Traditional Synchronization Standards Overview

Silvana Rodrigues

Phone: +1 613 2707258

silvana.rodrigues@zarlink.com

http://timing.zarlink.com/

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**

IEEE-1588^{TM} is trademark of its respective owner

ZARLINK
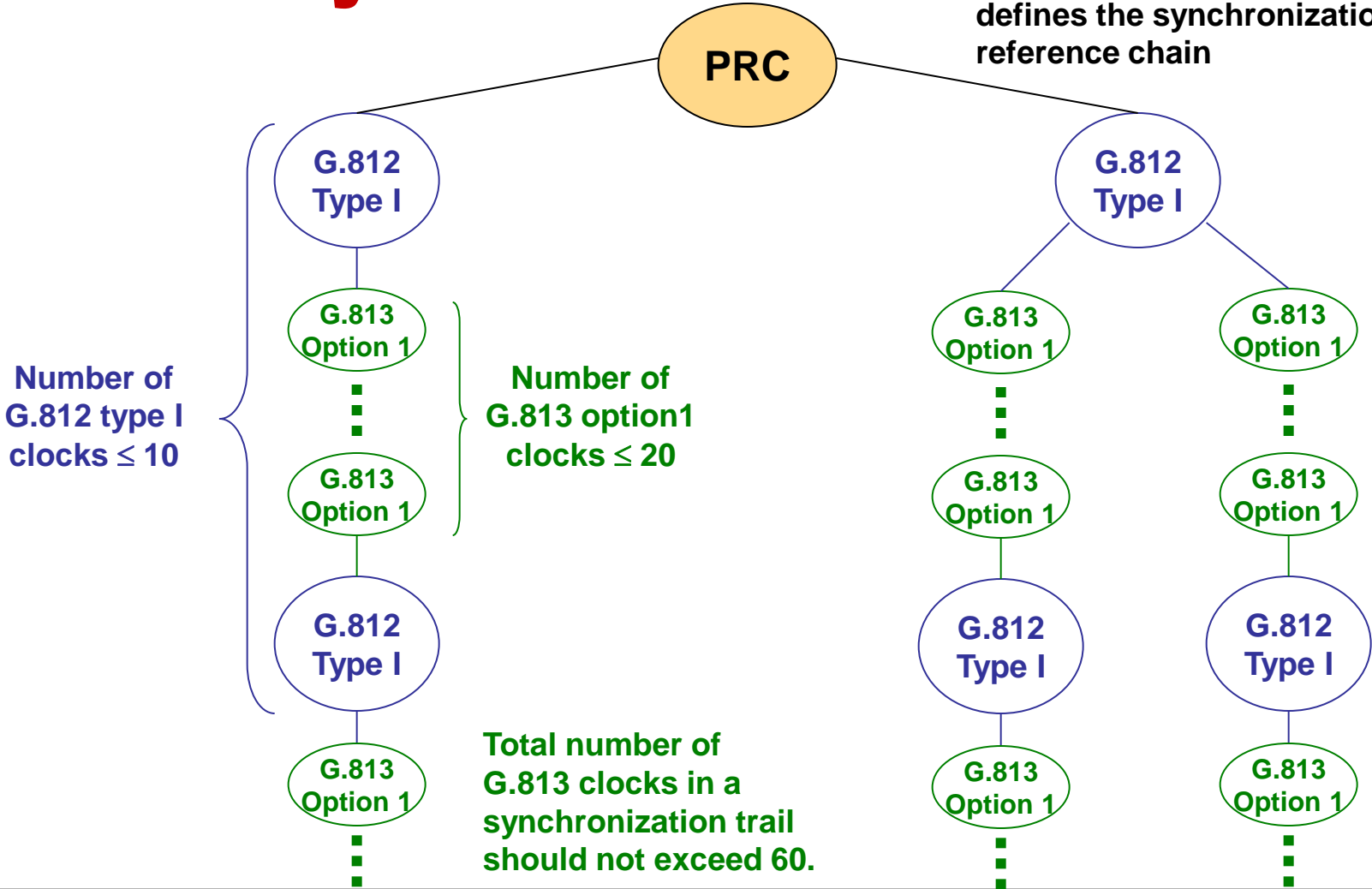SEMICONDUCTOR

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**

ZARLINK
SEMICONDUCTOR

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)**

ZARLINK
SEMICONDUCTOR

ITU-T SDH Timing Distribution Hierarchy

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

PRC

G.812 Type I

G.813 Option 1

G.813 Option 1

G.812 Type I

G.813 Option 1

Number of G.812 type I clocks ≤ 10

Number of G.813 option1 clocks ≤ 20

Total number of G.813 clocks in a synchronization trail should not exceed 60.

ZARLINK SEMICONDUCTOR

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)

ZARLINK SEMICONDUCTOR

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**

ZARLINK SEMICONDUCTOR

# North America Timing Distribution Hierarchy
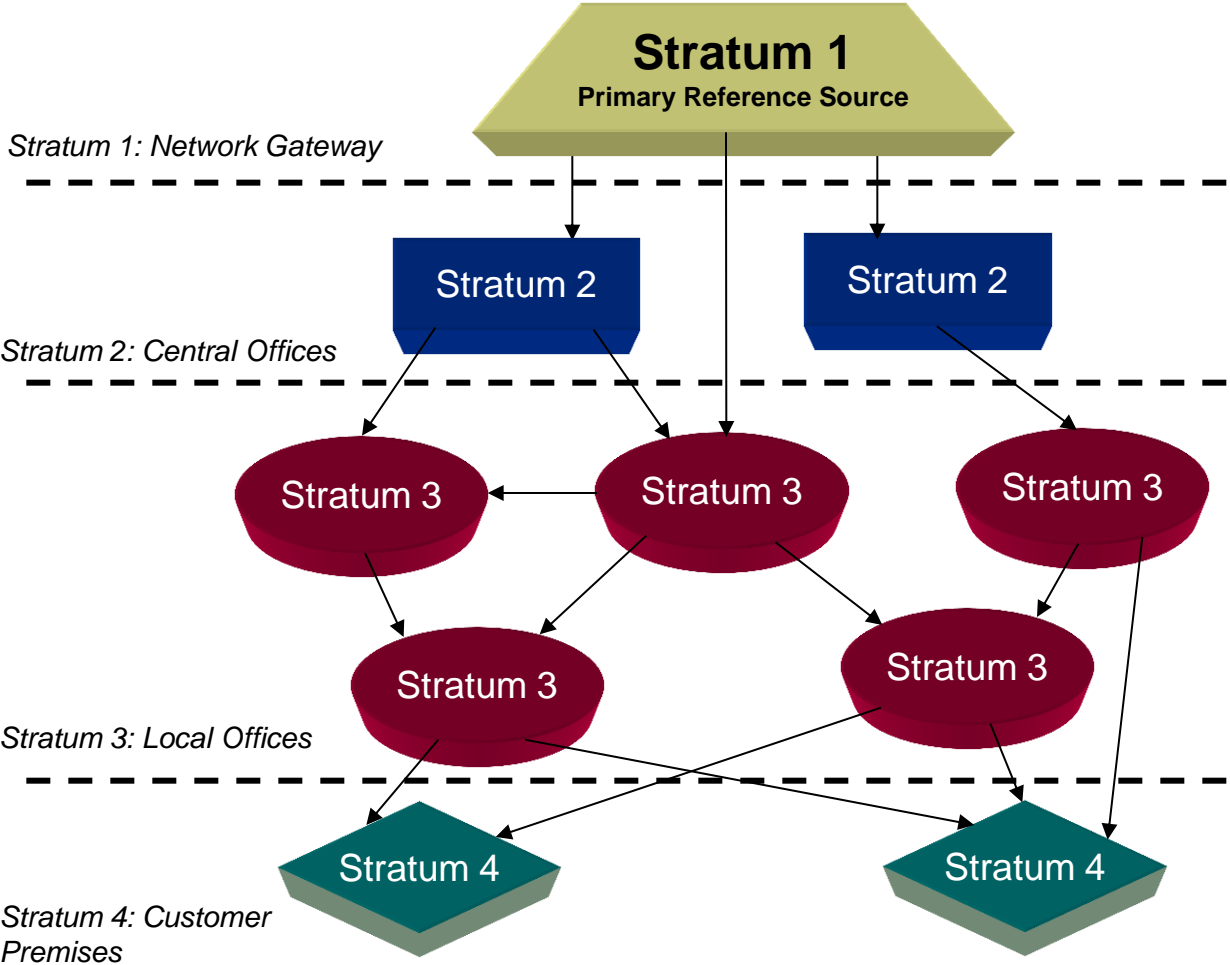
Quality Metrics

- **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

ZARLINK
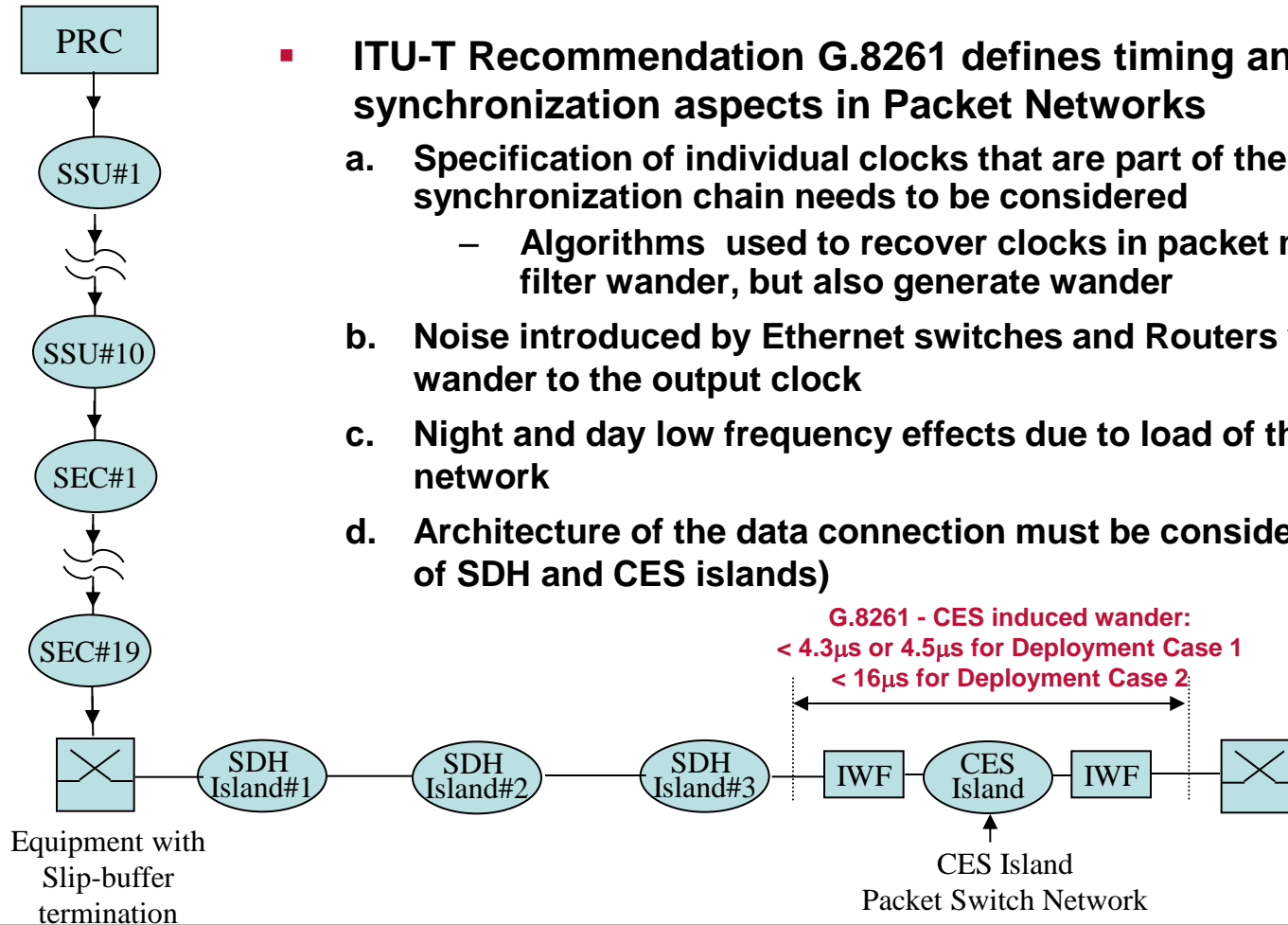SEMICONDUCTOR

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)	+/- 1×10^{-11}	N/A	N/A	N/A	N/A
2	Type II (G.812)	+/- 0.016 ppm	+/- 1×10^{-10} /day	0.016 ppm	0.001Hz	MTIE < 150ns
Not Defined	Type I (G.812)	N/D	+/- 2.7×10^{-9} /day	0.01 ppm	0.003Hz	MTIE < 1µs
3E	Type III (G.812)	+/- 4.6 ppm	+/- 1.2×10^{-8} /day	4.6 ppm	0.001Hz	MTIE < 150ns Phase slope 885ns/s
3	Type IV (G.812)	+/- 4.6 ppm	+/- 3.9×10^{-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	+/- 2×10^{-6} /day	4.6 ppm	1 – 10Hz	MTIE < 1µs
SMC	Option 2 (G.813)	+/- 20 ppm	+/- 4.6×10^{-6} /day	20 ppm	0.1Hz	MTIE < 1µs Objective mask 150ns Phase slope 885ns/s
4	Not Defined	+/- 32 ppm	N/A	32 ppm	No	No Requirement

ZARLINK
SEMICONDUCTOR

Synchronous Network Model
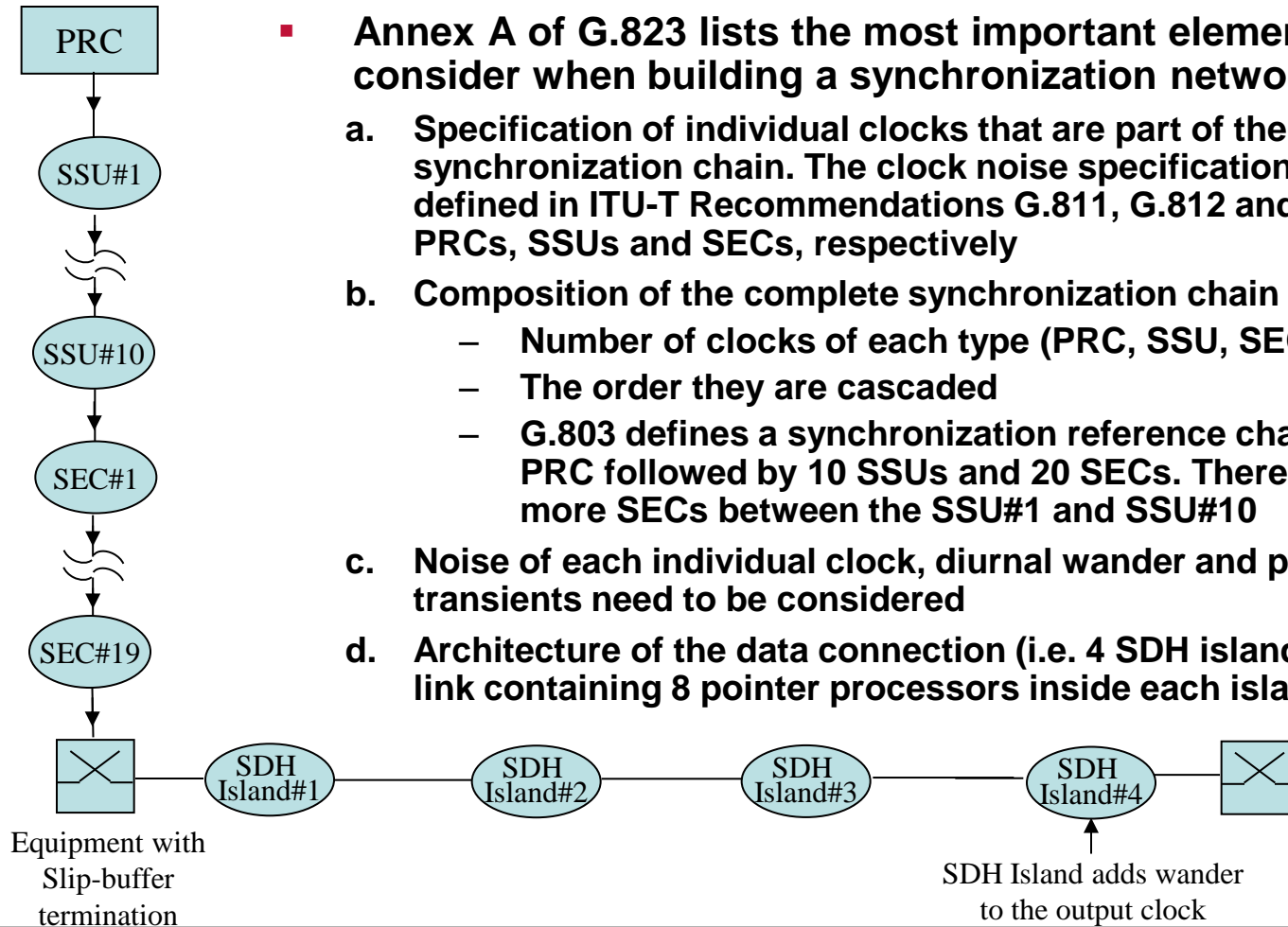
- Annex A of G.823 lists the most important elements to consider when building a synchronization network
  a. Specification of individual clocks that are part of the synchronization chain. The clock noise specifications are defined in ITU-T Recommendations G.811, G.812 and G.813 for PRCs, SSUs and SECs, 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)

PRC
SSU#1
SSU#10
SEC#1
SEC#19

SDH Island#1   SDH Island#2   SDH Island#3   SDH Island#4

Equipment with Slip-buffer termination

SDH Island adds wander to the output clock

ZARLINK
SEMICONDUCTOR

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)**

G.8261 - CES induced wander:
< 4.3μs or 4.5μs for Deployment Case 1
< 16μs for Deployment Case 2

PRC

SSU#1

SSU#10

SEC#1

SEC#19

Equipment with
Slip-buffer
termination

SDH Island#1

SDH Island#2

SDH Island#3

IWF

CES Island

IWF

CES Island
Packet Switch Network

ZARLINK
SEMICONDUCTOR

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**

ZARLINK SEMICONDUCTOR

Summary

- **Traditional synchronization standards are mature and well understood**

- **Next-Generation Networks synchronization standards are under development**
  - **G.8261**
  - **G.paclock**
  - **G.pacmod**

ZARLINK SEMICONDUCTOR

Thank you!