

# 10G及2.5G EPON 新技术研讨会

## 演讲参考资料

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# 10G-EPON: 标准化进展和出现的解决方案

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# 概要

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- **10GEPON** 市场驱动力
- 标准化状况
  - 目前的状态
  - 标准化的过程
  - 项目时标
- **P802.3av** 范围和目标
- **10GEPON** 技术综述
  - 功率预算和波长
  - 共存
  - 其他特性
- 如何参加**IEEE 802.3av** 任务组

# 10GEPON市场驱动力

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# EPON的简单历史脉络

- **Nov 2000**
  - CFI for Ethernet in the First Mile
- **Jan 2001**
  - The first Study Group meeting
- **Sep 2001**
  - The first Task Force meeting
- **Jun 2004**
  - IEEE Std 802.3ah–2004 is approved by RevCom and IEEE SA SB



## EPON Today...

- ... is in commercial deployments:
  - Carriers: Brighthouse, China Netcom, China Telecom, KDDI, K-Opticom, Korea Telecom, NTT, many others
  - Deployed volume: ~11 million lines worldwide
- ... has broad manufacturing base:
  - Optics/Transceivers/PHY: Delta Electronics, ETRI, Fiberxon, Hitachi/Lightron, NEC, Sumitomo, Vitesse, Zenko
  - ASIC: ETRI, Centillum, Conexant, Cortina, GW, PMC Sierra, Teknovus, ...
  - System: Allied Telesyn, Alloptic, Corecess, Dasan/Siemens, Entrisphere, Fiberhome, Fujitsu, Furukawa, Hitachi, Huawei, Hyundai, Mitsubishi, NEC, OKI-Fujikura, Salira, Samsung, Sumitomo, UTStarcom, ZTE, many others
  - Test Equipment: Agilent, Fujitsu
- Since IEEE Std 802.3ah approval, equipment cost has decreased by 50% and optics cost has decreased by 70%

# 为什么现在要考虑下一代EPON?

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- **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

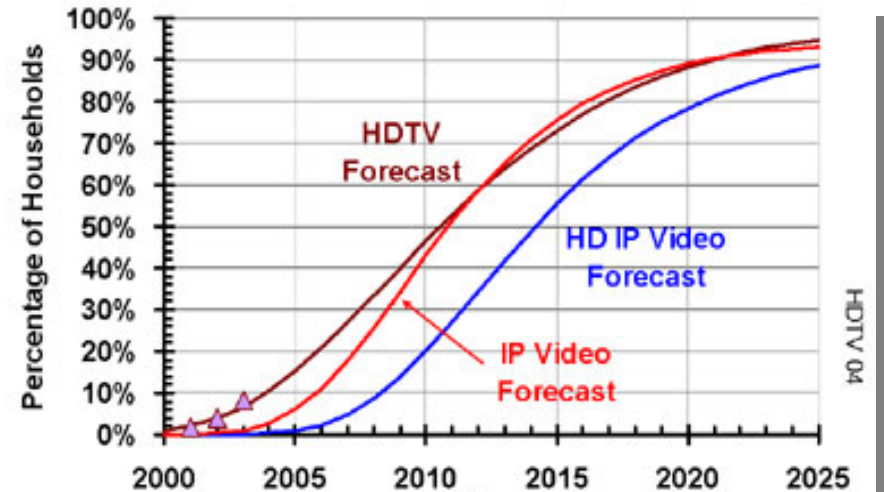
# 10G EPON应用于数字电视

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

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

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

Forecast of US Households Using HDTV

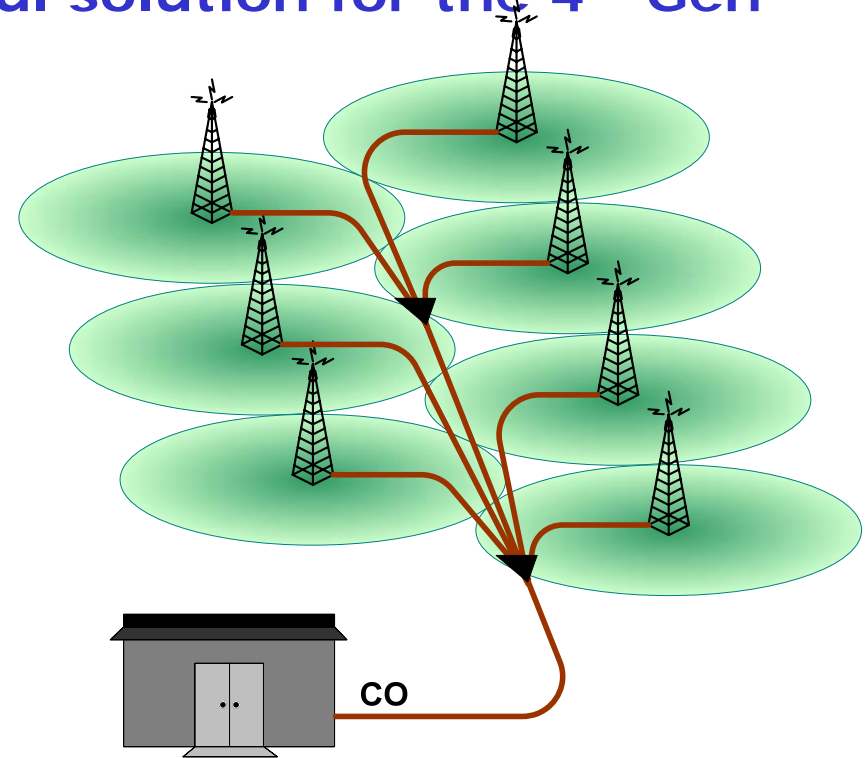


Reproduced with permission from Technology Futures, Inc.

- 3-5 STBs/home with built-in DVRs
- Gigabit ports in home are ubiquitous
- Audio/Video Bridging standards are coming soon
  - 802.1AS
  - 802.1Qat
  - 802.1Qav

# 10G EPON应用于无线回传

- 4<sup>th</sup> 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 4<sup>th</sup> 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
- Access bandwidth must grow beyond 1 Gbps

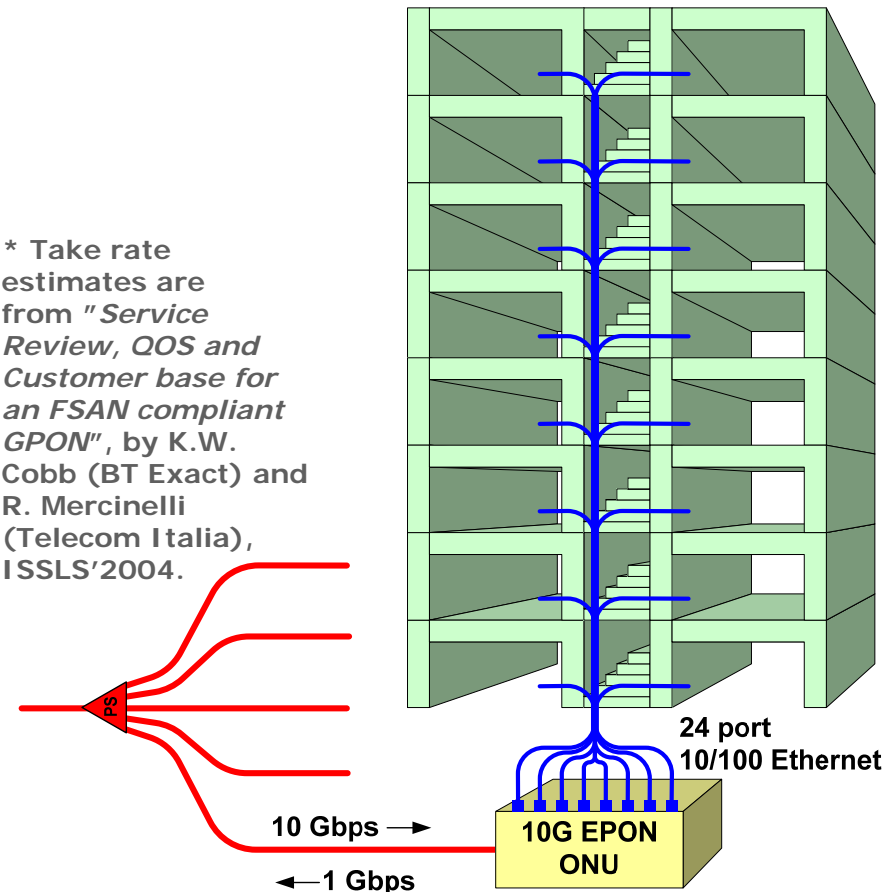


# 10G EPON应用于MDU市场

- 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

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

\* 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.



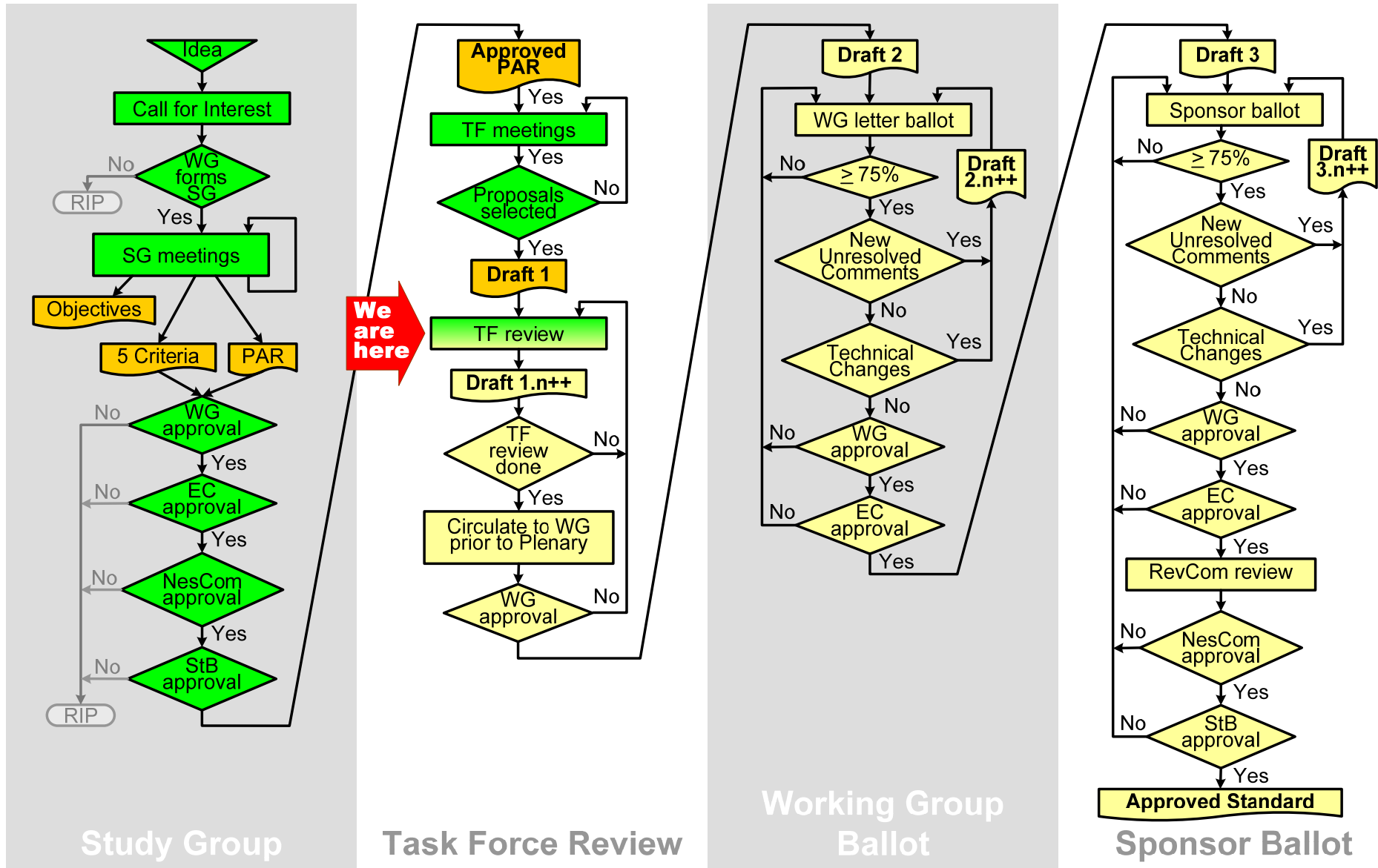
# 10GEPON 的支持者 (截至2006年3月)

Victor Blake,	Advance/Newhouse Communicati	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,	Centillum Communications	Brad Booth,	Quake Technologies
Joe Decarolis,	Centillum 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,	Telekom Malaysia
Dong Soo Lee,	ETRI	Sahrul Hilmi Ibrahim,	Telekom 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		

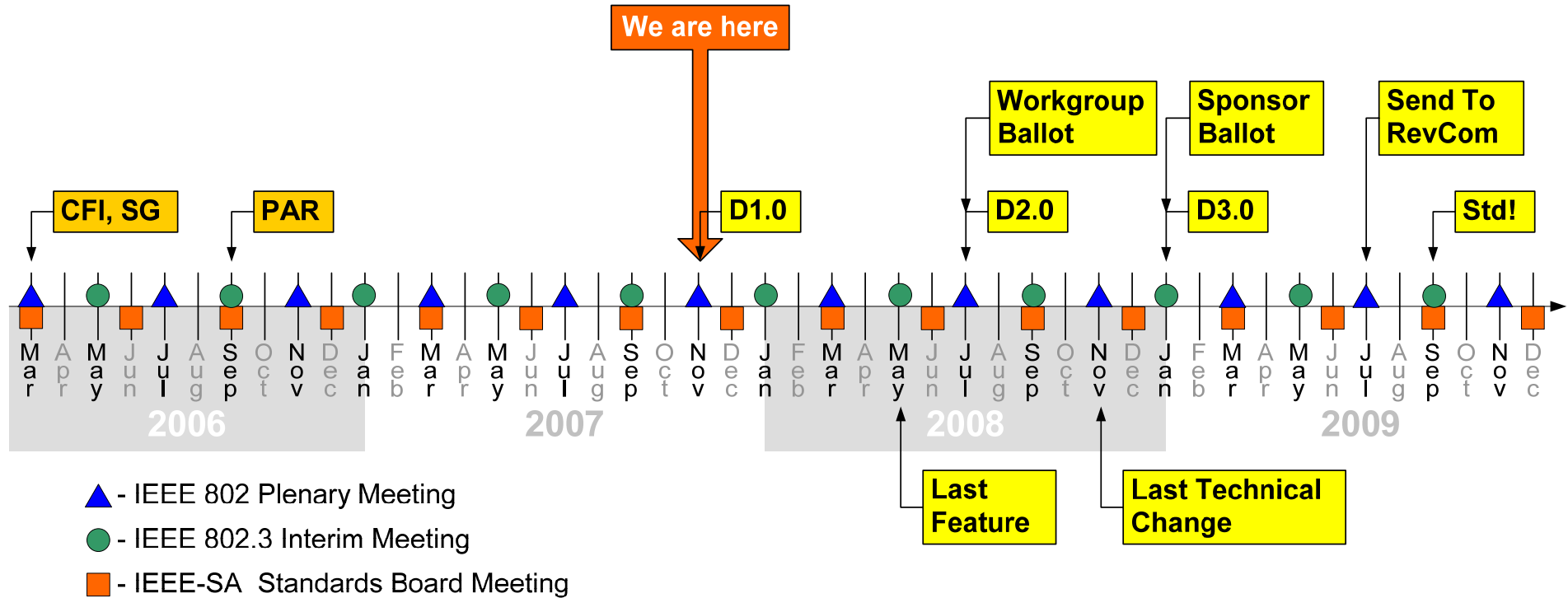
# 标准化状况

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# 标准化过程



# 项目时标



- **Timeline approved on November 15, 2007 (Y:29 N:0 A:4)**
- **Expected standard approval – September 2009**

# 目前P802.3av状况

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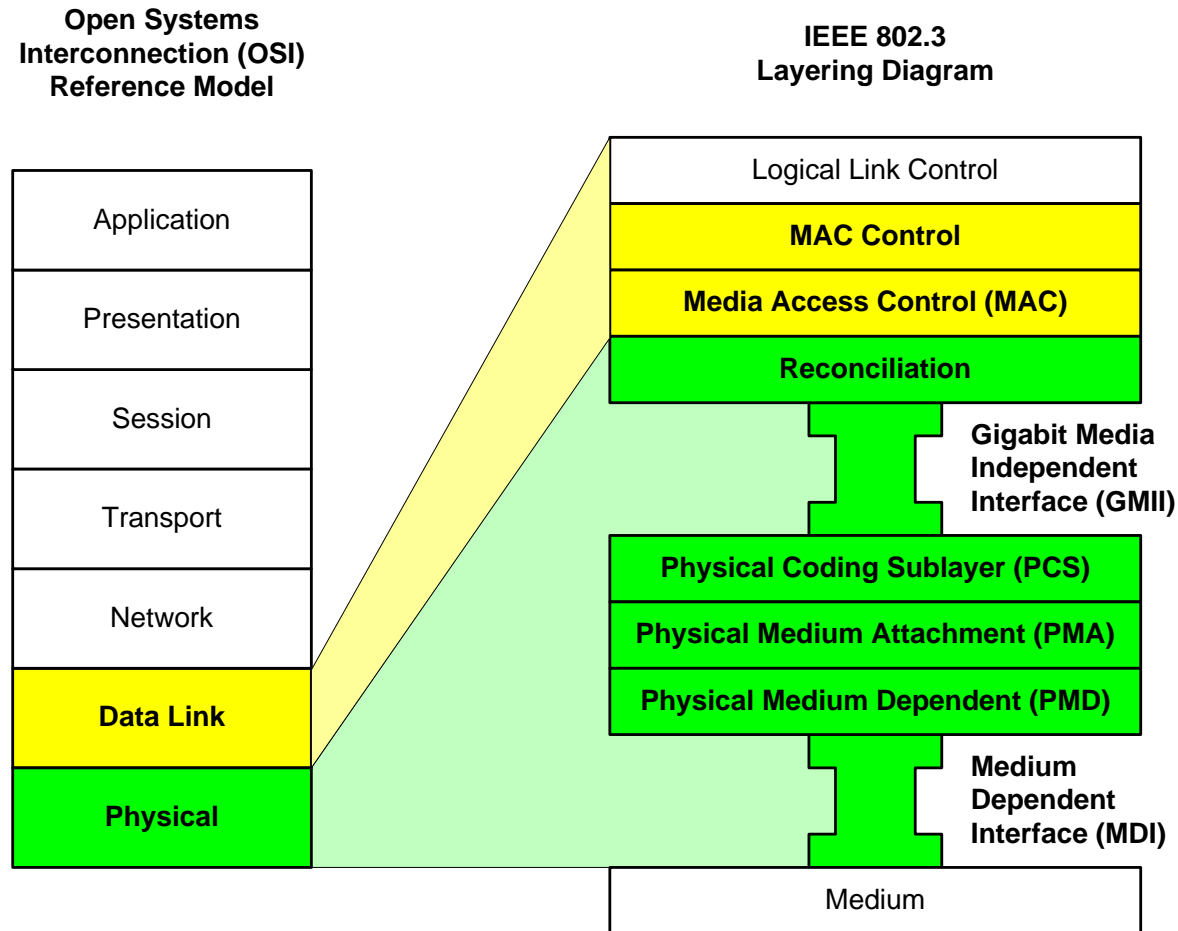
- Held 10 meetings (2 as study group, 8 as task force)
- Meeting attendance 40~60 people
  - Currently ~340 subscribers on 10GEPON reflector
- Selected 30 baseline proposals
  - <http://www.ieee802.org/3/av/public/baseline.html>
- **Released Draft 1.0**
  - **Clause 64**: Multipoint MAC Control
  - **Clause 91**: Physical Medium Dependent (PMD) sublayer ...
  - **Clause 92**: Extensions of the Reconciliation Sublayer (RS) and Physical Coding Sublayer (PCS) / Physical Media Attachment (PMA)...

# P802.3av范围和目标

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# IEEE 802.3标准的范围

- IEEE 802.3 only covers physical layer and a portion of data Link layer



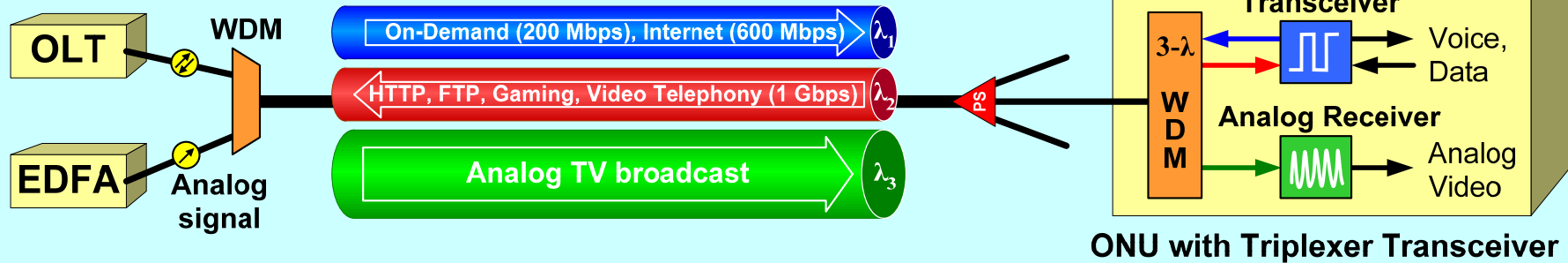
# 目标

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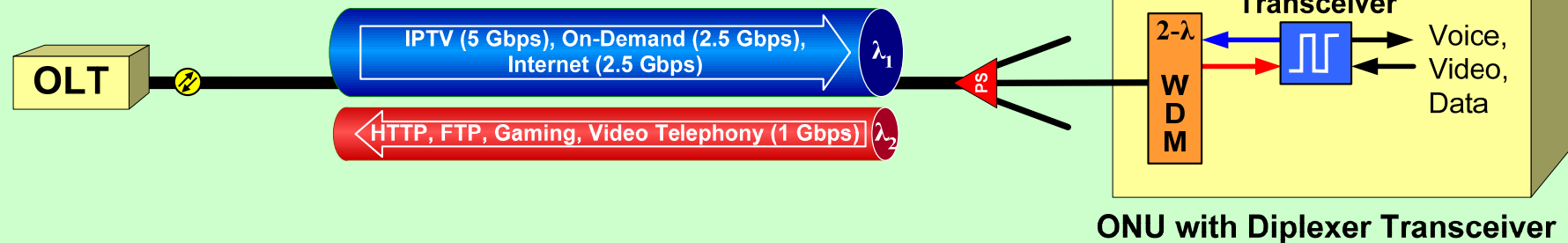
- Support subscriber access networks using point to multipoint topologies on optical fiber
- PHY(s) to have a BER better than or equal to  $10^{-12}$  at the PHY service interface
- Provide physical layer specifications:
  - PHY for PON, 10 Gbps downstream/1 Gbps upstream, single SM fiber
  - PHY for 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.

# 视频发送的选择

## 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

*Disclaimer: Material in this section reflects currently adopted solutions which form a baseline of P802.3av draft 1.0. It is possible that, in future drafts, the task force will modify these solutions or select different solutions altogether.*

## 10GEPON技术综述

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- 功率预算和波长
- 共存
- 其他特性

# 3级功率预算

## Symmetric power budgets (10G down/10G up)

	1:16	1:32
10 km	PR10	PR20
20 km	PR20	PR30

## Asymmetric power budgets (10G down/1G up)

	1:16	1:32
10 km	PRX10	PRX20
20 km	PRX20	PRX30

- **PR10 and PRX10**

- Channel insertion loss = 20 dB
- Specified for the same outside plant as PX10

- **PR20 and PRX20**

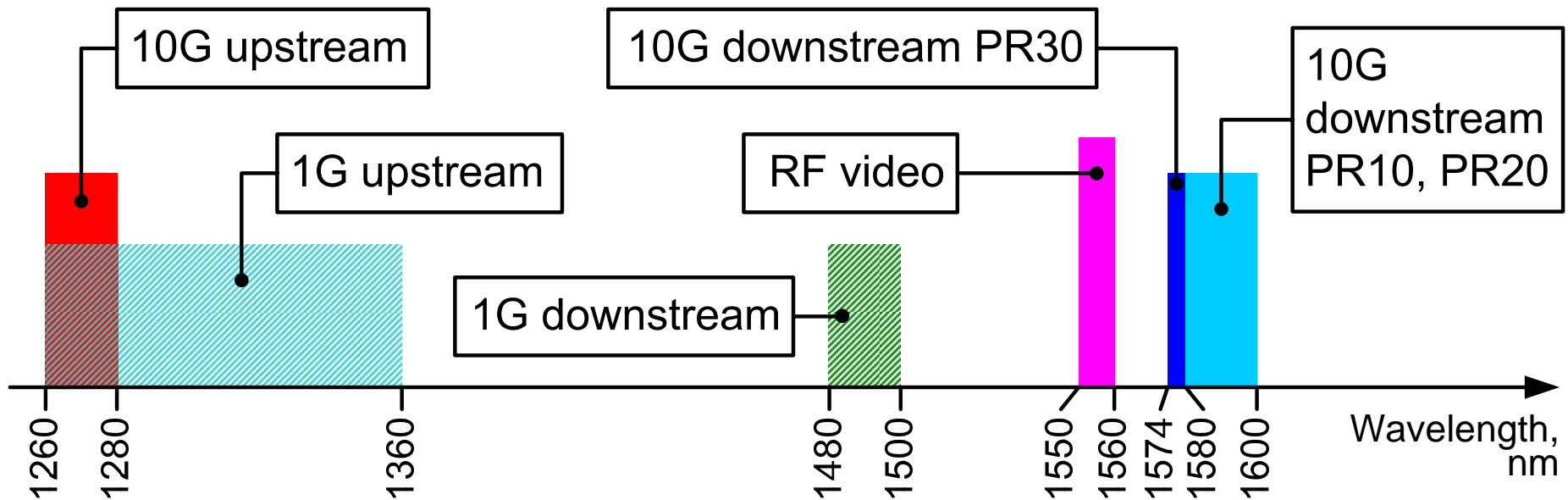
- Channel insertion loss = 24 dB
- Specified for the same outside plant as PX20

- **PR30 and PRX30**

- Channel insertion loss = 29 dB
- Carriers strongly required a power budget higher than class B+ in G.984

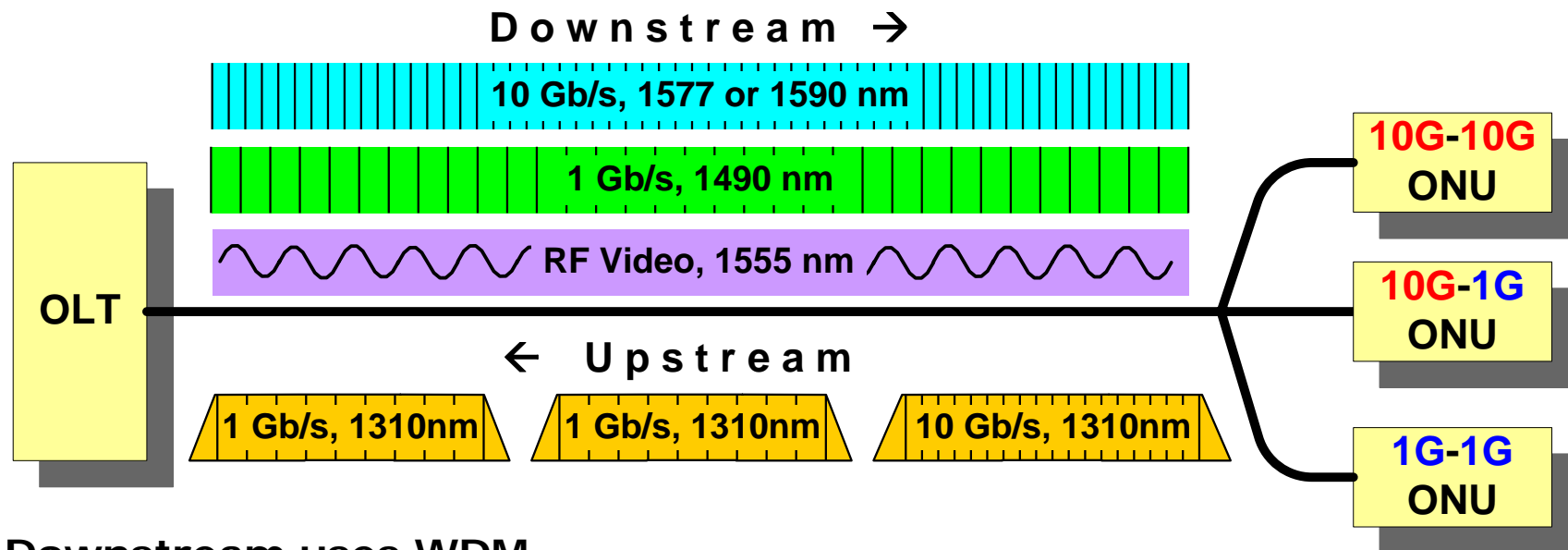
# 10GEPON 波长分配

- 10G EPON wavelengths are allocated to allow coexistence with 1G EPON and RF video



# 共存

The new draft standard supports coexistence of symmetric 10G ONUs, asymmetric 10G/1G ONUs, symmetric 1G ONUs, and RF video overlay on the same ODN

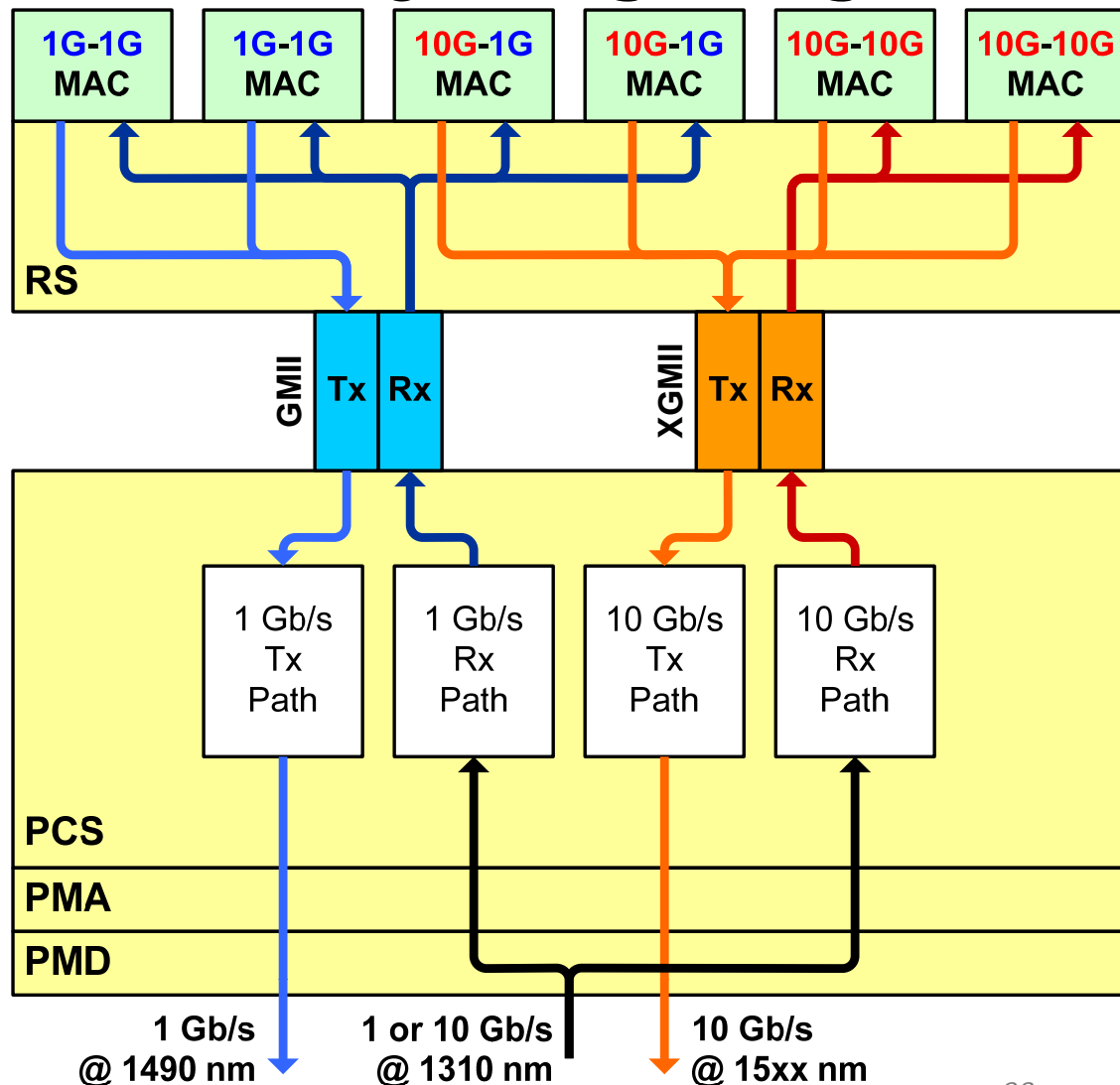


- **Downstream uses WDM**
  - 1Gb/s ONUs already have filters to block C- and L-bands
  - 10Gb/s ONUs will have filters to block C- and S-band
- **Upstream is dual-rate burst mode:**
  - All ONUs transmit in O-band (1260-1360)
  - 1Gb/s ONUs send bursts using 8b/10b @ 1.25 Gb/s
  - 10Gb/s ONU send bursts using 64b/66b @ 10.3125 Gb/s

# 双速率突发模式

- Dual-rate burst mode has no impact on ONUs.
- All the complexity is in the OLT's receiver and burst synchronization circuit
- The OLT can be built to support 3 types of ONUs simultaneously:
  - 1G/1G
  - 10G/1G
  - 10G/10G

## OLT Layering Diagram

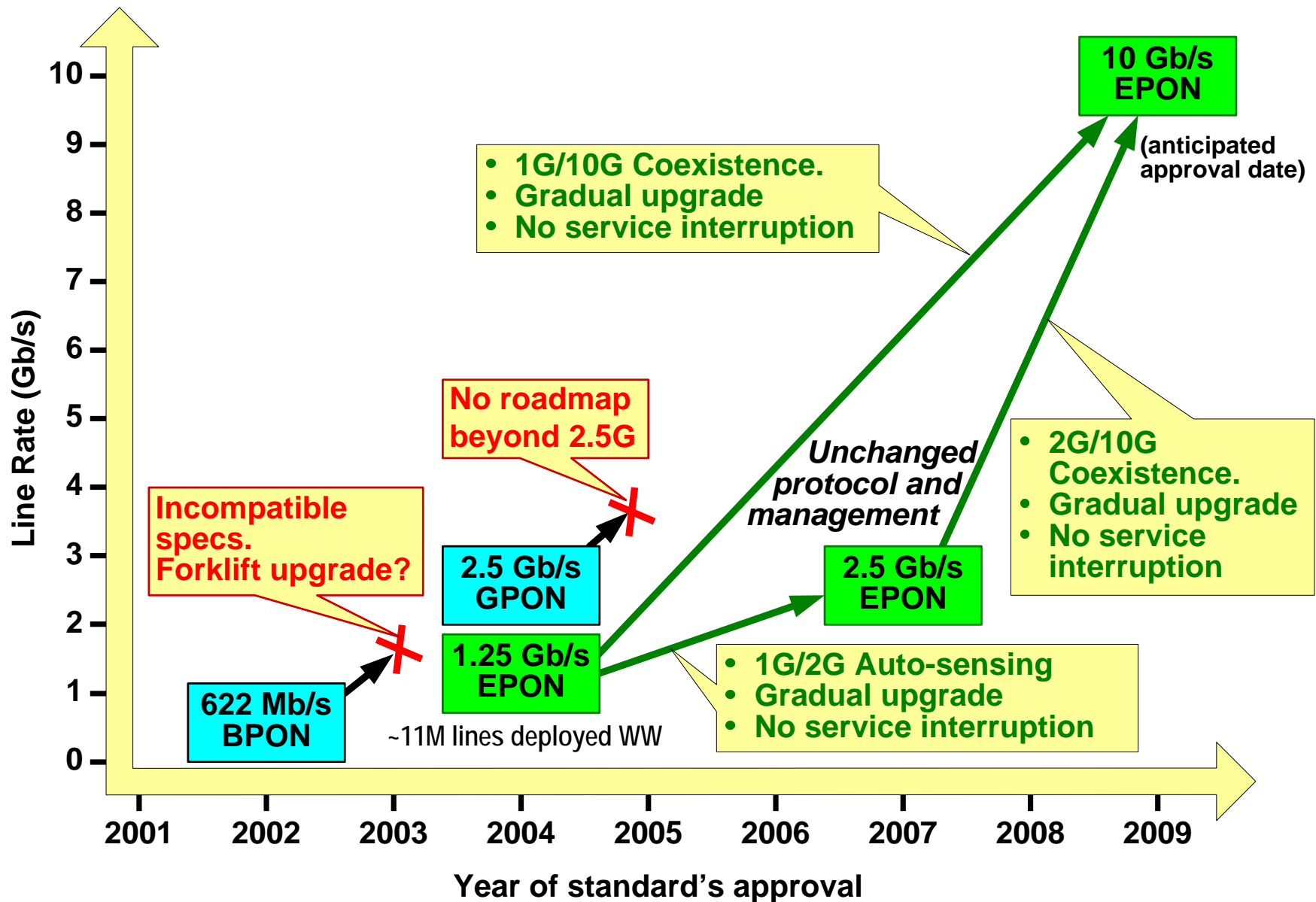


# 其他特性

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- 效率
  - 64b/66b line coding reduces coding overhead (only 3%)
  - Uses adjustable laser on/off times to improve efficiency with faster lasers
- **FEC**
  - Stream based FEC provides constant overhead and simpler integration with 64b/66b coding structure
  - Selected strong FEC method: RS(255, 223)

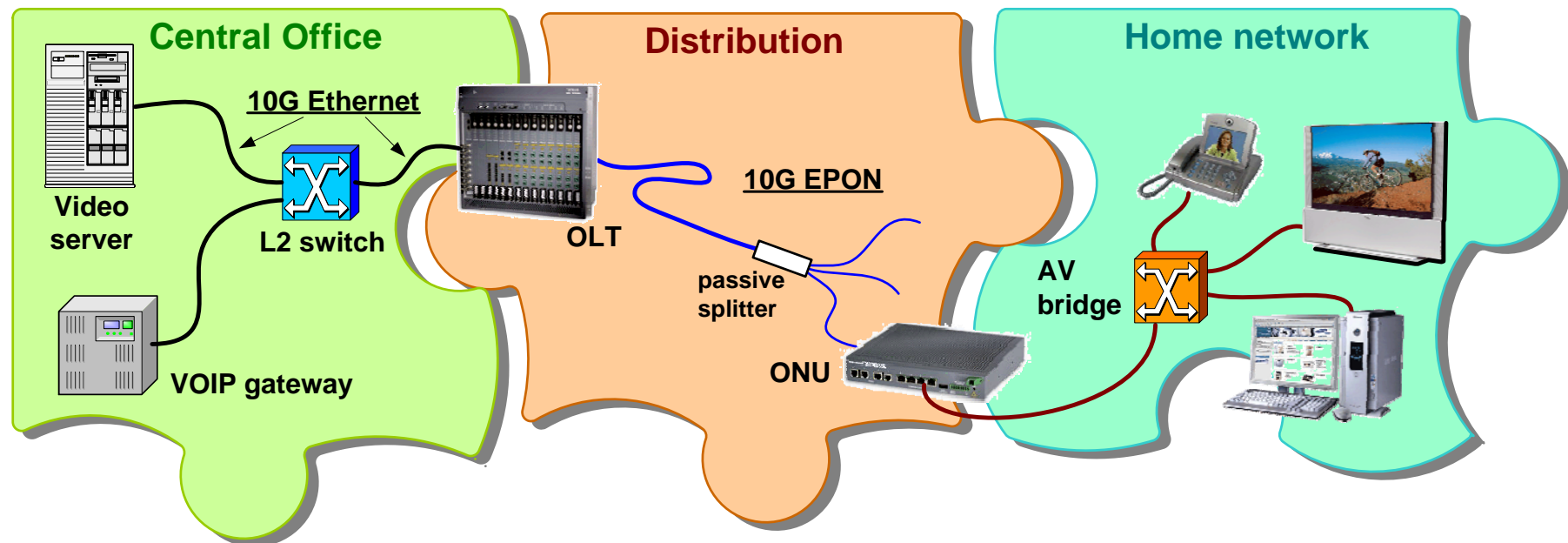
# EPON 致力于无缝升级



# 10GEPON是以太网生态系统的一部分

## Long Haul and Central Office Interconnects

- 802.3ae, 802.3ak, 802.3an: 10GbE point-to-point links
- 802.3ba: future 40G and 100G Ethernet solutions
- Residential Solutions
  - 802.1 Audio/Video Bridging TG (Residential Ethernet)



# 如何参加IEEE P802.3av任务组

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# P802.3av Reflector and Website

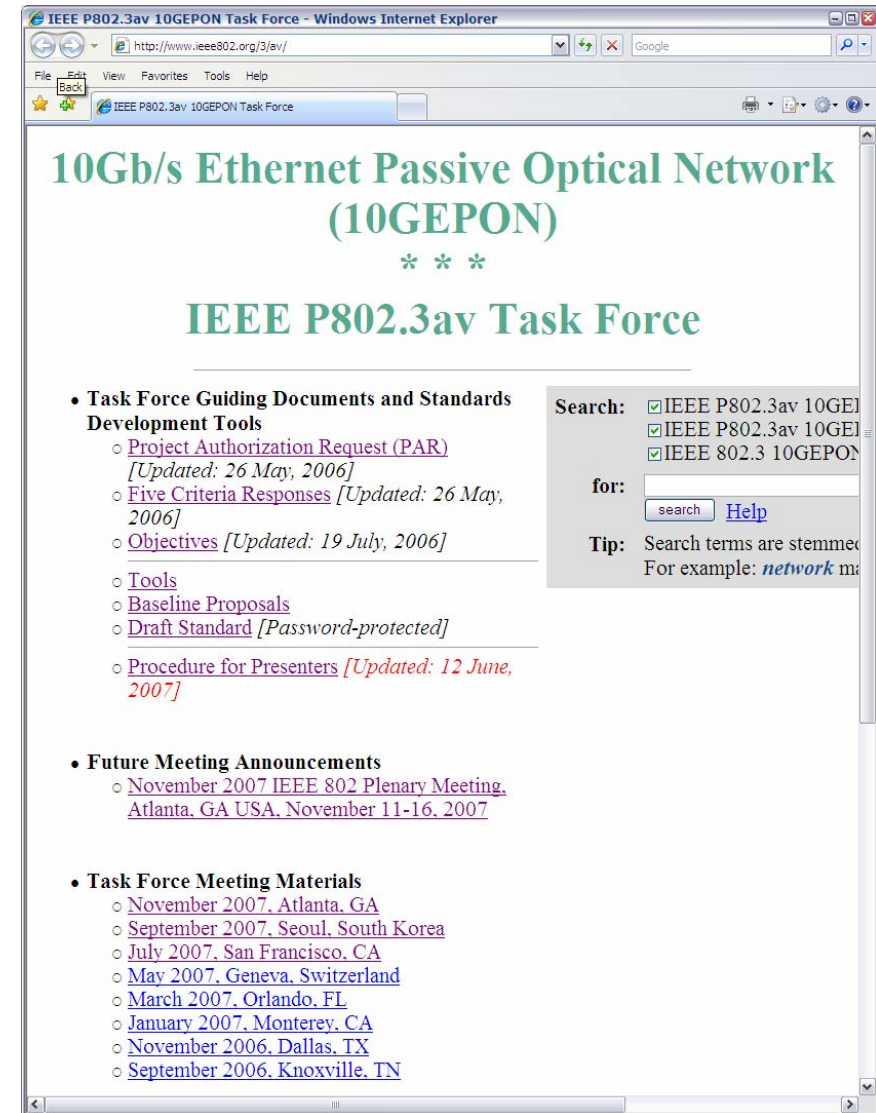
- Our web site is located at: <http://www.ieee802.org/3/av/>

- All meeting materials are publicly available (but standard drafts are password-protected)

- To subscribe to 10GEPON reflector, send email to: [listserv@ieee.org](mailto:listserv@ieee.org)

and include this line in the *body of the message*:

*[subscribe stds-802-3-10GEPON](#)  
Firstname Lastname*



# Ground Rules

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- No membership fees, no corporate fees – only individual registration fee to attend a meeting.
  - Do not need to be an IEEE member
- Anyone in the room may speak
- Voting:
  - In task force: Anyone in the room may vote
  - In working group: A participant becomes a voting member after attending 3 meetings (3 plen. or 2 plen. + 1 interim)
- Individual Participation
  - One person – one vote
  - No corporate representation

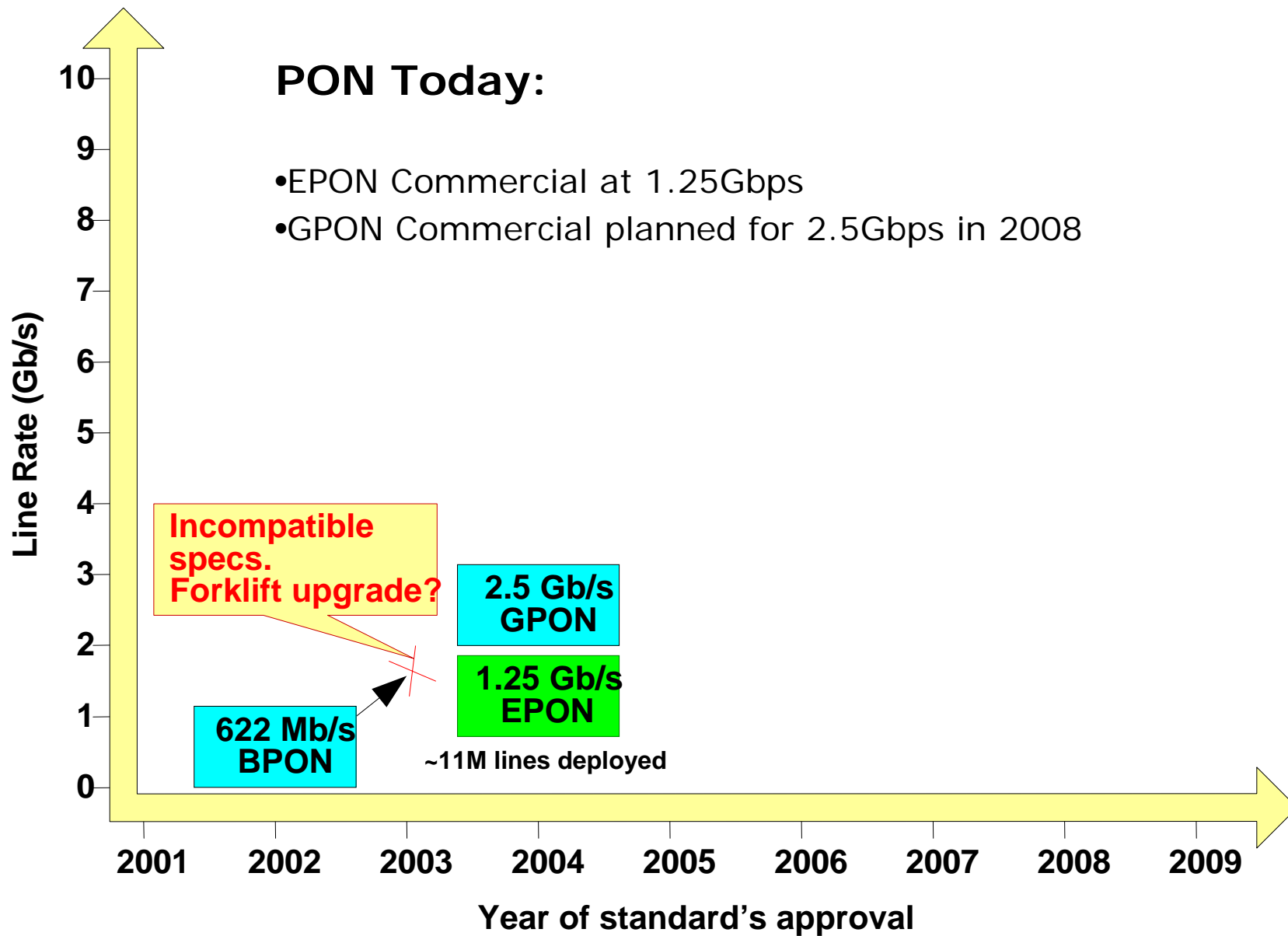
# 2.5Gbps EPON

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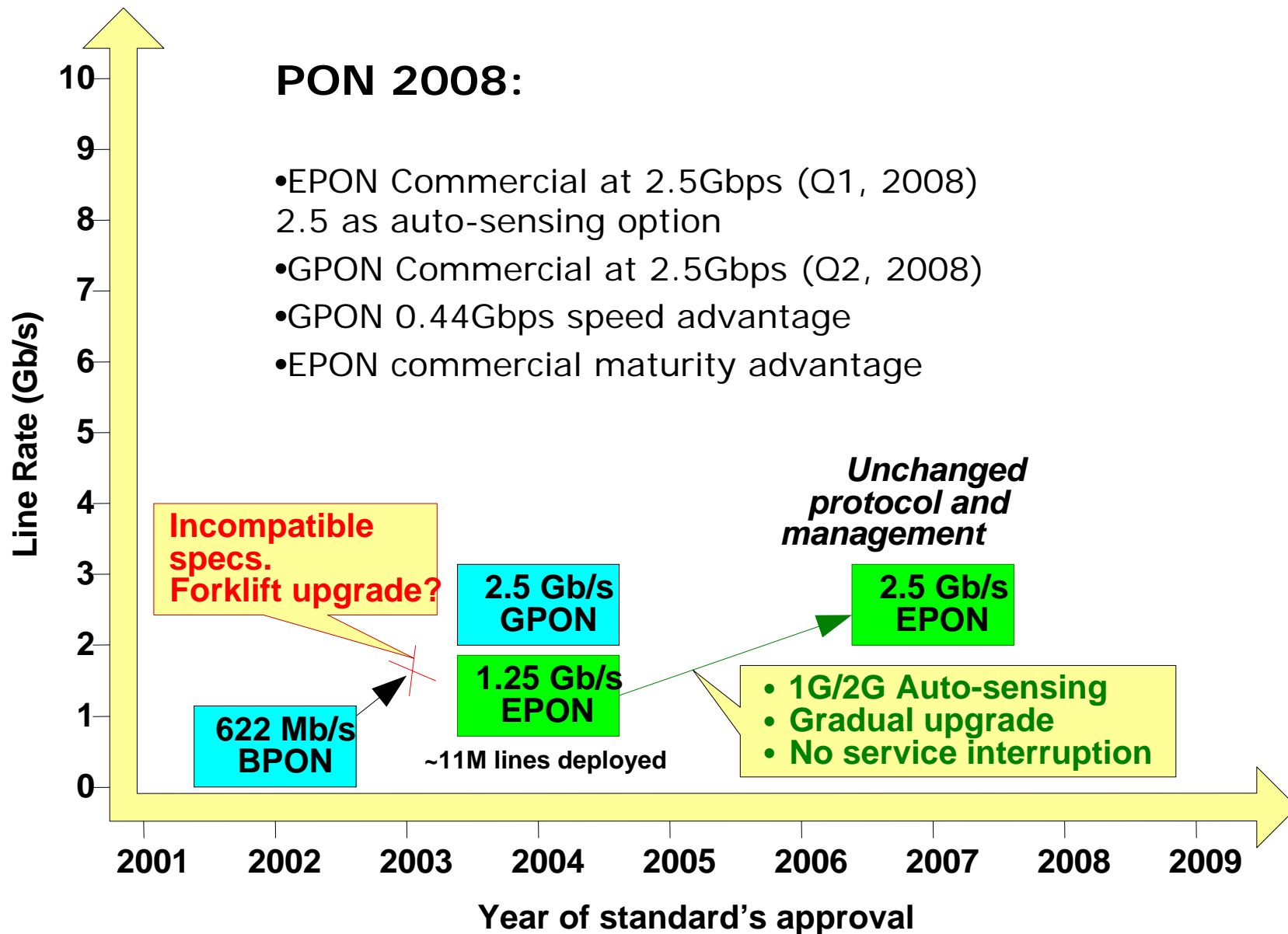
**Rick Li (rick.li@teknovus.com)**  
**Senior Director, Technology and Strategic  
Development**

**December 20, 2007**

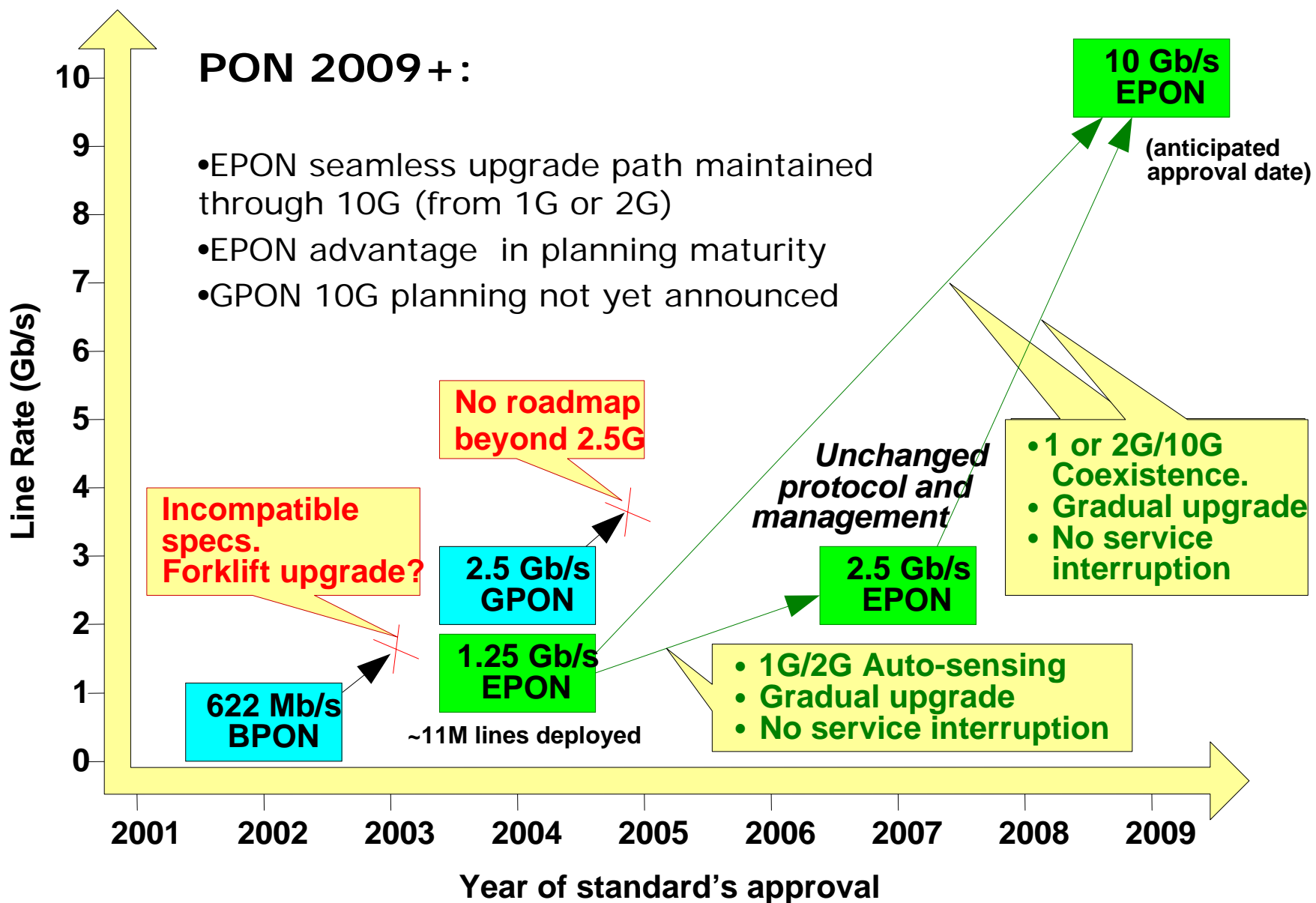
# PON 发展路标分析



# PON 发展路标分析



# PON 发展路标分析



# PON 发展演进 – 运营商的需要

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1. 清晰的发展路标
2. 更快的速率，更短的时间投放市场
  - History of broadband has been competition for higher peak rates, if even only for advertising
  - Korean advertising of 100Mbps and 1Gpbs peak rates have made it impossible for providers with 10Mbps offerings to sell their service. Operators with 2.5G EPON could enjoy similar advantage over even 1G PON.
3. 下行方向正在驱动着更高速度的需求  
(IPTV, HDTV, VoD, time-shifted TV, more channels, etc...)
4. 向后兼容 / 灵活升级
  - Never require simultaneous change of all subscriber equipment (on each PON or whole network)
  - Minimize/eliminate trip to subscriber premise
  - Install higher-speed OLT without affecting legacy (lower speed) ONUs
  - Install higher-speed ONU without affecting legacy OLT

*Flexible OLT & ONU swap allow the operator flexibility to upgrade their network at their own pace and without service disruption*

# 竞争优势 (1G service advertised in Japan & Korea)



Service started February 2006  
100 Mb/s to the home for  $\approx 32\text{€}$ / month  
1 Gb/s to the home for  $\approx 39\text{€}$ / month (370 人民币/月)  
2006-2008 Cable Market in Japan: 700k ~ 1M FTTH Subscribers

光ファイバーの  
1G(ギガ)  
アクセスラインを  
使った  
100メガプラン! 下り最大100Mbpsのベストエフォート★  
(税込)

**光 100メガ**  
プレミアム

戸建用 月額 **4,725円**

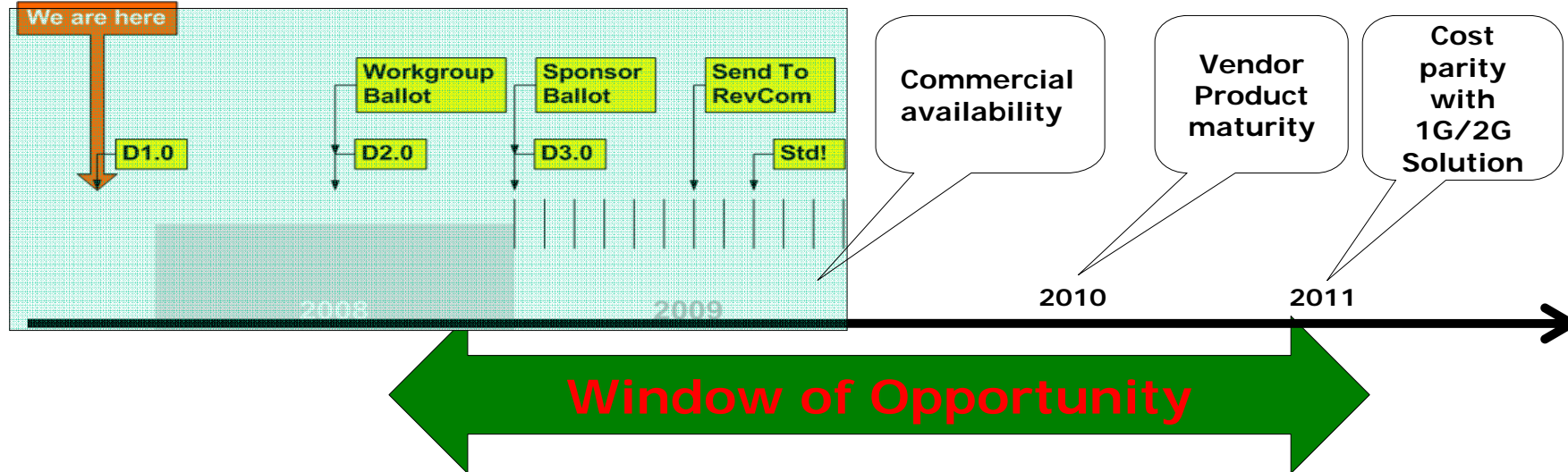
ご自宅の  
パソコンまで  
最大1キガ  
(=1,000メガ)  
を直結!  
下り最大1Gbpsのベストエフォート★  
(税込)

**光 1G**

戸建用 月額 **5,775円**

# 2.5G – 机遇窗口

## 10GEPON Timeline for Maturity - 2010



## Bandwidth Growth Projection - 2008

Per User	Bandwidth Need	Note
200 SDTV multicast IPTV (MPEG2)	$200 * 3.8\text{Mbps} = 760\text{Mbps}$	
20 HDTV multicast IPTV (MPEG4)	$20 * 12\text{Mbps} = 240\text{Mbps}$	
1 VOD session	$64 * 4\text{Mbps} * 10\% \approx 25\text{Mbps}$	Assume 10% usage
2 VoIP sessions	$64 * 0.1\text{Mbps} * 10\% \approx 1\text{Mbps}$	Assume only 10% usage
High speed Internet data	$64 * 10\text{Mbps} * 60\% = 384\text{Mbps}$	Assume 60% activity rate
<b>Total</b>	<b>1410Mbps</b>	

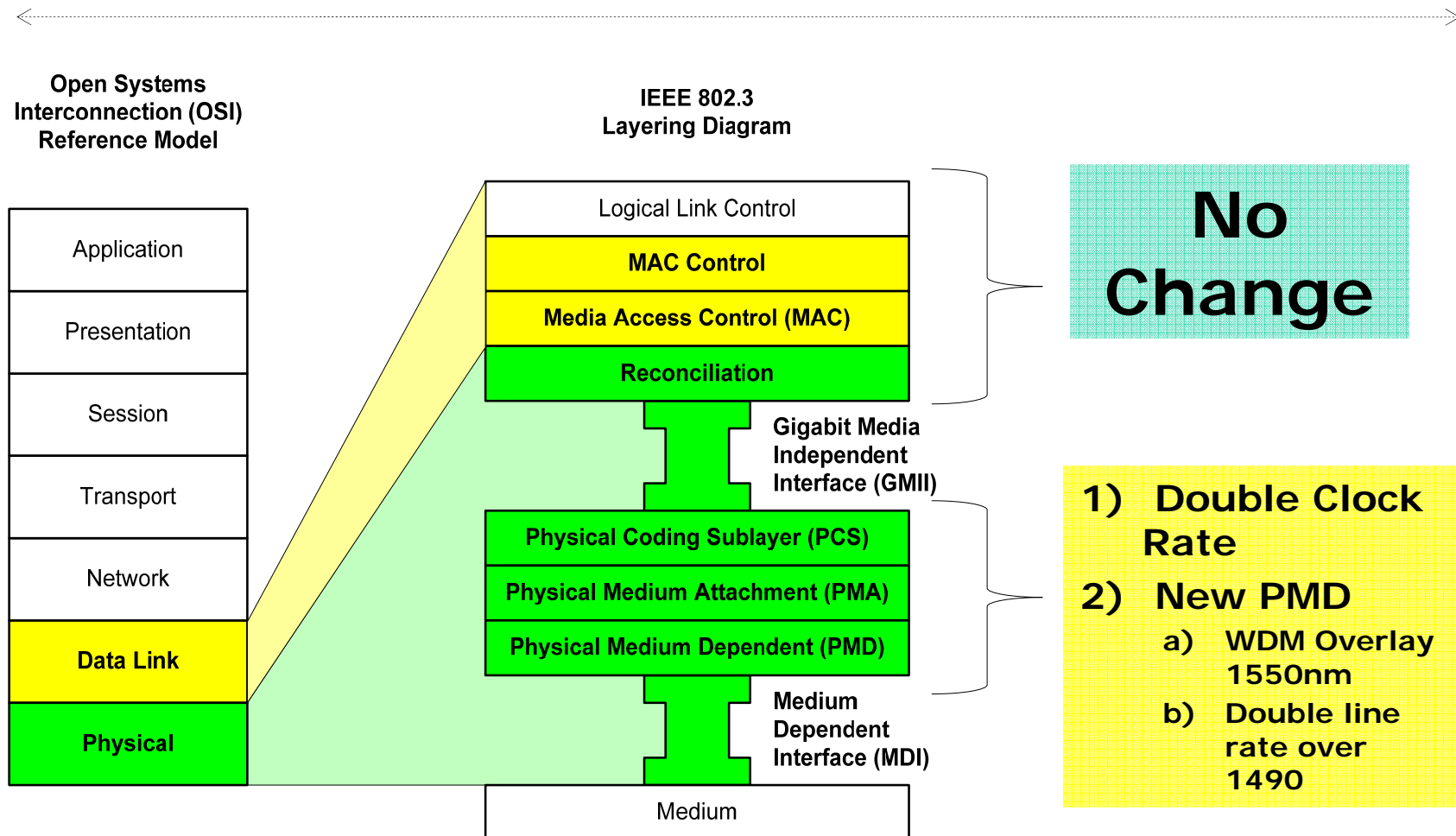
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# Teknovus 2.5G EPON 解决方案

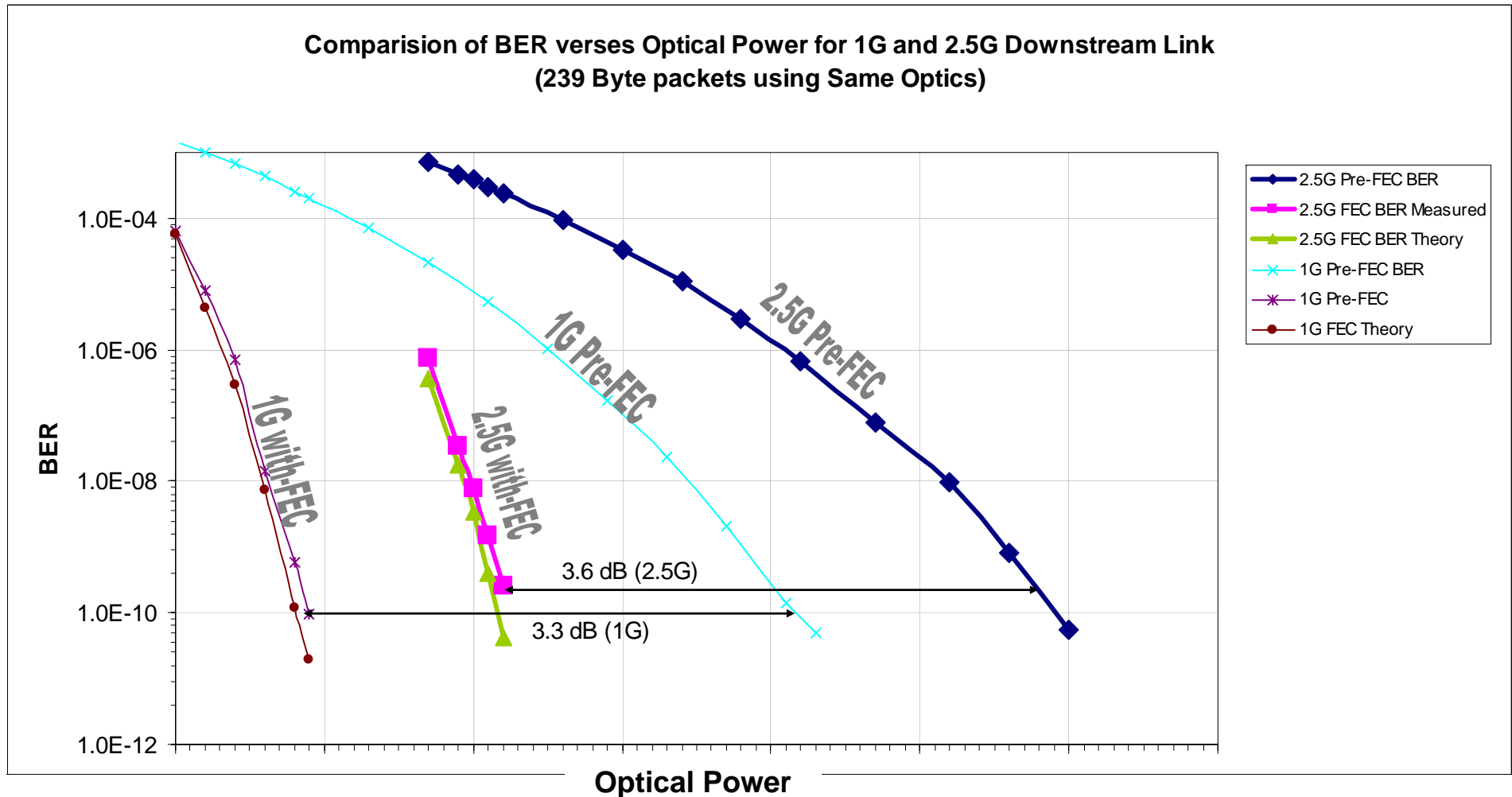
## 技术和设计

# 有限范围的技术变化

- MPCP Transparent – Minimal SW Change
- Phy Layer Only - Localized HW Change

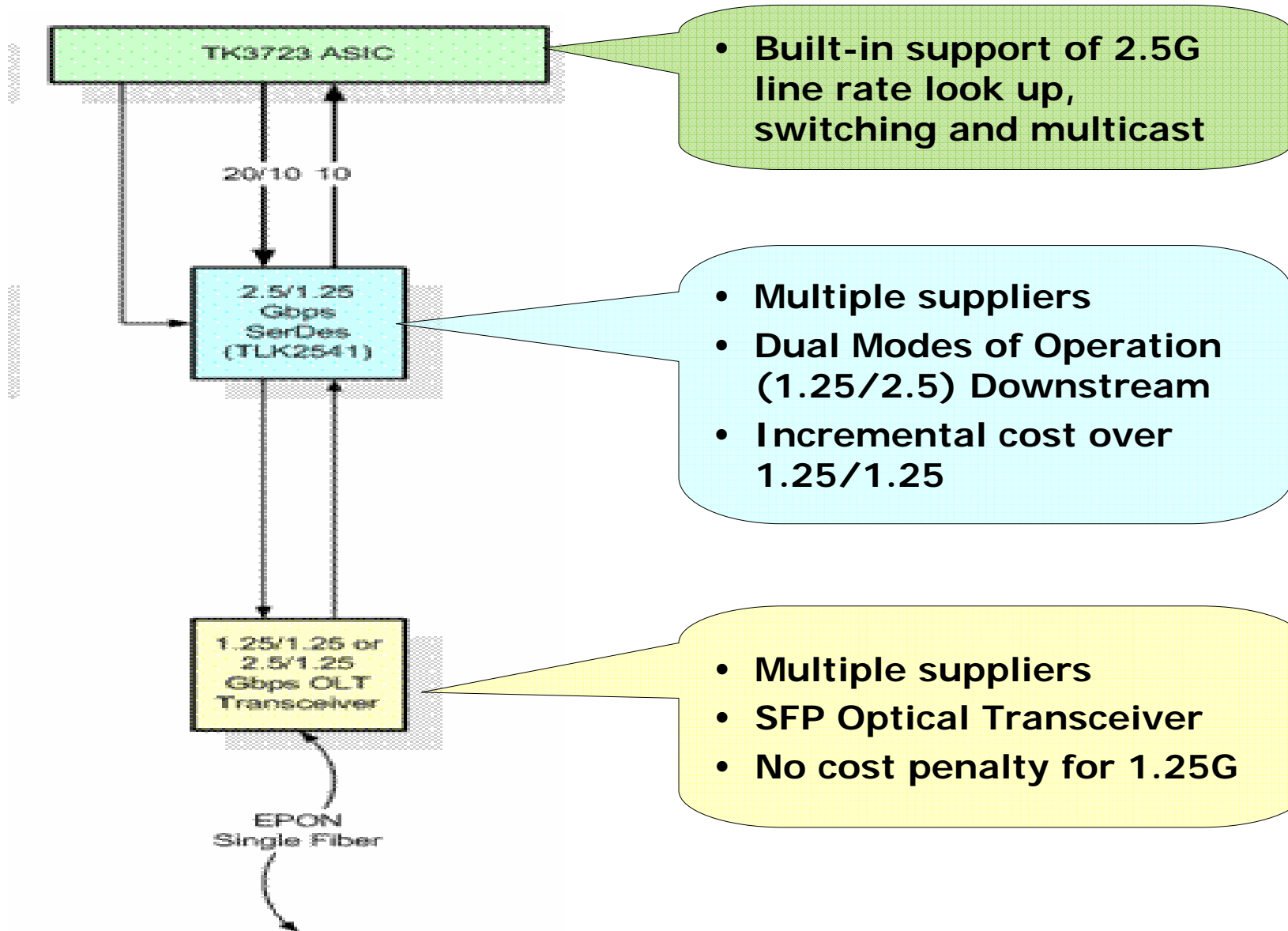


# 测量到的2.5 Gb/s FEC 性能 (1.25 Gb/s OLT & ONU Optics @ 2x Speed)



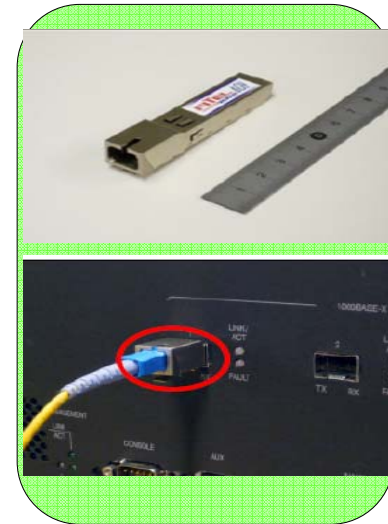
- 2.5 Gb/s EPON with FEC will operate on fiber plants built for 1 Gb/s EPON without FEC
- 2.5 Gb/s EPON optics can have very incremental cost over 1 Gb/s EPON optics

# 灵活的设计选择 - OLT

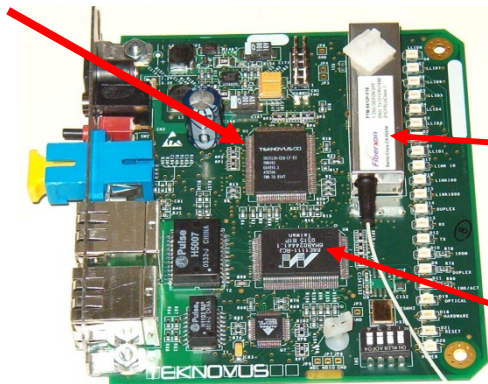


# 灵活的设计选择 - ONU

- Same power: 2.2w vs. 5.5w reduces power supply cost
- Same Integrated hardware-based traffic management (8 Logical Links)
- Same architecture & software for 1.25G and 2.5G
- Clock Speed doubled when operating in 2.5G mode
- Integrated 2.5G Optics (Fiberxon shown) or SFP ONU pluggable (Furukawa shown)



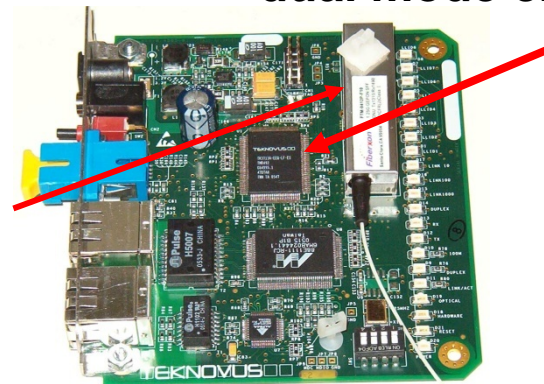
EPON 1.25G chipset



1.25 G ONU

1.25 Optics  
2.5 Optics  
\$1 Phy  
Misc Glue

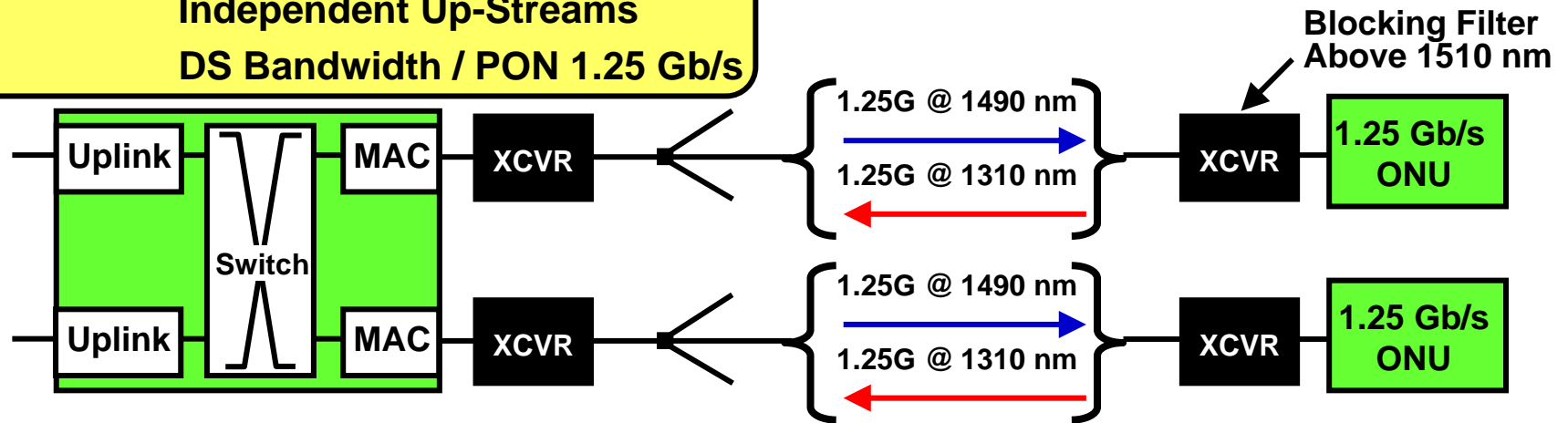
EPON 1.25G/2.5G dual mode chipset



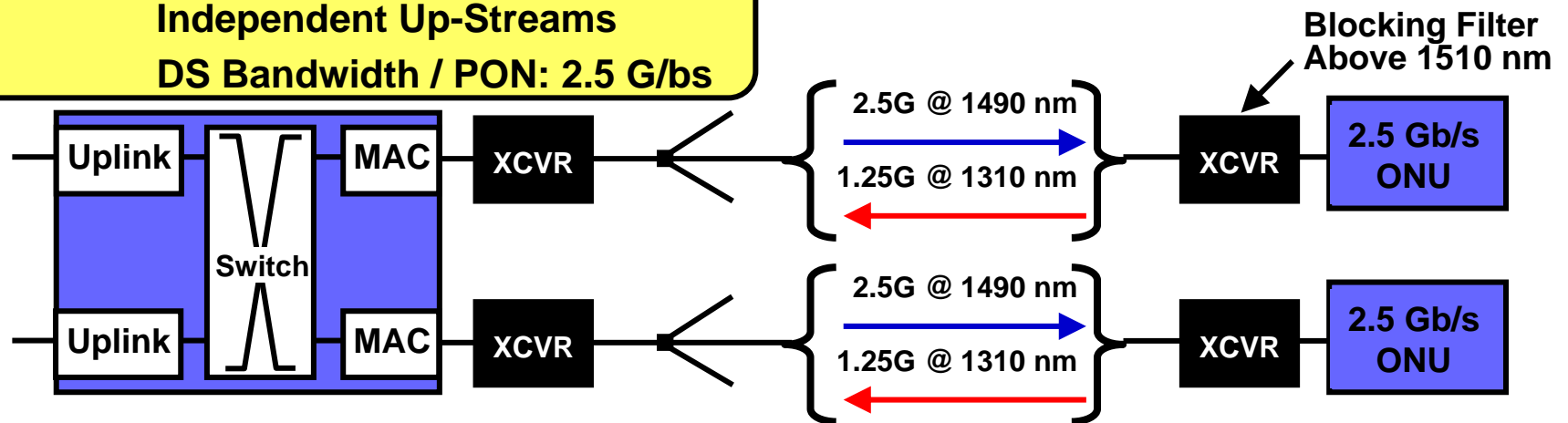
1.25/2.5 G Autosensing ONU

# 简单的操作模式 - 2λ

**Dual 1.25 Gb/s: Independent Down-Streams  
Independent Up-Streams  
DS Bandwidth / PON 1.25 Gb/s**

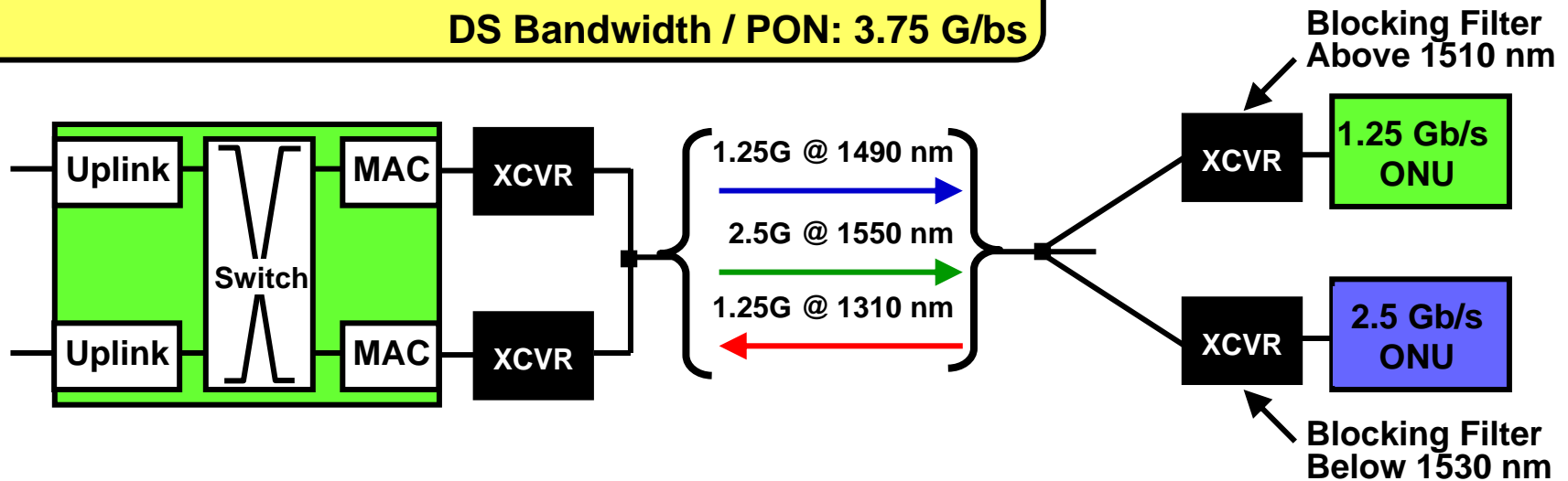


**Dual 2.5 Gb/s: Independent Down-Streams  
Independent Up-Streams  
DS Bandwidth / PON: 2.5 G/bs**



# 简单的操作模式 -3 $\lambda$

**Coupled 1.25 & 2.5 Gb/s: Independent Down-Streams  
Single Up-Stream  
DS Bandwidth / PON: 3.75 G/bs**

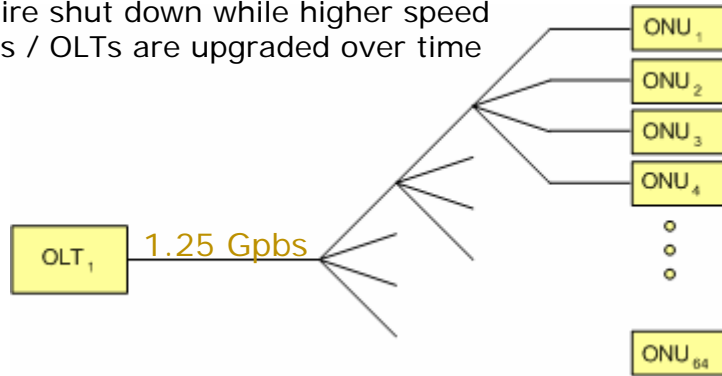


- 1) Maximum fiber saving – single fiber delivering 3.75Gbps/1.25Gbps (Down/Up) bandwidth
- 2) Replace 1550 nm Overlay Analog video with in-band IPTV

# 2λ模式下, 灵活的1.25G 到2.5G 的升级

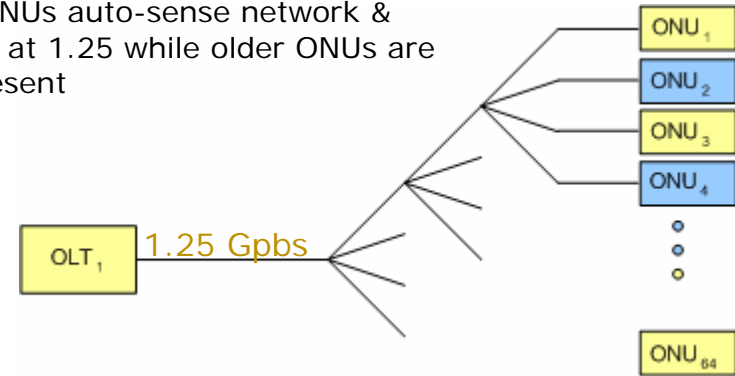
## Current 1.25 Gbps network.

Must allow flexible upgrade, and not require shut down while higher speed ONUs / OLTs are upgraded over time



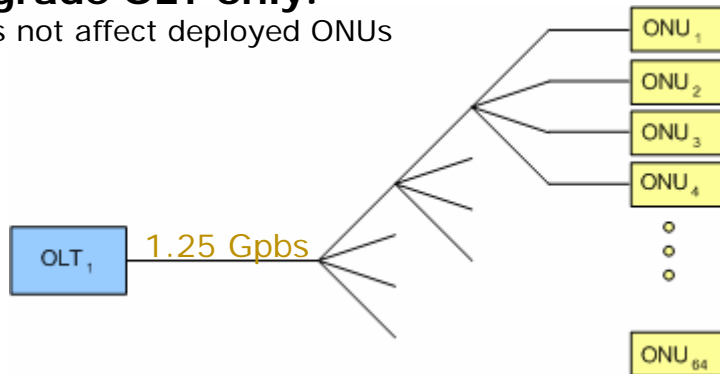
## Upgrade some ONUs only.

Does not affect rest of ONUs or OLT. 2.5G ONUs auto-sense network & remain at 1.25 while older ONUs are still present



## Upgrade OLT only.

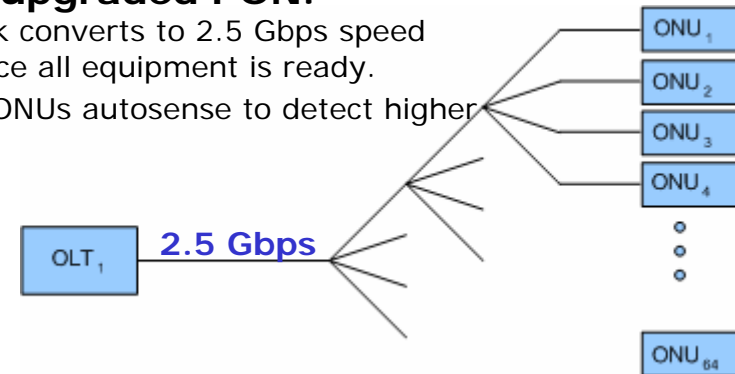
Does not affect deployed ONUs



## Fully upgraded PON.

Network converts to 2.5 Gbps speed only once all equipment is ready.

Again, ONUs autosense to detect higher speed.



## Meets Operator Objectives:

- 1) Clear roadmap
- 2) 2.5G EPON available in Q3, 2006
- 3) No disruption to installed network

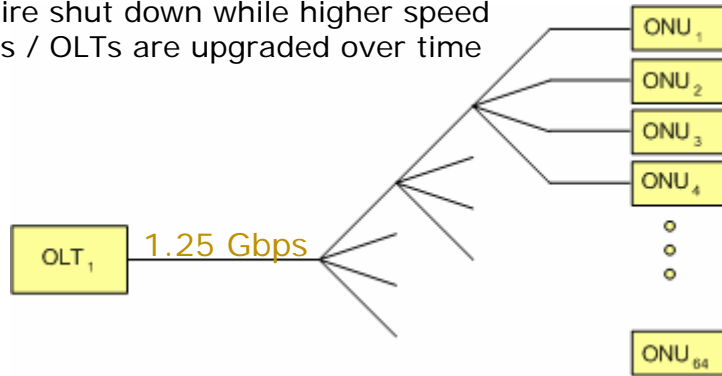
1.25 Gbps

2.5 Gbps

# 3λ模式下，1.25G/2.5G的共存

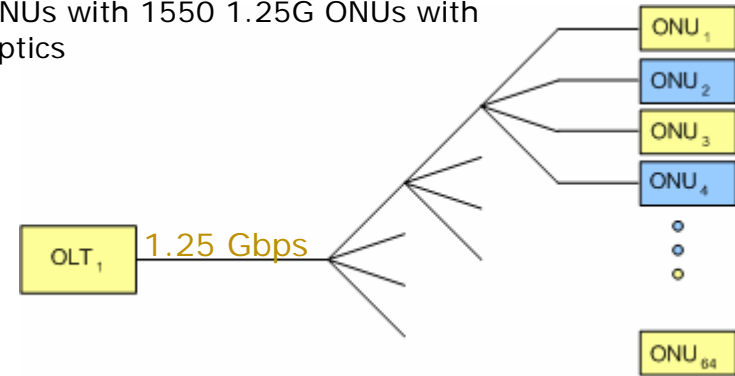
## Current 1.25 Gbps network.

Must allow flexible upgrade, and not require shut down while higher speed ONUs / OLTs are upgraded over time



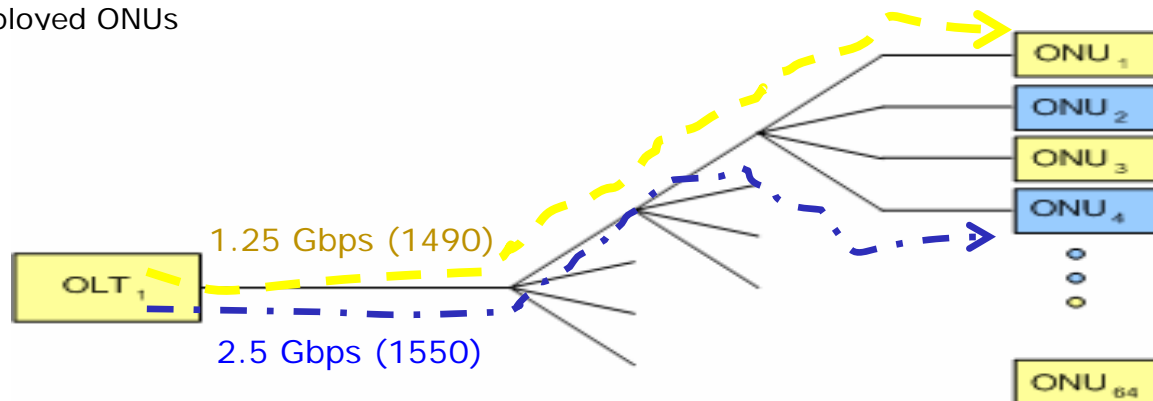
## Upgrade some ONUs only.

Does not affect rest of ONUs or OLT.  
2.5G ONUs with 1550 1.25G ONUs with 1490 optics



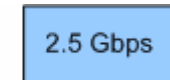
## Upgrade OLT for 1.25/2.5 Co-existence.

Does not affect deployed ONUs



## Meets Operator Objectives:

- 1) Clear roadmap
- 2) 2.5G EPON available in Q3, 2006
- 3) No disruption to installed network



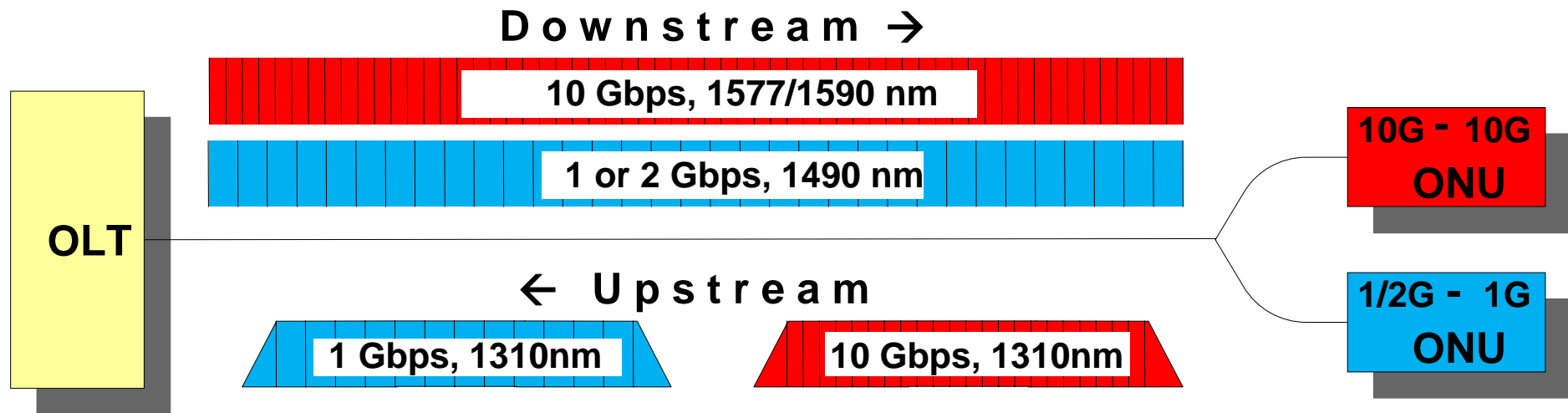
# EPON -> 2.5G: 简单的升级

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- **Single Central Office Boxes**
  - Blade by Blade Upgrade to 2.5G
  - 1.25G/2.5G can share management system and fiber.
- **Single Outside Plant Fibers**
  - 1.25G and 2.5G can share fiber during migration.
- **Double ONU Inventory**
  - 2.5G ONU can be used on both 1.25G and 2.5G OLTs
- **Same Service Model**
- **Single ONU Cost**
  - TK3714 ONUs are ready for deployment **NOW**.
  - **Installing TK3714 allows for upgrades without new equipment, home installation, or mixed networks.**

# EPON -> 10G: 清晰干净和平滑的升级

- 下行方向:
  - 1Gbps/2Gbps ONUs use 1490 nm per IEEE 802.3ah
  - 10Gbps ONUs use 1577 nm and 1590 nm per IEEE 802.3av 1.0 Draft
- 上行方向:
  - All ONUs use O-band (1260 nm – 1360 nm)
  - 1Gbps/2Gbps ONUs send bursts using 8b/10b @ 1.25 Gbps
  - 10Gbps ONU send bursts using 64b/66b @ 10.3125 Gbps



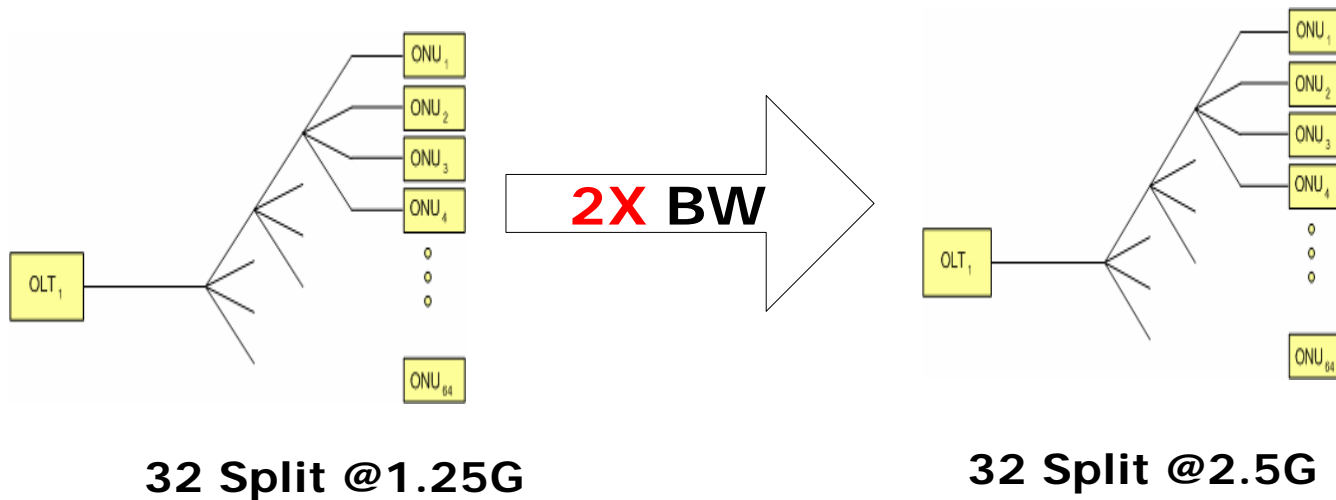
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# Teknovus 2.5G EPON 解决方案

应用和服务

# 数据业务 – 使每个引入段带宽加倍

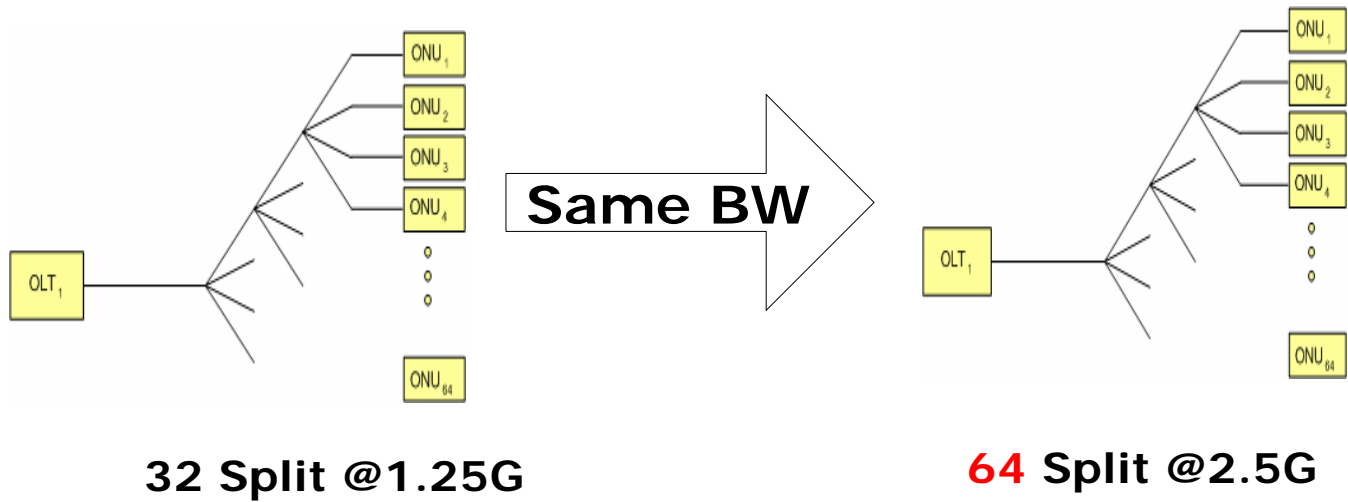
## Keep 1:32 Split



**Double the bandwidth per drop for competitive advantage or for more revenue (higher ARPU)**

# 数据业务- 使每个PON口的分光比加倍

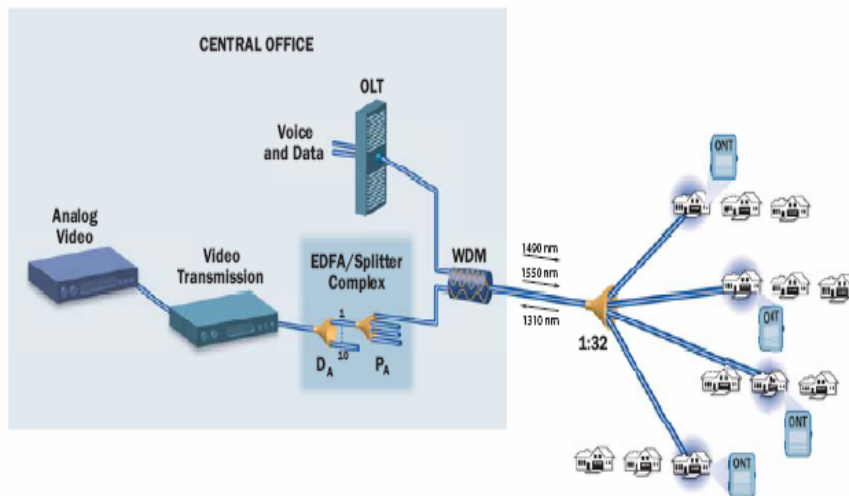
**Keep Same Downstream BW**



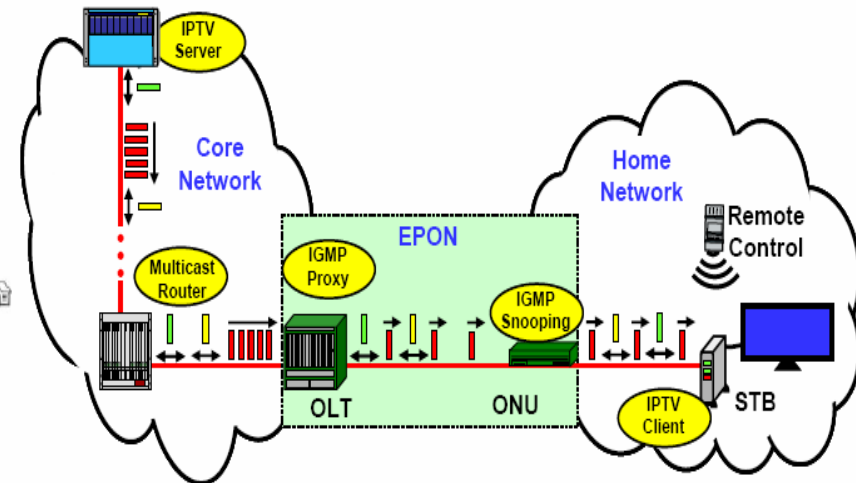
**Double the number of drops for more revenue (more paying customers) and for additional fiber saving**

# 视频业务 – 带内 vs 叠加

**2.5G Downstream leaves extra 500Mbps for multicast IPTV – enough for 200 SDTV channels (MPEG4) and 20 HDTV channels**



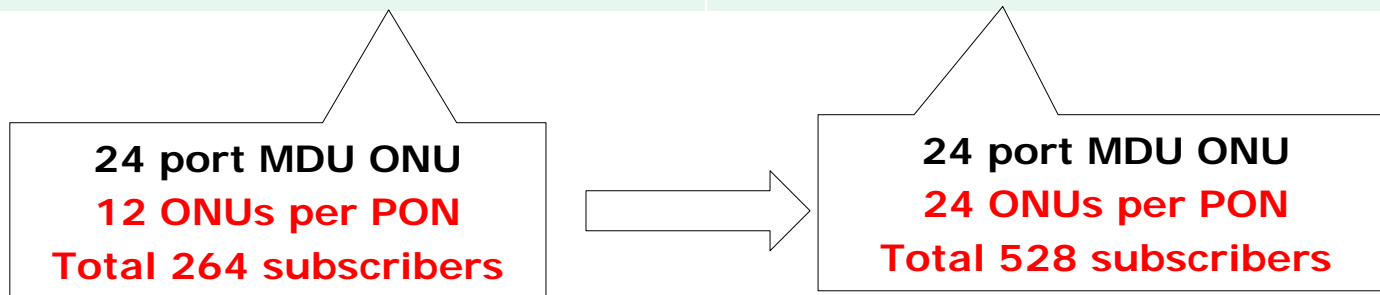
- Analog video over 1550
- Expensive, high Power EDFA amplifier at Head end
- More expensive Triplexer required on ONU
- Potentially leading to Raman effect



- IPTV streams as multicast traffic
- Centralized and shared video encoder equipment
- Diplexer required on ONU
- Flexible service control and management

# MDU 部署 – 更多的用户

Deployment and Service Profiles	Description
Single Service (RMB120) • 40% take rate	HSI only • 2Mbps
Dual Play (RMB150) • 40% take rate	HSI + 4*VoIP • 2.5Mbps
Triple Play (RMB200) • 20% take rate	HIS + 4*VoIP + 2 IPTV Channel • 10Mbps
Average BW need	3.8Mbps



Monthly Revenue per  
1.25G EPON: RMB39,072  
1.25G Cost: \$X

Monthly Revenue per  
2.5G EPON: RMB78,144  
1.25G Cost: < \$110% \* X

**Thank You!**

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