Tellion

E-PON Solution and Business Prospects

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- Trend of PON Technologies
- E-PON Solutions
- E-PON Cost Model
- E-PON Business Prospects
- Wrap-Up

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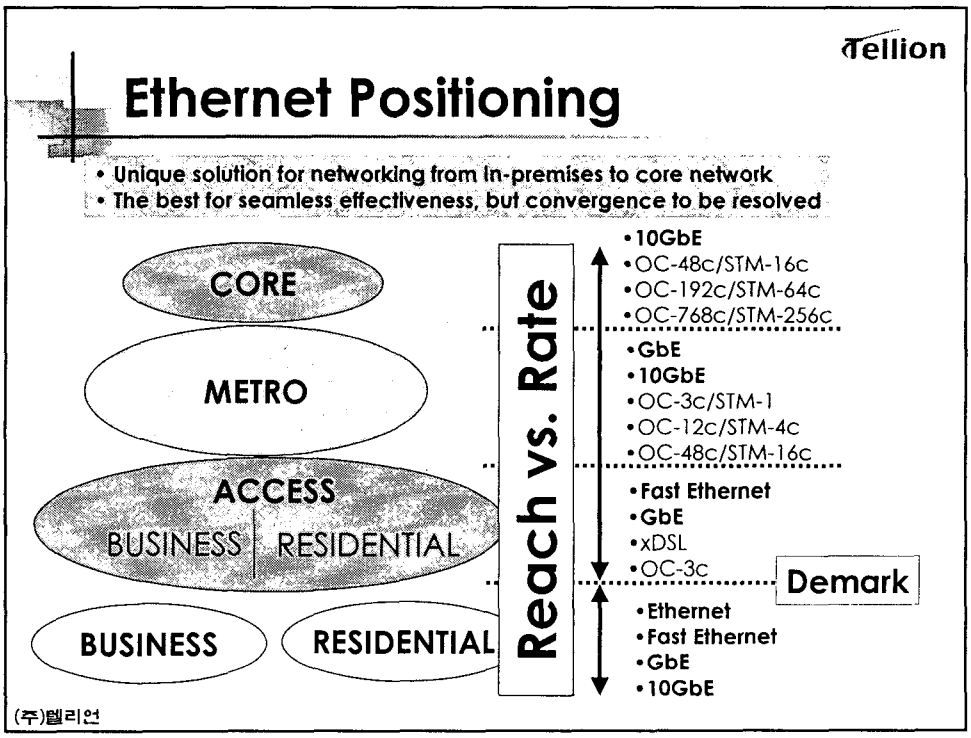
Tellion
Ethernet Positioning
• Unique solution for networking from in-premises to core network
• The best for seamless effectiveness, but convergence to be resolved
CORE
METRO
ACCESS
BUSINESS
RESIDENTIAL
BUSINESS
RESIDENTIAL
Reach vs. Rate
•10GbE
•OC-48c/STM-16c
•OC-192c/STM-64c
•OC-768c/STM-256c
•GbE
•10GbE
•OC-3c/STM-1
•OC-12c/STM-4c
•OC-48c/STM-16c
•Fast Ethernet
•GbE
•xDSL
•OC-3c
Demark
•Ethernet
•Fast Ethernet
•GbE
•10GbE
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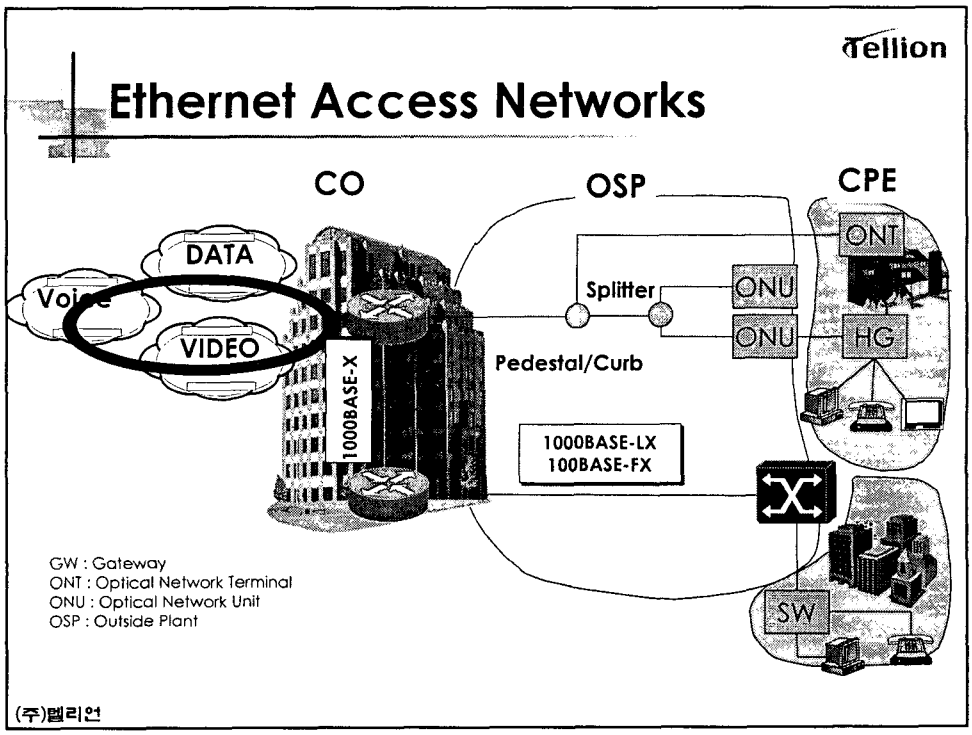
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Ethernet Access Networks
CO
OSP
CPE
DATA
Voice
VIDEO
1000BASE-X
Splitter
ONU
ONU
ONT
HG
Pedestal/Curb
1000BASE-LX
100BASE-FX
SW
GW : Gateway
ONT : Optical Network Terminal
ONU : Optical Network Unit
OSP : Outside Plant
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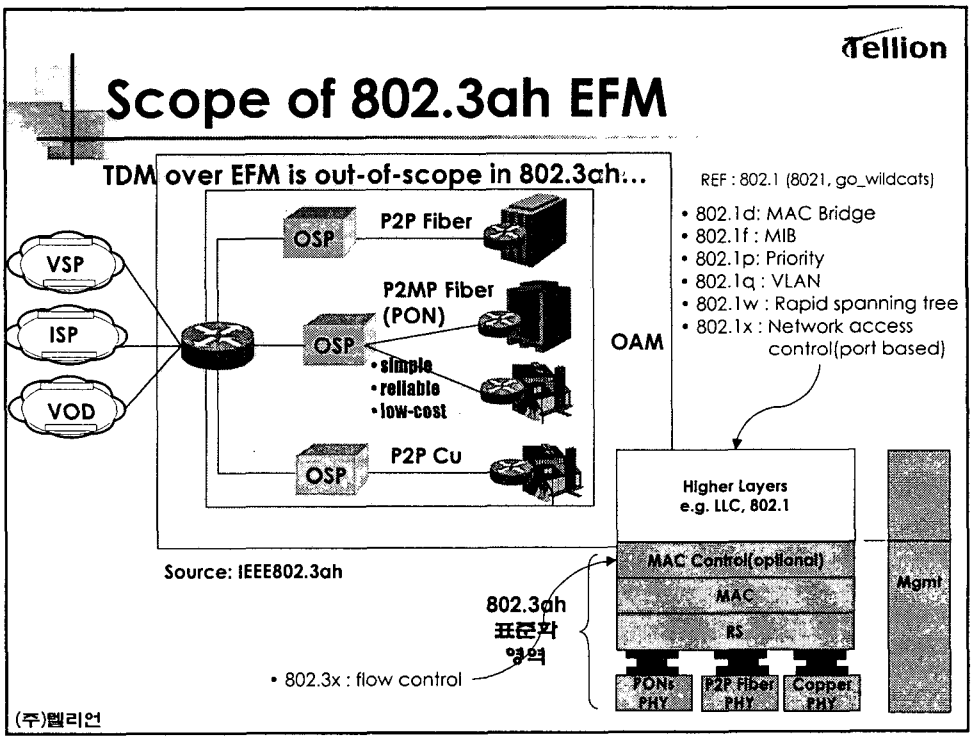
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Scope of 802.3ah EFM
TDM over EFM is out-of-scope in 802.3ah...
VSP
ISP
VOD
OSP
P2P Fiber
P2MP Fiber
(PON)
OSP
• simple
• reliable
• low-cost
OSP
P2P Cu
Source: IEEE802.3ah
OAM
REF : 802.1 (8021, go_wildcats)
• 802.1d: MAC Bridge
• 802.1f : MIB
• 802.1p: Priority
• 802.1q : VLAN
• 802.1w : Rapid spanning tree
• 802.1x : Network access control(port based)
Higher Layers
e.g. LLC, 802.1
MAC Control(optional)
MAC
RS
Mgmt
802.3ah
표준화
영역
• 802.3x : flow control
PON PHY
P2P Fiber PHY
Copper PHY
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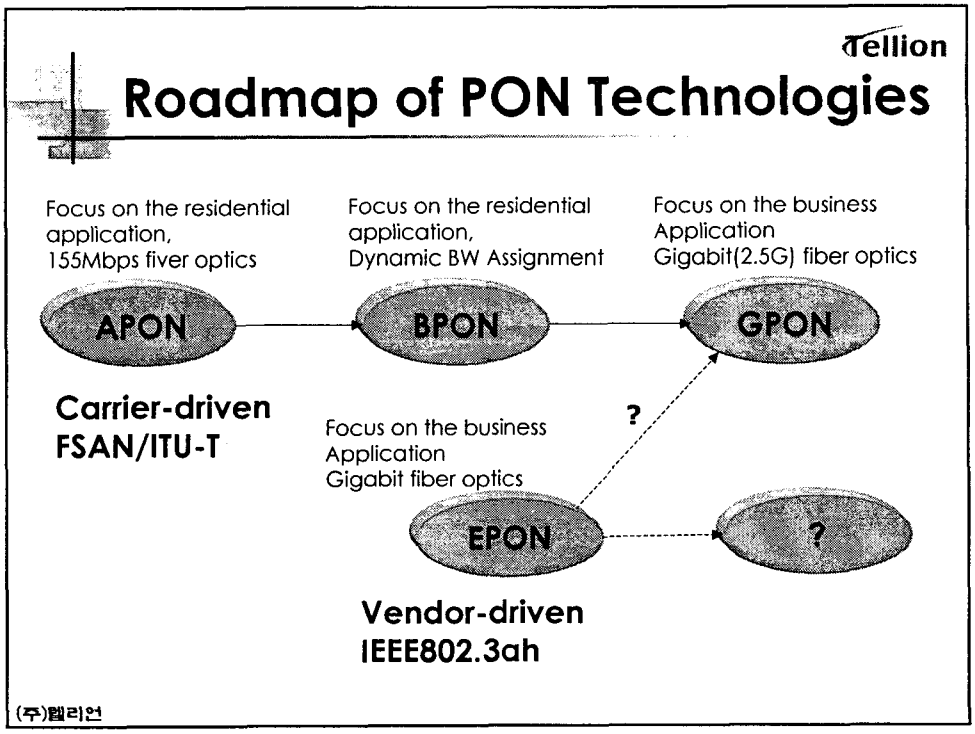
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Roadmap of PON Technologies
Focus on the residential application, 155Mbps fiver optics
Focus on the residential application, Dynamic BW Assignment
Focus on the business Application Gigabit(2.5G) fiber optics
APON
BPON
GPON
Carrier-driven
FSAN/ITU-T
Focus on the business Application Gigabit fiber optics
?
EPON
?
Vendor-driven
IEEE802.3ah
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Comparision of PON Alternatives

	Pros.	Cons.
ATM-PON (BBT)	• Maturity of technology • Multi-service QoS (ATM QoS)	• Relatively higher cost • Complexity of installation and operation
E-PON (AllOptic)	• Lower-cost of BW • Optimized for data	• Many E-QoS issues to be resolved • OAM&P
G-PON (FlexLight)	• BW efficiency over 90% (low overhead) • Transparency toward ATM and TDM edge	• Immaturity of technology

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Hot Issues : EPON

- **Evolutionary design**
  - MAC/MPCP
  - Upper layer compatible
- **Carrier-class design**
  - OAM
  - Protection
  - Security
  - QoS, Traffic control
  - Dynamic bandwidth assignment, SLA
  - WDM overlay
- **Harmonizing of networking requirements**
  - ILEC, CLEC, MSO
  - FTTB, FTTH, FTTC

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Vendors & Products

- **Equipment**
  - AllOptic
  - Salira
  - Wave7
  - Quantum Bridge
  - Optical Solutions
- **Component and Module**
  - BroadLight
  - NEC
  - Passave
  - Gould
  - Teemphotonics

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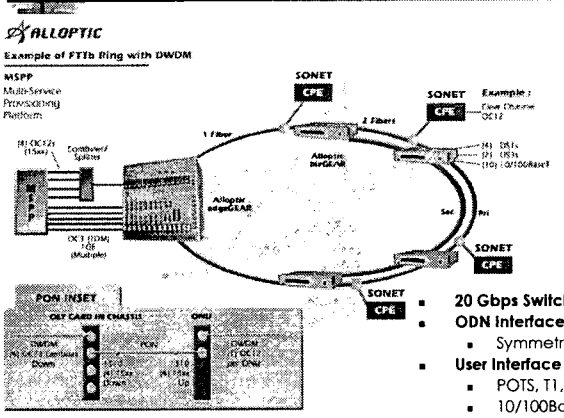
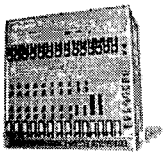
AllOptic Solution

Source: AllOptic



CurbG.E.A.R

HomeG.E.A.R



edgeG.E.A.R. 2000

- **20 Gbps Switch With Layer 2/3 Switching/Routing**
- **ODN Interface**
  - Symmetric 1.25 Gigabit Ethernet Bandwidth
- **User Interface**
  - POTS, T1, DS3
  - 10/100BaseT
  - dedicated wavelength services
- **Topology**
  - tree, diverse ring, star, bus, point-to-point topologies
- **Resiliency/QoS...**
  - Guaranteed QoS using TOS Field and DIFFSERV
  - Protection
  - VLAN closed user groups, VPN, IPSec, tunneling

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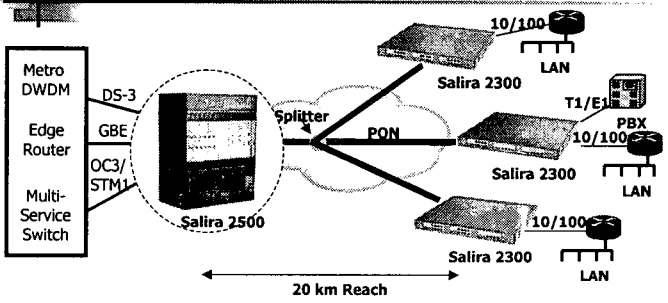
Salira Solution

Source: Salira



Salira 2500 Key Features

- Highest port density Optical Line Terminal (OLT) – 5376 Ports
- Up to 14 Optical Line Cards (14 GE & PON ports)
- Up to 8 Redundant, Trunk Line Cards (24 DS-3 ports, 8 OC3/STM1 ports)
- 2 System Controller Cards
- 16 2300s per PON Link

Salira 2300 Key Features

- First multi-customer Optical Network Unit (ONU)
- PON uplink, GbE port
- Fixed bay for 8 port 10/100Mbps module and two additional bays for modular plug-ins
- 8 port 10/100 Mbps modular plug-in
- 4 port T1/E1 modular plug-in

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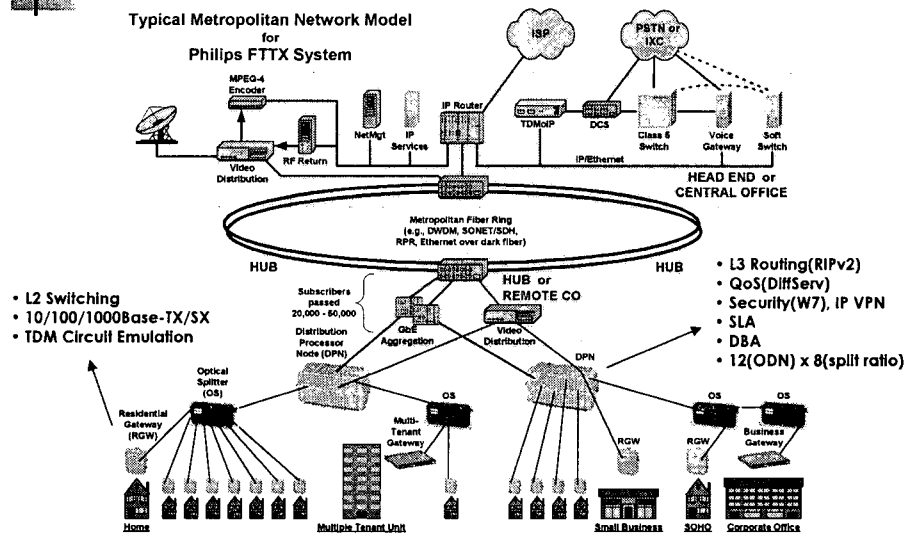
Wave7 Solution

Source: Philips & Wave7



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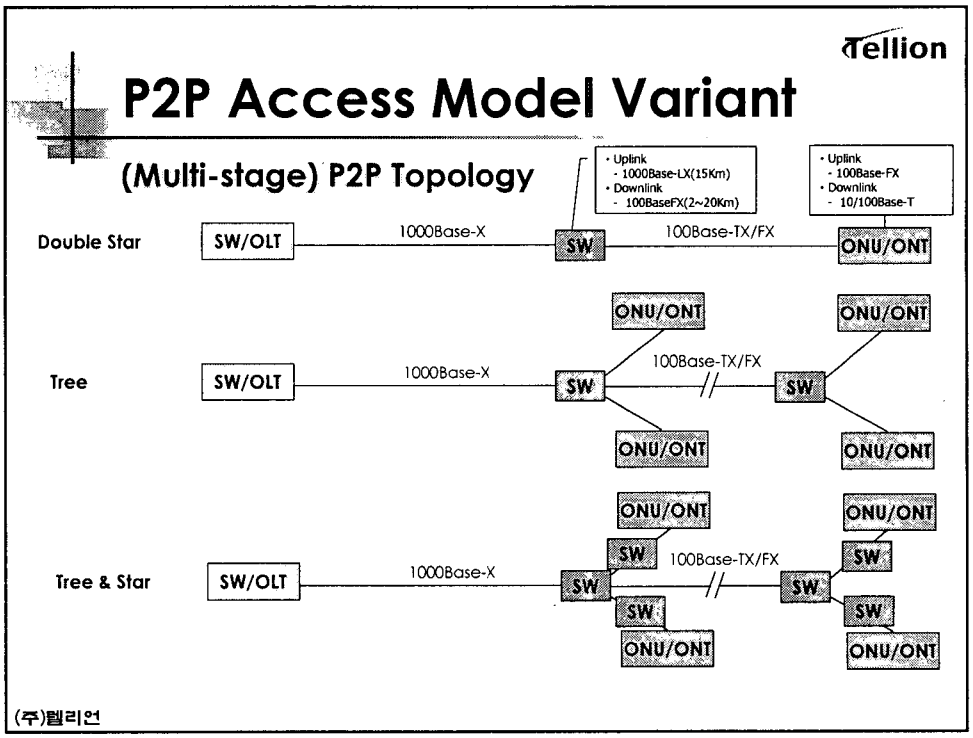
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P2P Access Model Variant
(Multi-stage) P2P Topology
• Uplink
- 1000Base-LX(15Km)
• Downlink
- 100BaseFX(2~20Km)
• Uplink
- 100Base-FX
• Downlink
- 10/100Base-T
Double Star
SW/OLT
1000Base-X
SW
100Base-TX/FX
ONU/ONT
Tree
SW/OLT
1000Base-X
SW
100Base-TX/FX
SW
ONU/ONT
Tree & Star
SW/OLT
1000Base-X
SW
100Base-TX/FX
SW
SW
SW
SW
ONU/ONT
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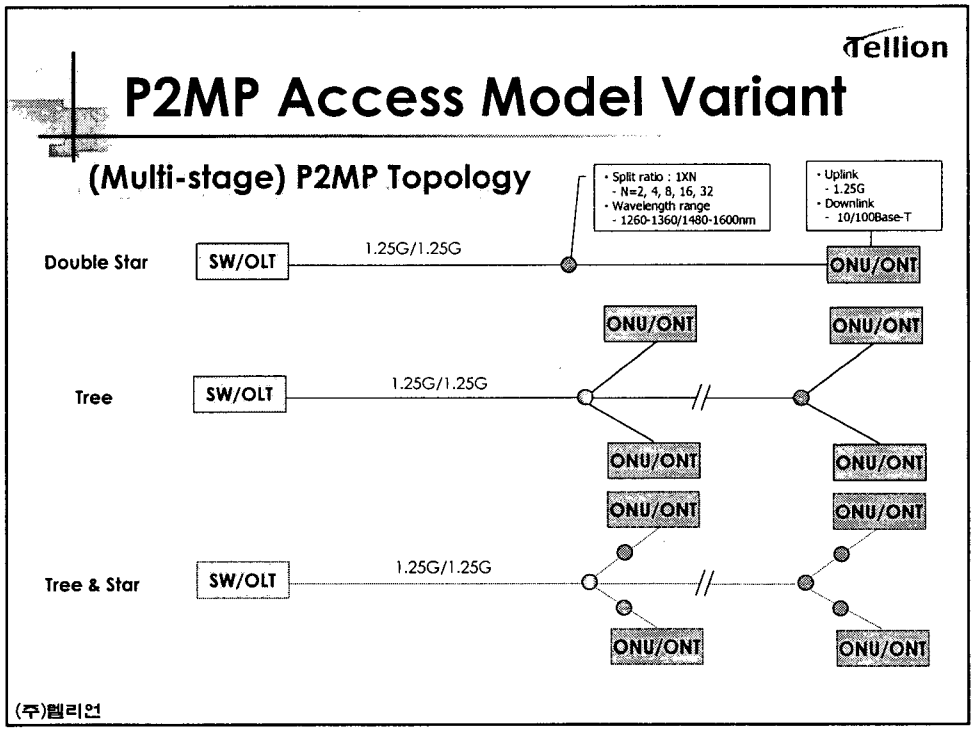
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P2MP Access Model Variant
(Multi-stage) P2MP Topology
• Split ratio : 1XN
- N=2, 4, 8, 16, 32
• Wavelength range
- 1260-1360/1480-1600nm
• Uplink
- 1.25G
• Downlink
- 10/100Base-T
Double Star
SW/OLT
1.25G/1.25G
ONU/ONT
Tree
SW/OLT
1.25G/1.25G
ONU/ONT
Tree & Star
SW/OLT
1.25G/1.25G
ONU/ONT
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A Cost Model

- **Optimizing life cycle cost**
  - **Objective function (refer to ITU-T)**
    - CAPEX
      - Active equipments, Passive infrastructure, Supporting facilities, Building
    - OPEX
      - Staff expenses, Admin expenses, Technical expenses, Sales & marketing expenses
  - **Dependent variables**
    - EPON-dependent system cost
      - OTRX, PHY(1.25G transceiver), MAC(controller)
    - Cable length
    - Splitter position
    - Split stage
    - Split ratio

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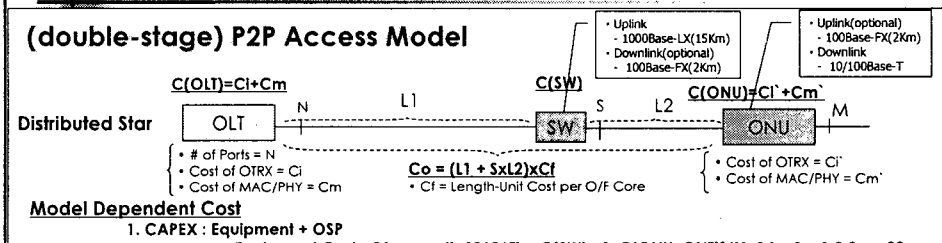
A Cost Model for Star Topology

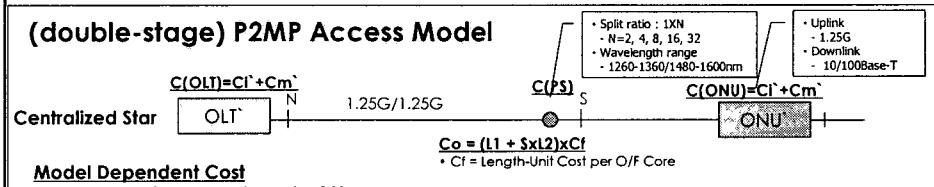
(double-stage) P2P Access Model



Model Dependent Cost

1. CAPEX : Equipment + OSP
   - Equipment Cost : C(per port)=[C(OLT) + C(SW)+ SxC(ONU, ONT)]/MxS for S = 1,2,3,... ,32
   - OSP Cost : C(per port) = [Co + Cabinet Cost + Power Feed Cost]/MxS
3. OPEX : Labor/Installation + OAM&P + Customer Support

(double-stage) P2MP Access Model



Model Dependent Cost

1. CAPEX : Equipment + OSP
   - Equipment Cost : C(per port)=[C(OLT) + C(PS)+ SxC(ONU)]/MxS for S = 1,2,3,... ,32
   - OSP Cost : C(per port) = [Co + Cabinet Cost] / MxS
3. OPEX : Labor/Installation + OAM&P + Customer Support

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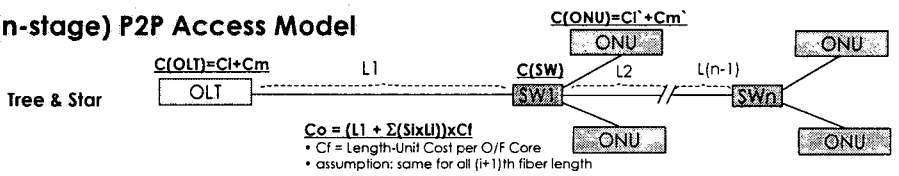
A Cost Model for Tree Topology

(n-stage) P2P Access Model

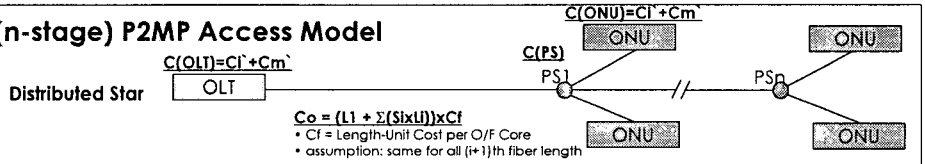


Co = (L1 + Σ(SixLi))xCf
- Cf = Length-Unit Cost per O/F Core
- assumption: same for all (i+1)th fiber length

Model Dependent Cost

1. CAPEX : Equipment + OSP
   - Equipment Cost : C(per port)=[C(OLT) + ΣC(SWI)+ (32-(n+1))xC(ONU, ONT)]/MxS
   - OSP Cost : C(per port) = [Co + Cabinet Cost] / MxS
3. OPEX : Labor/Installation + OAM&P + Customer Support + Power Feed

(n-stage) P2MP Access Model



Co = (L1 + Σ(SixLi))xCf
- Cf = Length-Unit Cost per O/F Core
- assumption: same for all (i+1)th fiber length

Model Dependent Cost

1. CAPEX : Equipment + OSP
   - Equipment Cost : C(per port)=[C(OLT) + ΣC(PSI)+ (32-(n+1))xC(ONU)]/MxS
   - OSP Cost : C(per port) = [Co + Cabinet Cost`] / MxS
3. OPEX : Labor/Installation + OAM&P + Customer Support

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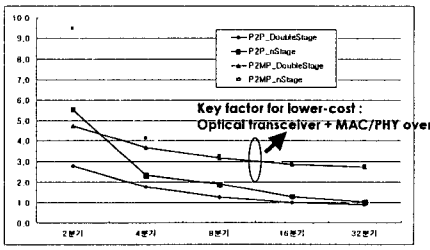
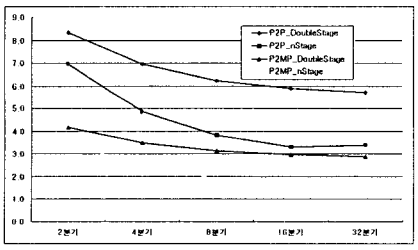
Cost Analysis

Relative Equipment Cost



Relative Cabling Cost



[ASSUMPTION]

1. Equipment cost covers only PON dependent cost, which means the selected variables are optical transceiver, PHY, MAC and relevant add-on logic.
2. Number of stages in P2MP is two.
3. Number of subscriber-side ports in 1st stage SW or PS : one less than 2nd stage
4. The uplink of 2nd SW in P2P model is expanded from 100Base-FX to 1000Base-LX when number of ONUs in 2nd stage becomes four.
5. Fiber in sub-stage is of equal length.

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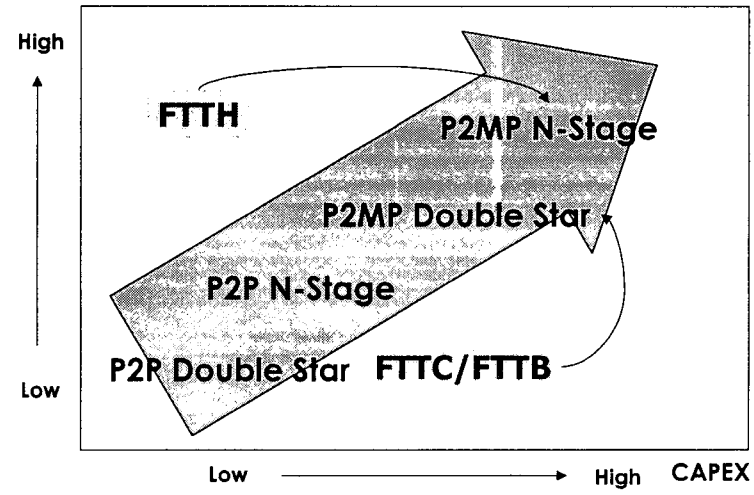
Expenditures Efficiency

OPEX Efficiency



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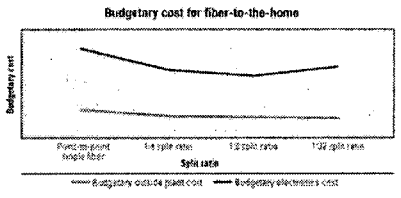
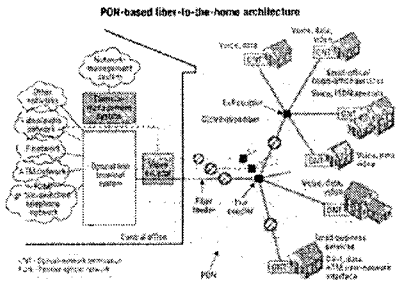
Case Study : FTTH Deployment

- **Corning Cable Systems**
  - Active equipment : 38%
  - Passive infrastructure : 8%
  - Labor/Installation : 54%
- **Marconi**
  - Optimum cost point
    - 1x8 split ratio





Source: Lightwave

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Carrier Consensus : SBC

Bit Rate	Preference	Positioning
155M up, 1.25G down	No consensus on need	R, B, S, M
622M up, 1.25G down	Medium-High	R, B, S, M
1.25G up, 1.25G down	High	B, S, M
622M up, 2.5G down	Medium-High	R, B, S, M
1.25G up, 2.5G down	Medium	B, M
2.5G up, 2.5G down	Medium	B, M
2.5G up, 10G down	Low	B
10G up, 10G down	Low	B

Service Requirements

- TDM for business applications
- Dynamic Bandwidth Assignment
- Triple play for business model

Distance Consensus

- 10Km : Low
- 15Km : Low-Medium
- 20Km : High

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Service Capabilities On Need

- Native TDM
- Dynamic Bandwidth Assignment
- Mixing Video and Data
- SLA

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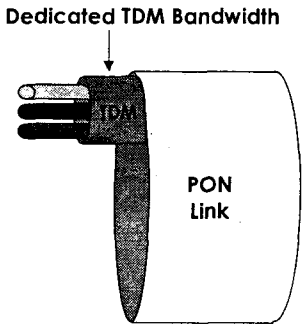
Native Mode TDM



- **TDM traffic is transported over dedicated bandwidth in its native protocol**
  - To protect legacy investments and maintains existing revenue streams
  - To reduce protocol conversion complexity

Refer. Salira materials

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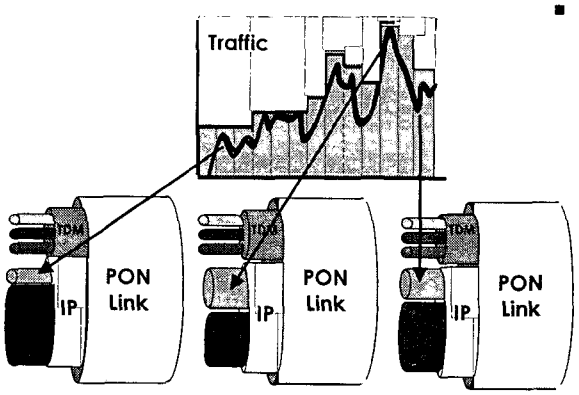
Real Time DBA



Real Time Dynamic Bandwidth Allocation automatically adjusts individual customer "pipe size" to accommodate bursty traffic

- **Distributed network intelligence enables the system to poll for available time slots in all connected ONUs**
  - Shared bandwidth enables over-subscription
  - Delivers better amortization of equipment and fiber

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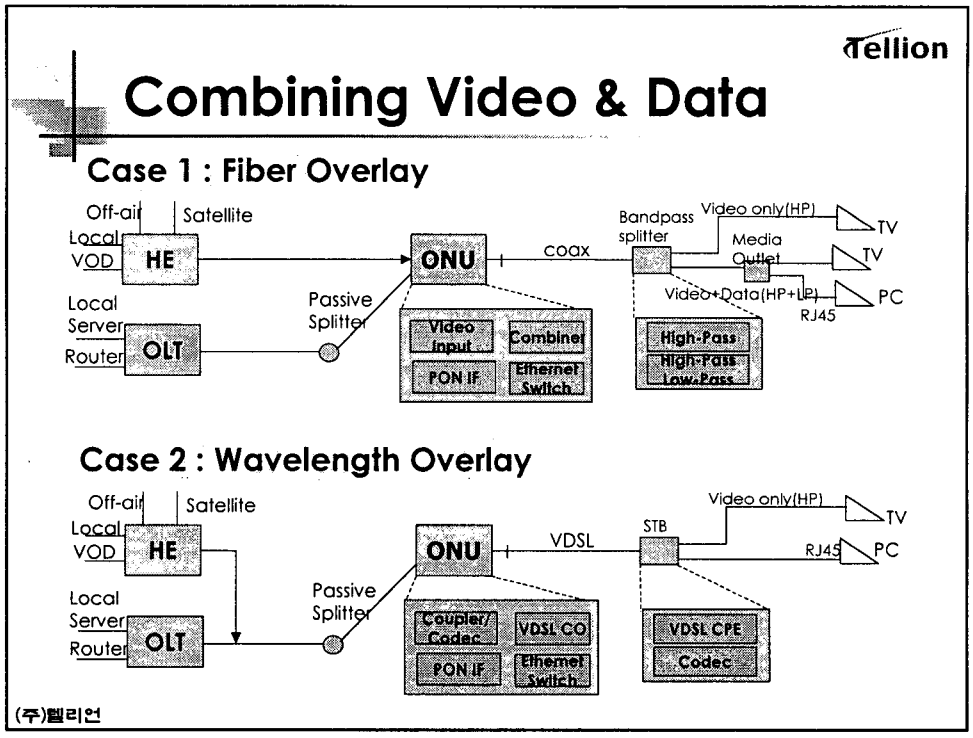
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Combining Video & Data
Case 1 : Fiber Overlay
Off-air
Satellite
Local VOD
HE
Local Server Router
OLT
Passive Splitter
ONU
coax
Bandpass splitter
Video only(HP)
TV
Media Outlet
TV
Video+Data(HP+LP)
RJ45
PC
Video Input
Combiner
PON IF
Ethernet Switch
High-Pass
High-Pass Low-Pass
Case 2 : Wavelength Overlay
Off-air
Satellite
Local VOD
HE
Local Server Router
OLT
Passive Splitter
ONU
VDSL
STB
Video only(HP)
TV
RJ45
PC
Coupler/ Codec
VDSL CO
PON IF
Ethernet Switch
VDSL CPE
Codec
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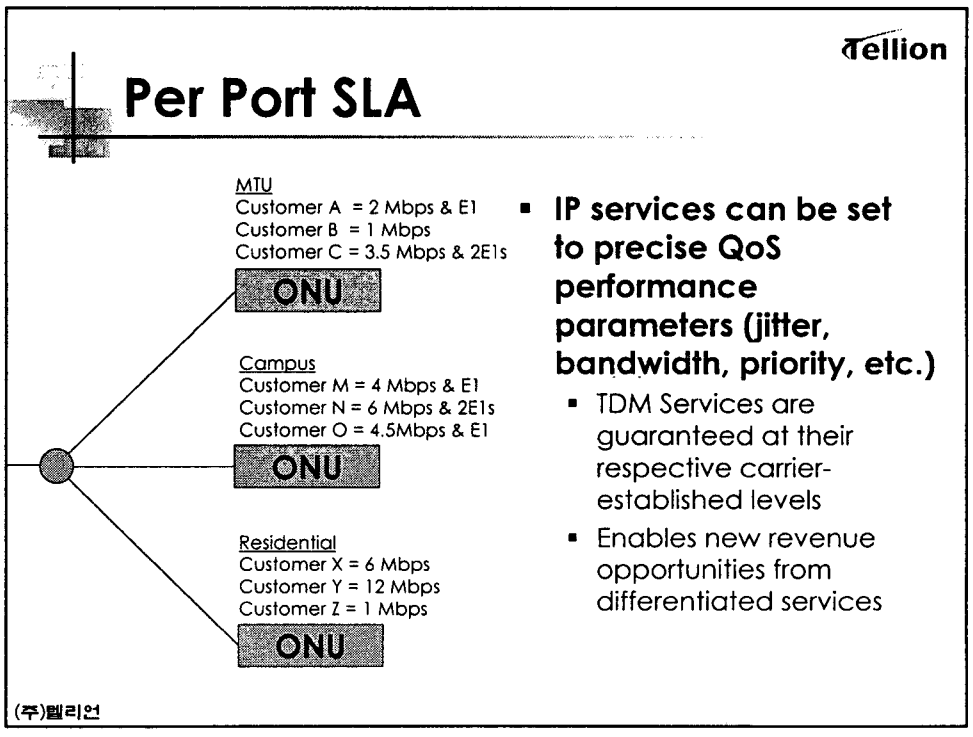
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Per Port SLA
MTU
Customer A = 2 Mbps & E1
Customer B = 1 Mbps
Customer C = 3.5 Mbps & 2E1s
ONU
Campus
Customer M = 4 Mbps & E1
Customer N = 6 Mbps & 2E1s
Customer O = 4.5Mbps & E1
ONU
Residential
Customer X = 6 Mbps
Customer Y = 12 Mbps
Customer Z = 1 Mbps
ONU
IP services can be set to precise QoS performance parameters (jitter, bandwidth, priority, etc.)
TDM Services are guaranteed at their respective carrier-established levels
Enables new revenue opportunities from differentiated services
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EPON Camp's Value Proposition

- Gigabit, symmetrical bandwidth
  - 1.25 Gbps scaling to 10 Gbps
- TDM and IP Ethernet
- Real Time Dynamic Bandwidth Allocation
- High subscriber density per PON
- QoS, Security and SLA enforcement
- Carrier-class design (OSP, five nines availability)

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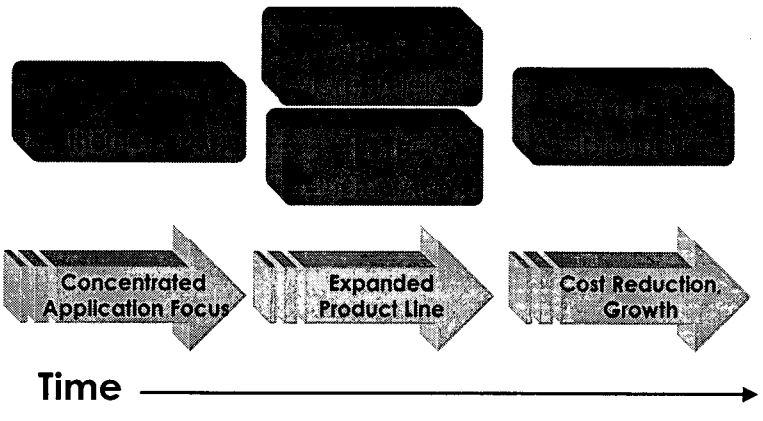
Application Focus & Roadmap



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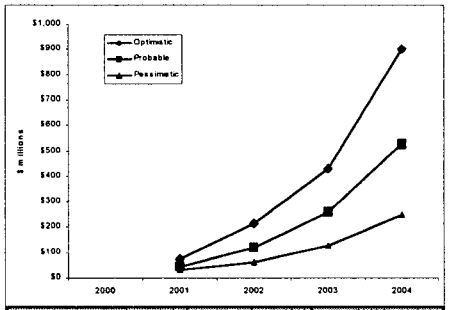
PON Market

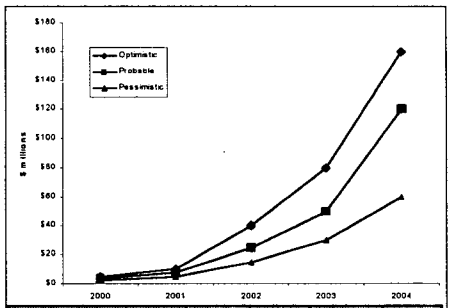
North America Market

Business PON



	2000	2001	2002	2003	2004
Optimistic		$75	$215	$430	$900
Probable		$43	$118	$260	$530
Pessimistic		$30	$60	$125	$250

Residential PON



	2000	2001	2002	2003	2004
Optimistic	$5	$10	$40	$80	$160
Probable	$4	$8	$25	$50	$120
Pessimistic	$3	$5	$15	$30	$60

Source : RHK, July 2001

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Wrap-Up

- **Hurdles to clear**
  - Unbundling issues
  - Technological maturity
  - Acceptance by carrier customers
- **Alternatives as new revenue generation**
  - EPON for rural application, GPON for business application, and APON multi-service application
- **Viewpoint of overall network planning**
  - Trade-off between revenue generation and investment
- **Willingness to pay for our better future**
  - Absolutely, FTTH is the future. But,...

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