Constant Innovation, Sustainable Development
——FTTx Research and Deployment in China Telecom

持续创新，持续发展
——中国电信光接入的研究和应用

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Contents

CTC Overview

2008.12

- **Fixed-line telephone subscribers: 208M (↓ 12M)**
- **Broadband subscribers: 47.2M (↑ 8M)**
  - ADSL/ADSL2+: 38.6M
  - IPTV: 2M
- **CDMA mobile subscribers: 35.4M**

CTC Overview

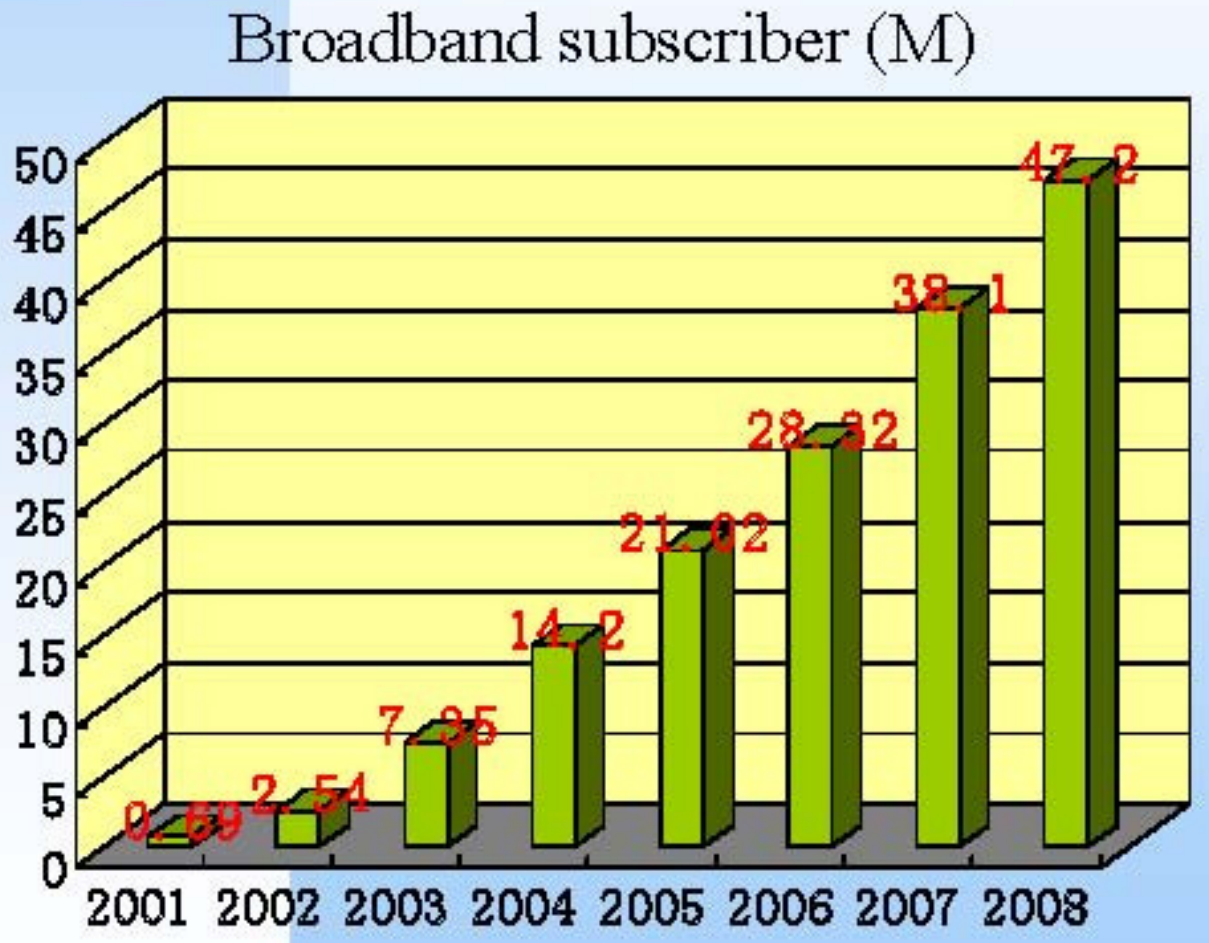
Full Services Offering

Integrated Information Service Provider

我的e家	商务领航 BizNavigator	天翼 surfing	
"One Home"	"BizNavigator"	"e-Surfing"	Customer brands
Household customers	Enterprise customers	Individual customers	

号码百事通 Best Tone	ChinaNet	互联星空 WWW.VNET.CN	Service brands

CTC Broadband Development



Largest broadband access networks in the world!

~8M annual growth in the past 5 years

Target: 2011, 75M

Broadband Access Technologies

- ADSL/ADSL2+
- Active Ethernet
  (old deployment)
- EPON
  - EPON+Ethernet
  - EPON+DSL
- VDSL2
- Wireless broadband
  - WLAN
  - CDMA2000 1x
  - CDMA2000 EVDO

VDSL2

- **Features**
  - High bandwidth, US BW>>ADSL2+
  - Backward adaptable with ADSL/ADSL2+
  - Strong capability against noise & interference (INP, UPBO, DPBO, virtual noise, DSM)

- **Comments**
  - Basically mature technology
  - Satisfying functionalities and performance of CO & CPE from major vendors
  - Good IOP and backward adaptability (chip & system)
  - Equipments from our major vendors are suitable for commercial deployment
  - High cost

WLAN

Technology

- Air interface
  - 802.11b/g (widely used)
  - 802.11a (wireless backhaul)
  - 802.11n (next step)
- Carrier class WLAN
  - Centralized Control Architecture (AC+AP)
  - Security
  - Management
  - QoS

Deployment

- Complement to fixed BB access and data domain of mobile network
- Hotspots covering
  - Universities, luxurious hotels, airports
- Combined broadband wireless access
  - WLAN
  - CDMA2000 1x
  - CDMA2000 EVDO

  * Unified authentication

  * Nationwide roaming

Home Gateway

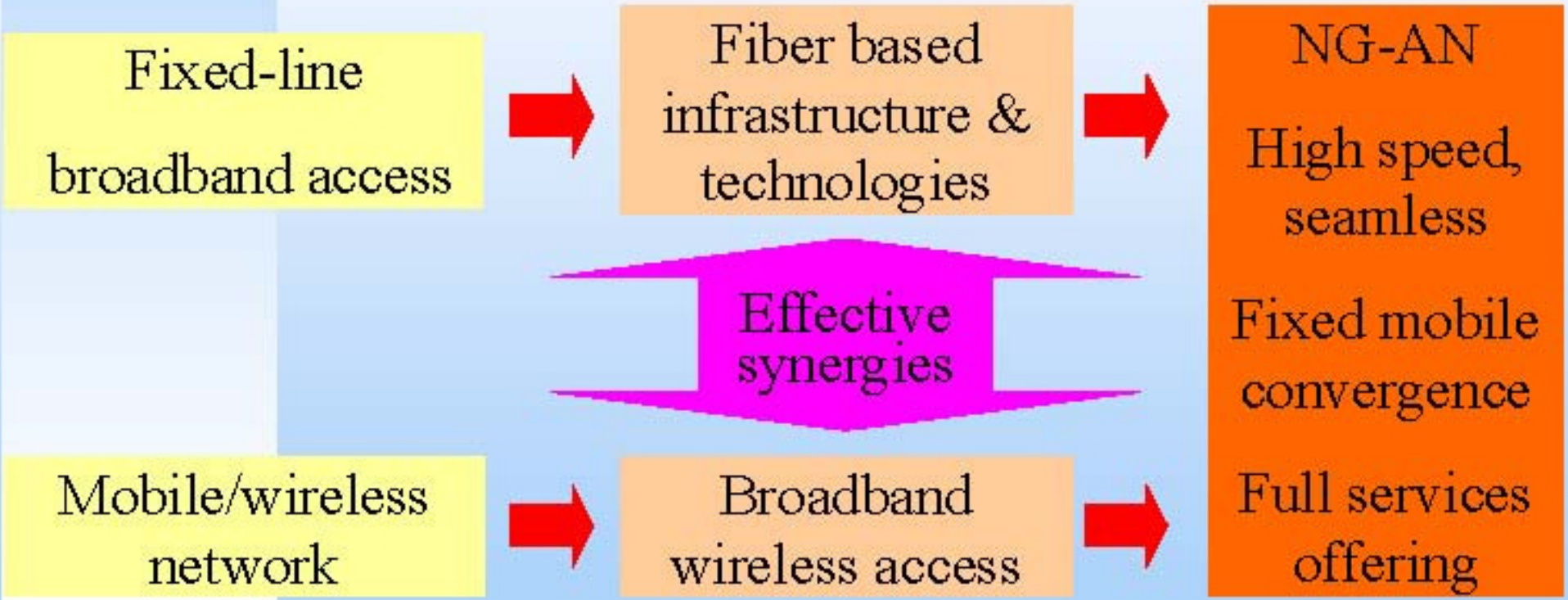
Features (e8-B/C)

- User interfaces
  - 4*LAN, WLAN, USB
  - POTS (VoIP, e8-C only)
- Uplink
  - ADSL2+ / Ethernet / EPON / VDSL2 / EVDO
- TR-069 based Remote management
- Open middleware archite.
  - Easy introduction of new functionalities and services,
  - Enhanced control
  - 3rd party application development

Deployment

- HGW massively deployed
- ITMS (Integrated terminal management system)
- User benefit
  - Multi-terminal access
  - Wireless connection
  - Easy configuration
  - Rich applications
- Operational benefit
  - Better control of network and service
  - Easy extension of new services
  - Zero-touch service provisioning
  - Diagnostic capabilities

Access Network Transformation



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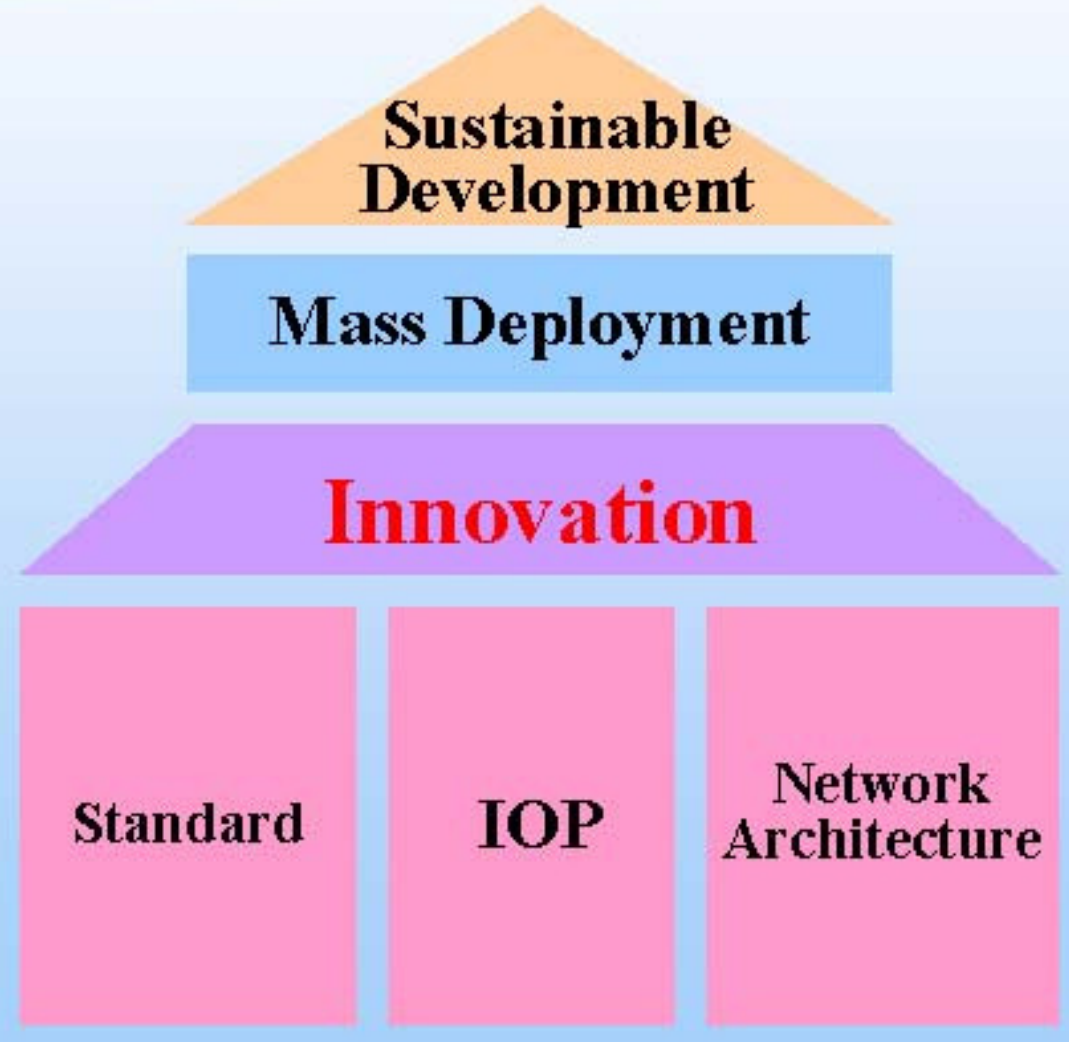
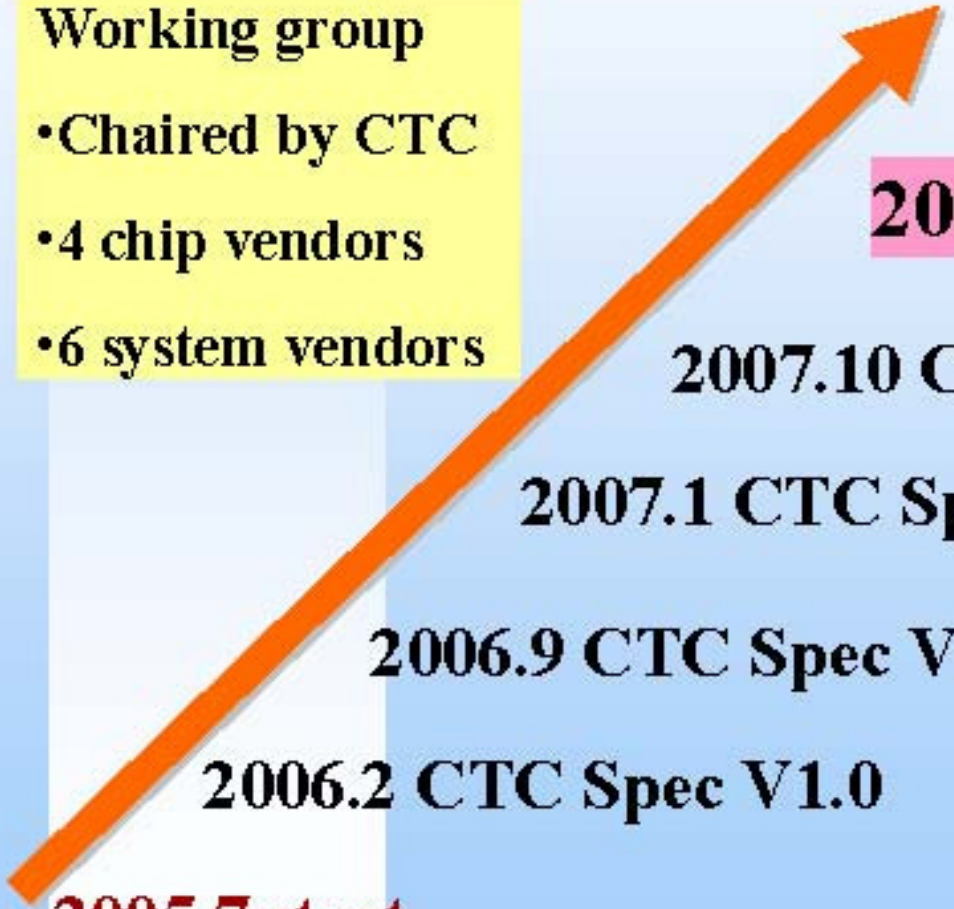
Innovation and Sustainable Development



EPON Spec

Working group

- Chaired by CTC
- 4 chip vendors
- 6 system vendors



Next step: CTC Spec V3.0

2009.4 CTC Spec V2.1

2007.10 CTC Spec V2.0

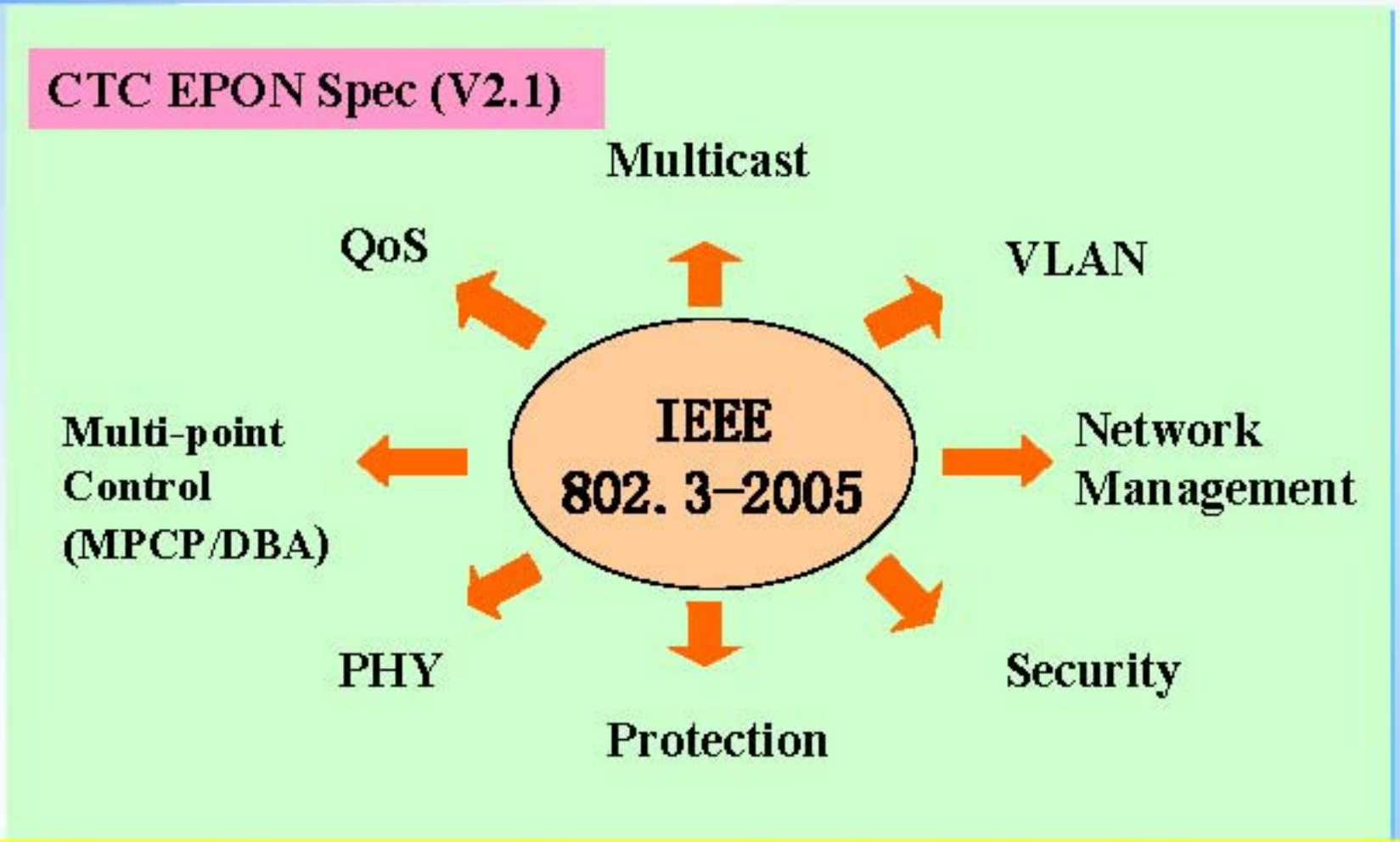
2007.1 CTC Spec V1.3

2006.9 CTC Spec V1.2

2006.2 CTC Spec V1.0

2005.7 start

EPON Spec



A quite complete spec, enhancing EPON standard to a new height

EPON Spec: Major Enhancements

- Improved MPCP discovery
- Clarified DBA report parameters
- Extended OAM based ONU remote manag.
- Triple-churning based DS security
- ONU VLAN modes
- Authorization based multicast control

(V2.1)

- Enhanced PMD (PX20+)
- Event notification and fault alarm
- Optical link protection
- Logical ID based ONU authentication
- Optical link test and diagnostics
- Software upgrade

Enhanced PMD (PX20+)

- 4 dB enhancement over PX20
  - Available power budget: 30/29.5dB
  - Channel insertion loss (max) : 28dB
- Target
  - 1:64, 20km
- OLT
  - Tx: power +2.5~ +7dBm
  - Rx: sens. -30dBm
- ONU
  - Tx: power 0~+4dBm
  - Rx: sens. -27dBm

Event Notification & Fault Alarm

Event & alarm types

- User port
- PON IF
- ONU
  - Temperature
  - Power
  - Battery
- Voice module related

Implementation

- Organization Specific OAMPDU
  - Enable/disable the alarms
  - Configure the thresholds
- "Event Notification" with "Organization Specific Event"
  - ONU report to OLT

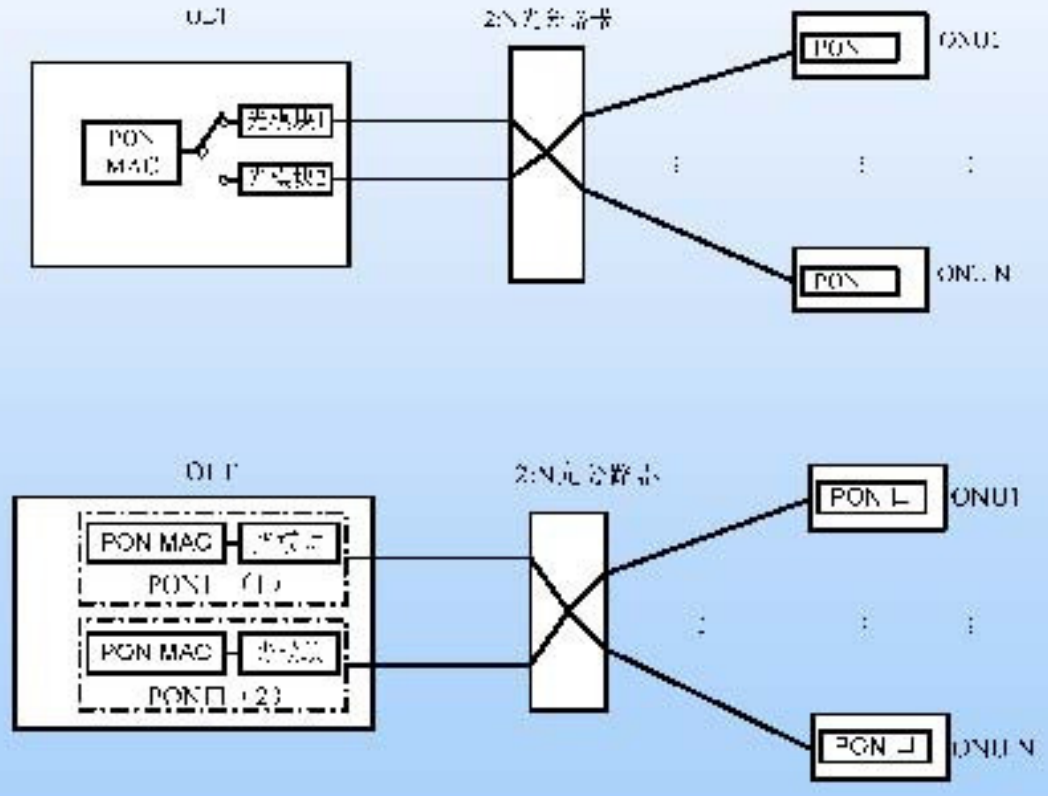
Optical Link Protection

Backbone duplex

- **Type a: feeder fiber & OLT optics redundancy**
- **Type b: Feeder fiber & OLT PON IF redundancy**

Service interruption time

- **Type a: <150ms**
- **Type b: <150ms**



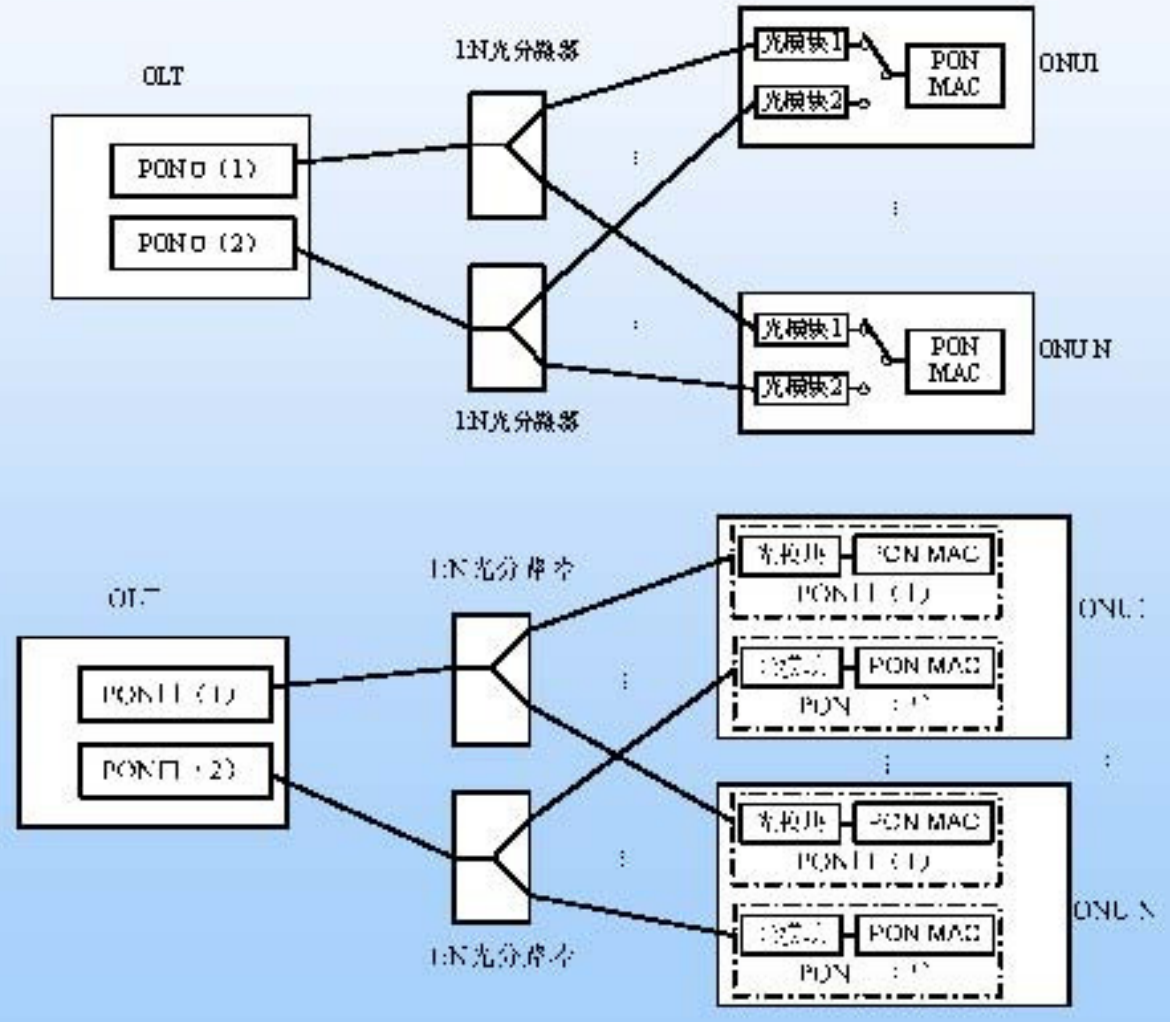
Optical Link Protection

Full duplex

- **Type c: OLT PON IF, ODN & ONU optics redundancy**
- **Type d: OLT PON IF, ODN & ONU PON IF redundancy**

Service interruption time

- **Type c: <200ms**
- **Type d: <50ms**



Optical Link Protection

Main mechanisms to accelerate protection switch

- Holdover
  - ONU: maintaining the "registered" state for a period time when the optical link is ineffective
  - OLT: retaining the ONU settings (e.g. MAC/LLID, OAM Ext. support, FEC) after protection switch
- Info Synchronization between duplicated PON MACs
- Fast ranging

New Features Being Discussed

ONU Tx power supply control

- **Goal**
  - Rogue ONU (abnormal light emission)
  - Diagnosis
- **Extended OAM**
  - Tx permanently shutdown
  - Tx shutdown for a period of time
  - Re-enable the Tx power
- **Broadcast LLID**
- **Independent power supply of the Tx and Rx in a TRX**
- **ONU special hardware design**

New Features Being Discussed

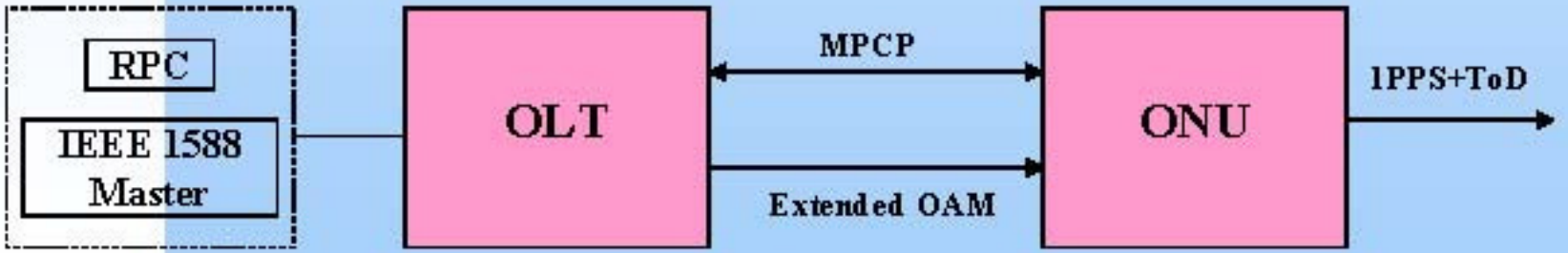
Phase and time synchronization for mobile backhaul

- Providing mobile backhaul (e.g. CDMA) by EPON
  - Frequency synchronization
  - Phase synchronization
  - Time synchronization
  - Precision requirement (CDMA2000)
    - Frequency: 0.05ppm
    - Time: 3 μ s
  - Transport of IEEE 1588

New Features Being Discussed

Phase and time synchronization for mobile backhaul

- Mechanism
  - MPCP synchronization and ranging mechanism
  - Extended OAM
    - Configure RTT
    - Broadcast MPCP timestamp for next 1PPS
    - Broadcast ToD

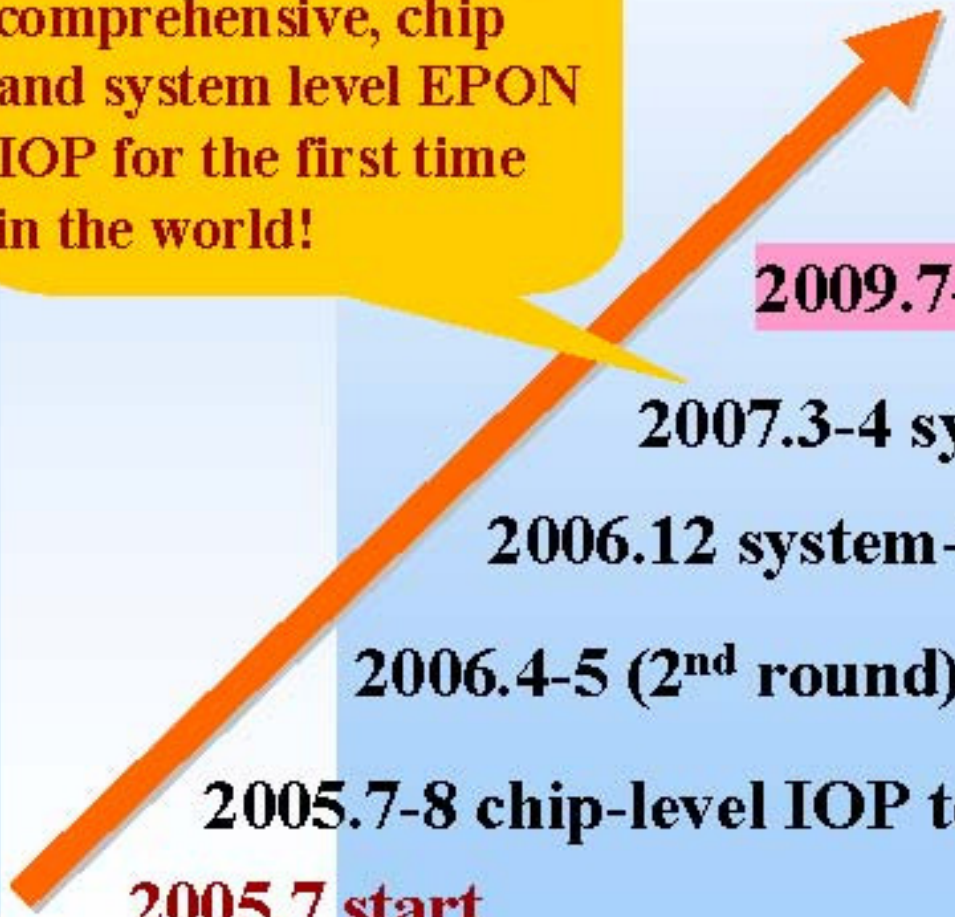


Importance and benefit of IOP

- Symbol of technology maturity
- Competition among chip & system vendors
- Flexible vendor selection for operators and system vendors
- Easy installation and use for operators and subscribers
- Benefit the whole ecosystem
- Foundation and driver of mass deployment

EPON IOP

Achieved large-scale, comprehensive, chip and system level EPON IOP for the first time in the world!



2009.9-10 CTC Spec V2.1 new features IOP test

2009.7-8 10G-EPON chip-level IOP test

2007.3-4 system evaluation test

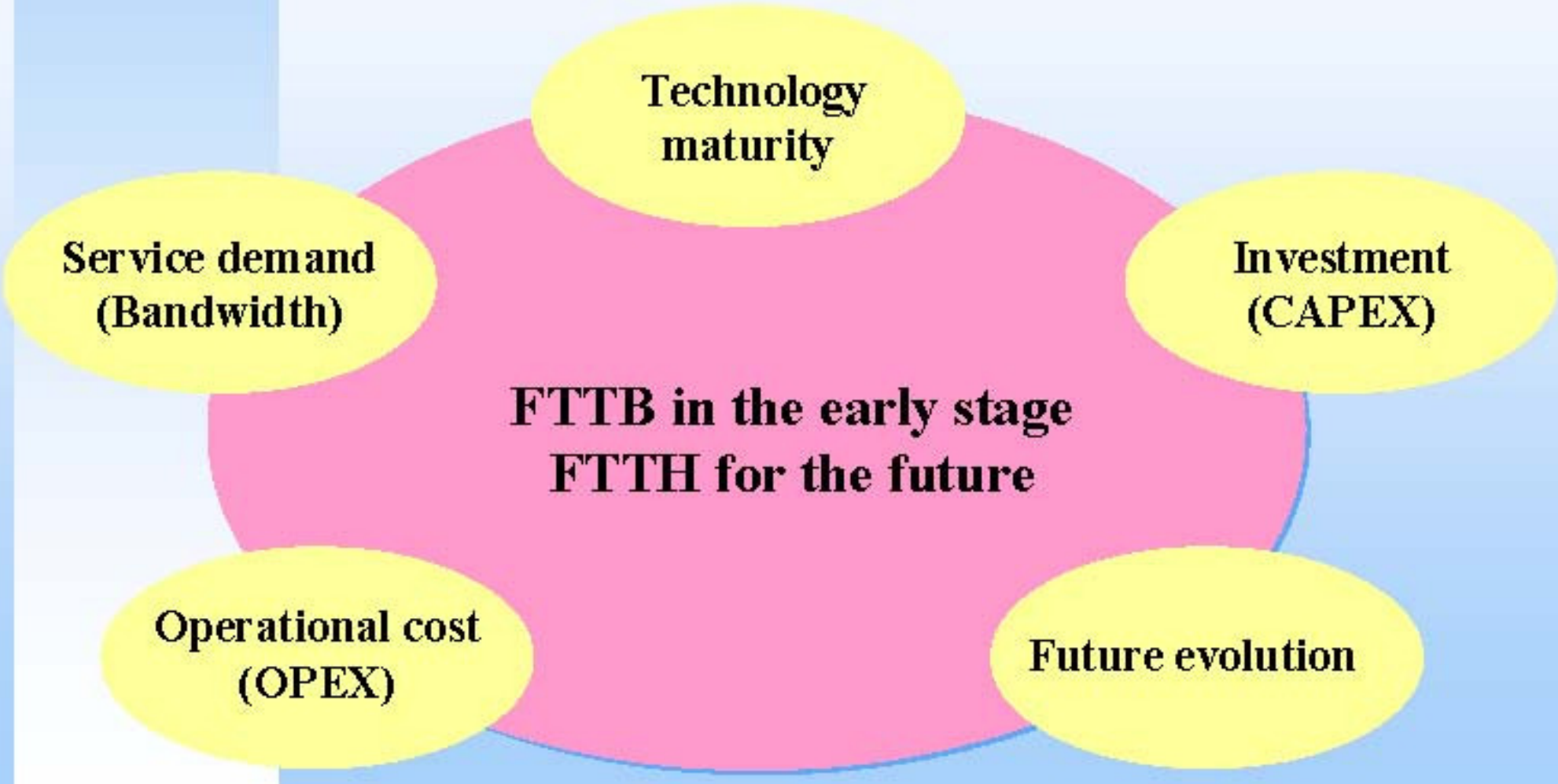
2006.12 system-level IOP test

2006.4-5 (2nd round) chip-level IOP test

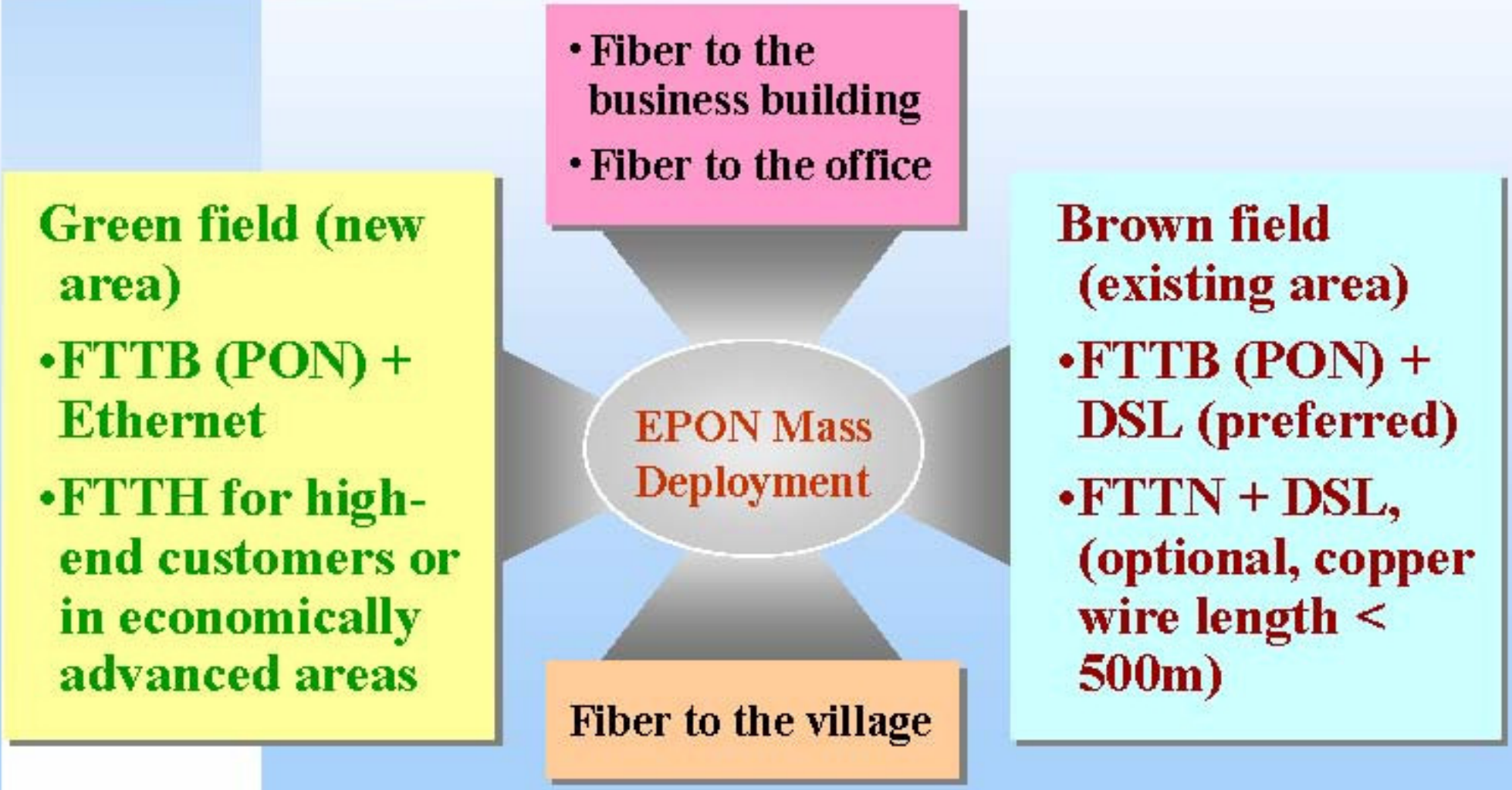
2005.7-8 chip-level IOP test

2005.7 start

Network Architecture



Network Architecture



GPON Development

- GPON system evaluation tests
  - 2005.6, 2 vendors (together with EPON)
  - 2006.7-8, 4 vendors
  - 2007.7-9, 9 vendors
- GPON IOP test
  - 2008.1-3, 6 vendors

- GPON spec formulation
  - 2007.11, V0.1
  - 2008.5, V0.2
- GPON field trial
  - 4 provinces, 6 cities
  - 5 vendors
  - 3000 users

General Situation of PON Ecosystem

Standard

- EPON
  - 1G-EPON: IEEE 802.3-2005, mature
  - 10G-EPON: IEEE 802.3av, to be released in Sept. 2009
- GPON
  - (2.5G) GPON: ITU-T G.984.x , mature
  - XGPON: G.987.x
    - G.987.1/G.987.2: to be consented in Sept. 2009
    - G.987.3/G.987.4: to be consented in June 2010

General Situation of PON Ecosystem

PON MAC Chip

- EPON
  - 4 vendors, 3 mass production
  - Mature, ASICs
- GPON
  - 7 vendors, 2-3? mass production
  - Few commercialized ASICs (especially for OLT)

General Situation of PON Ecosystem

Equipment

- EPON
  - mature, various & sufficient types (SFU/MDU/HGU) , verified in mass deployment
- GPON
  - needs further verification in mass deployment
- Many important vendors support both EPON & GPON

General Situation of PON Ecosystem

IOP

- EPON
  - Large-scale, comprehensive, chip-level and system-level IOP
  - 10G-EPON: 2010H1 (predicted)
- GPON
  - Great progress, but not fully realized
  - XG-PON: ??

General Situation of PON Ecosystem

Deployment

- EPON
  - massively deployed in Japan, China and South Korea
- GPON
  - more commitment, less deployment
  - Among all the important operators in the US & Europe, good progress only in one operator, but delayed or in small scale trial in other big operators

Contents

10G-EPON: Main Features

- Higher bandwidth
  - 10/1G, 10/10G
- Mandatory FEC
  - RS(255,223)
- Higher coding efficiency
  - 64B/66B, 97%
- Higher link budget
  - PRX30/PR30 29dB channel insertion loss
- Coexistence
  - 3 types of ONU: 10/10G, 10/1G & 1/1G

10G-EPON

- IOP test plan
  - Chip level, first round: 2009.7-8, 10/1G system
  - Chip level, second round: 2009.11?, 10/10G system
  - System level: 2010Q1?
- Spec

  IEEE802.3av + Churning + CTC Spec V2.1

  →CTC Spec V3.0
- Target
  - Achieve chip & system level IOP in 2010H1
  - Ready for commercial deployment in 2010H2

10G-EPON Chip IOP Test

Contents

- MPCP
  - MPCP Discovery
  - DBA
  - Coexistence
- OAM
  - Normal OAM discovery
  - Extended OAM discovery
  - OAM Based remote management
- FEC
- Performance

Results

- 10/1G system, 4 chip vendor
- **Satisfactory progress**
  - Good IOP in MPCP, OAM, coexistence & performance
  - Small problems in FEC & MPCP have been solved or will be solved soon
  - Optical module, not mature enough
  - No essential obstacles to IOP

10G-EPON

2005-2007
1G-EPON
field trial

2007-2009
1G-EPON
commercial
deployment

Sustainable development

Smooth upgrade

2010—
10G-EPON
commercial
deployment

- **Field trial**
- **Commercial deployment**
  - First stage: FTTB, enhancing num. /BW of MDUs
  - Future: FTTH/FTTO/FTTB
  - Asymmetric (10/1G): 2010 (predicted)
  - Symmetric (10/10G): 2011 (predicted)

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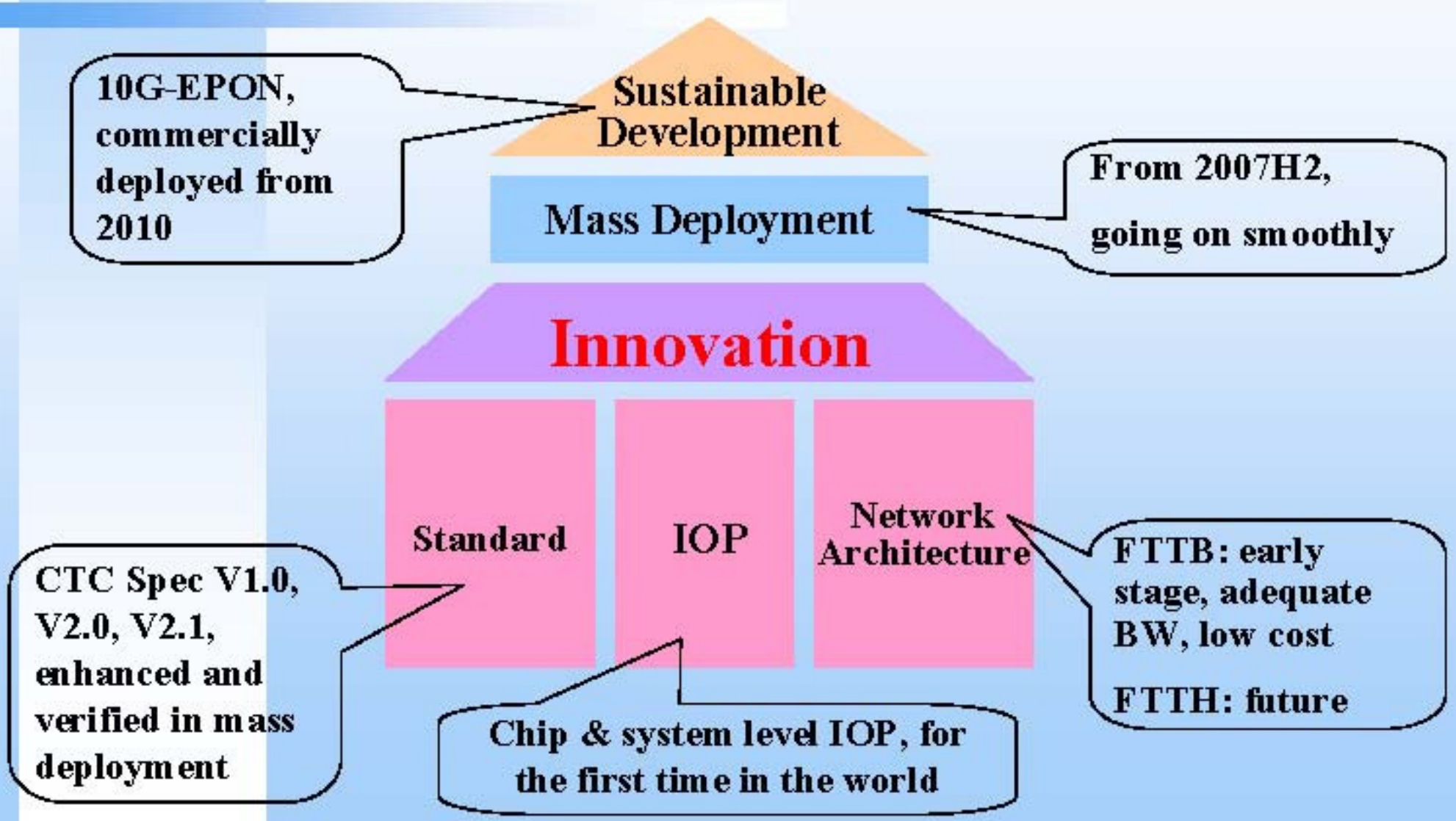
10G-EPON, commercially deployed from 2010
Sustainable Development
Mass Deployment
From 2007H2, going on smoothly
Innovation
Standard
IOP
Network Architecture
CTC Spec V1.0, V2.0, V2.1, enhanced and verified in mass deployment
Chip & system level IOP, for the first time in the world
FTTB: early stage, adequate BW, low cost
FTTH: future

Summary

EPON is a mature technology, has an enhanced spec, good IOP and a healthy ecosystem

EPON is verified and improved in deployment and practice

Accelerate EPON deployment

Push forward 10G-EPON maturity and IOP

GPON research

GPON field trial

Sustainable development of FTTx network

Thank you!