10BASE-T4 for EFM
Going the extra mile

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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 >=2500ft and speed >=10Mbps 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

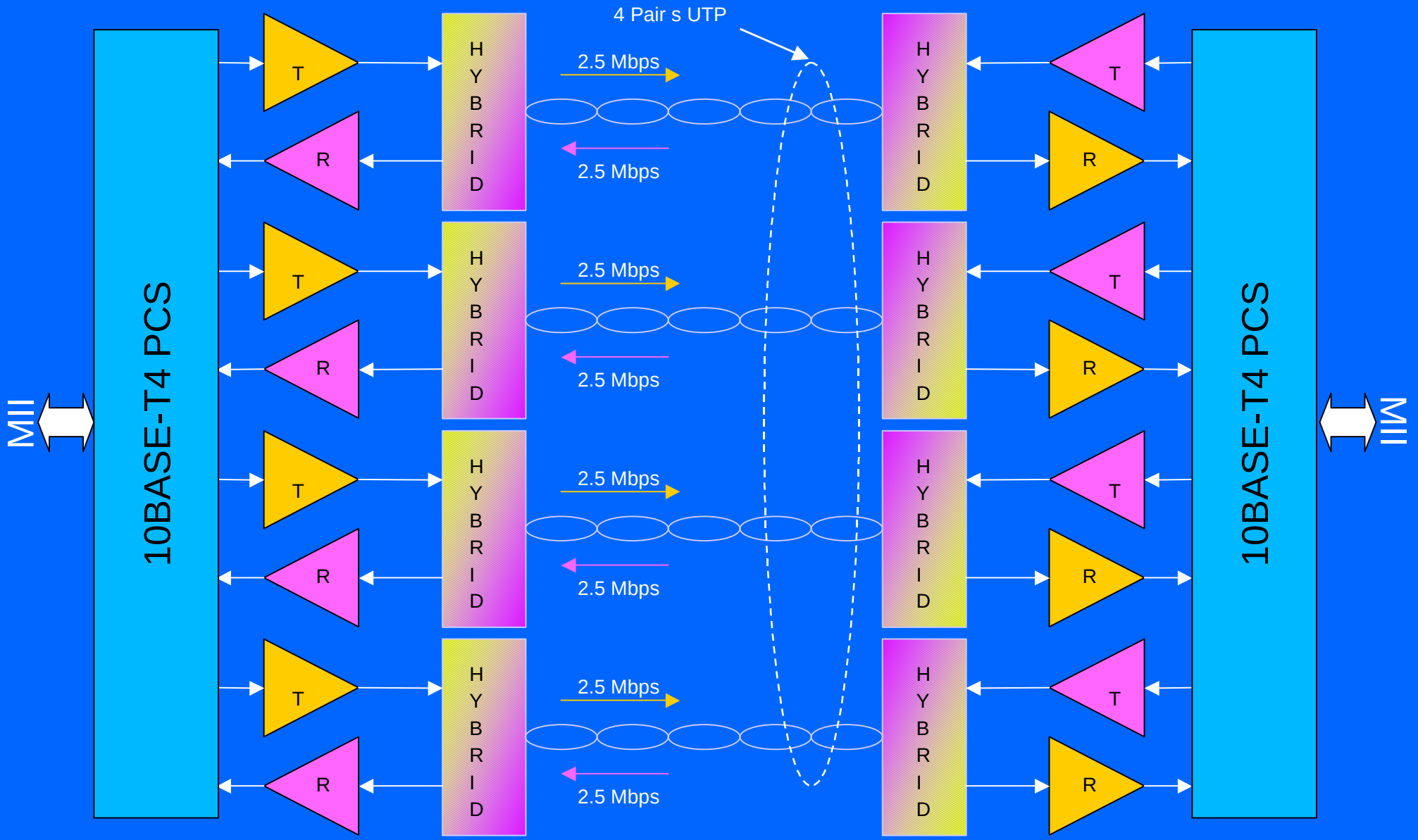
Use more pairs!

- 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

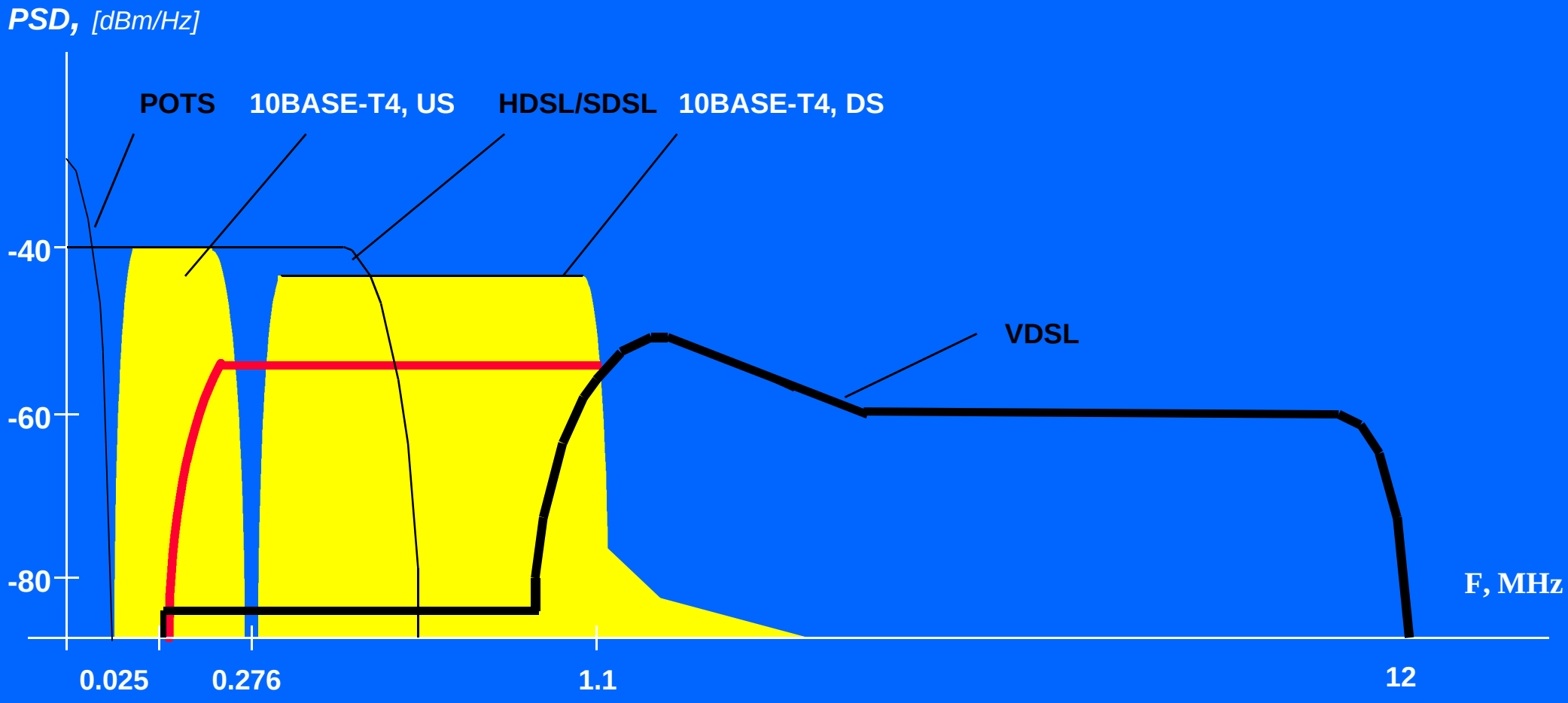
10BASE-T4


4 Pair s UTP
MII
10BASE-T4 PCS
T
R
HYBRID
2.5 Mbps
2.5 Mbps
2.5 Mbps
2.5 Mbps
2.5 Mbps
2.5 Mbps
2.5 Mbps
2.5 Mbps
10BASE-T4 PCS
MII

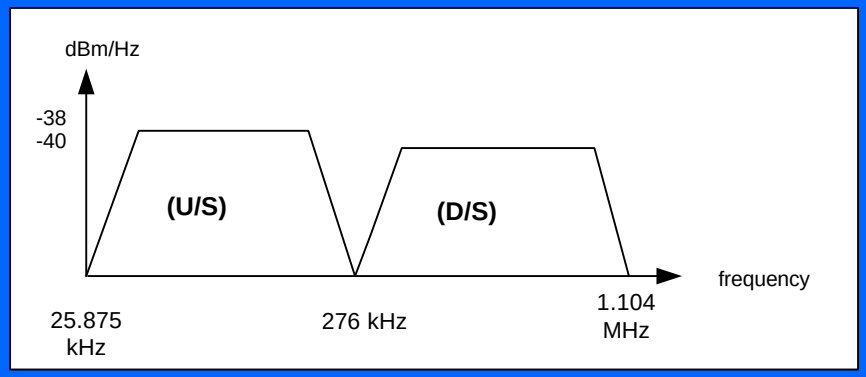
Resiliency and Incremental B/W

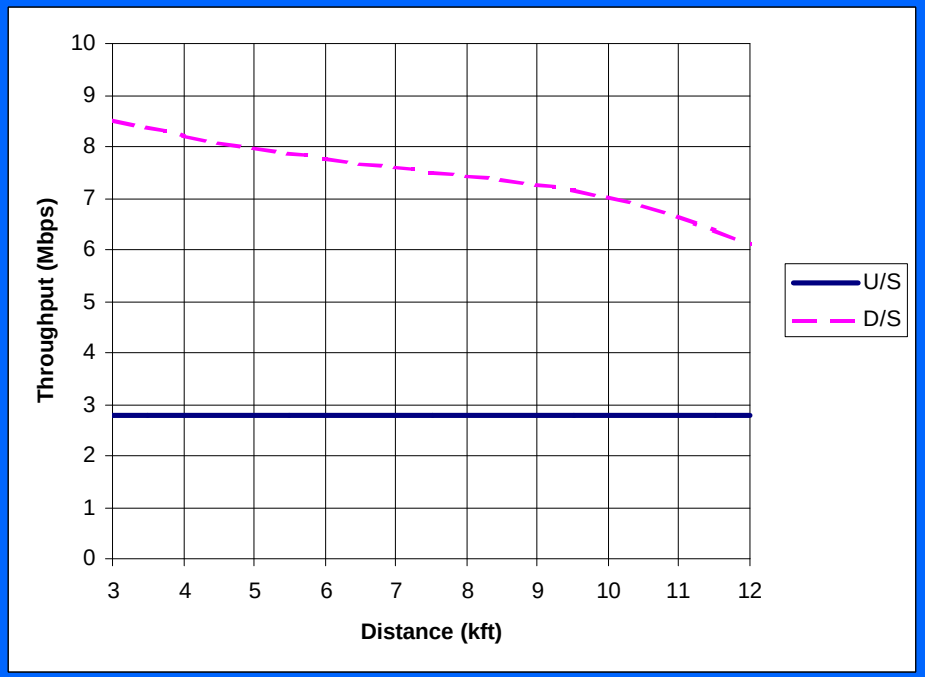
- Resiliency against pair failures
  - 4 pairs -> 10 Mbps
  - 3 pairs -> 7.5 Mbps
  - 2 pairs -> 5.0 Mbps
  - 1 pair -> 2.5 Mbps
- Sub 50 msec recovery time
- Allows 4 increments of bandwidth
- A must for mission critical business service

PSD


PSD, [dBm/Hz]
POTS
10BASE-T4, US
HDSL/SDSL
10BASE-T4, DS
VDSL
-40
-60
-80
F, MHz
0.025
0.276
1.1
12

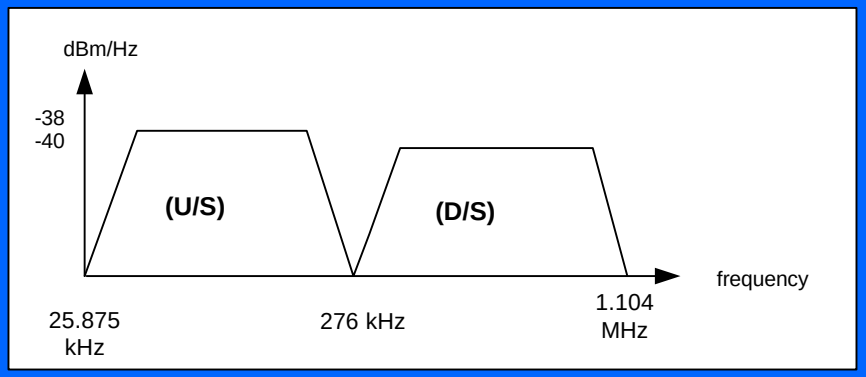
12 kft, 24 ADSL/HDSL-2

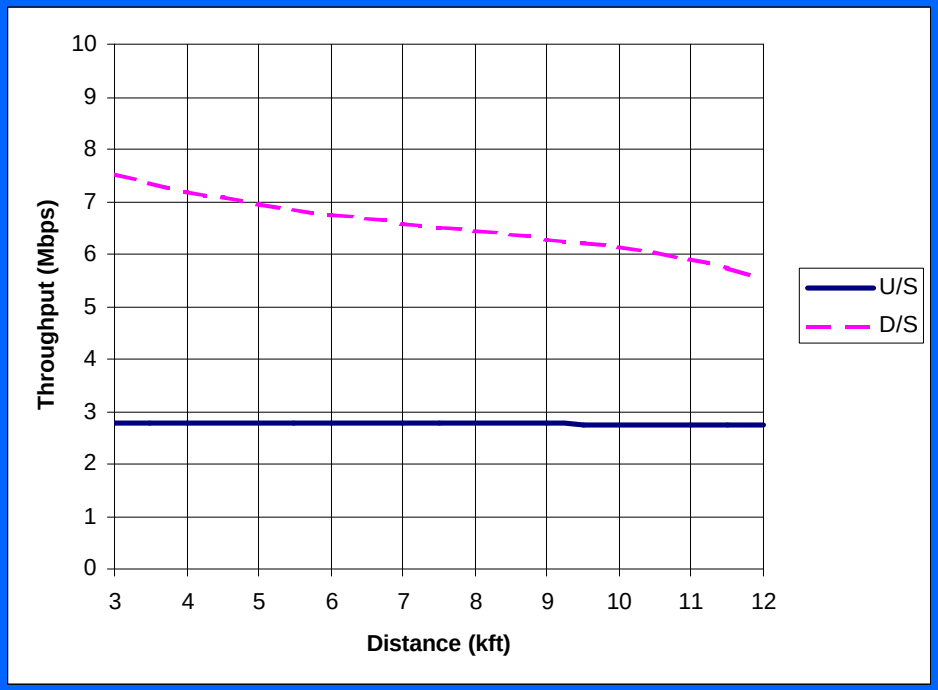




Assumptions:	
-140dBm/Hz AWGN	
24AWG	
5.5dB coding gain	
6 dB noise margin	
24 SHDSL & 24 ADSL	
spectrum as shown	
92.7% capacity	
12bits/tone*Hz max	

12 Kft, 24 ADSL, 24 self-FEXT





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Challenges and Issues

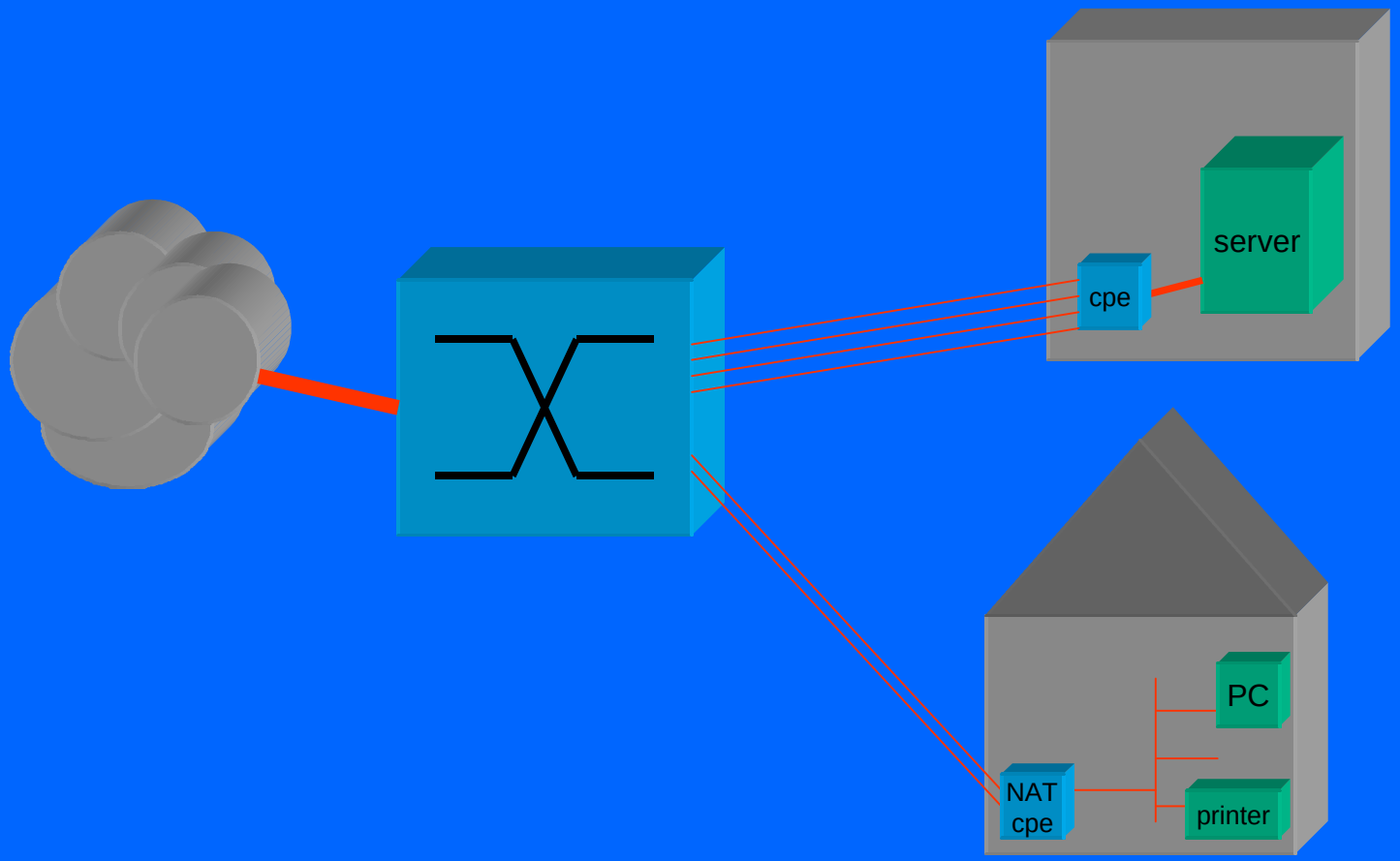
- Deskewing
- Rate adaptation?
- Unequal rate/pair?
- Spectral compatibility analysis

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 gained 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



Remote backup

NAT box

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