Optical Backplanes - Fantasy or Reality?

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Paper Outline

• Definition of a “Backplane”
• Overview of Backplane Technologies
• Advantages of an Optical Backplane
• Components of a Typical Optical Backplane
• Optical Backplane Applications & Examples
• The Future of Copper Backplanes
• Cost Comparison of Copper vs. Optical Backplane
Definition of a “Backplane”

• Traditional Copper Laminate Based Backplane

• Laminate Backplanes Interconnected with Copper Cables

• Optical Backplanes
Definition of a Logical Backplane

"Backplane" Path

- **Single Cu Backplane**
- **Cu Cable**
- **Cu Backplane**
- **Modulator**
- **Single Cu Backplane**
- **De-Modulator**
- **Optical Backplane**

- **Traditional**
- **Multi-Rack Cu Cabled**
- **Multi-Level**
- **Optical**
- **FO Cable**
- **FO Cable**
- **FO Cable**

**SERDES**

**AMP**
Limitations of Traditional Copper Backplanes

- FR-4 Laminate Backplanes
- Laminate Based Backplanes Interconnected by Copper Cable
  - 1.25 Gbps
  - 2.5 Gbps
  - 10 Gbps
Approximate Amplitude vs. Length Curves at 1.25 Gbps

Length vs. Attenuation at 1.25 Gbps

- 22 AWG Shielded Quad, 150 Ohm
- 28 AWG Shielded Quad, 150 Ohm
- 26 AWG Shielded Pair, 100 Ohm
- 30 AWG Shielded Pair, 100 Ohm
- 26 AWG Coax, 50 Ohm
- 30 AWG Coax, 50 Ohm
- 38 AWG Coax, 50 Ohm
Approximate Amplitude vs. Length Curves at 2.5 Gbps

- 22 AWG Shielded Quad, 150 Ohm
- 28 AWG Shielded Quad, 150 Ohm
- 26 AWG Shielded Pair, 100 Ohm
- 30 AWG Shielded Pair, 100 Ohm
- 26 AWG Coax, 50 Ohm
- 30 AWG Coax, 50 Ohm
- 38 AWG Coax, 50 Ohm
Length vs. Data Rate to 12.5 Gbps
Advantages of an Optical Backplane

• Native Optical Domain
• Reach (or Length)
• Obsolescence Proofing and Performance
• Scalability
Applications for Optical Backplanes

- Applications in the Optical Domain
- Applications Replacing Copper where Reach is the Driver
- Applications Replacing Copper where Performance is the Driver
Optical Backplane Technologies

- Polymer Waveguide
- Optical Fiber Circuit
Polymer Waveguide

ADVANTAGES:
• Low signal skew & distortion
• Noise immunity
• Very low crosstalk
• Frequency independent loss
• DWDM Multiplexing
• 12-60 channel LIGHTRAY MPX connectors
• Waveguide multi-channel connectors
• Mandatory in purely optical systems such as OXC
Polymer Waveguide

OPTICAL POLYMERS

Concept:
- Films or coatings
- 25-50 micron density
- Multilevels possible
- Light “channels” formed by imaging process

Development needs:
- Vector routing (“Bends”)
- Inter level connection
- Low Loss
Optical Fiber Circuit

- Fiber Equivalent of a Copper Backplane
Optical Fiber Circuit
Components of a Typical Optical Backplane

- Transceiver
- System Card Fiber Cable Assembly
- Backplane Connectors
- Optical Fiber Circuit
Typical Optical Backplane System Components

- Ribbon Cables
- Blindmate Optical Connectors
- Optical Transceivers
- Electrical Connectors
- 900 um Buffer Fiber

ELECTRICAL/MECHANICAL BACKPLANE

SYSTEM CARD
Examples of Optical Backplanes

- Inter-Rack Optical Backplanes
Optical Backplane “Inter-Rack” Components

- Ribbon Cables
- Blindmate Optical Connectors
- Optical Transceivers
- Electrical Connectors
- 900 um Buffer Fiber

ELECTRICAL/MECHANICAL BACKPLANE

SYSTEM CARD
Examples of Optical Backplanes

- Inter-Rack Optical Backplanes
- Intra-Rack Optical Backplanes
Examples of Optical Backplanes

• Inter-Rack Optical Backplanes
• Intra-Rack Optical Backplanes
• Inter-Device “Optical Backplanes”
“Inter-Device” Optical Circuit Components

- Optical Backplane
- Ribbon Cables
- Blindmate Optical Connectors
- Optical Array Devices
- Electrical Connectors

ELECTRICAL/MECHANICAL BACKPLANE

SYSTEM CARD

Optical Circuit
Fully Integrated Optical Backplane System

- Premise/User Interface
- Optical Backplane
- Electrical/Mechanical Backplane
- System Card
- Ribbon Cables
- Blindmate Optical Connectors
- Optical Array Devices
- Optical Cross Connect
- Electrical Connectors
- System Card Optical Circuit
- To Next Rack/Shelf
The Future of Copper Backplanes

• New Laminates
• Next Generation Copper Backplane Interconnects
• Multi-Level Signaling
The Effect of New Laminates at 4.8 Gbps

Trace Eye Patterns (4.8 Gbps, 36”)

FR4

GETEK

ROGERS 4350

ARLON CLTE

System Eye Patterns (4.8 Gbps, 18”)

FR4

GETEK

ROGERS 4350

ARLON CLTE
The Effect of New Laminates at 9.6 Gbps

Trace Eye Patterns (9.6 Gbps, 18”)

FR4
Opening = 338 mV

GETEK
Jitter = 0.33 UI
Opening = 238 mV

ROGERS 4350
Jitter = 0.21 UI
Opening = 268 mV

ARLON CLTE
Jitter = 0.14 UI
Opening = 426 mV

System Eye Patterns (9.6 Gbps, 18”)

FR4

GETEK

ROGERS 4350

ARLON CLTE

Fig 10
• Backplane Interconnects for 10 Gbps Applications
  – Plated Through-hole Capacitance and Inductance are the Bottleneck
  – Coaxial Performance at Non-coaxial Density
  – Footprint Loss vs. Density
Multi-Level Signaling

4 Level Pulse Amplitude Modulation PAM
<table>
<thead>
<tr>
<th>Data Rate / Channel</th>
<th>Copper Backplane</th>
<th>Copper Cables</th>
<th>Fiber – Std. SFF Optics Device</th>
<th>Fiber – Array</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.25 Gbps</strong></td>
<td>* see Note 1</td>
<td>~$30</td>
<td>~$106</td>
<td>~$116</td>
</tr>
<tr>
<td></td>
<td>Cost / Gbps</td>
<td>~$1.83-$7.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reach</td>
<td>~&lt;36”</td>
<td>30m 22 AWG</td>
<td>220m IEEE 802.3z (MMF)</td>
<td>300m HIPPI 6400 (MMF)</td>
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<tr>
<td></td>
<td></td>
<td>Shielded Quad with HSSDC like interconnect</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2.5 Gbps</strong></td>
<td>~$1.83-$3.53</td>
<td>$10</td>
<td>$180</td>
<td>TBD</td>
</tr>
<tr>
<td>Reach</td>
<td>~&lt;24”</td>
<td>18m 22 AWG</td>
<td>3-5 km (SMF)</td>
<td>TBD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shielded Quad with HSSDC like interconnect</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>5 Gbps</strong></td>
<td>~$3.22-$3.53</td>
<td>$4</td>
<td>(RO4350)</td>
<td>TBD</td>
</tr>
<tr>
<td>Reach</td>
<td>~&lt;24”</td>
<td>14m 22 AWG</td>
<td>TBD</td>
<td>TBD</td>
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<td></td>
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<td>Shielded Quad with HSSDC like interconnect</td>
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<tr>
<td><strong>10 Gbps</strong></td>
<td>~$4.46-$1.76</td>
<td>$2</td>
<td>$1060</td>
<td>TBD</td>
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<tr>
<td>Reach</td>
<td>TBD</td>
<td>8m 22 AWG</td>
<td>TBD</td>
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<td>Shielded Quad with HSSDC like interconnect</td>
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