THE DEVELOPMENT OF FTTH IN CHT

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Definition of FTTx *（FTTH Council Asia-Pacific）*

FTTCurb / **FTTN**ode – Fiber to Street Cabinet

- distribution and drop cables: telco copper (DSL) or new copper
- categorised as DSL technologies.

FTTBuilding – Fiber to Apartment / Office Building

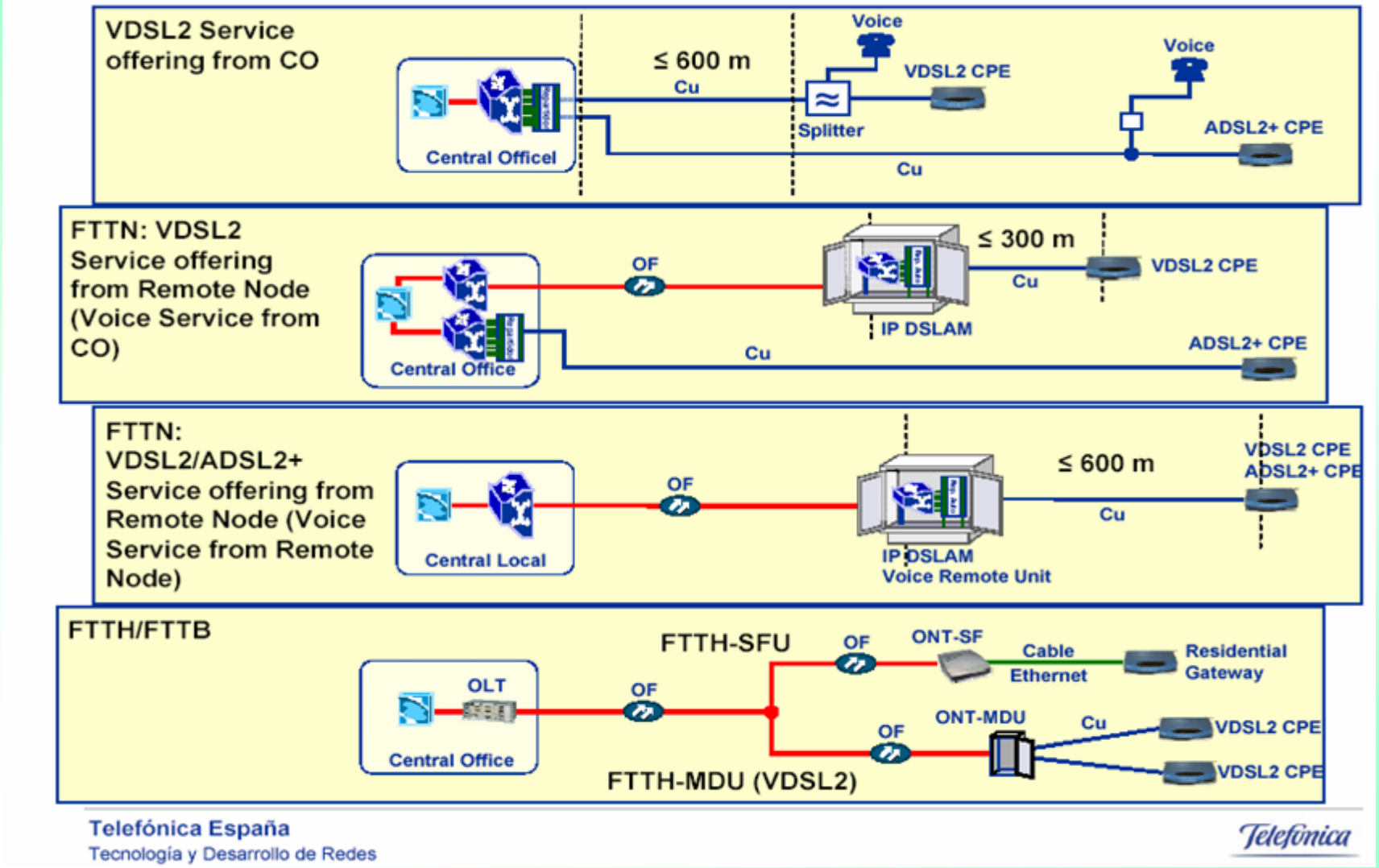
- in-building cables: building copper or fiber
- regarded as a transitional stage to FTTH

FTTHome – Complete Fiber Path to Home

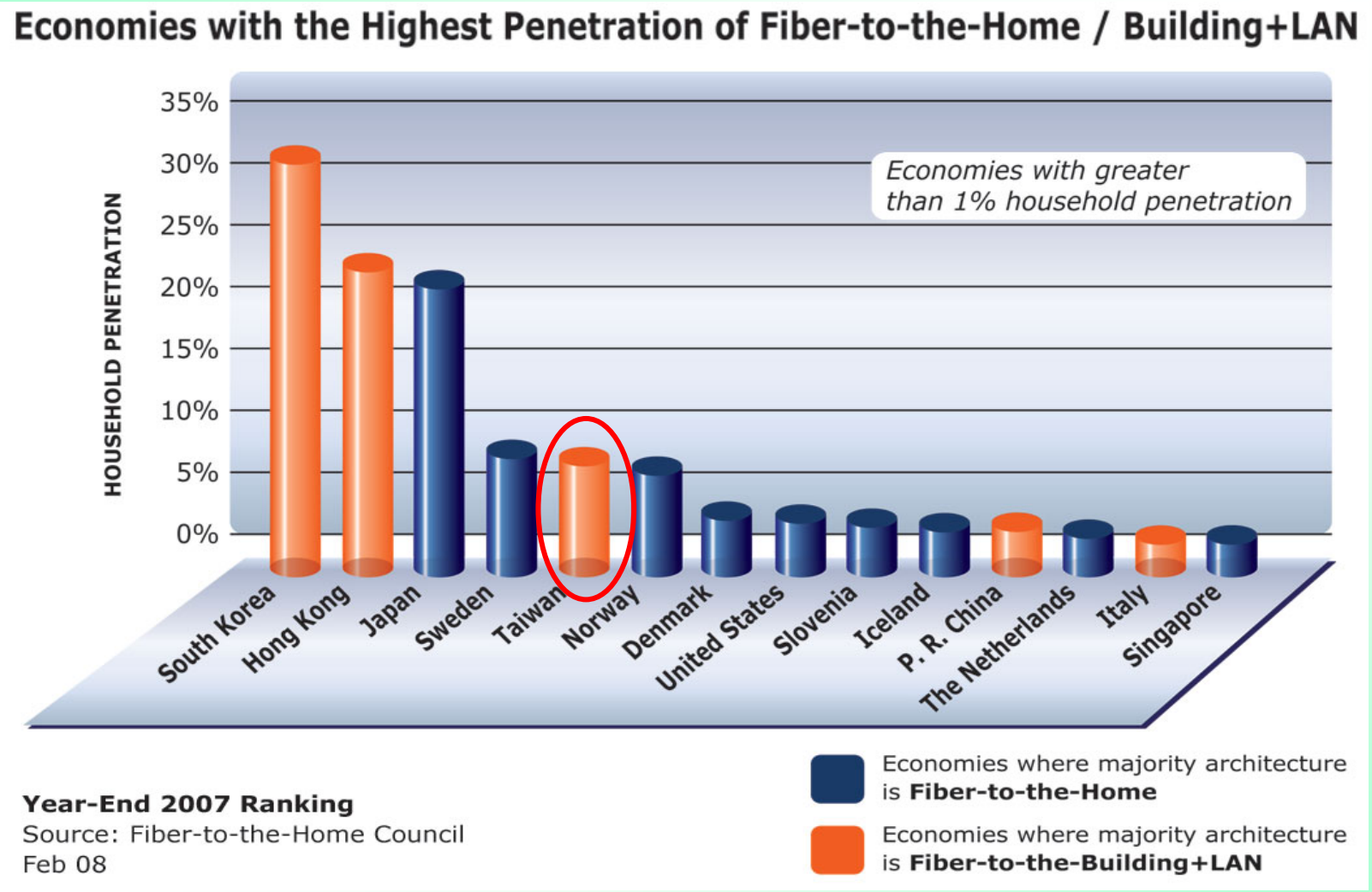
- in-building cables: house copper or fiber or wireless
- may require more initial investment (capex), but promises considerable savings in operating costs (opex).

(Note : FTTH is now a cost-effective alternative to the traditional copper loop. FTTH simultaneously handles several phone calls, TV/video streams, and Internet users in the home/office.)

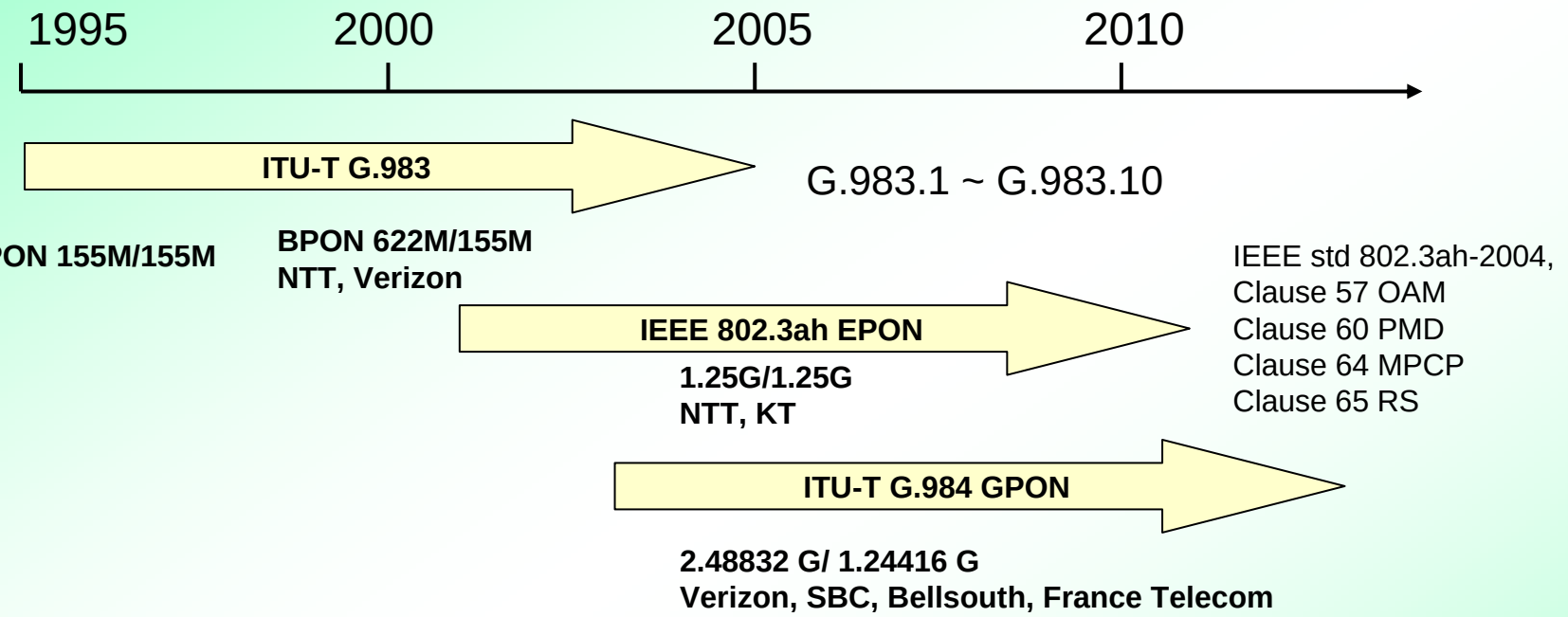
Loop Archit. of FTTH/FTTB/FFTN (*Ex.Telefonica*)



Global FTTH/FTTB Penetration



PON Standard



	Title
G.984.1	Gigabit-capable Passive Optical Networks (GPON): General characteristics
G.984.2	Gigabit-capable Passive Optical Networks (GPON): Physical Media Dependent (PMD) layer Specification
G.984.3	Gigabit-capable Passive Optical Networks (GPON): Transmission Convergence (TC) layer Specification
G.984.4	Gigabit-capable Passive Optical Networks (GPON): ONT management and control interface specification

PON Standard Comparison

	IEEE EPON	ITU-T GPON	ITU-T-BPON
Downstream Line Rates (Mb/s)	1250	1244 or 2488	155 or 622 or 1244
Upstream Line Rates (Mb/s)	1250	155 or 622 or 1244 or 2488	155 or 622
Line coding	8B10B	NRZ with scrambling	NRZ with scrambling
Addressing capability (min/max)	16/NA	64/128	32/64
Minimum Logical Reach	20km	60km with 20km differential	20 km
Layer 2 protocol	Ethernet	Ethernet over GEM and/or ATM	ATM
TDM Support	TDM over packet	Native TDM, TDM over ATM, TDM over packet	TDM over ATM
Number of traffic flows/PON system	# of LLIDs /ONT	4096	256
Upstream bandwidth capacity (for IP data throughput)	760-860 Mb/s	1160 Mb/s for 1244	500 Mb/s for 622
OAM and Management	Ethernet OAM	PLOAM + OMCI	PLOAM + OMCI
Downstream Security	Not Defined	AES counter mode	Churning or AES
FEC	RS(255,239)	RS(255,239)	Not Defined

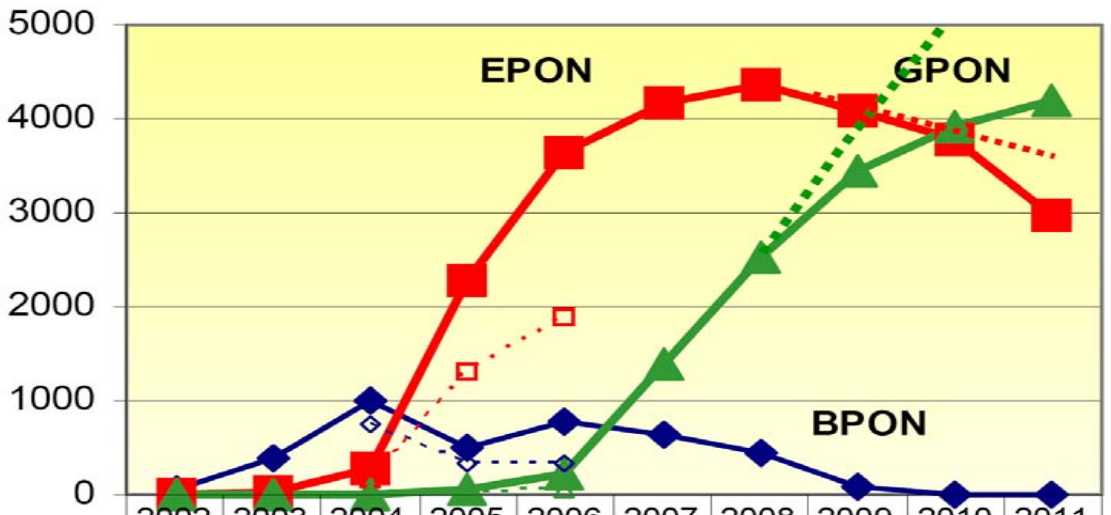
FTTH Market

DATA SOURCES:

Dell'Oro Group 2005

broadbandtrends.com the voice of broadband 2006-07

Global xPON market (1000 ports shipped)

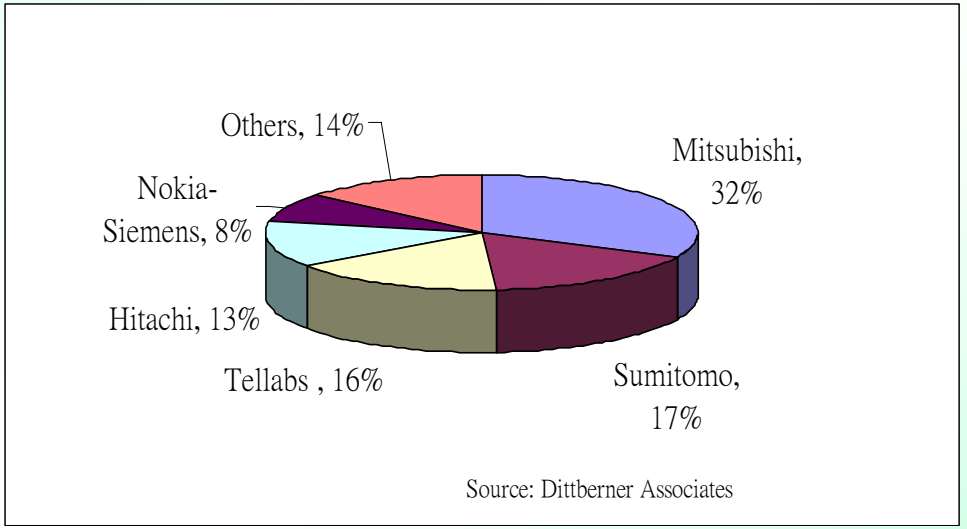


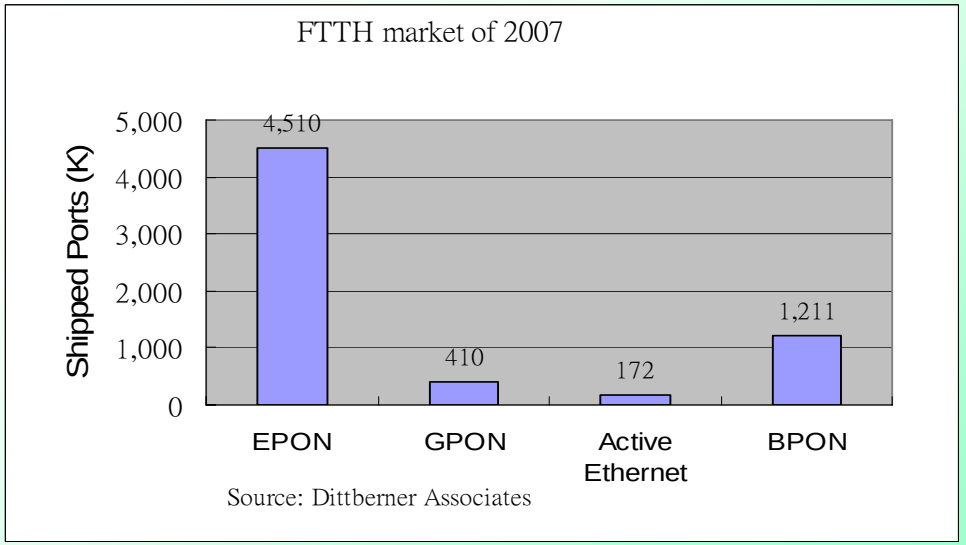
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
BPON - BBTrends	60	389	1005	509	778	635	443	75	0	0
EPON - BBTrends	4	33	289	2276	3644	4175	4356	4075	3769	2971
GPON - BBTrends	0	1	6	60	226	1397	2525	3456	3923	4196
BPON - Dell'Oro			737	347	344					
EPON - Dell'Oro			155	1,304	1,902					
GPON - Dell'Oro			21	36	47					

Early EPON Market driven by some APAC Early Adopters, GPON is the next wave with global attraction

FTTH Market in 2007

- FTTH shipments rose 5% Quarter on Quarter to 1.7 Million and 42% for the whole year to 6.3 Million
- EPON share of the overall market declined to 67% from 82% in 2006 and is projected to drop to 54% in 2008.
- GPON expected to grow from 7% to 38% share in 2008.
- BPON ports will shrink drastically in number and market share as Verizon shifts to GPON.
- Active Ethernet, which is seeing slow, but steady growth in Europe.





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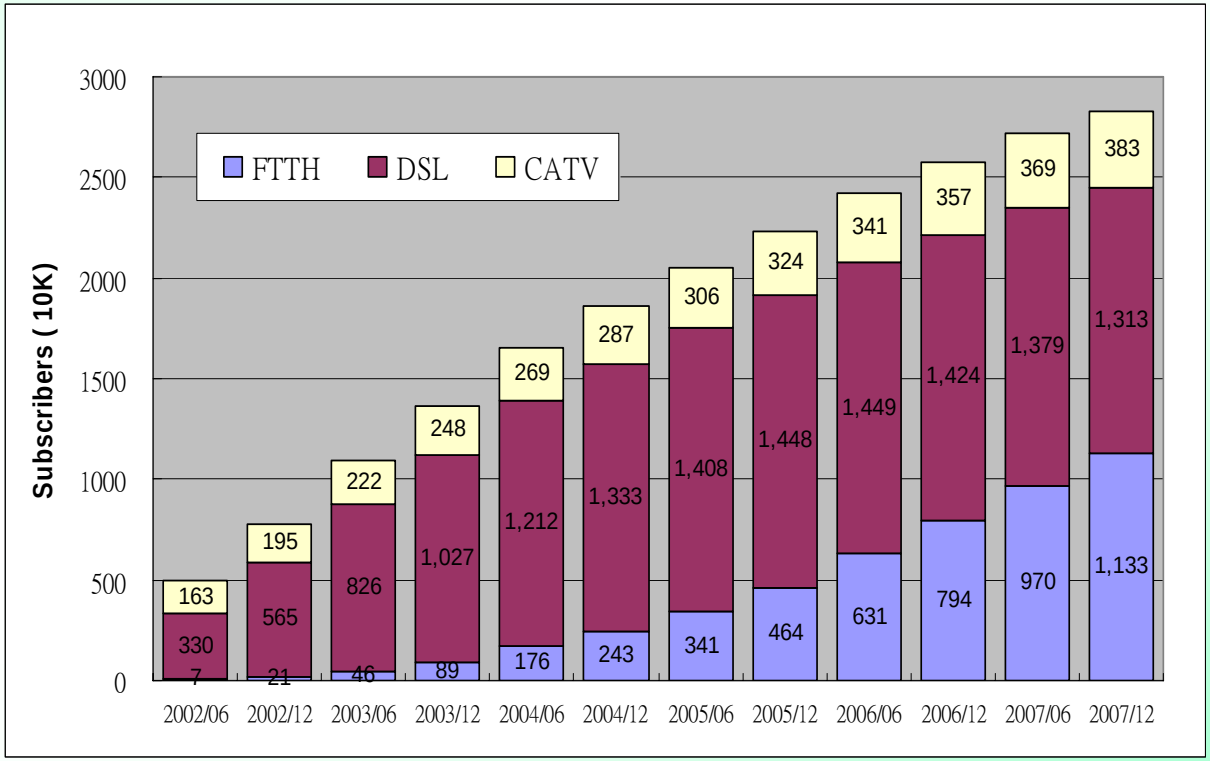
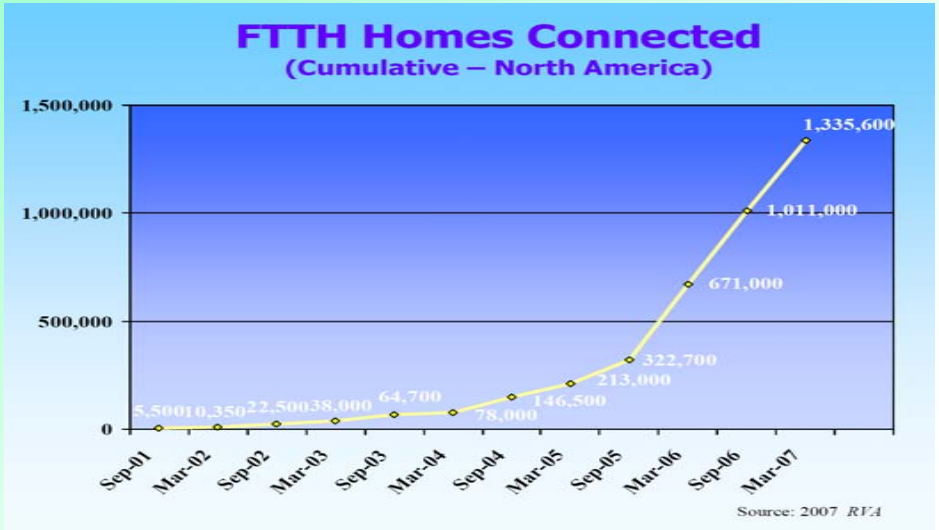
FTTH in Japan

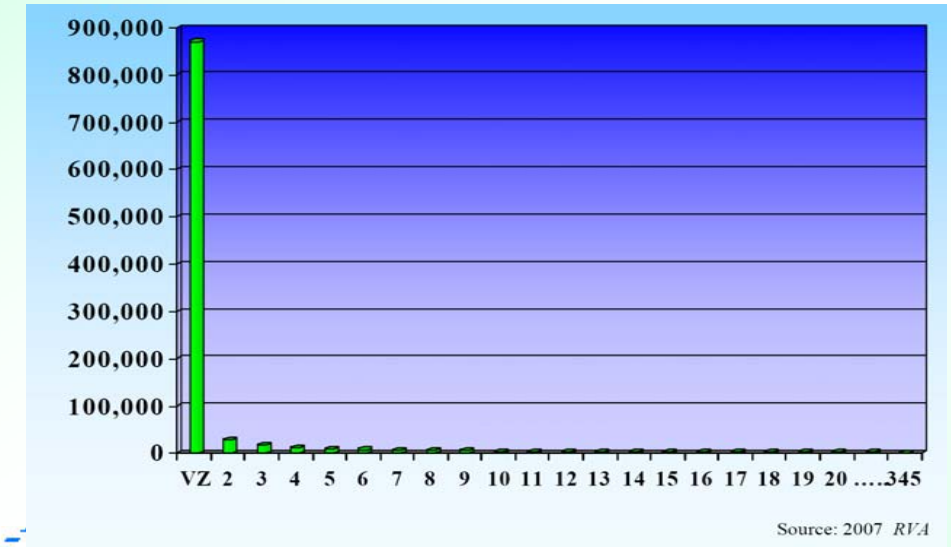
- BPON deployment started from 2002
- EPON deployment started from 2004, now is the main technology of FTTH
- Number of FTTH subscribers
  - End of 2004 : 2.43 million
  - End of 2005 : 4.64 million
  - End of 2006 : 7.94 million
  - Sep. of 2007 :10.52 million
  - End of 2007 :11.33 million
- About 800 ,000 subscribers per quarter
- Number of DSL s was saturated in 2006 March.
- Percentage of FTTH subscribers
  - FTTH/O : 57 %
  - FTTB (GEPON/MC +VDSL): 43 %



Source: MIC

FTTH in United State



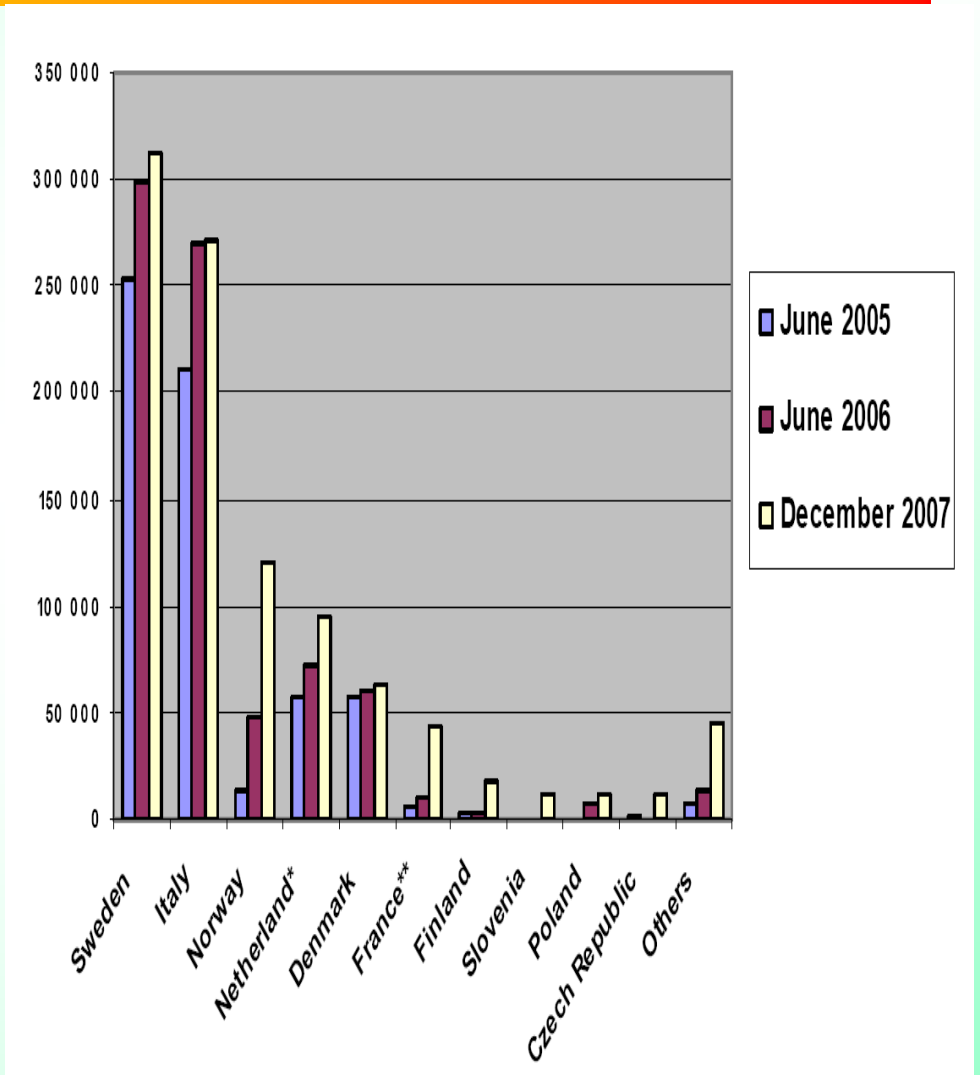


- **The number of households in the US with fibre-to-the-home (FTTH) connections has reached 2.14 M (2007/09)**
  - **Verizon continues to lead the FTTH market with around two-thirds of total installations**
  - **369 other service providers hold around one third of the US market**
- **There were 1.01mn fibre connections in September 2006, indicating a growth rate of 112%, compared to a growth rate of 99% in March of this year.**
- **FTTH connections now pass 9.55mn US households, compared to 6.1mn a year previously.**
- **The number of households that receive video services such as IPTV over their FTTH connection has also increased dramatically over the past six months to reach 1.05mn, meaning an annual growth rate of around 160%.**

Source: TIA and FTTH Council.

FTTH in Europe

- At end 2007, 1 million FTTH/B subscribers and nearly 5 million Homes Passed
- Concentrated in 5 countries (86% of FTTH/B subscribers are located in Sweden, Italy, Norway, the Netherlands and Denmark)
- Ethernet still dominates European FTTH/B deployments
- Significant deployments are using PON(BPON/GPON) technologies
  - EnergiMidt in Denmark
  - the Government of Asturias in Spain
  - France Telecom is deploying GPON in France (146 000 Homes Passed)
  - Slovakia with his subsidiary Orange Slovakia (30 000 Homes Passed)



Source: IDATE

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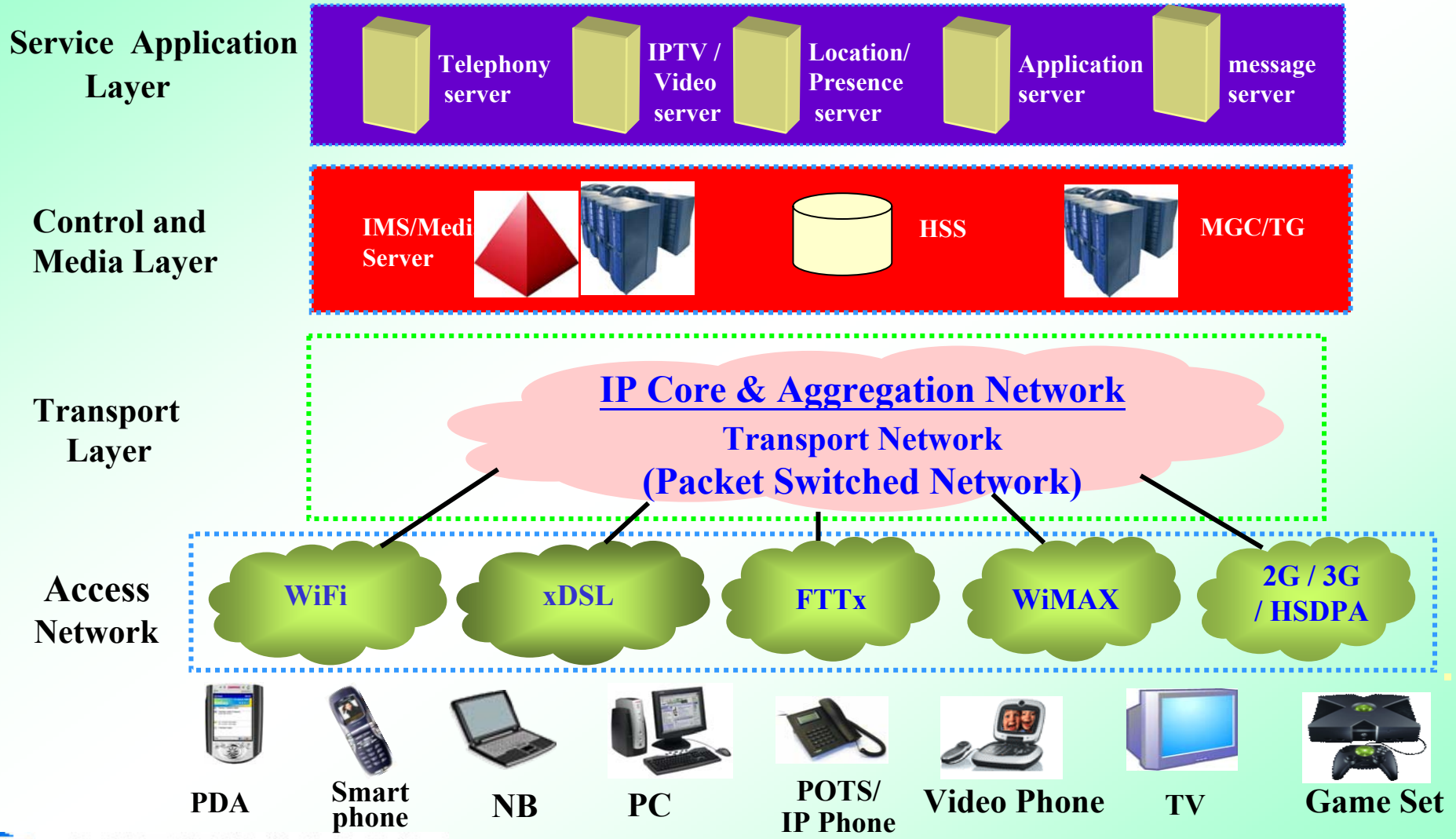
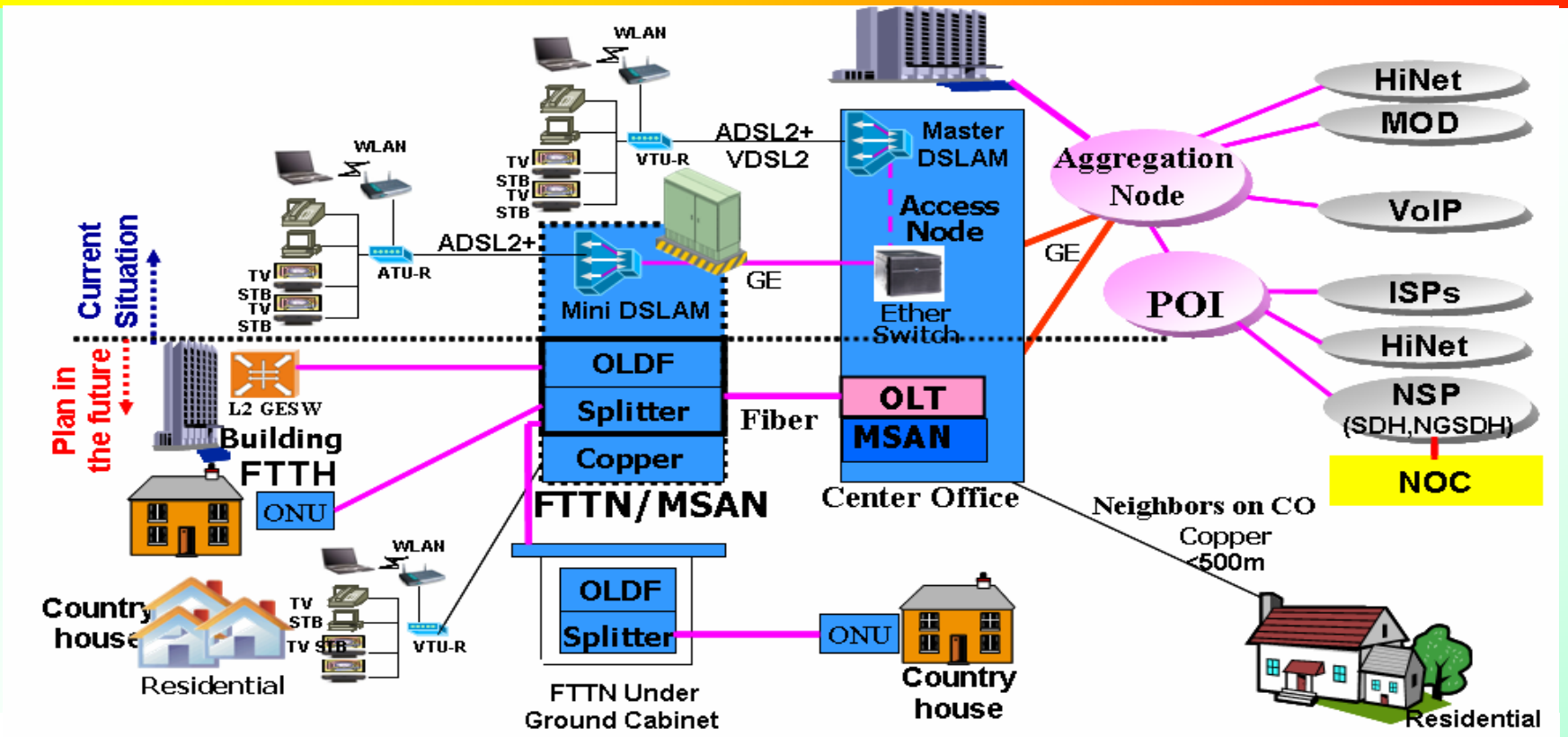
CHT NGN Network Architecture



CHT's Light Era (光世代) FTTx Network

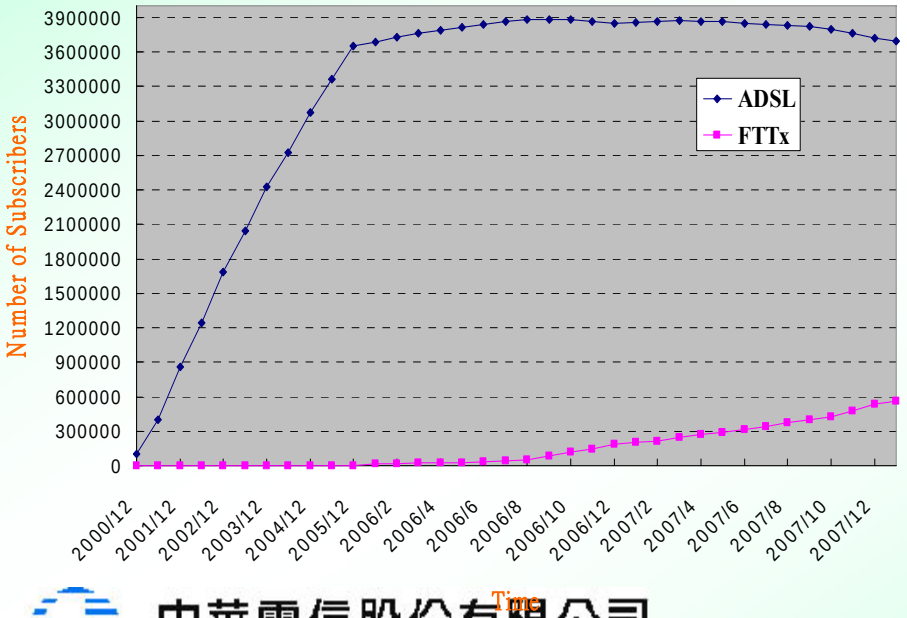


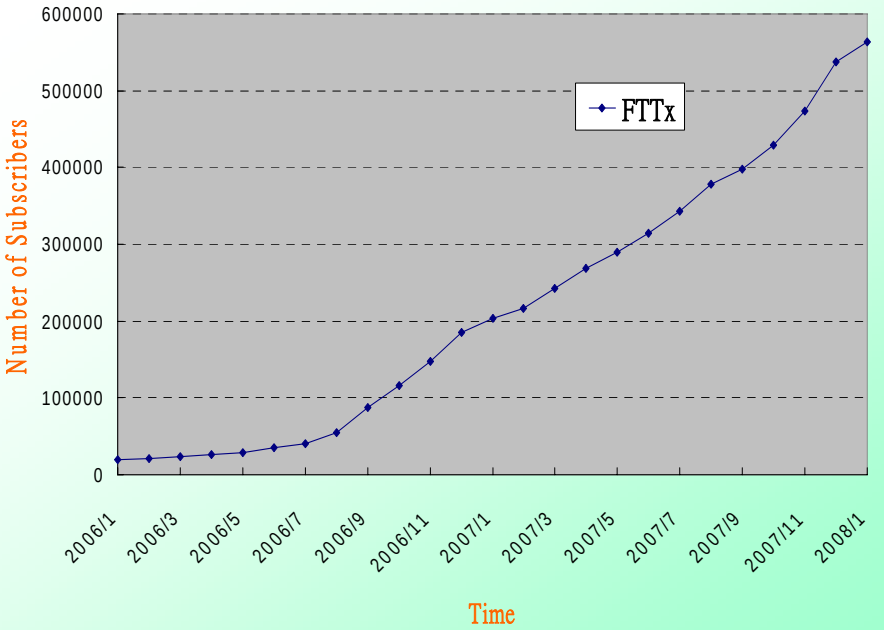
CHT's goal by the end of 2011：

- **Penetration of business customer： 60%@>50Mbps；100% @>10Mbps**
- **Penetration of residential customer： 35.6%@>10Mbps；25%@ >25Mbps**
- **The total FTTx customer is more than 2.4 million subscribers.**

Broadband Access Services in CHT

- **ADSL and FTTx subscribers**
  - **CHT's number of DSL subscribers more than 3.8 million by 2007 Q4**
  - **ADSL growth rate saturated in the end of 2006**
  - **FTTx has a significant growth since 2006 Q3**





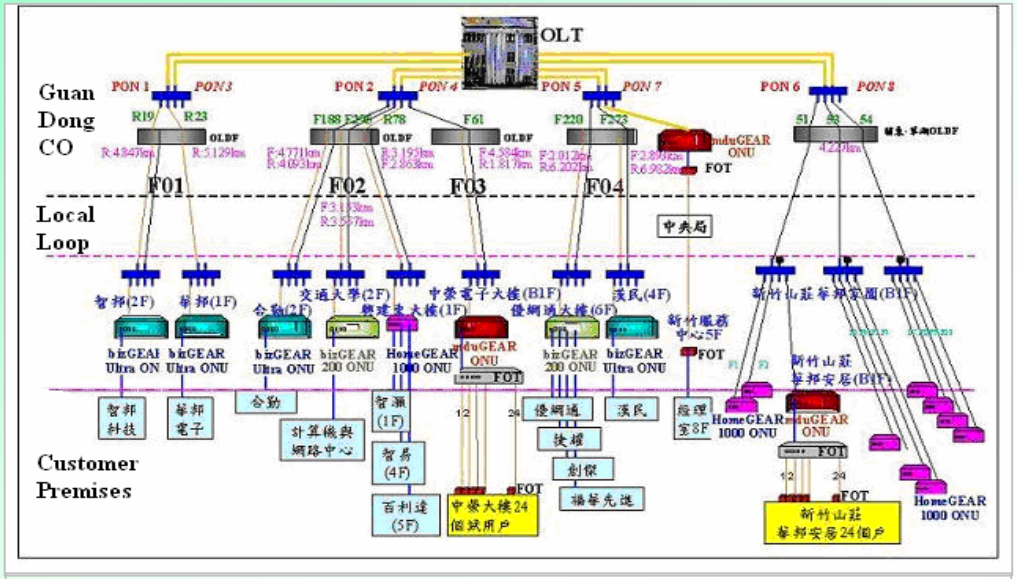
FTTH Activity in CHT (1/2)

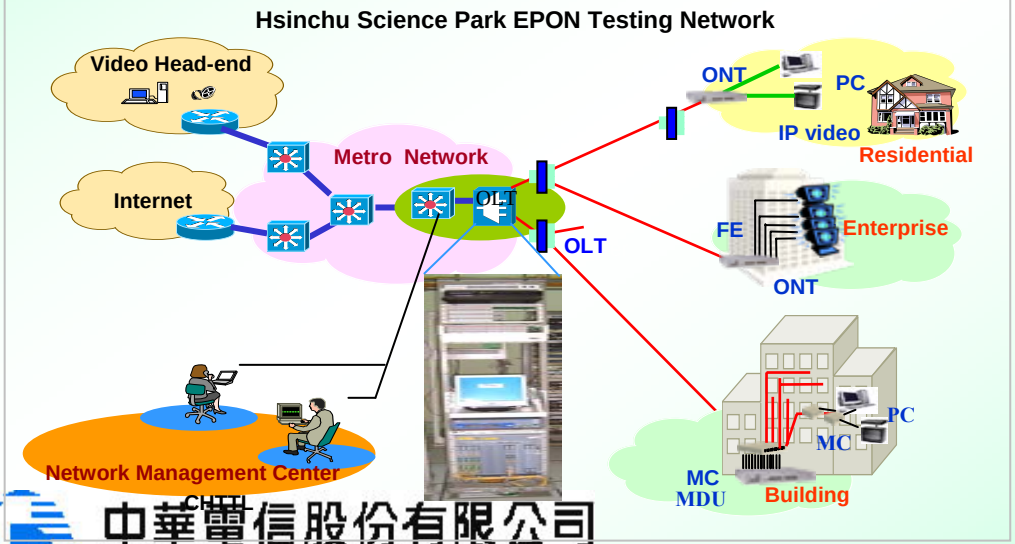
- **FTTH Field Trial at Hsinchu Science-based Industrial Park from 2004/10 to 2005/10**
- **CHT Specification for EPON commercial trial was approved in December 2005**
  - First commercial EPON system cooperated with FarGlory construction company has serviced since 2007.
- **CHT Specification Version 2 for EPON was approved in December 2006**
  - 30000 ports of EPON equipment
  - BMT test was completed in April of 2007
  - EPON Service has deployed since the end of 2007

FTTH Activity in CHT (2/2)

- **EPON test in CHT-TL**
  - EFM Alliance was organized by CHT and ITRI in 2005 to promote FTTH Industry in Taiwan
  - Build FTTH PON test environment including EPON equipment, ODN and service platform
  - Develop EPON protocol analyzer to capture and analyze the EPON signal
  - Provide IOP test for EPON equipment vendor and chipset vendor
- **CHT specification for GPON was completed in December of 2007, System test started at CHT-TL Laboratories in H1 of 2008.**
- **CHT became a FSAN operator member in May of 2007**

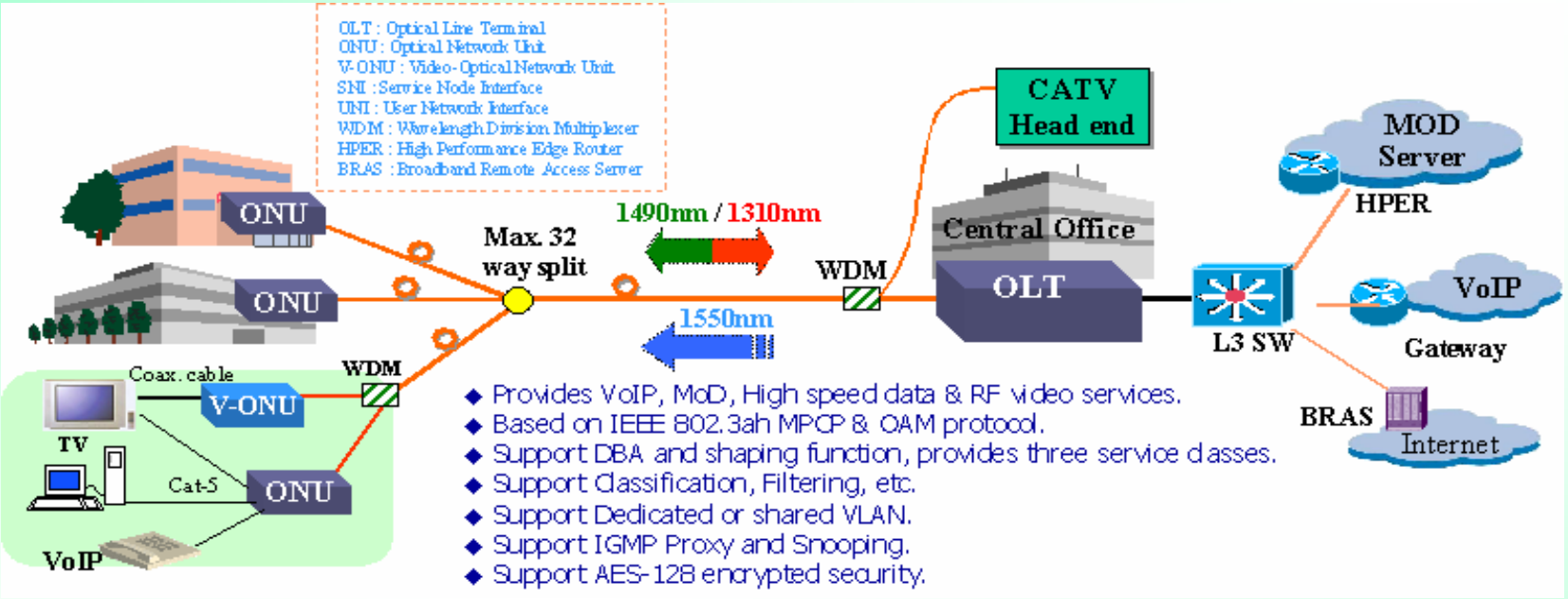
Field Trial @ Hsinchu Science-based Industrial Park





- Trial period: 2004/10 ~ 2005/10
- Trial system
  - EPON system with different types of ONUs, including home-type, business-type, and MDU-type ONUs
  - FOT (used with MDU-type ONU)
  - Splitting Ratio 1:16 (2 stage 2x4 splitters)
- Number of trial users: 72, including residential, enterprise and academic users
- Services: High-Speed Internet Access, Multimedia on Demand (MoD)

FTTH Experimental Network in CHT-TL



Features

- Using EPON systems for broadband access
- different types of tenants/buildings (Condominium, apartment, stand alone, residential)。

Application

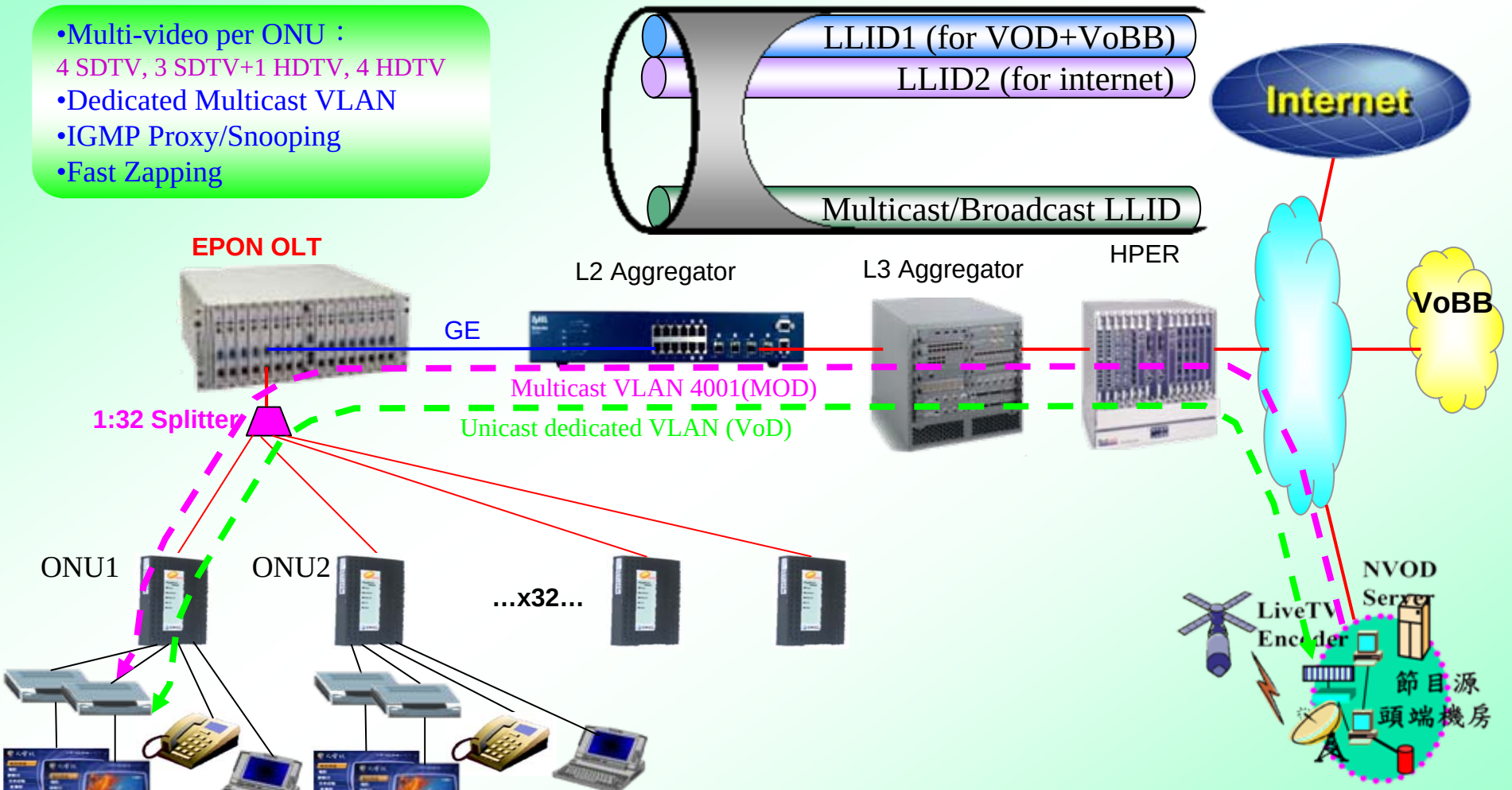
- Establish the technical evaluation and test methodology of optical access equipment and loop architecture
- A platform for on-line test of FTTH system to provide test environment of domestic FTTH equipment vendor
- To build the FTTH access platform to connect digital home

Features of CHT's EPON spec.

- **System Features**
  - 1.25Gbps/1.25Gbps line rate for downstream/upstream
  - Supports triple play service : High speed internet access + MoD + VoIP
  - Reach up to 10 km and 20km using PX20E-D/PX10E-U and PX20E-D/PX20E-U
  - 32 ONUs for each PON interface
- **OLT**
  - 16 PON interfaces
- **ONU**
  - 4-port 10/100BASE-TX Ethernet
  - 1-port 10/100/1000BASE-T Ethernet

Service application in EPON System

- Multi-video per ONU：
  4 SDTV, 3 SDTV+1 HDTV, 4 HDTV
- Dedicated Multicast VLAN
- IGMP Proxy/Snooping
- Fast Zapping



Another choice? From GPON Evaluation

- GPON has good performance
  - More splitting ratio : up to 64, 128
  - Longer distance : 60 km with 20 km differential
  - Higher Bandwidth efficiency
  - Support Better QoS
  - Flexible traffic mapping (Port ID/T-Cont)
- GPON supports TDM service
- GPON supports Protection function
- GPON has better IOP capability
  - Has common specification
    - Need more IOP test
- CHT will do GPON system test and field Trial in 2008
- CHT will push GPON industry ahead especially in IOP test.

Issues Concerning Both of EPON & GPON

Technical issues	✓QoS model ✓Encryption ✓TDM service ✓Protection ✓Interoperability
Cost	✓Bandwidth ✓Splitter ratio ✓Optical transceiver
Timing	✓GPON is the trend from the market information ✓The debate of GPON versus EPON is all about timing.

EPON vs.GPON

EPON viewpoint	GPON viewpoint
✓Ethernet has won every time it has competed with “higher speed” and “higher efficiency” technologies ▸ **Ethernet vs. Token Ring** ▸ **Ethernet vs. FDDI** ▸ **Ethernet vs. ATM** ▸ **Ethernet vs. SONET** ▸ **Ethernet vs. ATM in the DSLAM** ▸ **Ethernet vs. Multi-service in the Metro** ✓Ethernet is cheap, simple, easy to install & manage ✓Ethernet PON will win a large fraction of the market	✓Bit rate of 2.5Gb/s for GPON ✓GEM – GPON Encapsulation Method (ATM, TDM, ethernet) ▸ **GPON supports legacy TDM traffic** ✓GPON has a higher splitter ratio (128 in std) ✓GPON derived from FSAN telecom grade stds ▸ **End to end solution** ▸ **OAM & Management** ▸ **DBA** ▸ **AES Encyption** ✓GPON has greater logical reach (20km physical, 60km logical) ▸ **Class C ODN support** ✓GPON is more efficient in transporting packets ✓GPON costs will reduce quickly with volume

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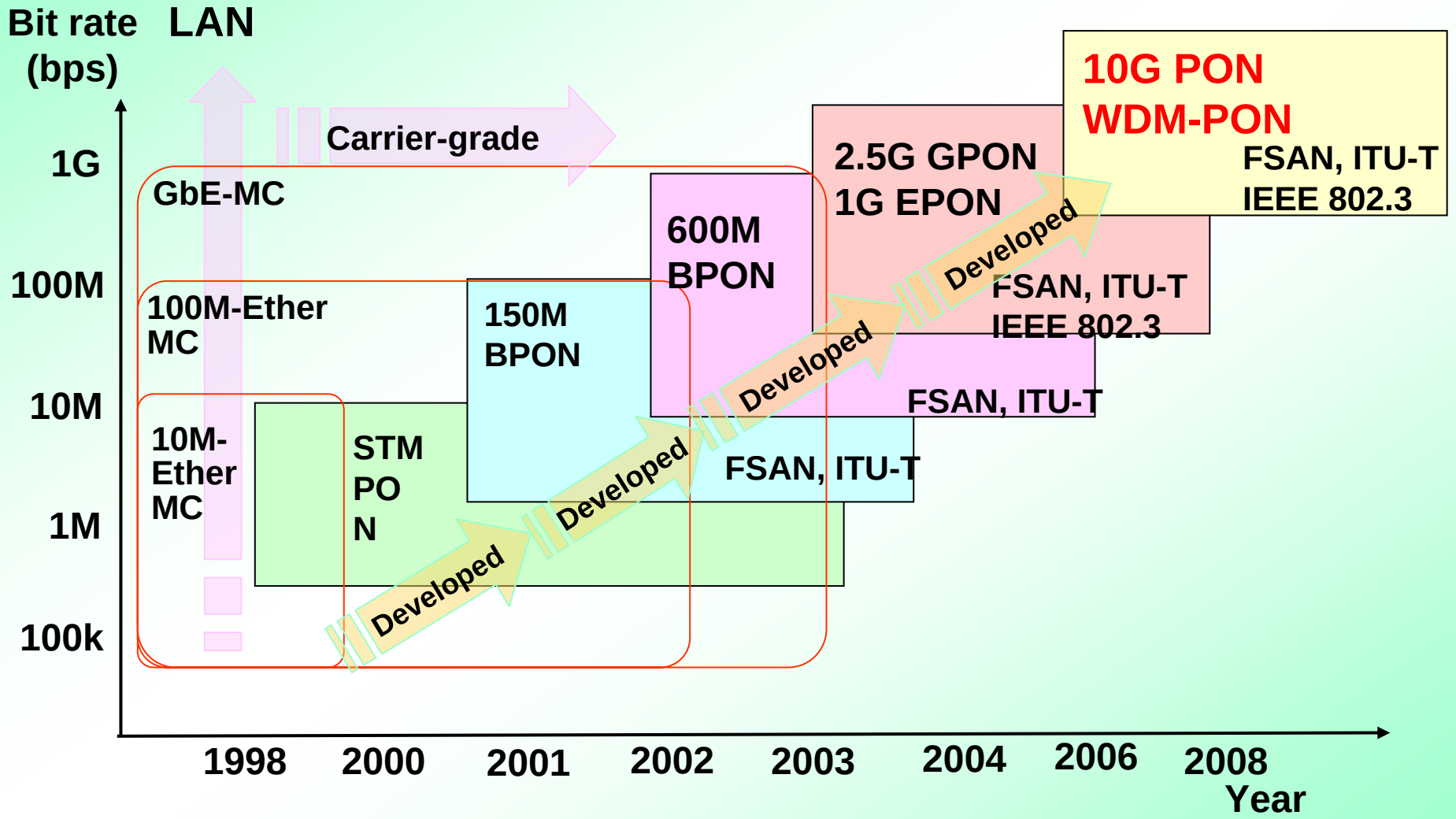
Development of PON systems



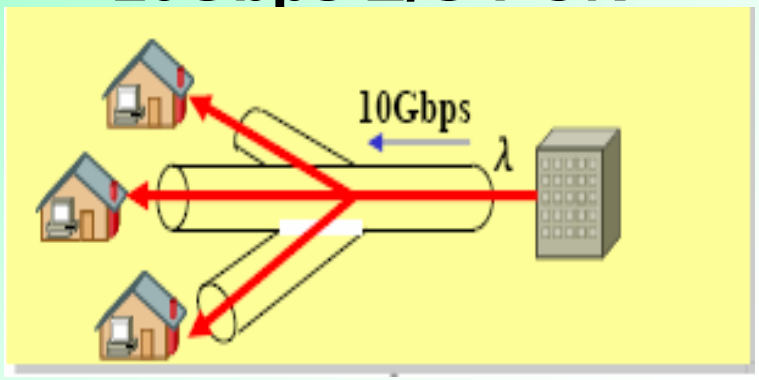
Topics of Next-Generation PON

- **Scope of NG-PON**
  - Maximum utilization of ODN installed for legacy Giga PONs.
  - Capability to provide higher bandwidth/capacity than current Giga PONs.
  - Optimized technology combinations in terms of cost and performance
  - Flexible upgradeability to accommodate to various upgrade requirements at various times.
- **NG-PON architecture**
  - WDM PON
  - 10G TDM PON
    - 10G down/10G up
    - 10G down/1G up
  - Hybrid WDM/TDM PON
  - Extension Box to extend distance up to 60 km
    - Optical amplification
    - Regeneration (O/E/O)

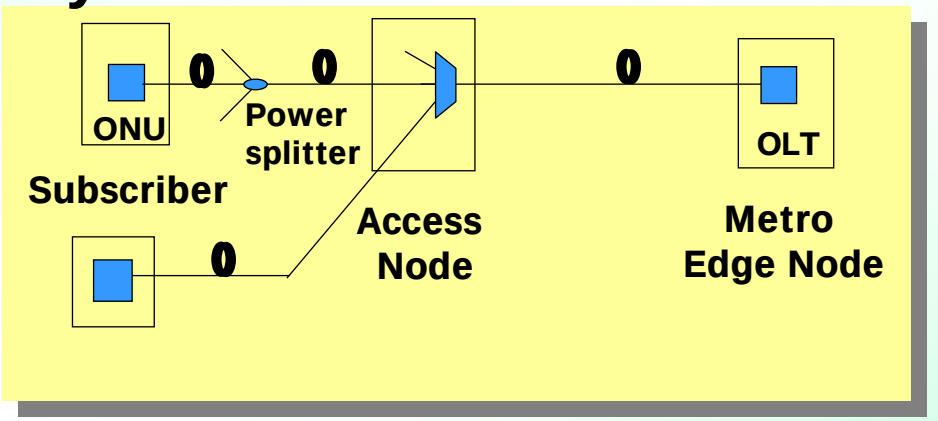
Ref: FSAN Forum

NG-PON Evolutional Path

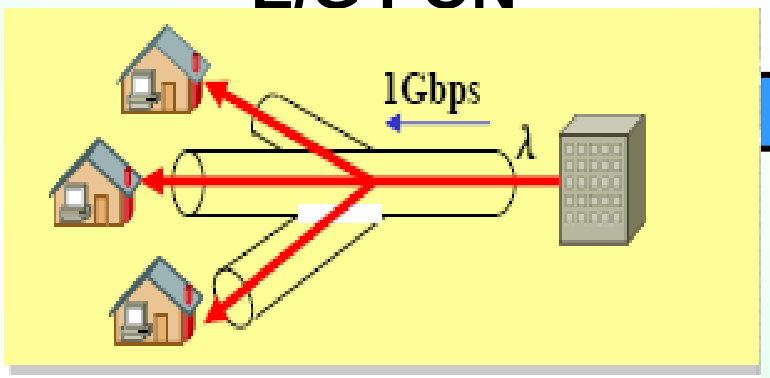
10Gbps E/G PON



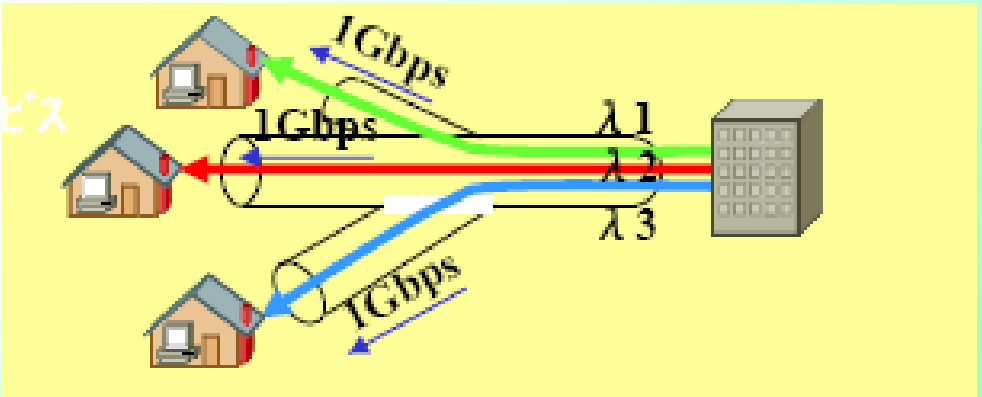
Hybrid WDM-PON/TDM-PON



E/G PON



WDM-PON

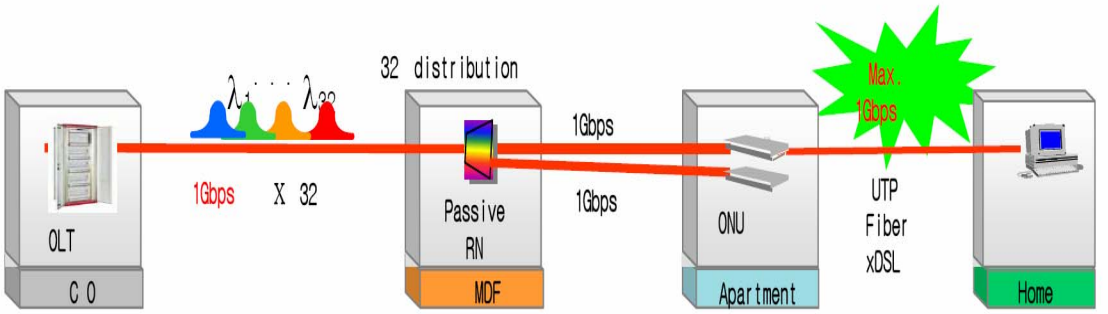


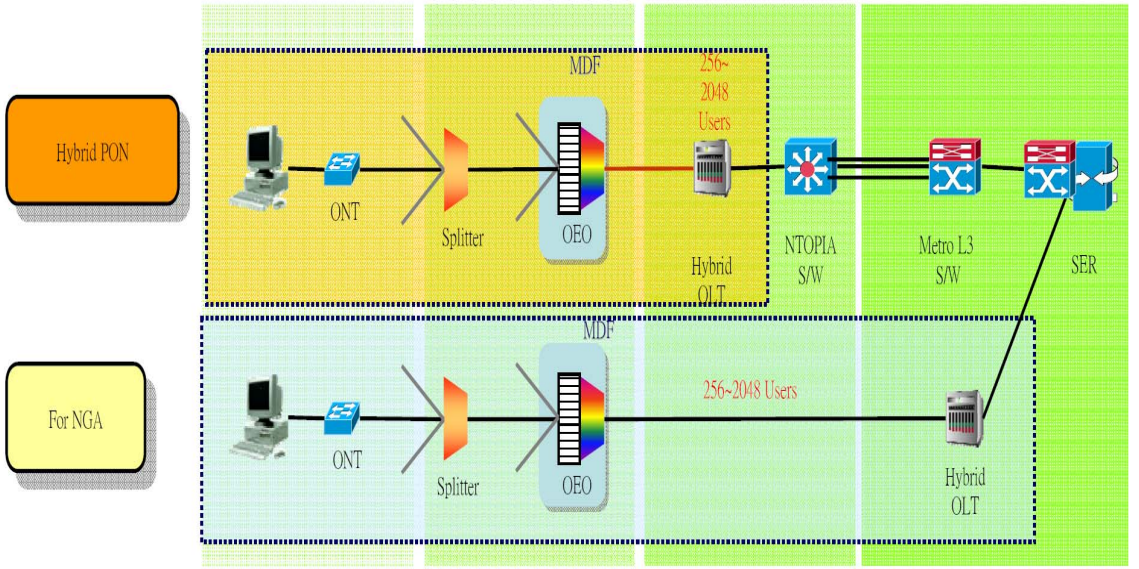
10G EPON Status

- IEEE has initiated 10G EPON work in March 2006
- Official Task Force, 802.3av, “PHY for 10Gb/s EPON” had first meeting in Sep 2006, D1.1 draft was completed in February 2008
  - Two “nominal” PHYs: 10/1 and 10/10
    - Support symmetric line rate: 10G down/10G up
    - Support asymmetric line rate: 10G down/1G up
  - Three power budgets
    - PR10 = 20dB, PR20 = 24dB, PR30 = 29dB
  - Wavelength allocation
    - PR30 downstream : 1574-1580 nm
    - PR10 & PR20 downstream : 1580-1600 nm
    - Upstream : 1260 – 1280 nm
  - Serial 10.3125 Gb/s transmission
    - 64b66b line code is used as basic protocol
    - Strong “E-FEC”, with RS(255,223)
- Standard will be completed in September in 2009.

WDM-PON Solution

- **FTTB/C Solution**
  - 1 Gbps per 1 wavelength channel
  - 16 wavelength channels
  - Colorless light source technology
- **Hybrid TDM/WDM PON**
  - Reuse of currently deployed E/G-PON ONTs without any modification
  - Supports 256 ~ 2048 users on a single fiber core



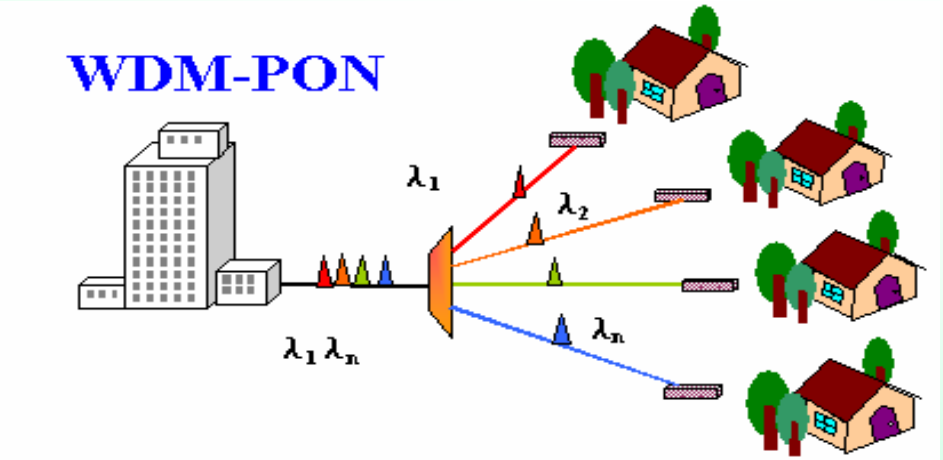


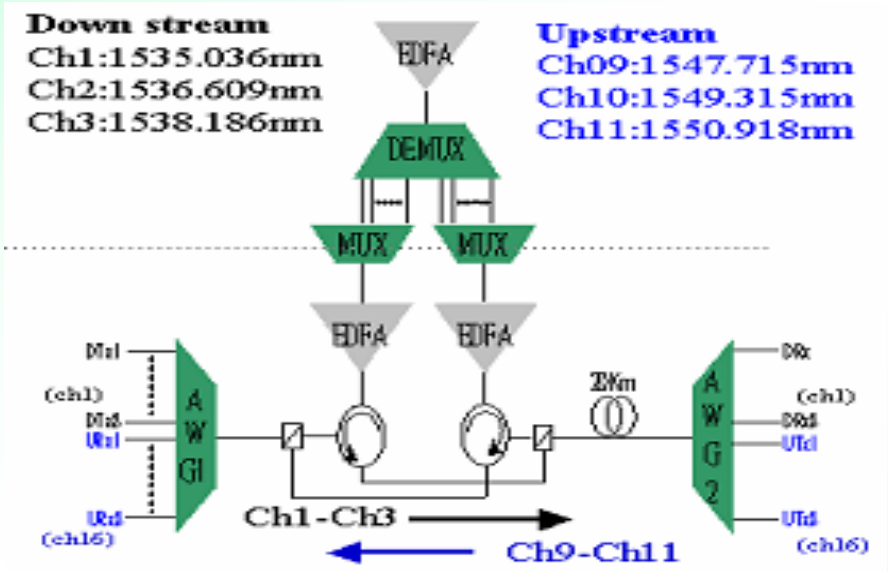
Source: FSAN, KT

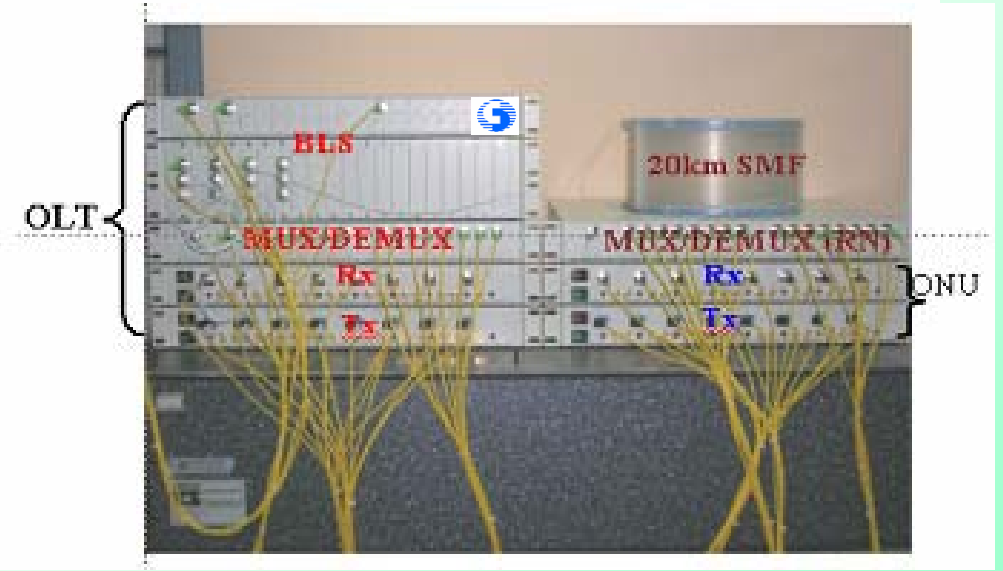
WDM PON System Developed by CHT TL

The WDM-PON assigns different wavelength channel to each subscriber.

- large transmission capacity (100Mbps-1.25Gbps)
- high security (point-to-point)
- upgradeability
- Cost-down
  - OLT: shared by more channels
  - ONU: colorless light source







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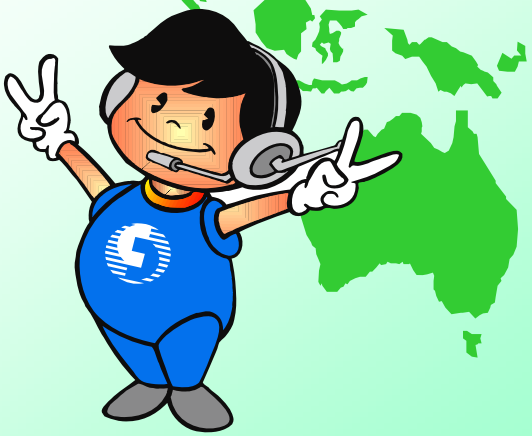
Summary of CHT's FTTH Development

- CHT's Light Era Network has introduced. By the end of 2011, the total FTTx customer is more than 2.4 million subscribers.
- FTTH network using EPON technology has been deployed in CHT before 2008. EPON or GPON adoption after 2009 not decided.
- First version of GPON specification was completed in December of 2007. System test started at CHT-TL Laboratories in H1 of 2008.
- 10G PON and WDM PON technology will be the next generation PON technology.

Thanks for your attention!



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