



**Standardization on  
Optical Access System**

**Tohru Kazawa**

Hitachi Communication Technologies

[tohru.kazawa.en@hitachi.com](mailto:tohru.kazawa.en@hitachi.com)

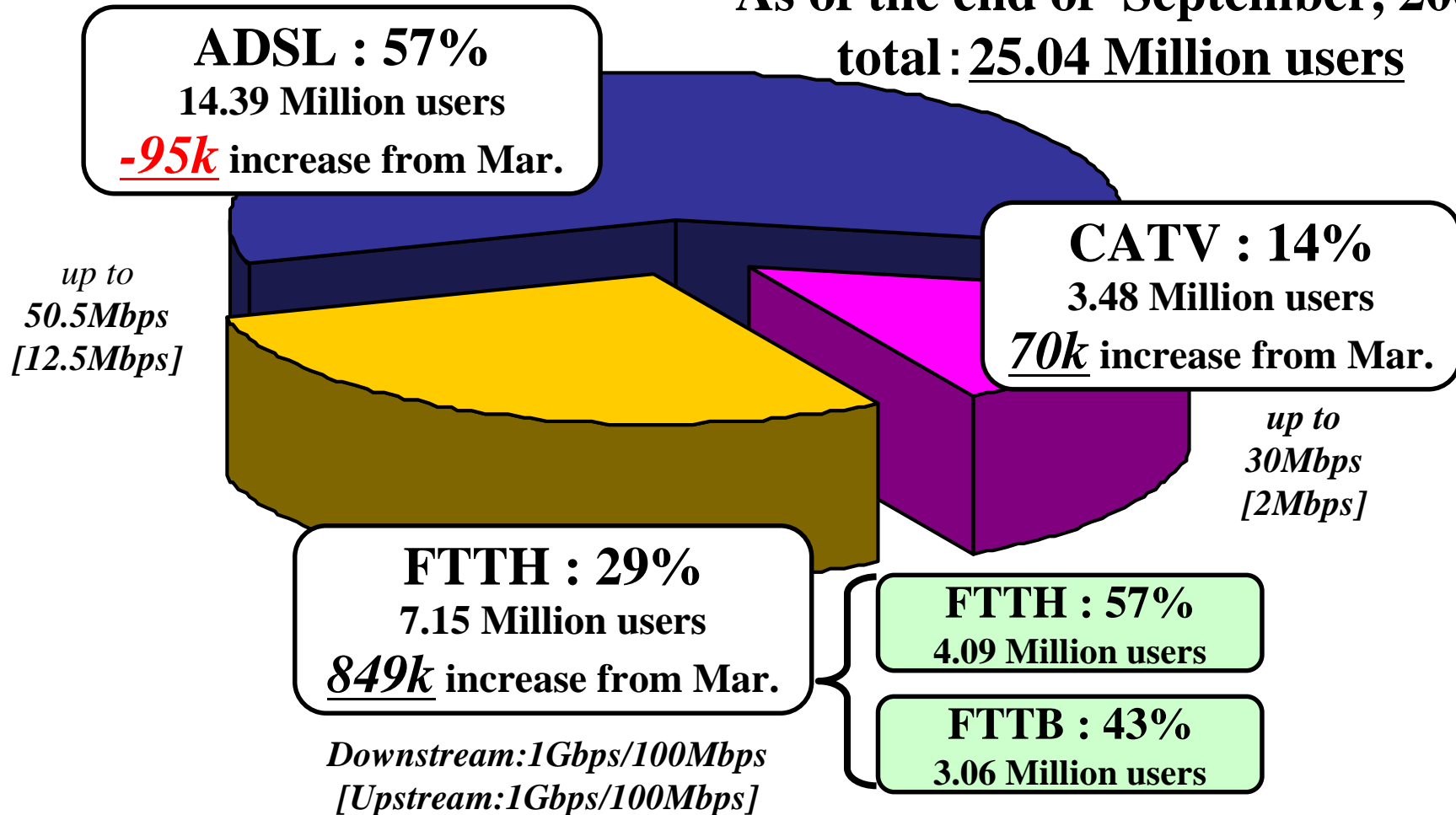


# *Contents*

- 1 Optical Access System Market**
- 2 G-PON and Standardization**
- 3 Implementation of G-PON System and Service**
- 4 Toward future -10G-PON-**

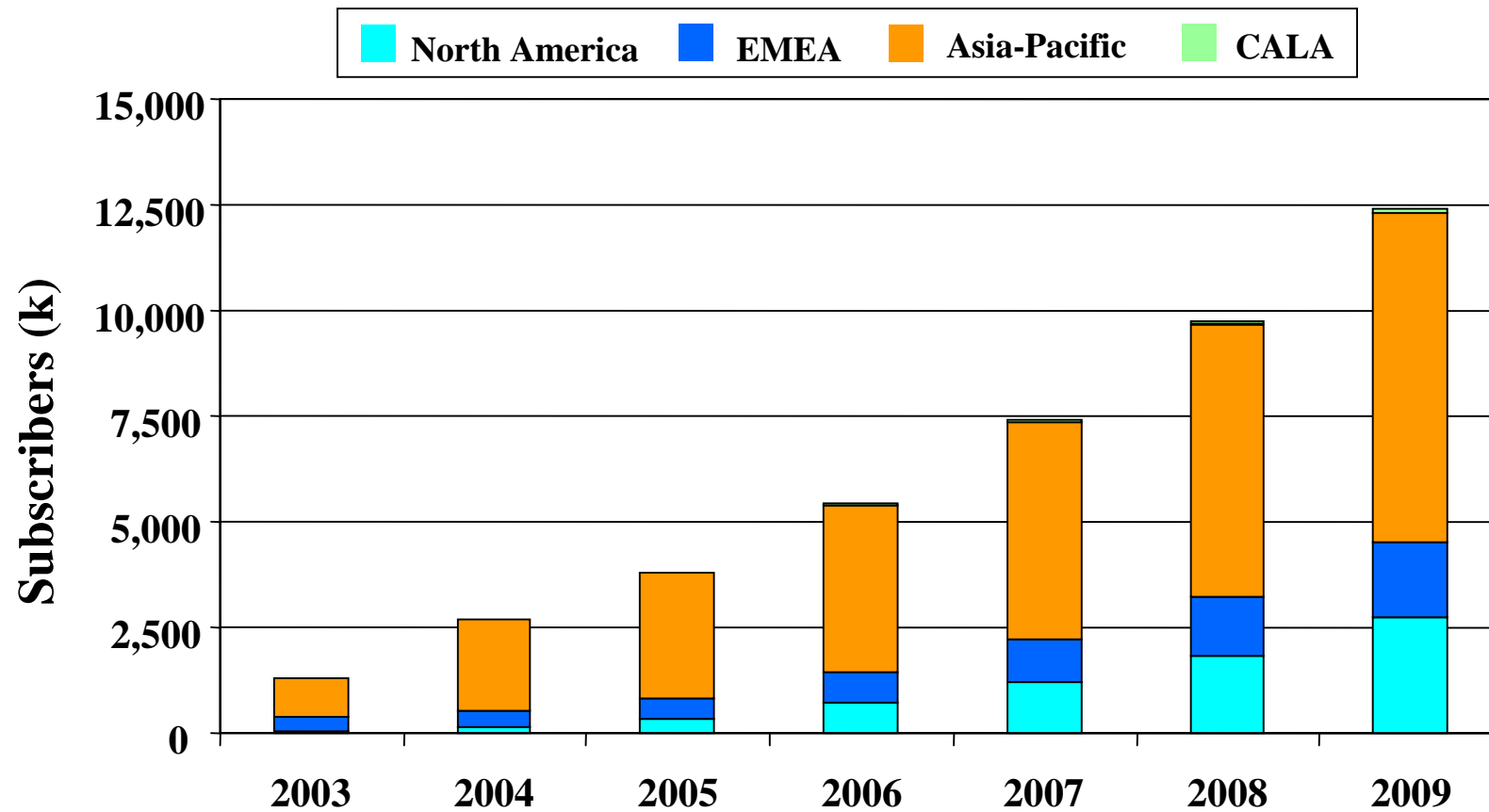
# Broadband Users in Japan

As of the end of September, 2006  
total: 25.04 Million users



\* Source: Japanese Government numbers

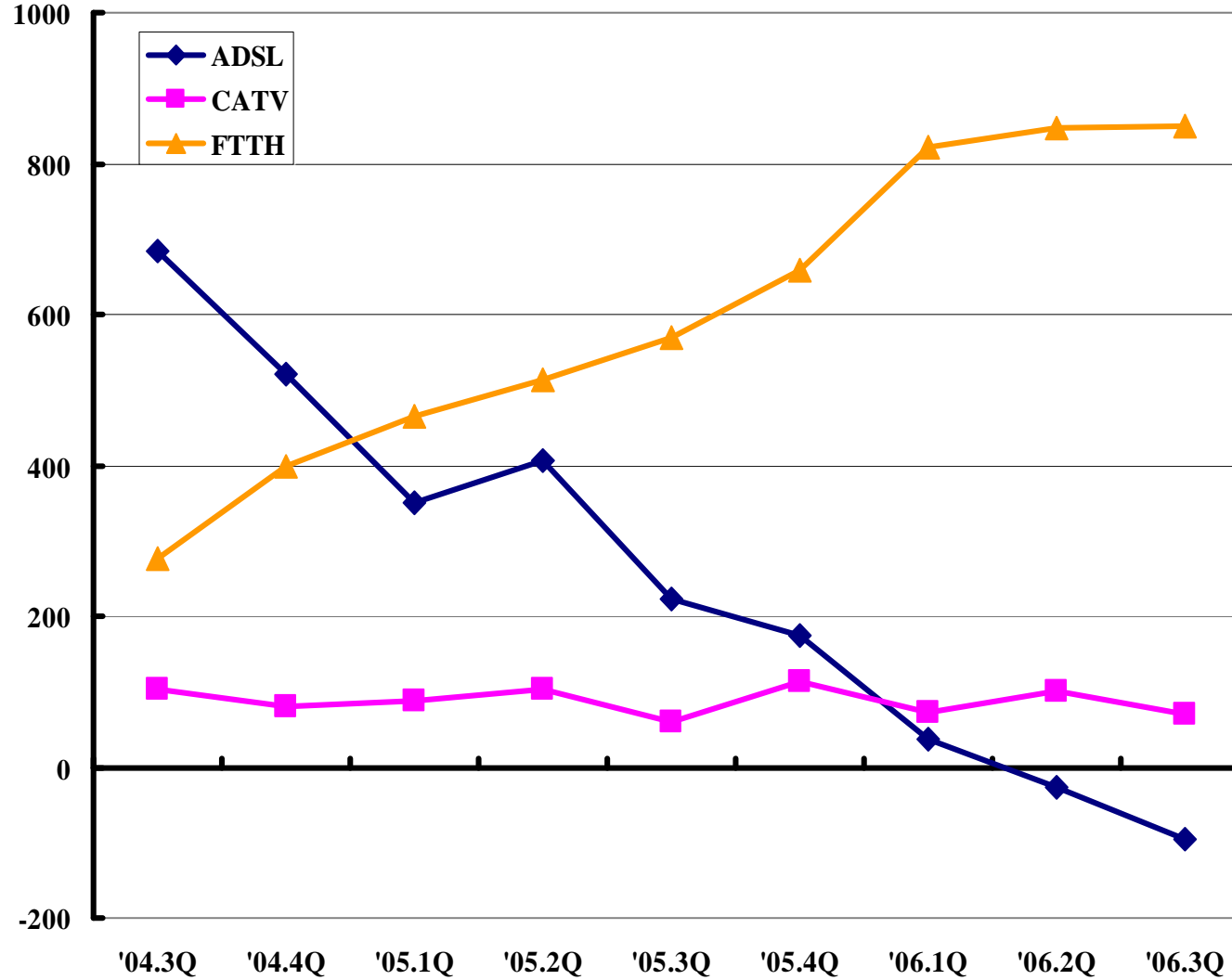
# Global FTTH Market



Source : Ovum-RHK

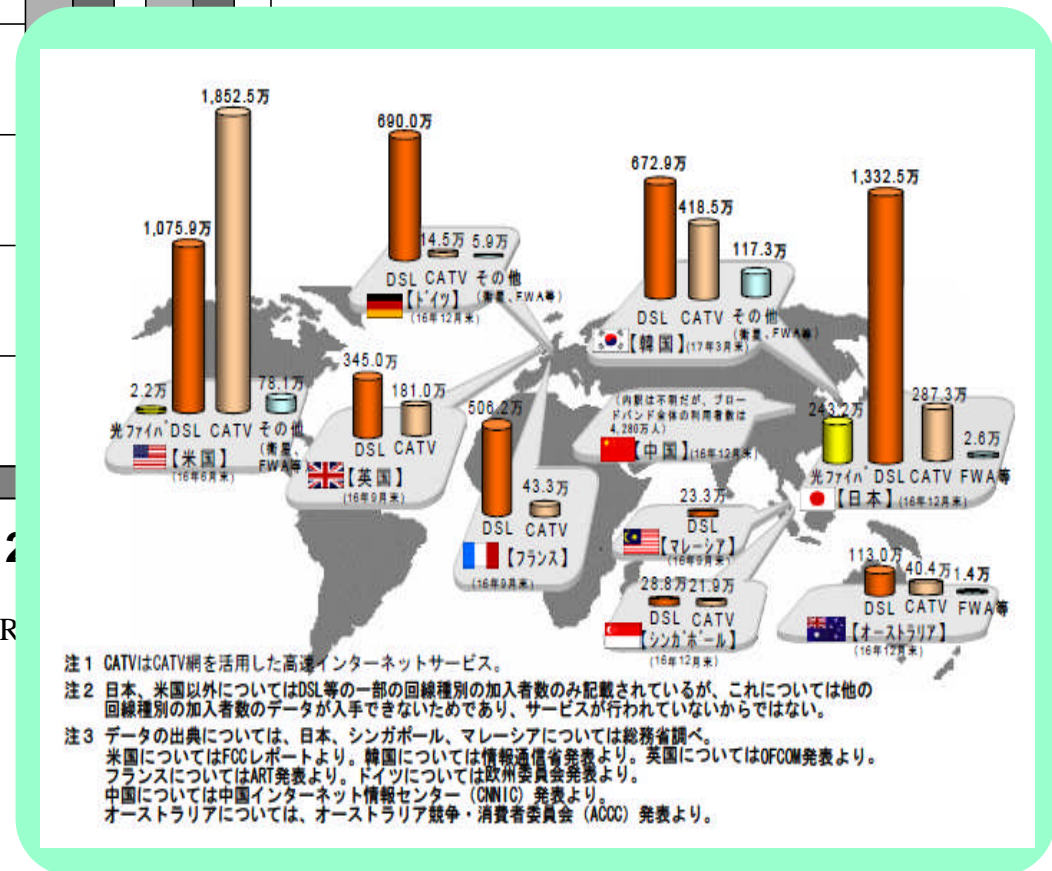
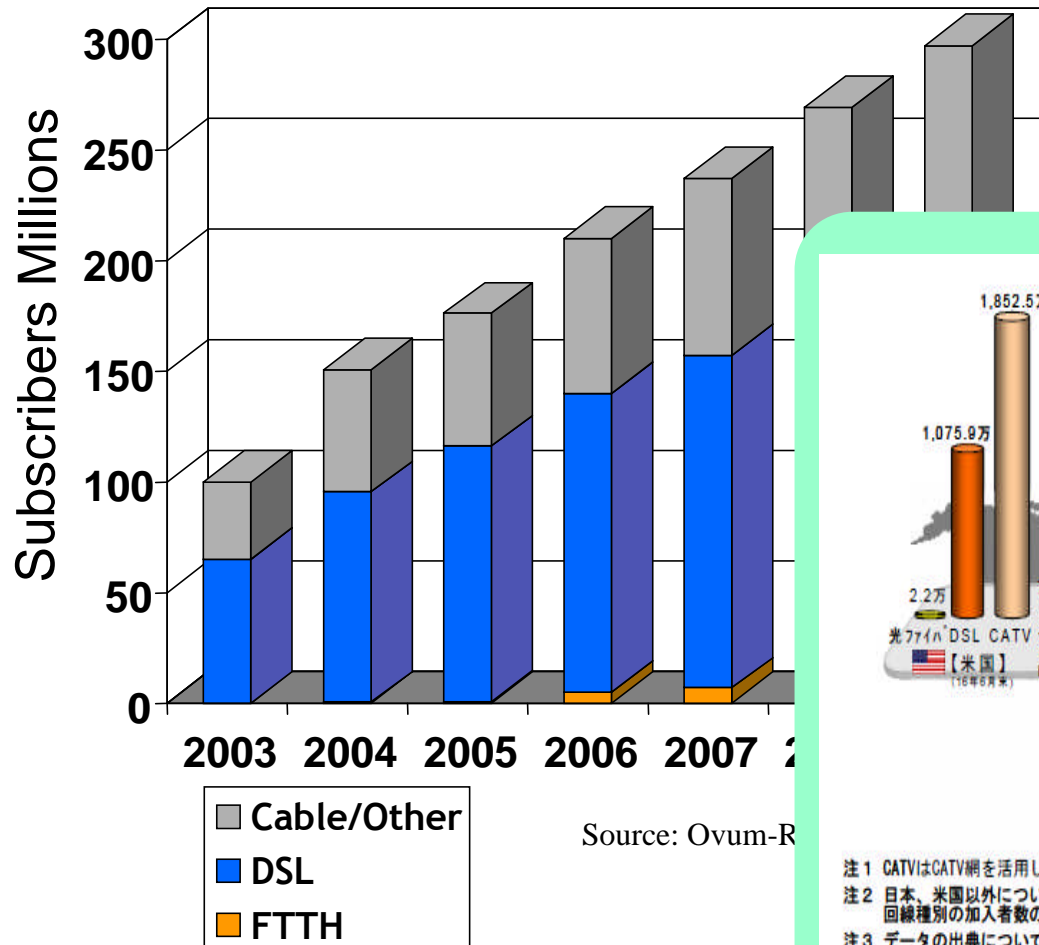
# FTTH Growth in Japan

Number of Subscribers ( k users)



Source: Ministry of Internal Affairs and Communication (Japan)

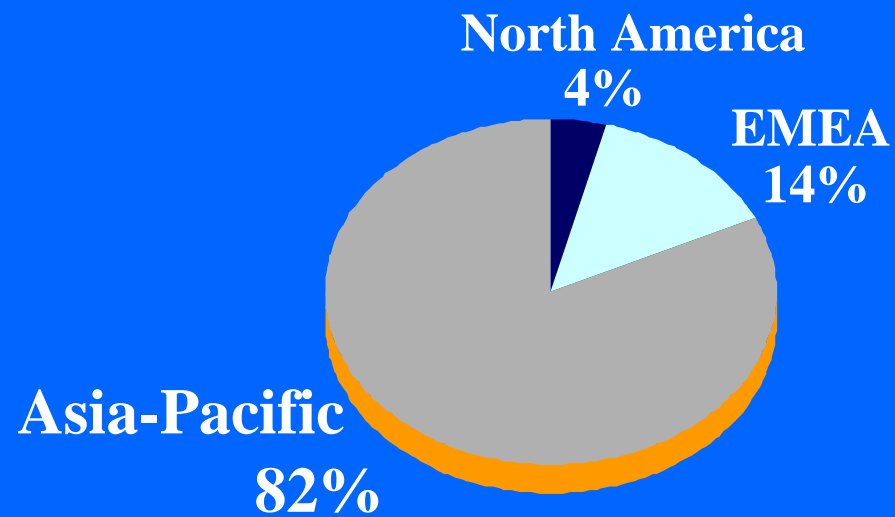
# Global Broadband Services



Source : 総務省報告書「次世代BB構想2010」(05.5)

# Global FTTH Market Segmentation

*Global FTTH Subscribers – 1Q05*  
*4.5 million*



Source : Ovum-RHK

## ■ **Activity**

Aggressive Incumbent builds

(Verizon, SBC, BellSouth)

Numerous Community-Utility,

Property Developer builds

## ■ **Competitive Situation**

Cable-TV operators providing

telephony competition



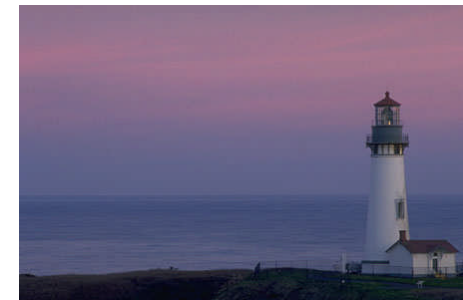
- Europe is late
- 500K subscribers, 2.6M homes passed by the end of 2004
- More than 90% of FTTH-subscribers concentrated in just 5 countries
  - Sweden : 200K, Italy : 185K, Denmark : 85K, Netherlands : 50K, Norway : 15K
- 167 FTTH-projects – most of them small and/or pilots
- Only modest growth in next years
- G-PON is gaining momentum

**“See The Light”** : Asia-Pacific is unique



■ **Market Leaders** : **“lighthouses on the coast”**

- Japan
  - More than 3M FTTH subscribers
- Korea
  - Extremely high broadband penetration and FTTB
- Hong Kong



■ **Potential and Rising Market** : **“bright future”**

- China
- India
- South-East Asian Countries



## ■ Activity

- Most mature broadband market in the world 95% penetration of broadband services via DSL, HFC or Apartment LAN
- Incumbent (Korea Telecom) trials in Pusan & Guanju  
50K users of WDM-PON trials underway in Guanju City  
2K users GE-PON trials

## ■ Competition

- Extremely competitive environment

## ■ Government/Regulatory

- Government has moved from e-Korea (2002) to u-Korea (“ubiquitous” integration)
- Plan to build BcN (Broadband Convergence Network) as core network for U-Korea

## ■ BcN Vision

- 50-100Mbps services, HDTV, Video phone
- 1.5M subs 2005, 4.5M subs 2007, 10M subs 2010



## ■ Activity

- 15-16 pilots and regional rollout commenced in 2004 Pilots from China Netcom, China Telecom & China Railcom
- Yongfeng Park Beijing : 1700 users in 2005, target 40-50k
- 3TNET Yangtze Triangle : 5000 subs in 2005, target 60k by 2007  
Chuangye Street Wuhan
- 1000 subs in 2005, target (all Wuhan) 500k-1M subs

## ■ Government/Regulatory

- Government has announced goal of 75M broadband by 2008
- Regulatory position unclear; risks for new carriers

## ■ Carriers/Vendors

- Carriers looks like to use GPON.
- GPON under development in Major vendors such as Huawei



## ■ **Government Policies and Influence**

- Korea and China : Initiatives and Support
- Japan : Unbundling

## ■ **Housing and Population Density : High Profitability**

- MDU : Apartment houses and Condominium
- Smaller Houses
- MDU in China : > 85 %
- Back to Tokyo downtown

## ■ **Access Loop Network : Efficient CAPEX**

- Asia loop length average is 2-2.5 km, vs. 3.5 to 4 km in U.S.

## ■ **Some Competitive Areas : Japan**

- Multiple FTTH service providers

## ■ **Cultural Issues**

- Speed is a key in Korea
- Status Symbol in Japan



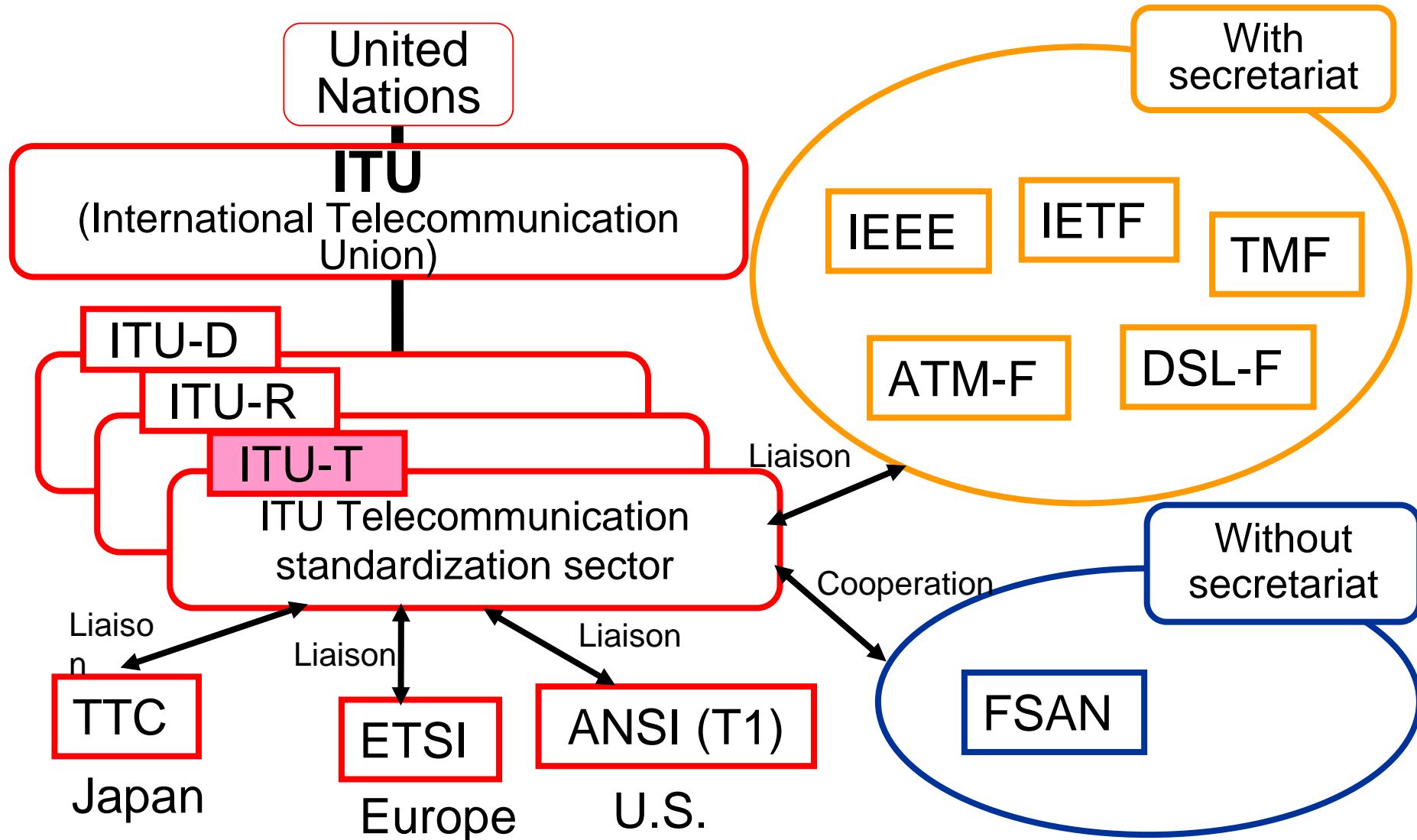
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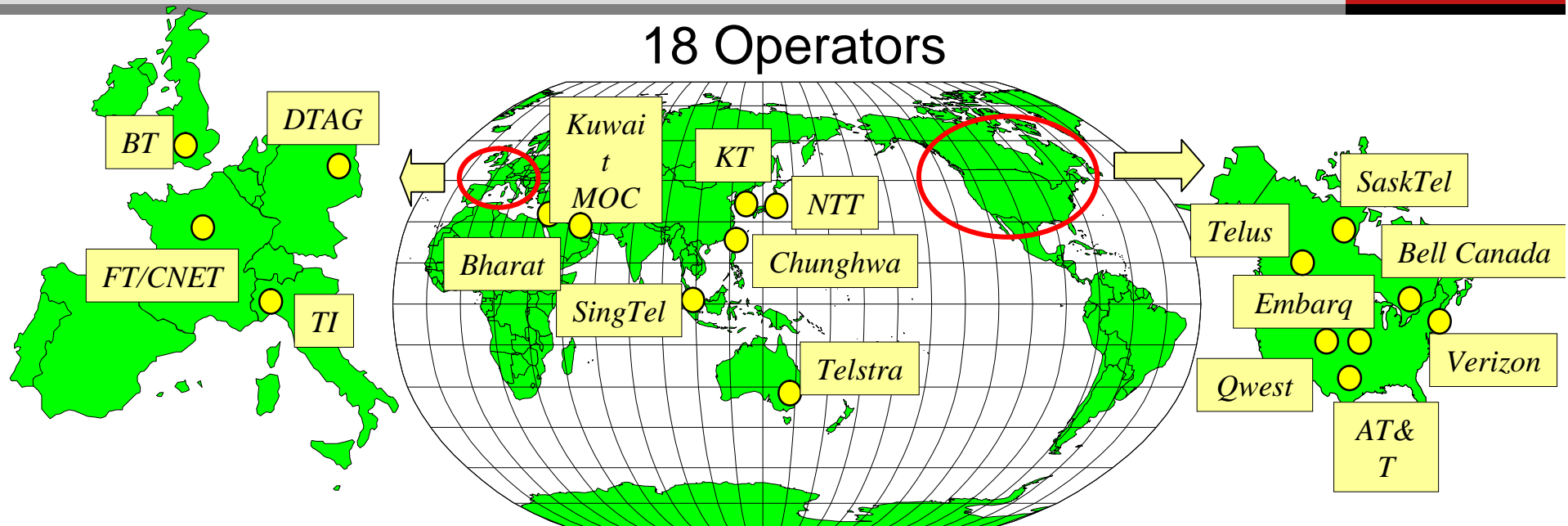
# Standardization bodies

Public organizations

Private organizations



# FSAN Participants



## 36 Vendors

Adtran Alcatel-Lucent Alphion AMCC BroadLight Calix Cambridge  
Conexant ECI Telecom Ericsson FlexLight Freescale Fujitsu Hitachi  
Huawei Iamba Infineon iPhotonics/TXP LG Electronics Maxim/Dallas Mitsubishi  
LS Cable Motorola NEC Nortel Novera Optics OKI Optical Zonu  
PMC Sierra Samsung Siemens Tellabs Terawave Vitesse Zarlink ZTE

## 6 Observers

ETRI ICL/ITRI KTL NTS NTT-AT Telcordia



- **Broadband**
- **Multi-service**
- **OAM**
- **Interoperability**

# PON Bandwidth(Physical bitrate)

	B-PON	ITU G-PON	IEEE E-PON
<b>Downstream Bitrate</b>	<u>622.08 Mb/s</u> 155.52 Mb/s	<u>2.48832 Gb/s</u> 1.24416 Gb/s	<u>1.25 Gb/s</u>
<b>Upstream Bitrate</b>	622.08 Mb/s <u>155.52 Mb/s</u>	2.48832 Gb/s <u>1.24416 Gb/s</u> 622.08 Mb/s 155.52 Mb/s	<u>1.25 Gb/s</u>
<b>Transmission coding</b>	Scrambled NRZ	Scrambled NRZ	8B10B
<b>Splitting ratio</b>	16, 32	16, 32, 64	More than 16
<b>span loss</b>	20 dB (Class A) <u>25 dB (Class B)</u> <u>28 dB (Class B+)</u> 30 dB (Class C)	20 dB (Class A) 25 dB (Class B) <u>28 dB (Class B+)</u> 30 dB (Class C)	<u>20 dB (PX10)</u> <u>25 dB (PX20)</u>

# Bandwidth Requirements for IP-TV

	Category (not exclusive)	characteristics	Number of TV channel Over PON	Channel bandwidth	PON downstream required BW
1	All TV program Broadcasted	Simple and end-to-end broadband network	e.g. 100ch~200ch	SDTV:6Mbit/s	600Mbit/s ~1.2Gbit/s
				HDTV:20Mbit/s	2~4Gbit/s
2	Requested TV program Multicast	IGMP-based Rich equipment (further study For channel selection speed)	e.g. 4chx32ONU (single family)	SDTV:6Mbit/s	770Mbit/s
				HDTV:20Mbit/s	2.6Gbit/s
			e.g. 4chx16 users x32ONU (multiple families) =2048ch (but program limited e.g.200ch)	SDTV:6Mbit/s	1.2Gbit/s
				HDTV:20Mbit/s	4Gbit/s
3	Video-on- Demand (P-to-P)	Super-high grade video- server &  Simple and end-to-end broadband network	e.g. 4chx32ONU (single family)	SDTV:6Mbit/s	770Mbit/s
				HDTV:20Mbit/s	2.6Gbit/s
			e.g. 4chx16 usersx32ONU (multiple families)	SDTV:6Mbit/s	13Gbit/s
				HDTV:20Mbit/s	41Gbit/s

- **Broadband**
- **Multi-service**
- **OAM**
- **Interoperability**

# PON Comparison(service viewpoint)

## B-PON

RF Video	Internet	IPTV	VoIP	Voice over ATM
	IP			
	Ethernet			
	ATM			

## IEEE E-PON

RF Video	Internet	IPTV	VoIP
	IP		
	Ethernet		

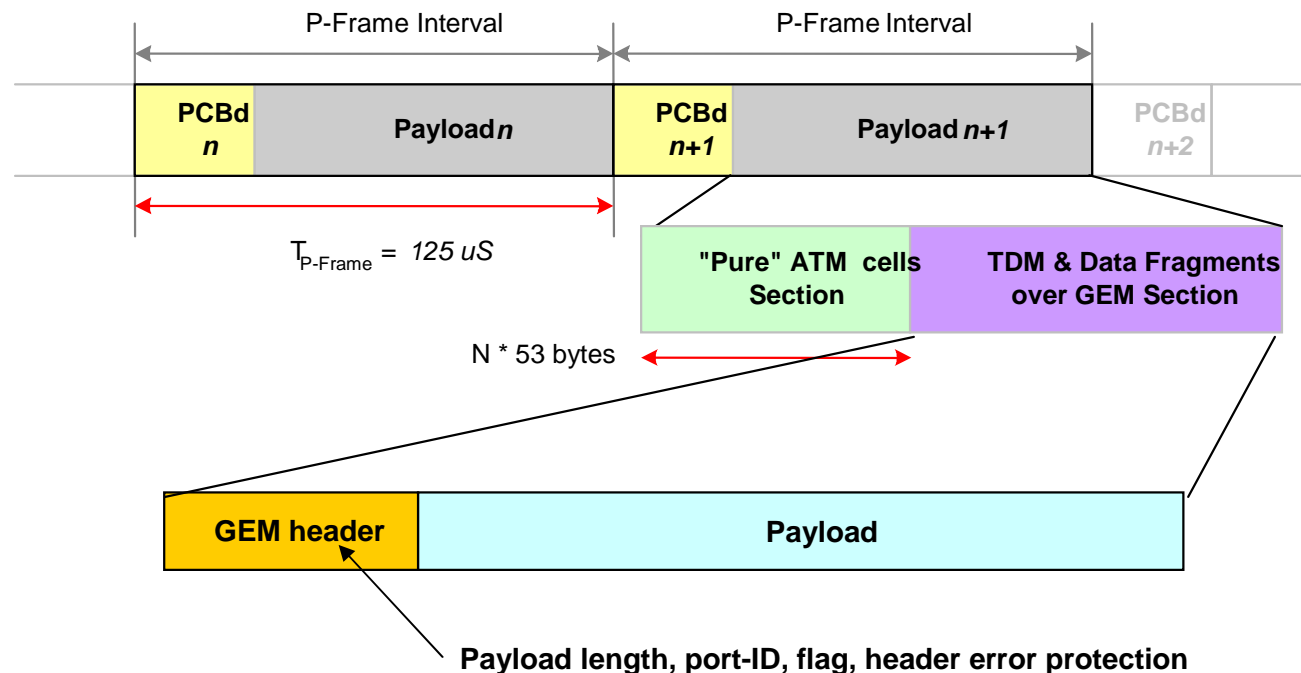
## ITU-T G-PON

RF Video	Internet	IPTV	VoIP	POTS (64k)	T1	Voice over ATM
	IP			TDM		
	Ethernet					
	GEM					ATM
	GTC (125 $\mu$ s frame)					

GEM: G-PON Encapsulation Method

# G-PON Downstream(G.984.3)

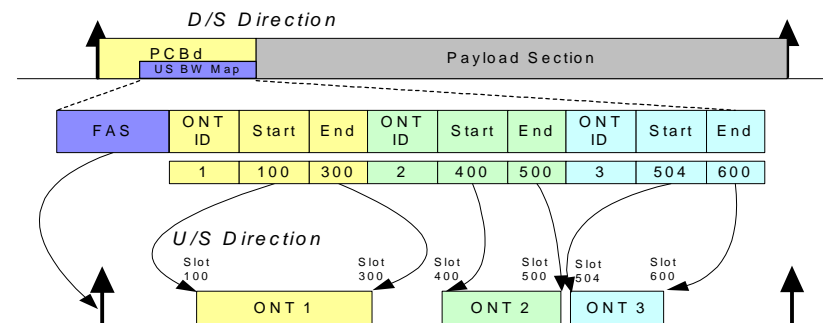
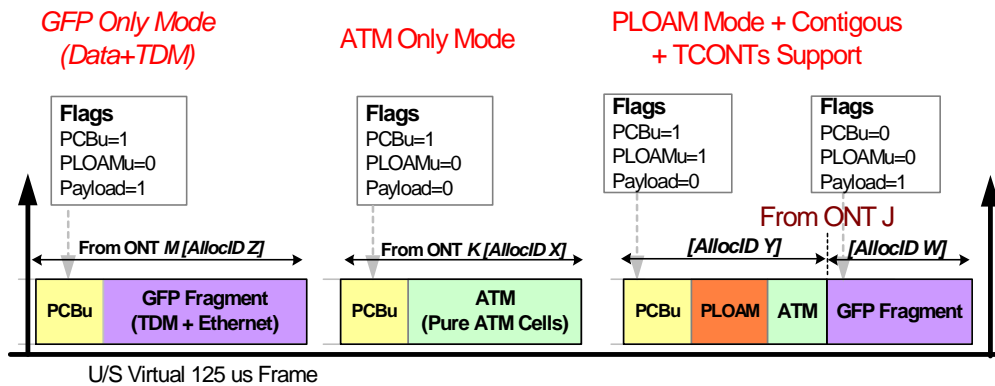
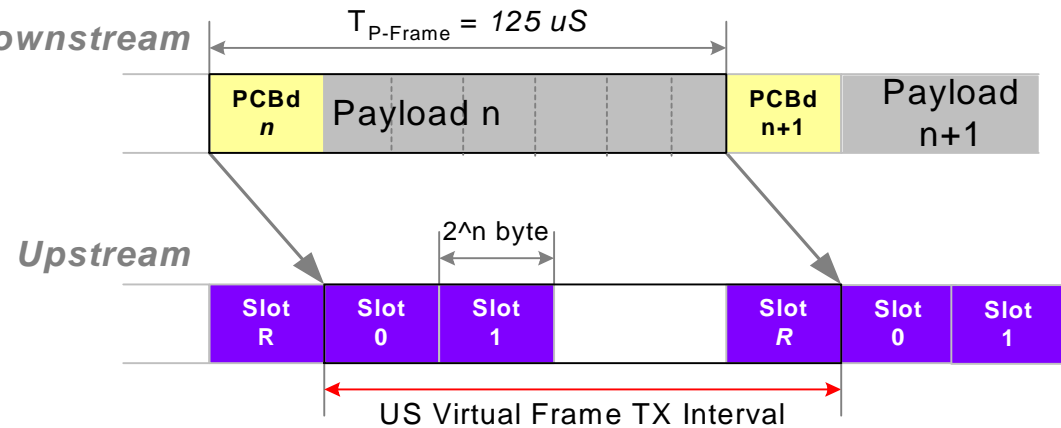
- 125  $\mu$ s-based framing
- Full-service(Voice, Data, video supported)
- Payload = ATM+GEM
- TDM and variable-length packet over GEM



GEM: G-PON Encapsulation Mechanism

# G-PON Upstream(G.984.3)

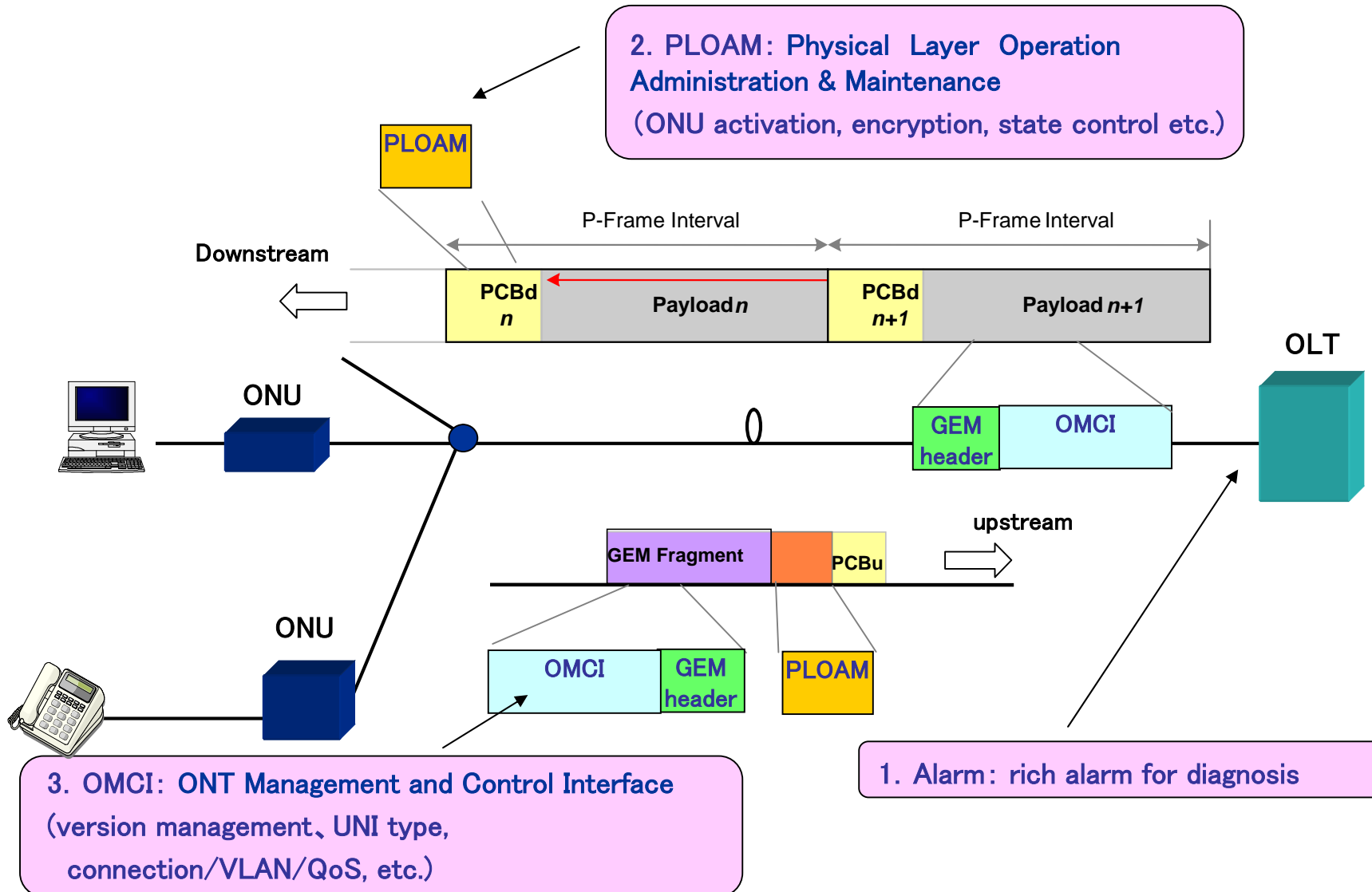
- Upstream variable-length framing (byte-oriented)
- Payload = ATM+GEM
- Pointer of start & stop of burst frame from ONUs



- **Broadband**
- **Multi-service**
- **OAM**
- **Interoperability**



# OAM Function



# Alarm Function

## Alarm detected by OLT (partial portion)

“i” indicates ONU-ID

items	descriptions
TF	Transmitter failure
LOSi	Loss of signal of ONUi
LOFi	Loss of frame of ONUi
PEEi	Physical Equipment Error of ONUi
LCDGi	Loss of GEM channel delineation of ONUi
OAMLi	PLOAM cell loss for ONUi
DOWi	Drift of window for ONUi
SUFi	Startup failure of ONUi
LOAi	Loss of Acknowledge with ONUi
DFi	Deactivate Failure of ONUi
ERRi	Block error detection of ONUi
SDi	Signal Degraded of ONUi
REIi	Remote Error Indication of ONUi
MEMi	Message_Error Message from ONUi
DGi	Receive Dying Gasp of ONUi

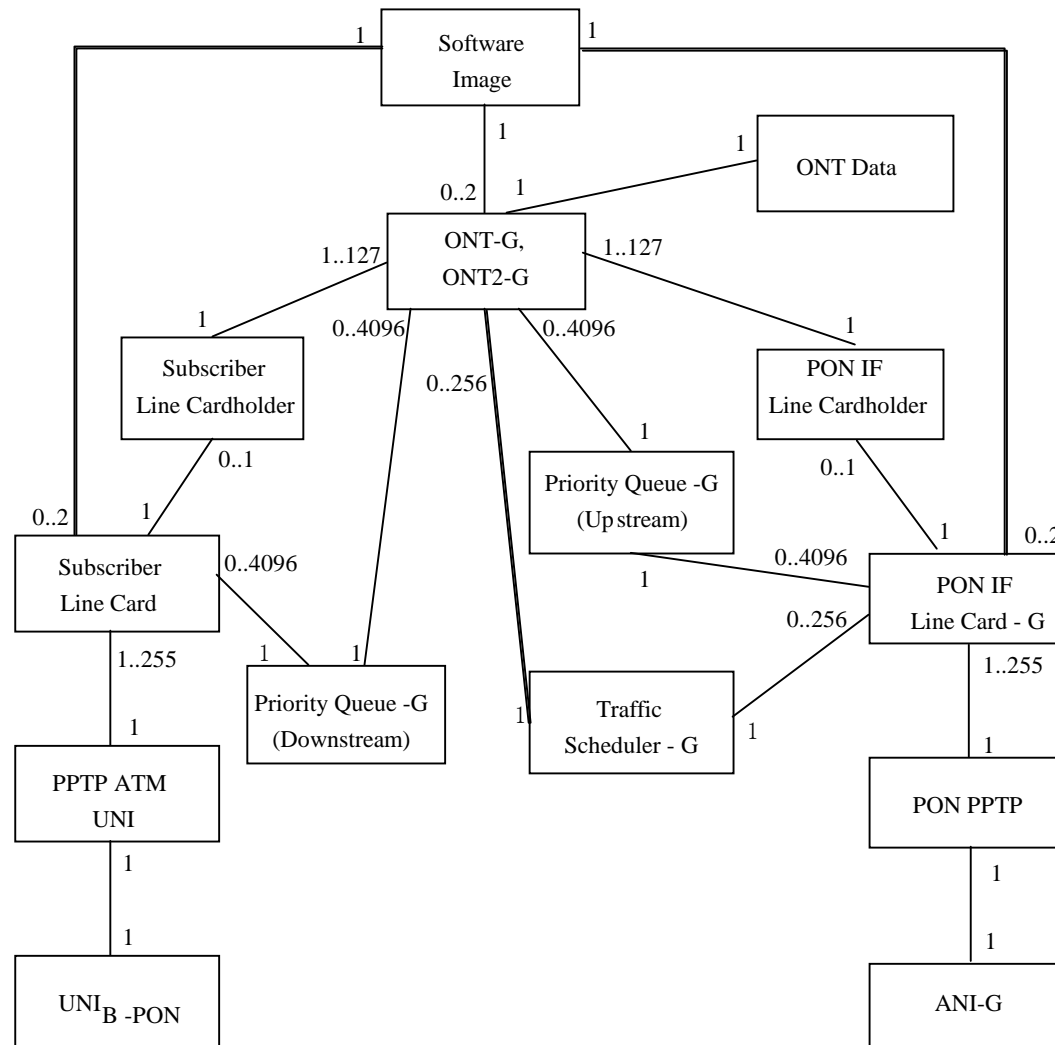
# PLOAM: Physical Layer Operation Administration & Maintenance

PLOAM messages (partial portion)

Messages	Description
Upstream_Overhead	OLT assigns burst overhead pattern and pre-assigned delay
Serial_number_mask	Only Indicated serial number ONU can be activated
Assign_ONU-ID	Assign ONU-ID(e.g. 0-31)
Ranging_Time	Equalized delay is set to ONU based on distance measurement
Deactivate_ONU-ID	De-activation of indicated ONU
Disable_serial_number	Isolation of indicated ONU for system maintenance
Assign_Alloc-ID	Assign Alloc-ID(bandwidth control unit by DBA)
POPUP	Quick re-activation process
Configure Port-ID	Set of port-ID for OMCI communication
Password	Password notification for authentication
Dying_Gasp	Notification of ONU Power-down

# OMCI: ONT Management and Control Interface

## OMCI Managed Entity (partial portion)



- **Broadband**
- **Multi-service**
- **OAM**
- **Interoperability**

# Interoperability activities in FSAN

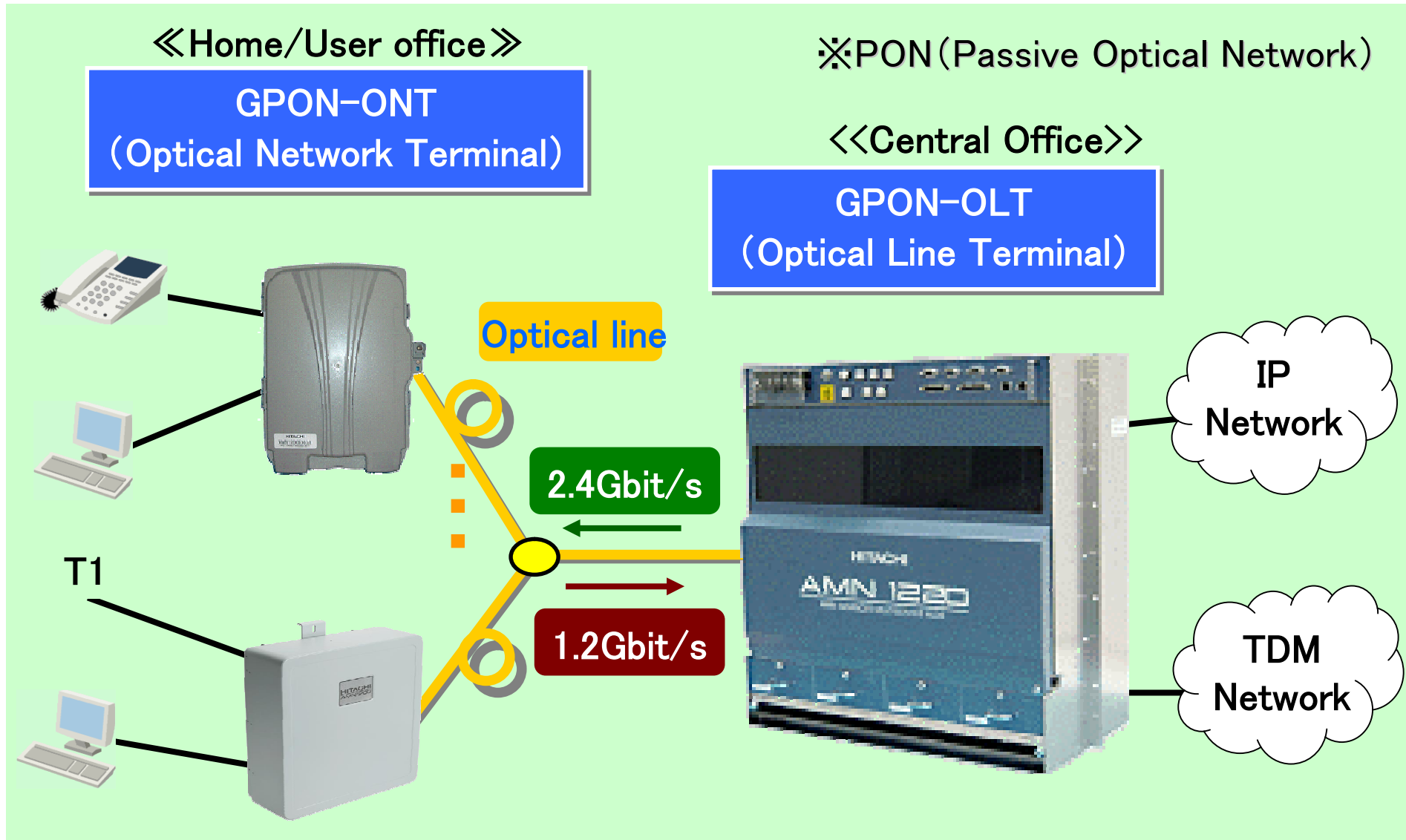
- **06/01 Physical layer connection @ Piscataway NJ**
- **06/05 Physical layer connection @ Piscataway NJ**
- **06/09 OMCI @ Santa Clara CA**
- **06/12 Telecom2006 @ Hong Kong**
- **07/03 OMCI @ Piscataway NJ**
- **07/06 Nextcomm 2007 @ Chicago IL**
- **07/10 OMCI @ Piscataway NJ**
- **08/04 OMCI @ Trino Italy**
- **08/10 OMCI @ Piscataway NJ**



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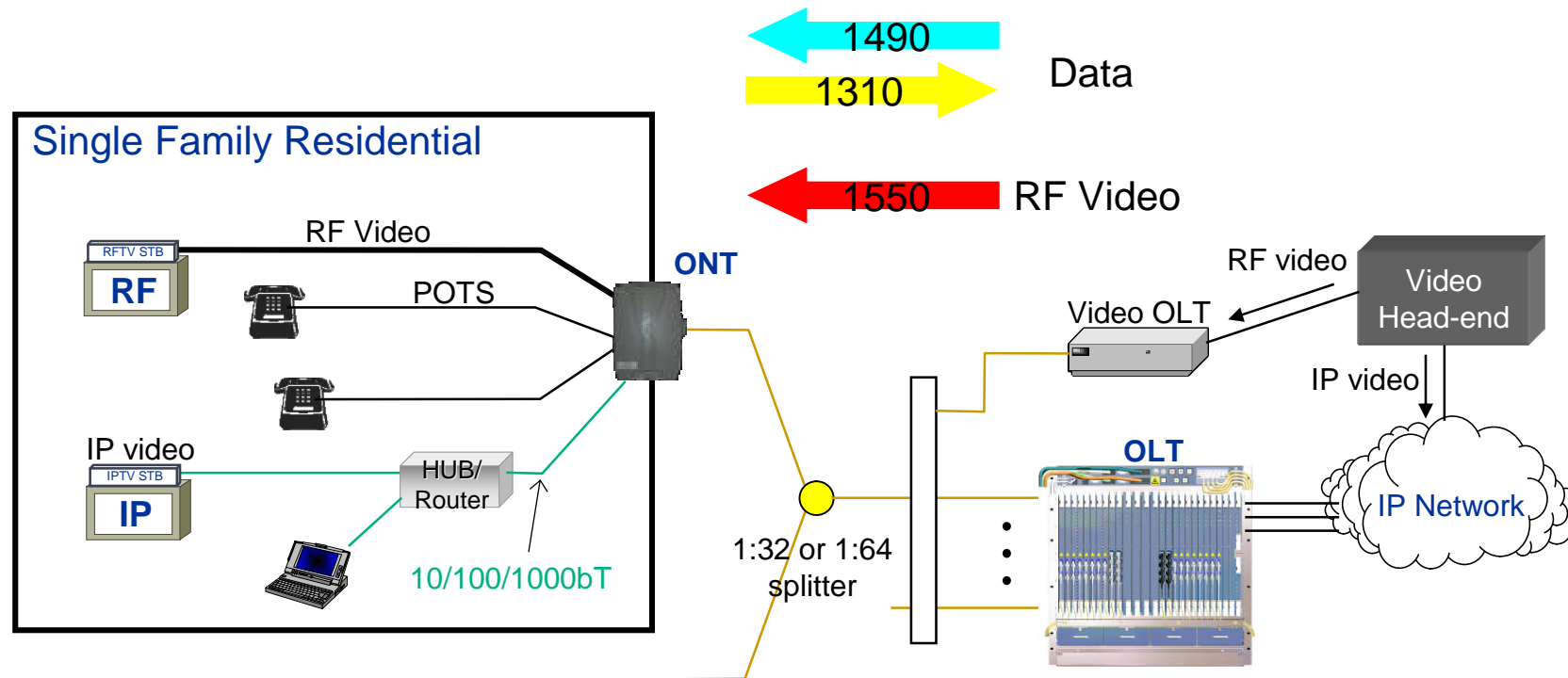
# GPON System Implementation



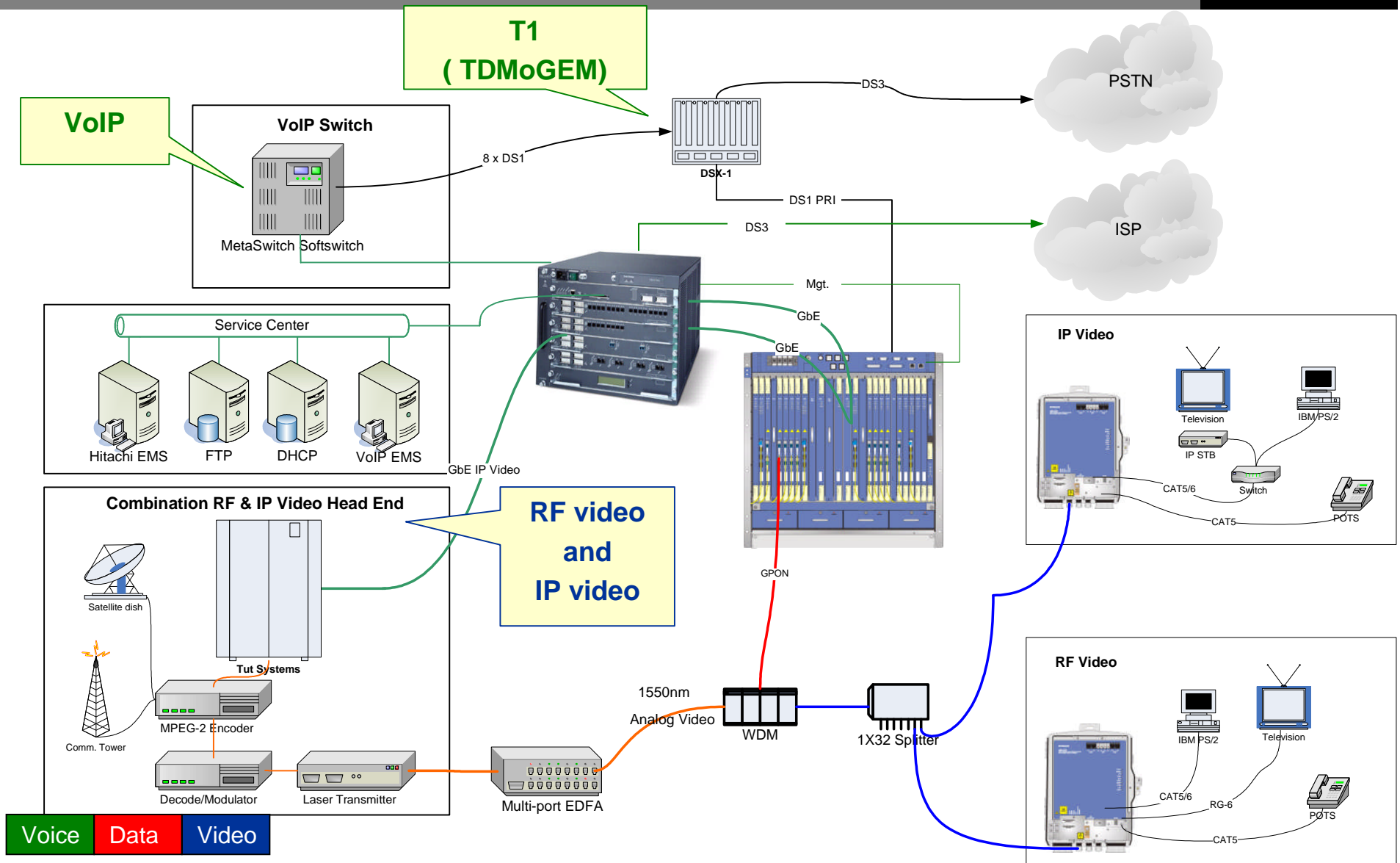


# Video Service

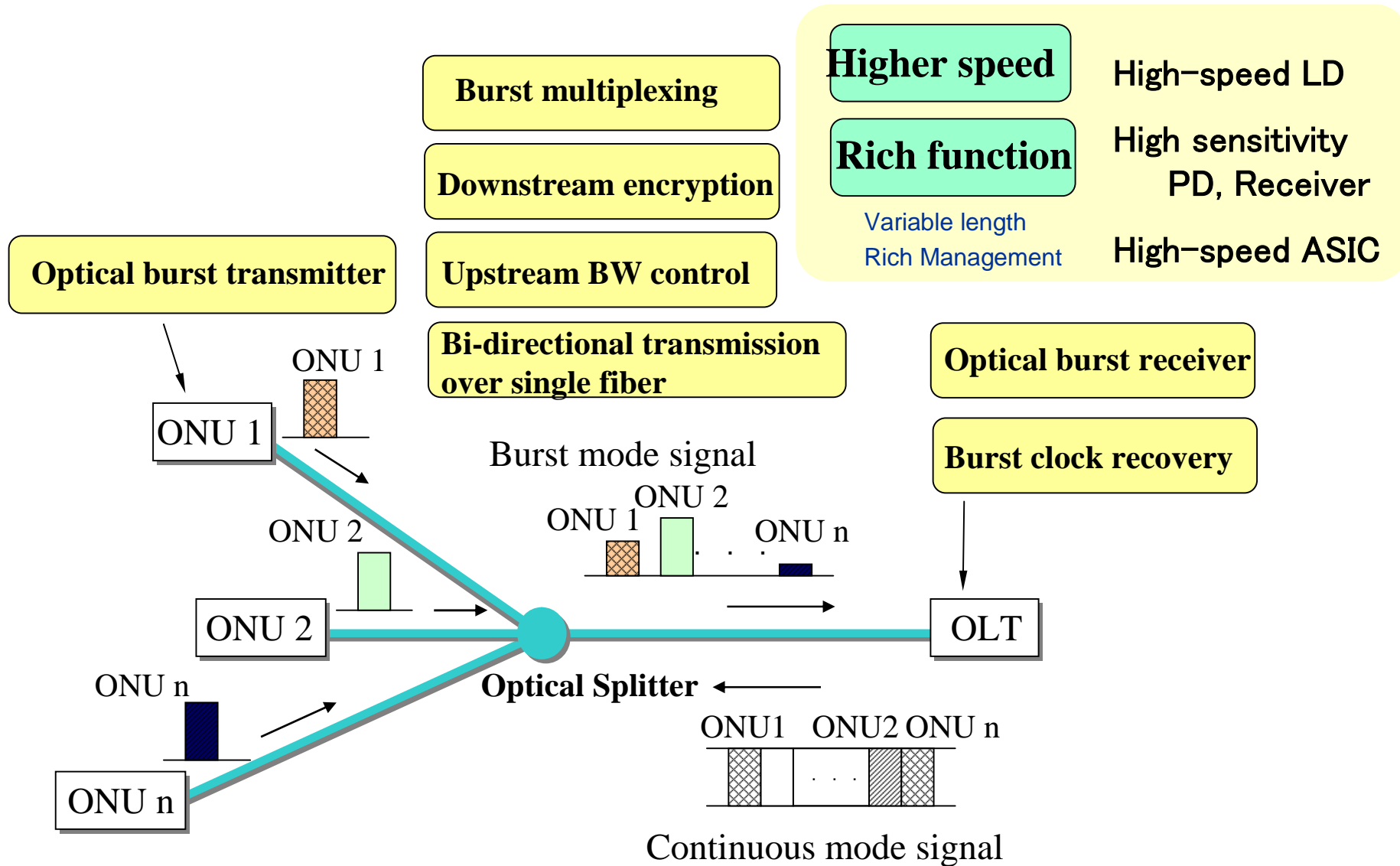
- 1. Analog video by WDM
- 2. IP multicast



# G-PON Network example

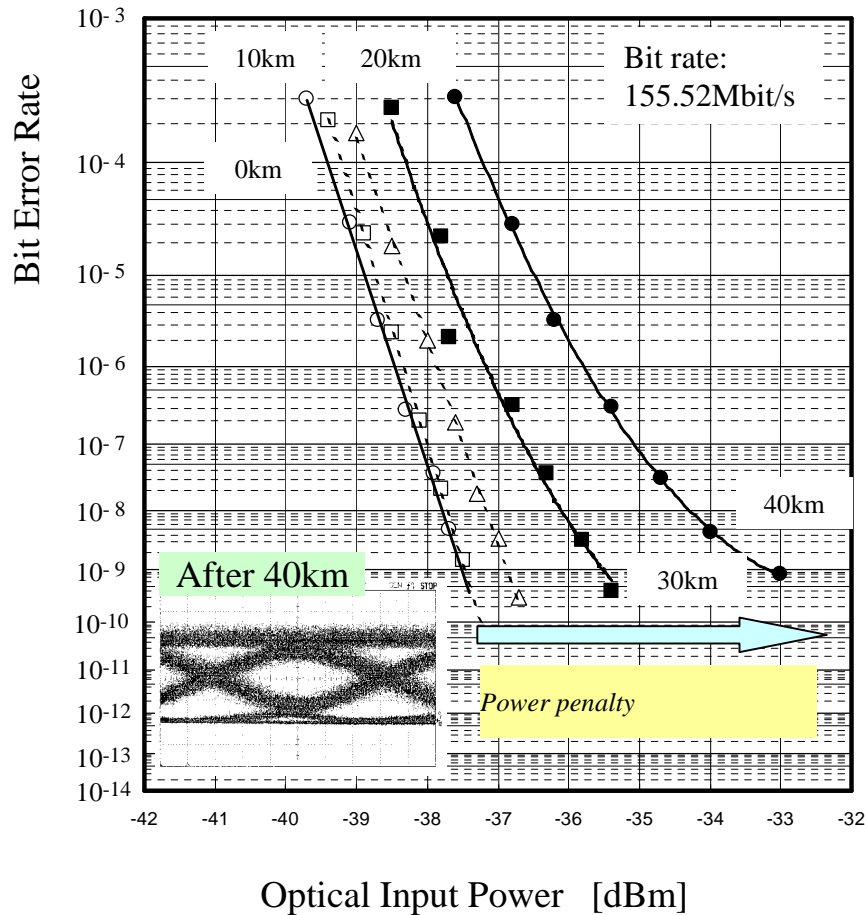


# G-PON technical study items

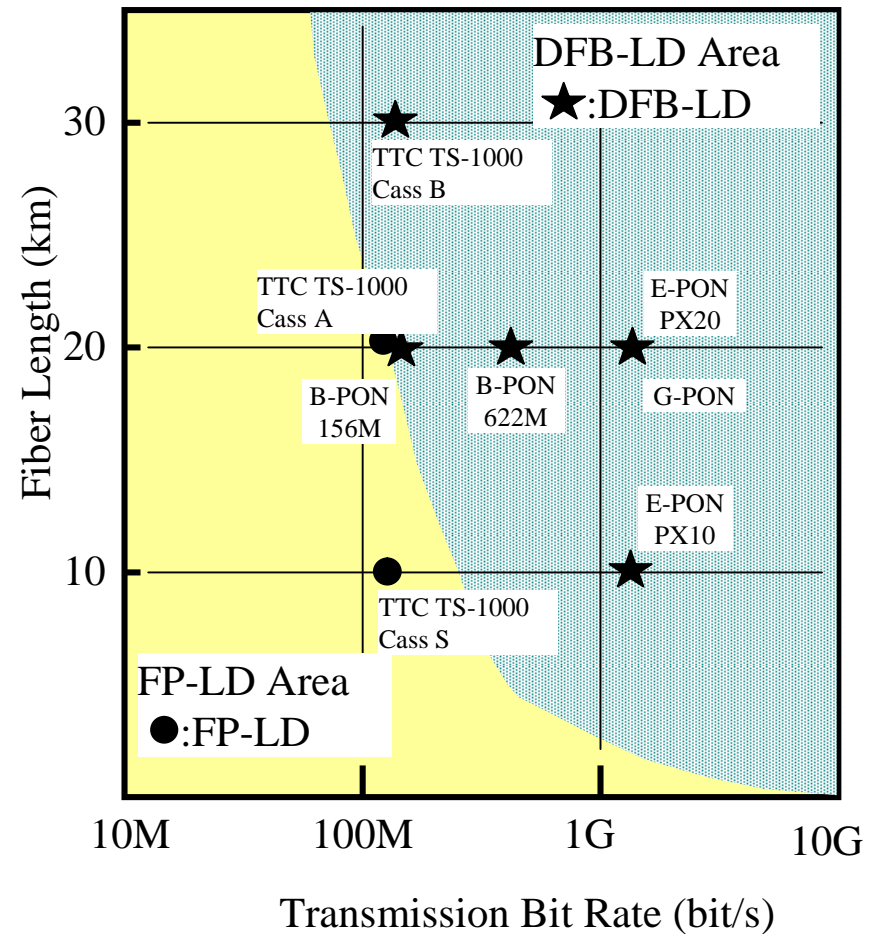


# How to use FP-LD and DFB-LD

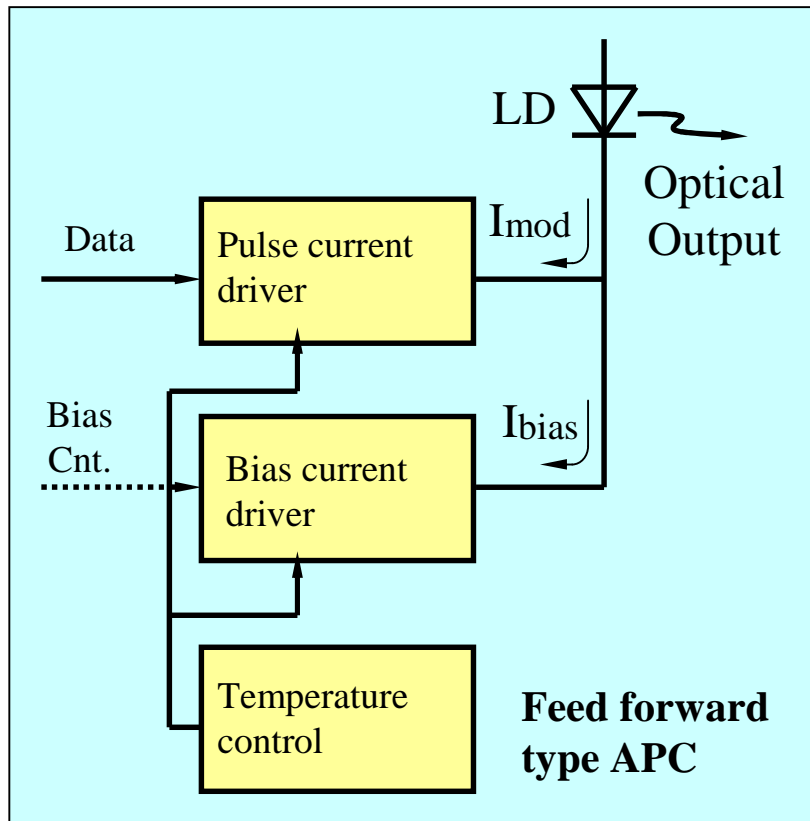
1550nm FP-LD transmission (example)



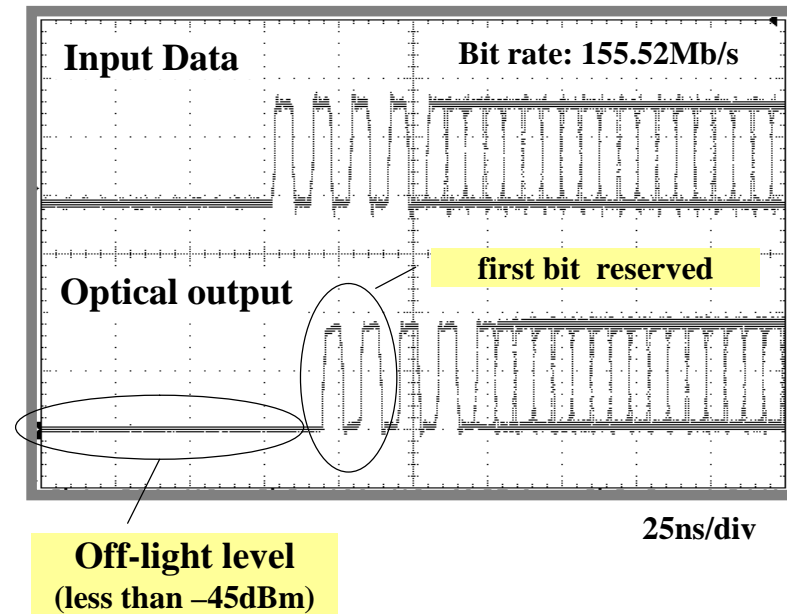
1500 nm Band transmission



# ONU Transmitter Design



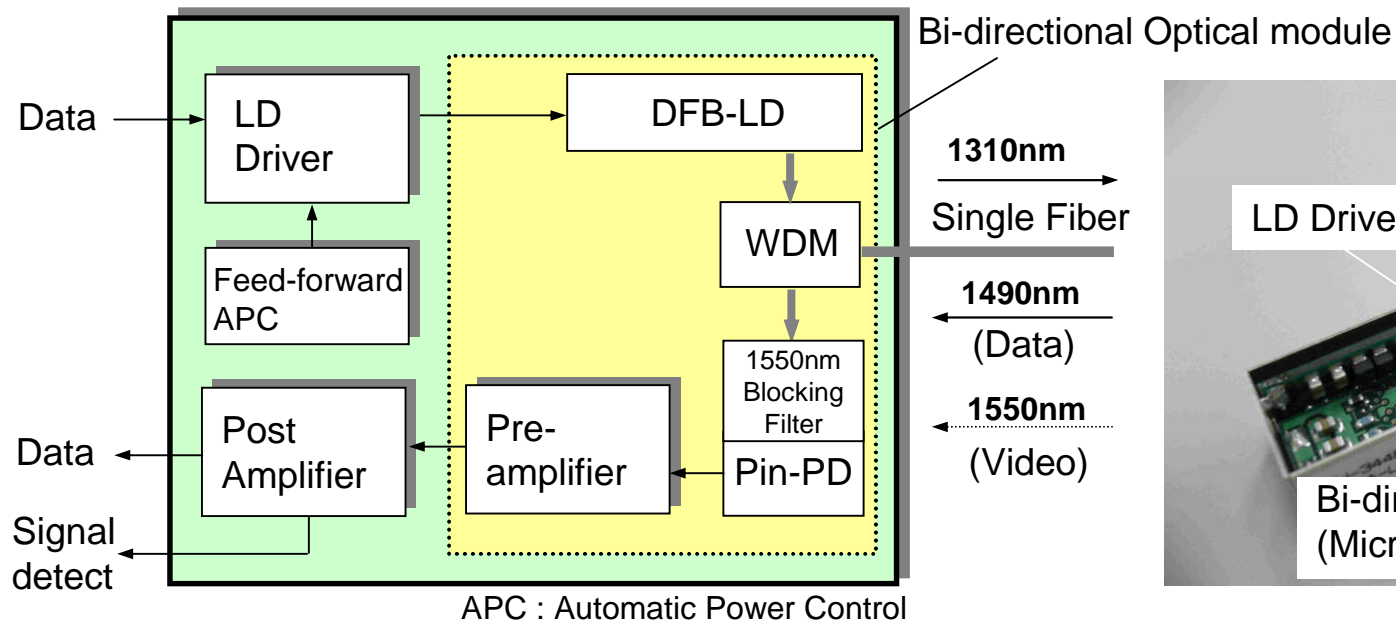
Optical burst transmitter (example)



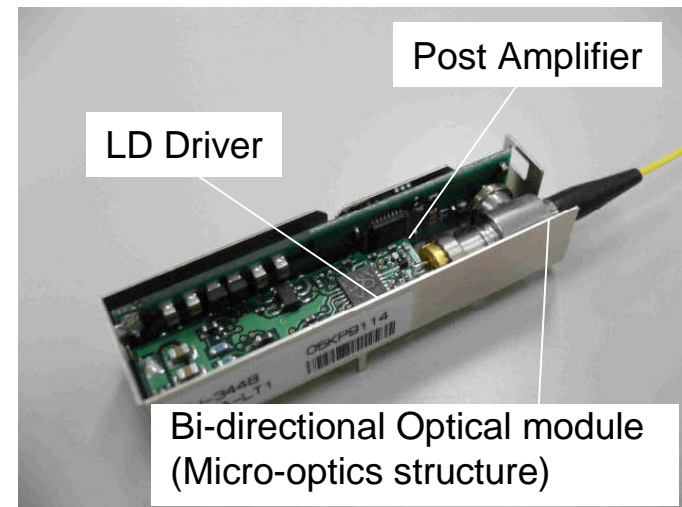
Optical burst waveform (example)

# G-PON ONU Transceiver

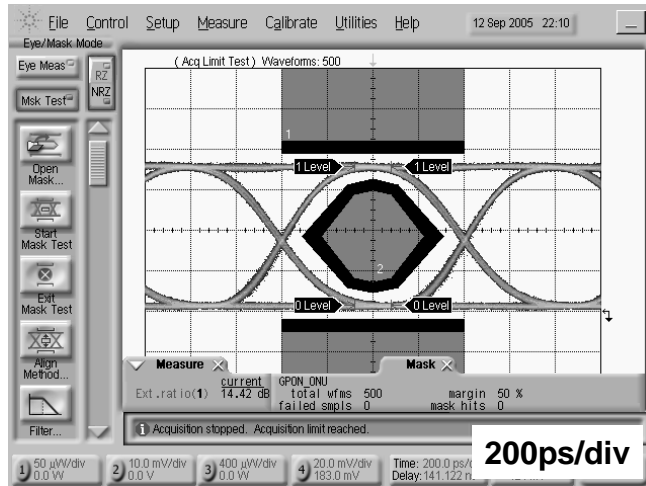
- Compact structure by Micro-optics
- 1.244Gbit/s burst-mode transmitter with feed-forward APC circuit
- 2.488Gbit/s continuous-mode receiver



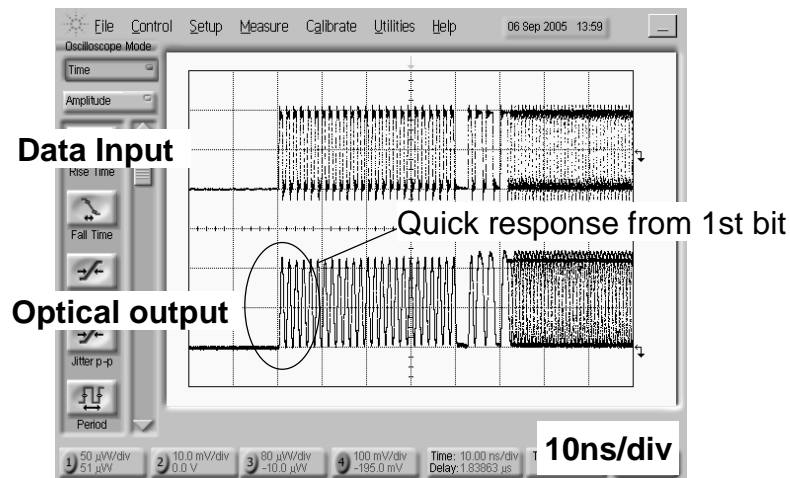
**Block diagram**



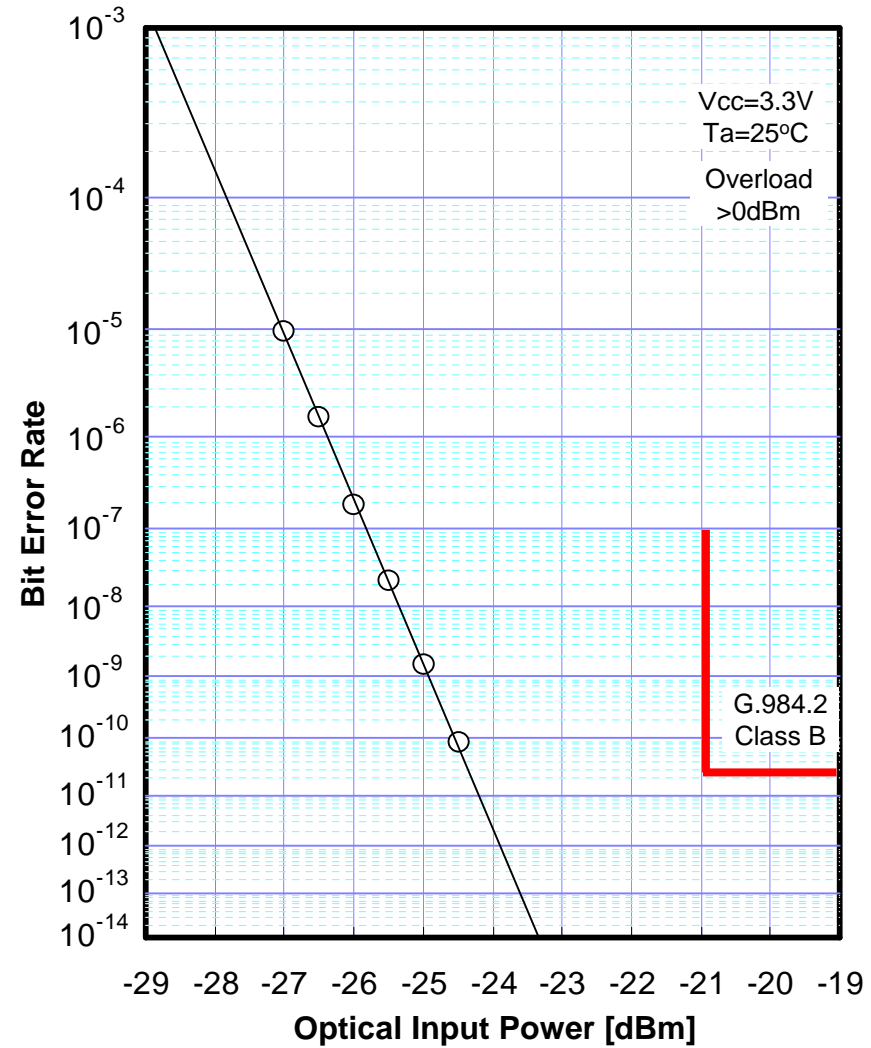
# G-PON ONU Transceiver Operation



**Optical Eye Diagram (1.244Gbit/s)**



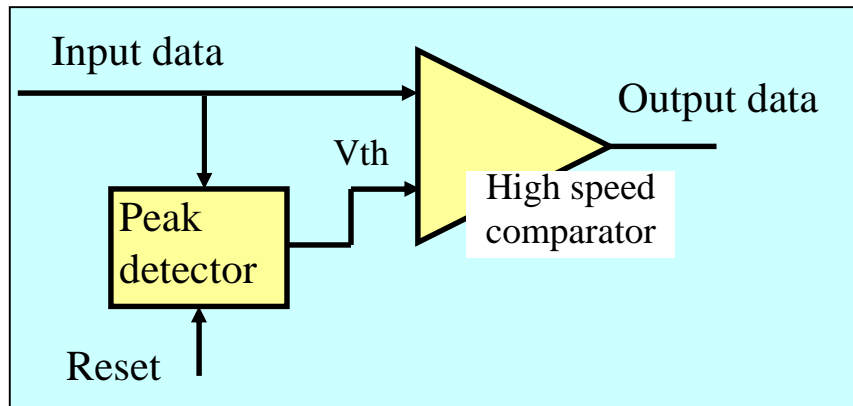
**Transmitter response of Burst-mode signal**



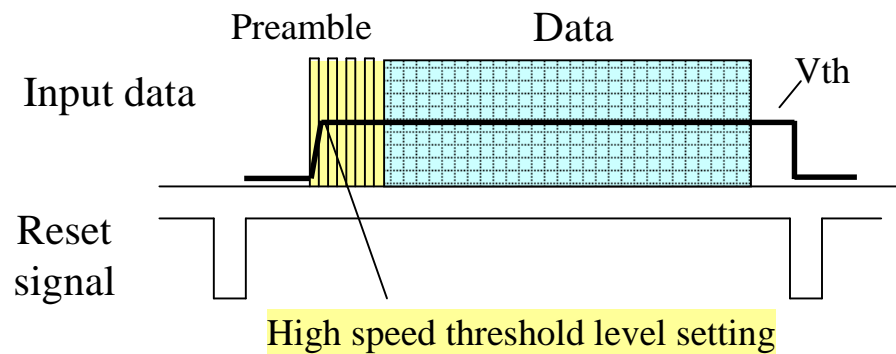
**Receiver sensitivity**



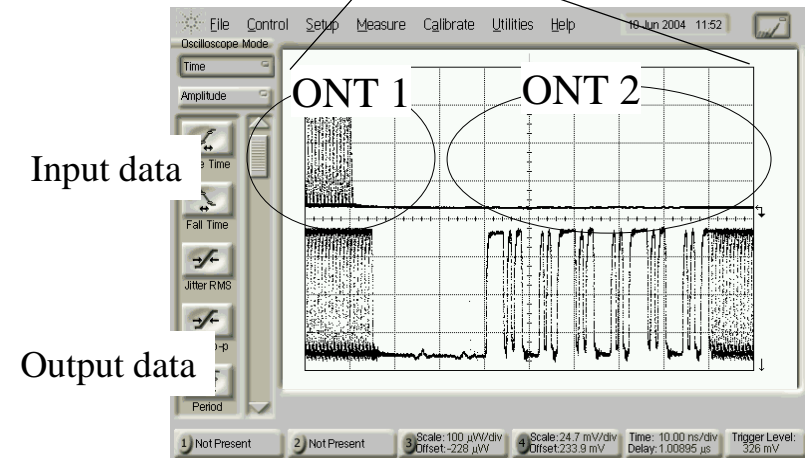
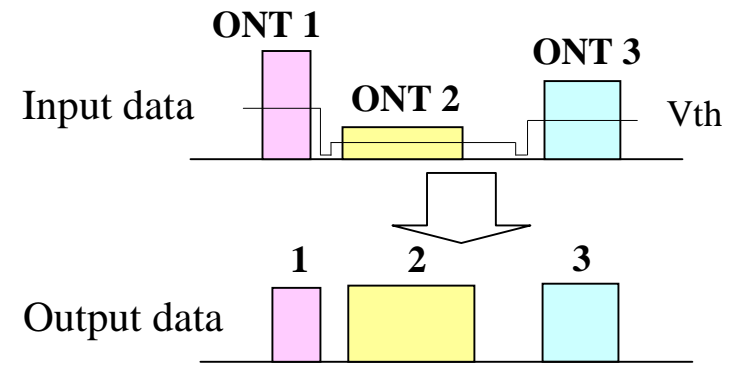
# OLT Receiver ATC Design



Block diagram of ATC



Response of ATC

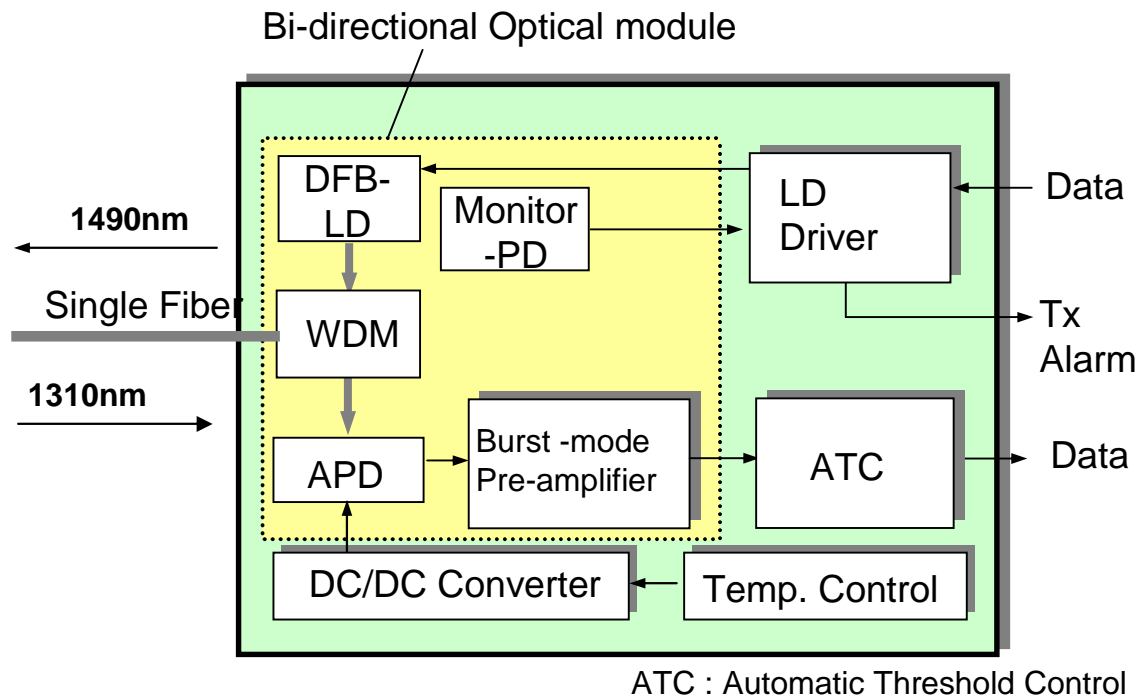
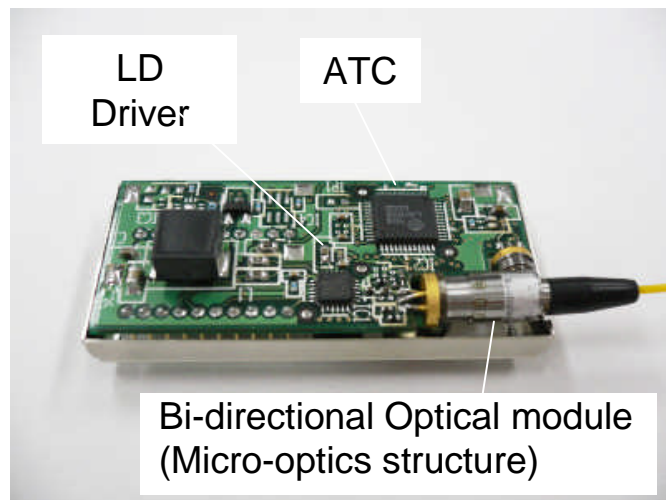


Example of Experimental response



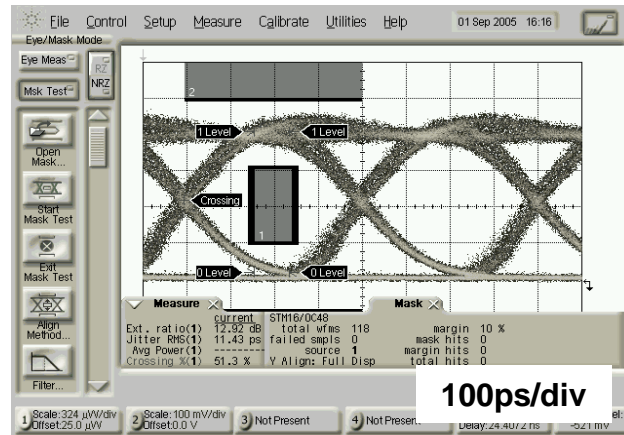
# G-PON OLT Transceiver

- Compact structure by Micro-optics
- 2.488Gbit/s continuous-mode transmitter using DFB-LD
- 1.244Gbit/s burst-mode receiver with high speed ATC circuit

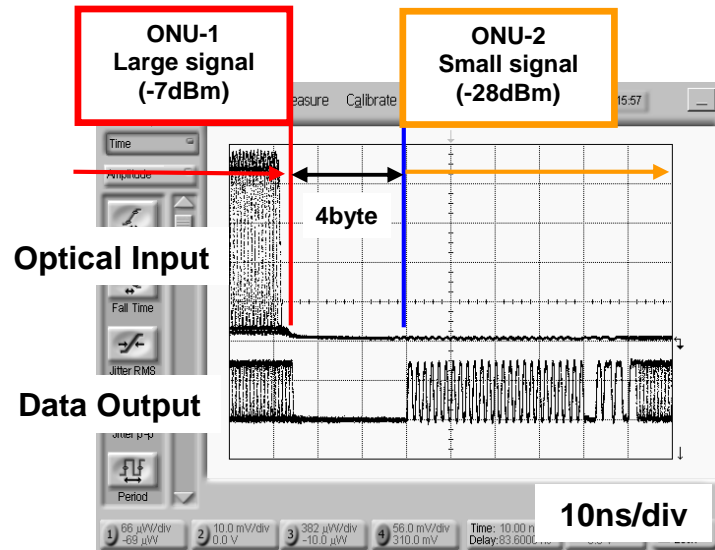


**Block diagram**

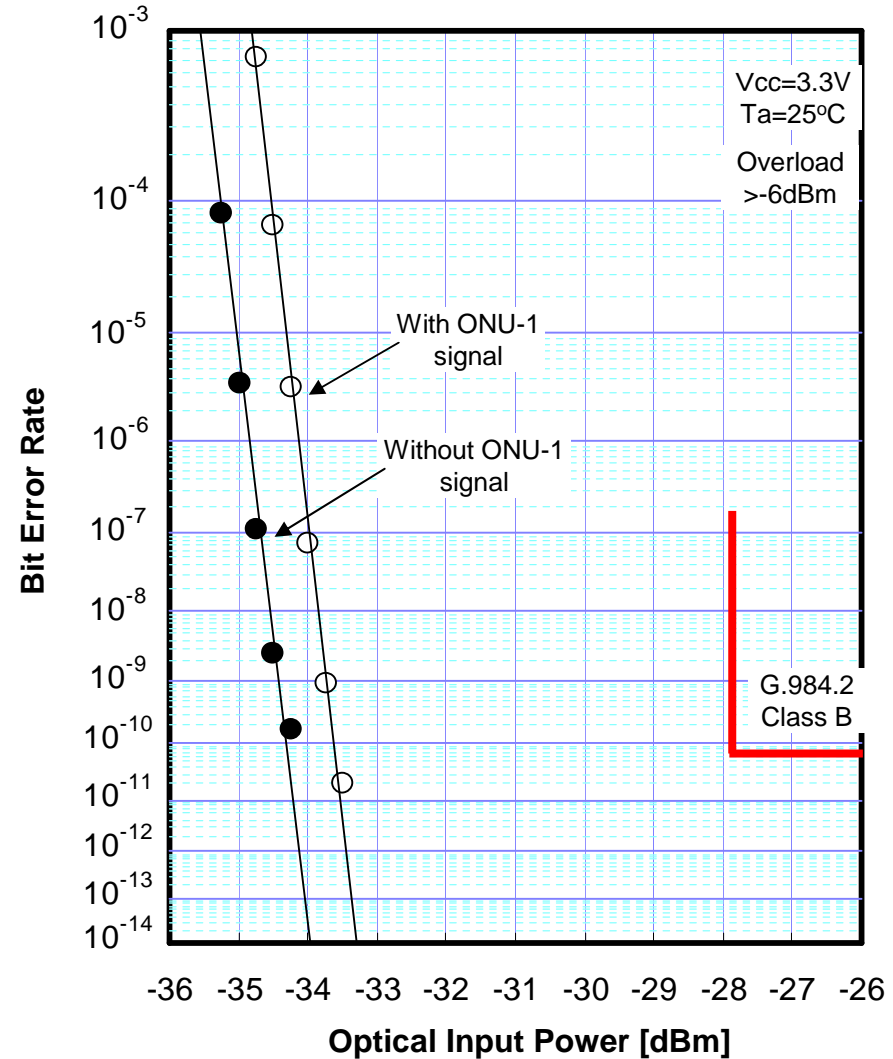
# G-PON OLT Transceiver Operation



**Optical Eye Diagram (2.488Gbit/s)**

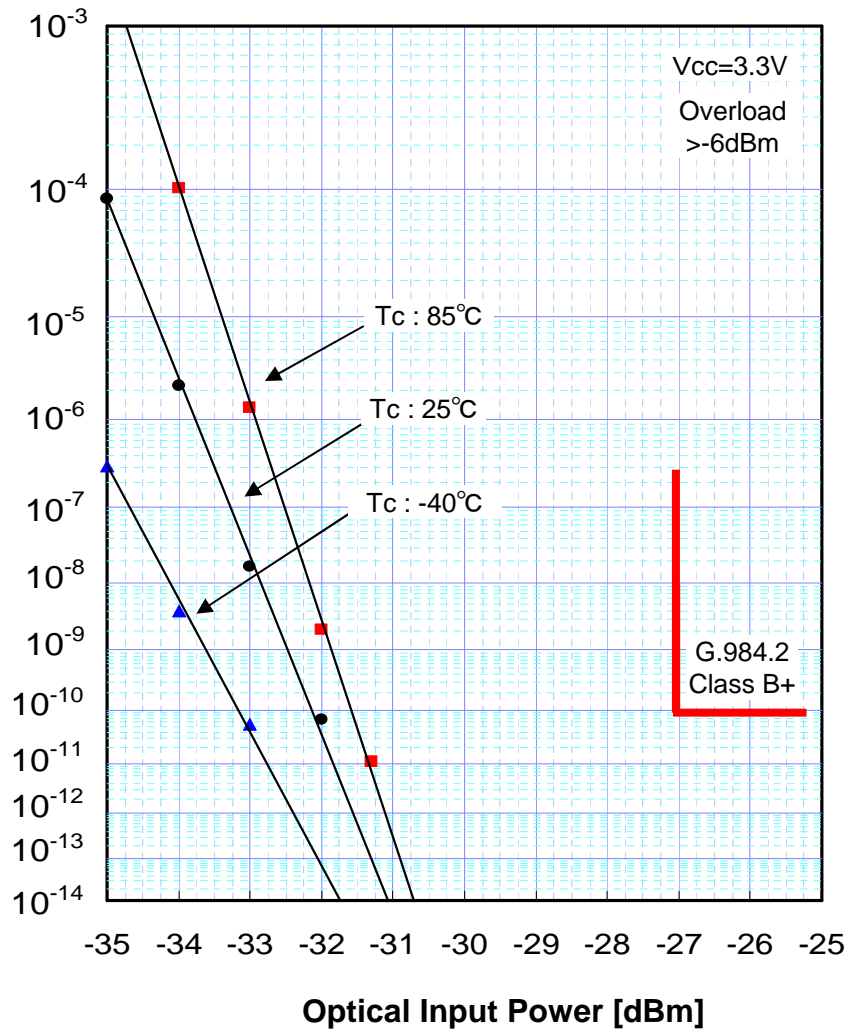


**Burst-mode signal response**

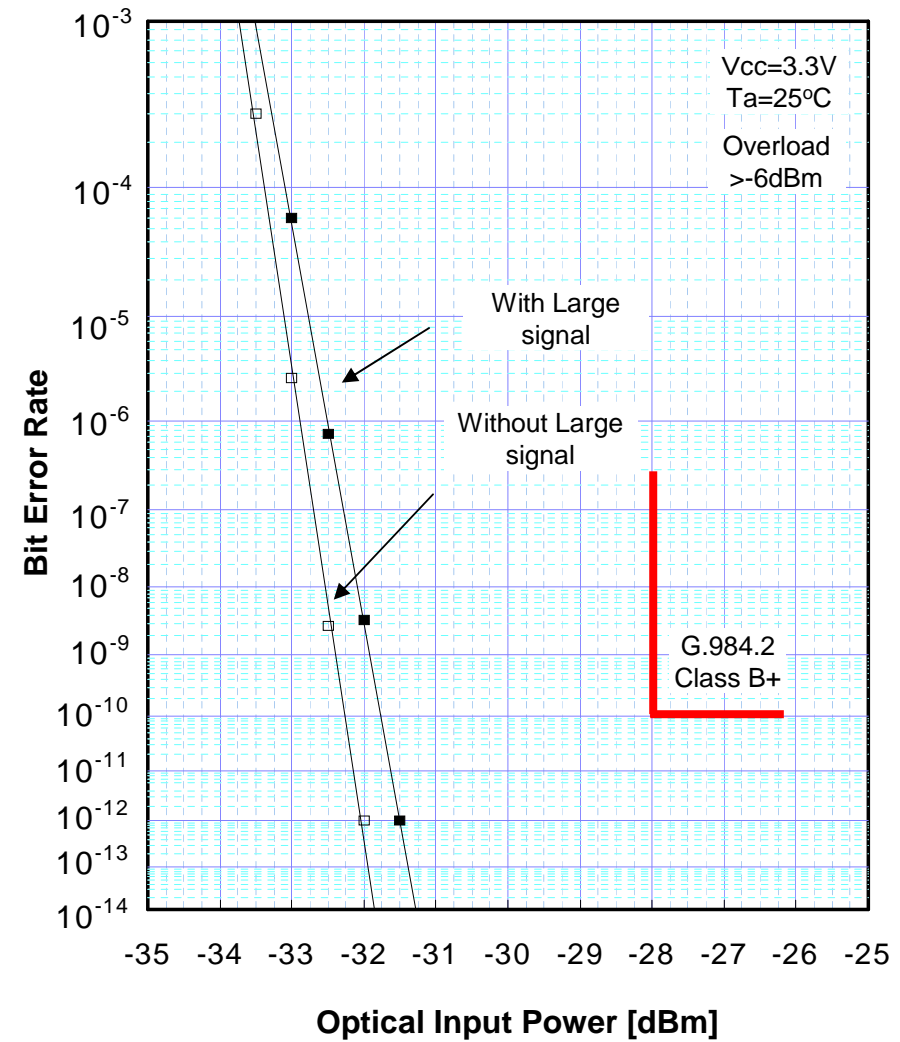


**Receive sensitivity (@ONU-2 signal)**

# G-PON OLT/ONT Receiver (class B+)

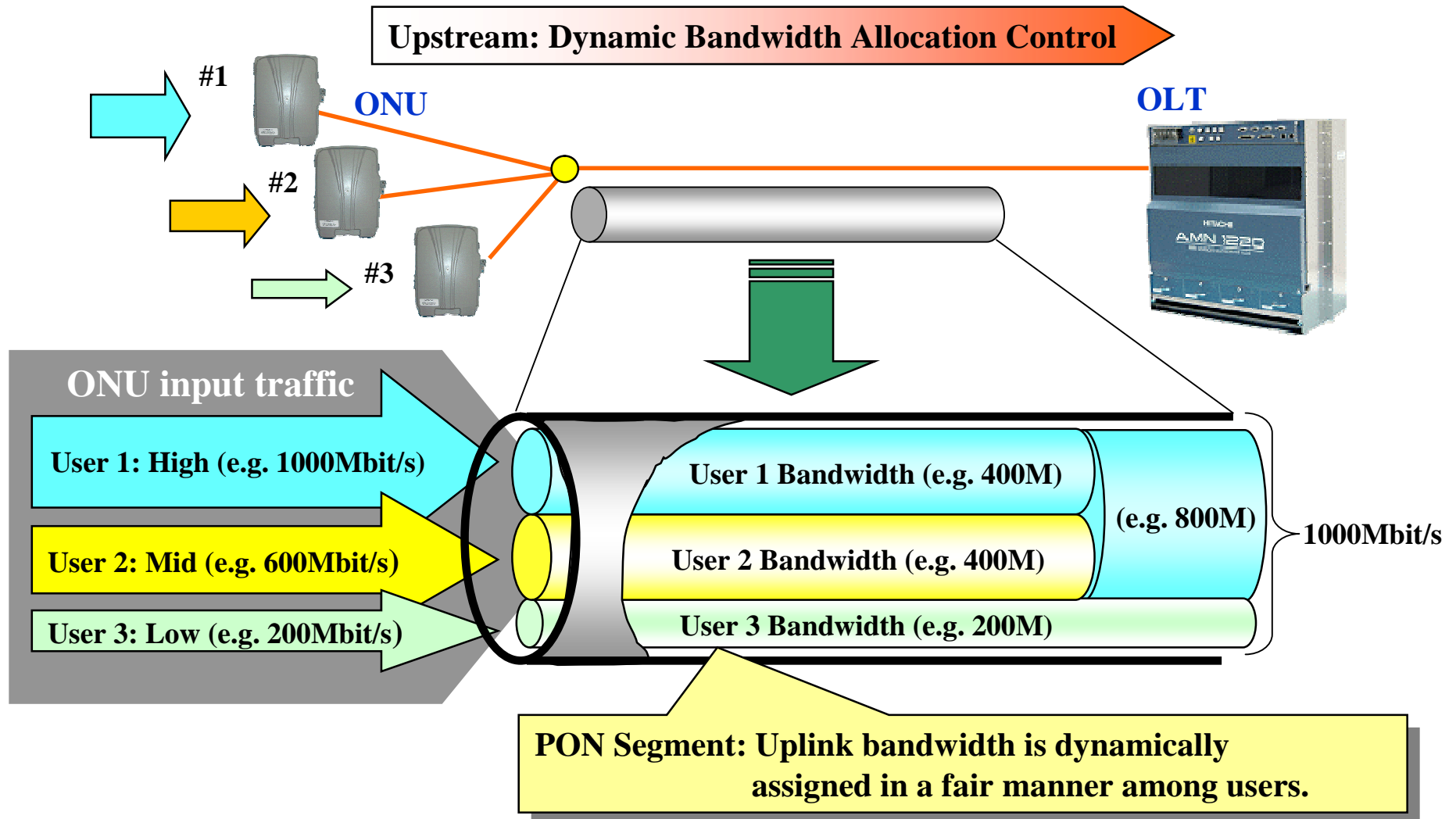


**ONU Receive sensitivity**



**OLT Receive sensitivity**

# DBA (Dynamic Bandwidth Assignment)



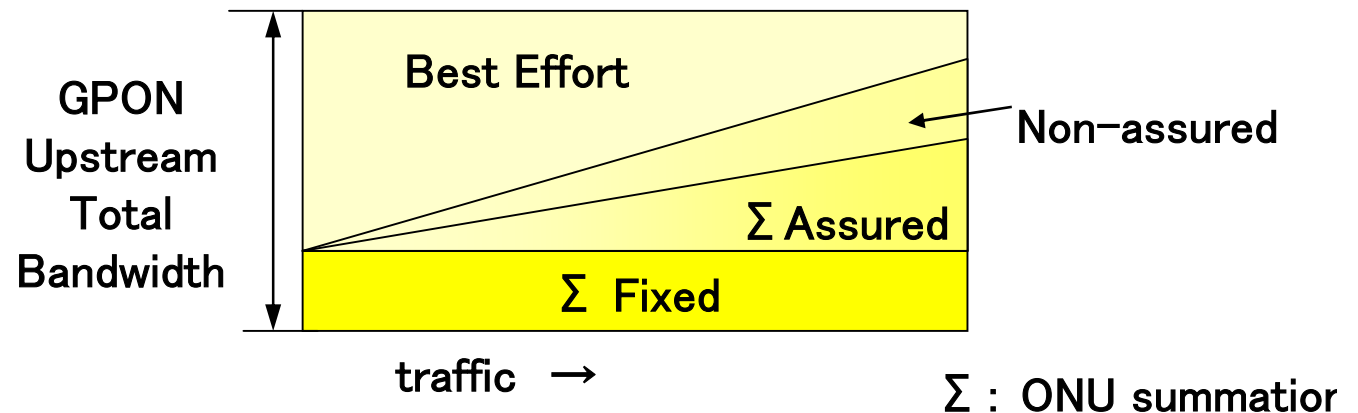
# DBA Policy

category	characteristics
Fixed Bandwidth	Always allocated to ONU <b>independent</b> of traffic request For delay/jitter sensitive services (e.g. TDM)
Assured Bandwidth	Allocated to ONU <b>based on traffic request</b> from ONU If not requested, allocated to other ONUs
Non Assured Bandwidth	Allocated after assured bandwidth <b>Not guaranteed</b> , and <b>Proportion to assured BW</b>
Best Effort Bandwidth	Allocated from surplus BW after non assured bandwidth <b>Not guaranteed</b>

## BW configuration

### Bandwidth parameters

- (1) Fixed Bandwidth (FXB)
- (2) Assured Bandwidth (ASB)
- (3) Maximum Bandwidth (MAB)



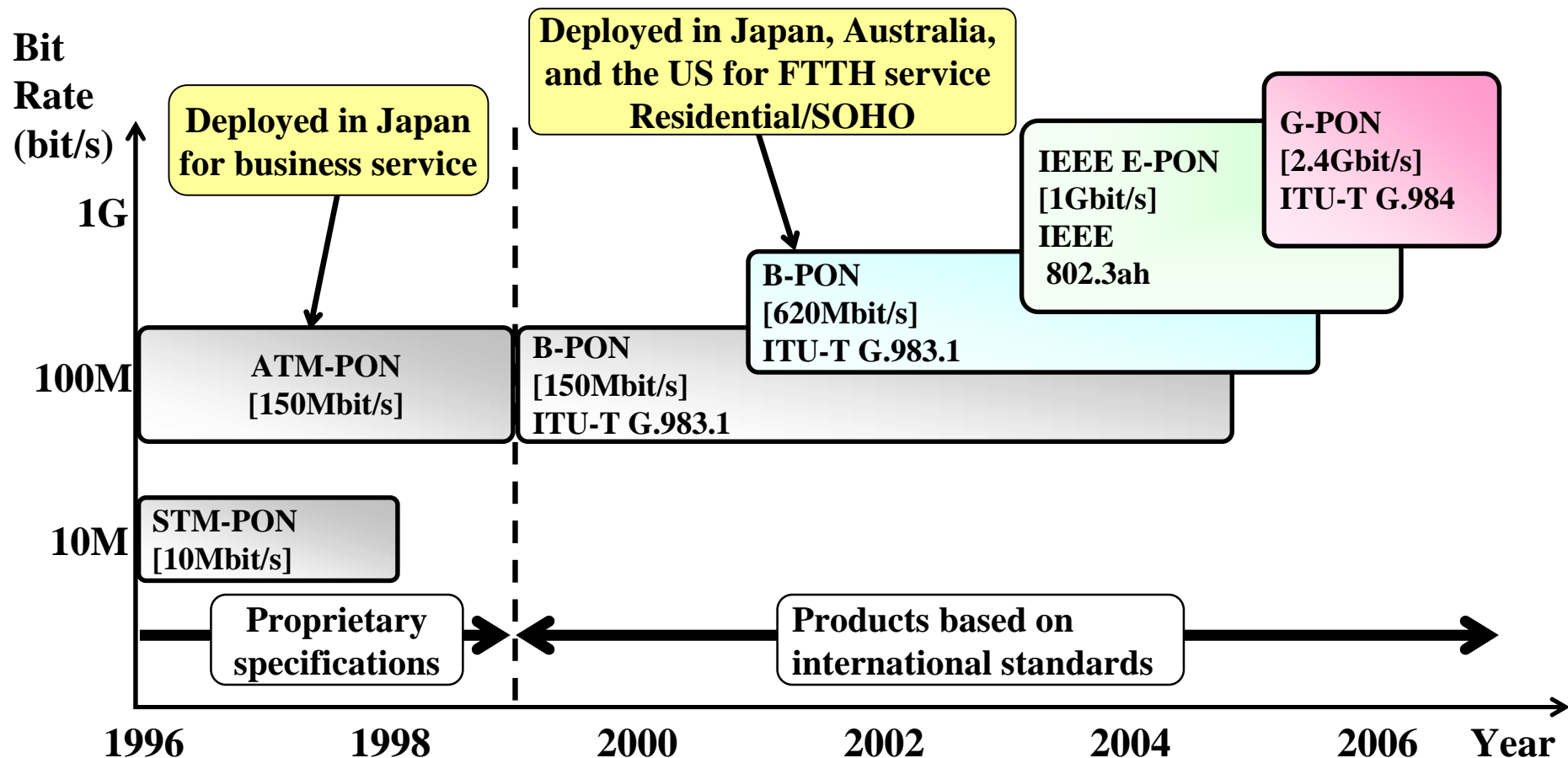


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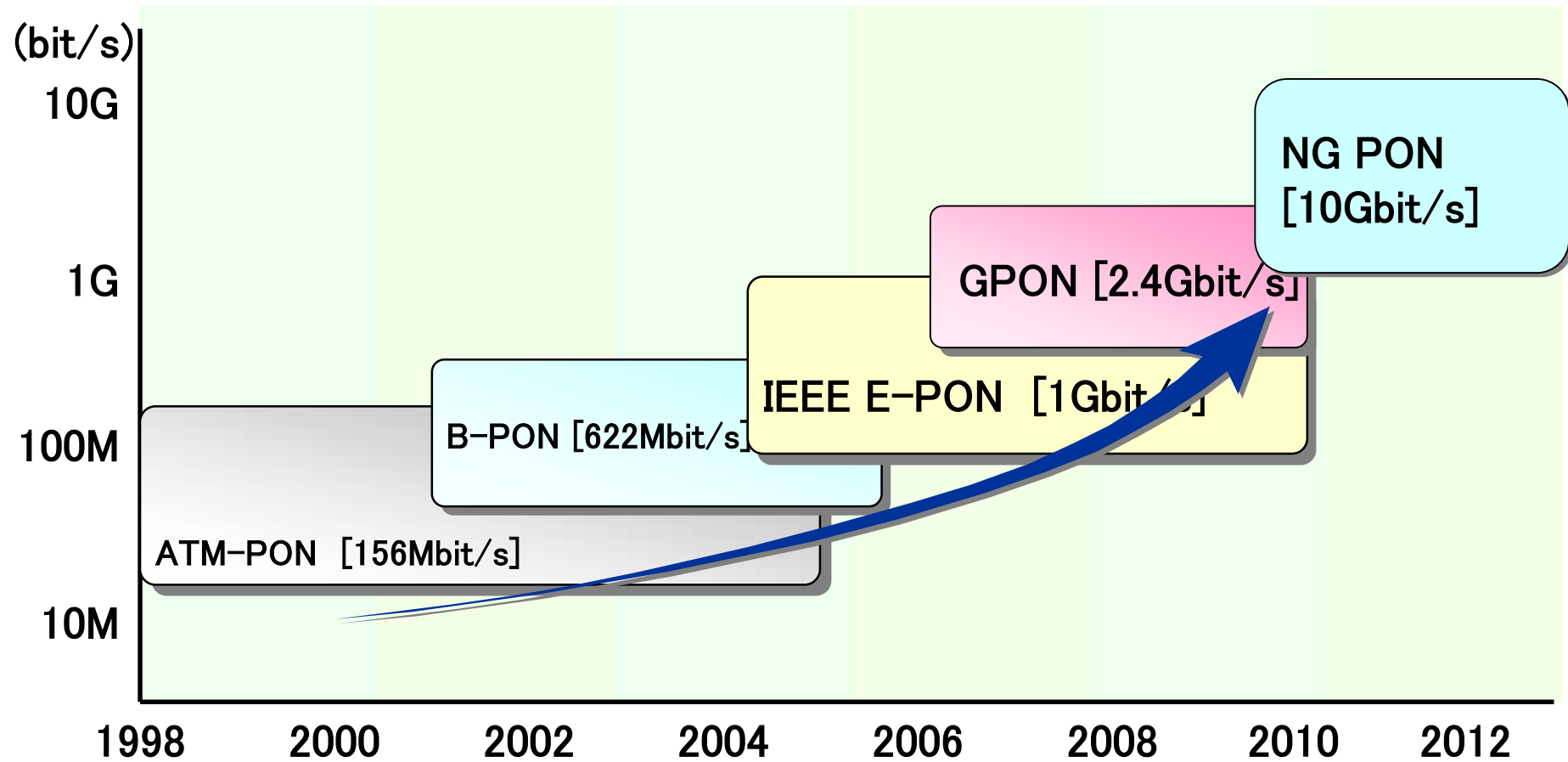
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# PON Roadmap

- From Business/specific use To FTTH.
- long (more than 8 years) development and continuous investment to PON



# PON Roadmap 2







- **Existing fiber plant** ( Conventional SMF)
- Distance 20km
- **Loss budget** 29dB(class B+)

e.g.

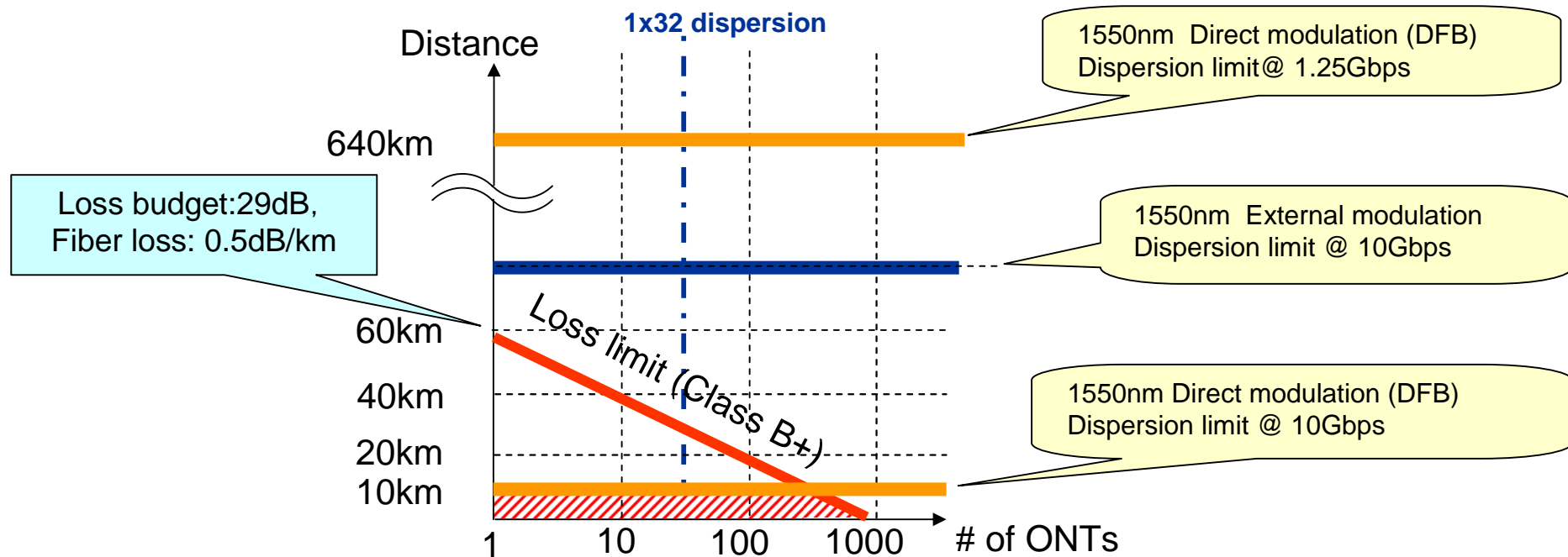
- 20 km optical fiber (10dB loss at 0.5dB/km)
- 1x32 optical split (more than 15dB)

→**study required on Optical power budget and dispersion**

# Study item on 10G Optical Access

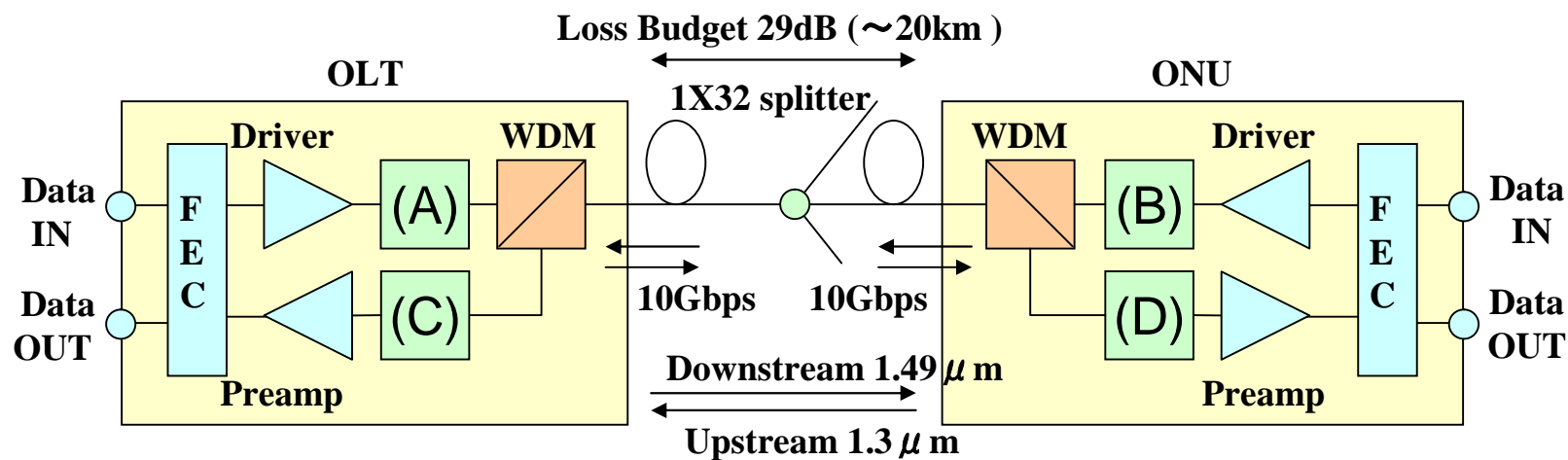
- 64 x Impact of dispersion 10G vs 1.25G(Downstream)
- Economical external modulator is required

Correlation between dispersion in the ONT and transmission range (SMF)



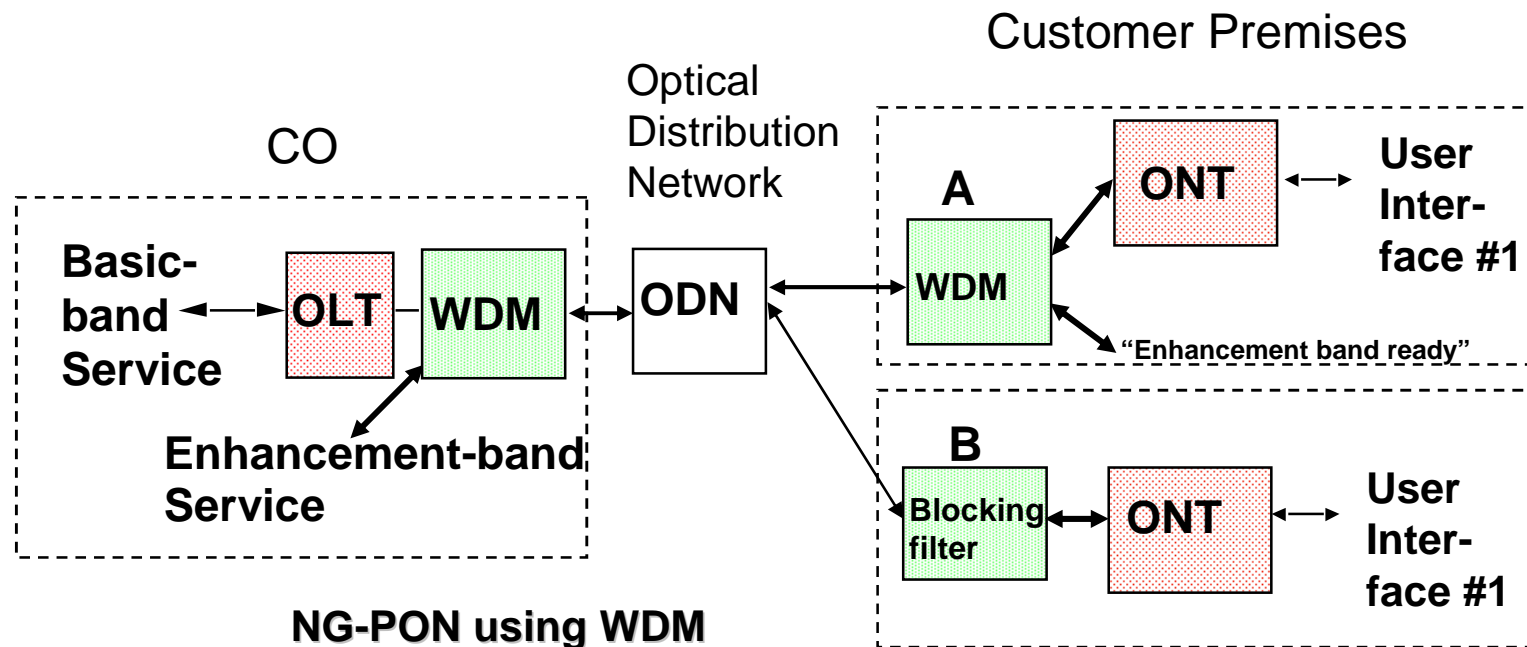
# 10G TDM PON optical components

	Plan 1		Plan 2	
	OLT	ONU	OLT	ONU
Downstream: 1.49 $\mu\text{m}$	(A) EA-DFB	(B) APD+FEC	EA-DFB +SOA	PD+FEC
Upstream: 1.3 $\mu\text{m}$	(C) APD+FEC	(D) DFB	APD+FEC	DFB

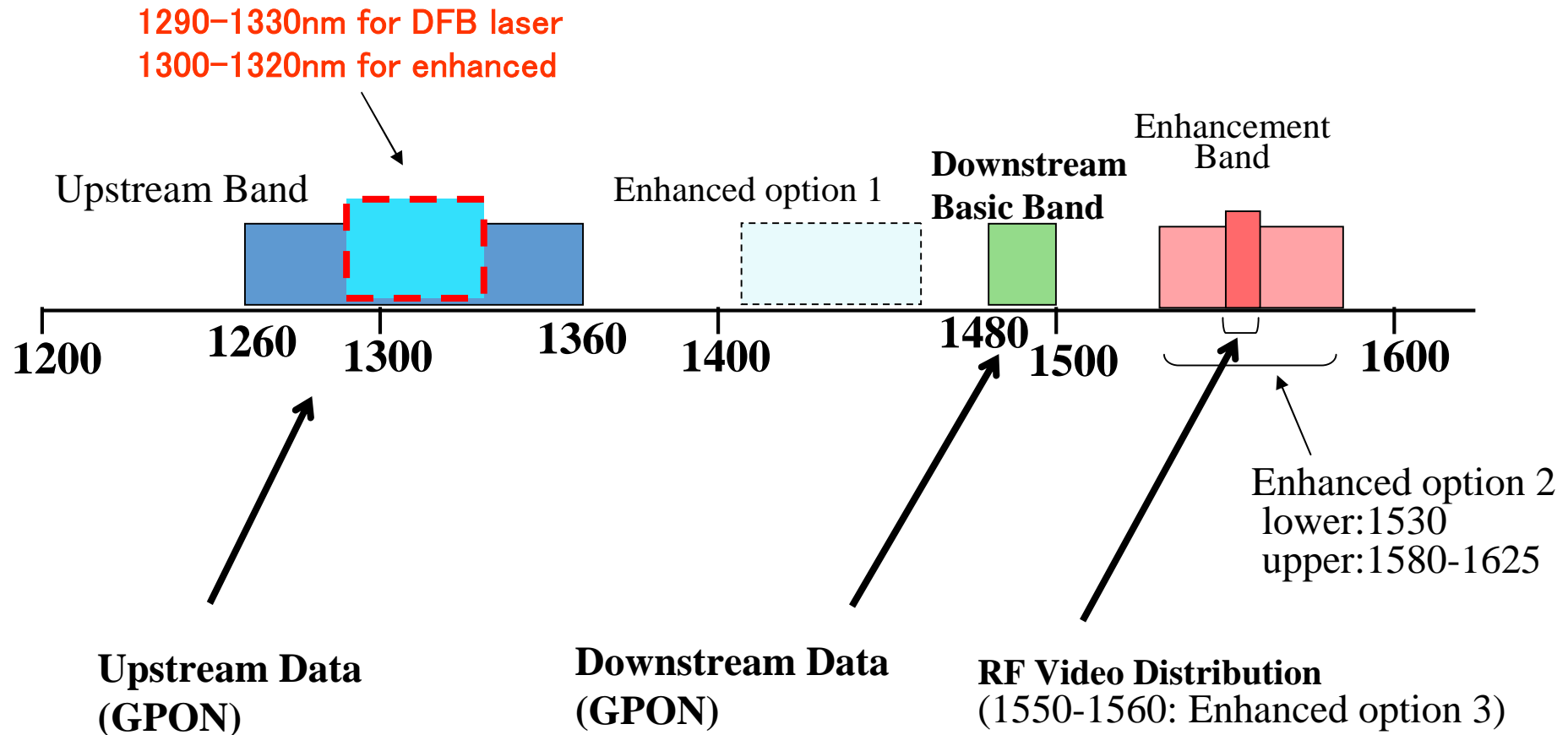


\*1 QD-LD: quantum dot laser

- NGA(Next Generation Access ) target  
WDM-PON, 10G-PON, enhanced GPON
- NGA should co-exist with existing PON by WDM



# PON Wavelength Plan Discussion



Based on ITU-T Recommendation G.984.5 discussion

- **G-PON for IP-TV deployment**

- **G-PON characteristics**

**Broadband, Multi-service, OAM, Interoperability**

- **Next generation access(including 10G) will co-exist with G-PON**