Integration of Innovative Access Technologies for wider broadband coverage

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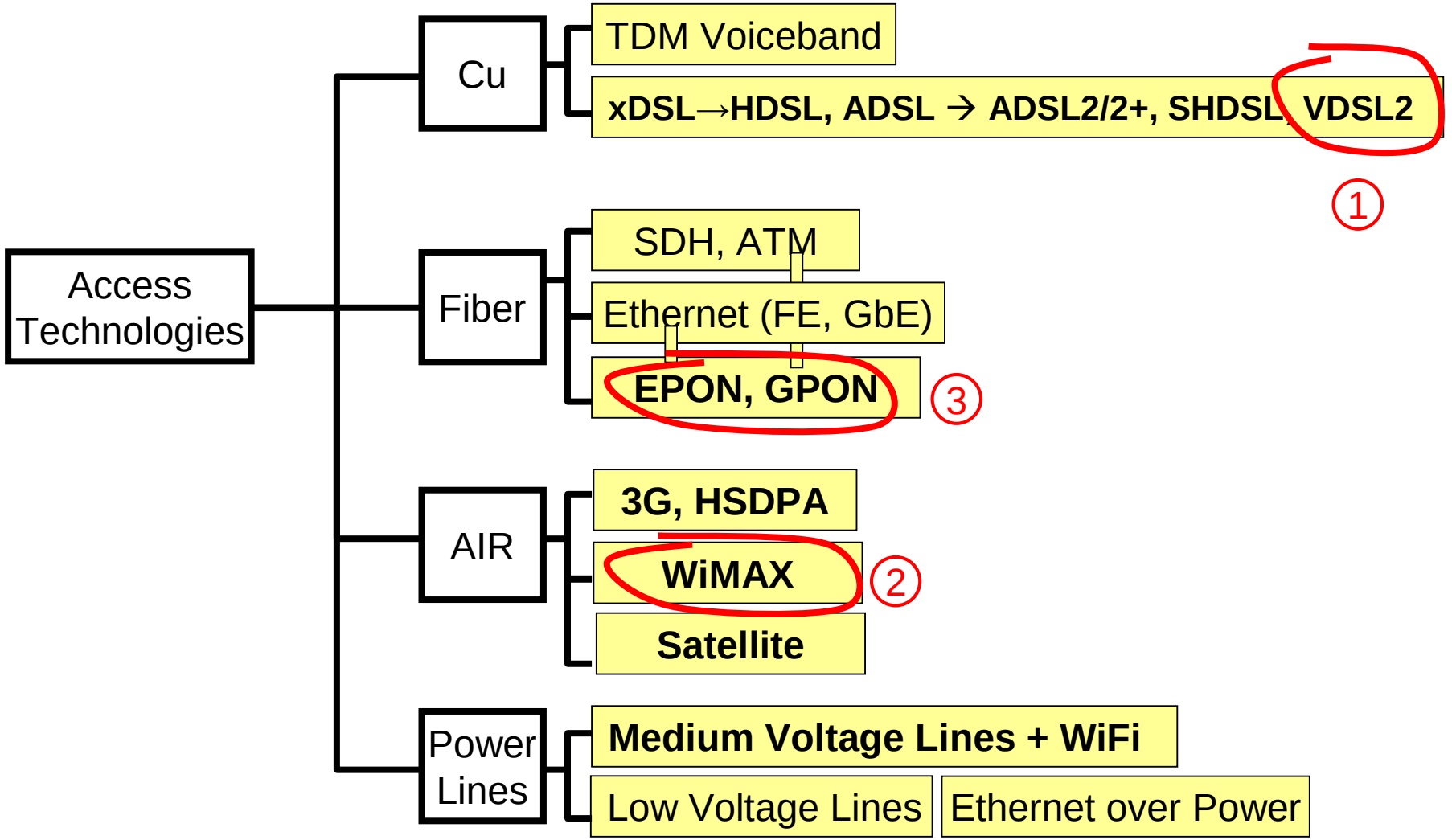
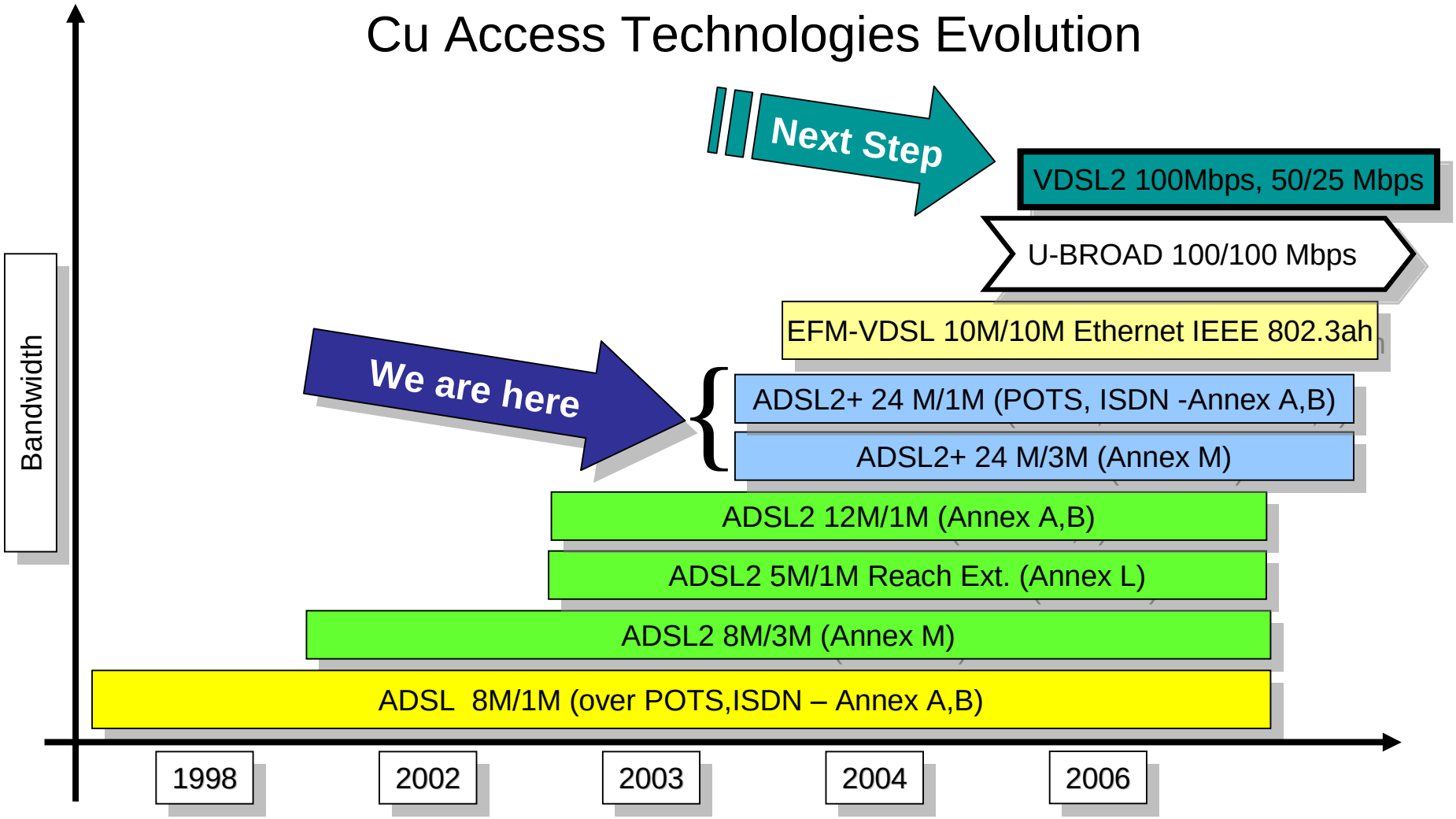
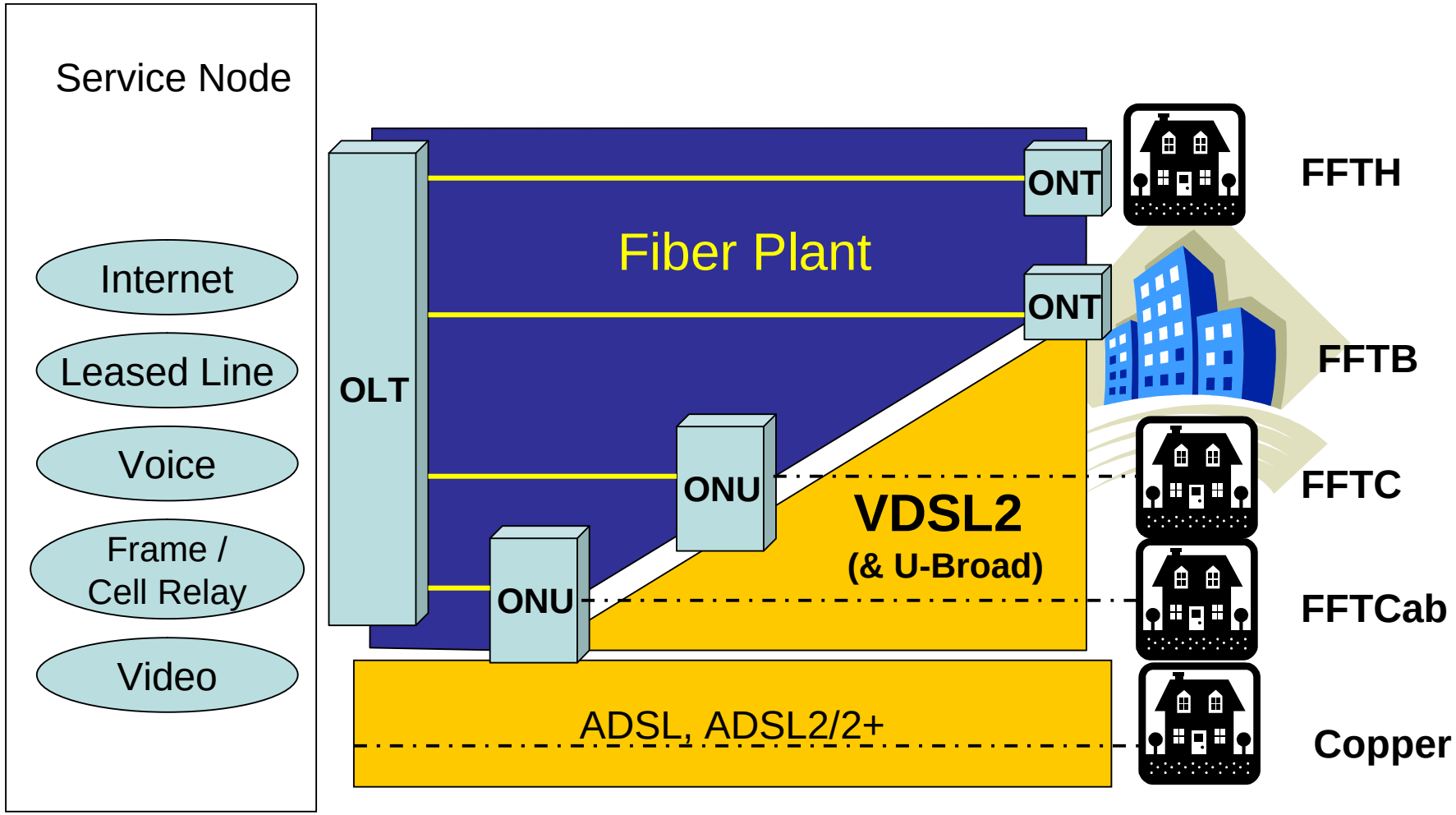
Broadband Access Trends

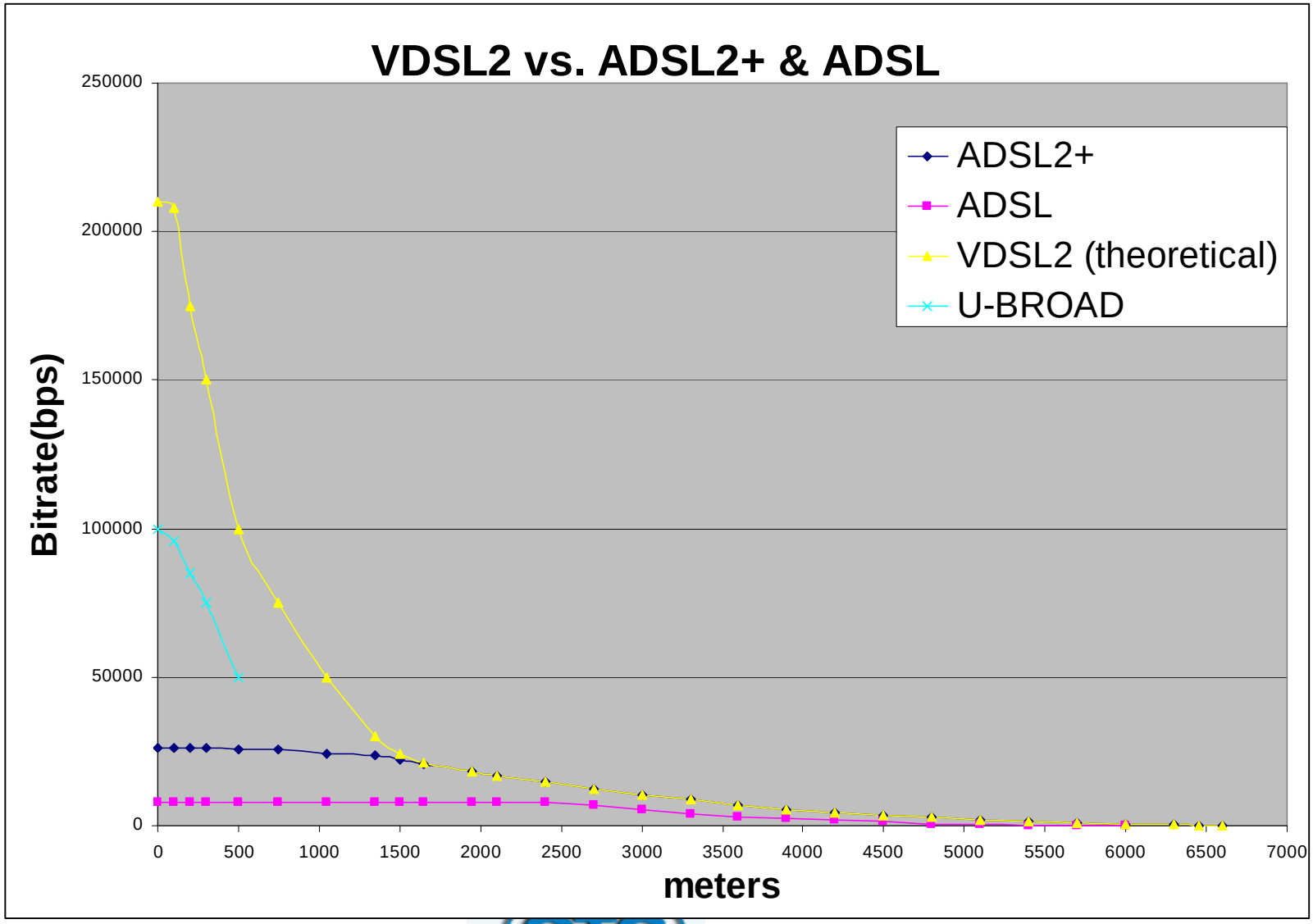
- More b/w to the end user. This trend seems to accelerate with the introduction of Video Services and HDTV.
- Multiple service offering over same line (triple play!).
- Fiber plants penetrate deeper on the network reducing the Cu-Cable distance to end customer.
- New technologies are introduced (Ethernet vs. ATM, ADSL2+ vs ADSL, VDSL2, …).
- Multiple technologies coexist on the network.
- Demand for leased line services still high.


Access Technologies
Cu
TDM Voiceband
xDSL→HDSL, ADSL → ADSL2/2+, SHDSL, VDSL2
1
Fiber
SDH, ATM
Ethernet (FE, GbE)
EPON, GPON
3
AIR
3G, HSDPA
WiMAX
2
Satellite
Power Lines
Medium Voltage Lines + WiFi
Low Voltage Lines
Ethernet over Power

Cu Access Technologies Evolution




Service Node
Internet
Leased Line
Voice
Frame / Cell Relay
Video
OLT
Fiber Plant
ONT
ONT
ONU
ONU
VDSL2
(& U-Broad)
ADSL, ADSL2/2+
FFTH
FFTB
FFTC
FFTCab
Copper

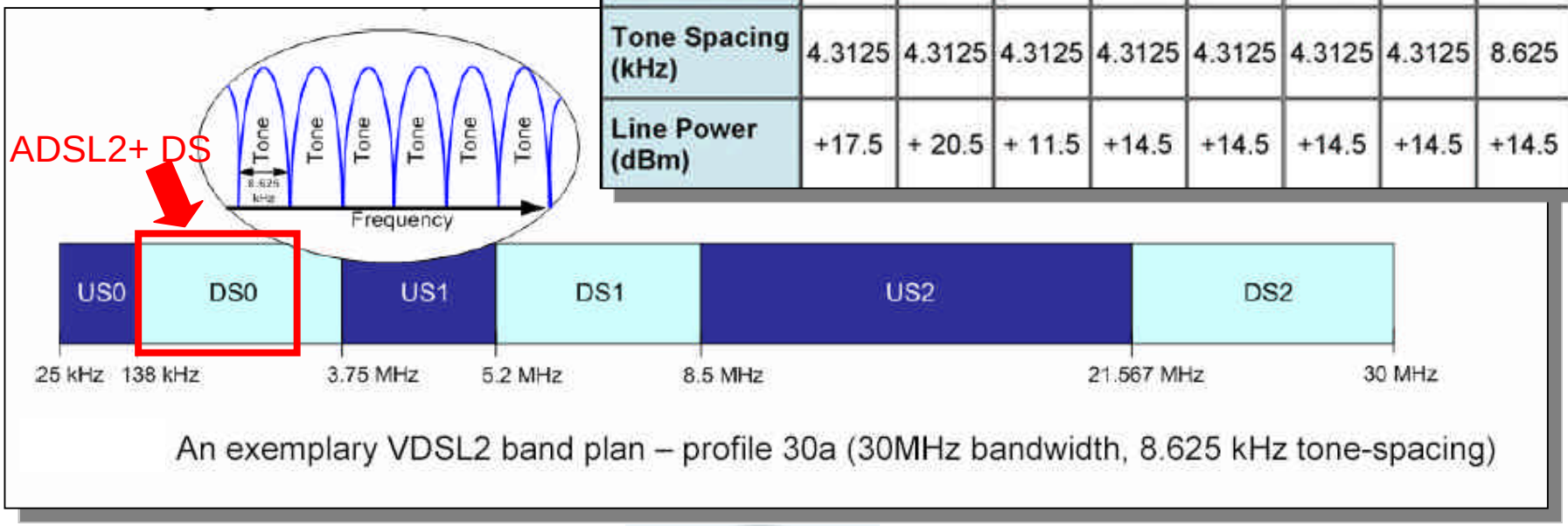

VDSL2 vs. ADSL2+ & ADSL
Bitrate(bps)
250000
200000
150000
100000
50000
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
meters
ADSL2+
ADSL
VDSL2 (theoretical)
U-BROAD

	ADSL2/2plus	VDSL2
Bandwidth	Up to 24 Mbps	Up to 200 Mbps
Symmetry	Highly Asymmetric	Symmetric & Asymmetric
Band Zones	two	Multiple (4-6)
Carrier Tones	512	Up to 4096
Framing	ATM only	ATM and Ethernet
QoS mechanism	Not inherent	Build-in (dual latency)

VDSL2 Band Plan

Should be chosen carefully

Profile	8a	8b	8c	8d	12a	12b	17a	30a
Bandwidth (MHz)	8.832	8.832	8.5	8.832	12.	12.	17.664	30.
Tones	2048	2048	1972	2048	2783	2783	4096	3479
Tone Spacing (kHz)	4.3125	4.3125	4.3125	4.3125	4.3125	4.3125	4.3125	8.625
Line Power (dBm)	+17.5	+ 20.5	+ 11.5	+14.5	+14.5	+14.5	+14.5	+14.5



An exemplary VDSL2 band plan – profile 30a (30MHz bandwidth, 8.625 kHz tone-spacing)

New Considerations

- Transmission Power management is important and needed (weak ADSL signal from CO will interfere with strong VDSL2 signal as it reaches street cabinet)
- Environmental requirements for outdoor installation is a greater challenge (-5 to 45^{o} C vs. -40 to 60^{o} C)
- Power provisioning in installations more complex
- Operation and Maintenance Cost higher (access to cabinet time consuming and costly per user wiring)

The xDSL environment

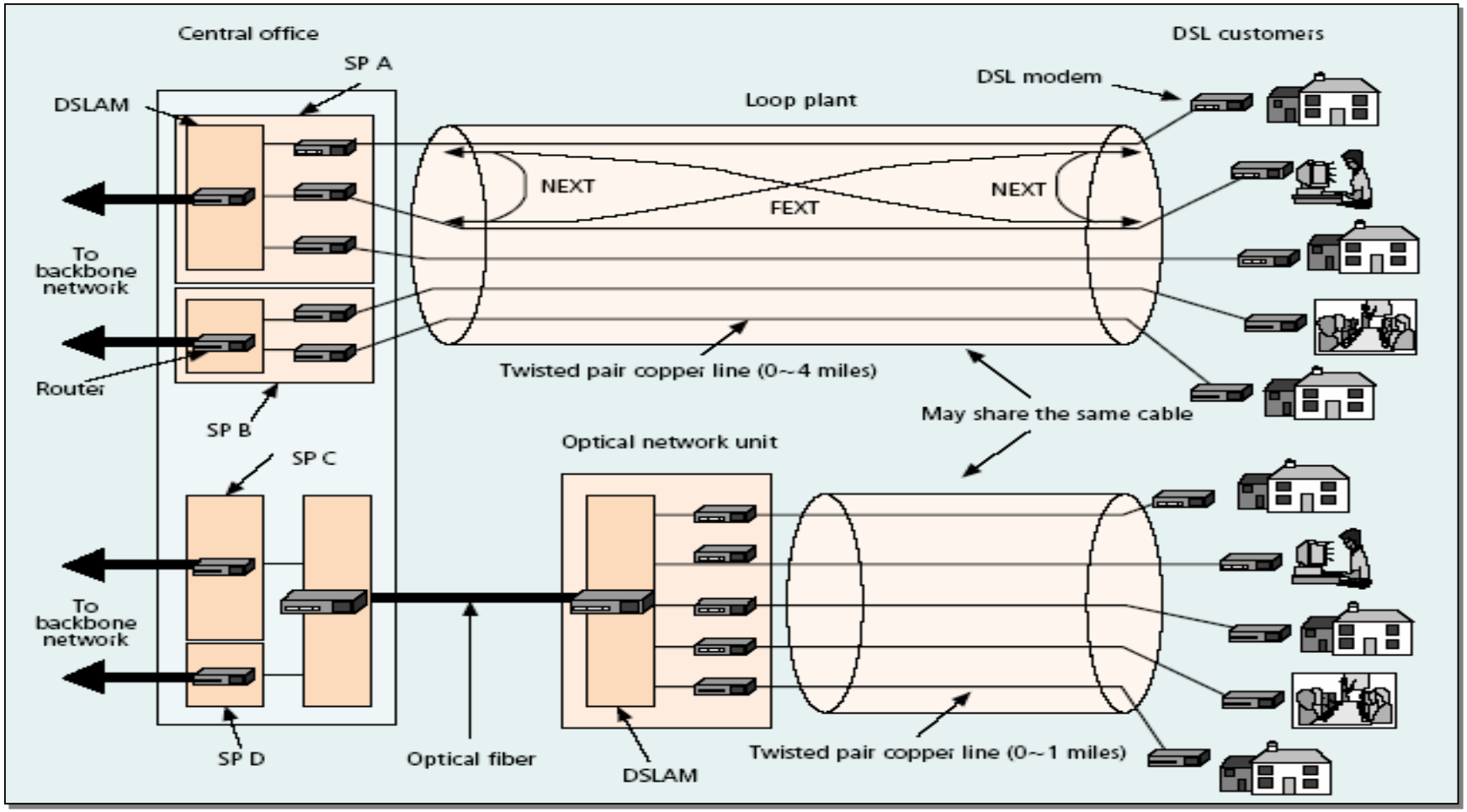
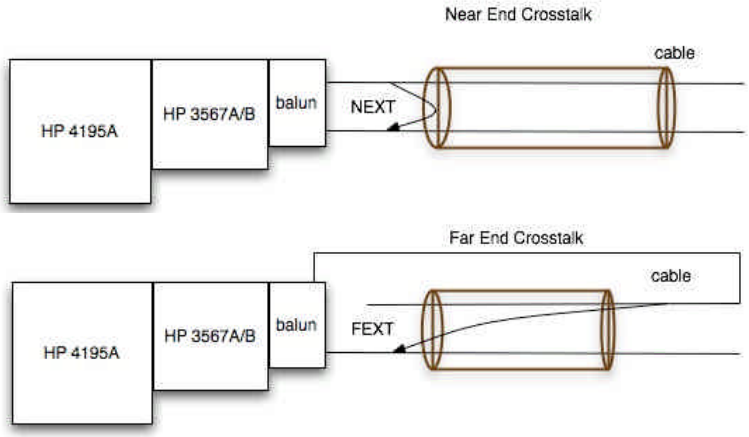


Figure © IEEE, Song, Chung, Ginis, Cioffi, COM Mag Oct 02

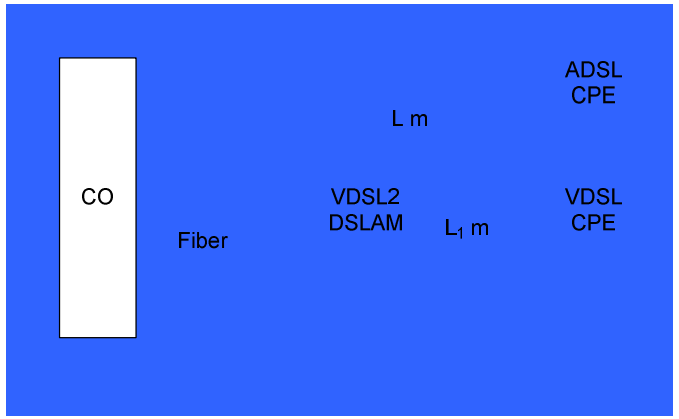
What do we focus on?

- Detailed measurements of Crosstalk Noise (FEXT & NEXT) in the VDSL2 band (up to 30 MHz) on telephone grade Cu cables
- Modeling of the Noise

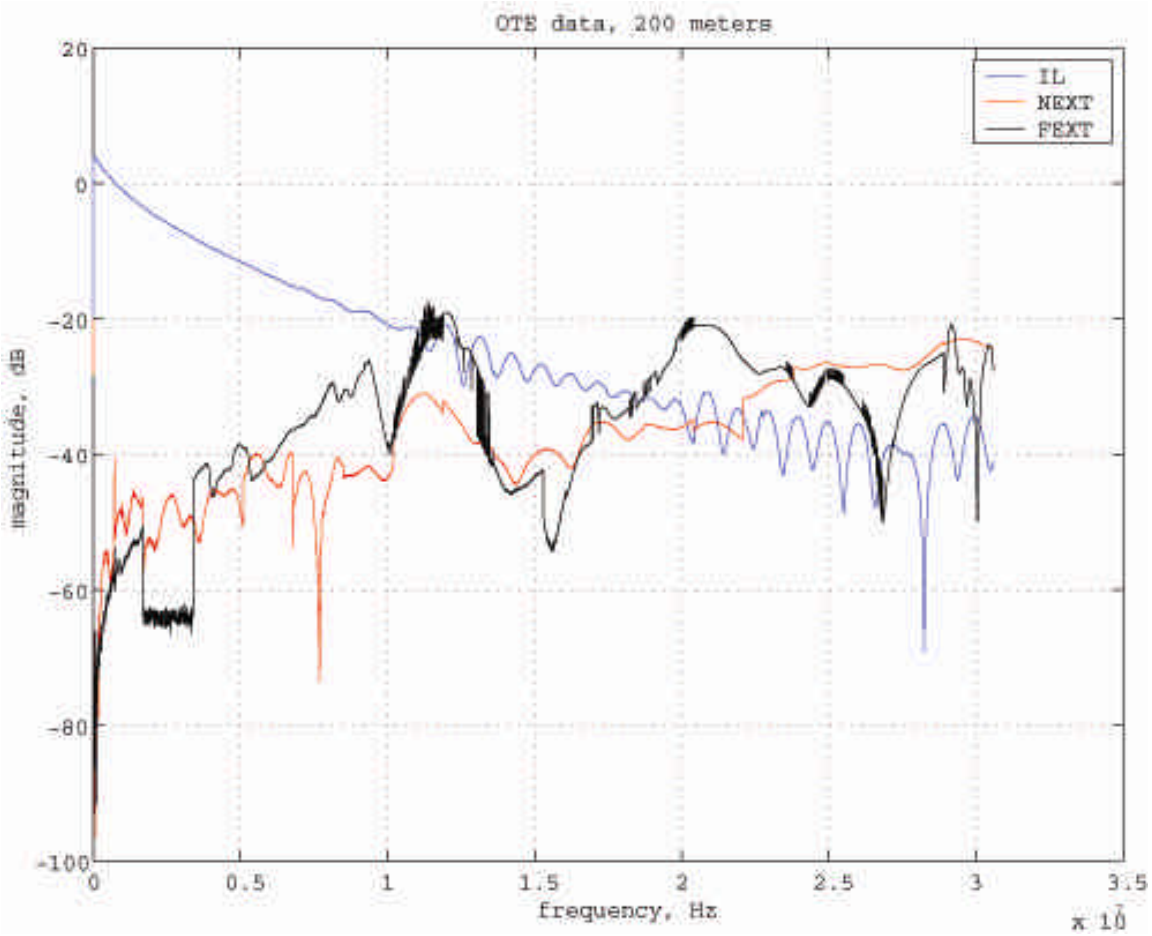


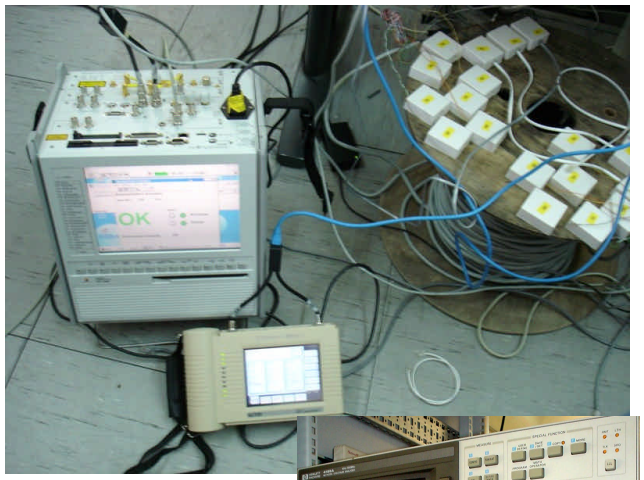
results (case of multiple pair transmission):

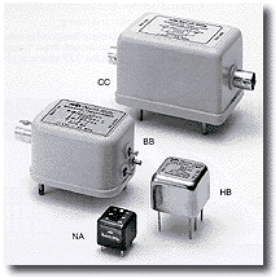
- FEXT, NEXT crosstalk interference losses and the insertion losses are very important quantities that need to be measured in order to qualify the performance of copper wires that are aimed to provide high speed services to the premises of the end users.
- The above losses increase as the frequency and the length of the copper wires increase.



FEXT & NEXT Measurements



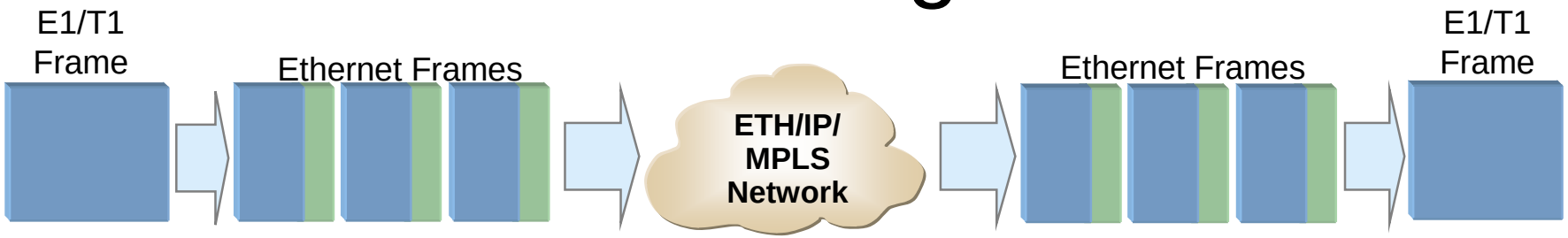




What we think? (FEXT,NEXT,IL)

- Crosstalk appears as the limiting factor in wireline Cu transmission (beyond length and diameter).
- Crosstalk reduction can achieve great performance improvement.
- Methodologies to reduce it can include automatic transmission power management and in the future Coordinated transmission and MIMO system approaches.

Leased Line & TDM over IP technologies



- The synchronous bit stream is segmented
- Headers are added to each segment to form the Packet
- Packets are forwarded to destination over the PSN network
- At destination, the original bit stream is reconstructed transparently

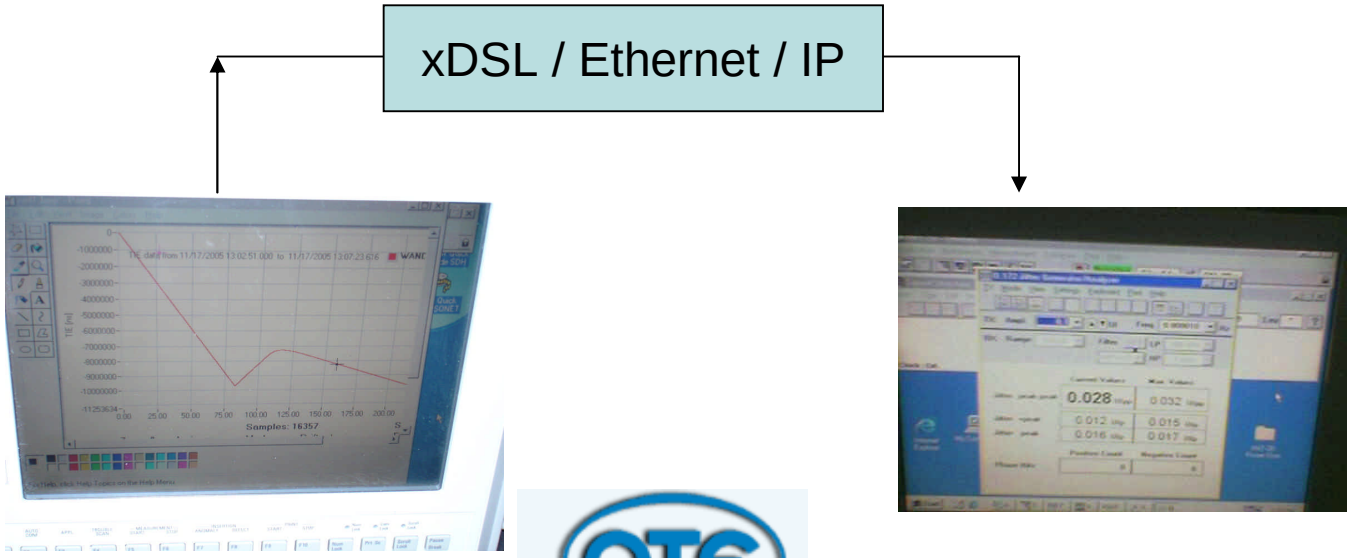
What do we focus on?

Measure parameters that affect QoS for real time services in packet networks

Latency	→	End to end delay impairment for interactive services such as voice
Packet Jitter & Wander	→	Variable delay Degrades service delivery
Clock recovery	→	System synchronization Degrades real time applications

Jitter-Wander measurements
Clock synchronization

- Lab results very encouraging with respect to clock recovery (from internal and/or external source).
- Successfully can provide legacy E1 and/or E3 services over IP/Ethernet network with xDSL access.



Concluding remarks

- IP appears to be the “all encompassing” technology.
- In the Broadband access ATM is slowly being replaced by Ethernet protocol.
- The different broadband access technologies will coexist on the network in the near future in the network.
- Extra care should be taken when different technologies share the same medium (i.e. VDSL2 & ADSL2+).
- Crosstalk noise is a limiting factor of the maximum bitrate that can be offered to end-customer.
- Reduction of cross-talk can achieve multiple benefits
- In the network synchronous and asynchronous transfer of data should be supported, necessitating the incorporation of technologies like TDM over Packet.