

Joint ITU-T/IEEE Workshop on Carrier-Class Ethernet

From 1 to 10 Gb/s in Five Years - The EPON Story

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Outline

- **1Gb/s EPON (IEEE 802.3ah)**
 - Architecture Overview
 - Main Differences with ITU-T G.984 GPON
 - Commercialization Status
- **10Gb/s EPON (IEEE P802.3av)**
 - History and Standardization status
 - Market Drivers
 - 10GEPON Objectives
 - ▶ Symmetric and Asymmetric Configurations
- **10Gb/s Emerging Architectural Solutions**
 - Power Budgets
 - Compatibility and Coexistence
- **How to participate in IEEE 802.3av Task Force**

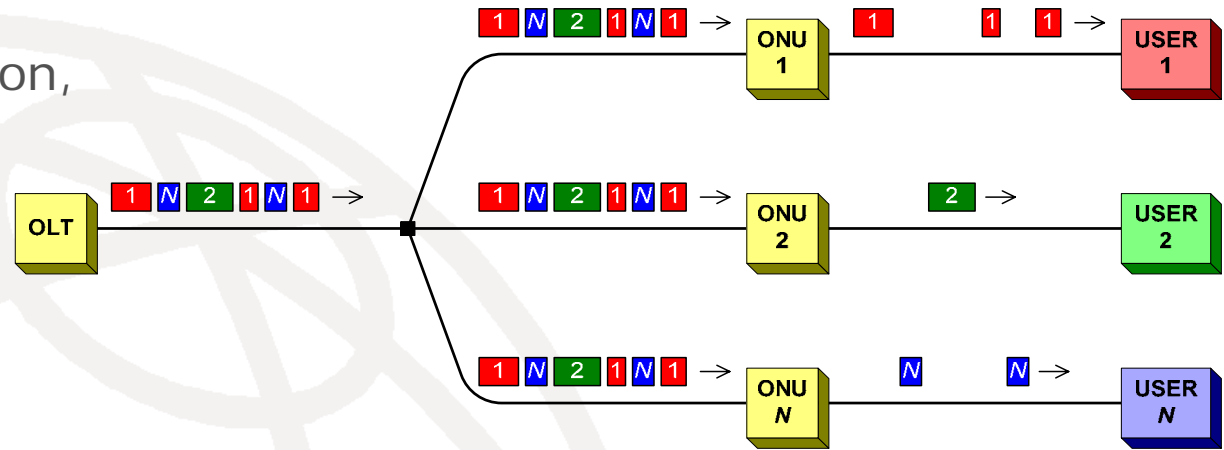


1GEAPON (IEEE Std. 802.3ah-2004)*

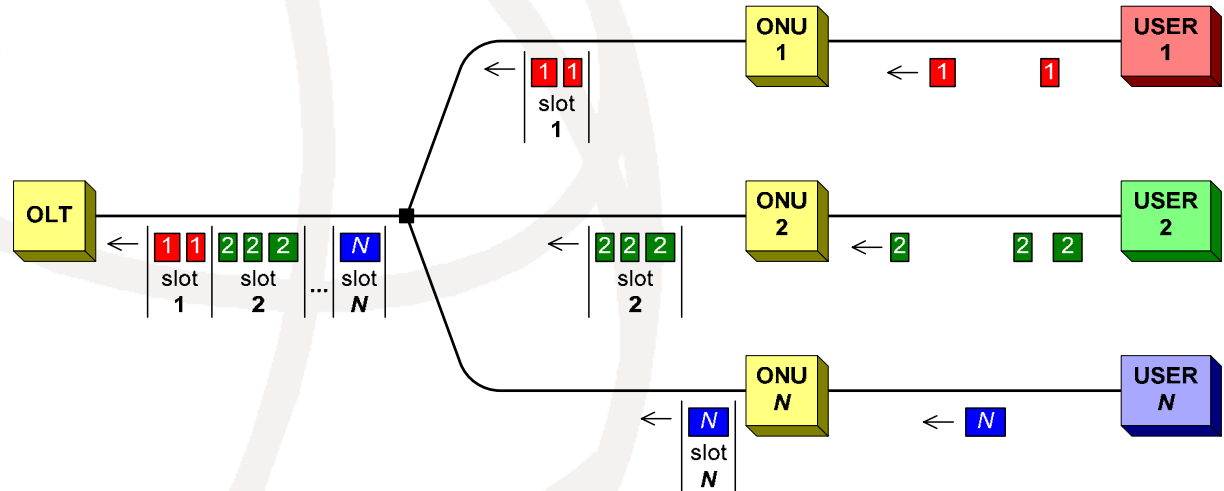
*** IEEE Std. 802.3ah-2004 is now part of IEEE Std. 802.3-2005**

EPON Transmission

- In downstream direction, ONUs selectively forward frames based on unique tag (Logical Link ID)



- In upstream direction, ONUs aggregate frames and transmit them in a burst during a timeslot assigned by the OLT.



- Bandwidth Assignment is done using request/grant mechanism.
- All grant and request messages are Ethernet MAC Control frames
- All OAM messages are Ethernet frames

Some EPON/GPON Differences

	ITU-T G.984 GPON	IEEE 802.3ah EPON
Layer 2		
Payload encapsulation	GPON Encapsulation Method (GEM)	Ethernet framing + a tag in preamble
Frame Fragmentation	Yes	No
Max Logical Reach	60 km	unlimited
Max Logical Range	20 km	unlimited
Max Logical Split	128	32767 ¹⁾
Layer 1		
Downstream line rate (Gbps)	1.244 / 2.488	1.25
Upstream line rate (Gbps)	0.155/0.622/1.244	1.25
Line Coding	Scrambling	8bit/10bit
Max Channel Insertion Loss (dB)	A: 20 dB B: 25 dB B+: 28 dB C: 30 dB	PX10: 20 dB PX20: 24 dB ²⁾
Laser on/off	≈ 13 ns	512 ns
AGC	44 ns	≤ 400 ns
CDR		≤ 400 ns

1) Limited by LLID address space (2¹⁵)

2) Current commercially-deployed EPON transceivers provide 29 dB power budget. Majority of EPONs are deployed in 1:32 and 1:64 configurations.

1G EPON is Very Successful

- **1G EPON Standard (IEEE802.3ah) was approved in June 2004 (< 3 years ago)**

- **Today 1G EPON...**
 - ... is in commercial deployments:**
 - **Carriers:** China Netcom, KDDI, K-Opticom, Korea Telecom, NTT, SBB, ...
 - **Deployed volume:** > 6 million lines

 - ... has broad manufacturing base:**
 - **Optics/Transceivers/PHY:** Delta Electronics, ETRI, Fiberxon, Hitachi/Lightron, NEC, Sumitomo, Vitesse, Zenko
 - **ASIC:** ETRI, Centillum, Conexant, Immenstar, GW, Passave, Teknovus, ...
 - **System:** Allied Telesyn, Alloptic, Corecess, Dasan/ Siemens, Entrisphere, Fiberhome, Fujitsu, Furukawa, Hitachi, Huawei, Hyundai, Mitsubishi, Nayna, NEC, OKI-Fujikura, Salira, Samsung, Sumitomo, UTStarcom, ZTE, ...
 - **Test Equipment:** Agilent, Fujitsu

- **Since IEEE Std 802.3ah approval, equipment cost has decreased by 50% and optics cost has decreased by 70%**

Why Next-Generation EPON Now?

- **Ethernet PON opened floodgates for advanced services**
 - Video-on-Demand
 - High-definition IP TV
 - Time-shifted broadcast
 - Online video games

- **Users began to accept, like, and demand more bandwidth-intensive services**
 - File sharing, picture uploading, video conferencing
 - More simultaneous IP TV channels
 - More on-demand, less broadcast (“information pull” instead of “information push”)

- **EPON’s success has created a strong demand for greater bandwidth**

- **Carriers are looking for a next generation solution**
 - Compatible with existing outside plant
 - Compatible with existing NMS and OAM



10GEPON (IEEE P802.3av Task Force)

History and Current Status

November 2005	A group of system vendors, chip vendors, and carriers began to exchange ideas on next generation EPON.
March 2006	After successful Call for Interest, IEEE approves 10GEPON Study Group .
September 2006	IEEE Standards Board approves formation of IEEE P802.3av (10GEPON) Task Force .
Currently	<ul style="list-style-type: none">■ 300 people subscribed to 10GEPON mailing list■ Task force is selecting baseline technical proposals
July-September 2007	First draft is expected
1H 2009	Anticipated standard approval

10G EPON for Digital Television

Service Offerings

Today	Near Future (2010)
<ul style="list-style-type: none"> ■ Broadcast ■ Video-on-Demand 	<ul style="list-style-type: none"> ■ Time-shifted / narrowcast ■ All-channel personal video recorder ■ Picture-in-picture / split screen ■ Digital cinema distribution ■ Personal multimedia publishing ■ Residential and business digital video surveillance

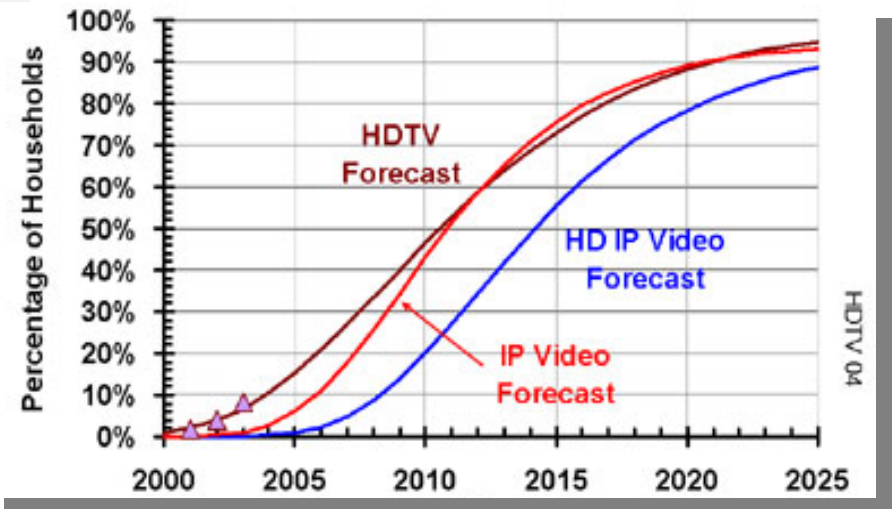
Bandwidth per Channel

Today	Near Future (2010)
<ul style="list-style-type: none"> ■ Standard Definition TV (SDTV) <ul style="list-style-type: none"> • 2 Mbps per channel 	<ul style="list-style-type: none"> ■ High-Definition TV (HDTV) <ul style="list-style-type: none"> • ~10 Mbps per channel ■ Large Screen Digital Imagery (LSDI) <ul style="list-style-type: none"> • Standardized by ITU-T J.601 • 40 to 160 Mbps per channel

Number of Channels

Today	Near Future (2010)
<ul style="list-style-type: none"> ■ 30 ~ 100 channels 	<ul style="list-style-type: none"> ■ 1000 or more channels <ul style="list-style-type: none"> • Mix of SDTV, HDTV, LSDI

Forecast of US Households Using HDTV



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For now, AT&T will offer 200 channels, though it expects to offer 1,000 or more channels when it expands the service to other markets in about six months. Its channel lineup already includes major networks as well as ESPN, HBO, the Discovery Channel, the Disney Channel, MTV, the History Channel, USA, CNN, National Geographic and others.

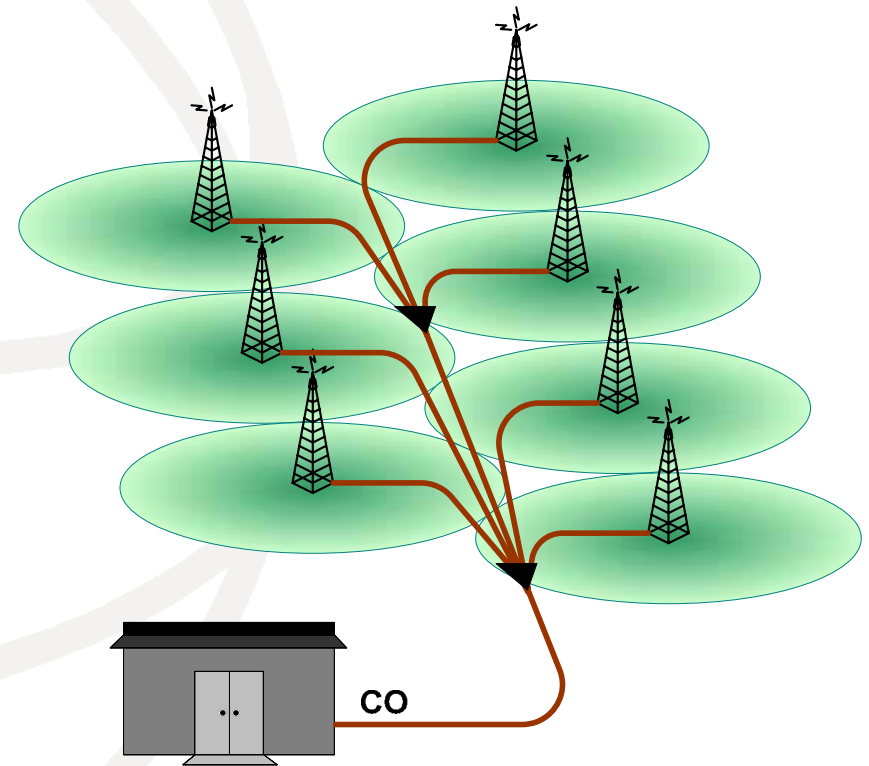
The Wall Street Journal
January 5, 2006

10G EPON for Digital Home

- In 2010, residential gateways will require *much* more bandwidth
 - 3-5 STBs/home with built-in digital video recorders
 - Large fraction of television will be HDTV
 - Large fraction of television will be on-demand/time-shifted
 - Gigabit UNIs in home networks will be ubiquitous
 - AV Bridges will be ubiquitous

10G EPON For Wireless Back-Haul

- 4th Gen mobile communication will be ubiquitous
 - Bandwidth: ~30Mbps/user, 100M~1Gbps/access point
 - Access point coverage will decrease
 - Number of access points will increase
 - EPON is a natural back-haul solution for the 4th Gen access points
- Next generation wireless back-haul
 - 802.11n: up to 100 Mbps per device
 - 802.16e: up to 70 Mbps per access point

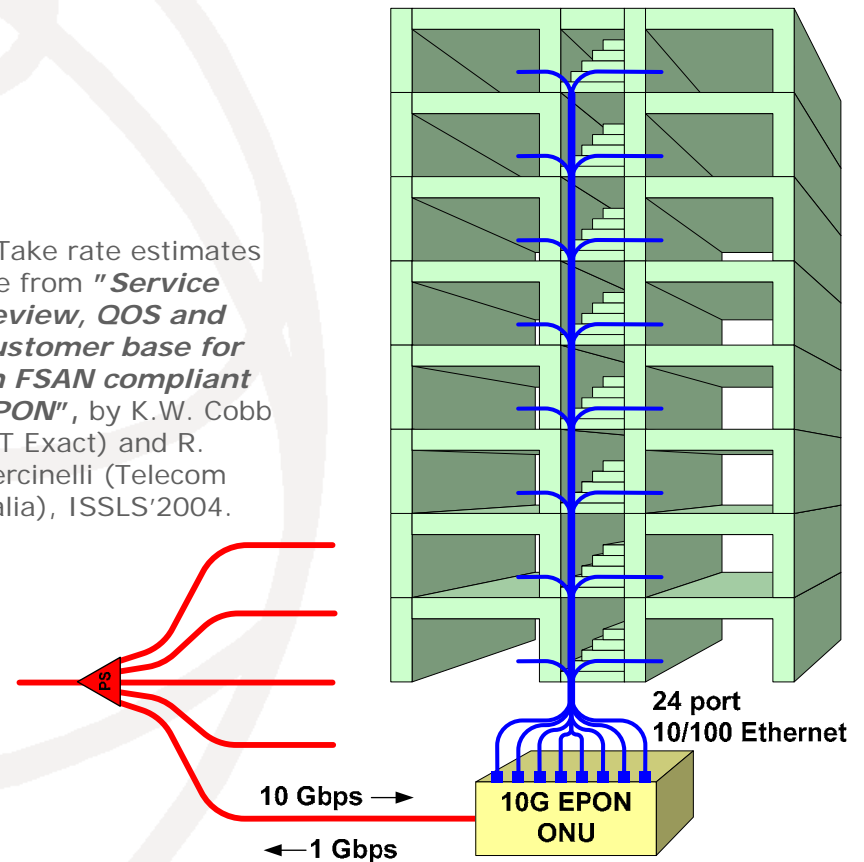


10G EPON for MDU Market

- A large fraction of broadband users lives in Multiple Dwelling Units (MDUs)
- Each of 16 MDU ONUs can provide service to 24–48 subscribers, a total of 384-768 subscribers per EPON

Broadcast Video	100 channels x 10 Mbps/channel =	1.0 Gbps
Video on Demand	10 Mbps/channel x 2 channels/user x 24 users/ONU x 16 ONUs/PON x 30% take rate*	2.3 Gbps
Video Conferencing & Surveillance	10 Mbps/user x 24 users/ONU x 16 ONUs/PON x 10% take rate	0.4 Gbps
Internet	5 Mbps/user x 24 users/ONU x 16 ONUs/PON x 50% take rate	1.9 Gbps
Gaming	10 Mbps/user x 24 users/ONU x 16 ONUs/PON x 30% take rate	1.2 Gbps
Required PON bandwidth =		6.8 Gbps

* Take rate estimates are from "*Service Review, QOS and Customer base for an FSAN compliant GPON*", by K.W. Cobb (BT Exact) and R. Mercinelli (Telecom Italia), ISSLS'2004.



10GEPON Supporters

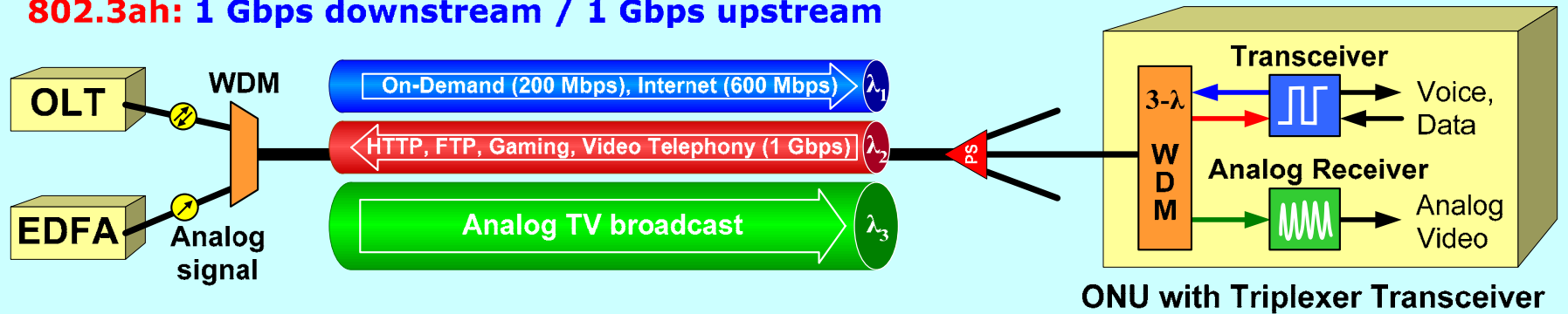
Victor Blake,	Advance/Newhouse Communications	Charles Chen,	ImmenStar
Lars Thon,	Aeluros	Eugene Lee,	ImmenStar
Dean Jackson,	Agilent	Niel Ransom,	Independent
Guy Trotter,	Agilent	Drew Perkins,	Infinera
Hai Vodinh,	Allied Telesyn	Chou Yun Lung,	ITRI
David Walsh,	Alloptic	DarZu Hsu,	ITRI
Ketan Gadkari,	Alloptic	Yun-Lung Chou,	ITRI
Vikrama Ditya,	Alloptic	Keiji Tanaka,	KDDI R&D Labs.
Sanjay Sharma,	Ample Communications	Hiroaki Katagawa,	K-Opticom
Petre Popescu,	Astar-ODSM	Hiroataka Wada,	NEC
Howard Frazier,	Broadcom	Naoto Saeki,	NEC
Wael Diab,	Broadcom	Ed Cornejo,	OpNext
Scott Powell,	Broadcom	Mike Dudek,	Picolight
Bill McDonald,	Centillium Communications	Brad Booth,	Quake Technologies
Joe Decarolis,	Centillium Communications	Rick Li,	Salira Systems
Zhong Deqiang,	China Netcom	Byeong Hoon Kim,	Samsung Electronics
Shen Cheng Bin,	China Telecom	Eric Hyunsurk Ryu,	Samsung Electronics
Wang Bo,	China Telecom	Geoffrey Garner,	Samsung Electronics
Ching-Sheu Wang,	Chunghwa Telecom	Jung Won Park,	Samsung Electronics
Russ Gyurek,	Cisco Systems	Yosuke Komiyama,	Softbank BB
Paul Voois,	ClariPhy Communications	Ed Boyd,	Teknovus
William Keasler,	Conexant Systems	Glen Kramer,	Teknovus
David Hare,	Conexant Systems	Ryan Hirth,	Teknovus
Seuk-Jin Kang,	Corecess	Sanjay Kasturia,	Teranetics
Steven Swanson,	Corning	Denis Beaudion,	Texas Instruments
Ming Wu,	Delta Electronics	Jaafar Haji Mohamad Abu Bakar,	Telecom Malaysia
Dong Soo Lee,	ETRI	Sahrul Hilmi Ibrahim,	Telecom Malaysia
Hark Yoo,	ETRI	Alex Conta,	TranSwitch
Bin Yeong Yoon,	ETRI	Eric Lynskey,	UNH IOL
Douglas Cheng,	Fiberxon	Henry Tzeng,	UTStarcom
Hu Baomin,	FOTEK Optoelectronics	Frank Chang,	Vitesse
Liu Wu,	FOTEK Optoelectronics		

Objectives

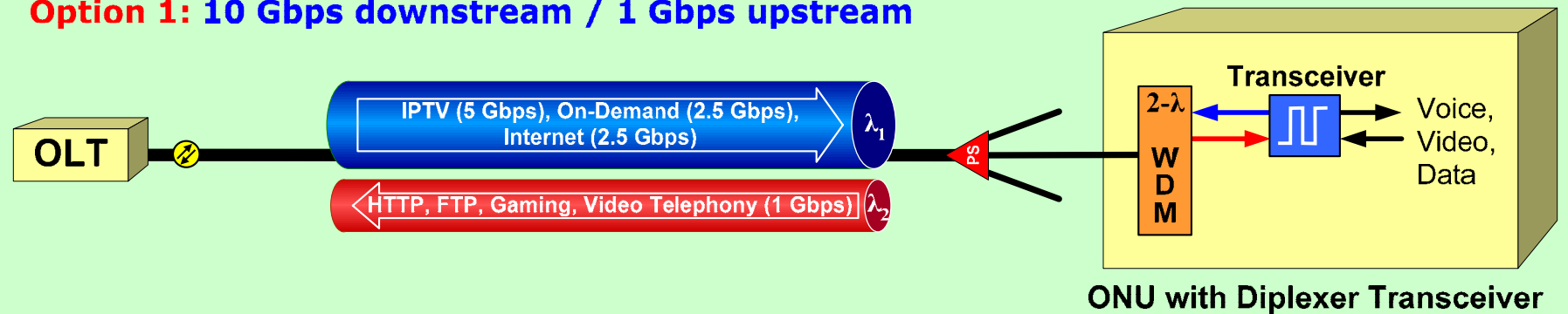
- Support subscriber access networks using point to multipoint topologies on optical fiber
- PHY(s) to have a BER better than or equal to 10^{-12} at the PHY service interface
- Provide physical layer specifications:
 - PHY for PON, 10 Gbps downstream/1 Gbps upstream, single SM fiber
 - PHY for PON, 10 Gbps downstream/10 Gbps upstream, single SM fiber
- Define up to 3 optical power budgets that support split ratios of 1:16 and 1:32, and distances of at least 10 and at least 20 km.

Video Delivery Options

802.3ah: 1 Gbps downstream / 1 Gbps upstream



Option 1: 10 Gbps downstream / 1 Gbps upstream



- 10G EPON eliminates the bandwidth need to provision a third wavelength for video
- 10G EPON simplifies architecture for video delivery
- 10G EPON facilitates IP convergence



10GEPON Emerging Solutions

- Power budgets
- Compatibility and Coexistence

Material in this section is presented only as an illustration of problems and solutions being discussed by the IEEE P802.3av task force. As of time of this presentation, no formal decision has been made on these topics.

Three Classes of Power Budgets

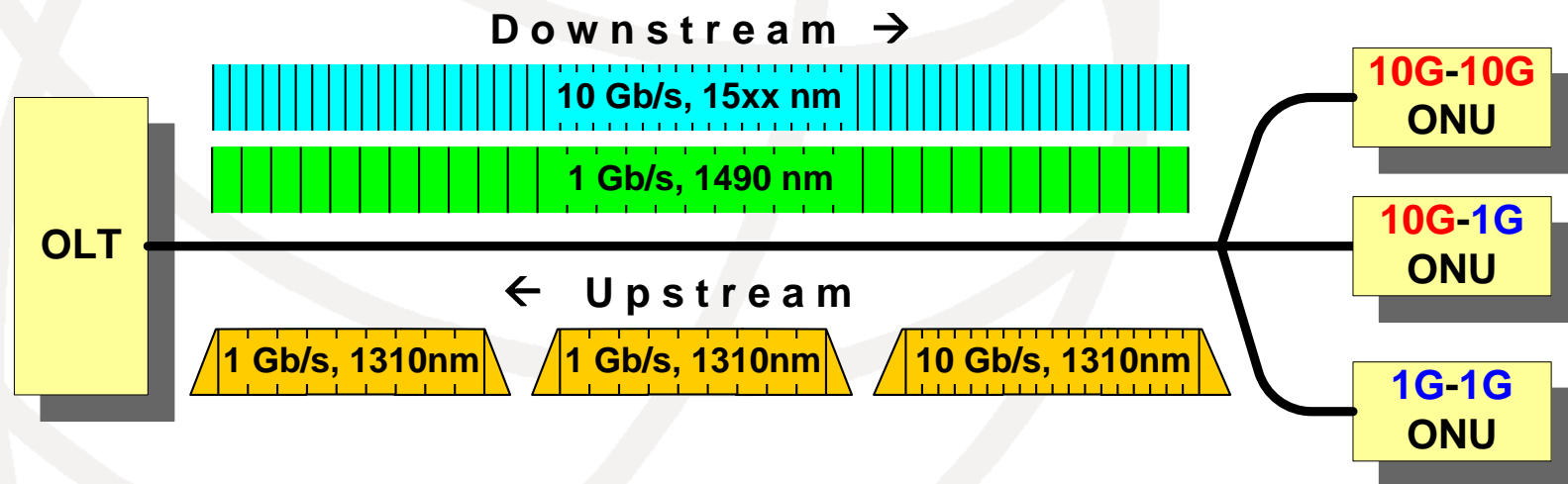
- One of requirements is to standardize a power budget better than class B+ in G.984
 - Class B++
- PX10 and PX20 should remain compatible with 1G EPON
- Standard should allow higher power budgets when optics improves

	1:16	1:32
10 km	PX10	PX20
20 km	PX20	B++

	Max Channel Insertion Loss	Power Budget
PX10	~20 dB	~22 dB
PX20	~24 dB	~26 dB
B++	~29 dB	~31 dB

10GEPON's Focus on Coexistence

- **10G EPON will be able to operate on the same ODN with 1G EPON at the same time.**
- **Downstream is WDM**
 - 1490 nm – 1G EPON
 - 15xx nm – 10G EPON
 - 1550 nm – optional video overlay
- **Upstream is dual-rate TDMA**
 - Using 1310 nm allows 10G ONU to use un-cooled directly-modulated lasers
 - Dual-rate burst mixing has no impact on ONUs - an ONU is blind to upstream transmissions from other ONUs



Participation in IEEE P802.3av

- Our web site is located at: <http://www.ieee802.org/3/av/>
- All meeting materials are publicly available (but draft standards will be password-protected)
- To subscribe to 10GEAPON reflector, send email to listserv@ieee.org

with this line in the body of the message:

*subscribe stds-802-3-10GEAPON
Firstname Lastname*

- Individual Participation
 - One person – one vote
 - No corporate representation
 - No membership fees, no corporate fees – only individual registration fee to attend a meeting

