Broadband (II): DSL access

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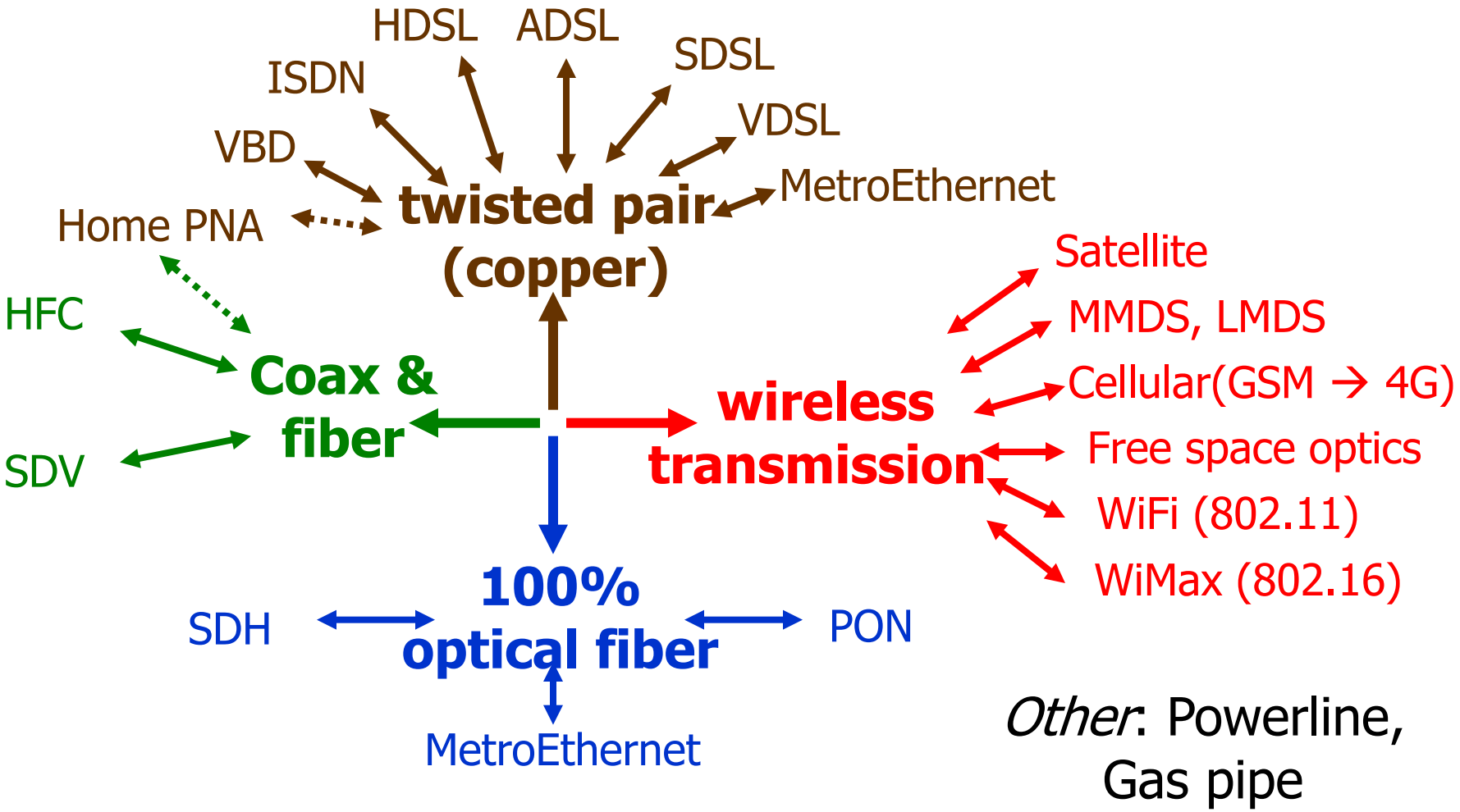
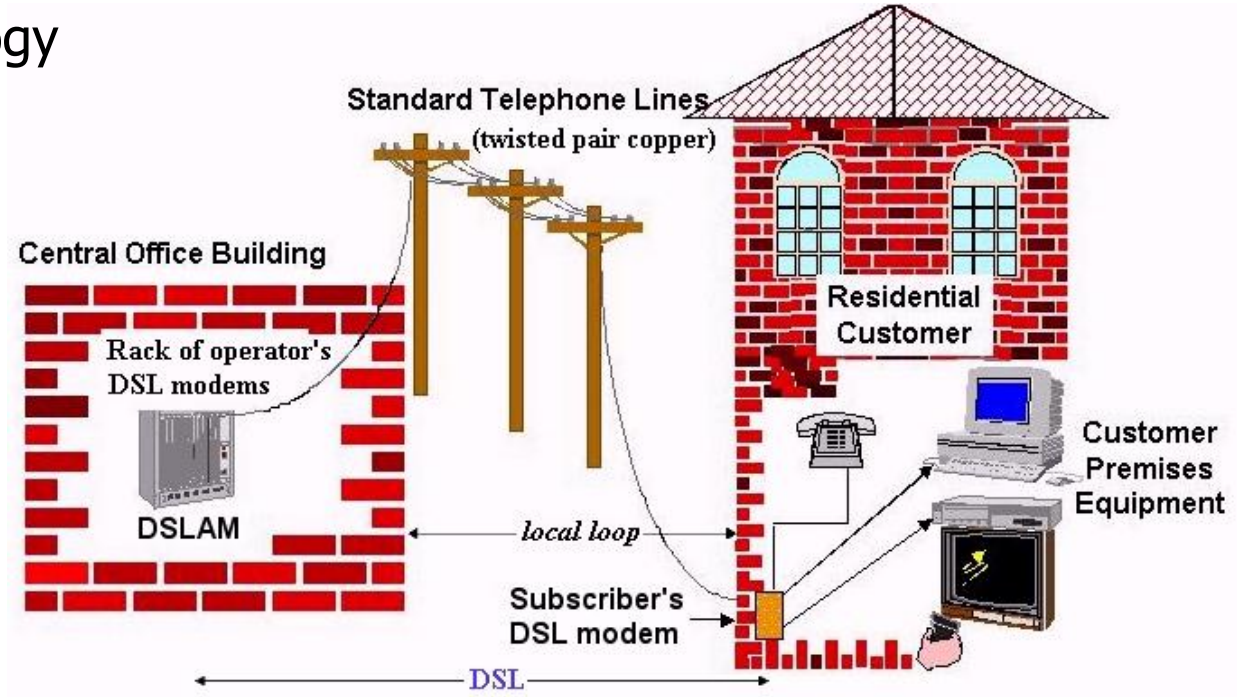
Basic access technologies



Digital Subscriber Line (DSL)

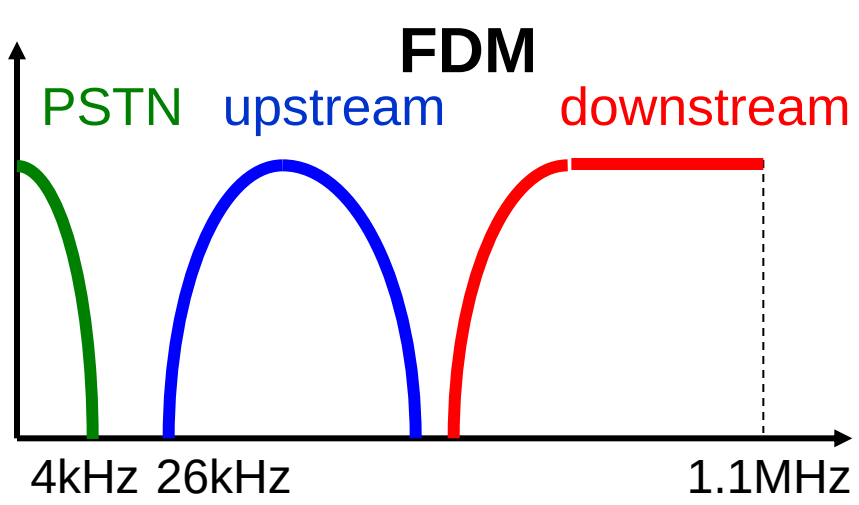
Definition

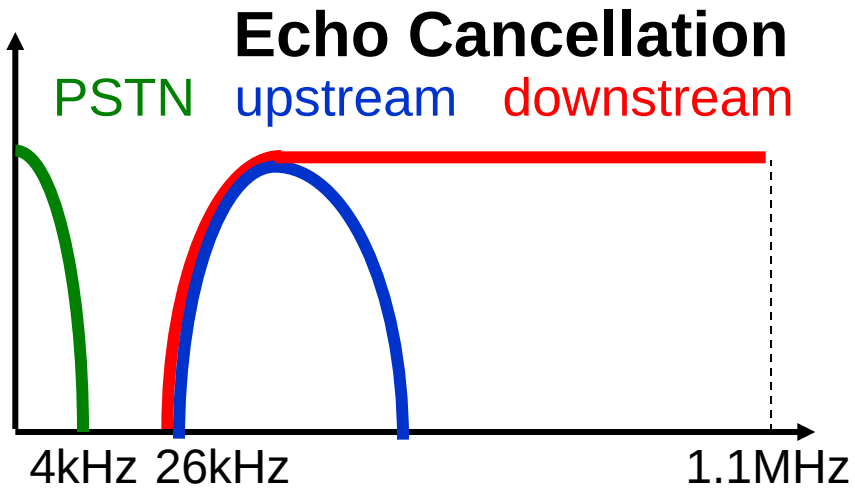
- DSL enables broadband physical connectivity between a remote site (e.g. home) and the nearest telco CO over the telephone twisted pair copper wires.
- DSL is
  - an access line technology
  - a modem technology
  - an OSI physical layer (layer1) protocol



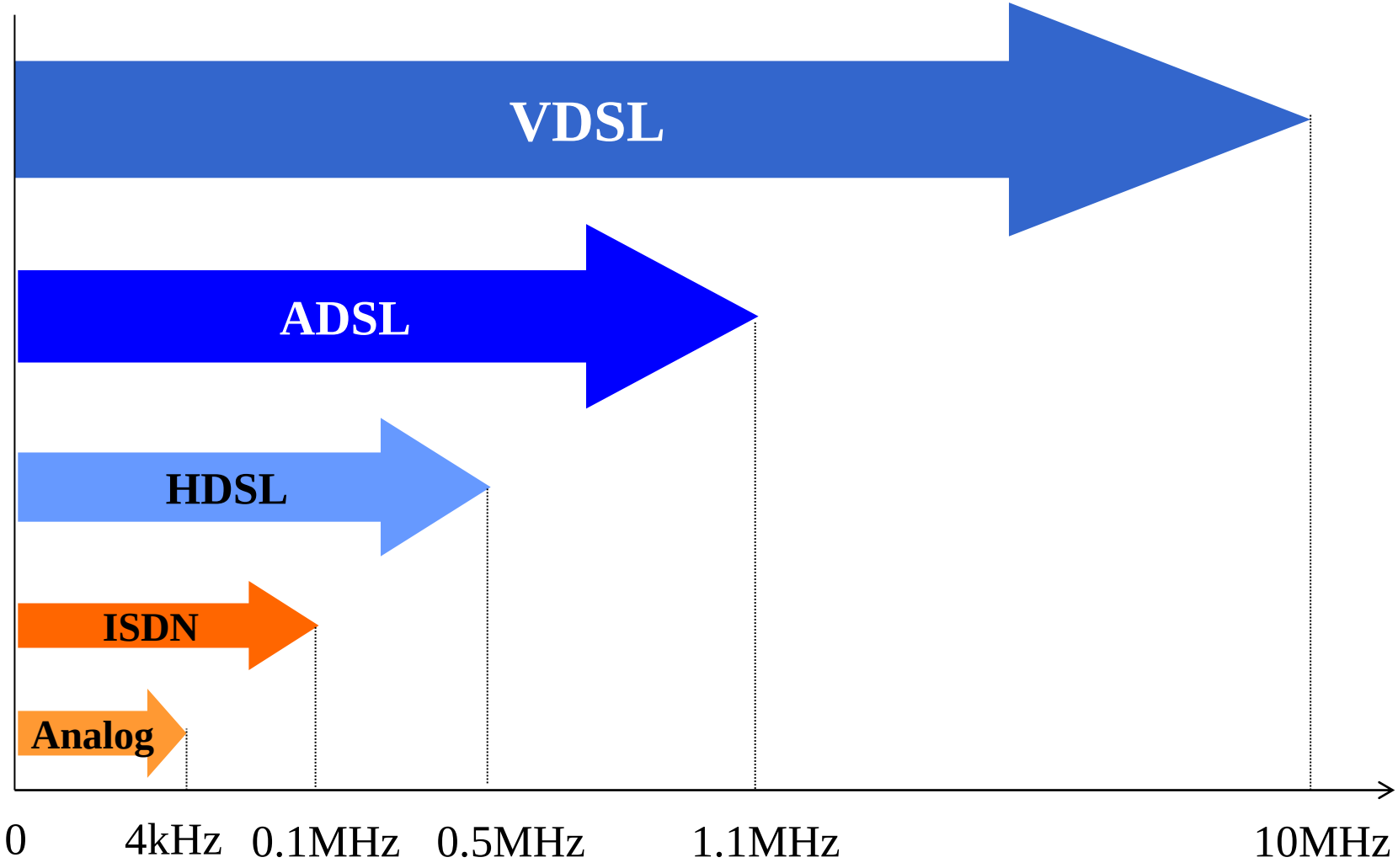
Management of copper wire bandwidth

- DSL employs advanced digital modulation techniques
- Exploits the entire spectrum of frequencies usable over copper wires
  - Example: 0 - 1.1MHz for ADSL





Utilization of copper wire bandwidth

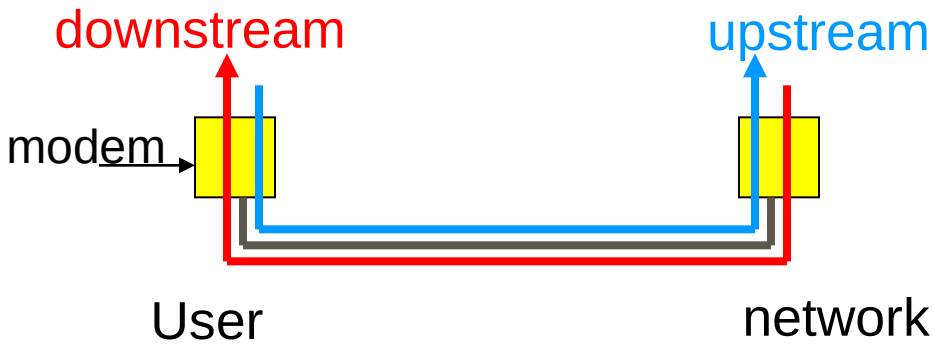


Characteristics - Benefits

- DSL avoids the bandwidth bottleneck of the local loop in analog transmission,
- DSL brings broadband to the home (BTTH) over ordinary telephone copper wires
  - can exploit ~750-800 million copper wires existing worldwide
  - postpones FTTH (Fiber to the Home)
- Always on
- Concurrent transmission of voice and data over the same copper wire
- PSTN available even when DSL fails

DSL (xDSL) Classification

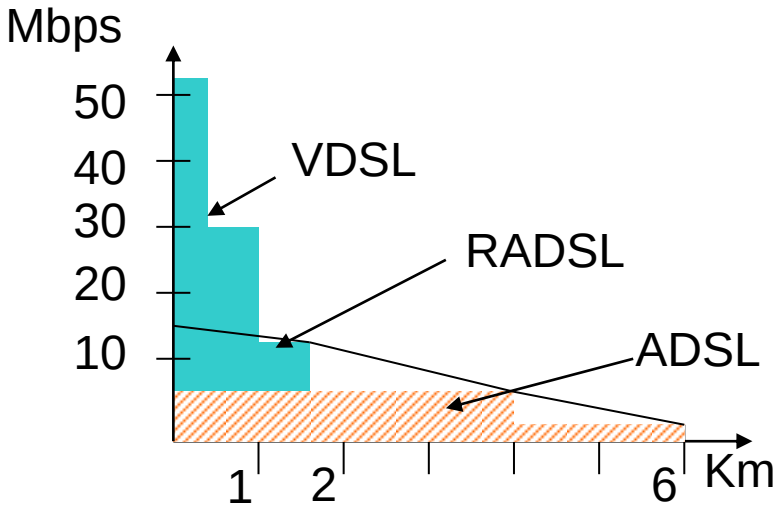
- Asymmetric vs. symmetric:
  - asymmetric DSL → most bandwidth is devoted to the downstream direction
  - symmetric DSL → equal bandwidth and data rates in the upstream and the downstream directions



- PSTN can be provided in a splitter-based or a splitter-less mode, or it may not be provided at all.

xDSL data rates (I)

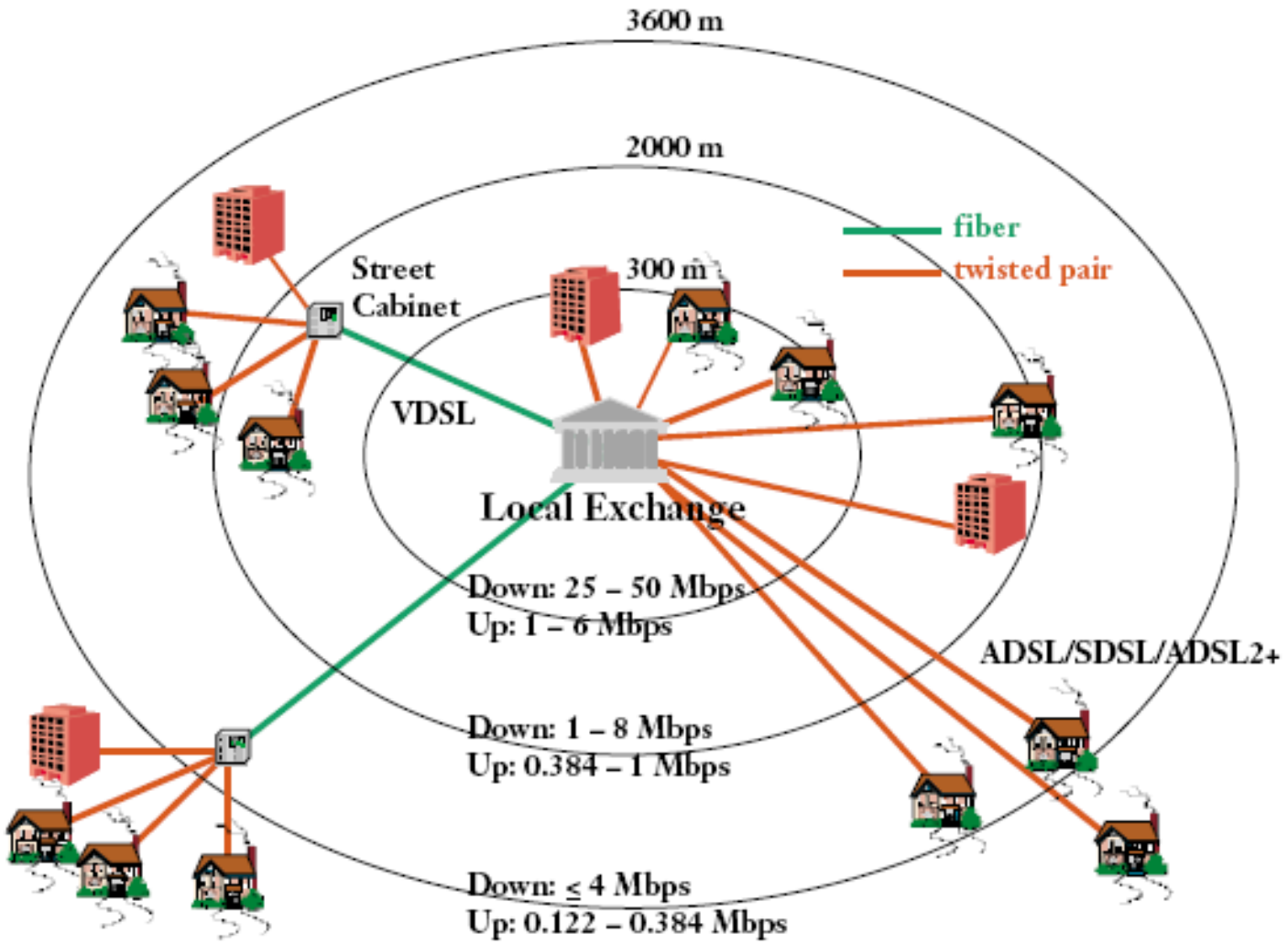
- A wide variety of data rates is available.
- The data rate depends on the specific modem technology. Also affected as follows:
  - as the distance between CPE and CO increases, the achievable data rates decrease
  - thicker wires carry the same data rates further
  - more copper pairs → higher data rates



xDSL: data rates

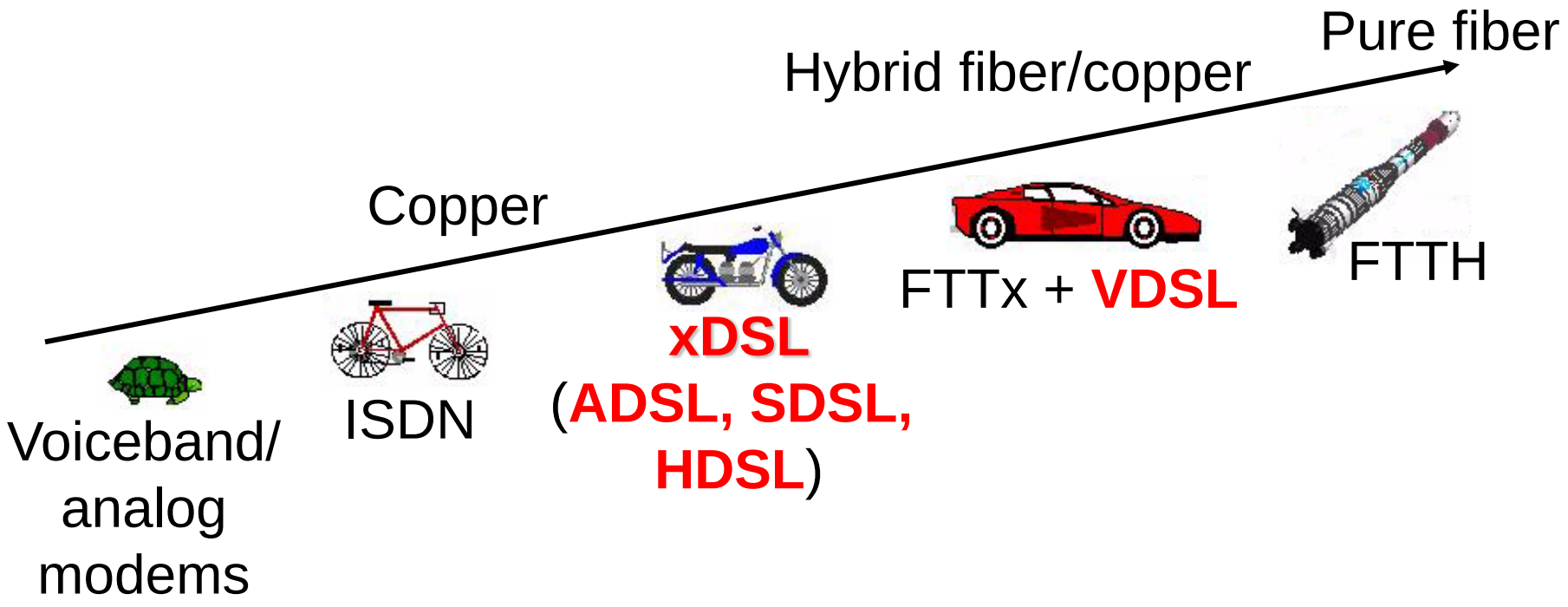
DSL Type	Download	Upload	Distance (feet)
ADSL (Asymmetrical)	1.5 - 8 Mbps	16 kbps to 640 kbps	9K to 18K
UDSL(a.k.a. G.lite, DSL Lite)	1.5 Mbps	384 kbps	12K to 18K
RADSL (Rate Adaptive)	Variable to 7 Mbps	Variable to 640 kbps	18K to 25K
VDSL (Very High Bit Rate)	26 Mbps to 52 Mbps	3 Mbps to 6 Mbps	1K to 3K
IDSL (ISDN over DSL)	144 kbps	144 kbps	18K (more w/ repeater)
SDSL (Symmetrical)	144 kbps to 2 Mbps	144 kbps to 2 Mbps	11.5K to 22K
HDSL (High Bit Rate)	1.544 Mbps	1.544 Mbps	12K on 2 pairs
HDSL (High Bit Rate)	2.048 Mbps	2.048 Mbps	12K on 3 pairs
HDSL2	1.544 Mbps	1.544 Mbps	12K on 1 pair
SHDSL (Single-pair HDSL)	192 kbps to 2.312 Mbps	3 Mbps to 6 Mbps	1K to 3K

xDSL: data rates vs distance

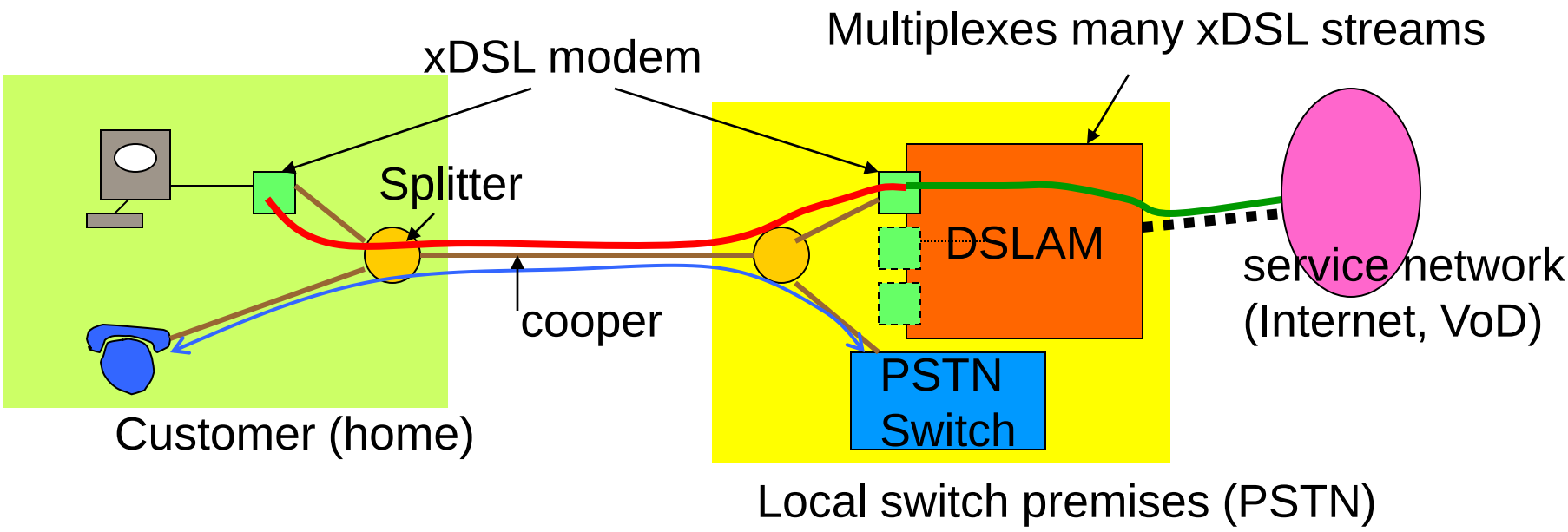


Source: © Corning

Comparison of access technologies



xDSL Architecture

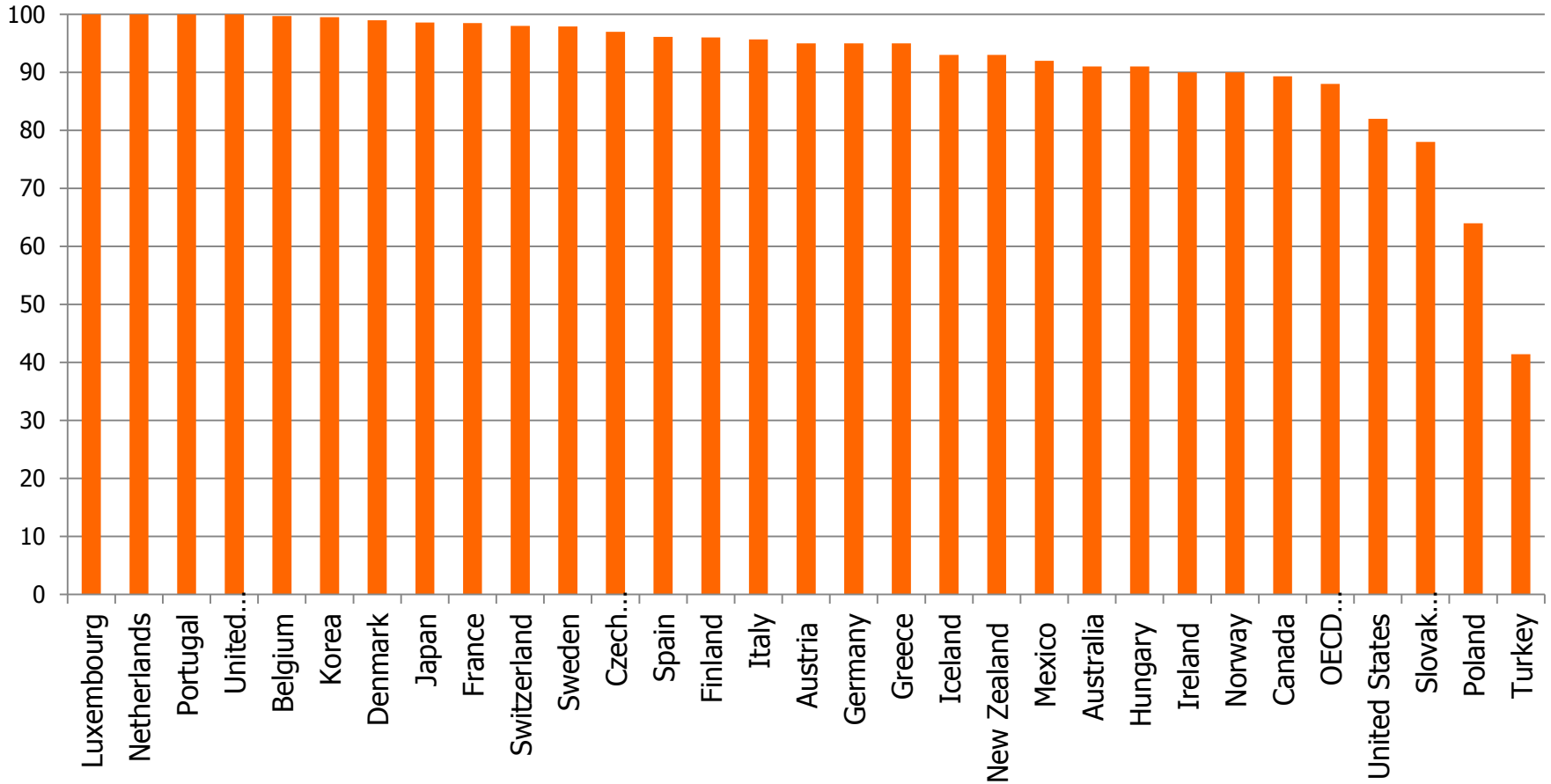


xDSL data stream

interconnection service

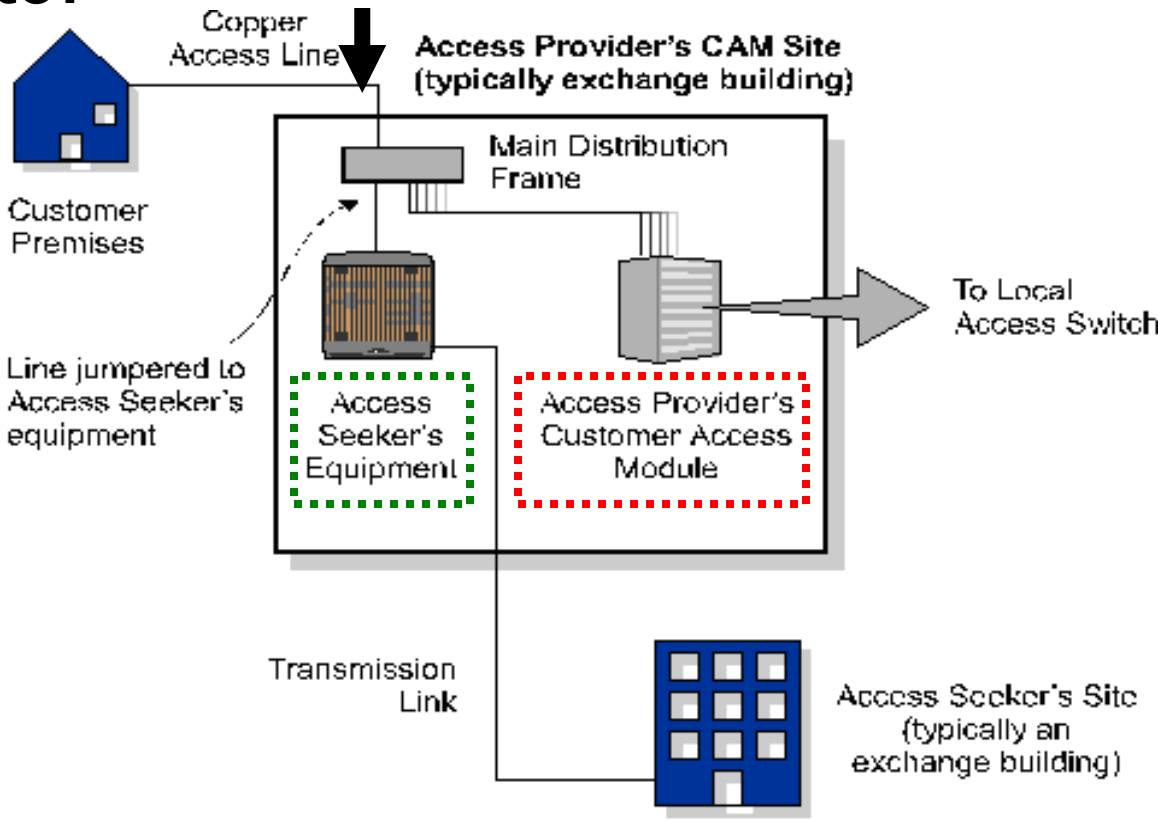
Coverage of xDSL networks: up to 2009

(% population or % households or % lines)



Who owns the DSLAM ?

- DSLAM = Digital Serial Line Access Multiplexer
- DSLAM may belong to:
  - Incumbent PSTN operator
  - alternative service provider,
- Local Loop Unbundling (LLU)



Local Loop Unbundling (I)

- Network elements and elementary services are offered by the incumbent as "stand-alone" services

- … to alternative operators, who can now offer new value-added services to the customer (e.g. broadband Internet, VoD) by :
  - combining them with their own new infrastructure,
  - fully controlling the local loop but without owning it.

Local Loop Unbundling (II)

- Introduced by Telecom Act ’96 in USA
  - Mandated provision of LLU by incumbent PSTN provider at cost
  - Enabled competition, by avoiding laying of new local loop, which would require huge investments.

- Variations of LLU:
  - Shared access: incumbent retains PSTN spectrum of copper wire
  - SLU: Sub-Loop Unbundling, i.e. at a box “closer” to the end user, allowing FTTx

LLU assessment

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- Economies of Scale
- Relaxes entrance barriers to local loop
- Promotes competition
- Avoidance of social and environmental problems arising when laying new local loop

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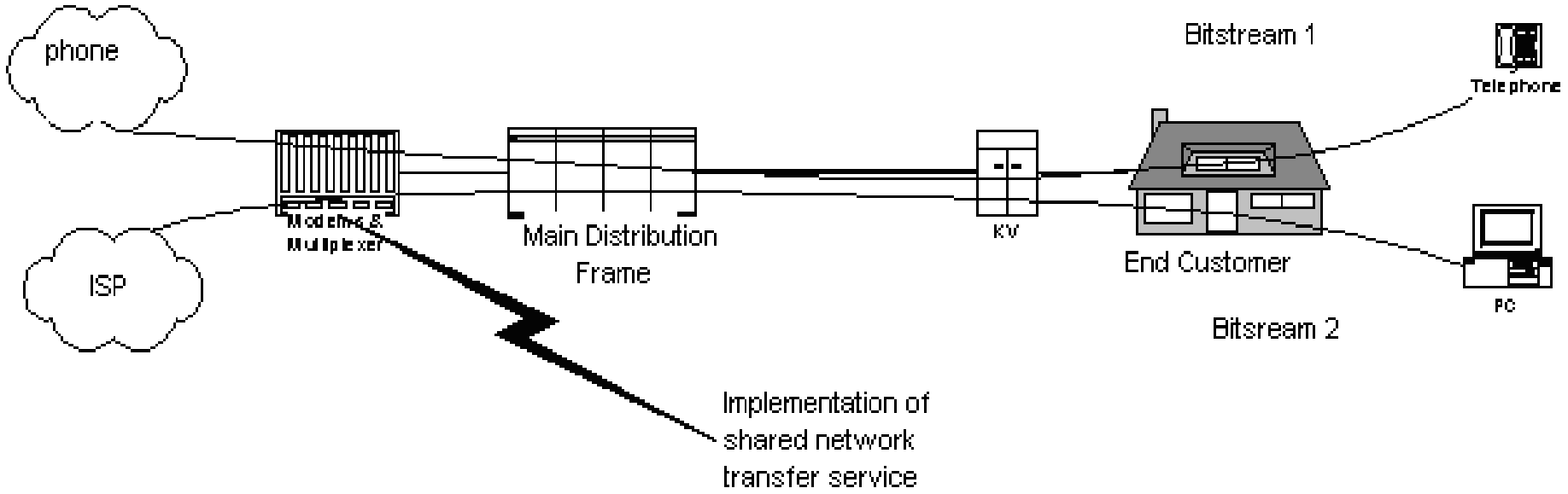
- Limits incentives for investing in alternative access infrastructure; e.g. wireless
  - Previous such investments in risk
- Limits incumbent's incentives for upgrading existing local loop infrastructure
- Requires large investments (DSLAMs) by alternative provider
- Complicated regulation and procedures
  - Numerous issues e.g. co-location

Bitstream access service

- Bitstream is the simple alternative to LLU
  - Alternative providers get "bit-pipes" of a certain rate
    - can offer data services without controlling the local loop
  - Telephony still offered by the incumbent



Bitstream assessment

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- Economies of Scale
- Relaxes entrance barriers to local loop more than LLU: No need for large invenstments
- Promotes competition
- Maintains incumbent's incentives for upgrading existing local loop infrastructure
- Simple regulation and procedures

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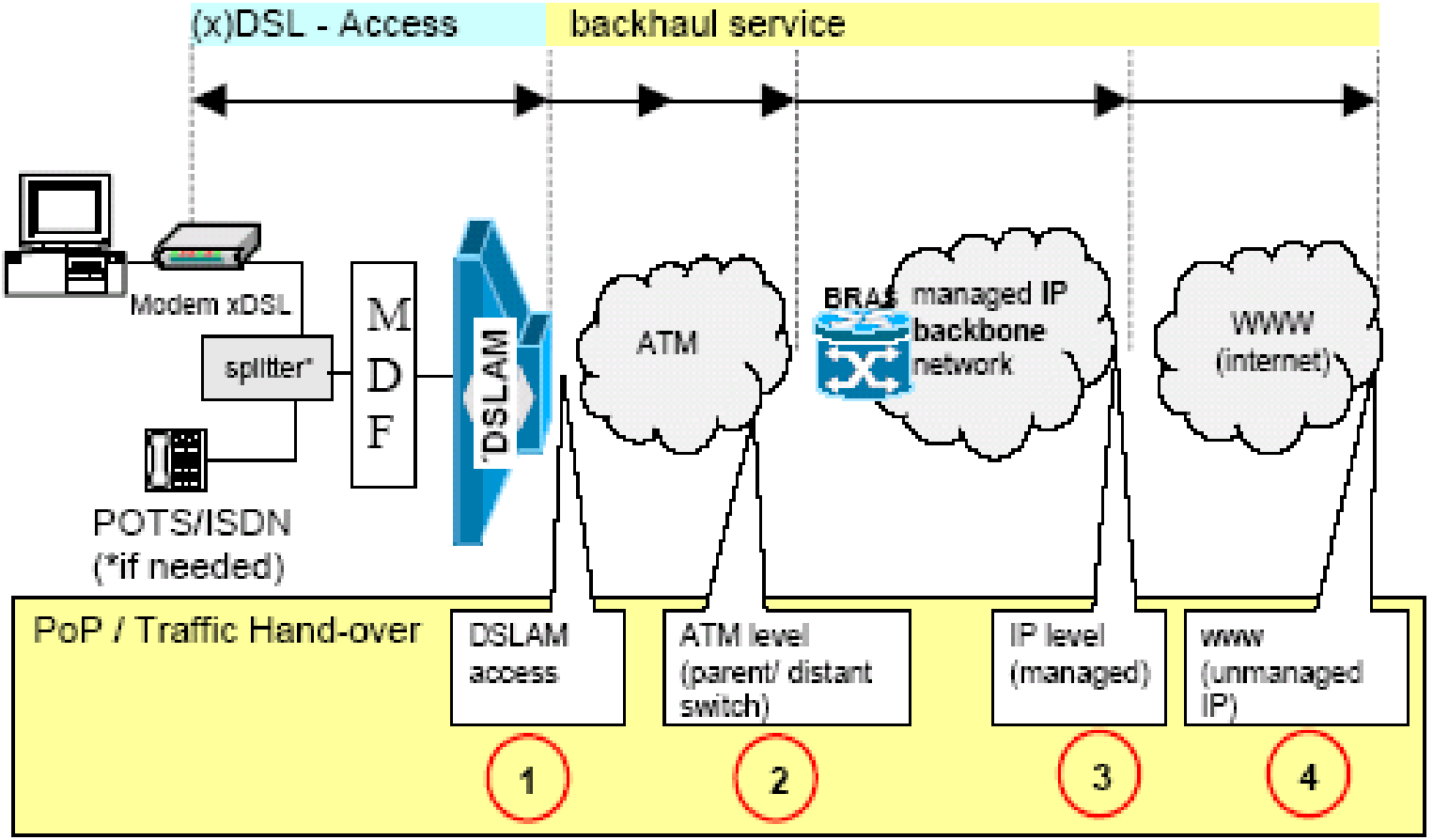
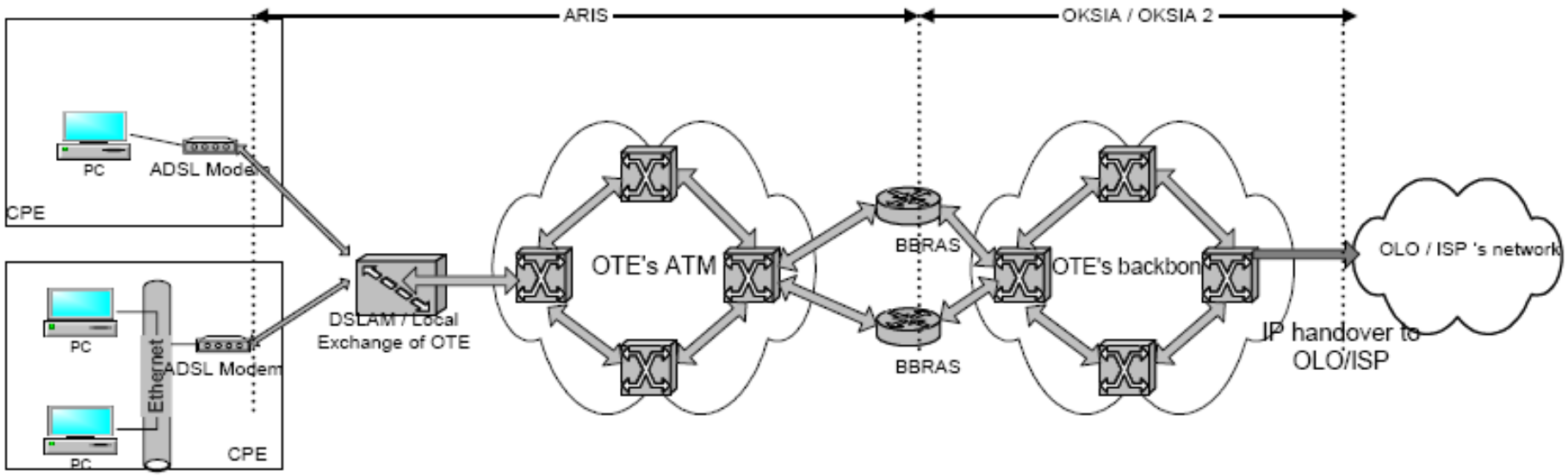
- Limits incentives for investing in alternative access infrastructure (e.g. wireless)
  - Previous such investments put in risk
- Lower quality of retail service

Bitstream versions



Bitstream Services offered by OTE



Which bitstream option ?

- The bitstream termination point determines the alternative provider's:
  - level of control to the retail service he offers to the end user
  - ability to differentiate his service
    - and thus the extent to which value can be added by the alternative

  which both decline from Option 1 to 4,
  i.e. moving away from the DSLAM

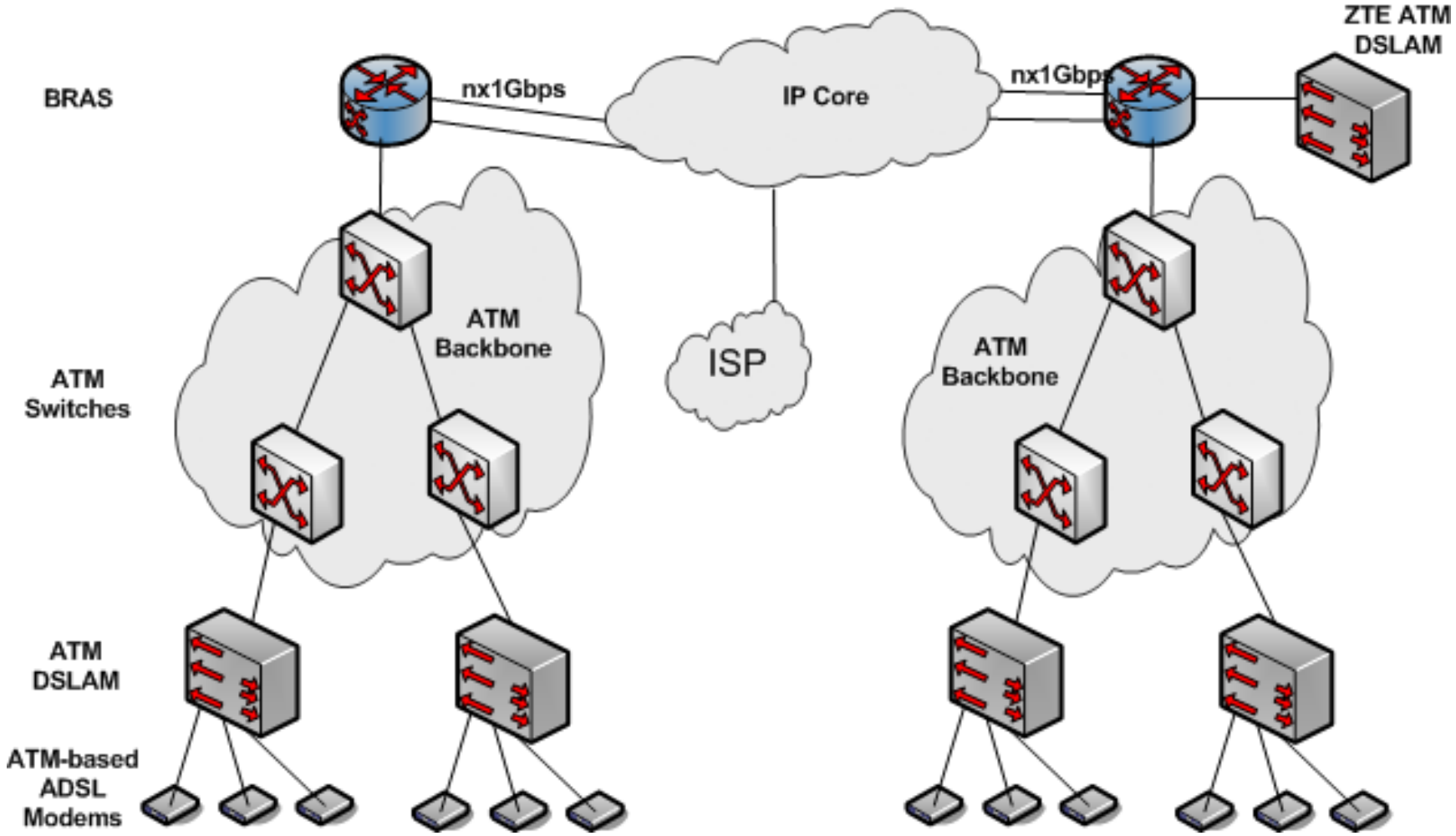
- Over-subscription factor in backhaul network is decisive for quality differentiation.
  It is controlled by
  - The alternative provider in option 1 (and LLU)
  - The incumbent in options 2-4

Impact of DSL penetration to OTE

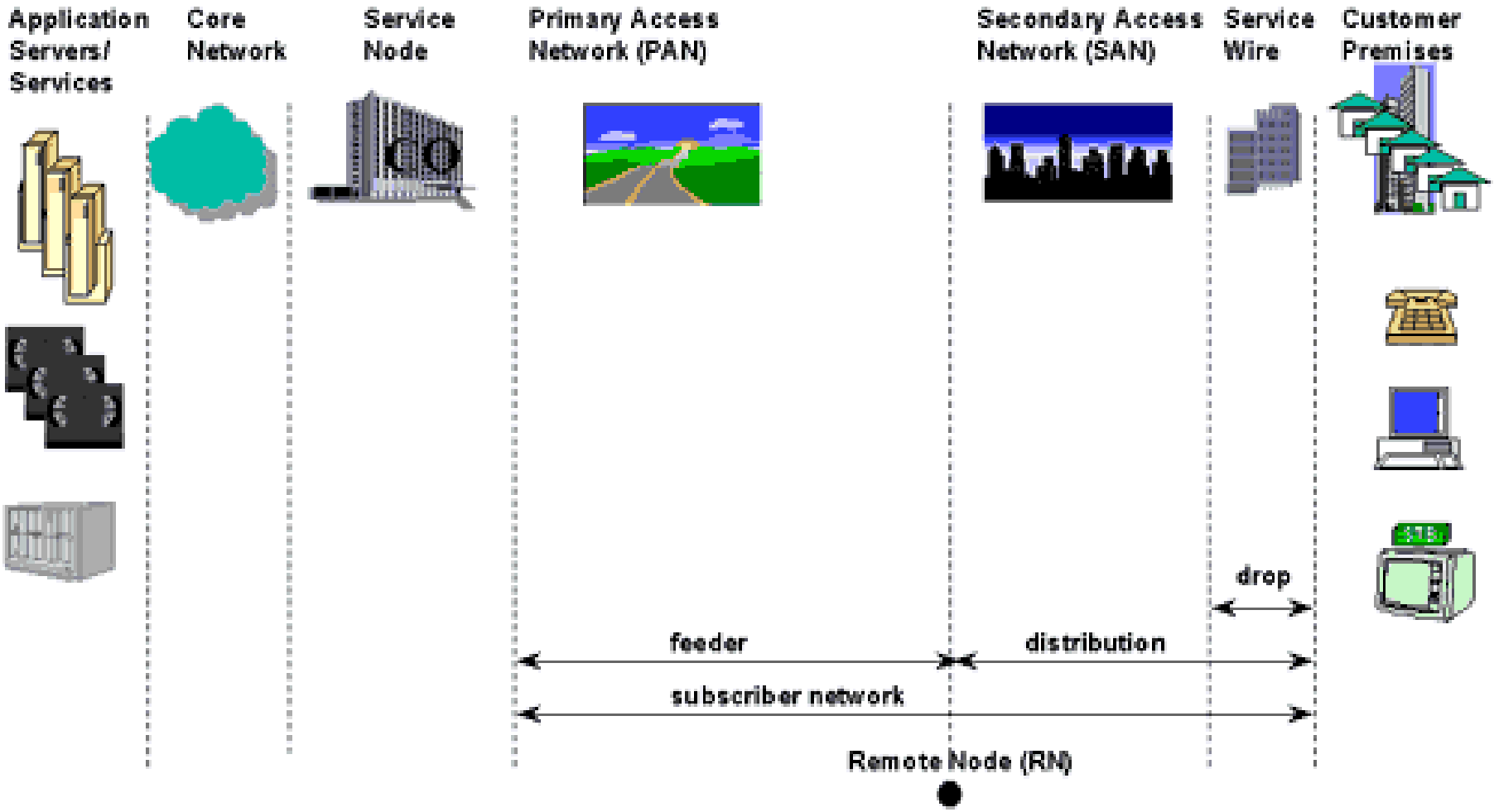
- Developing market, still dominated by OTE despite competition
- Symmetric DSL connections can serve as a substitute for leased lines with less than 2 Mbps in the retail market
- VoIP over DSL offered by alternative providers competes with OTE fixed telephony
  - Naked DSL: LLU without paying for and using the PSTN spectrum

Extra Slides: DSL architecture

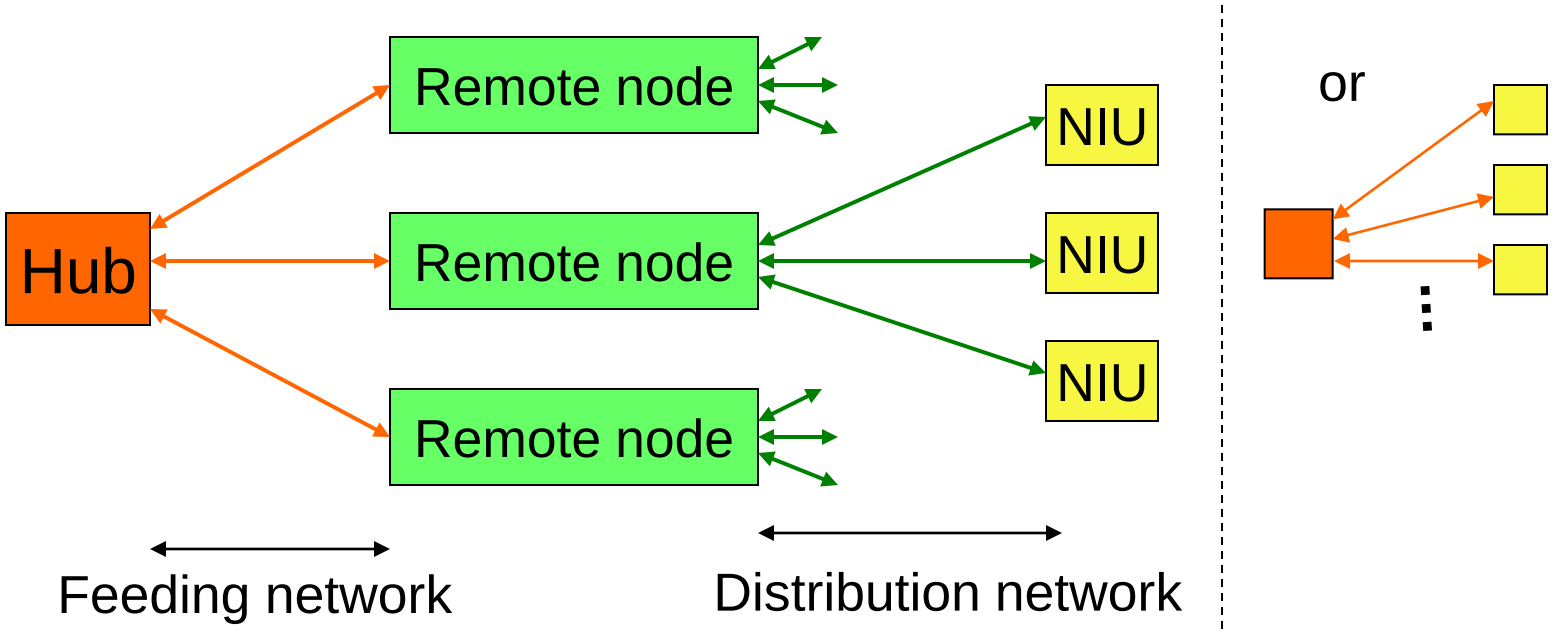
The detailed DSL access network



Hierarchy in the access network architecture



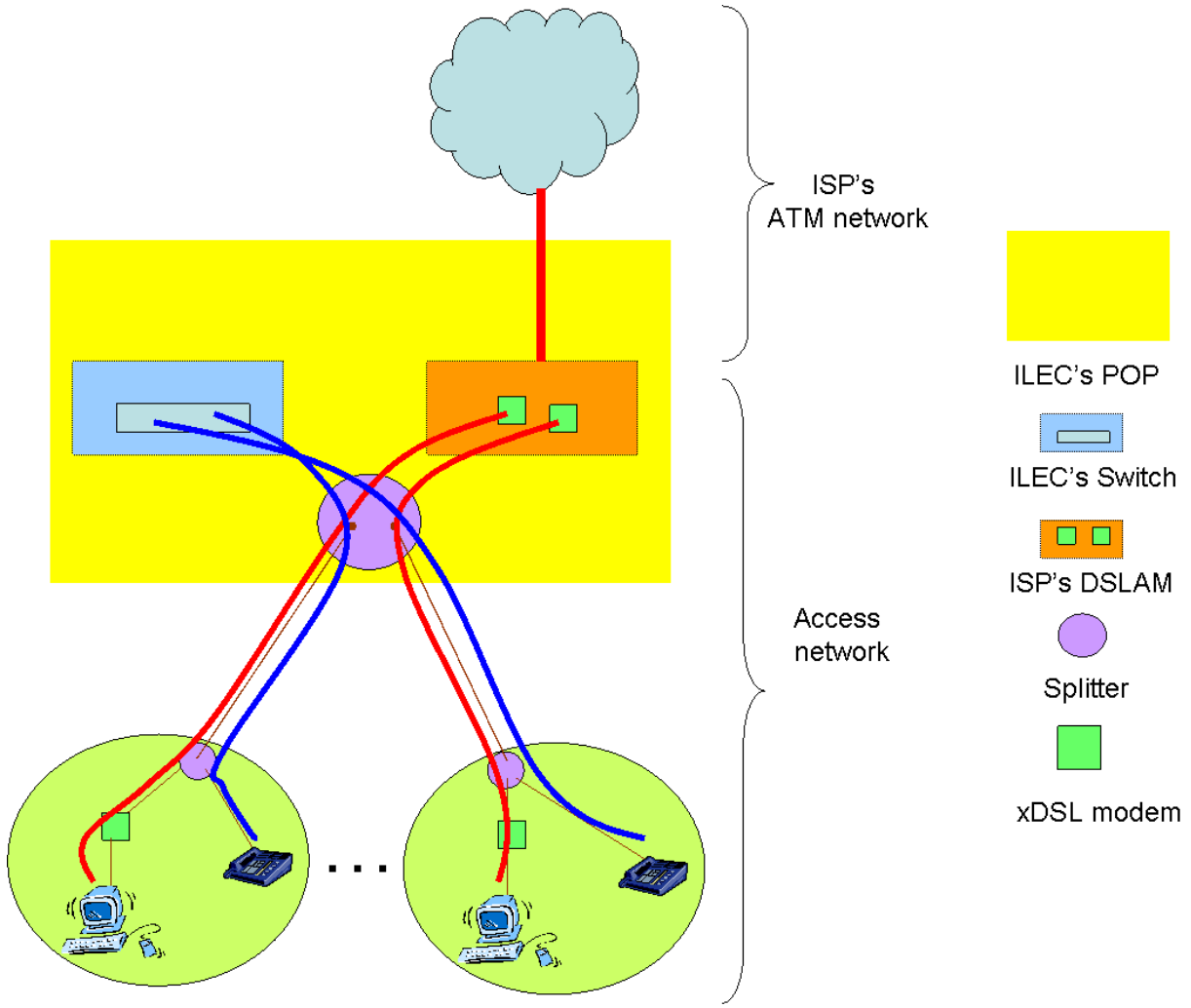
Feeding and distribution networks



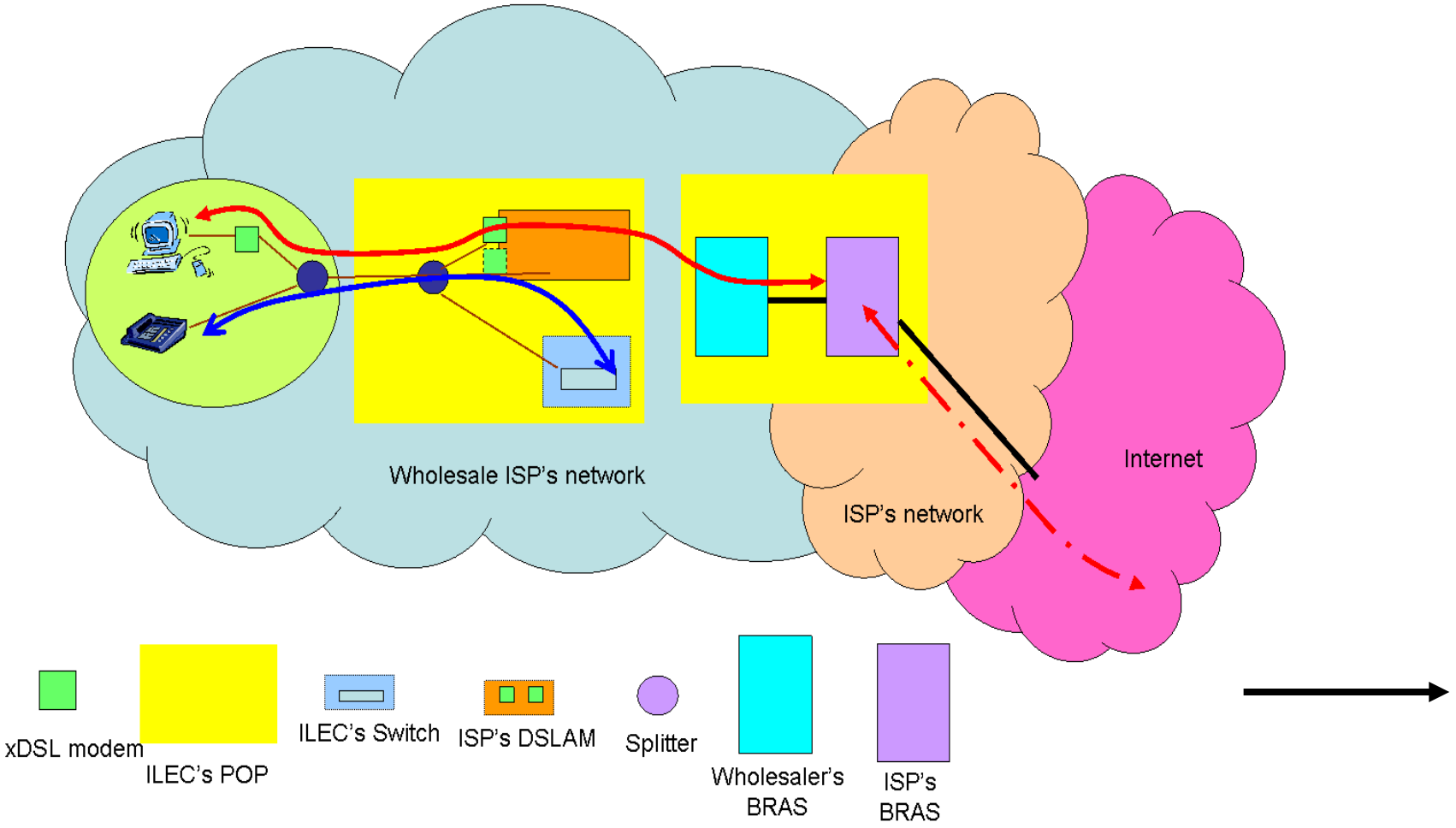
- Basic properties:
  - Feeding network: broadcast – switched
  - Distribution network: shared – dedicated

Extra Slides:
DSL → LLU shared access
& Bitstream versions

LLU Architecture (Shared Access)

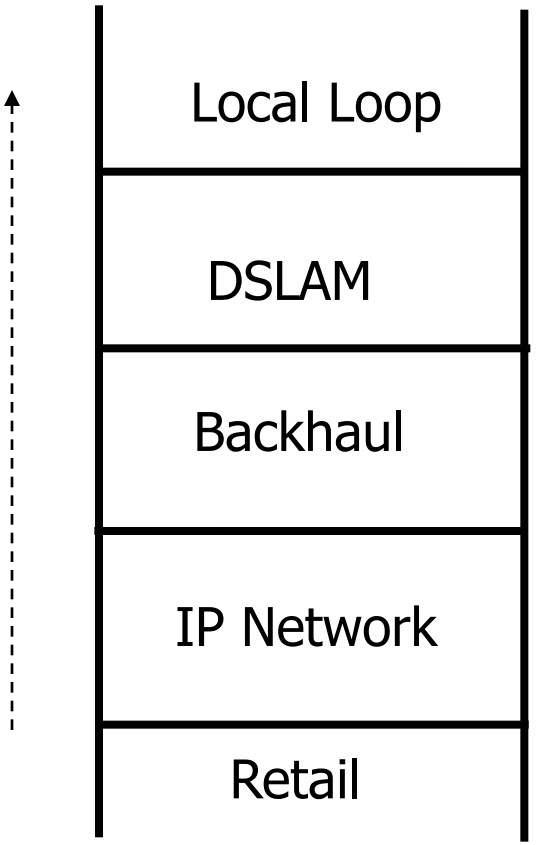


Where does the bitstream service end?



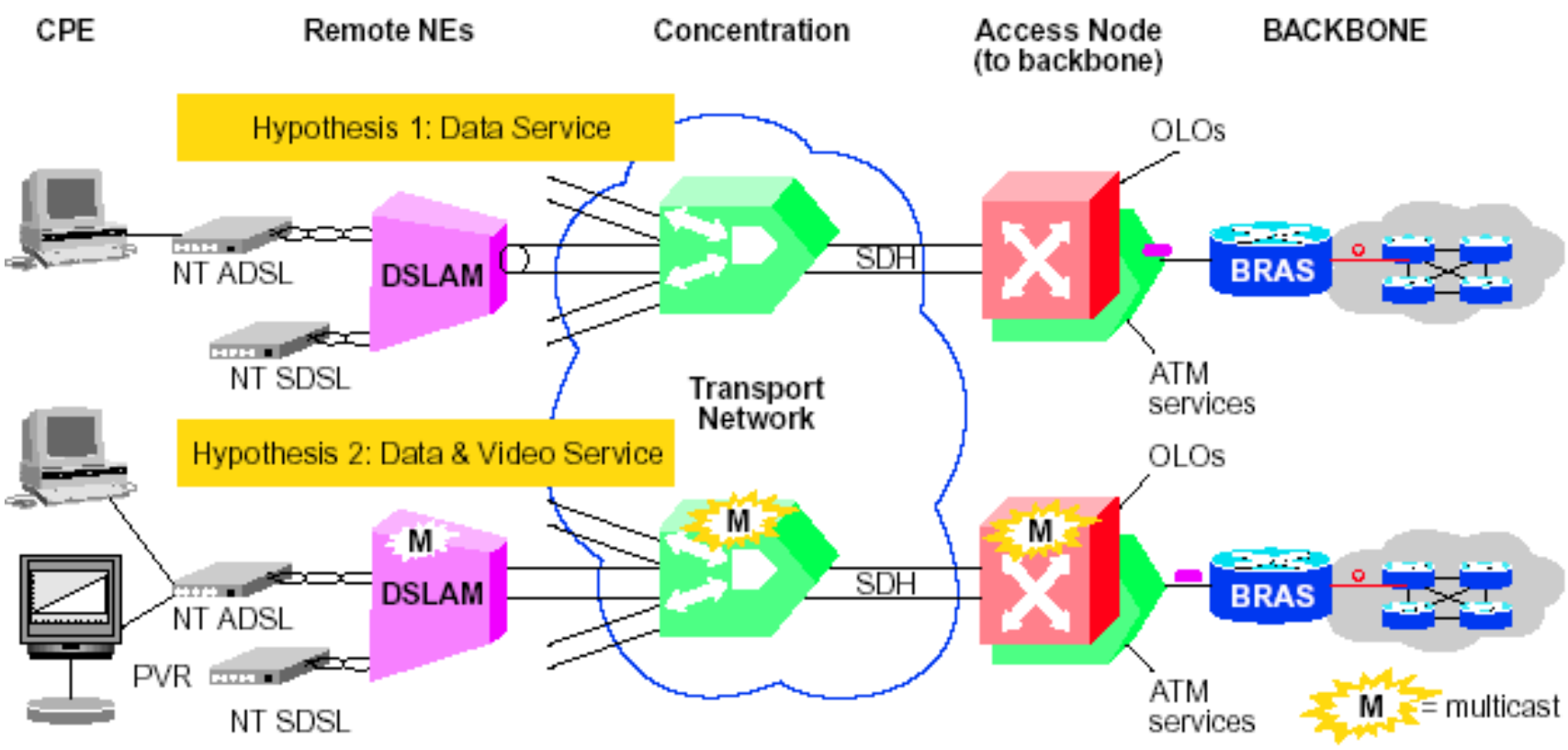
Ladder of Investment, by M.Cave

- The closer to the customer the wholesale access service → the higher the investments to be made by the alternative provider



Extra Slides:
DSL→Transport Network Dimensioning

Transport network dimensioning (I)



Source: “Network solutions for Broadband-over-DSL services, Marco Rittore, July 2002

Transport network dimensioning (II)

- The operator must efficiently manage the bandwidth in the transport network:
  - Using as efficiently as possible the existing resources
  - Planning the introduction of traffic consolidation and concentration systems, but
    - without sacrificing quality for a high over-subscription factor
  - Introducing transmission systems with increased capacity

Transport network dimensioning (III)

- Multicast service imposes a heavy dimensioning of the network and intermediate traffic concentrators
  - approx. 9 times that required for phone traffic, when number of multicast channels = 16