

International Student Days at the FH Leipzig (FHL)
September 11-18, 1999

xDSL -

An introduction to

Digital Subscriber Line Technology

Prof. Dr.-Ing. Martin Pollakowski

Fachhochschule Gelsenkirchen

Contents

1. Principles of xDSL systems

→ Access network infrastructure, twisted pairs, crosstalk, bitrates

2. HDSL = High Bitrate Digital Subscriber Line

→ Overview, dual-duplex transmission, 2B1Q linecode

3. ADSL = Asymmetric Digital Subscriber Line

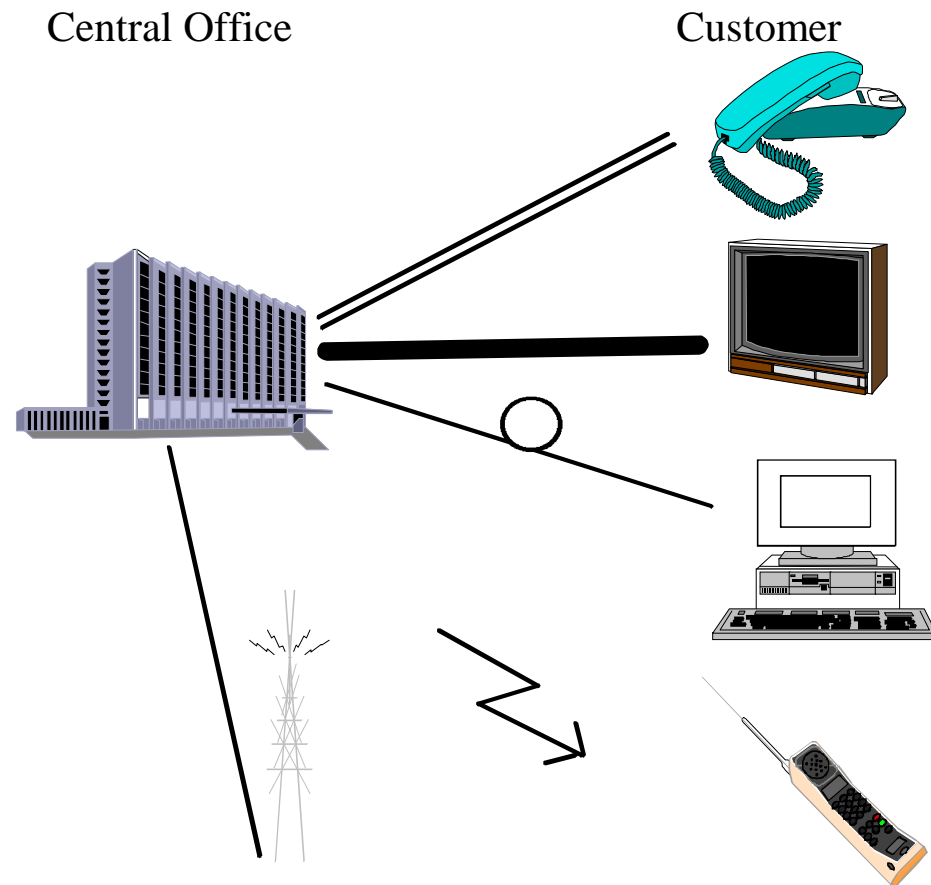
→ Overview, reference model, splitter, ADSL and ISDN

4. VDSL = Very High Bitrate Digital Subscriber Line

→ Overview, hybrid access networks

1. Principles of xDSL systems

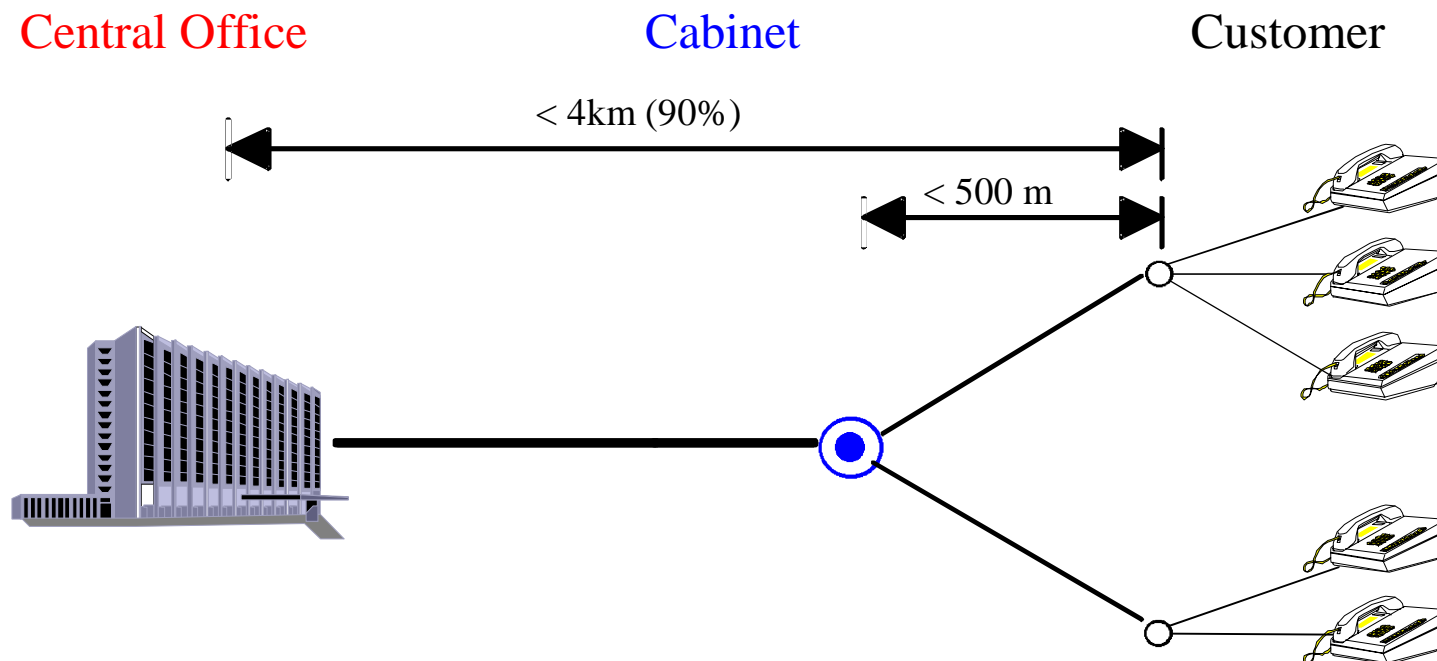
1.1. Alternatives for Broadband Access Networks



- Twisted Pairs (Telephone Access Network)
 - 40 Million Lines in Germany
- Coax-Cable (Cable TV Network)
 - distribution network topology
- Optical Fibre
 - optical access network not yet available
- Radio
 - problems with bandwidth allocation

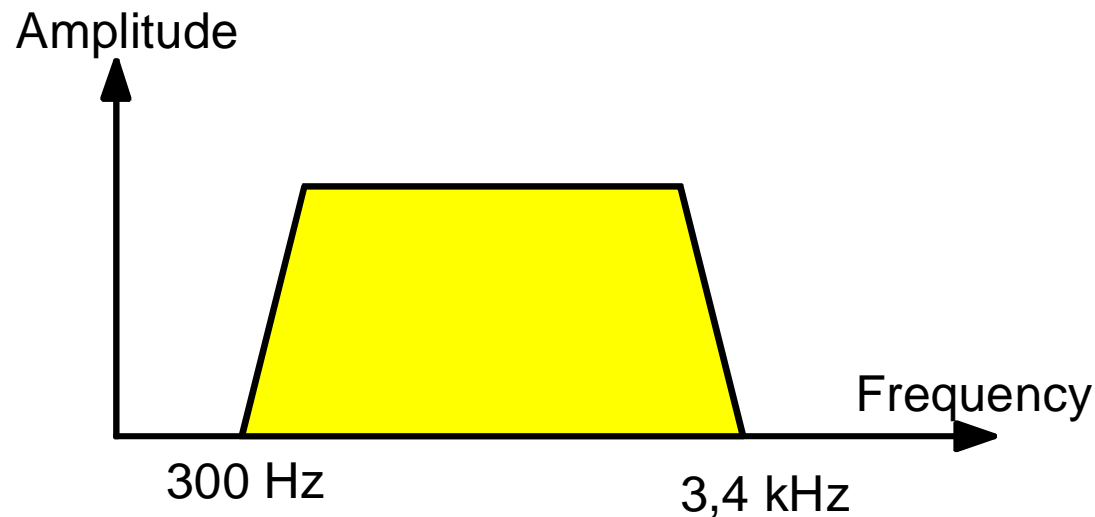
1.2. Access Network Topology

- Components:
- feeder cable from central office to the cabinet
 - distribution cable from cabinet to the customer



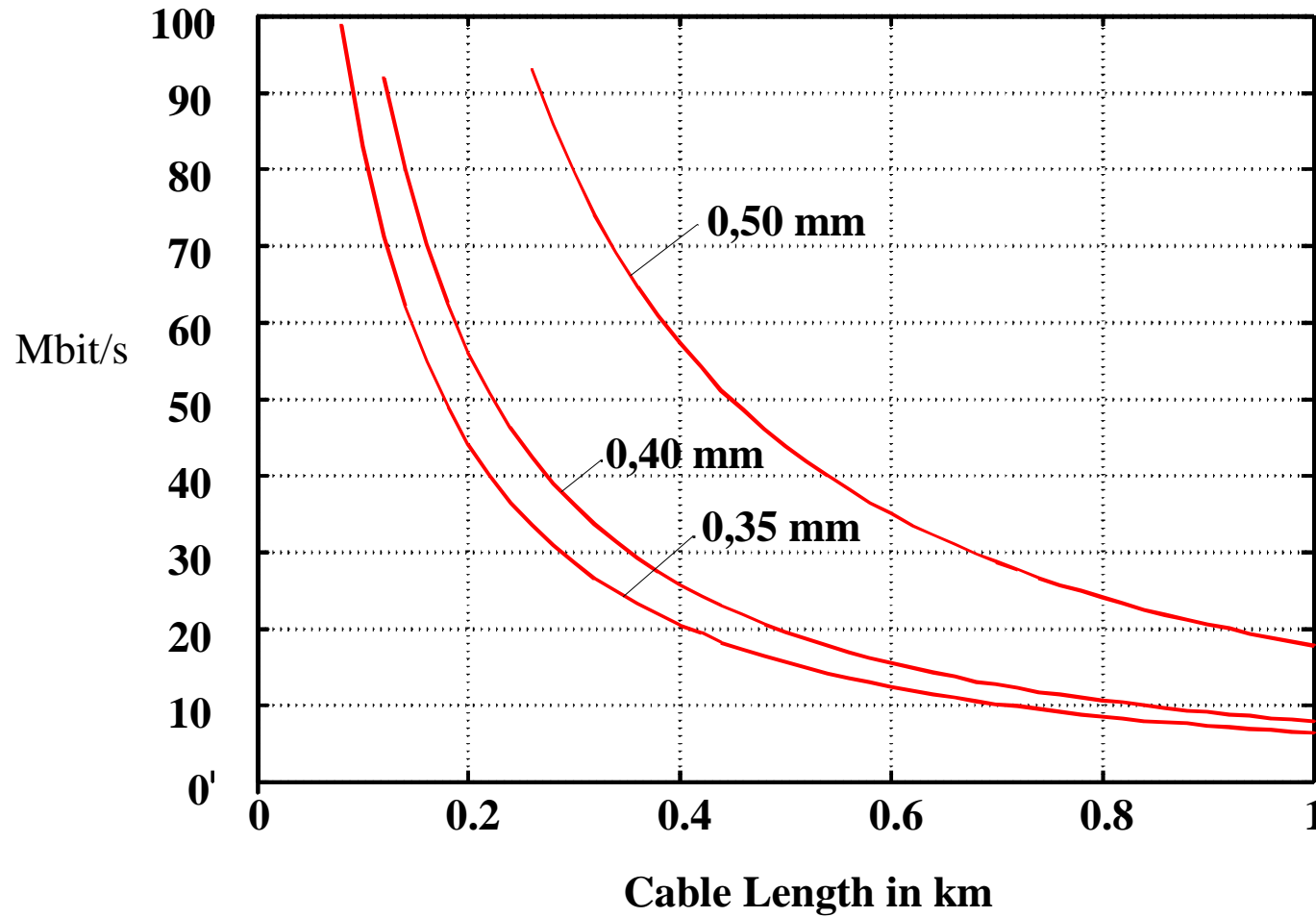
1.3. Limits for the bitrate of telephony-network-modems

frequency range of human speech:



- ✦ bandwidth of the telephone network is optimized for speech transmission
- ✦ telephony network modems can only use this bandwidth (i.e. 28,8 kbit/s)
- ✦ digital speech transmission: for example within the ISDN: 64kbit/s (8 kHz, 8 Bit)
- ✦ bandwidth is limited by the telephony switch rather than by the access network cables

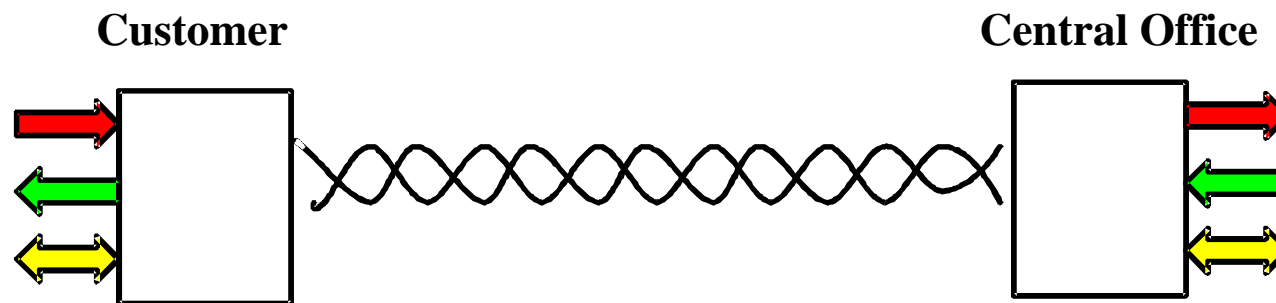
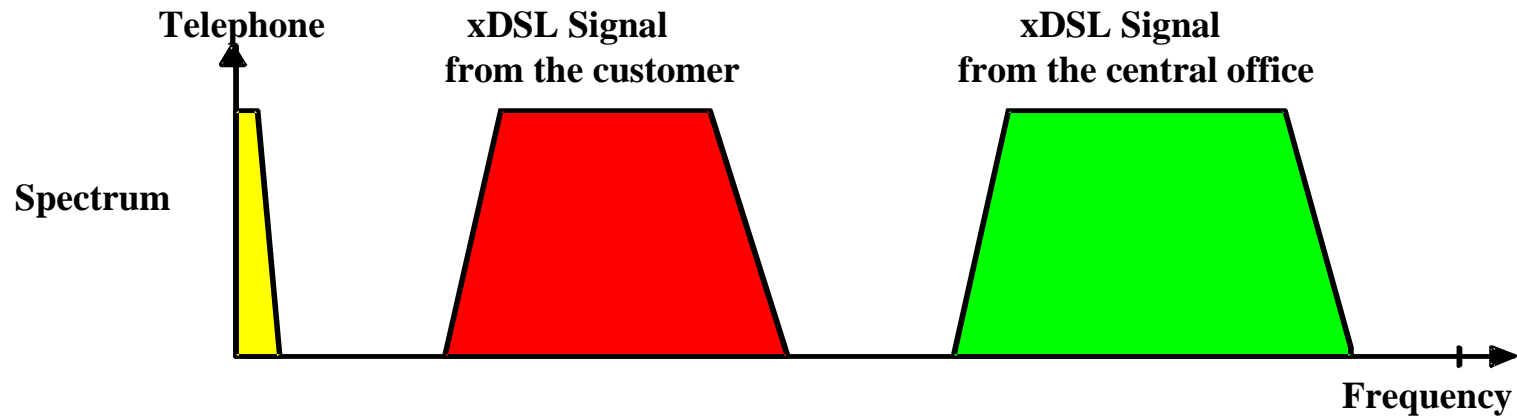
1.4. Maximum bitrate in the access network



Parameters:

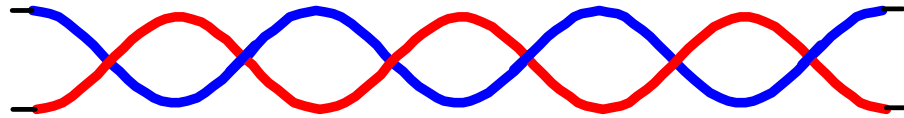
- cable length
- conductor diameter
- noise

1.5. Principle: Data-over-Voice

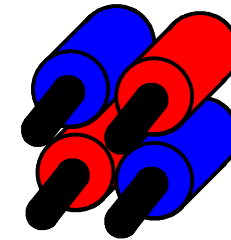


→ xDSL and Telephone/ISDN coexist by frequency division multiplexing

1.6. Design of symmetric multipair cables

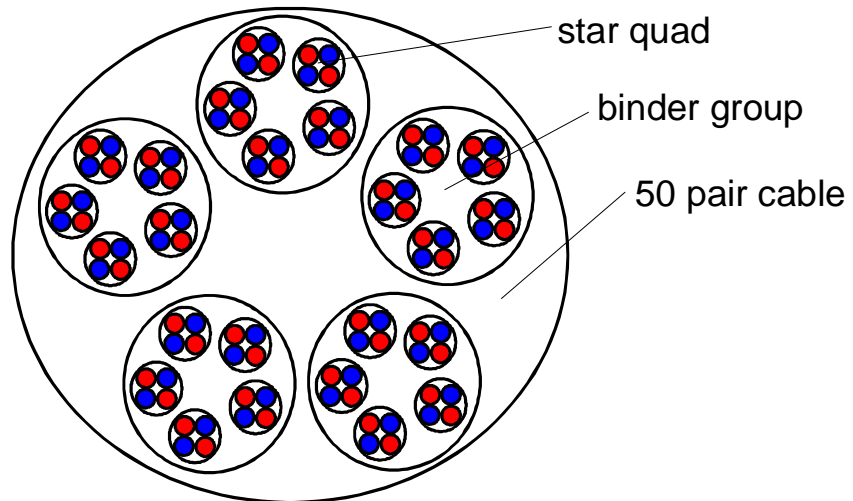


symmetric wire pair



star quad

Multipair Cable:



2 pairs = 1 star quad

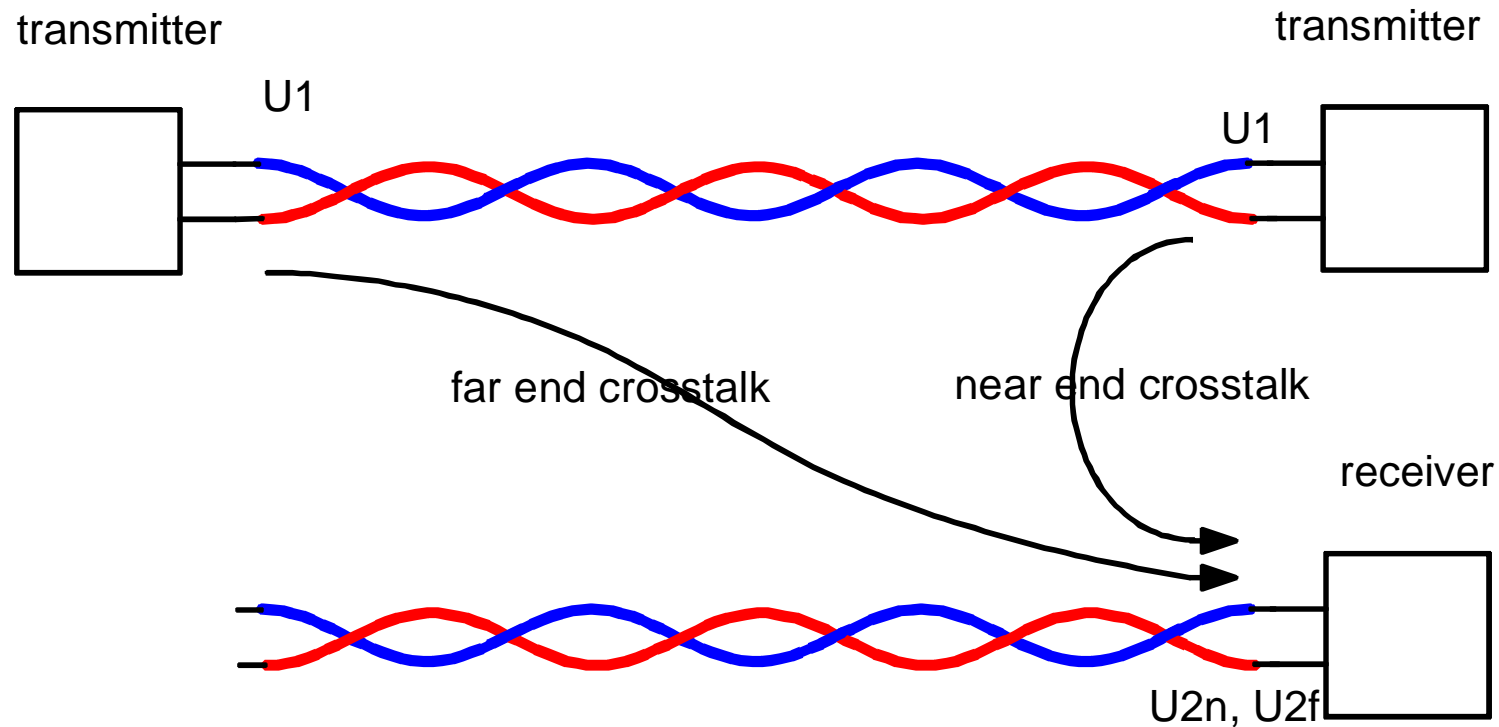
5 star quads = 1 binder group

5 binder group = ... etc

up to 2000 pairs
typical: 100 pairs

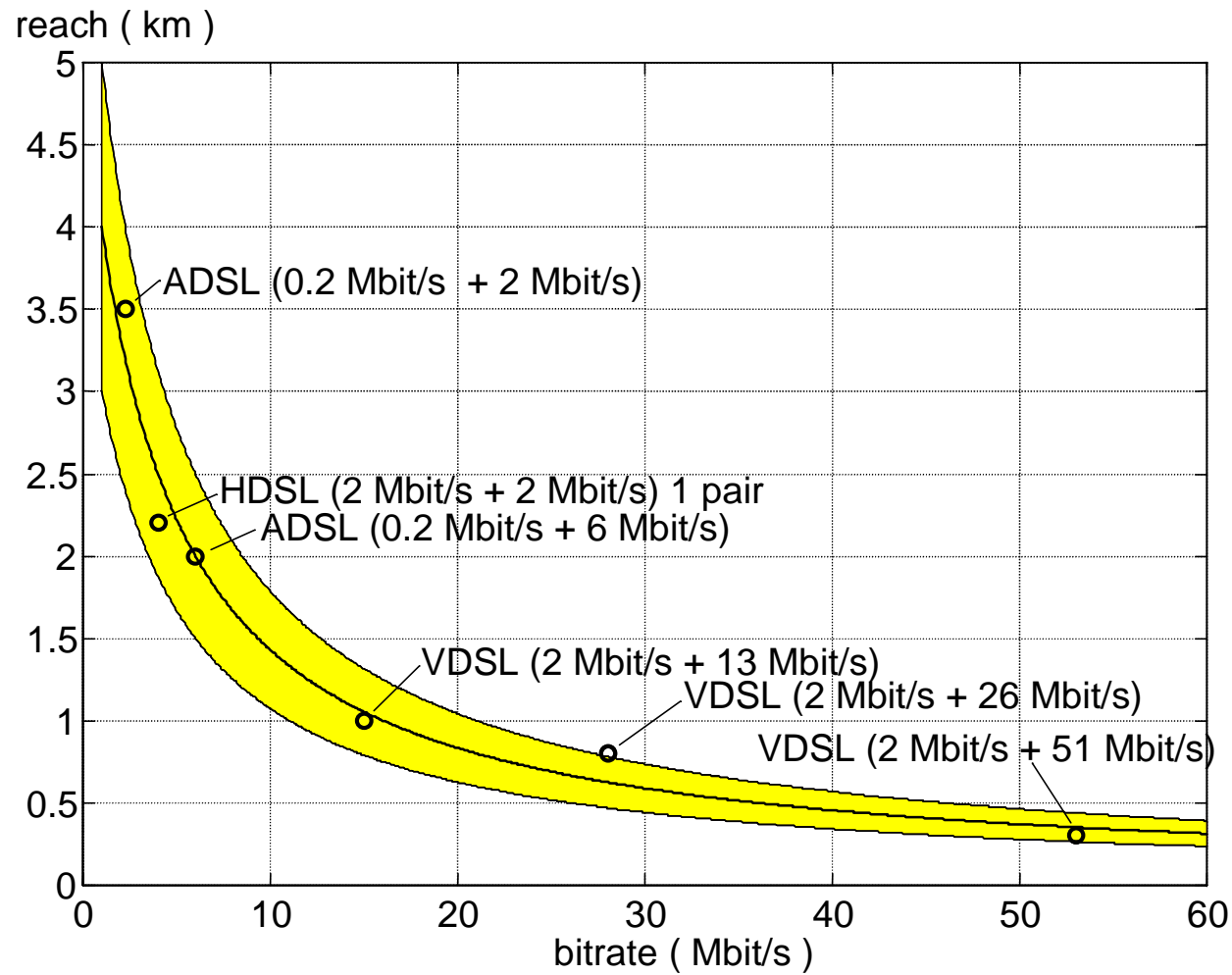
1.7. Crosstalk

Transmission in multipair cables is limited by crosstalk:



→ crosstalk depends on cable quality, frequency, cable length

1.8. Bitrate and reach of xDSL Systems



2. HDSL = High Bitrate Digital Subscriber Line

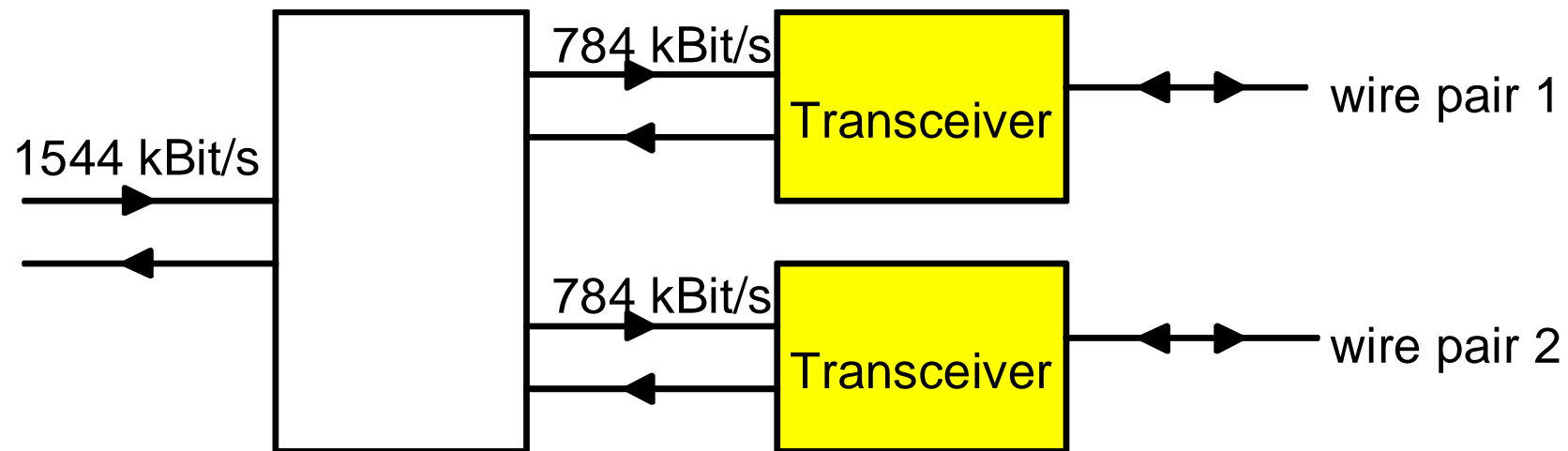
2.1. The "HDSL-family" of xDSL Systems

HDSL	High-Bit-Rate Digital Subscriber Line a) USA: 1544 kBit/s, 2 pair system b) Europe: 2048 kBit/s, 1, 2 or 3 pair systems
HDSL2	new 1 pair HDSL for USA (1544 kBit/s)
SDSL	Symmetrical High-Bit-Rate Digital Subscriber Line rate adaptive symmetric system for Europe (up to 2048 kBit/s)
MDSL	Medium Bit Rate Digital Subscriber Line (not standardized)
IDSL	ISDN Rate Digital Subscriber Line (not standardized)

→ symmetric bitrates, up to 2 MBit/s

2.2. Principle: Dual Duplex Transmission

Example: 2-pair HDSL for USA (1544 kBit/s):

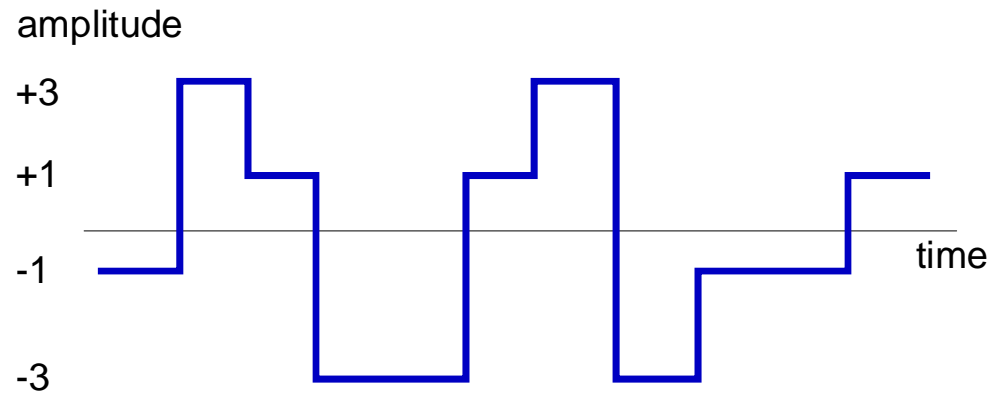


Principle: bitrate is divided between two pairs

⇒ reduced bitrate = lower bandwidth = less attenuation = higher reach

2.3. Principle: Multilevel Linecode

Example: **2B1Q** Linecode (= **2 Binary** Symbols converted to **1 Quaternary** Symbol)



-1	+3	+1	-3	-3	+1	+3	-3	-1	-1	+1	quaternary symbol
0 1	1 0	1 1	0 0	0 0	1 1	1 0	0 0	0 1	0 1	1 1	binary symbol

advantage: lower symbol rate = lower bandwidth = less attenuation = higher reach

3. ADSL = Asymmetric Digital Subscriber Line

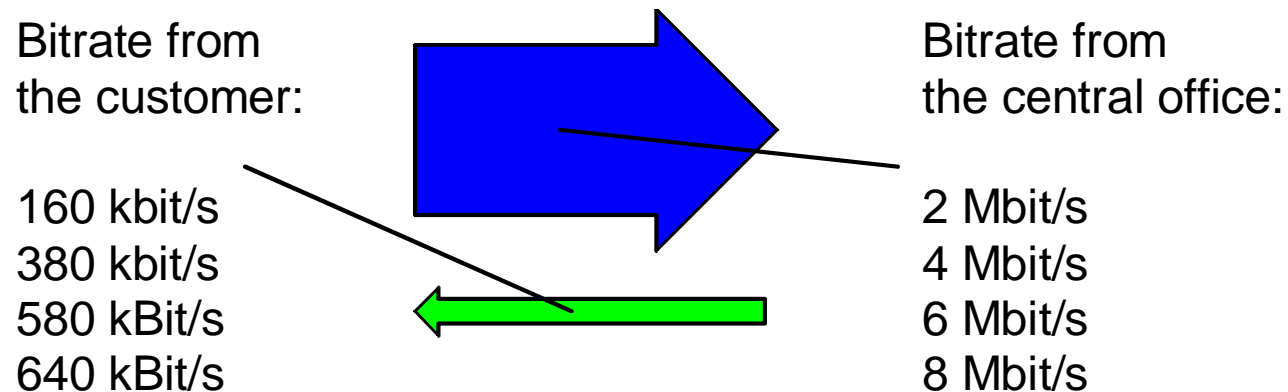
3.1. The "ADSL-family" of xDSL Systems

ADSL	Asymmetrical Bit-Rate Digital Subscriber Line a) USA: compatible with analogue telephone b) Europe: compatible with analogue telephone and ISDN standardized in ITU-Recommendation G.992.1
RADSL	Rate Adaptive ADSL (not standardized)
UDSL	Universal ADSL (splitterless ADSL, ADSL-Lite) standardized in ITU-Recommendation G.992.2
CDSL	Consumer DSL (not standardized)

→ asymmetric bitrates, up to 8 MBit/s

3.2. Principle: asymmetric bitrates

ADSL: asymmetry ratio = 1 : 10

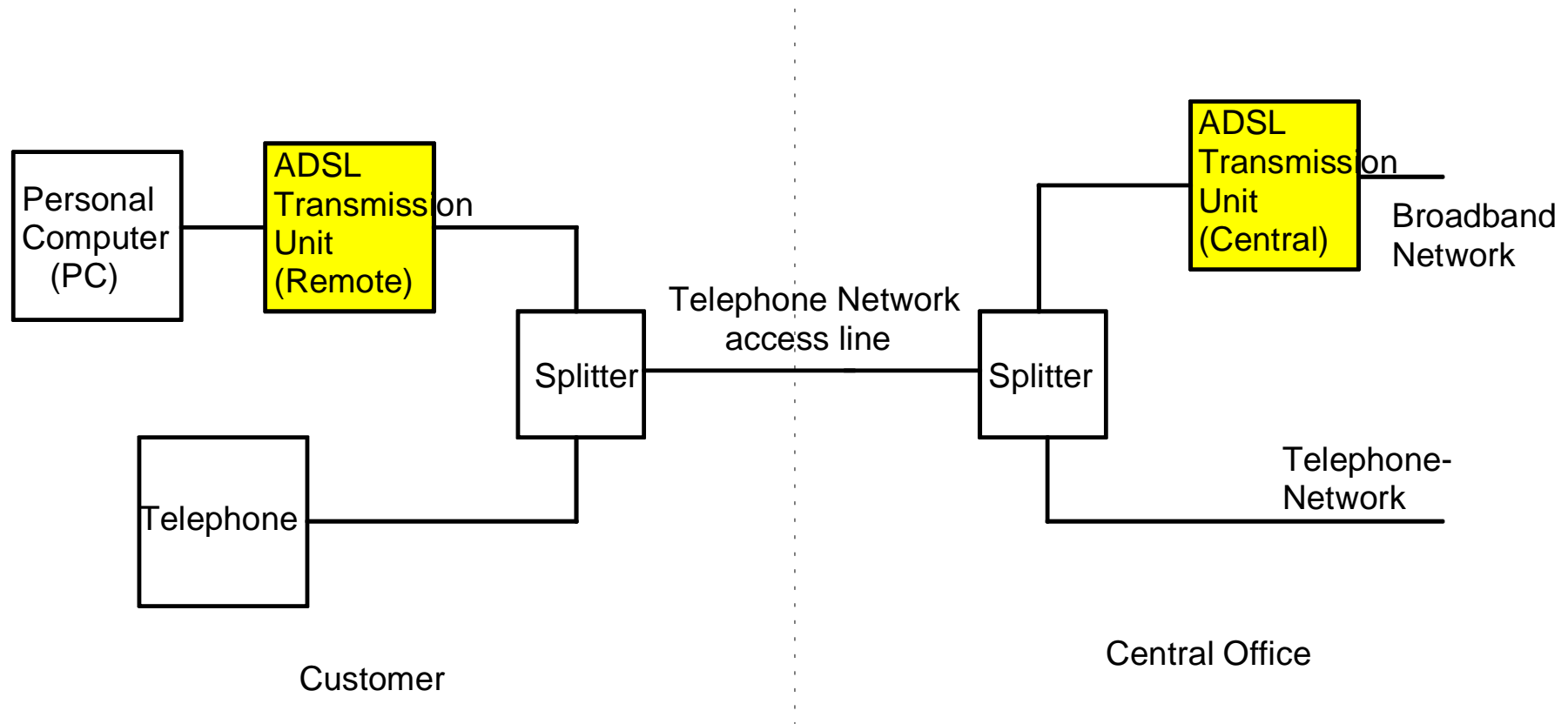


optimized for internet access: high bitrates to the customer

advantage: optimized use of available transport capacity

disadvantage: service dependant (high bitrate to the central office not possible)

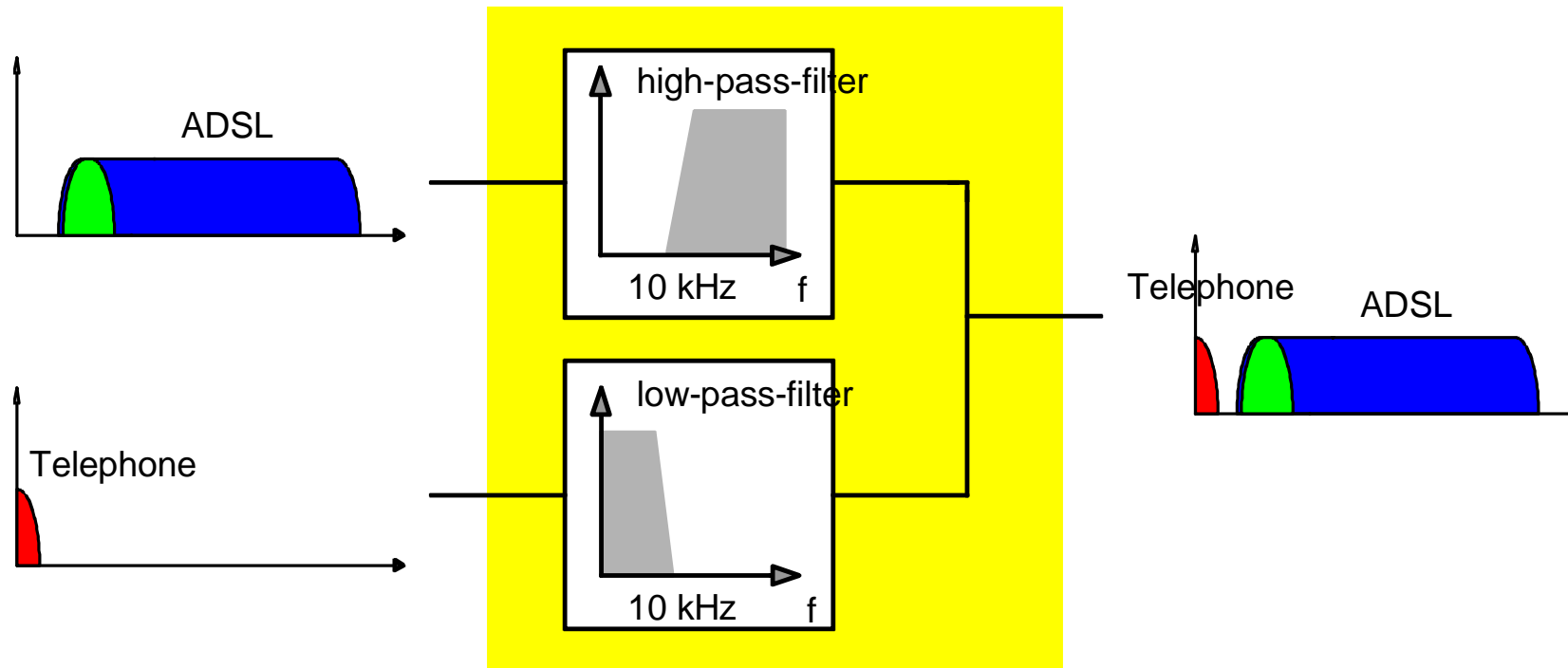
3.3. ADSL Reference-Model



→ coexistence of ADSL and Telephony (or ISDN) on one wire pair

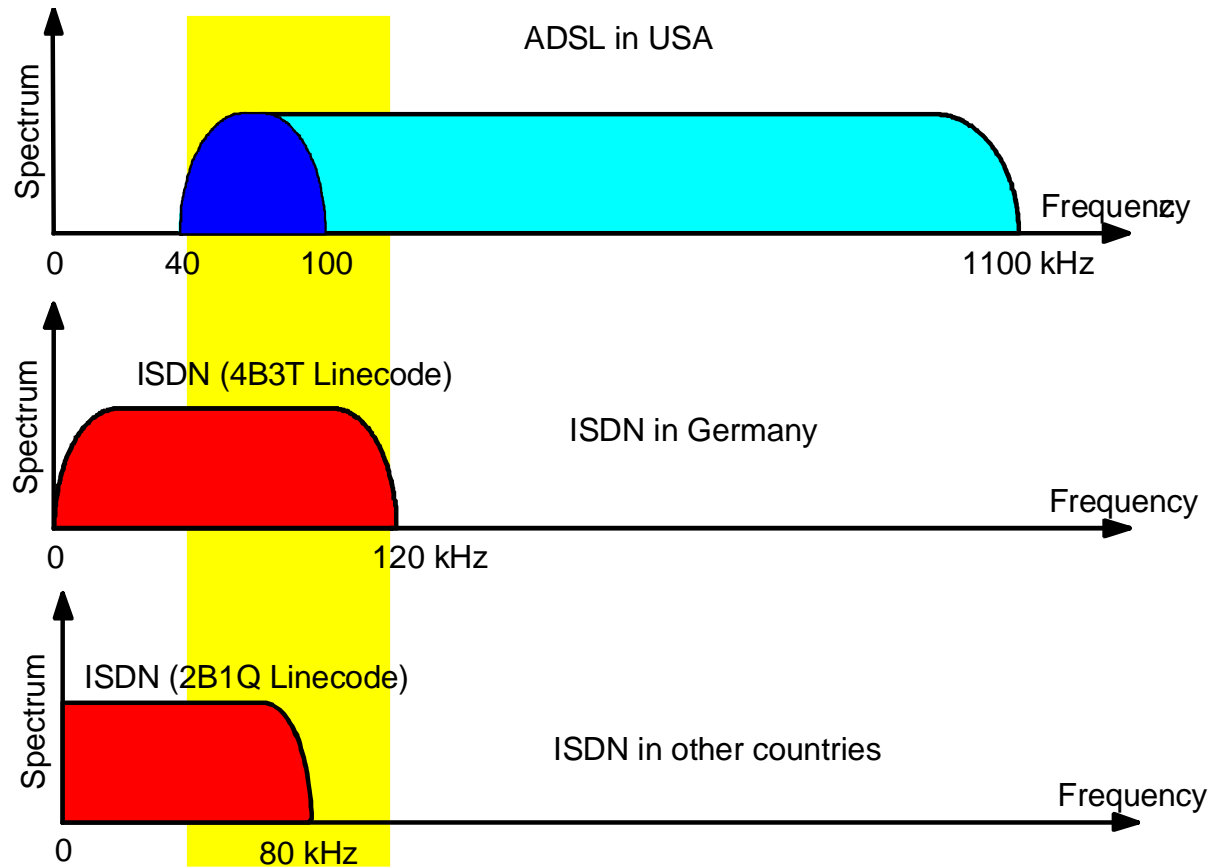
3.4. Splitter for narrowband- (telephony) and broadband- (ADSL) signal

Example: ADSL with analogue Telephone on the same wire pair



"passive" Splitter = guarantee of "lifeline service"

3.5. Coexistence of ADSL and ISDN



→ ADSL in USA can not coexist with ISDN

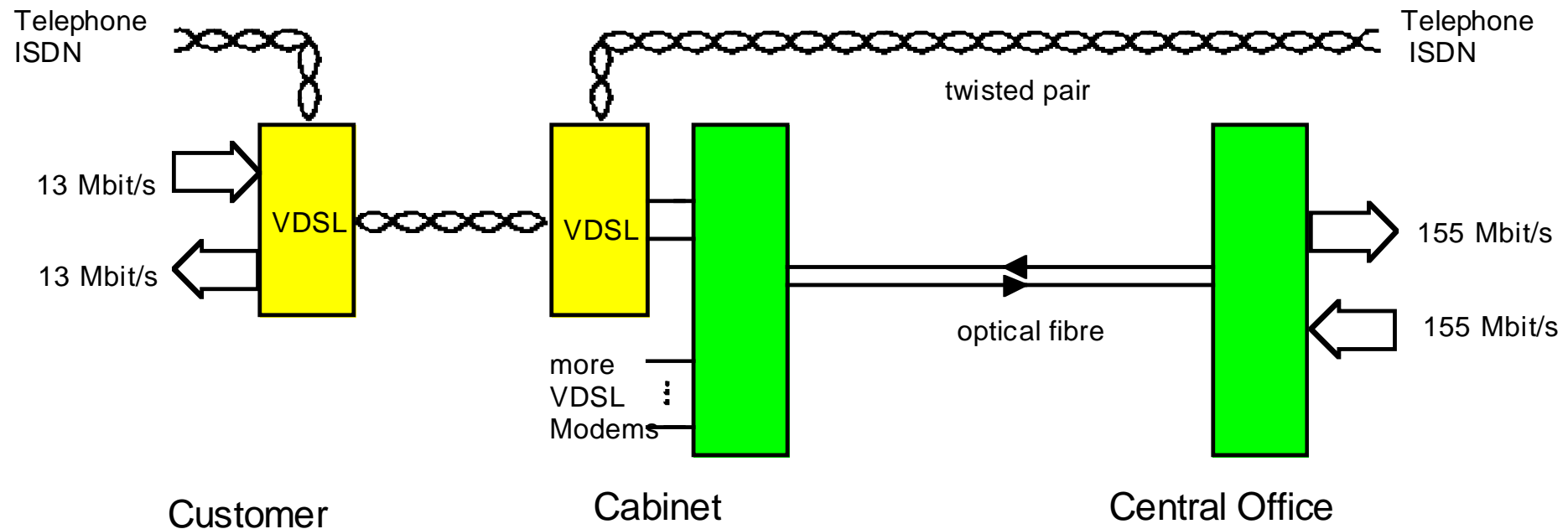
4. VDSL = Very High Bitrate Digital Subscriber Line

4.1. The "VDSL-family" of xDSL Systems

VDSL	<p>Very High Bit-Rate Digital Subscriber Line</p> <p>a) ITU-Recommendation is under development reach: 500 m - 1500 m bit rates: 25 MBit/s - 12 MBit/s first prototypes are available</p> <p>b) DAVIC (Digital Audio Visual Council) Specification reach: 300 m bit rates: 52 Mbit/s equipment in production state</p>
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→ symmetric and asymmetric bitrates, up to 52 MBit/s

4.2. VDSL Reference Configuration



→ VDSL uses a hybrid access network (fibre and copper)
short distances, high bitrates

Summary

xDSL = digital transmission over the existing telephone access network

HDSL = High Bitrate Digital Subscriber Line
up to 2 MBit/s, **symmetric** bitrate

ADSL = Asymmetric Digital Subscriber Line
up to 8 MBit/s, **asymmetric** bitrate

VDSL = Very High Bitrate Digital Subscriber Line
up to 52 MBit/s, **hybrid** access network