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10G EPON: The Next Generation PON Technology

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Agenda

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- PMC-Sierra introduction
- Key technologies in 1G EPON
- 1G to 10G EPON migration

PMC-Sierra Overview

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- PMC-Sierra provides leading communications and storage semiconductor solutions
- Major areas of product focus include:
  - **COMMUNICATIONS**: WAN Infrastructure, FTTH (EPON/GPON), Access (Wireless, WiMAX)
  - **ENTERPRISE**: Enterprise Storage (FC/SAS/SATA), Laser Printers, Networking, SMB NAS
- Revenues over last 12 month period totaled $506 million*; net cash of $195 million**
- Company has approximately 1,050 employees worldwide (Q2'08)

Communications Infrastructure

Enterprise Infrastructure

*(July'07-June'08) **(as of June 29,'08)

Complete Portfolio for End-to-End Connectivity Solutions

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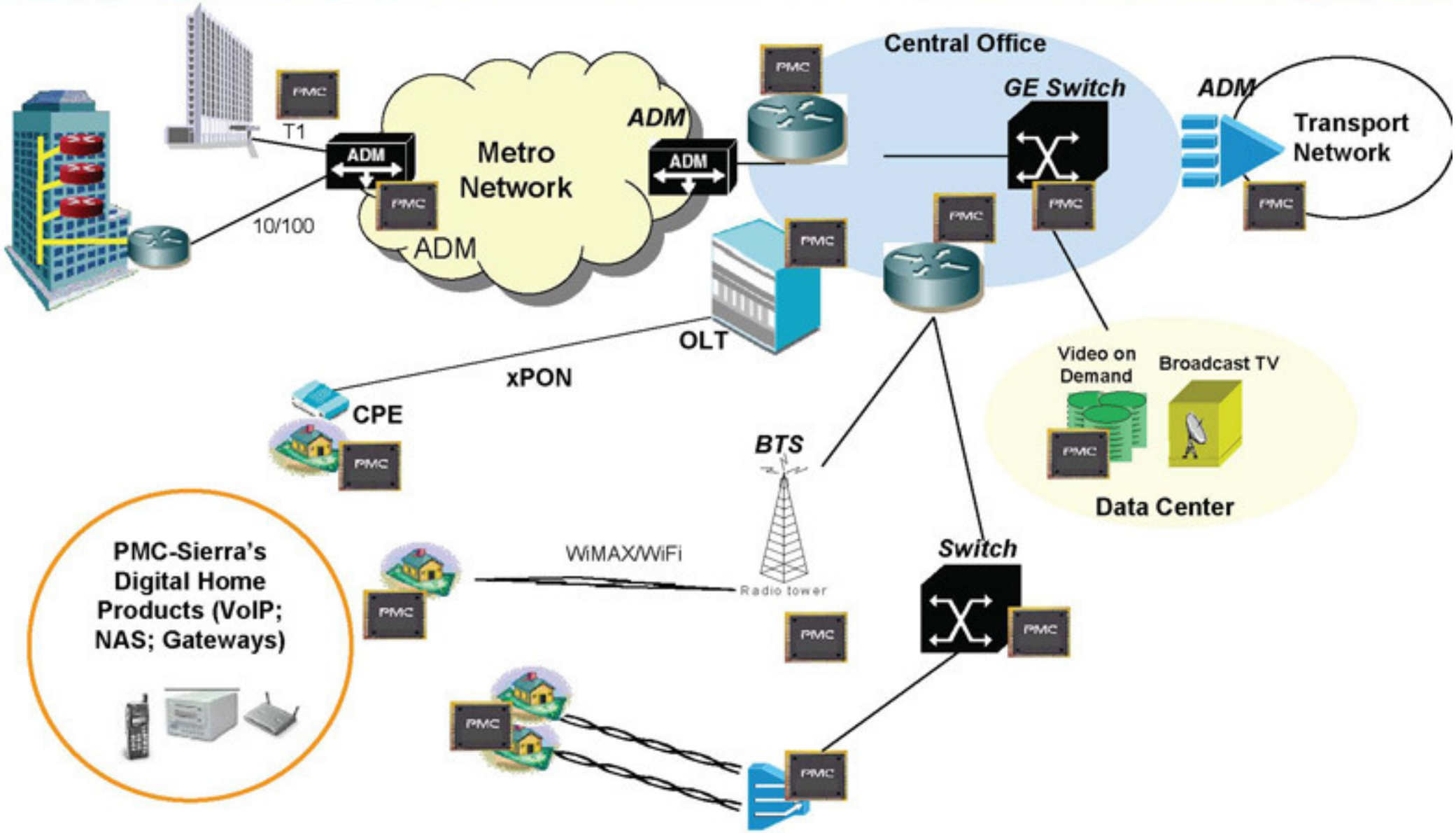

PMC-Sierra's Global Presence

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FTTH Business Unit Overview

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- Market leader in 1G EPON
- First to demonstrate 10G EPON (Optinet 2008)
- Only chip vendor with both EPON & GPON product lines
- Market leading 10G EPON development - Large teams of Analog and ASIC experts enabling breakthrough next generation designs

Key Technologies in EPON (The 5 As)

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- **A**djustable platforms
  - OLT (DBA) – Standard and adaptable Quality of Service implementation
  - ONU – Powerful integrated CPU Reduces systems costs and power consumption (e.g. MDU application)
- **A**dvanced Diagnostics to lower carrier OPEX
- **A**djacent technologies such as Residential Gateway and VoIP to allow rapid integration
- **A**nalog expertise to enable new technologies and cost optimize current ones (e.g. 10G EPON SERDES)
- **A**SIC vendor expertise to enable a cost effective and predictable supply chain

Adjustable DBA (Dynamic Bandwidth Allocation)

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- PMC enables an adjustable DBA to meet specific carrier service needs
- A few carriers have already chosen to develop their own DBA when EPON matures in order to fine-tune it to their own needs
- In China, for example, the DBA was adjusted to enable guaranteed bandwidth per service and weighted fair queue based on the standard compliant Single LLID QoS mechanism and **without** any bandwidth overhead

"All things change, and we change with them."

- Chinese saying

"It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change. "

– Charles Darwin

Adjustable ONU – MDU Example

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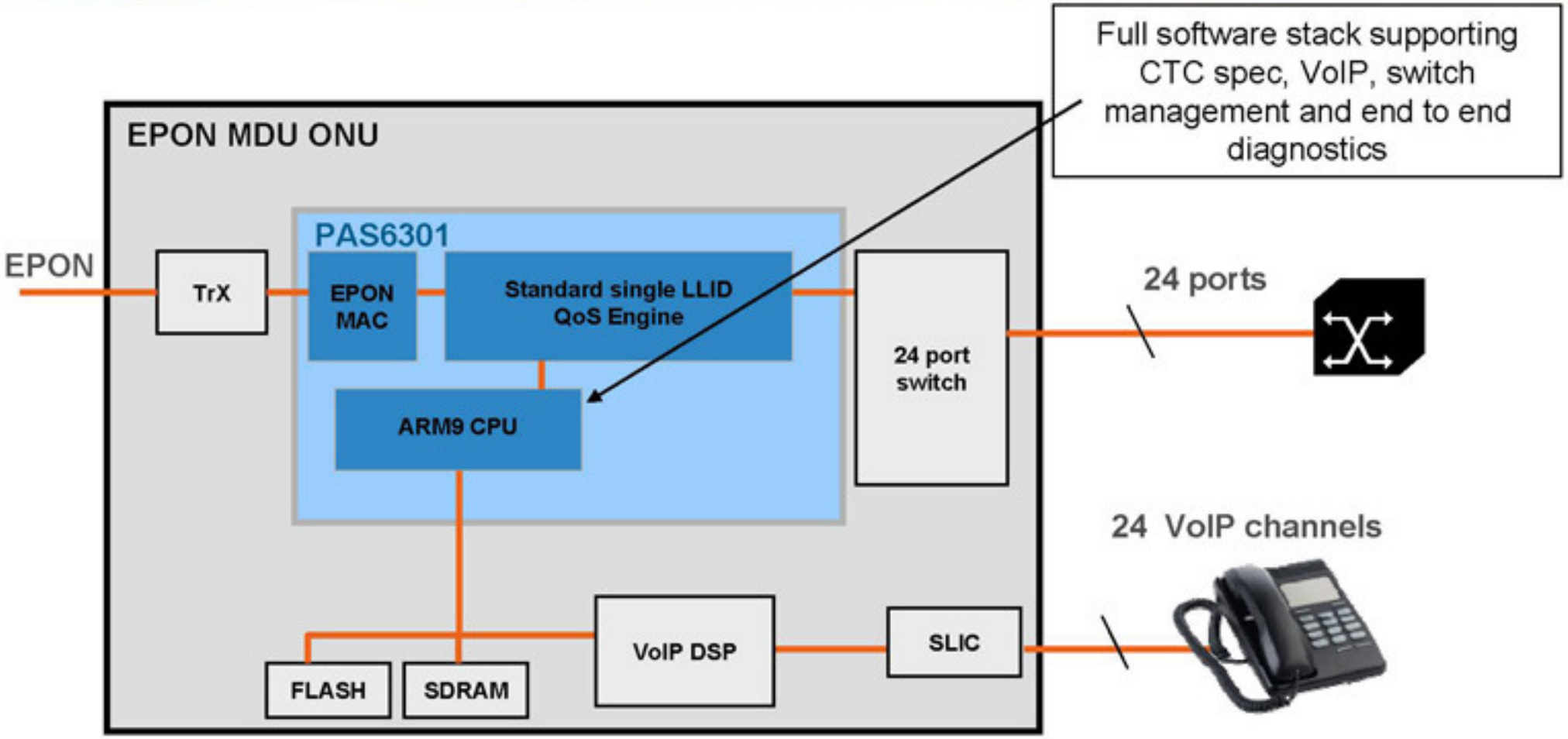

Significant cost and power consumption reduction achieved by utilizing the integrated ARM to support an MDU application eliminating the need for a host subsystem and dedicated VoIP devices

Adjustable ONU – MDU Example (cont.)

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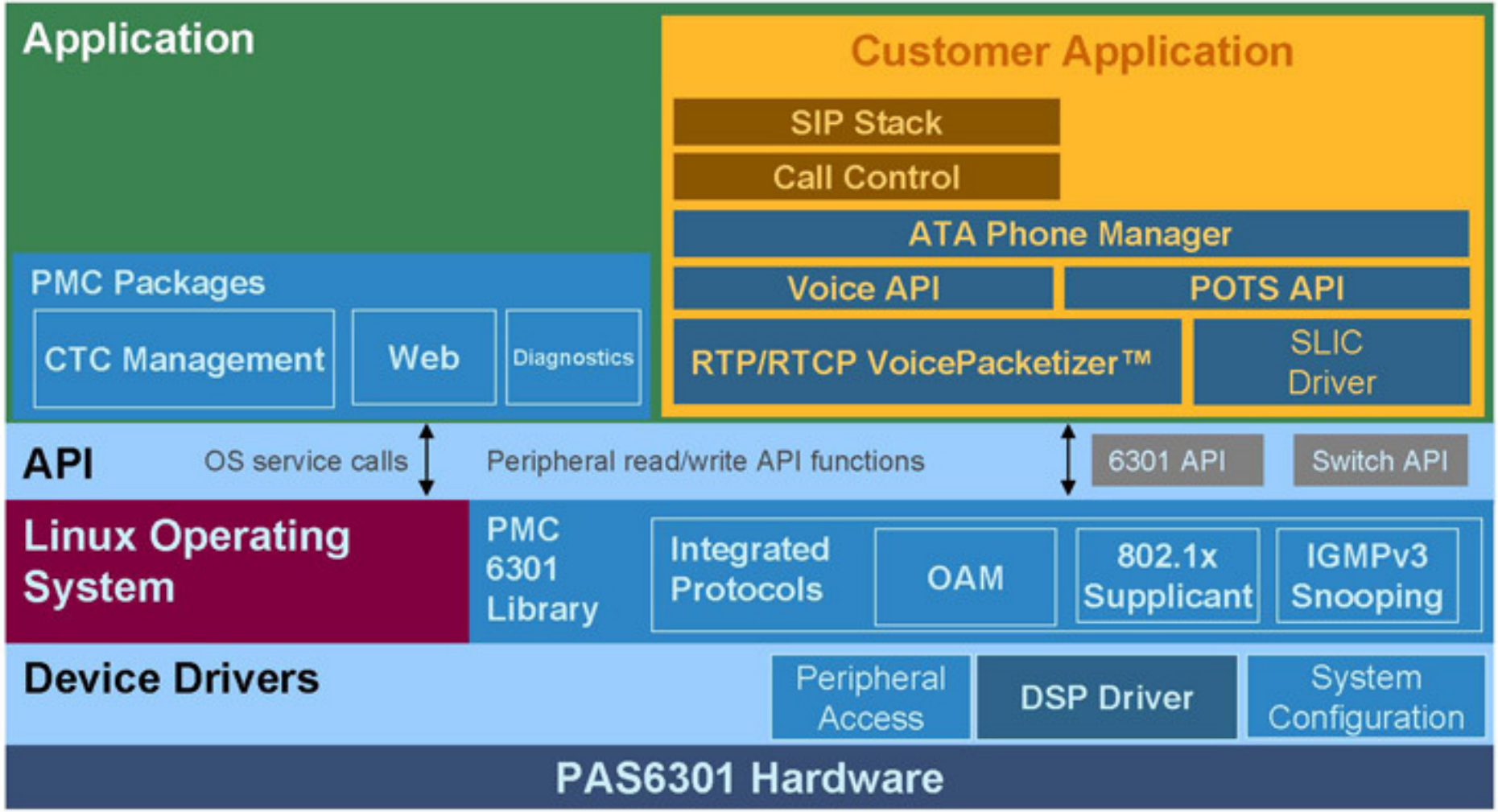

Adjustable ONU enables a rich and flexible software stack

Advanced Diagnostics Lowering OPEX

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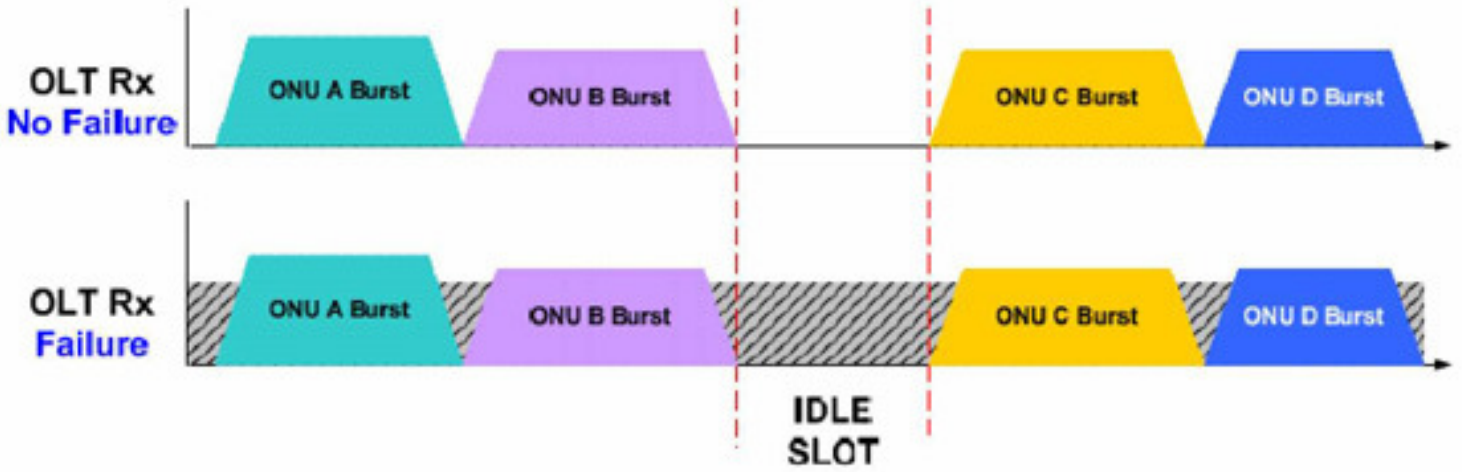
- As EPON matures, enhanced diagnostics are becoming critical, enabling carriers to provide high quality service with lower operating expenses
- PMC has enabled a rich set of diagnostics capabilities through the development of analog products (TIA/LIA) designed into the EPON transceivers
- One example of a failure that can be resolved is an ONU laser transmitter that is stuck at an “always one” state



Advanced Diagnostics – Example #2

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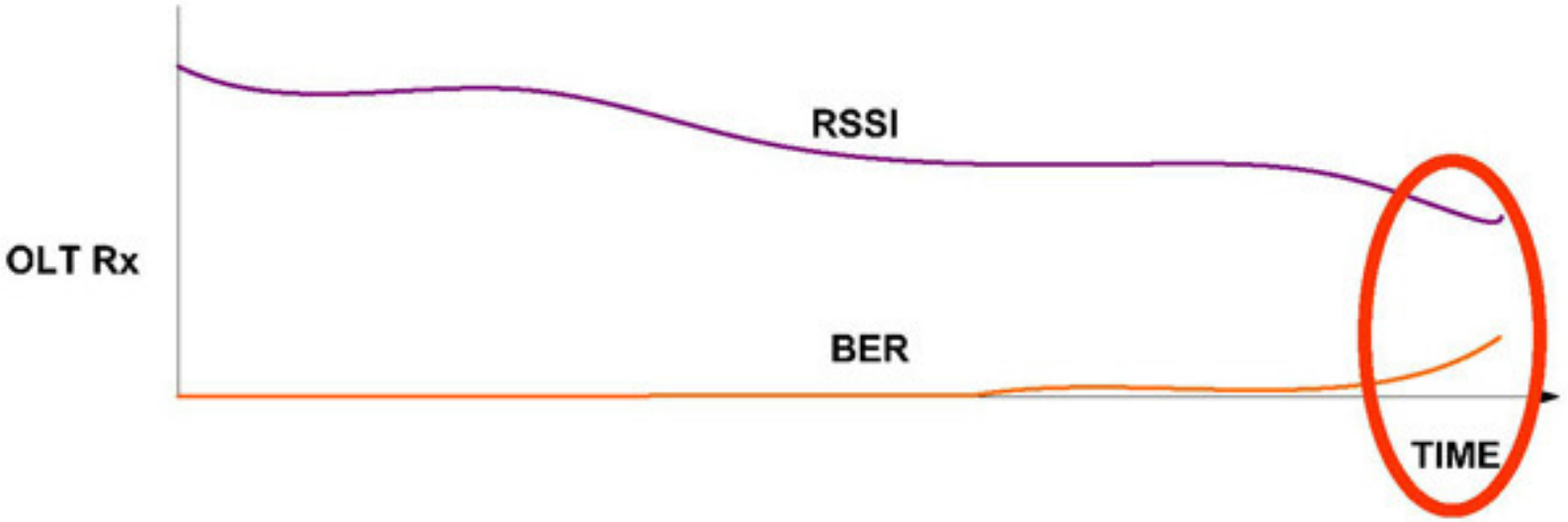
- Proactively detects the end-of-life of an EPON ONU transceiver and alerts the carrier technicians
- Enables improved uptime service – raising end-customer satisfaction and lowering carrier operating expenses



An adaptable diagnostics infrastructure allows carriers to add capabilities by software upgrades based on changing needs

1G to 10G EPON Migration

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- 10G EPON standard (IEEE 802.3av) is in its final drafting stages. Draft 2.0 released
- Initial carrier trials have begun in APAC
- Strong market demand in order to enable high quality IPTV service and the unification of FTTH and FTTB technologies to lower CAPEX and OPEX
- Key feature is co-existence with 1G EPON allowing a smooth upgrade from 1G to 10G EPON

1G to 10G EPON Migration (cont.)

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- The China 1G EPON market has expanded dramatically with an emphasis on FTTB that requires very high bandwidth
- 10G enables ten times more customers for every OLT line card
- PMC has announced the first 10G EPON reference design and demonstrated the technology for the first time publicly at OptiNet 2008
- The 10G EPON demonstration included commercially viable 10G EPON transceivers developed by a leading transceiver vendor

Co-existence of 1G and 10G EPON - Concepts

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- Draft 2.0 of the standard is now reviewed
- Backward compatibility
  - Deployed ONUs will work with new OLTs
  - Same link budget as 1G. Three variants-
    - PR30/ PRX30 - (29dB)
    - PR20/ PRX20 - (24dB)
    - PR10/ PRX10 - (20dB)
- MPCP changes for 10G operation

Co-existence of 1G and 10G EPON

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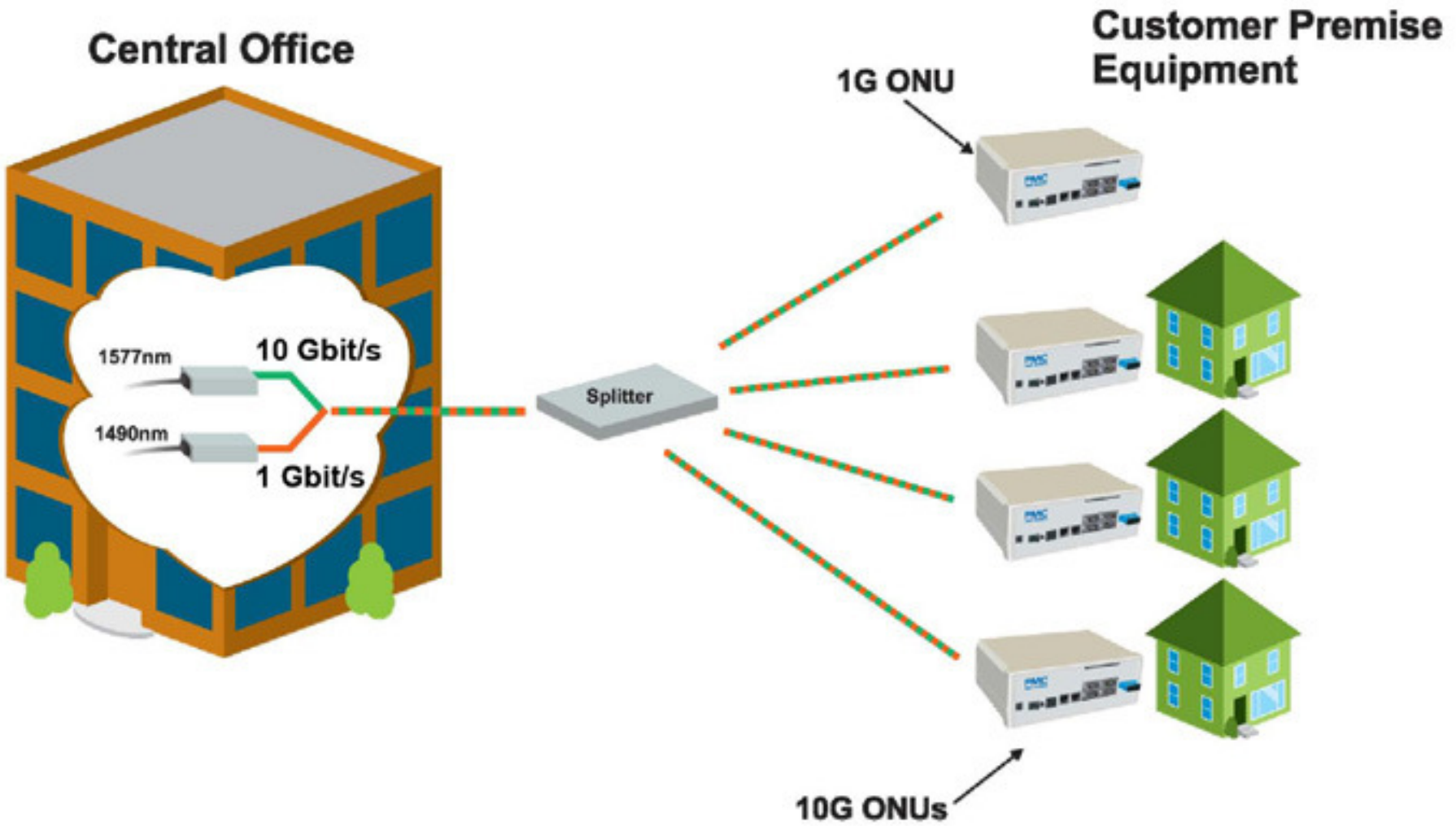

Co-existing 1G and 10G EPON Network

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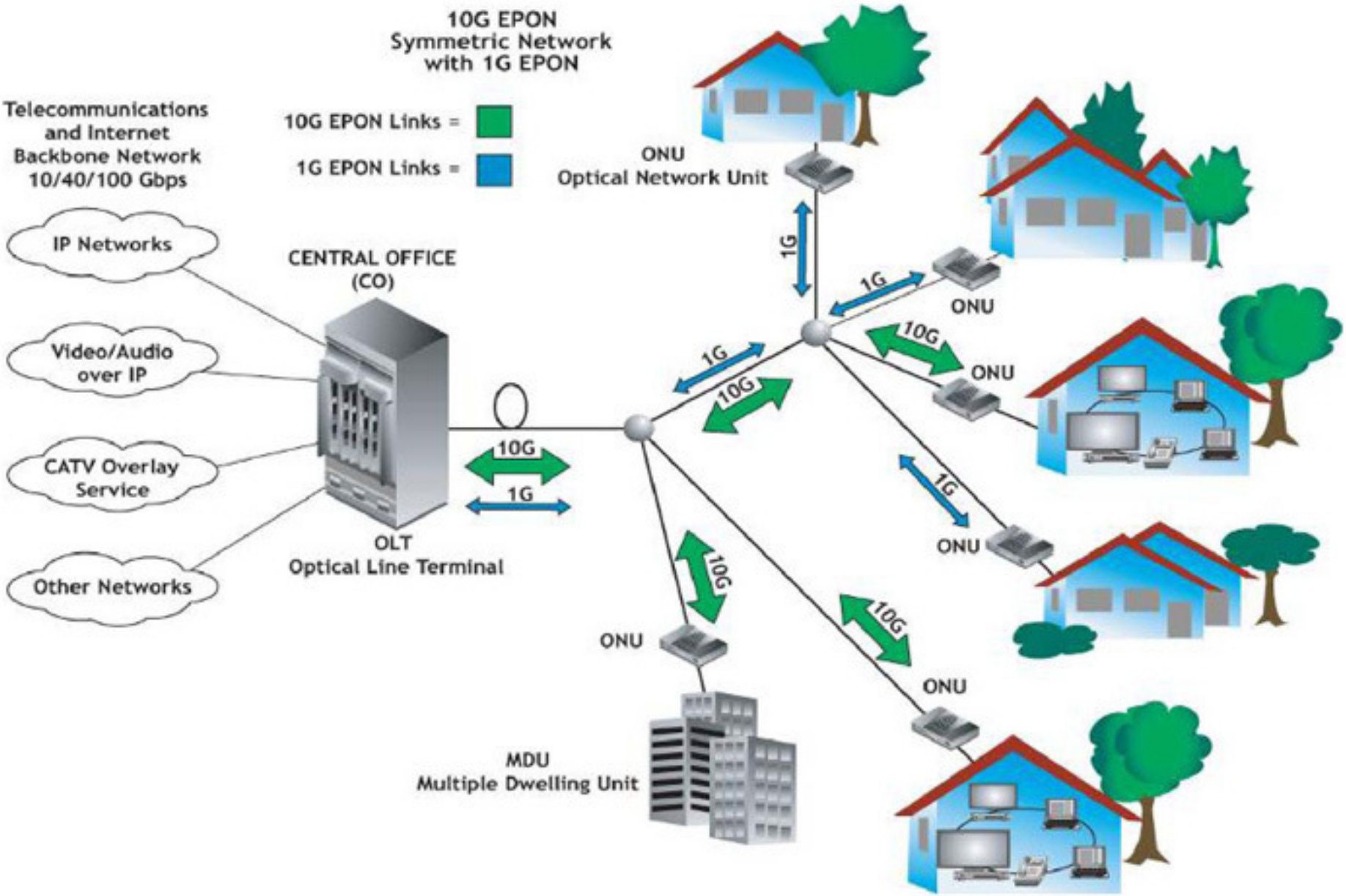

Co-existing 1G and 10G EPON Network Consequences

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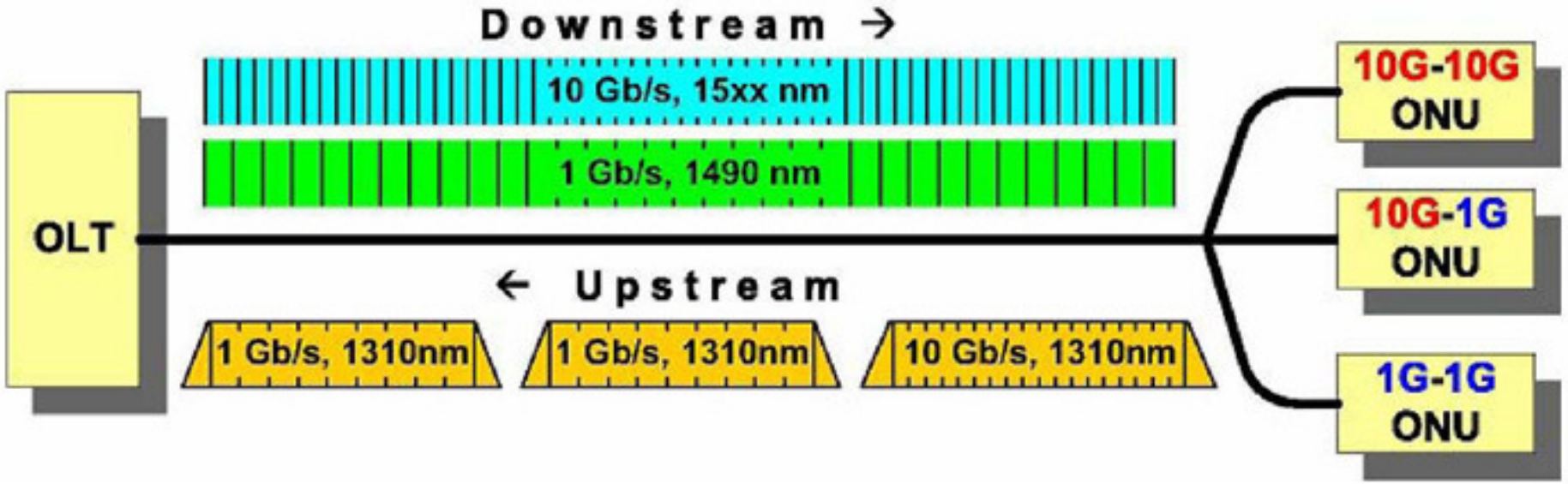
- 1G DL must be uninterrupted
  - A new wavelength should be assigned for 10G DL
    - 1577nm for PR30/PRX30
    - 1590nm for the rest



Co-existing 1G and 10G EPON Network Wavelengths Allocation

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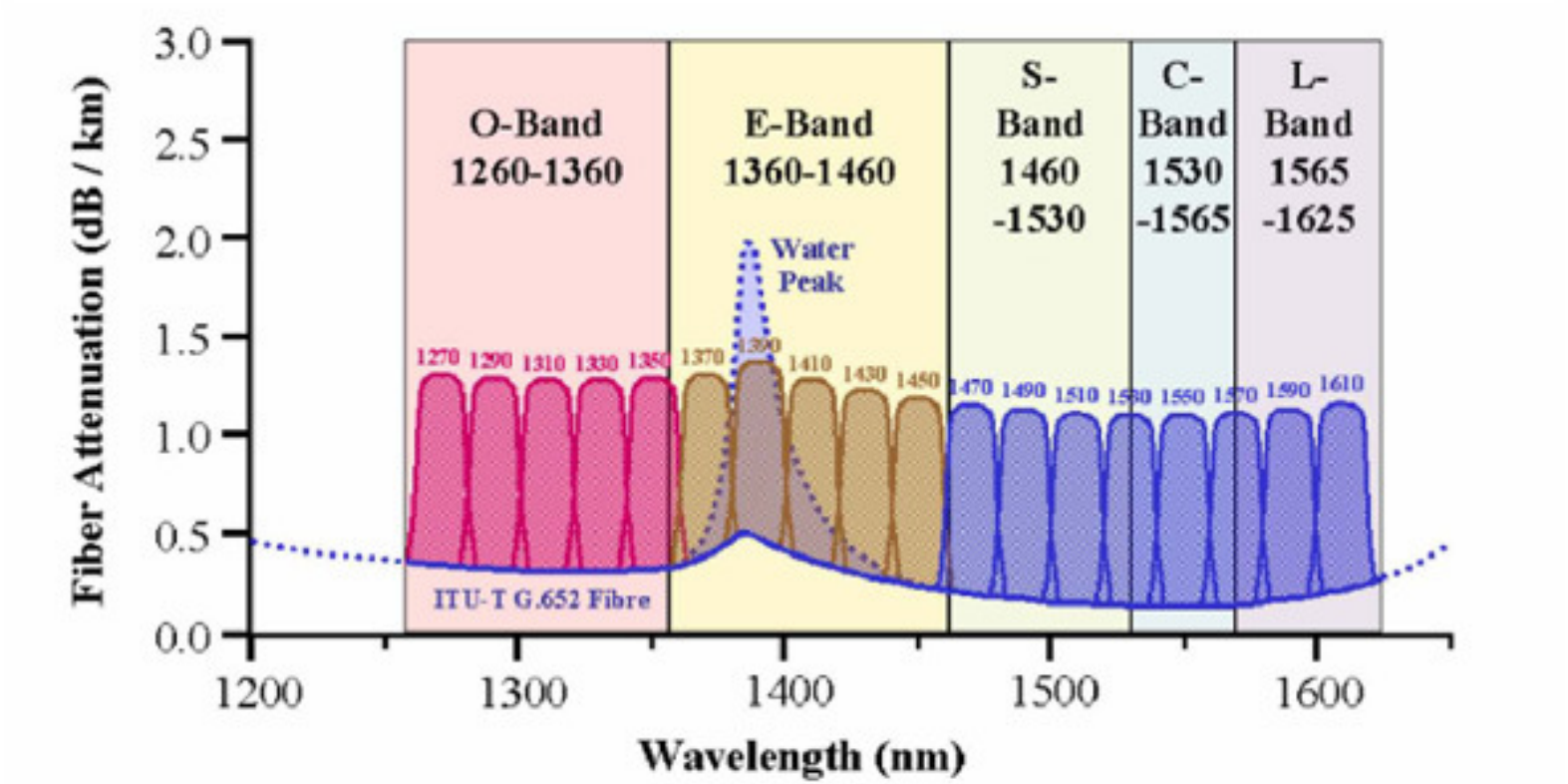
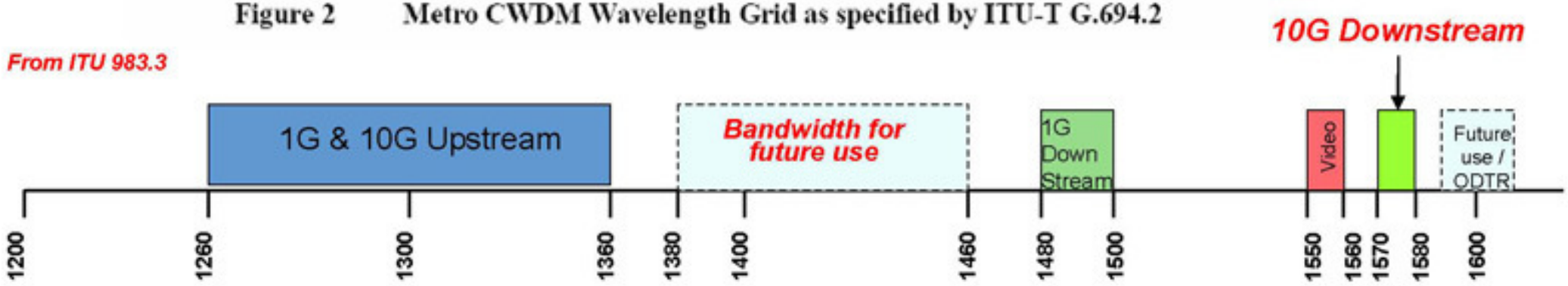


Figure 2 Metro CWDM Wavelength Grid as specified by ITU-T G.694.2



10G EPON PMD Parameters – PR and PRX

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		PR10	PR20	PR30	PRX10	PRX20	PRX30
US	ONU TX Power	4dBm	4dBm	9dBm	4dBm	4dBm	5.62dBm
		-1dBm	-1dBm	4dBm	-1dBm	-1dBm	0.62dBm
	TX Type	DML	DML	HP DML	DML	DML	DML
	OLT RX	-21dBm	-25dBm	-25dBm	-22.3dBm	-24.4dBm	-28.38dBm
	RX Type	APD	APD	APD	APD	APD	APD
	FEC Gain	3dB	3dB	3dB	3dB	3dB	3dB
	Total Insertion Loss	***20dB***	***24dB***	***29dB***	***21.3dB***	***23.4dB***	***29dB***
DS	OLT TX Power	4dBm	9dBm	5dBm	4dBm	9dBm	5dBm
		1dBm	5dBm	2dBm	1dBm	5dBm	2dBm
	TX Type	EML	HP EML	EML	EML	EML	EML
	ONU RX	-19dBm	-19dBm	-27dBm	-19dBm	-19dBm	-27dBm
	RX Type	PIN	PIN	APD	PIN	PIN	APD
	FEC Gain	3dB	3dB	3dB	3dB	3dB	3dB
	Total Insertion Loss	***20dB***	***24dB***	***29dB***	***20dB***	***24dB***	***29dB***

10G EPON link budget reaches the same 29dB as 1G EPON

EPON/GPON/10GEPON PMD Compare

Source from our partner – Hisense-Ligent

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	EPON		GPON		10GEPON
	PX-10	PX-20	Class B+	Class C+	PR-10/20/30
Link Budget	23dB	27dB	28/30dB	32/33dB	23~32dB
Data rate	1.25G	1.25G	2.5G/1.25 G	2.5G/1.25 G	10.3125G
TX Laser	FP/DFB	DFB	DFB	H DFB	H EML H DML
RX PD/TIA	PIN/TIA	PIN/TIA	APD/TIA	H Sen. APD/TIA	APD+ TIA(S)+ FEC
Driver	Discrete/Integrated		Discrete	Discrete	Discrete
PA			Discrete	Discrete	Discrete
Cost	Low	Medium Low	High	High+ (OLT)	High++ (ONU/OLT)

10G and 1G system PMD cost comparison

Source from our partner – Hisense-Ligent

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Type	Channel IL	Module	Data Rate (DS/US)	Transmitter	Receiver	Cost
PRX10	20	ONU	10.3G/1.25G	1G FP	10G PIN	1.5X
		OLT	10.3G/1.25G	10G EML	1G PIN	2Y
PRX20	24	ONU	10.3G/1.25G	1G DFB	10G PIN	2X
		OLT	10.3G/1.25G	10G H EML	1G PIN	3Y
PRX30	29	ONU	10.3G/1.25G	1G DFB	10G APD	2.5X
		OLT	10.3G/1.25G	10G EML	1G PIN	2.5Y
PR10	20	ONU	10.3G/10.3G	10G DFB	10G PIN	3.5X
		OLT	10.3G/10.3G	10G EML	10G APD	3Y
PR20	24	ONU	10.3G/10.3G	10G DFB	10G PIN	3.5X
		OLT	10.3G/10.3G	10G H EML	10G APD	4Y
PR30	29	ONU	10.3G/10.3G	10G H DFB	10G APD	4X
		OLT	10.3G/10.3G	10G EML	10G APD	3Y

Note: X is the GPON Class B+ ONU module cost and Y is the GPON Class B+ OLT cost.
The cost of the 10G PON modules are estimated for mass production quantity.

Summary

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- PMC-Sierra is the sole FTTX SoC provider offering both EPON and GPON solutions
- PMC-Sierra is the 1G EPON market leader with over 6 Million ONUs sold and first to demonstrate 10G EPON
- 10G EPON co-existence offers a smooth migration path from 1G to 10G EPON
- The 10G EPON standard is technically finalized allowing companies to develop the eco-system needed for actual deployment
- 10G EPON optical module has been available commercially

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