Ethernet over copper

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Hugh Barrass

(Cisco Systems)

With thanks to:

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What is EFM?

- **Ethernet in the First Mile is about access.**
- **This means access for everybody!**
- **How is this different to Enterprise Ethernet?**
  - **The user is not employed by the switch owner.**
  - **The user may be hostile!**
  - **There is no recourse against “dumb” users.**
  - **Access is often a “luxury item.”**
- **Most residential access is not currently profitable…**

How does access work now?

- **Dial-up, ISDN, ADSL (& other DSL), Cable modem.**
- **Access is usually over local loop – owned by Telco.**
- **“Unbundling” has changed the local loop landscape.**
- **Elements of the local loop:**

  Central Office (CO)

  Sub-office, crossbox, cabinet (often grouped together)

  In-building plant (NID, MDF, PBX)

Make-up of the local loop

- **Problem - local loop is too democratic…**
  - **Poor people live close to CO = good service**
  - **Rich people live far from CO = lousy or no service**
- **CO (generally) governed by NEBS requirements.**
  - **Houses Class-5 switches, DSLAMs etc.**
  - **Up to 30kft from CO to some residences**
  - **Variation internationally, large cities maybe <5kft**
- **Cross-box / cabinet – generally <5kft, generally ~500 subscriber lines.**
- **Basement / in-building: depends on type – residential / commercial. Also worth considering some enterprise & industrial.**
- **Shared with other technologies – no interference!**

Technology

- **The burning question is always – what is the data rate / reach?**
- **This is governed by “Shannon Capacity.” – Claude Elwood Shannon (1916-2001)**
- **Very difficult to predict precise capacity of any given loop.**
- **Statistics available for some countries – ANSI, ETSI, FSAN etc.**

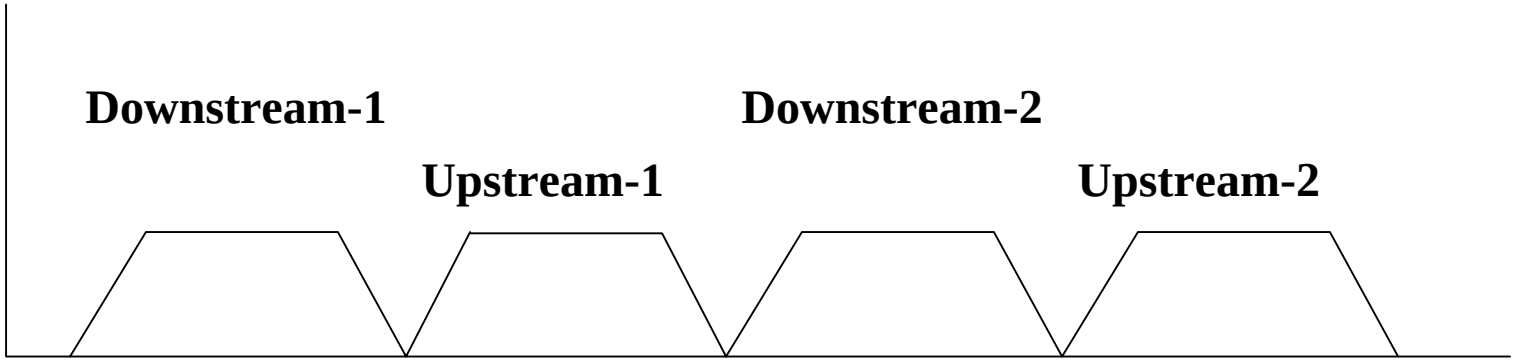
Parameters

- **Length:**
  - Wire gauge, copper quality
  - Twist (consistency)
  - R, L, C, G
- **Noise:**
  - Twist
  - Environment
- **Crosstalk:**
  - NEXT, FEXT
  - Twist, bundling, wire gauge
- **Mismatches:**
  - Connectors, punch-down
  - Bridge taps, stubs

Solution - VDSL

- **Very (high bit rate) Digital Subscriber Loop.**
- **ETSI, ANSI, ITU, >6 years of development.**
- **(almost) complete agreement on physical layer.**
- **3 spectral plans, very similar – plan 998 “winning”.**
- **2 line codes – one will be chosen.**

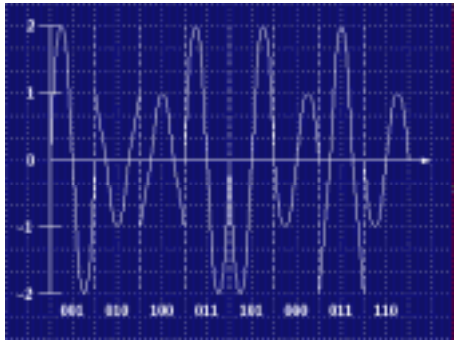
Standard Frequency Bands



Plan 998	**138 kHz**	**3.75 MHz**	**5.2 MHz**	**8.5 MHz**	**12 MHz**
Plan 997		**3 MHz**	**5.1 MHz**	**7.05 MHz**	
Plan fx		**2.5 MHz**	**3.75 MHz**	**fx**	

- **Upstream and downstream transmissions separated by frequency (FDD).**
- **4 bands (instead of 2) gives more flexibility for performance vs reach.**

Standard Modulation



- **QAM**
  - **Modulations (QAM-256 - QAM-4)**
  - **Supported by VDSL Coalition**
- **DMT**
  - **Δ f = 4.1325 kHz**
  - **Supported by VDSL Alliance**
- **Both methods *theoretically* identical performance.**
- **Awaiting proof:**
  - **Adaptability to line faults**
  - **Smaller silicon area**
  - **Etc. Etc. …**

Support for Standards

- **VDSL Coalition - http://www.vdsl.org/**

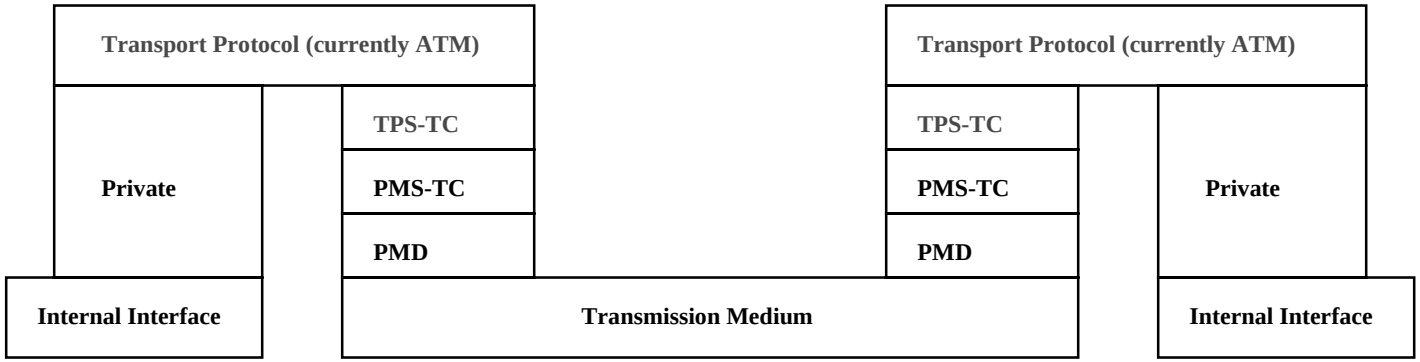
  Acronet, ADC, Advanced Fibre Comm, Alpha Telecom, APC, AT&T Broadband, BATM (& Telco Systems), Be Connected, Broadcom, Brooktree/Rockwell, Chunghwa Telecom, Cisco Systems, Connoisseur Electronics, CT&T, DVTel, ECI Telecom, Efficient Networks, Elastic Networks, Free.fr, General Dynamics, Globespan, Harris Corporation, Infineon & Savan, Lucent Technologies, Magnetic Concepts, Marconi Communications, Metalink, MeTV, Midcom Byron, Mitsubishi Electric (ITA), NeoWave, NextLevelComm, Nokia Networks, Orckit Comm (EDSL), Pace Microtechnology, Paradyne, Parks Data Comm, PixStream, Pliant Systems, Proscend Comm, Qwest (USWest), S2 Entertainment, Samsung Electronics, Sapphire Communications, Schmid Telecom, Siroyan, Space Cyberlink, Tektronix, Telco Systems (BATM), Telebyte/NextDay, TeleChoice, Tellabs, Teradyne, Thomson, Tioga Technologies, Tut Systems, Via Gate Technologies, VDSL Systems, Vovtel Networks, Wavetek, Wandel Goltermann

- **VDSL Alliance - http://www.vdslalliance.com/**

  ADCTelecommunications, Alcatel, Alpha Telecom, AnalogDevices, Aware, Bandspeed, Beijing Institute of Technology (BIT), Cadence, Center for Customized Training, East Valley Institute of Technology, Chunghwa Telecommunication Labs, Cisco Systems, CLEAR Research, Connoiseur Communication Technologies, E&E Magnetic Products, Ericsson, Electronics and Telecommunications Research Institute (ETRI), Genesis Network Development, Globespan, IBM Research, Ikanos Communications, Italtel, Integrated Telecom Express (ITeX), LG Information & Communications, LSI Logic Corporation, Marvell Semiconductor, Metrodata, Midcom, Mitel Corporation, Mitsubishi Electric Corporation, NEC America, NEC Japan, Nortel Networks, Pace Micro Technology, Parks Data Communications, PixStream, Qwest Communications, Samsung Advanced Institute of Technology, SK Telecom, Spectrum Signal Processing, ST Microelectronics, Stanford University, TELCO INFO-COM, Telia AB, Texas Instruments, Toshiba, Transcend Access Systems, Tripath, VDSL Systems, Vovtel Networks

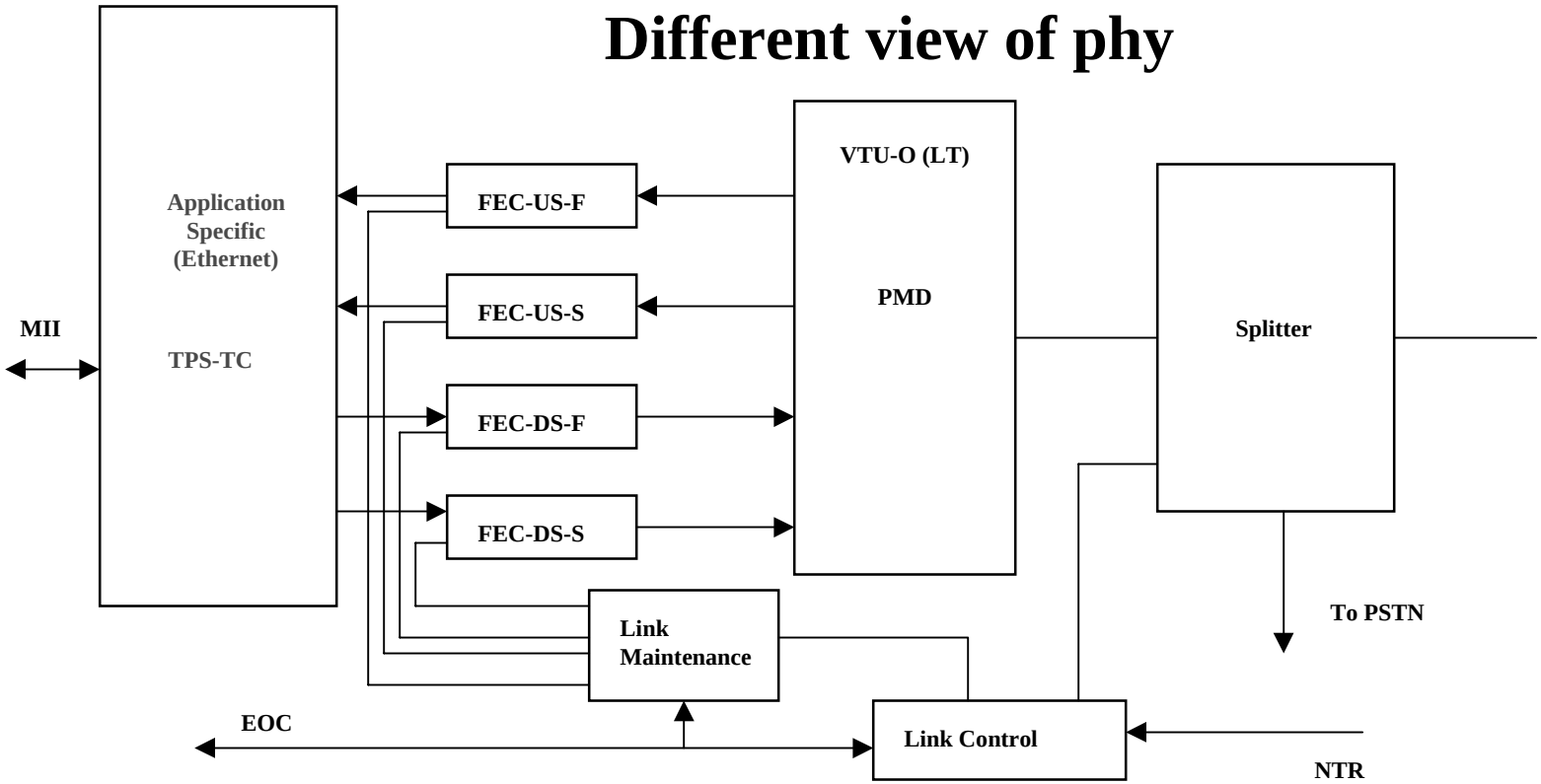
How it fits…

ANSI Layer Definition



- All layers shown are specified (draft) for ATM
- Only the TPS-TC needs modification for Ethernet
- No ANSI activity for Ethernet – some ITU discussion

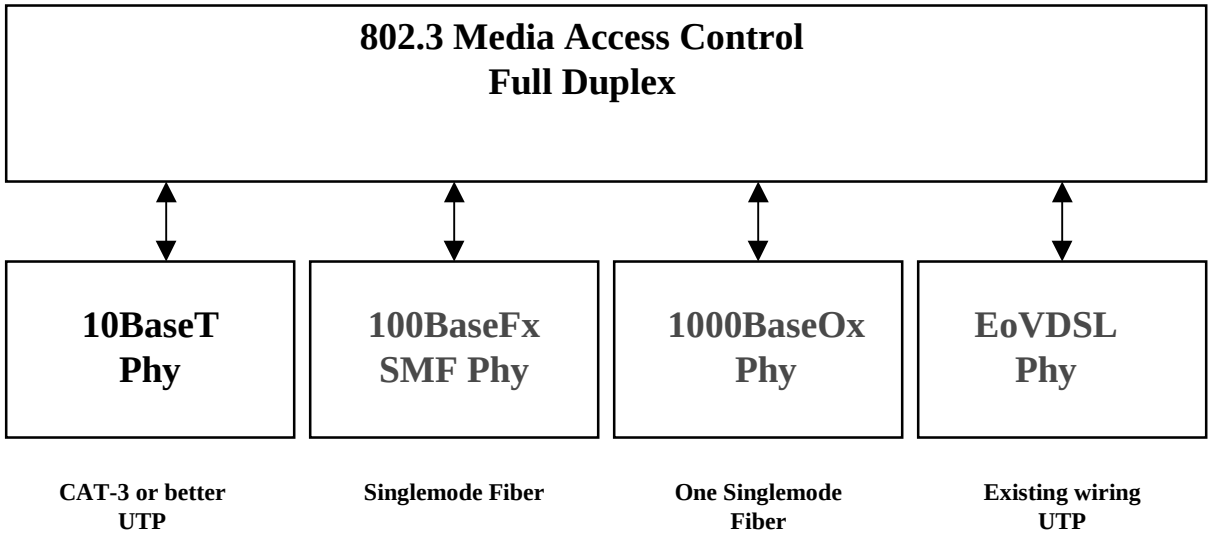
How it fits (2)…



- Silicon available now for PMD
- Silicon available CY01 for PMS-TC (& ATM TPS-TC)
- Need IEEE std for TPS-TC & OAM

How it fits (3)…

Ethernet view



- **Builds on known working Physical Layer (historical precedent)**
- **Ethernet “value add” – simple & low cost**

Rate and Reach

Distance	D/S 1	U/S 1	D/S 2	U/S 2
500 ft	21.76Mb/s	6.66Mb/s	17.33Mb/s	10.50Mb/s
1000 ft	21.76Mb/s	6.66Mb/s	13.00Mb/s	10.50Mb/s
1500 ft	21.76Mb/s	6.66Mb/s	13.00Mb/s	5.25Mb/s
2000 ft	21.76Mb/s	6.66Mb/s	8.66Mb/s	5.25Mb/s
2500 ft	21.76Mb/s	5.00Mb/s	8.66Mb/s	-
3000 ft	21.76Mb/s	5.00Mb/s	4.33Mb/s	-
3500 ft	21.76Mb/s	3.33Mb/s	4.33Mb/s	-
4000 ft	16.32Mb/s	3.33Mb/s	-	-
4500 ft	16.32Mb/s	1.66Mb/s	-	-
5000 ft	10.88Mb/s	1.66Mb/s	-	-
5500 ft	10.88Mb/s	-	-	-

- **For illustration only – based on simple simulations.**

  (CAT-3, 10FEXT – QAM granularity)

Demand

- **EFM must be MUCH better than ADSL to gain market.**
  - Marginal cost or performance not sufficient
  - Needs overwhelming reason to displace ATM
  - EoVDSL can offer 50x improvement in price/performance
- **Service from the CO is already saturated.**
- **IP over ATM over ADSL (xDSL).**
  - Expensive, underperforming – but it's there!
- **ATM gives Telco the "comfort factor."**
  - EFM must better this
- **Current ADSL not suited to video distribution.**
  - Low bandwidth, difficult multi-cast

New Demand

- **FTTC – Ethernet over VDSL first mile**
  - Massive potential market
  - In need of study (and standards)
- **FTTBasement, EoVDSL in building - commercial**
  - Already active – hospitality, MTU, industrial
  - Customers demanding standards
- **FTTBasement , EoVDSL in building - residential**
  - Small penetration – monopolistic, disparate solutions
  - Desperately seeking standards!
- **Must support existing wiring**
  - New wire dominates installation cost
  - Copper dominates existing wiring

5 Criteria - EoVDSL

- **Broad market potential.**
  - Potential demand in 10's of millions of ports
  - Bandwidth for wide range of applications
- **Compatibility.**
  - Ethernet + ANSI Phy – as 100BaseTx, 1000BaseX
  - Rates in the classic Ethernet range
- **Distinct identity.**
  - There is no 802 standard for wire-line access
- **Technical feasibility.**
  - VDSL silicon already deployed (multiple vendors)
  - VDSL layering specifically accommodates Ethernet
- **Economic feasibility.**
  - Re-use of existing wiring
  - Access market *needs* Ethernet – cost, ease-of-use, etc.

In summary

- **EFM must have clear advantage over ATM/ADSL.**
- **If speed is sufficient for video – opens new revenue stream.**
- **IP unbundling could be “killer app.”**
- **Major competition from HFC – cable modem + digital video.**
  - **Could take investment / revenue from IP+optical buildout**

Conclusion - proposals

- **Pass PAR+5 ASAP!**
- **Propose objective for Ethernet over VDSL.**
  - **Ethernet TPS-TC over ANSI physical layer**
  - **Build on others work – also ITU, ETSI**
  - **Most solutions will reach the same point – given the same constraints**
- **Discussion of rate and reach left to project group.**
  - **It's a tough problem – needs focus of PG**
  - **Allows biggest scope for IEEE "value add" (PnP)**
- **Keep one eye on the market – and one on the clock!**