FTTH Technology Considerations

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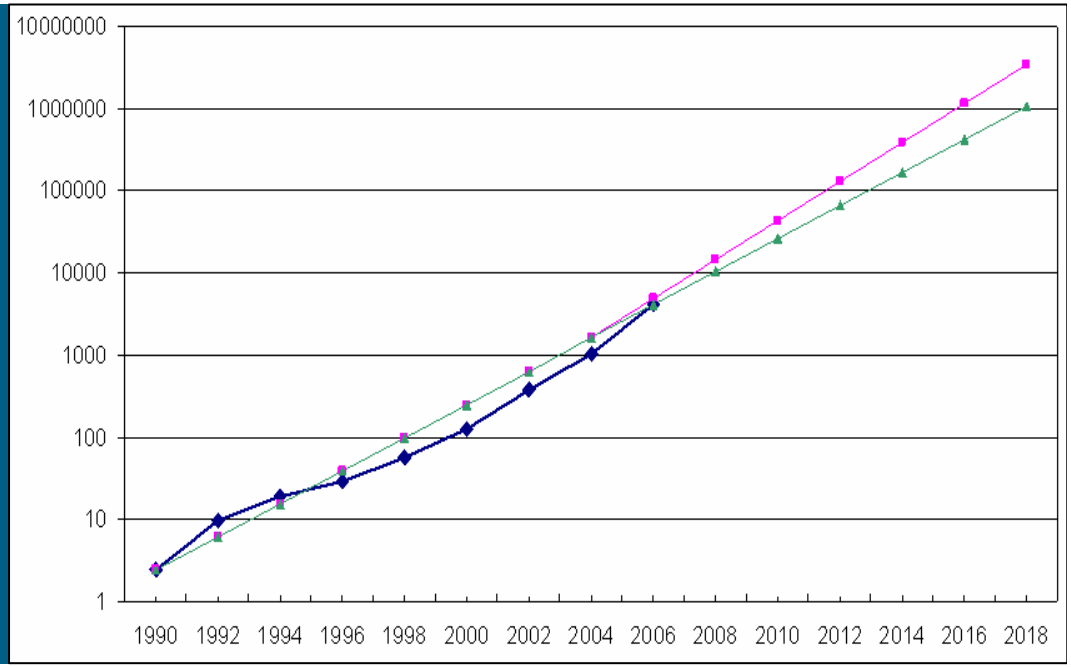
Trends for access bitrates



Video as a major driver for high access bitrate requirements

- What kind of video?
- TV – broadcast, video on demand
  - SDTV
  - HDTV
- Video / image up-/ download (YouTube & Co.)
- Remote collaboration on video content
- Video / image e-mail
- Video surveillance
- Gaming
- Remote health-care via High-Definition Telepresence, ...
- ...

Video-related access bitrate requirements

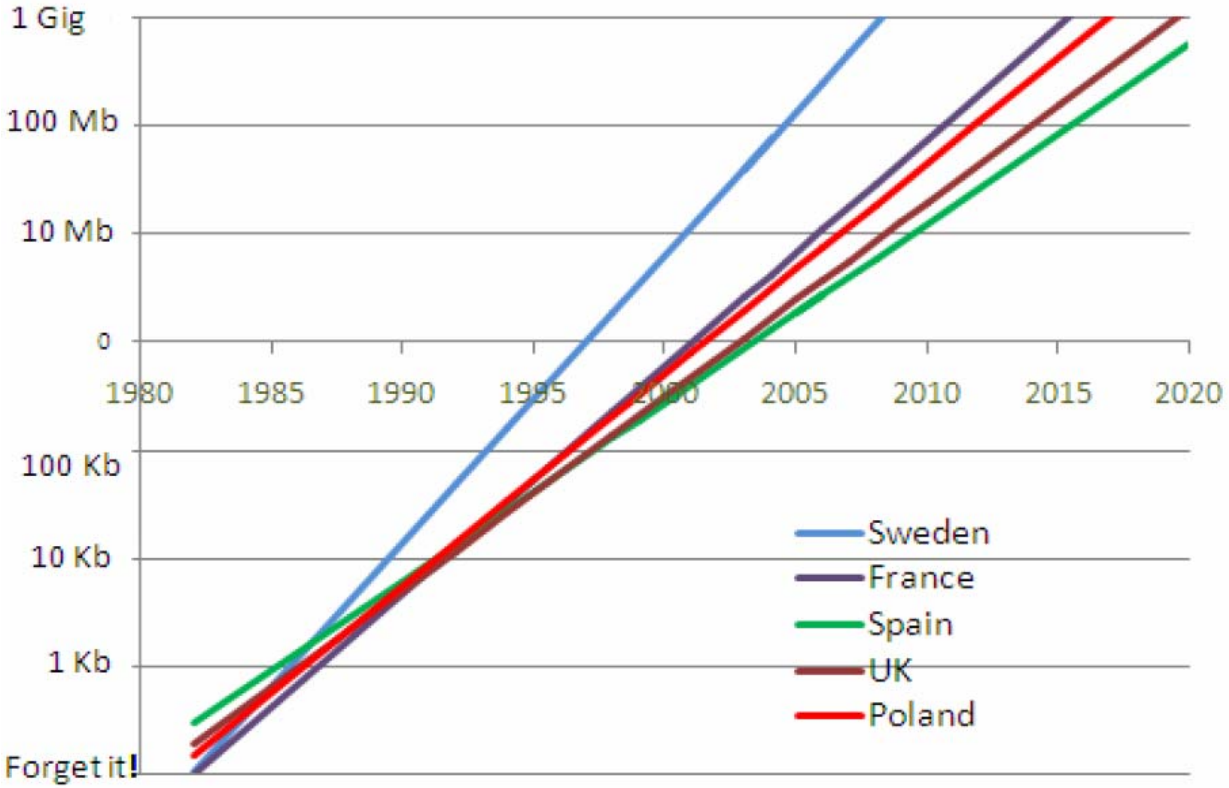
- “Video” is more than just TV
- Video related applications and services will determine access bitrate requirements
- Need to support multiple video applications concurrently in a household
- Content will become more and more “high definition”
- Majority of video applications require symmetrical access bitrates

Nielsen's law: bitrate growth differentiated

- Nielsen's law

  high-end users' connection speeds grow 50% YoY

  mass market lags high-end by 2...3 years



Source: Usage of Broadband Study, Ventura

Requirements for a future-proof FTTH solution

- Support for

  growing bitrate requirements ... *50% YoY*

  => DSL technologies will reach their limits during the next decade

  over the lifetime of the fiber plant ... *>40 years*

  without any major modification of the passive infrastructure
  ... *no introduction of additional components in the fiber plant*

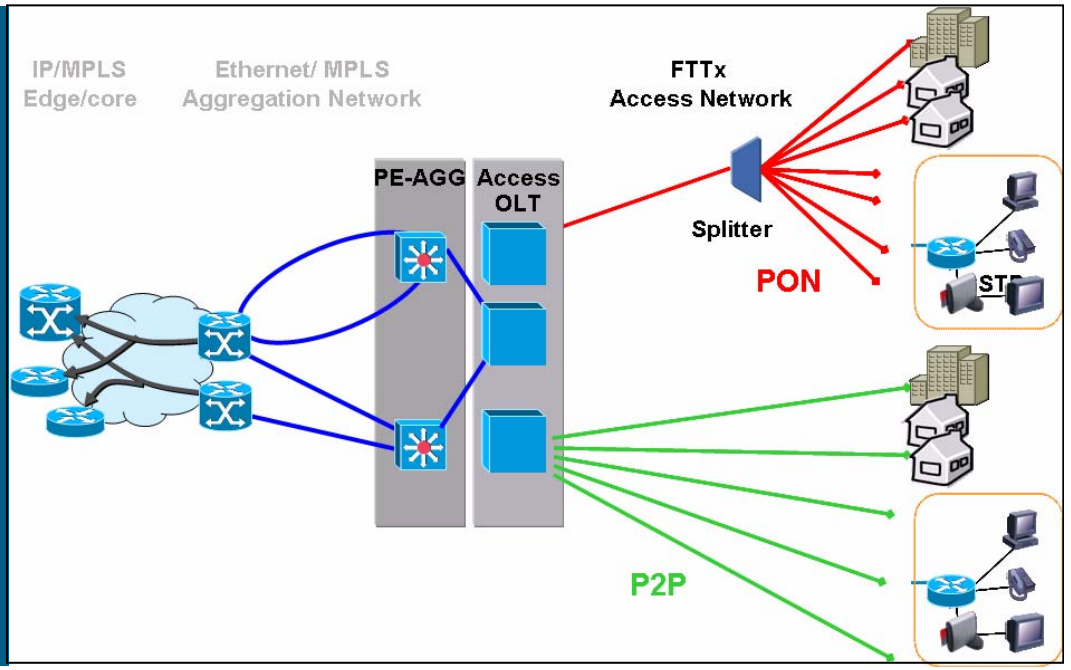
  easy upgrade of transmission speeds
  ... *on a per-customer basis*

- Easy management

  simple trouble-shooting

  self-installation of CPEs

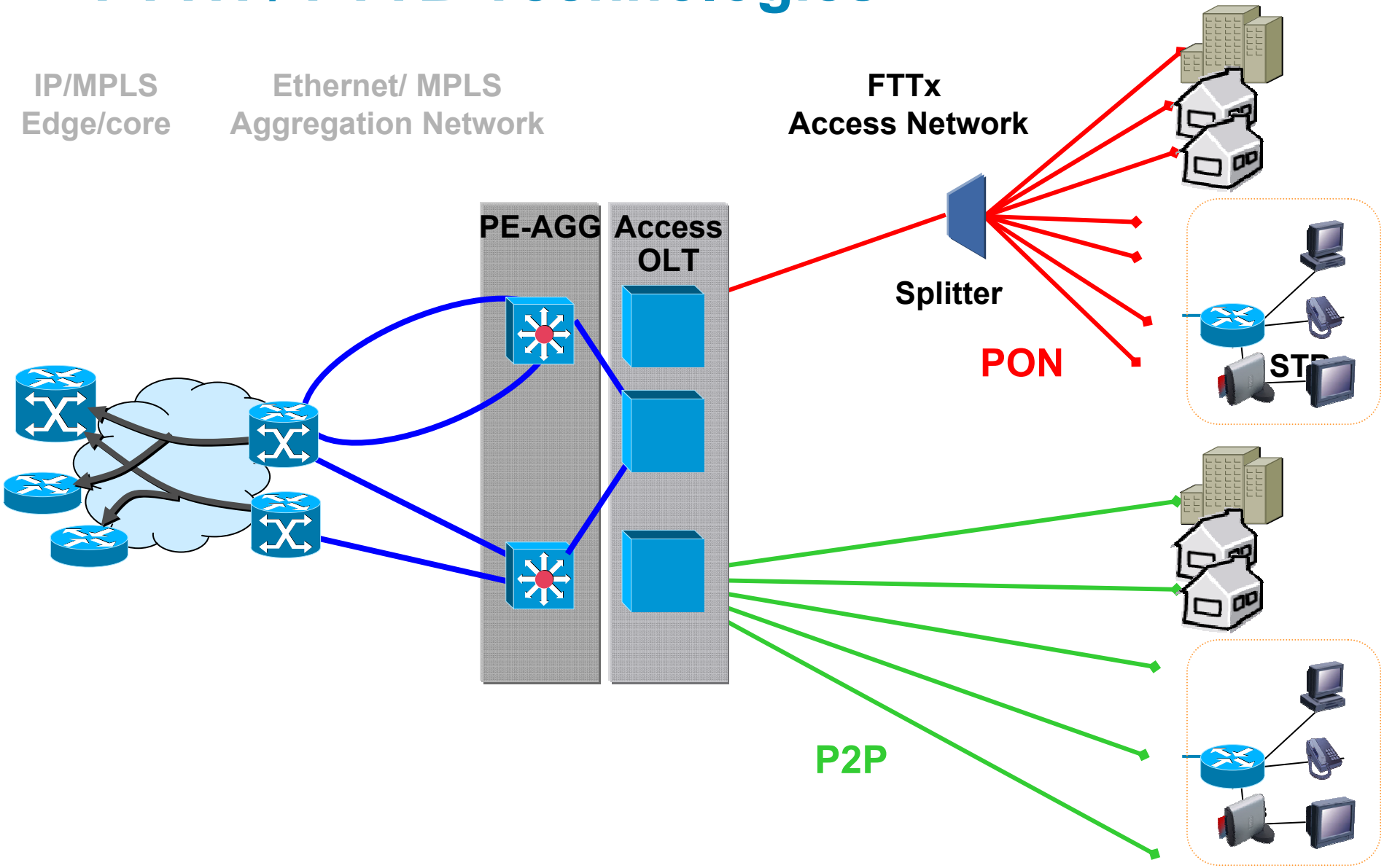
Technology considerations



Classification of FTTx approaches

	Dedicated Medium	Shared Medium / Tree
Dedicated Bandwidth	**Ethernet Point-to-Point**	**WDM-PON**
Shared Bandwidth	**(Active Ethernet) FTTB / FTTC**	**TDM-PON**

FTTH / FTTB Technologies



Technological evolution

	Dedicated Medium	Shared Medium / Tree
Dedicated Bandwidth	**Fast Ethernet Gigabit Ethernet**	**n * Fast Ethernet / DWDM (n≈32)**
Shared Bandwidth	**Gigabit Ethernet backhaul**	**EPON GPON**

Technological evolution

	Dedicated Medium	Shared Medium / Tree
Dedicated Bandwidth	**10 Gigabit Ethernet**	**n * Gigabit Ethernet / DWDM (n≈32)**
Shared Bandwidth	**10 Gigabit Ethernet backhaul**	**n *GPON / WDM (n≈4)**

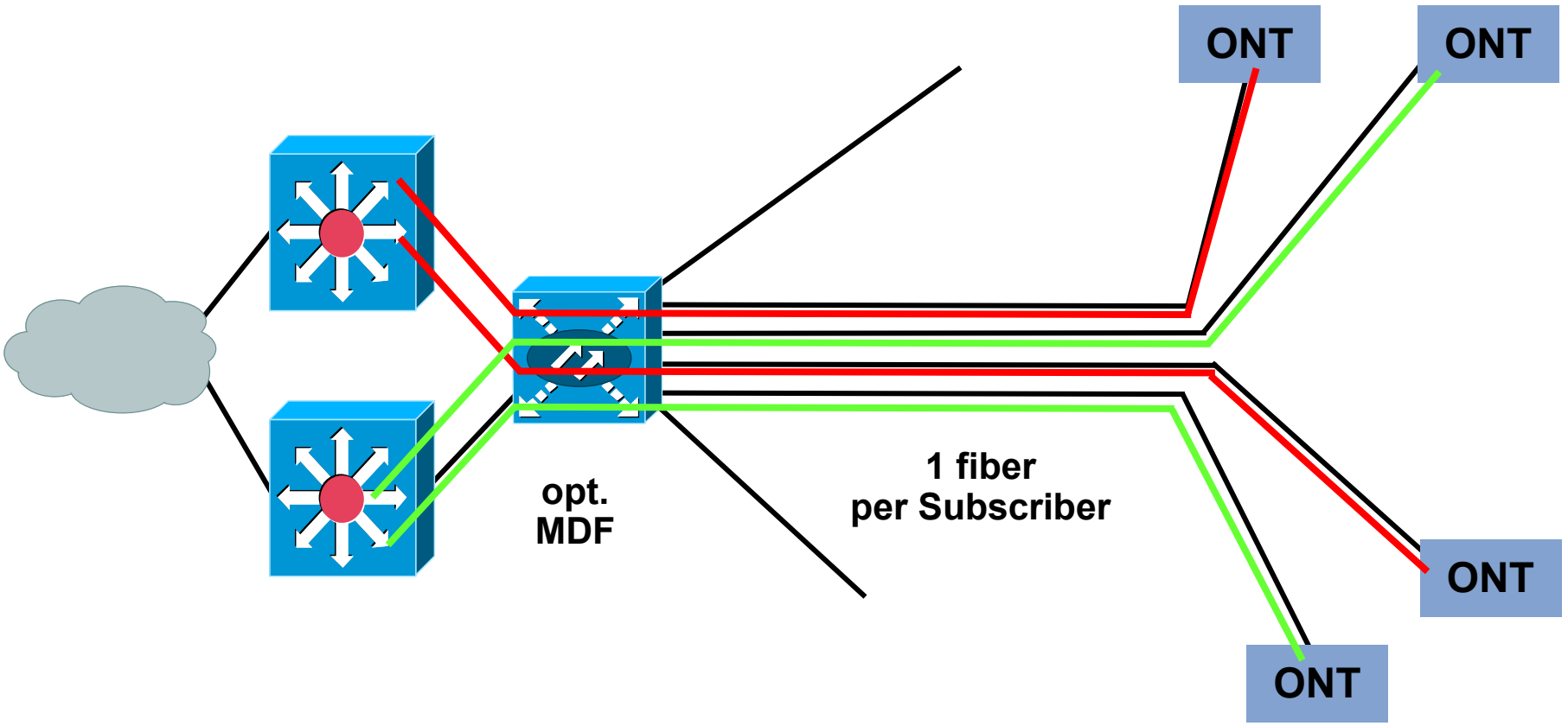
Technological evolution

	Dedicated Medium	Shared Medium / Tree
Dedicated Bandwidth	**10 Gigabit Ethernet**	**n * 10 Gigabit Ethernet / DWDM (n≈32)**
Shared Bandwidth	**10 Gigabit Ethernet backhaul**	**10GEPON 10G-PON**

Characteristics and sweet spots of FTTH technologies

	Ethernet p2p	Active Ethernet	TDM PON	WDM PON
Flexibility / per sub upgrade	+	-	-	+
Physical Open Access	+	-	-	+
OTDR troubleshooting	+	+	-	+
Security	+	+	-	+
Pay as you grow	+	+	-	+
Traffic management	+	+	-	+
Usage of feeder fibers	-	+	+	+
POP real estate	-	+	+	-
POP power consumption	-	+	+	-

Open fiber access is simple for point-to-point deployments



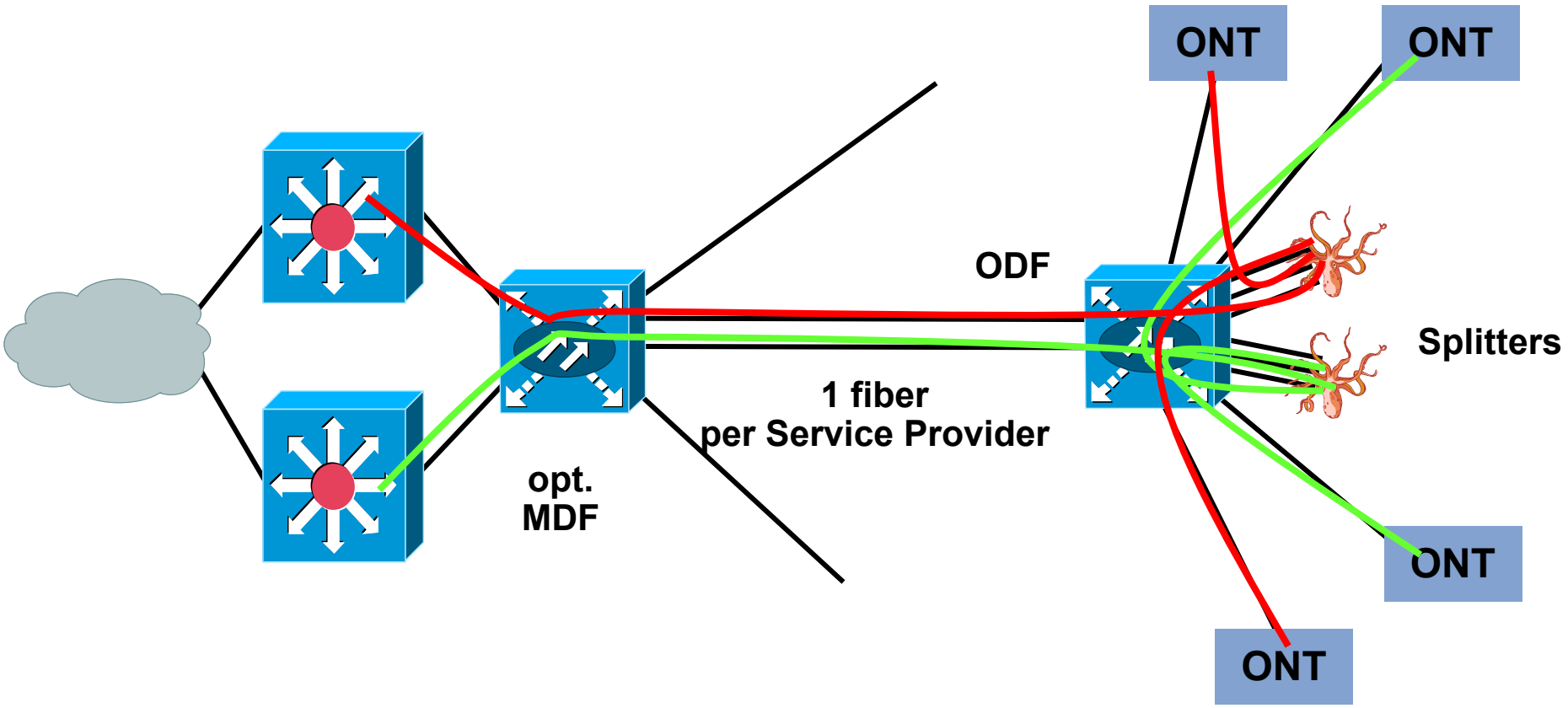
High-density fiber management example

- ODF for 2304 fiber terminations
- Rack for 1152 active fiber interfaces
  - 50% take rate
  - up to 100% take rate achievable with second switch rack

Source: Huber & Suhner

PON deployment – remote ODF with splitters: additional Capex and Opex for open fiber access

Open fiber access through SP-specific splitter in ODF and SP-specific feeder fiber



Remote ODF cabinet example

Source: FTTH Council Europe, FTTH Handbook

FTTH leadership in Europe: Technologies

At the end of 2008, FTTH architecture and Ethernet technology are clearly leading NGA deployments in Europe

Total Europe at end 2008

- **52.8% of subscribers on FTTH**
  (from 50.2% in June 2008)
- **47.2% of subscribers on FTTB**
  (from 49.8% in June 2008)
- **80.8% of subscribers on Ethernet**
  (from 83.8% in June 2008)
- **19.2% of subscribers on PON**
  (from 16.2% in June 2008)

Architectures FTTH & FTTB and choice of technology - PON & Ethernet (in % of subscribers as of December 2008)

	Architecture and technology deployed (in %)			
	FTTH	FTTB	PON	Ethernet
Andorra	100	0	100	0
Austria	80	20	0	100
Belgium	na	na	na	na
Croatia	90	10	10	90
Cyprus	100	0	100	0
Czech Republic	80	20	20	80
Denmark	80	20	15	85
Estonia	50	50	100	0
Finland	50	50	0	100
France (*)	35	65	55	45
Germany	10	90	0	100
Greece	0	100	0	100
Iceland	100	0	5	95
Ireland	80	20	5	95
Italy	5	95	5	95
Latvia	100	0	na	na
Lithuania	0	100	0	100
Netherlands	90	10	5	95
Norway	100	0	0	100
Poland	100	0	0	100
Portugal	100	0	100	0
Romania	na	na	na	na
Slovakia	100	0	95	5
Slovenia	100	0	0	100
Spain	100	0	100	0
Sweden	50	50	10	90
Switzerland	100	0	10	90
United Kingdom	100	0	na	na

(*) excluding Numericable

Source: IDATE for FTTH Council Europe

Benefits of point-to-point deployments

- Simplicity
- Virtually unlimited bitrate per subscriber
- Fiber is neutral with respect to transmission technology (Ethernet, SDH, FiberChannel, PON, ...)
- Migration to higher speeds or new technologies on a per-customer basis
- Pay as you grow
- Open Access to fiber inherently embedded in the architecture

Flexible

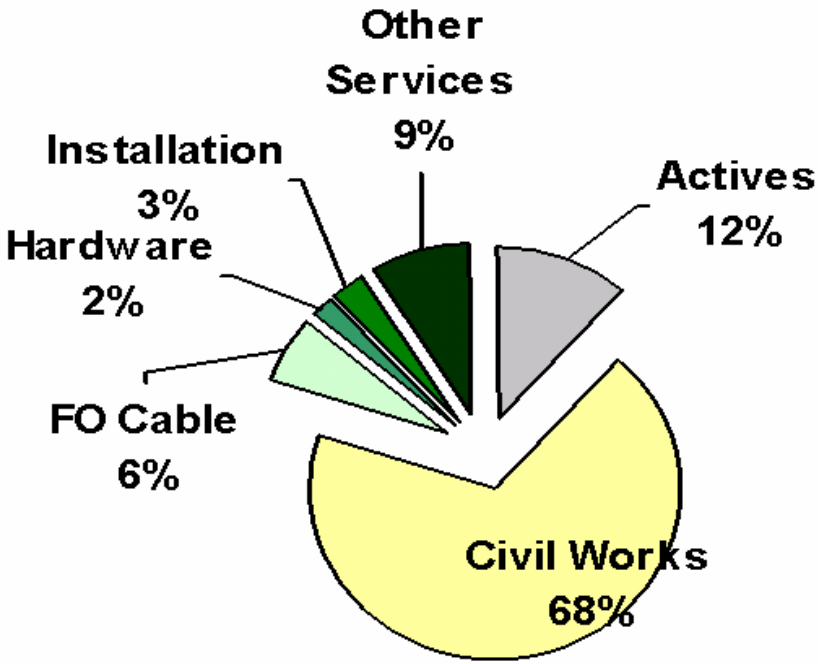
Future Proof

Cost considerations

Cost considerations for Ethernet point-to-point access networks

- Ethernet technology is very cost-effective due to high volume manufacturing
- Modern Ethernet switches provide high port density
- Fiber is cheap
- Very dense fiber management solutions reduce space requirements
- Only ports for paying subscribers need to be installed

  => take rate!
- Cost difference to PON only significant where existing ducts are "just big enough" for PON
  => civil works for p2p



Source: Corning & FTTH Council Europe

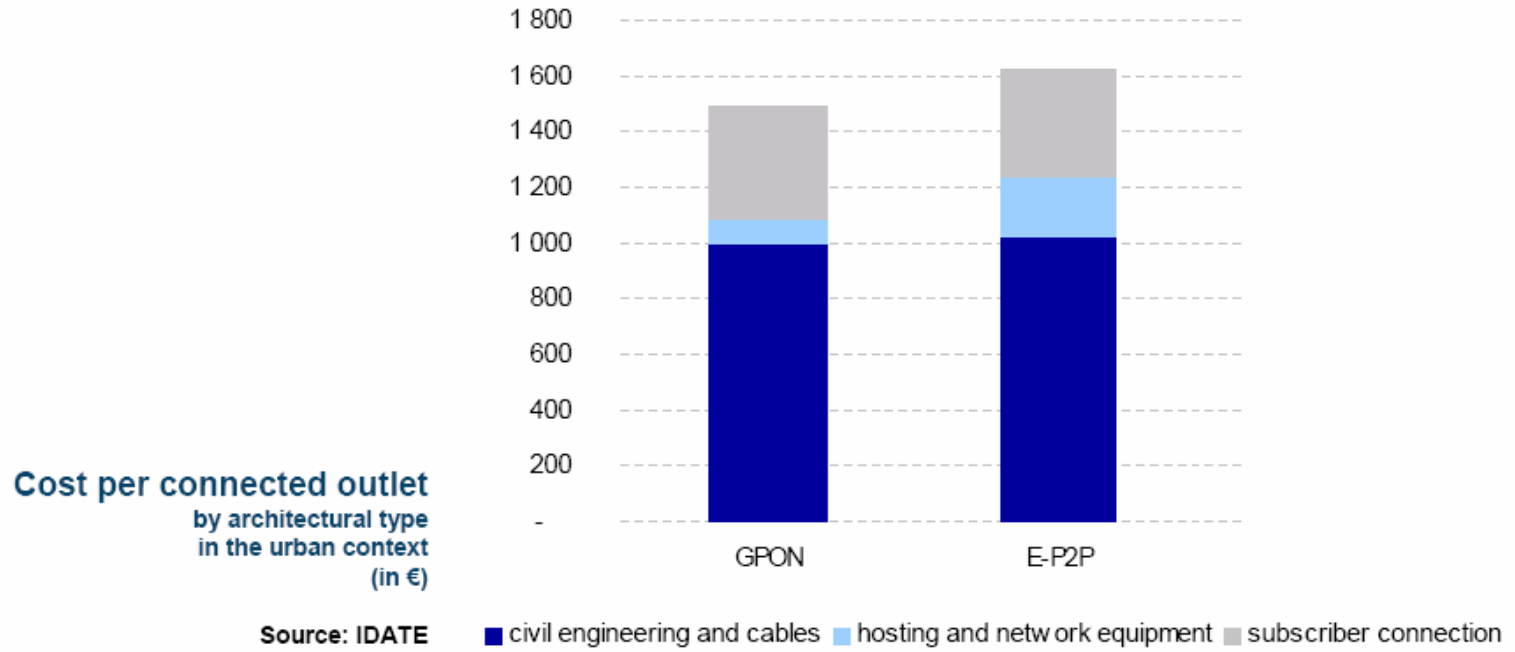
Case study of real European urban deployment

Scenario	p2p cost (€M)	GPON cost (€M)	p2p cost difference
Plenty of ducts (little civil works needed for both)	91	87	5%
Limited ducts (more civil works needed for p2p)	109	87	25%
No ducts (civil works needed for both)	140	137	2%

Data represents net present value of costs over 10 years
Source: Cisco IBSG

Independent cost analysis

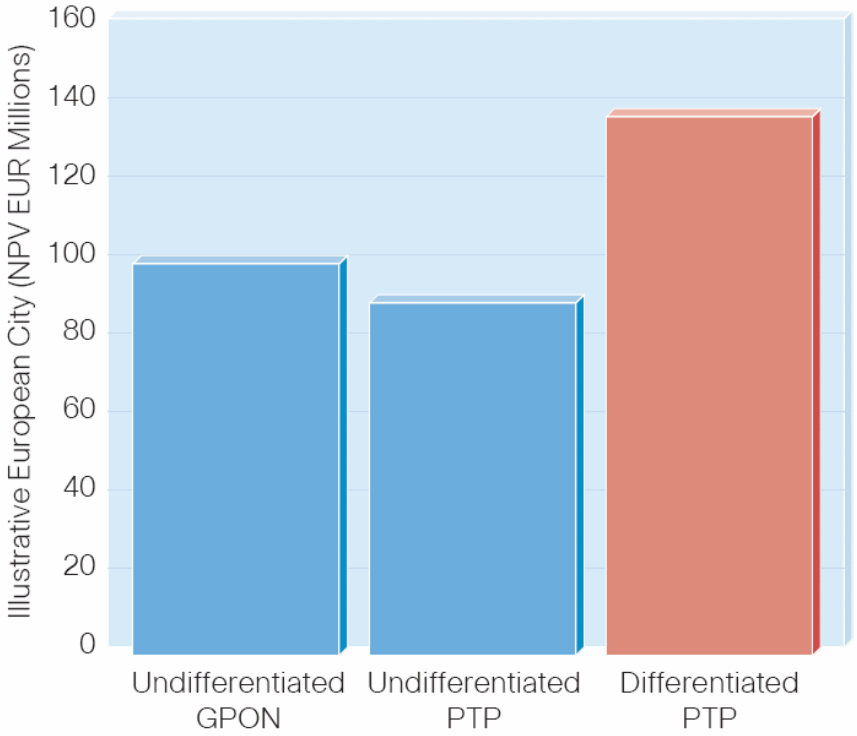
Costs of different FTTH solutions are quite similar



Cost per connected outlet
by architectural type
in the urban context
(in €)

Source: IDATE

NPV analysis



Components of differentiation:

- easier operation of point-to-point networks
- easier migration of individual customers to higher bitrates
- improved penetration rates of fiber plant due to open access to fiber

Source: Cisco IBSG

Summary

Conclusion

- Fiber deployment to residences and SMBs is a large investment into the future
- Changes in the access network architecture are very costly
- Deployment of a new access network should take into account the known mechanisms for bitrate growth
- The choice of fiber topology and architecture has a long-term impact on the capabilities (i.e. achievable bitrates) and the competition scenarios enabled
- Shared medium architectures should only be deployed if dedicated fiber solutions are not economically viable