EFM-Copper: Operators’ Perspective

Dong Wei, SBC
Pete Youngberg, Sprint
Charles Cook, Qwest

Presentation at the IEEE 802.3ah Task Force (EFM) Meeting in Edinburgh, U.K., May 20-22, 2002
Introduction

• To have **broad market potential**, EFM-copper should address the need for both business and residential markets

• Consequently, it should support both symmetric and asymmetric services

• We propose to modify the rate/reach objective to cover both markets
EFM-Cu for Residential Customers

- Should be optimized for broadcast video with support for voice and data
- Should be optimized for asymmetric data-rate transmissions
- Should be compliant with the current issue of T1.417 and Band Plan 998
EFM-Cu for Business Customers

• Should be optimized for data only
• Should be optimized for symmetric data-rate transmissions
• Should be compliant with the current issue of T1.417
Two Solutions Needed

• Both markets are important for the success of EFM-Cu
• The two markets demand different sets of applications
• Therefore, two distinct technical solutions are required for asymmetric and symmetric services, respectively
A Classic Ethernet Perspective

- Ethernet is inherently and traditionally a symmetric technology
- Many PHYs for symmetric transmissions have been developed
- EFM-Cu deserves to have a PHY suitable for symmetric transmissions
VDSL for EFM-Cu

- Can achieve high data rates on shorter loops (< 5 kft)
- Not suitable for longer loops (> 5kft): data rate drops rapidly
- Need to choose one line code from QAM and DMT, which has been a very difficult problem for many years
VDSL for Asymmetric Services

• As an FDD technology, VDSL is appropriate for asymmetric services
• Band Plan 998 is designed in favor of asymmetric services
  – 2-3 digital video channels
  – high-quality audio
  – high-speed data
VDSL for Symmetric Services

- Achievable data rates are highly asymmetric between upstream and downstream
- Supporting symmetric transmissions wastes significant amount of bandwidth
- Achievable symmetric data rates are far below capacities
VDSL Performance

The table below is based on contribution T1E1.4/2002-125

<table>
<thead>
<tr>
<th>Loop Length (kft)</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
<th>3.5</th>
<th>4.0</th>
<th>4.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Rate (Mbps)</td>
<td>14.2</td>
<td>13.0</td>
<td>12.1</td>
<td>9.2</td>
<td>5.5</td>
<td>3.7</td>
<td>1.7</td>
<td>0.4</td>
</tr>
<tr>
<td>DS Rate (Mbps)</td>
<td>44.5</td>
<td>40.9</td>
<td>38.2</td>
<td>34.9</td>
<td>29.1</td>
<td>23.3</td>
<td>19.7</td>
<td>16.2</td>
</tr>
</tbody>
</table>
This is Not New

- The highly asymmetric capacity has been recognized
  - mizrahi_1_0501.pdf
  - oksman_1_0701.pdf
  - penazzi_1_0701.pdf
  - oksman_1_0901.pdf
SHDSL for Symmetric Services

- SHDSL = Symmetric High Bit-rate DSL
- Theoretically, echo-cancellation (EC) systems are appropriate for symmetric transmissions: offering symmetric data rates independent of loop conditions
- EC DSL systems have been successfully deployed for business market (e.g., SDSL, HDSL/HDSL2/HDSL4, G.shdsl)
How About G.shdsl (G.991.2)?

• The leading DSL technology primarily designed for symmetric services on medium and long loops

• It utilizes bandwidth for symmetric transmission in a highly efficient way compared with other DSL technologies

• Data rate decreases gracefully as loop length increases
Two Limitations of G.shdsl

• Not optimized for short loops: the maximum data rate on a single pair is about 2.3 Mbps
• Support aggregate operation over at most two pairs
Enhancing G.shdsl

• To increase the rate/reach capabilities of G.shdsl, the following issues are under study at ITU-T and T1E1.4
  – using larger constellations on shorter loops
  – support an aggregation mode for more than two pairs
  – others
Performance of Enhanced G.shdsl

• Simulation model:
  – 32 TC-PAM
  – 5 dB coding gain
  – 6 dB noise margin
  – 24 self-NEXT/FEXT plus -140 dBm/Hz background noise
Performance of Enhanced G.shdsl

• Achievable data rates per pair
  – 5 Mbps at 3.6 kft or 1.2 km (26 AWG)
  – 3.33 Mbps at 5.0 kft or 1.6 km (26 AWG)
• A true “First Mile” technology!
• Achieve longer reaches than VDSL
Why Go Farther

• Borrowed from Howard (frazier_1_0901.pdf)
  – 750 m reach covers < 40% of DLC-fed loops
  – 3600 m reach covers 95% of DLC-fed loops
  – 750 m reach covers about 20% of business and residential loops
  – 3600 m reach covers > 85% of business and residential loops
Other Advantages

• No line code war is needed for enhanced G.shdsl
• If we cannot resolve the VDSL line code issue, Ethernet-over-SHDSL can save the EFM-Cu standard
• Since it is a short-term project in T1E1.4, it will be available very soon
The Problem of the Current Rate/Reach Objective

• Among existing DSL technologies, it allows only VDSL as a PHY
• This symmetric objective is only met by a highly asymmetric transmission technology
• The reach in the objective (750 m) is less than half a mile - way too short
The Problem of the Current Rate/Reach Objective

- It severely limits the reach of EFM-Cu
  - even with a reasonable number of pairs, VDSL cannot offer high-speed symmetric services on loops that are a mile long
- It severely limits the applicability of EFM-Cu
- It fails to meet the criterion of “Broad Market Potential”
Proposal 1

• Replace the current rate/reach objective with the following two
  – objective for asymmetric services: PHY for single pair non-loaded voice-grade copper with distance $\geq 1200$ m (26 AWG) and speed $\geq 20$ Mbps aggregate
  – objective for symmetric services: PHY for single pair non-loaded voice-grade copper with distance $\geq 1200$ m (26 AWG) and speed $\geq 5$ Mbps full-duplex
Proposal 2

• Adopt VDSL as the PHY for asymmetric services
  – ANSI VDSL Trial-Use Standard is a good starting point
Proposal 3

• Adopt enhanced G.shdsl as the PHY for symmetric services
  – Copper Sub-TF should work closely with ITU-T Q4/15 and T1E1.4
  – there should be only one standard for enhanced G.shdsl
Proposal 4

• Develop a generic Ethernet-over-xDSL Adaptation Layer that fits on the Gamma-interface and rides on the top of either PHY