



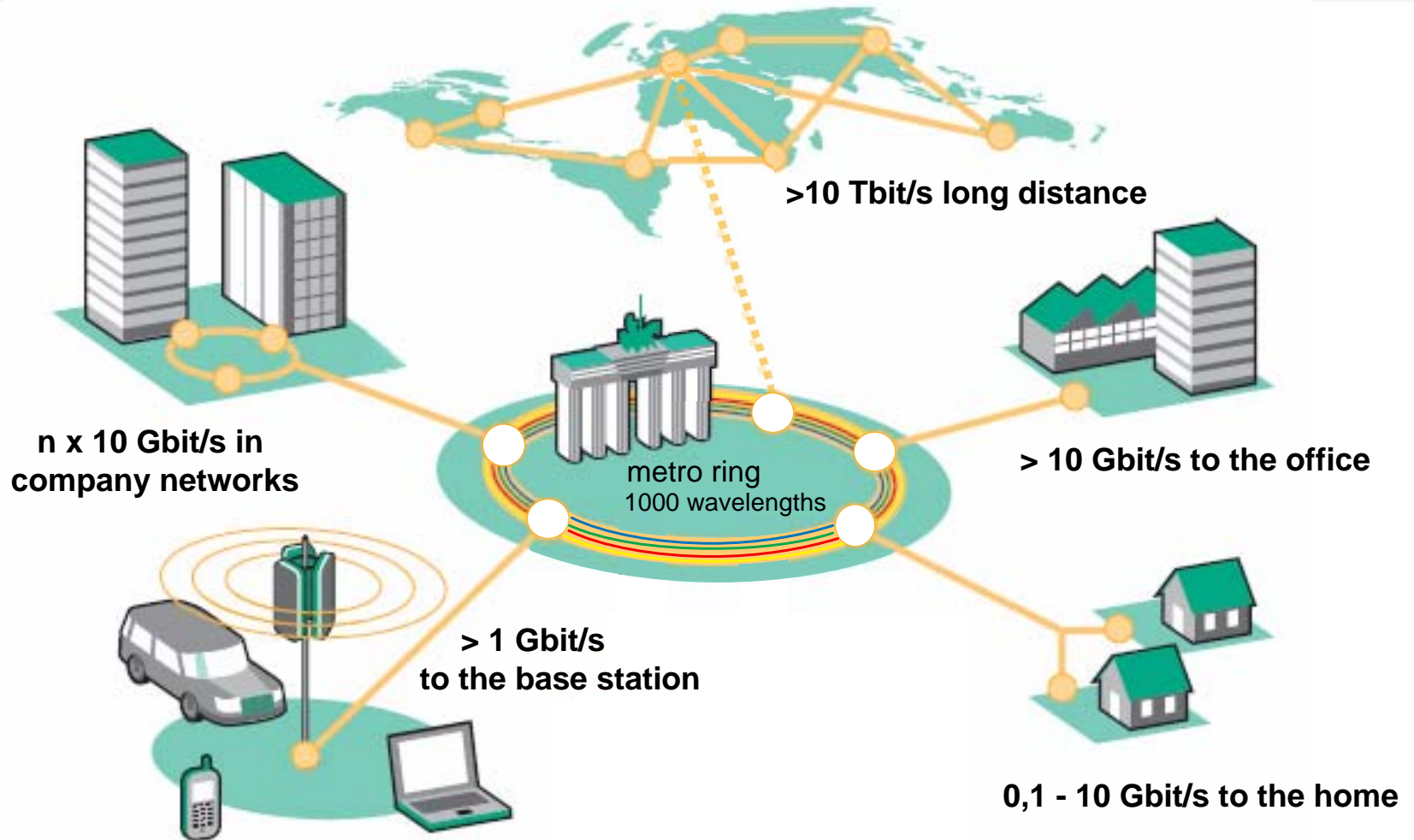
Access Networks for 10 Gbps everywhere

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Fraunhofer Institute for Telecommunications**

Future Global Network



Outline

- **Introduction**
- **Bandwidth requirements**
- **FTTH requirements and network structures**
- **In-house and home networks**
- **Conclusion**



Bandwidth Requirements

Bandwidth requirements mainly defined by:

- **Information content to be transmitted per time unit (image, video, voice, text,)**
- **Response time (interactive services: human – human, human – machine)**



New Services

- **Peer to peer transmission of high resolution pictures and movies**
- **Web-TV**
- **Super-HDTV**
- **3D-HDTV**
- **High-quality immersive video conferencing**
- **....**



High-quality Immersive Video Conferencing



Folie 6

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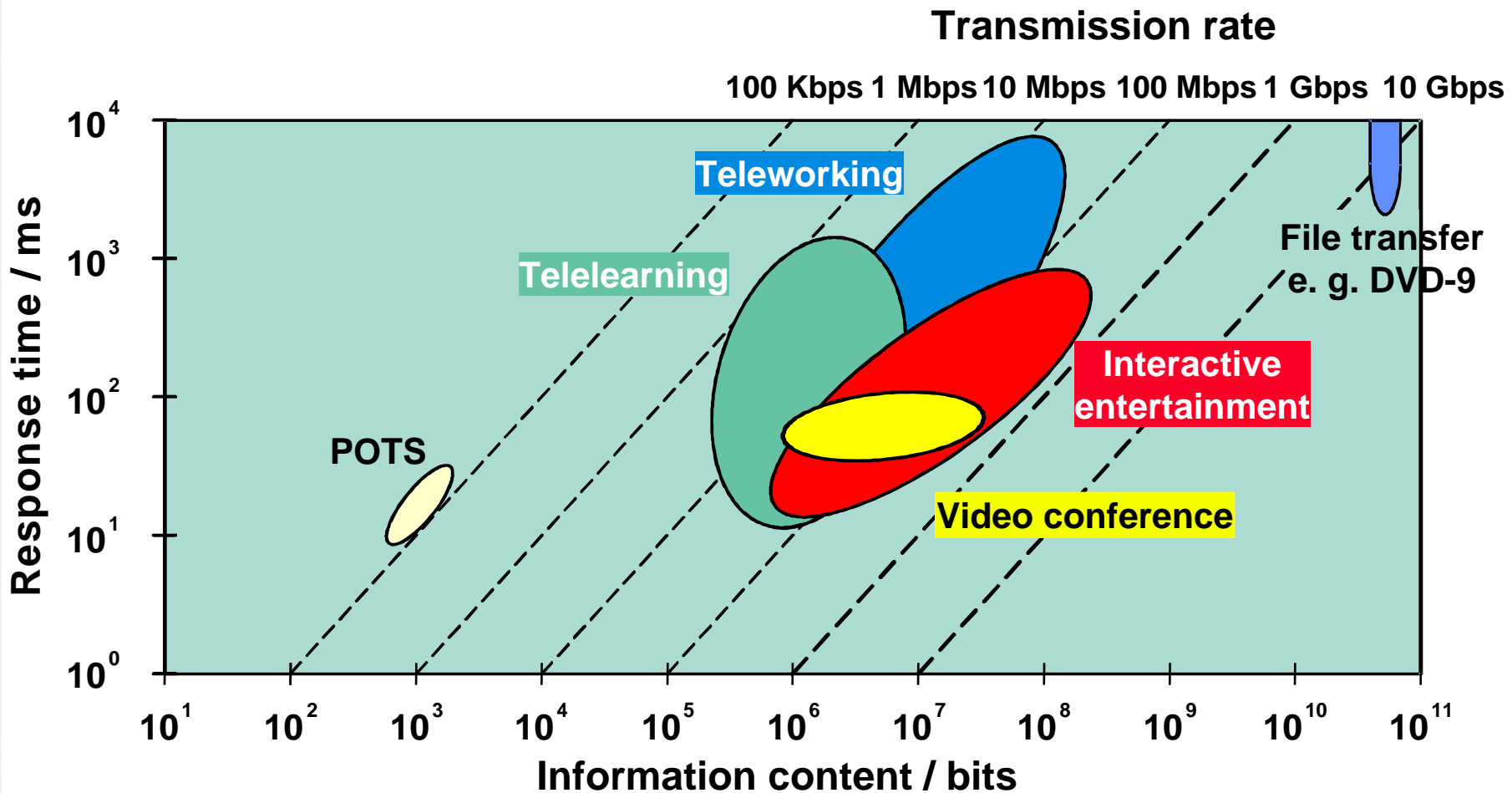
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HDTV vs Super-Hi-Vision

	HDTV	Super-Hi-Vision (NHK)
• Resolution	1080 x 1920	4320 x 7680
• Data rate uncompress.	1,5 Gbps	24 Gbps
• Data rate compressed	10 Mbps	160 Mbps
• Europe premiere of Super-Hi-Vision at Olympia 2012		
• Super-Hi-Vision will reach private homes in 10 years		

Response Time and Transmission Rate



1 Gbps up to 10 Gbps everywhere

- **Future data rates for broadband access**
 - **private: 100 Mbps → 1 Gbps → 10 Gbps (long term)**
 - **business: n x 1 Gbps up to n x 10 Gbps**
 - **Fiber to the Home, Fiber to the Office**
 - **Fiber in the Home, Fiber in the Office**
- **Symmetrical access (downstream – upstream)**
- **Broadband access for everybody**

FTTH Requirements and Network Structures

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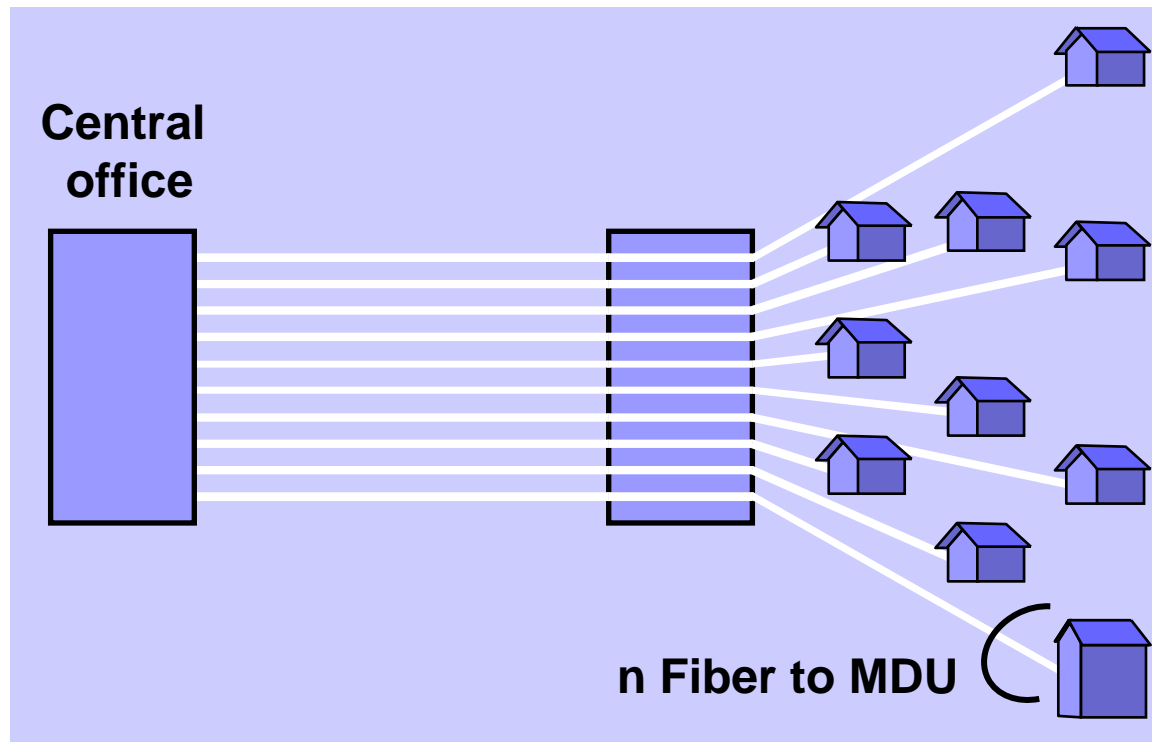
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Key Requirements for FTTH

- **Long lifetime of fibre plant, > 30 years up to 100 years**
- **Open access**
- **Scalability and flexibility**
- **Zero touch of fibre plant**
- **Uniform components and sub-systems**
- **Easy installation**
- **Low operation and maintenance**
- **High security and reliability**
- **High energy efficiency, low power consumption**
- **Low cost**



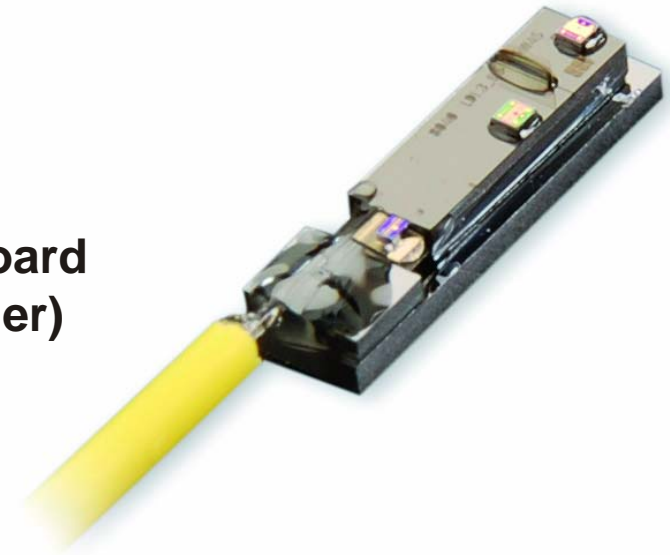
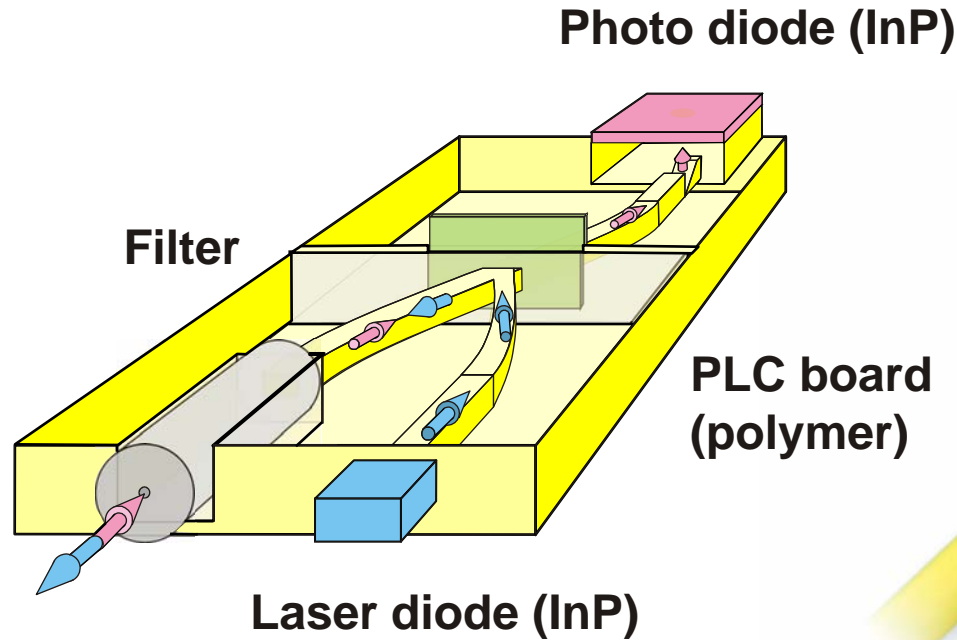
Home Run, Point to Point



- **Unlimited bandwidth**
- **Simple structure**
- **Uniform components**
- **Easy open access by fiber**

MDU: Multi dwelling unit

Low Cost Transceiver on Polymer Basis

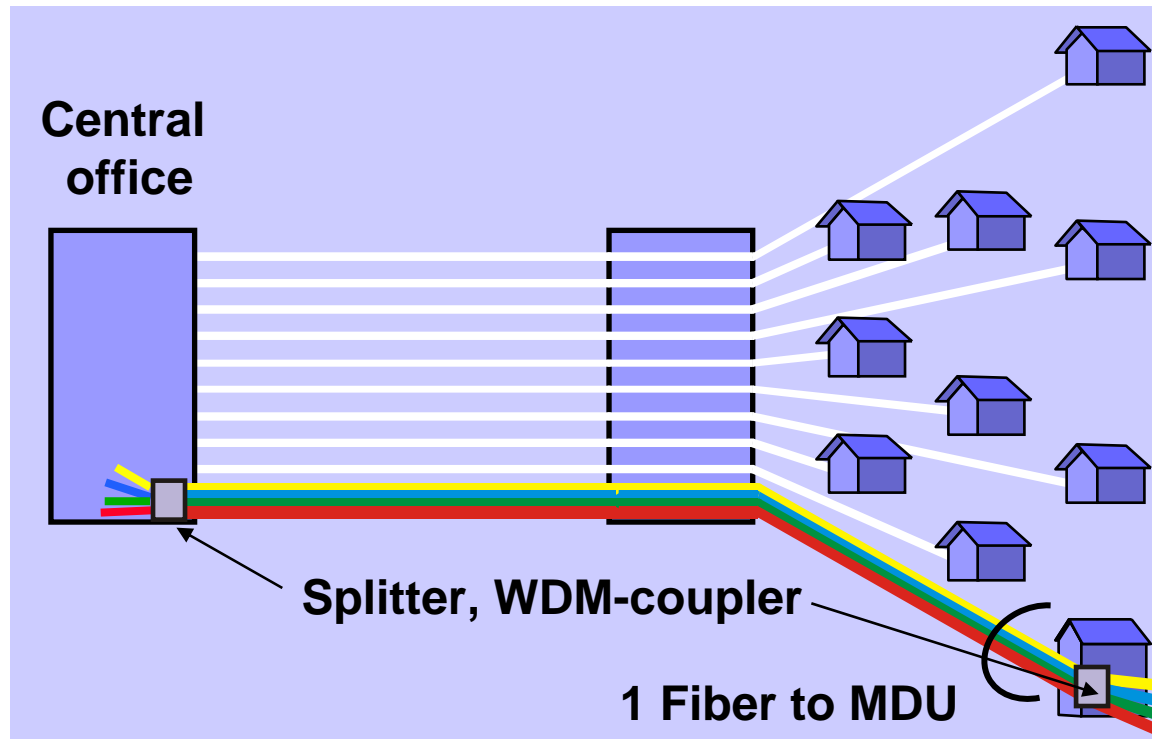


Optical Output:

+2dBm (@ 50mA / 1310nm)

+5dBm (@ 50mA / 1490nm)

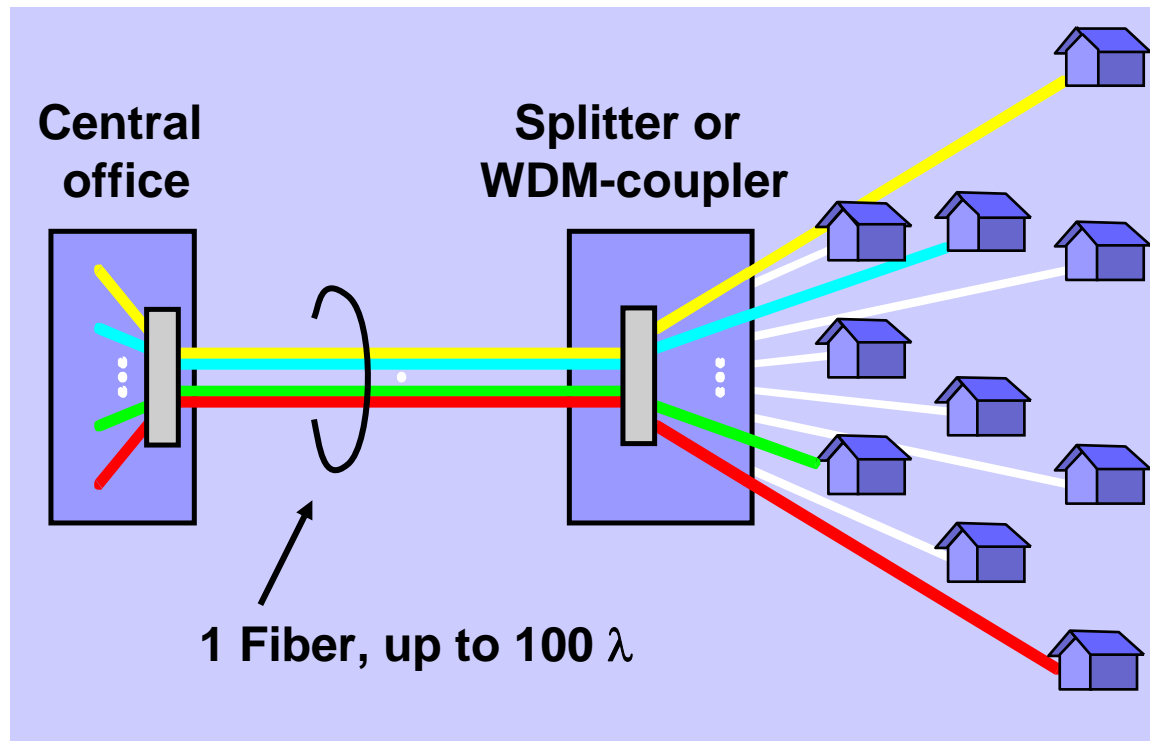
Virtual Home Run with CWDM or DWDM



MDU: Multi dwelling unit

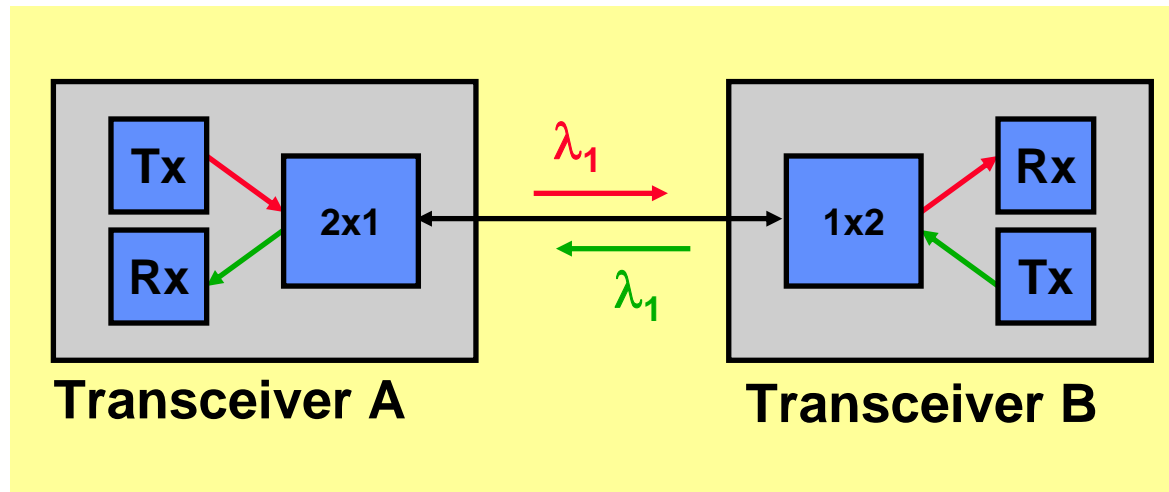
- **Fiber sharing**
- **High bandwidth**
- **Open Access by wavelength channel**

Virtual Home Run with DWDM



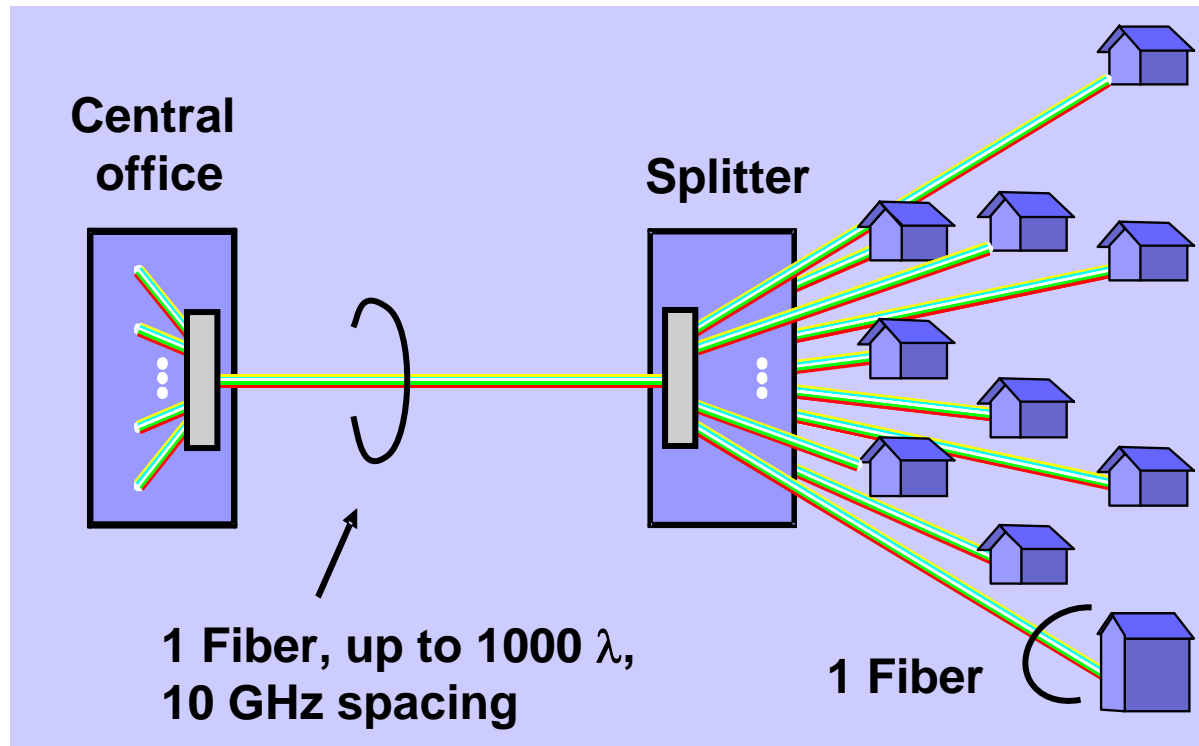
- **Single fiber star topology, classical PON structure**
- **Fiber sharing in the feeder**
- **High bandwidth**
- **Open Access by wavelength channel**

Full-Duplex Transmission Using Same λ



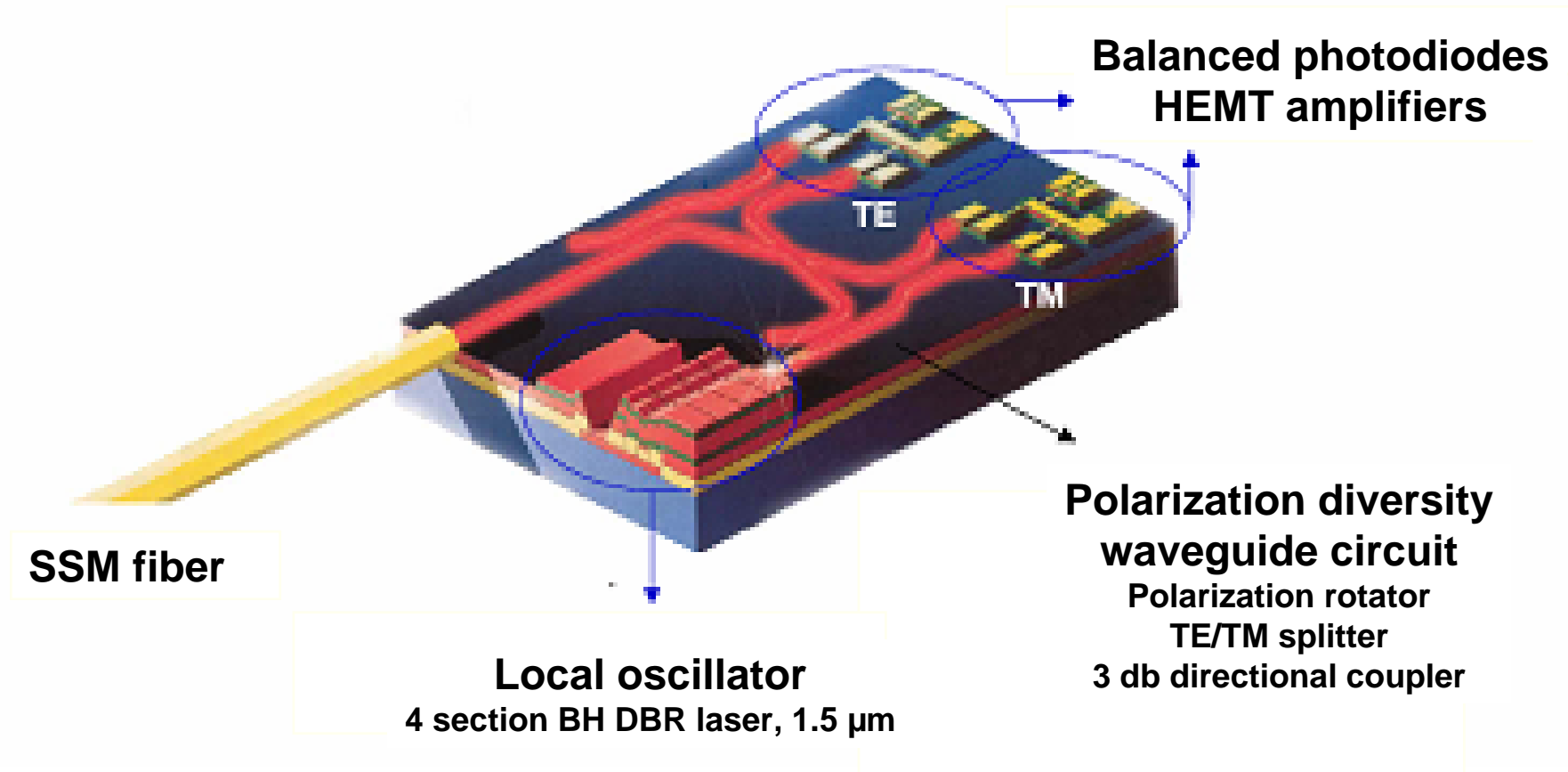
- Full-duplex transmission using same wavelengths for both directions
- Reach crosstalk limited \rightarrow 40 km
- Coupling of Tx and Rx
 - Power splitter \rightarrow low cost
 - Directional coupler (circulator) \rightarrow low insertion loss

Virtual Home Run with UDWDM, Coherent TRx



- Fiber sharing in the feeder and last meters
- Bandwidth limited by channel spacing
- Open access by wavelength channel
- Experiments by DTAG and HHI in 1993

Integrated Coherent Receiver



World's first integration by HHI in 1995



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In-House and Home Networks

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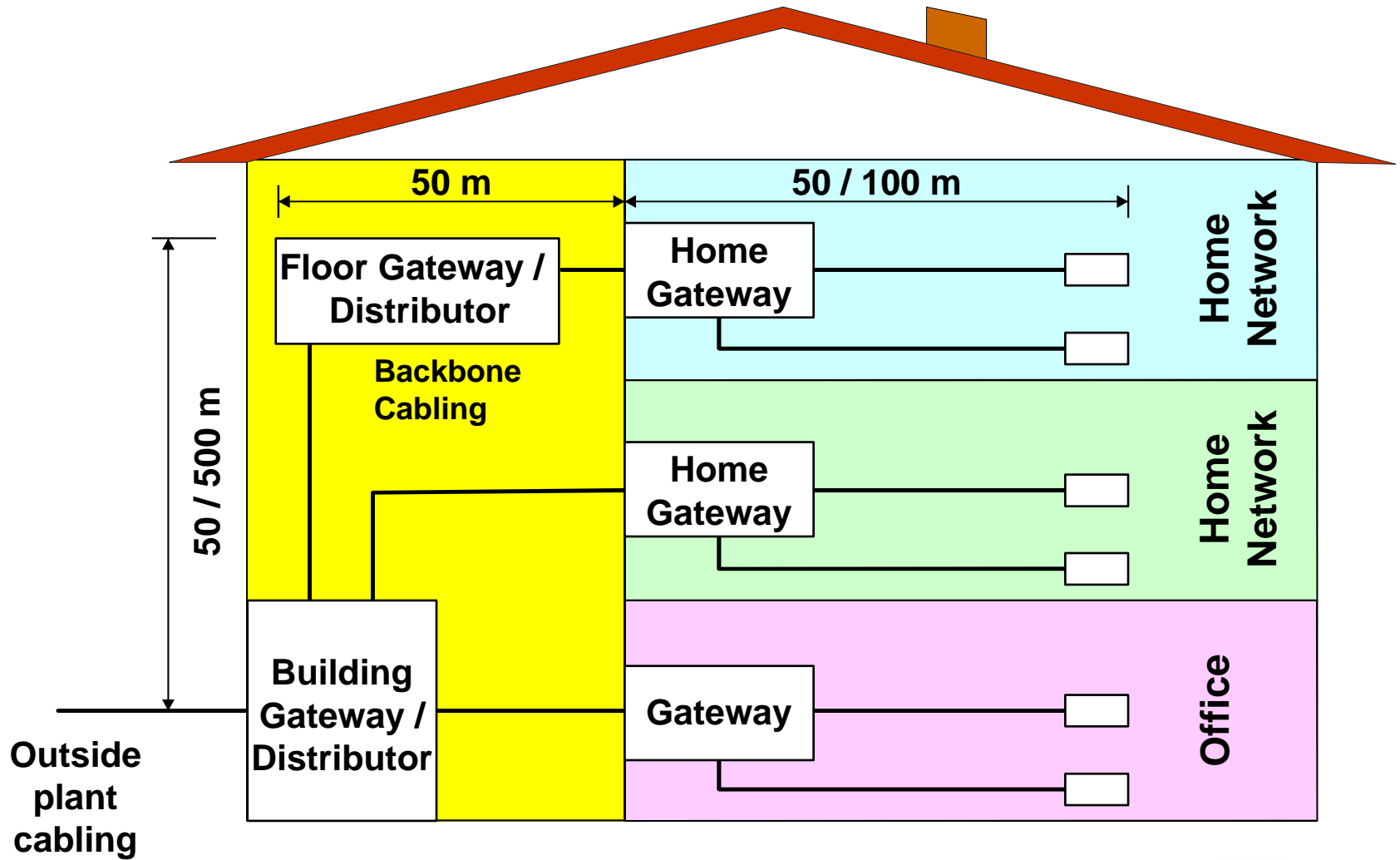
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In-House and Home Network Topology



In-House and Home Network Requirements

- **High bandwidth up to 10 Gbps**
- **Future-proof solution, scalability**
- **Long lifetime of installation, up to 30 years**
- **Distance > 50 m**
- **Robust and cheap network elements**
- **Simple & flexible network installation (Do It Yourself, DIY)**
- **Plug&Play solutions**
- **High energy efficiency, low power consumption**
- **Standards**



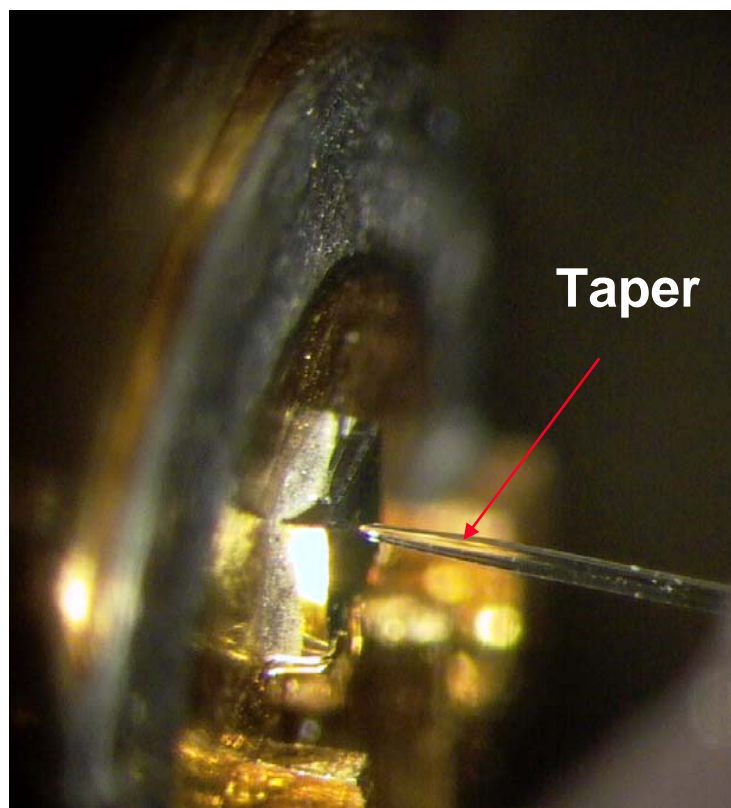
Broadband In-House & Home Network Media

- **Copper wires***
 - CAT7 cable (> 10 Gbps)
 - Coaxial cable (several Gbps)
- **Optical fibers***
 - Plastic optical fiber (SI, up to 1 Gbps)
 - Glass optical fiber, SMF (unlimited), GIF (> 40 Gbps)
- **Wireless, only concentrated of a room**
 - Radio (several Gbps)
 - Light (several 100 Mbps)

*Bit rates for approx. 100 m



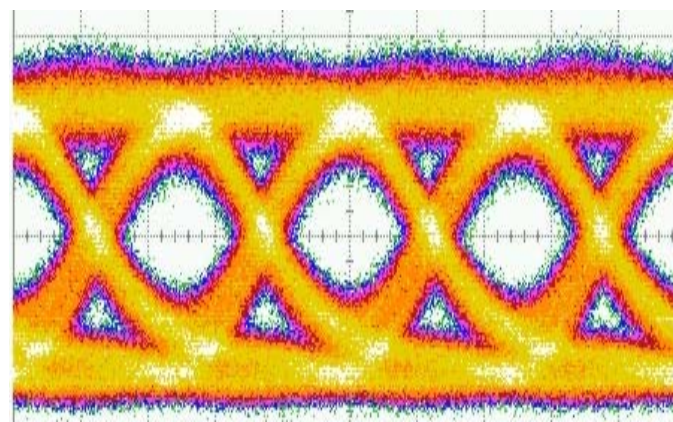
40 Gbps Transmission over 600 m GI-Fiber



Photodiode

Spot Diameter: 10 μm

Working Distance: 15 μm

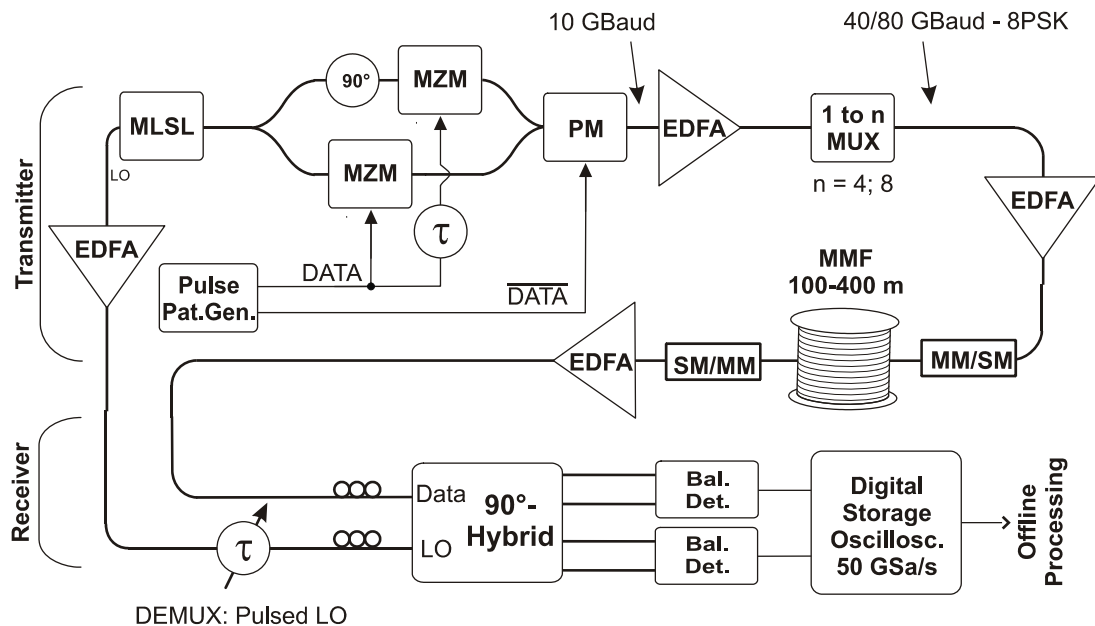


Eye diagram

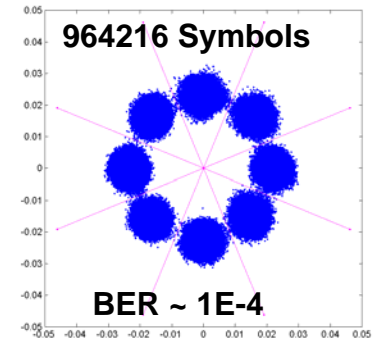
40 Gbps @ 600 m GI-fiber



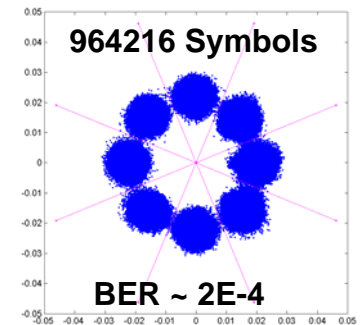
240 Gbps over 200 m MMF



80 Gbaud RZ-8PSK
@ 200 m OM4



40 Gbaud RZ-8PSK
@ 400 m OM4



- Higher-order modulation format, OTDM, SSMF/MMF and MMF/SSMF coupling, pulsed LO for de-multiplexing
- 120 Gbps (40 Gbaud) RZ-8PSK over 400 m @ BER ~ $2 \cdot 10^{-4}$
- 240 Gbps (80 Gbaud) RZ-8PSK over 200 m @ BER ~ $2 \cdot 10^{-4}$
- Highest serial bitrate on 50 μ m MMF so far!

Conclusion

- **Future data rates for broadband access**
 - private: 100 Mbps → 1 Gbps → 10 Gbps (long term)
 - business: n x 1 Gbps up to n x 10 Gbps
 - Fiber to/in the Home, Fiber to/in the Office
- **Long lifetime of fiber plant of > 30 up to 100 years**
 - FTTH fiber plant must be future-proof
- **PtP fiber system fulfill technical requirements best**
- **WDM technologies are very suitable for fiber sharing and upgrade of PON-systems, but more complex → OAM**
- **Optical in-house and home networks become the same significance like FTTH-systems**
- **Low cost components, automatic mounting technologies**





Thank You!