and G.813 for PRCs, SSUs and SECs, respectively**
  - **b. Composition of the complete synchronization chain**
    - **Number of clocks of each type (PRC, SSU, SEC)**
    - **The order they are cascaded**
    - **G.803 defines a synchronization reference chain with 1 PRC followed by 10 SSUs and 20 SECs. There may be 40 more SECs between the SSU#1 and SSU#10**
  - **c. Noise of each individual clock, diurnal wander and phase transients need to be considered**
  - **d. Architecture of the data connection (i.e. 4 SDH islands on the link containing 8 pointer processors inside each island)**

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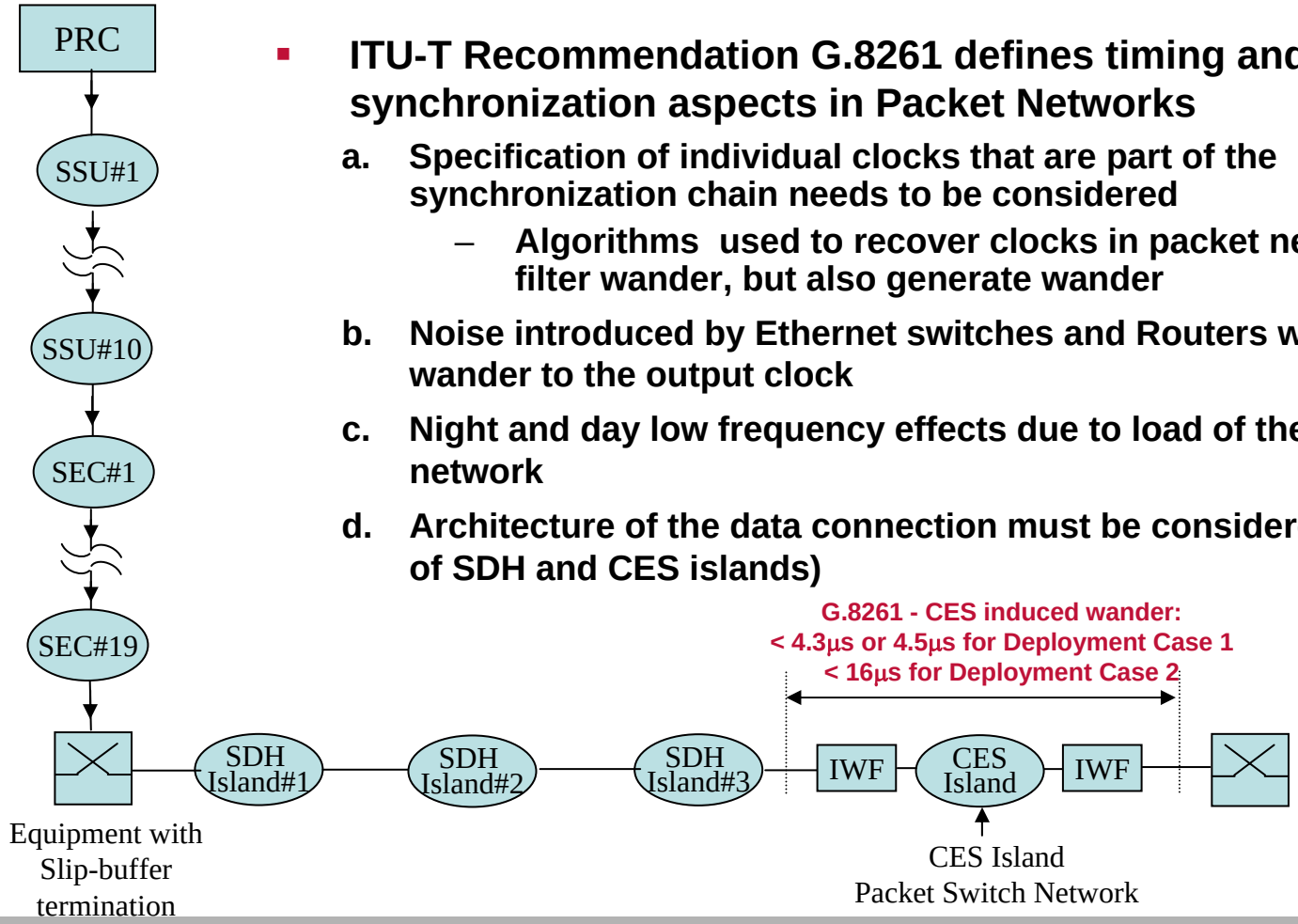
Converged Network Model



- **ITU-T Recommendation G.8261 defines timing and synchronization aspects in Packet Networks**
  - **a. Specification of individual clocks that are part of the synchronization chain needs to be considered**
    - **Algorithms used to recover clocks in packet networks filter wander, but also generate wander**
  - **b. Noise introduced by Ethernet switches and Routers will add wander to the output clock**
  - **c. Night and day low frequency effects due to load of the packet network**
  - **d. Architecture of the data connection must be considered (i.e. mix of SDH and CES islands)**

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ITU, Study Group 15, Question 13 – Future Work

- **G.8261 – Timing and Synchronization Aspects in Packet Networks**
  - **Formerly G.pactiming**
  - **Consented in February 2006**
  - **Work is ongoing**
- **G.paclock**
  - **ITU is working on a new recommendation to address requirements for timing devices used in synchronizing network equipment that operates in the IWF defined in G.8261**
- **G.pacmod**
  - **ITU is working on a new recommendation that will consider various aspects related to timing distribution in packet networks and to its modeling**

Summary

- **Traditional synchronization standards are mature and well understood**
- **Next-Generation Networks synchronization standards are under development**
  - **G.8261**
  - **G.paclock**
  - **G.pacmod**

Thank you!

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