
10BASE-T4 for EFM

Going the extra mile

Howard Frazier - Dominet Systems

Hugh Barrass - Cisco Systems

Behrooz Rezvani - Ikanos

IEEE 802.3ah EFM Task Force

Copenhagen, Denmark

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EFM Copper Objectives

- ❑ Support subscriber access network topologies:...
 - ❑ Point to point on copper
- ❑ Provide a family of physical layer specifications:...
 - ❑ PHY for single pair non-loaded voice grade copper distance $\geq 2500\text{ft}$ and speed $\geq 10\text{Mbps}$ aggregate
- ❑ The point-to-point copper PHY shall recognize spectrum management restrictions imposed by operation in public access networks, including:
 - ❑ Recommendations from NRIC-V (USA)
 - ❑ ANSI T1.417-2001 (for frequencies up to 1.1 MHz)
 - ❑ Frequency plans approved by ITU-T SG15/Q4, T1E1.4 and ETSI/TM6

Why Go Farther?

2500 ft < 1 mile

Outside plant loops are >> 2500 ft

Why Go Farther?

- ❑ 750 m (~2500 ft) reach will cover
 < 40% of DLC fed loops
- ❑ 3600 m (~12,000 ft) reach will cover
 ~ 95% of DLC fed loops
 - ❑ Telcordia Technologies T1E1.4/2001-132, May 2001
- ❑ 750 m (~2500 ft) reach will cover
 ~ 20% of business and residential loops
- ❑ 3600 m (~12,000 ft) reach will cover
 > 85% of business and residential loops
 - ❑ Telcordia Technologies (1983 BellCore)
 T1E1.4/2000 - 219R1, November 2000

Whoa There, Big Fella

- ❑ 10 Mbps, full duplex, 3600 meters, .4 mm wire-> exceeds the Shannon capacity of the medium ☹
- ❑ Could deliver less than 10 Mbps
 - ❑ Is this really Ethernet?
 - ❑ Does it really have a Distinct Identity?
- ❑ Could deliver less than Full Duplex
 - ❑ 10 Mbps “Aggregate” is cheating

Recycling an Old Idea

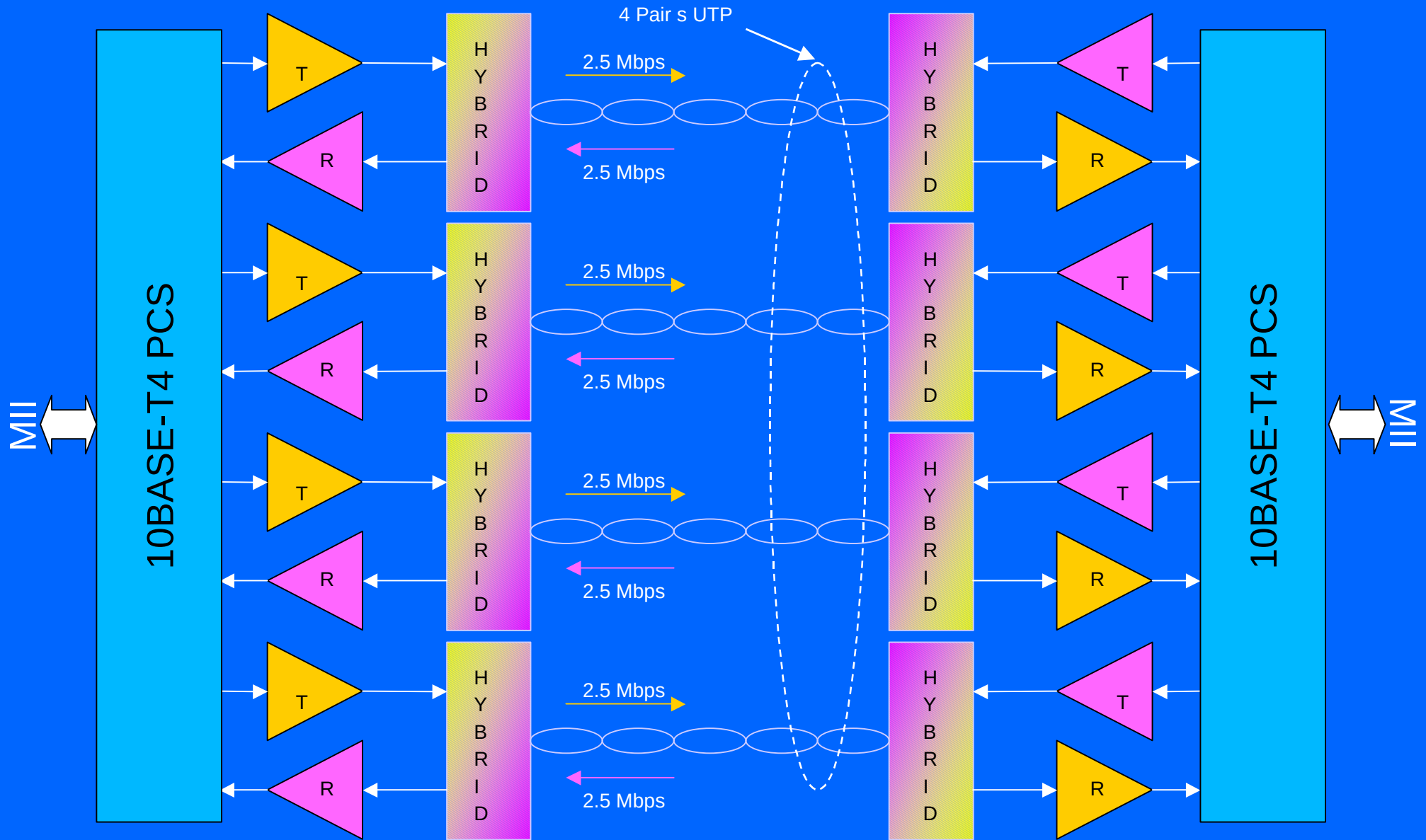
Use more pairs!

- ❑ 10BASE-T, 100BASE-TX, 100BASE-T2
 - ❑ Use 1 pair in each direction (2 total)
- ❑ 100BASE-T4
 - ❑ Uses 3 pairs in each direction (4 total)
- ❑ 1000BASE-T
 - ❑ Uses 4 pairs in each direction (4 total)
- ❑ 802.3ae (XAUI)
 - ❑ Uses 4 pairs in each direction (8 total)

10BASE-T4

- ❑ Ethernet in the First Mile for CO & Remote Terminal Deployment
- ❑ Transmit bi-directionally on 4 wire pairs
- ❑ 10 Mbps full duplex communication (2.5 Mbps per pair)
- ❑ ~12,000 foot reach
- ❑ Use ADSL spectrum, but increase upstream band
- ❑ Spectrally compatible with xDSL
- ❑ Can be deployed on “wet” pairs

10BASE-T4

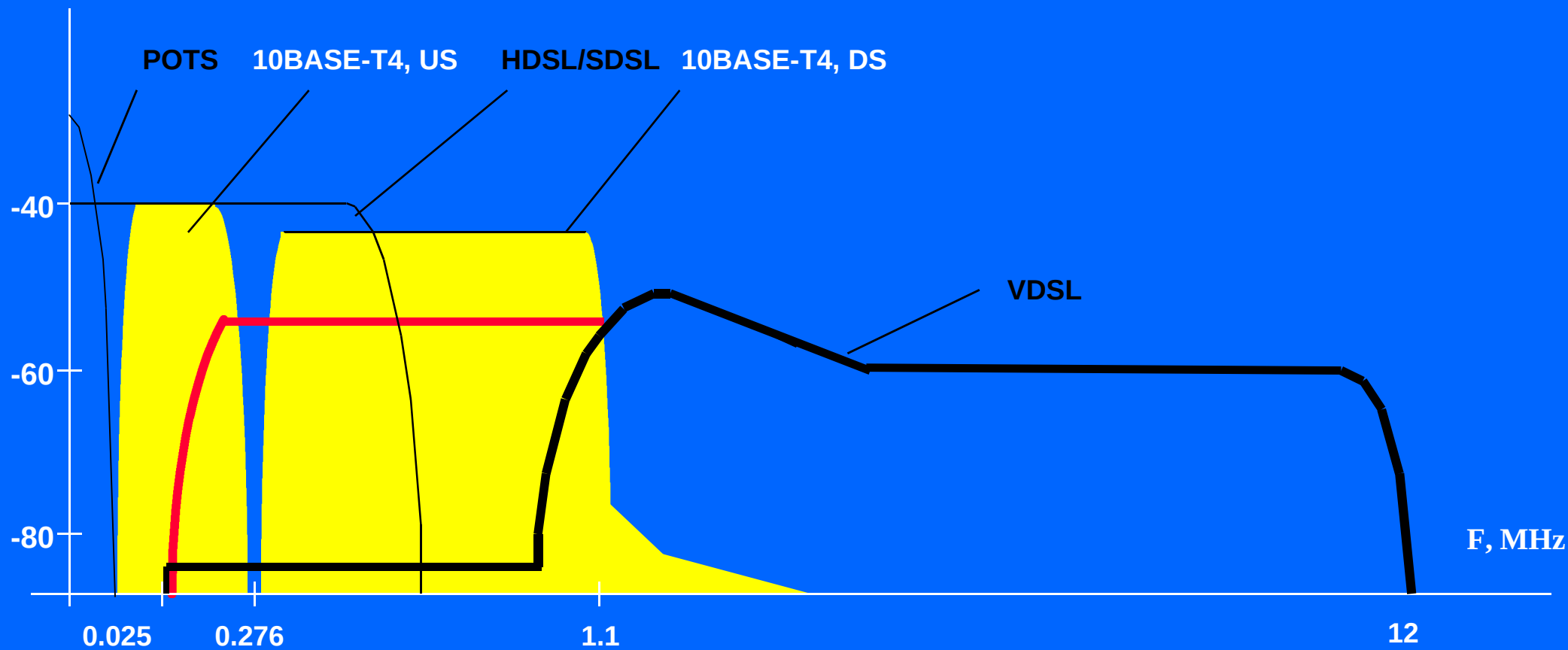


Resiliency and Incremental B/W

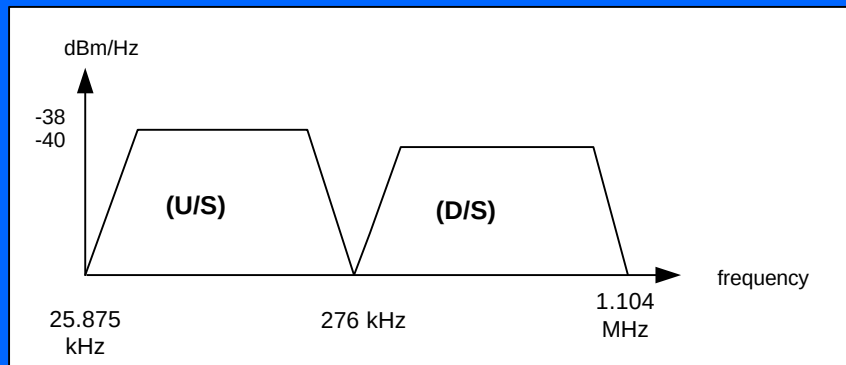
- ❑ Resiliency against pair failures
 - ❑ 4 pairs -> 10 Mbps
 - ❑ 3 pairs -> 7.5 Mbps
 - ❑ 2 pairs -> 5.0 Mbps
 - ❑ 1 pair -> 2.5 Mbps
- ❑ Sub 50 msec recovery time
- ❑ Allows 4 increments of bandwidth
- ❑ A must for mission critical business service

PSD

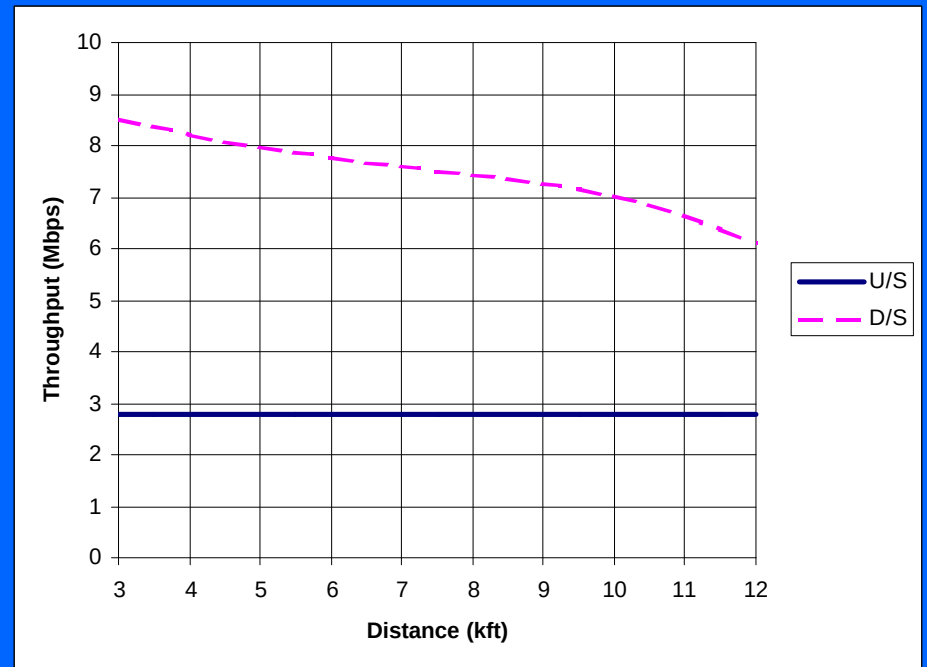
PSD, [dBm/Hz]



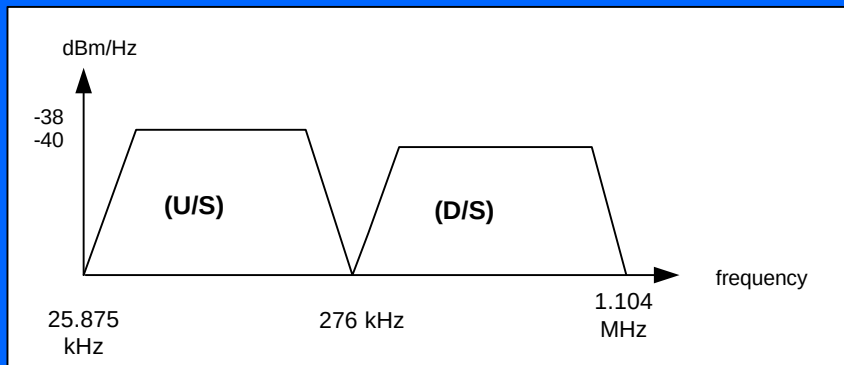
12 kft, 24 ADSL/HDSL-2



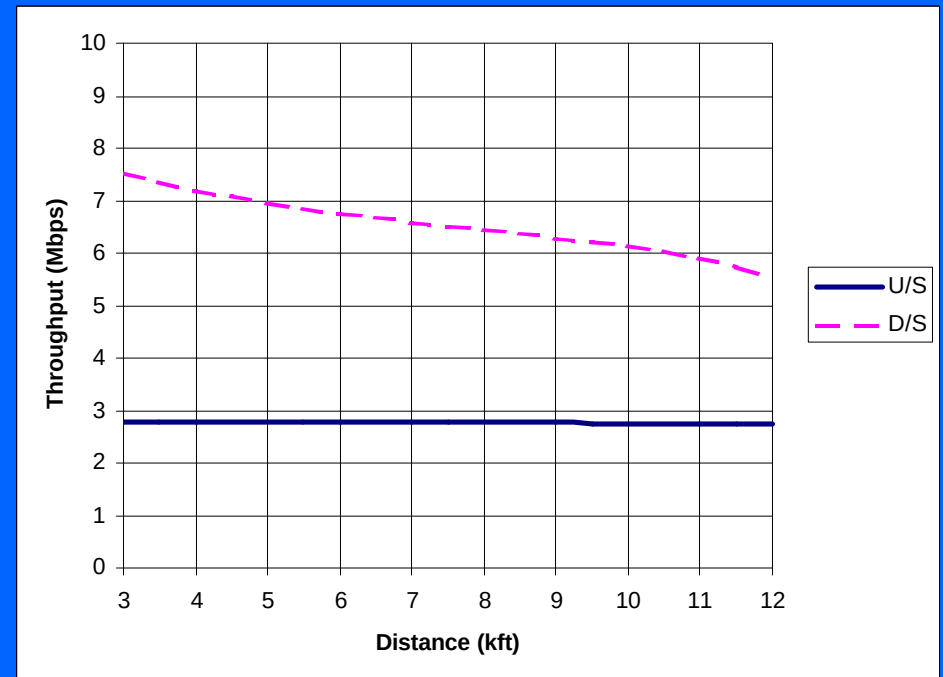
Assumptions:	
-140dBm/Hz AWGN	
24AWG	
5.5dB coding gain	
6 dB noise margin	
24 SHDSL & 24 ADSL	
spectrum as shown	
92.7% capacity	
12bits/tone*Hz max	



12 Kft, 24 ADSL, 24 self-FEXT



Assumptions:	
-140dBm/Hz AWGN	
24AWG	
5.5dB coding gain	
6 dB noise margin	
24 self-FEXT & 24 ADSL	
spectrum as shown in figure	
92.7% capacity	
12bits/tone*Hz max	



Challenges and Issues

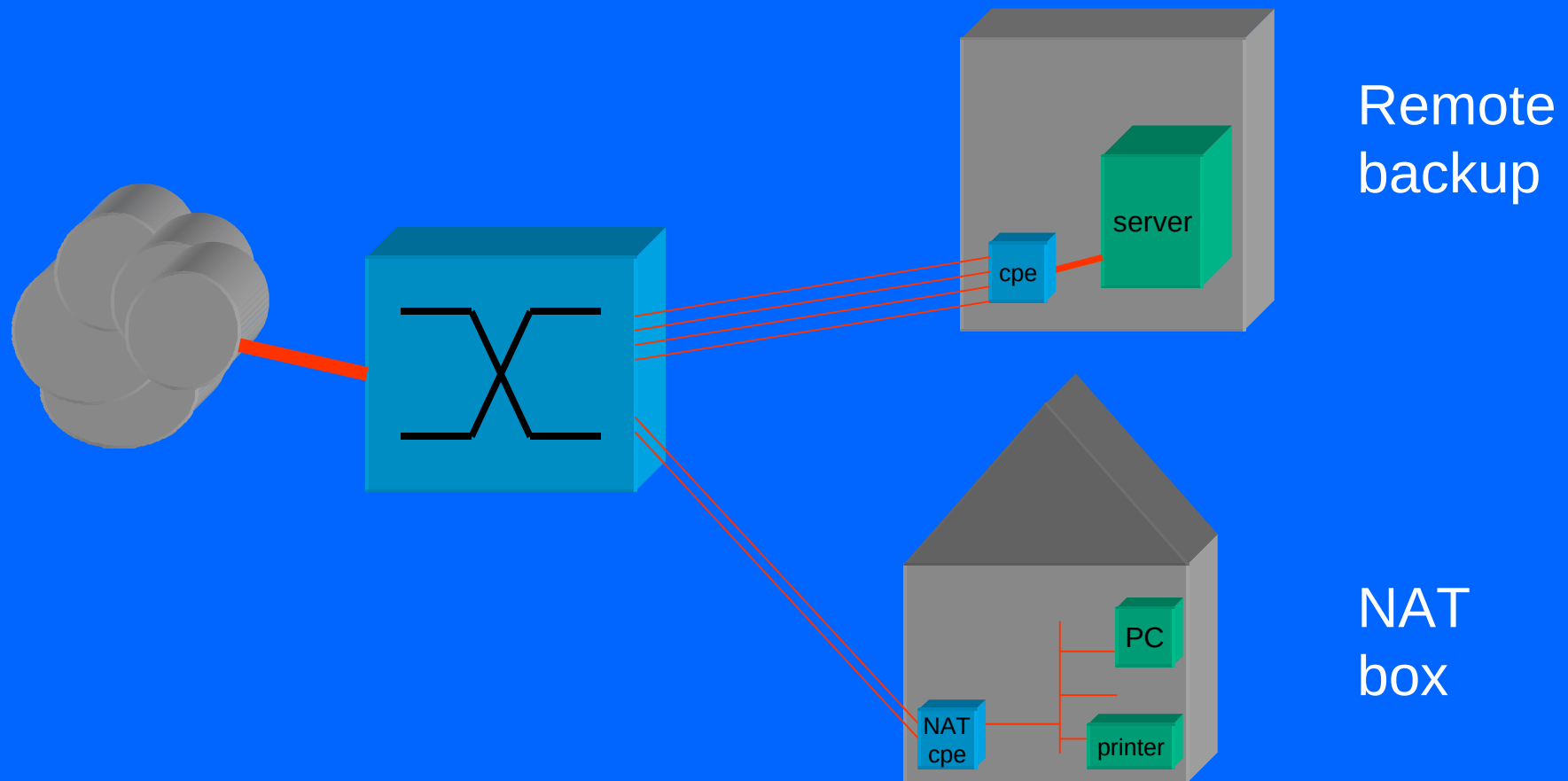
- ❑ Deskewing
- ❑ Rate adaptation?
- ❑ Unequal rate/pair?
- ❑ Spectral compatibility analysis

Why Not Link Aggregation?

- ❑ IEEE Std 802.3ad defines Link Aggregation
 - ❑ Logically aggregate multiple, same speed, full duplex Ethernet links into one interface
 - ❑ Enjoying widespread acceptance
 - ❑ Includes resiliency mechanism
- ❑ “Collection” and “Distribution” done on a coarse grained basis -> “flows” or “sessions”, or source/destination pairs
- ❑ Can (and probably will) be used with EFM links

Why Not Link Aggregation?

- 802.3ad is a fine idea, but it doesn't truly behave like a single high speed pipe



Technical Feasibility

- ❑ Three and four band VDSL chips already need some form of striping
- ❑ Octal VDSL chips are coming
- ❑ Quad and Octal ADSL chips exist
- ❑ Quad and Octal 10/100BASE-T chips exist (and sell in the millions!)
- ❑ ADSL is widely deployed and well proven
- ❑ The proposal will use the ADSL PSD mask as described in G.992.1, Annex-B

Summary

- ❑ Extending the reach of EFM Copper from 750 meters to 3600 meters will increase its market potential
- ❑ With 4 pairs, we can achieve 10 Mbps, Full duplex, 3600 meters
- ❑ Use of multiple pairs is an “old idea” in Ethernet
- ❑ Can be combined with Link Aggregation to provide fiber speeds at copper costs