Fiber Optics and xDSL
last mile access technologies applicable to E-health

Presented by:

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Optical and other transport networks

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Theme 8 from the G7 (’94 – ‘95)
10 Pilot Projects for the I.S.
“ Global Healthcare Applications “

- demonstrate the potential of telematics technologies in the field of telemedicine in the fight against major health scourges;
- promote joint approaches to issues such as the use of data cards, standards and other enabling mechanisms.

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Theme 8
Sub-projects

- public health,
- cancer,
- cardiovascular disease,
- telemedicine,
- harmonization of datacards and medical imaging.

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Theme 8
Project Results (1999 →)

- Encouraging results including:
  - world-wide interoperability of medical images and health cards
  - demonstration of services for a second opinion in oncology and treatment of cardiovascular patients irrespective of their geographic location.
- Most projects developed are in the pilot implementation phase.
- Demonstrated the potential of telematics technologies in telemedicine and common approaches and standards for individual health smartcards

http://www.europa.eu.int/ISPO/intcoop/g8/i_g8pp_matrix.html

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Theme **2 :**
Global Inter-operability for Broadband High Speed Networks (GIBN)
MAIN RESULTS

- 19 major applications projects,
- tested technologies and inter-working performance
- realized interconnection of a number of high speed, national and regional broadband research networks
- facilitate the establishment of international links between the various high speed networks and testbeds supporting advanced applications.

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Optical and other transport networks

Responsible for studies relating to:

- transport networks, systems and equipment for access, metropolitan and long haul sections and relevant G-series Recommendations.

Lead Study Group on

- Access Network Transport (ANT)
- Optical Technology

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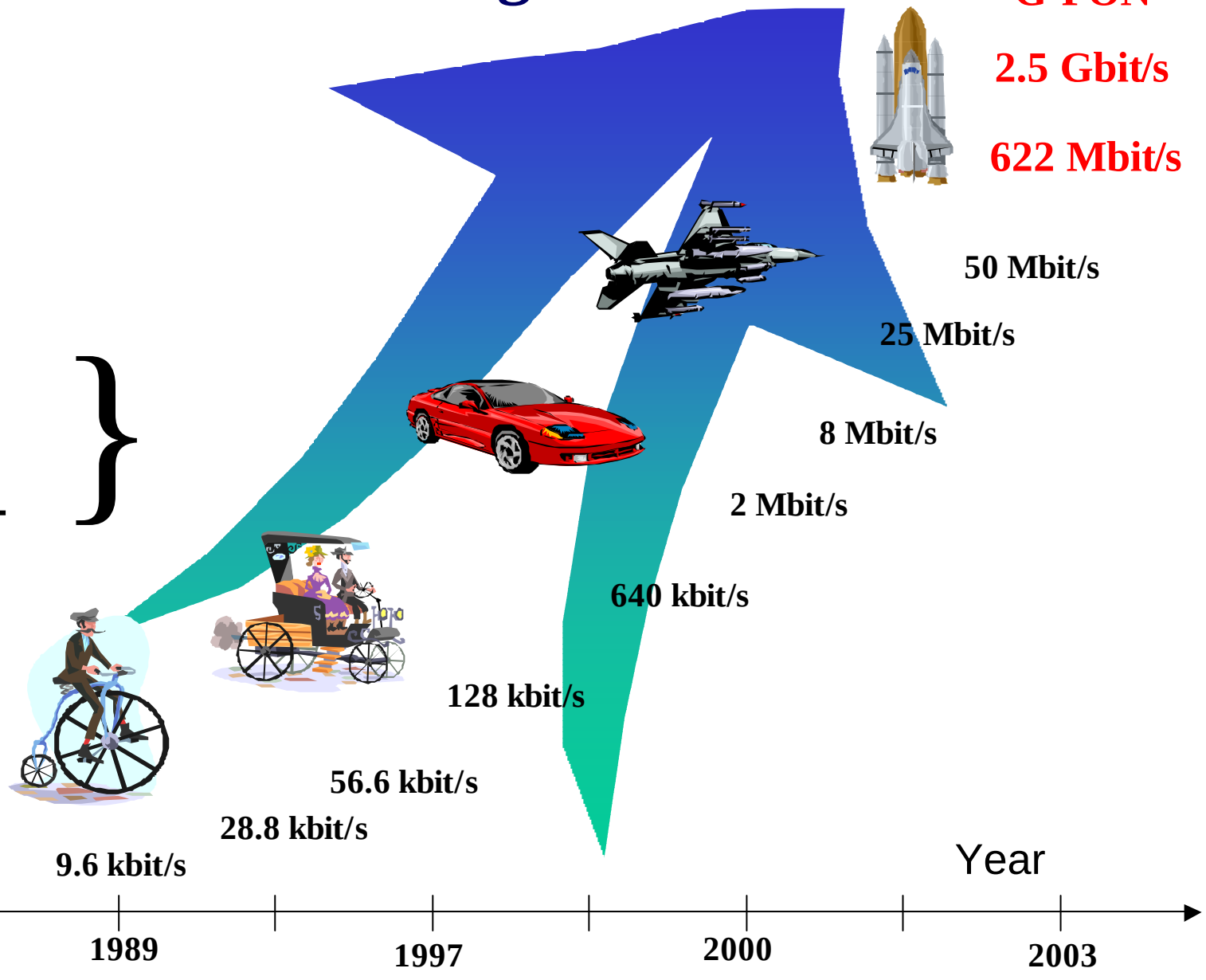
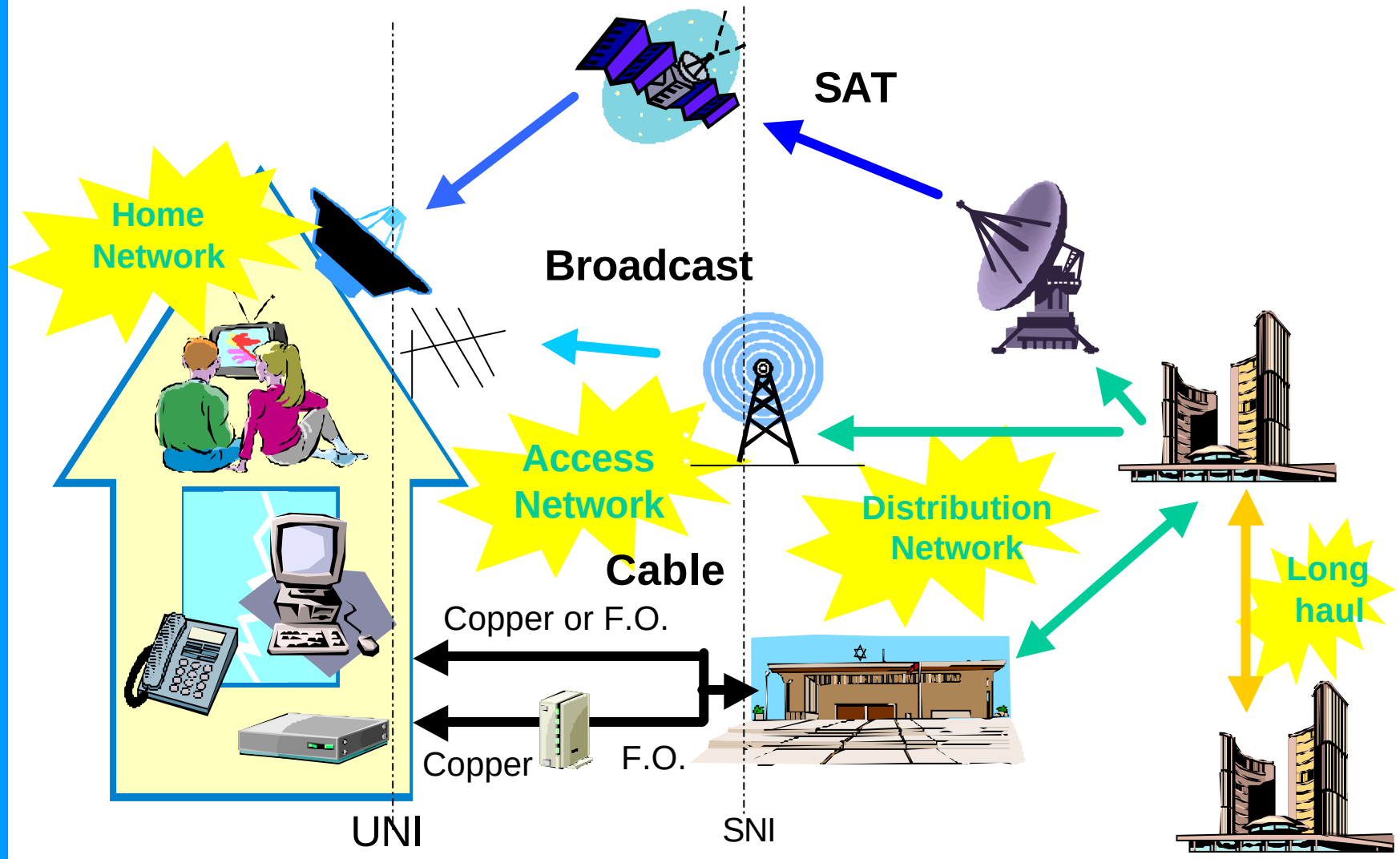
Access technological evolution



Many a type of access



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Service definition and requirements
ITU-T F.700-series: umbrella definitions:

- Definition of several MM tasks:
  - *Conferencing* (multipoint, bi-directional, real-time)
  - *Conversation* (point-to-point, bi-directional, real-time)
  - *Distribution* (point-to-multipoint, unidirectional)
  - *Sending* (point-to-point distribution, Tx controlled, UD; info pushing)
  - *Receiving* (point-to-point distribution, Rx controlled, UD; info retrieval)
  - *Collecting* (multipoint-to-point distrib., UD, Rx controlled; info polling)
- Media components: audio, video, text, graphics, data and still-pictures
- Quality level for media components: {-1, 0, 1, 2, 3, 4}

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The
Copper Wires Access Network

xDSL technique

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xDSL outline

- What is xDSL ?
- Why xDSL ?
- How it works ?
- Typical components
- xDSL evolution, standards and applications

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What is xDSL

- DSL: Digital Subscriber Line

  DSL as a transmission technology using the existing copper wires between a central exchange and a customer with a bit rate speed up to 26 Mbit/s
- Signals: symmetrical/asymmetrical, digital, text, audio, video
- Concepts of local loop, management, handshake, interoperability, scalability, legacy

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Why x-DSL

- Faster than analog (56 kbit/s) and ISDN (>128 kbit/s) modems, reasonable cost, reach 3-6 km
- Less expensive that E1/T1 systems, 1.5-2.0- Mbit/s, reach 1 km
- Use already existing copper pairs (depending on the performance): start as equipments installed.
- Alternative ⟹ Optical access:
  - Wait for full availability
  - current cost
  - better performance

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Why x-DSL

- Transforms potential 700 millions copper wires installed worldwide into multimegabit data pipes
- Scenario convenient to providers and users immediately available
- Enable the management of different providers of different services to different users tipology

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How it works

- Remove line components limiting the bandwidth to the voice frequency (4 KHz = 64 Kbit/s)
- Use of copper low attenuation frequencies sending more bits x Hertz for longer reach
- Use higher bit rate with a low increase of signal rate (baud) in the line
- Use of line codes allowing the transmission of 2 to 15 bits x Hertz (up to 1.1, 2.2, 12 MHz)
- Adoption of techniques/phylosophies limiting negative effects (crosstalk, echo, spectrum, etc.)

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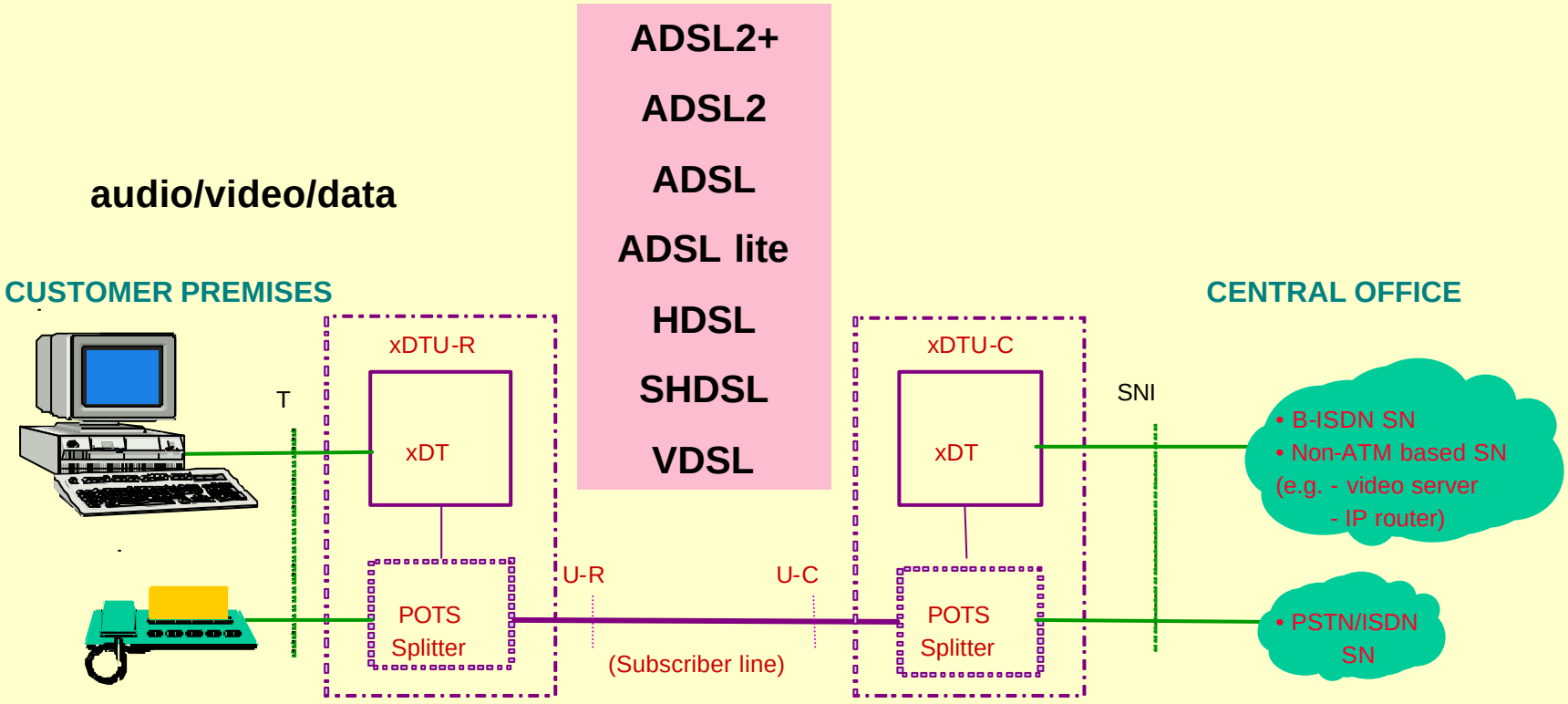
Typical components of an xDSL system



ADSL2+ G.992.5	Video/ voice/ data/copper	16 – 25 Mb/s Down Up to 800 Kb up Higher-optional	video capabilities. Dist 1.5 km/BW
ADSL2 With and without splitter – G.992.3 / 4	Video/ voice/ data/copper	8 Mb/s down 800 Kb/s up Higher-optional	video capab. Dist + 200m ADSL
ADSL With and without splitter – G.992.1 / 2	Voice/data /copper	Up to 8 Mb/s down Up to 1.5 Mb/s up	Full use existing copper. Web brows/Voice 2.7- 5.4 km
VDSL Symmetric Asymmetric G.993.1	Video/ voice/ data (V/V/D) over copper	Up to 52 Mb/s down asymm Up to 26 Mb/s Symm.	Broadcast video, VoD, internet TV, 1.5 km - 300m
SHDSL Symmetric G.991.2	Voice/data/ Video 1/2 pairs	192 K to 4.6 M Steps 8/16 Kb/s Poss amplif.	V/V/D Services mainly for business appl.
HDSL Symmetric G.991.1	Voice data and video 1/2/3 pairs	784 Kbit/s to 2320 Kbit/s	V/V/D Services mainly for business appl.

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ADSL2 versus ADSL
(G.992.3 x G.992.1)

- 2nd generation of ADSL with improvements on:
  - Loop-reach increase for equivalent bit rates (300m)
  - Higher down/up bit rates
  - loop diagnostics
  - Adjustable spectrum shaping during operat/initializ
  - Power vs traffic control: L0(full),L1, L2
  - robustness against loop impairments and RFI
  - Improved multivendor interoperability
- Improved application support for an all digital mode of operation and voice over ADSL operation;

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ADSL 2+ : G.992.5

- Performance
  - Increase downstream: to 16 Mbit/s
  - Maybe increase in upstream (Oct. 2003)
  - Increase reach (1.5 - 3 Km)
- ADSL+ doubles the bandwidth (from 1.1 to 2.2 MHz) with a significant increase of data rates on short loops
- Backwards compatibility (needs G.992.3)

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The
Optical Access Network

G/B-PONs Technique

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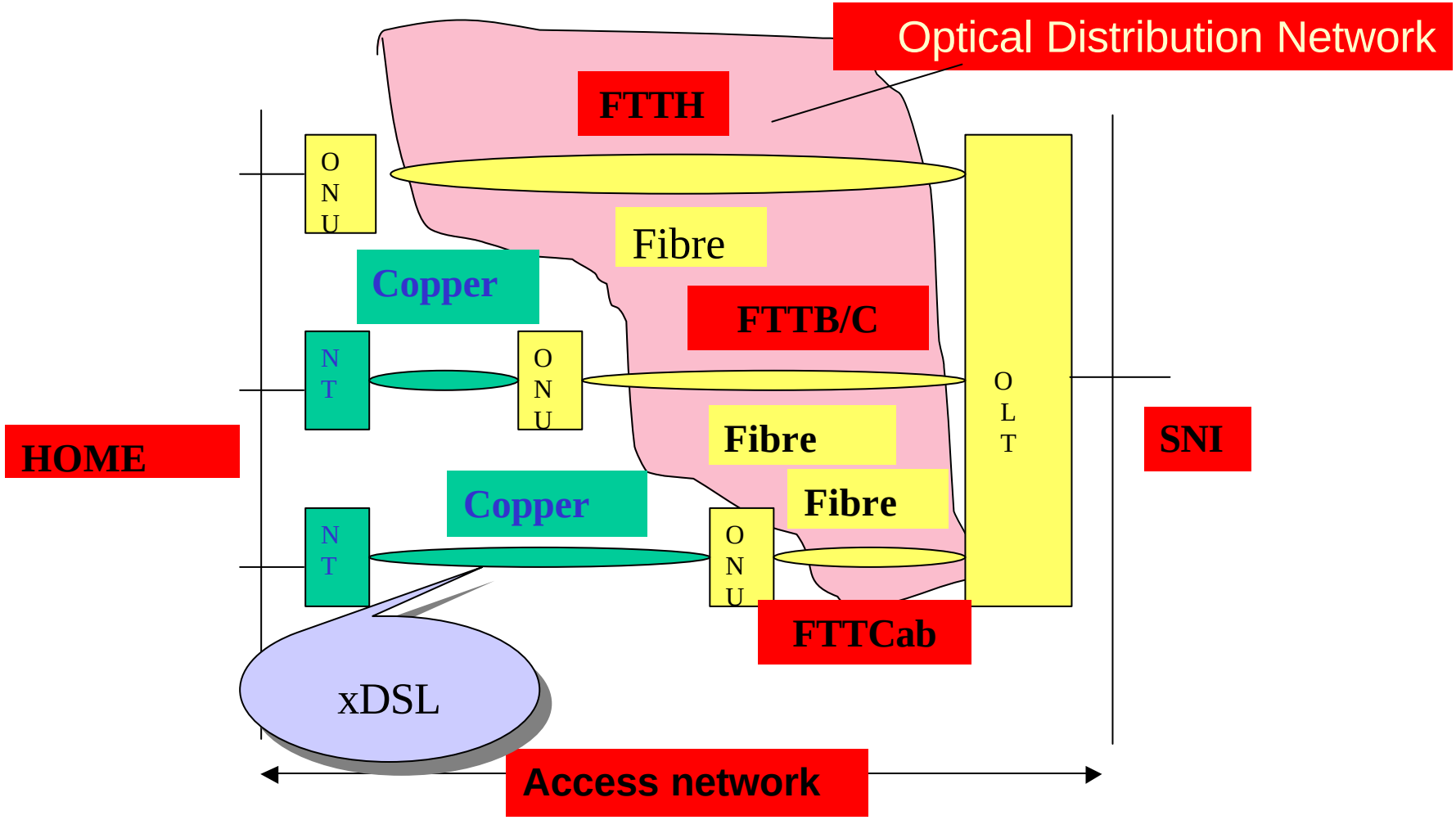
Optical access network architecture (G.983.1)



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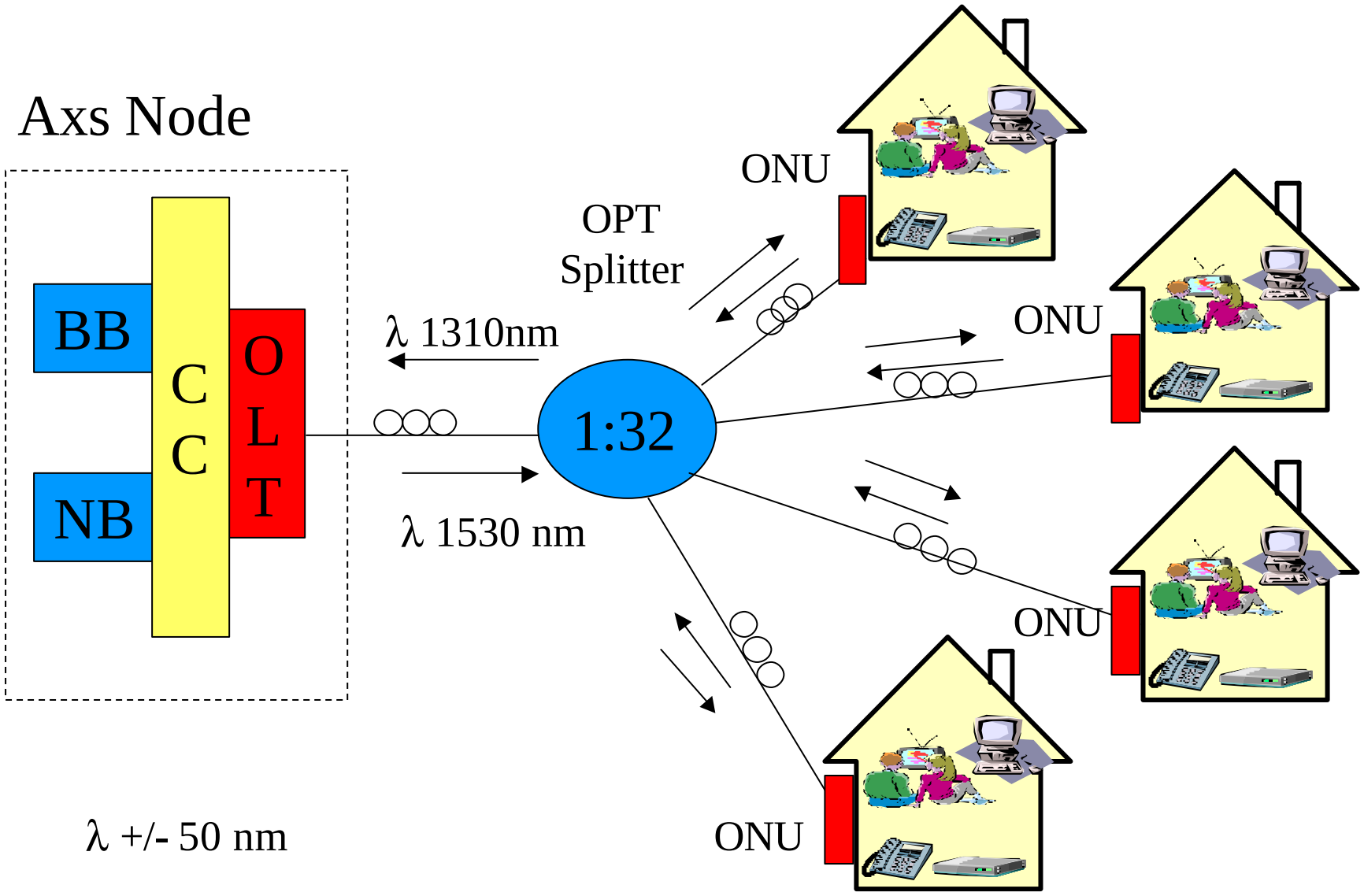
PON Access System



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Evolution of Standardization for Multigigabit systems Physical Layer

G.692	622 Mbit/s – 10 Gbit/s (STM-4 to STM-16)	WDM from 4 to 32 ch Longit. Compat.- Line amplifiers mono/bidirect.	1996 / 1998
G.959.1	2.5 and 10 Gbit/s	Single ch / up to 16 ch WDM Transv. Compat. - Opt Amplif.s	2000
G.693	10 – 40 Gbit/s (STM-64 to STM-256)	Single channel Transv. Compat. Intra office	2001
G.694.1 G.694.2	2.5 / 10 Gbit/s	Dense WDM = 80 Ch/10 Gbit/s Coarse WDM = 18 Ch/2.5 Gbit/s	2002
G.983 G.984	155/622 Mbit/s 155M/2.5 Gbit	B- and G-PON Access WDM, uni & bidirectional	2002/2003

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Optical systems for access networks
G.983.x- series : B-PON

- **Systems supported**:
  - **symmetrical line rates of 155.520 Mbit/s**
  - **asymmetrical line rates of 155.520 Mbit/s upstream and 622.080 Mbit/s downstream.**
- **Transmission techniques:**
  - **Bi-directional - 1 fibre - WDM technique (1.3 mm upstream and 1.5 mm downstream) or**
  - **Unidirectional 2 fibres in 1.3 mm region (both down and upstream)**
  - **Reach at least 20 km**
  - **Enhanced bandwidth for WDM**
  - **Dynamic band assignment**

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Optical systems for access networks G.984.x -series - G-PON (01-2003)

New!

- **2.5 Gbit/s** capable PON systems
- Symmetrical/Asymmetrical
- 1.244 and 2.488 Gbit/s downstream
- 155 Mbit/s up to 2.488 Gbit/s upstream
- Business and residential users
- Convenient support of IP and Ethernet
- **Same wavelength** plan and full-network design principles as in **G.983.x**-series (B-PON)

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G-PONs

•**Bit Rate**: 7 transmission speed combinations as follows:

- 155 Mb/s up, 1.2 Gbit/s down
- 622 Mb/s up, 1.2 Gbit/s down
- 1.2 Gb/s up, 1.2 Gbit/s down
- 155Mb/s up, 2.4Gbit/s down
- 622 Mb/s up, 2.4 Gbit/s down
- 1.2 Gb/s up, 2.4 Gbit/s down
- 2.4 Gb/s up, 2.4 Gbit/s down

•**Max Reach** :

• 20 km for less than 1.25 Gbit/s

• 10 km for 1.25 Gbit/s and

•**Split ratio** : up to 1: 32 (64) , optical power implications, operators convenience, bidirectional

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Targets for the e-health

- Executives & Senior Management
- Physicians, Nurses, other Health Professionals
- Educators, Students, Consultants
- CIOs & Information Managers
- Government Employees
- Health Care Organizations and Association
- Health Record Professionals
- Security & Privacy Professionals
- Vendors of Information Technology and Information Management Solutions
- Consumers/citizens

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Health information

- Health information includes information for staying well, preventing and managing disease, and making other decisions related to health and health care.
- It includes information for making decisions about health products and health services.
- It may be in the form of data, text, audio, and/or video.
- It may involve enhancements through programming and interactivity.

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Ethics

- Honesty
- Security - Privacy
- Professionality
- Ease understanding for e-patients and e-physicians
- Up-dated information/services
- Respect fundamental ethical obligations to patients and clients.
- Inform and educate patients and clients about the limitations of online health care.
- Trustworthy organizations

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Thank you for your attention!

For further information, please feel free to contact:

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http://www.itu.int/ITU-T

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Additional slides

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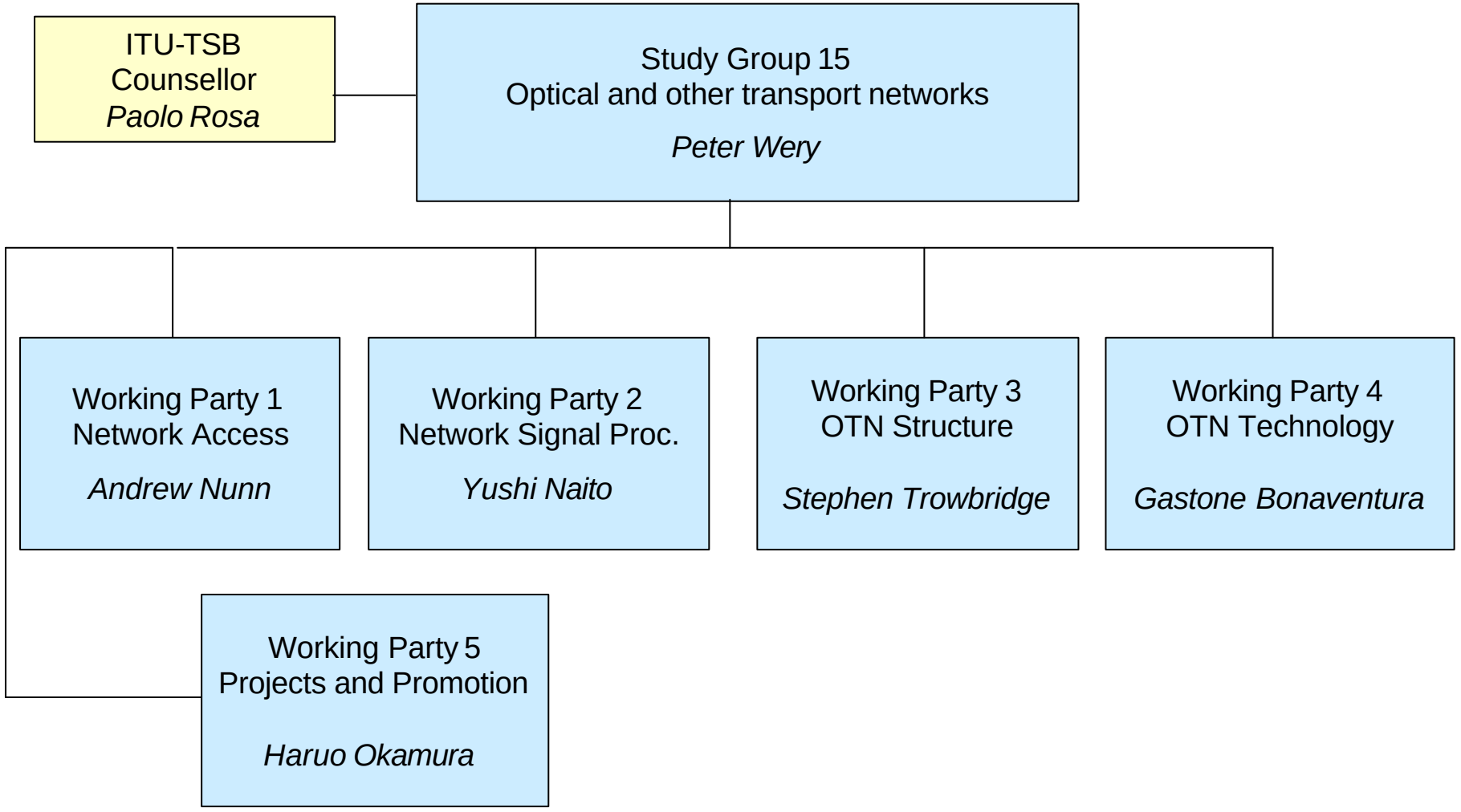
ITU-T Study Group 15 Structure

http://www.itu.int/ITU-T/studygroups/com15/index.asp



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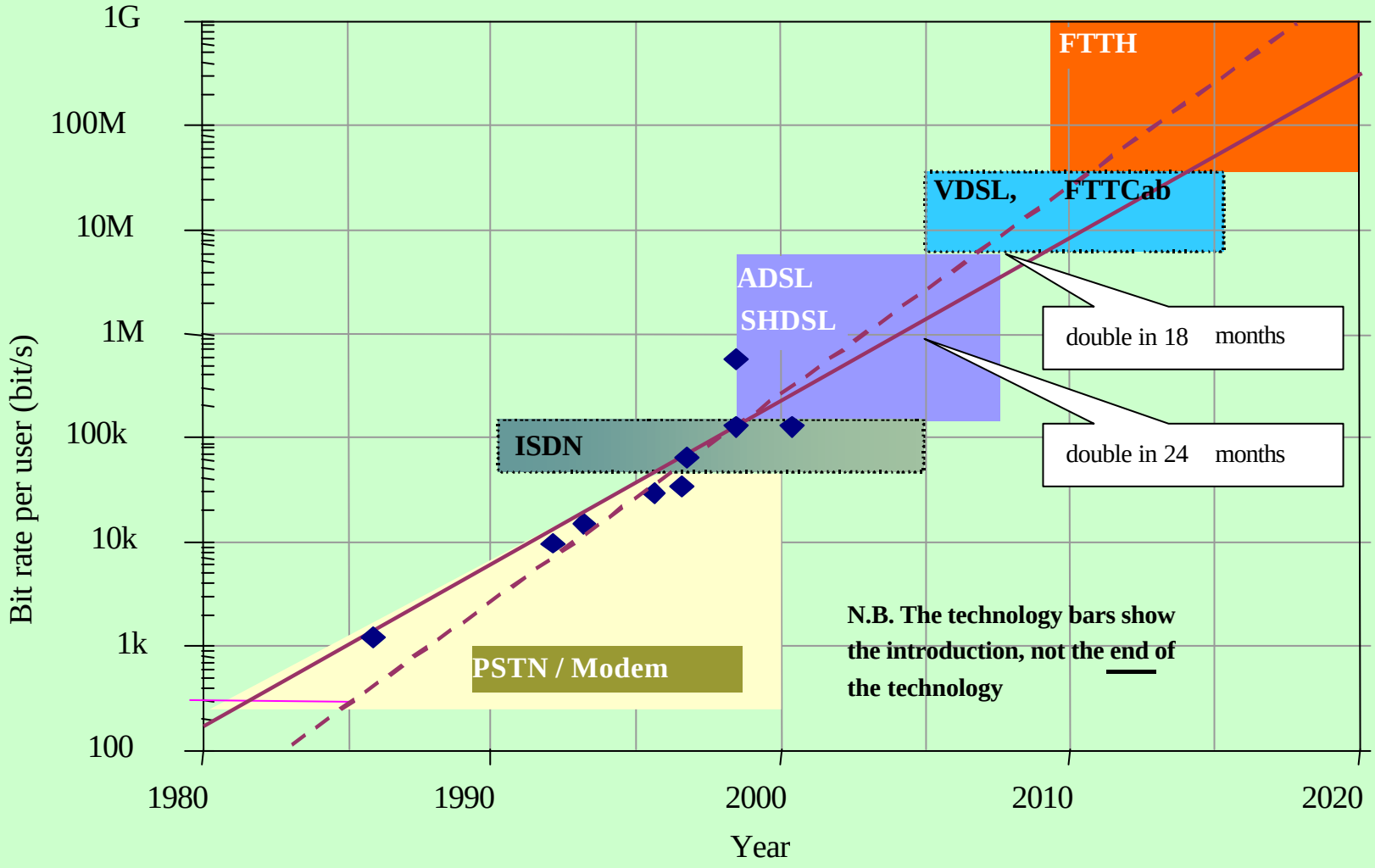
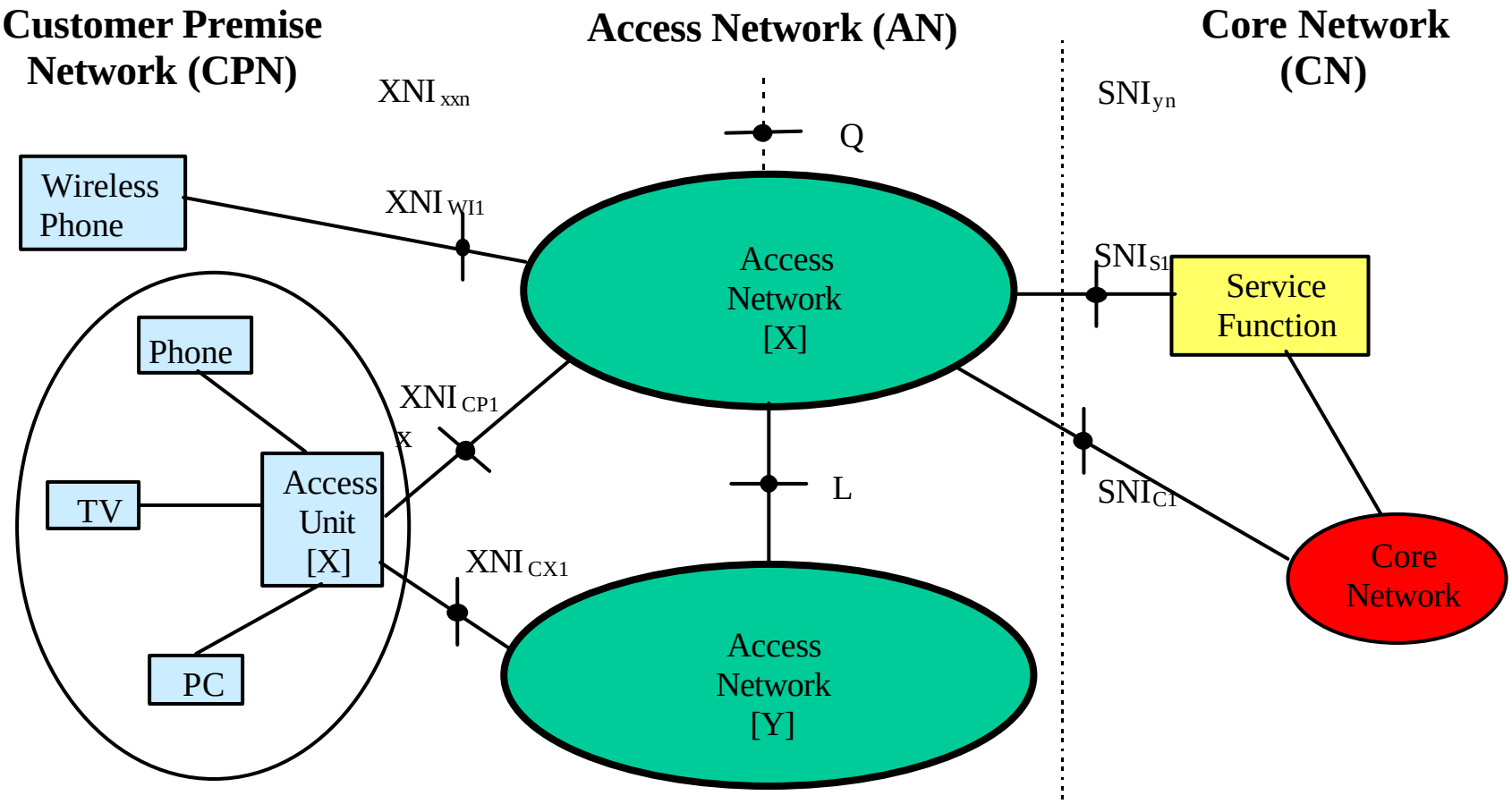
Capacity, technologies & availability



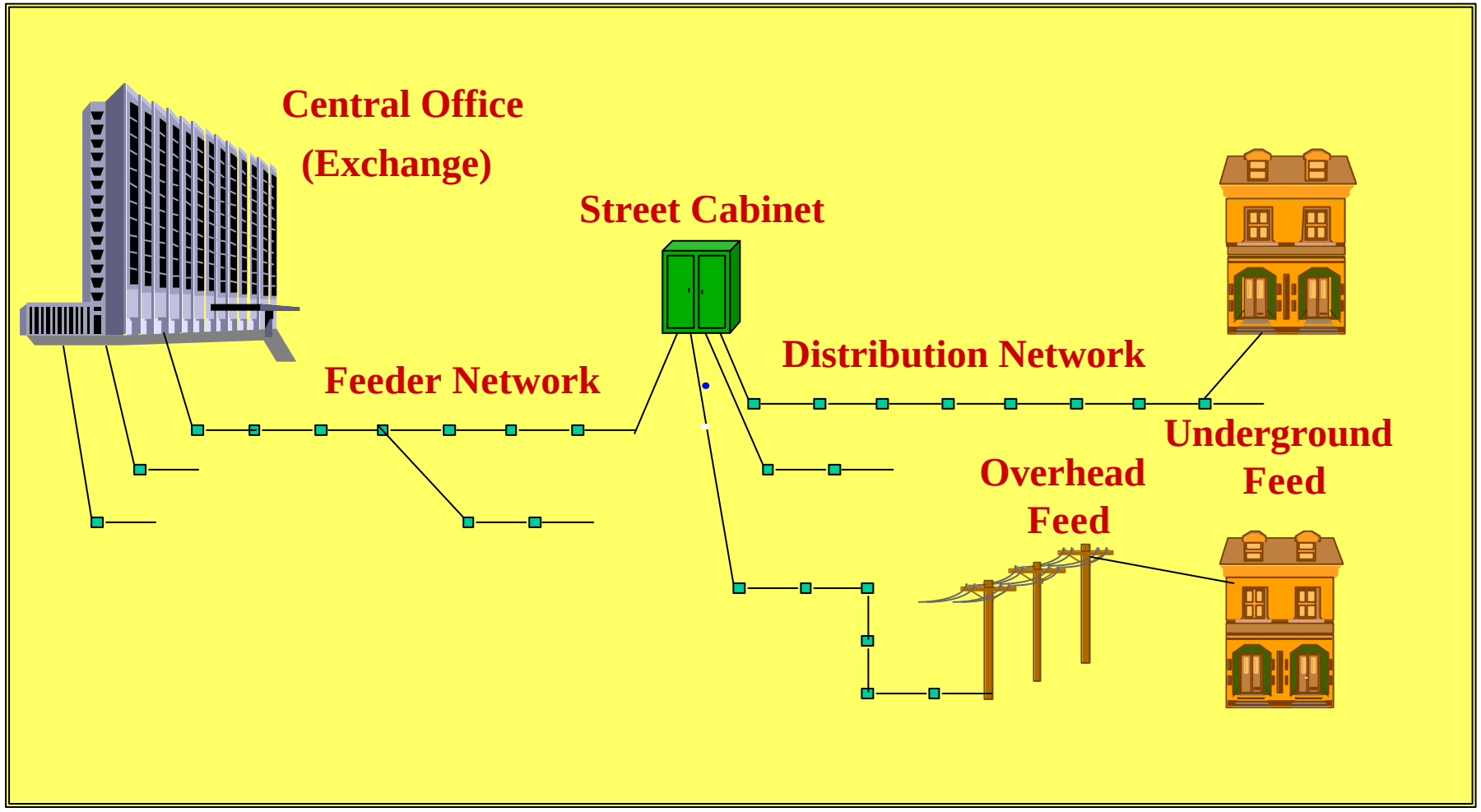
There will never be enough! The bandwidth demand will continue to grow. Fiber to the home will be necessary sooner or later.

Source Siemens

Access Network Transport Reference Model for Scenarios



Typical Access Network Construction



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Access Scenarios 1 - 2

	Scenario 1	Scenario 2
Services	a) Voice/Data over telecom network and Video over cable, radio&DSB b) Voice/Data/Video over 2-way cable	a) Voice/Data over telecom network and Video over cable b) Voice/Data/Video over 2-way cable
Core Network	Existing Infrastructure (PSTN/N-ISDN)	B-ISDN
Access network	a) 1-way Cable Distribution Network b) 2-way Cable Distribution Network DSB/terrestrial broadcasting in 1 a)	
CPN	Access Unit TV, PC, Phone	
Information Flow	a) Video Distribution over 1-way cable network, return via PSTN/ISDN	

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Access scenarios – 3 - 4

	Scenario 3	Scenario 4
Services	**Voice/Data & Video over ADSL/VDSL**	**Voice/Data & Video over Fibre Network**
Core Network	**B-ISDN**	**B-ISDN**
Access network	**ADSL/VDSL**	**Fibre (Fibre to the curb/home)**
CPN	**Access Unit TV, PC, Phone**	**Access Unit TV, PC, Phone**
Information Flow		

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Access Scenario 5

	Scenario 5
Services	**a) Wireless Phone Voice/Data over telecom network and Video over cable** **b) Voice/Data/Video over Radio**
Core Network	**N-ISDN or** **B-ISDN**
Access network	**Radio/Wireless** **for Voice/Data - Cable for a) Video**
CPN	**Access Unit** **TV, PC, Phone, wireless Phone**
Information Flow	**2-way wireless**

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Access Scenarios 6 - 7

	Scenario 6	Scenario 7
Services	**B-ISDN, Internet and Mobile Phone via Satellite**	**a) Data over Internet Voice/Video and/or Data over Internet**
Core Network	**B-ISDN or Existing (N-ISDN)**	**a) POTS/FR/ATM b) ATM Backbone**
Access network	**Satellite**	**a) ADSL/VDSL b) PSTN/ISDN, HFC, PON c) Fixed wireless Access**
CPN	**Access Unit: TV, PC, Phone**	**Access Unit: TV, PC, Phone**
Information Flow	**2-way satellite**	

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ADSL 2

- Performance
  - Downstream: 8 Mbit/s to 15 Mbit/s
  - Upstream: 800 Kbit/s to 1.5 Mbit/s
  - Data rate on long distances
- Improved initialization
- Fast Start up : 3 seconds
- Fast return to L0 status full operation (0.5 s)
- Additional 256 Kbit/s upstream data rate
- In-line filters for home installation
- Backwards/Legacy compatibility

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ITU-T Recommendations on ADSL (1)

- **G.991.1** (G.hdsl) - High bit rate Digital Subscriber Line (HDSL) transmission system on metallic local lines.
- **G.992.1** (G.dmt) - Asymmetrical Digital Subscriber Line (ADSL) Transceivers.
- **G.992.2** (G.lite) - Splitterless Asymmetrical Digital Subscriber Line (ADSL) Transceivers.
- **G.992.3** Asymmetric digital subscriber line transceivers - 2 (ADSL2.dmt)
- **G.992.4** Splitterless asymmetric digital subscriber line transceivers - 2 (ADSL2.lite)

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ITU-T Recommendations on ADSL (2)

- **G.992.5** – Asymmetric Digital Subscriber Line (ADSL) Transceivers – Extended Bandwidth ADSL2 (ADSL2plus) (Jan '03)
- **G.995.1** - Overview of Digital Subscriber Line (DSL Recommendations).
- **G.991.2** (G.shdsl) - Single pair High bit rate speed Digital Subscriber Line
- **G.993.1** (G.vdsl) - Very high bit-rate Digital Subscriber Line
- **G.994.1, G.996.1** and **G.997.1** for tests, management and handshake

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Optical Systems for Access Networks Market & Business Drivers (1)

- Getting PSTN, data and cable TV together on one system at competitive prices
- Fibre To The Home (FTTH), to the Curb (HTTC) to the Business (HTTB) are the next step for many operators
- The major change is driven by the explosive growth of the Internet usage
- Public and private networks evolve from multiple overlay networks to a unified network platform able to carry multiple applications

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Optical Systems for Access Networks
Market & Business Drivers (2)

- IP routers and ATM switches are providing higher and higher speed optical interfaces
- Major carriers are realizing that services at **STM-16 (2.5 Gbit/s)** optical pipes may well represent more than **50% of the bulk bandwidth** entering networks in the near future
- The new high speed data requirements are requiring a new category of Wavelength Services
- These new services will require new networking functions (performance monitoring, fault localization, network restoration, etc)

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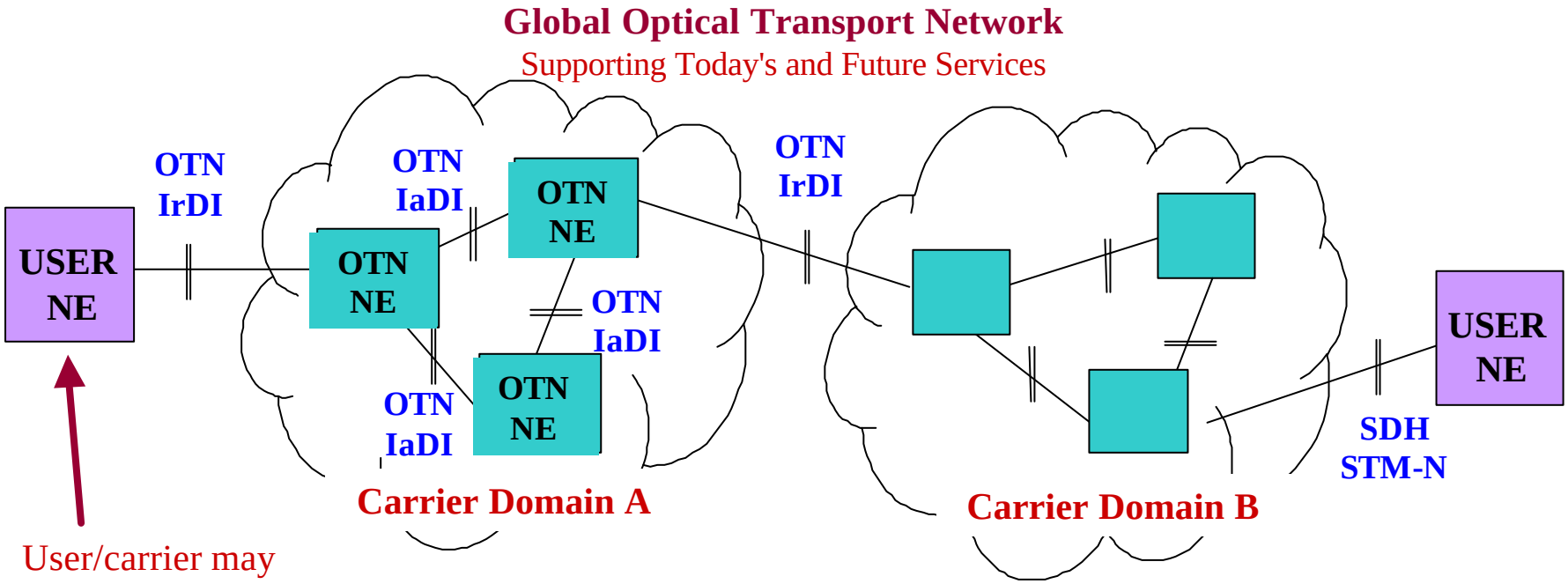
OTN Standardization Work Plan



User/carrier may originate/terminate the OTN framing for any digital payload (IP, ATM, SDH,,,)

IaDI = Intra-Domain Interface
IrDI = Inter-Domain Interface
NE = Network Element
Interfaces:For single/multichannels with performance monitoring

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Key aspects for optical technologies

- IP over optical, business and market aspects
- Switched optical networks
- Optics in access and metropolitan networks
- Optical interfaces
- Optical/IP network OAM and protection and restoration
- WDM and C&D-WDM
- Signalling and routing
- Optical fibres, cables and components
- Optical network management
- Optical switching equipment
- Network performance (IP/Optical)
- Optical network clients and services
- Services and network evaluation

→ *Making fully-optical networks viable*

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OTN Structure and Technology

- Optical Transport Network (OTN) structure
  - Automatic Switched Optical Network (**ASON**)
  - Architecture and interfaces for the OTN
  - Optical Cross-Connect and Switch functions
  - Network management and control
- OTN technology (terrestrial and submarine)
  - Coarse and Dense WDM, **40 Gbit/s** signal channels
  - Optical components & amplifiers (e.g. tunable filters)
  - Fiber characteristics, more channels/fiber
  - Transmission technology (Soliton/RZ), long reach

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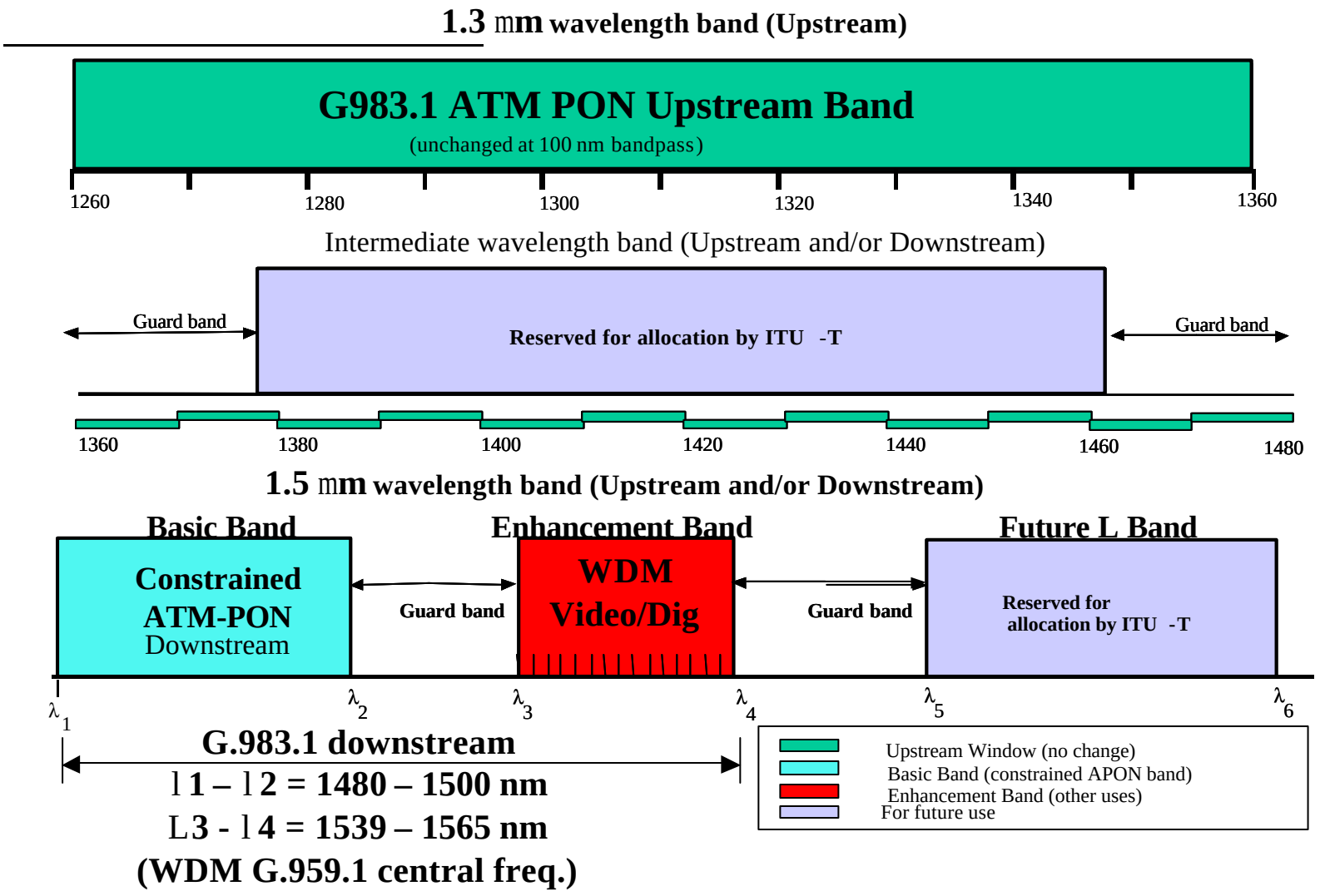
G.983.3 wavelength allocation



G.983.4 – Dynamic Bandwidth Assignment

- Improves efficiency of upstream
- Adjust bandwidth among Optical Network Units in response to bursty traffic requirements
- More customers to the PON
- More efficient utilization
- Possibility of enhanced services (BW peaks) beyond the fixed allocation
- Symmetrical 155 Mbit/s
- Asymmetrical up 155 Mbit/s down 622 Mbit/s

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Optical systems for access networks
Broadband PON: G.983.x-series Recs.

- **Passive Optical Network up to 622 Mbit/s symmetrical / asymmetrical**
- Supports wide range of **narrow- & broadband services** like:
  - PSTN / ISDN / Multiple Line
  - Data / LAN interconnection / High speed Internet (~100 Mbit/s)
  - Cable TV / Video on demand (up to 400 TV channels on single wavelength)
  - Videoconferencing
- **Independent from bit rates, signal formats** (digital or analogue, SONET/SDH etc.) **and protocols** (IP, Ethernet, ATM etc.)
- Need to **deploy only the equipment at the ends** of the network **as needed** to add new services to existing customers or to add new customers.

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WDM Spectral bands (proposal)

definition for classification and not specification purposes

Band	Descriptor	Range (nm)
O-band	Original	1260 to 1360
E-band	Extended	1360 to 1460
S-band	Short Wavelength	1460 to 1530
C-band	Conventional	1530 to 1565
L-band	Long Wavelength	1565 to 1625
U-band	Ultra-long wavelength	1625 to 1675

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Recommendation G.983.3
(Enhancement band)

- Defines new wavelength allocations to distribute WDM and additional service signals simultaneously.
- Allows distribution of video broadcast services or data services without disturbing basic ATM-PON system
- Potentially provides unidirectional and bi-directional services.
- New reference points and optical interface parameters for new WDM and/or optical power splitter/combining functions at OLT and/or ONU sites.
- Full compatibility with the G.982 and G.983.1.
- Central frequencies => Recs. G.959.1 and G.692

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G-PONs (Cont'd)

- **Operating wavelengths**
- ***Downstream direction***
- single fibre systems shall be 1480 - 1500 nm.
- two fibre systems shall be 1260 - 1360 nm.
- ***Upstream direction***
- The operating wavelength range for the upstream direction shall be 1 260 - 1 360 nm.

Physical/Optical parameters

fibres, lasers, detectors, Pin, sensitivity, margins etc, in G.984.2

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G.PONs (cont'd)

- Improved interoperability – One-to-Many
- Symmetric/Asymmetric
- Backward compatibility to G.983.1
- Fast start-up for initialization
- Increased network capacity
- More efficient IP and ethernet handling
- Video-on-demand, streamed video, games, voice over IP, distance learning, telemedicine
- Less expensive, more reliable
- VDSL, other xDSL backhaul

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G.984.1 – General Characteristics of Gigabit-capable PONs

Describes flexible optical fibre access networks capable of supporting the bandwidth requirements of business and residential services

G.984.2 –Gigabit-capable PONs: Physical media dependent layer specification

General characteristics of a G-PON such as architecture, bit rates, reach etc.

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Metropolitan Optical Network

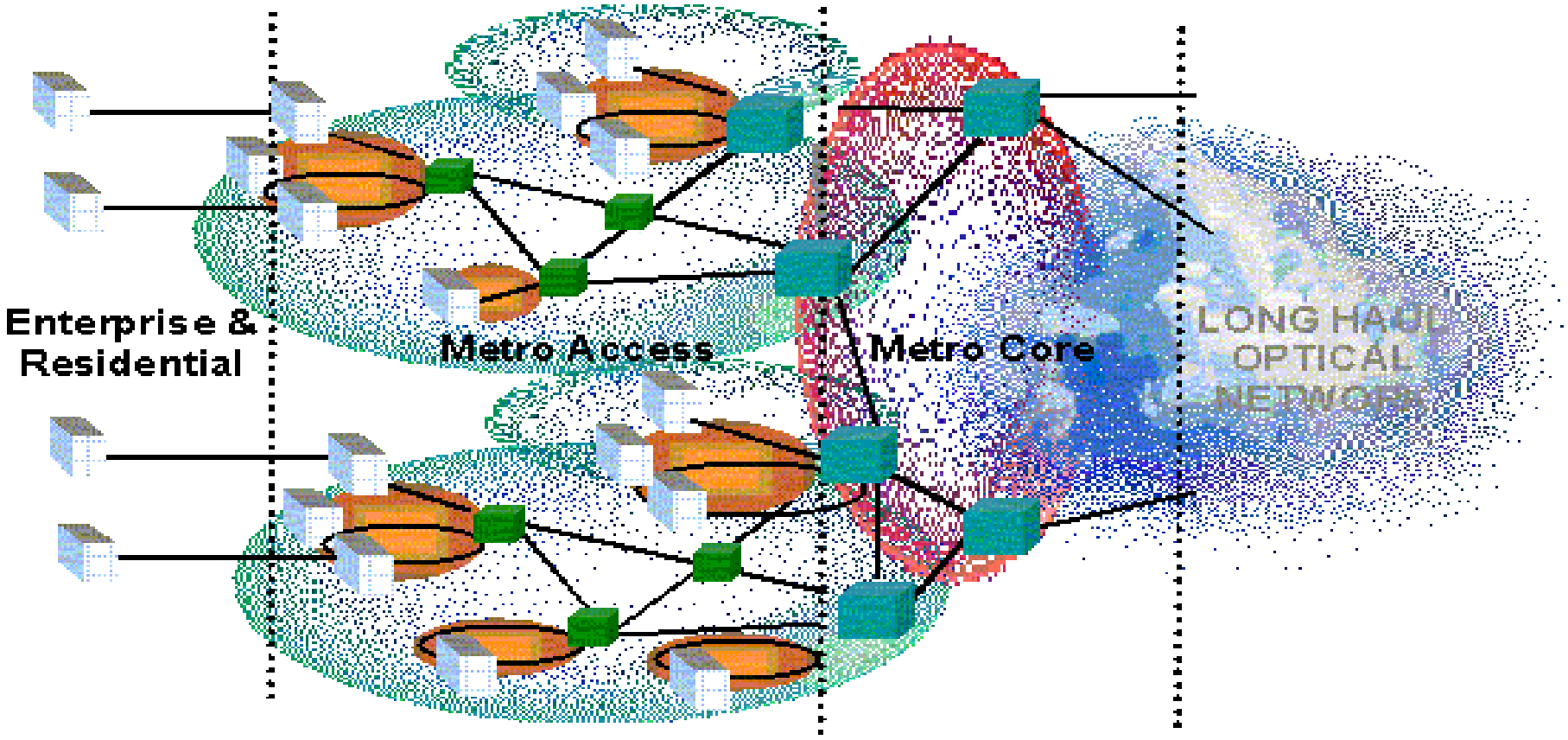
Short to medium length distances in metropolitan areas. That is, typically, within the limits of a single optical span and often less than 200km distance. signal regeneration, in-line amplification and error correction are of lesser importance than in Long Haul Optical Networks

Maximized coverage commensurate with low cost connectivity

Combined with the wider variety of client signals is a key driver for flexible aggregation (e.g., 100Mb-1Gb rate), higher bandwidth interfaces for inter office

Bandwidth-on-demand services, and multiple classes-of-services leading to further topology and technical considerations.

Metropolitan Optical Network



Access Network
Collection, Consolidation &
Grooming of Access Traffic

Metro Core
Interconnect of Collector POPs
with the Long Haul Optical Network