Optical Communication in Access Network

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Outline

• Introduction
• Elements of Access Network
  – CAU, Access Node, Access Transport, Edge Node
• Access Transport
  – Optical Communication
• Next Generation Network
• Conclusions
Introduction
Drivers of the Access Network Evolution

- Unbundling of local loop
  - CLEC can provide new access technologies
- New Technologies
  - xDSL
  - Radio Access
  - Fiber Access
- IP-Based Network with QoS
  - Rapid Growth in Data Services
  - VoIP Applications
- Multi-Services Concept
  - High Bandwidth Data Services
  - PSTN/ISDN
- Cost Issue

Elements of Access Network

CAU: Customer Access Unit
# Technologies for Access Networks

<table>
<thead>
<tr>
<th>CAU</th>
<th>Interfaces / Technologies</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access Node</td>
<td>POTS, ISDN, T1/E1 Lease Line, DSL, Ethernet</td>
<td>Narrow band → Broad band</td>
</tr>
<tr>
<td>Access Transport</td>
<td>Legacy DLC, Multiservice Platform</td>
<td>Legacy → Multiservice</td>
</tr>
<tr>
<td>Edge Node</td>
<td>Local Exchange, V5, Access Server, Router</td>
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## Integrated Access Node

<table>
<thead>
<tr>
<th>Interface</th>
<th>Technology</th>
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</thead>
<tbody>
<tr>
<td>E1 lease line</td>
<td>• Time Division Multiplex Technology</td>
</tr>
<tr>
<td>Fractional E1</td>
<td>• Dynamic Time Slot Assignment</td>
</tr>
<tr>
<td>NxE1</td>
<td>• Point-to-Point</td>
</tr>
<tr>
<td>POTS</td>
<td>• Tree / Hub</td>
</tr>
<tr>
<td>E&amp;M</td>
<td>• Drop and Insert</td>
</tr>
<tr>
<td>RS232</td>
<td>• xDSL Technology</td>
</tr>
<tr>
<td>V.35 / V.36</td>
<td>• ATM Technology</td>
</tr>
<tr>
<td>G.703 CO64</td>
<td>• Broadband Service Access Platform</td>
</tr>
<tr>
<td>ISDN (2B+D)</td>
<td>• Single-ended Channel Bank</td>
</tr>
<tr>
<td>N64k</td>
<td>• Data Port Processor</td>
</tr>
<tr>
<td>DSL</td>
<td>• SNMP</td>
</tr>
<tr>
<td>SHDSL</td>
<td></td>
</tr>
<tr>
<td>ADSL</td>
<td></td>
</tr>
<tr>
<td>STM-1</td>
<td></td>
</tr>
<tr>
<td>IMA</td>
<td></td>
</tr>
<tr>
<td>Ethernet</td>
<td></td>
</tr>
</tbody>
</table>

- DDN
- E1 Network
- G.703 64Kbit/s Network
- ISDN
- Internet
- ADSL, FE1, V.35/V.36
- STM-1, IMA, DS3
- ATM Network
MSAN (Multi-Service Access Network)

Access Transport

- SDH / SONET – Next Generation
- GbE / XGbE Network
- PON
- Others - RPR
EOS Transport Model

Internetworking Functions
- 802.3x Flow Control
- Ethernet Status Collection
- GFP/LAPS Mapping
- Virtual Concatenation

EOS Transport Technology

- Frame Mapping Technology
  - Generic Framing Procedure (GFP-F/T)
  - Link Access Procedure – SDH (LAPS)

- Dynamic Bandwidth Allocation Technology
  - Virtual Concatenation (VCat)
  - Link Capacity Adjustment Scheme (LCAS)
Link Capacity Adjustment Scheme (LCAS)

- A real-time control mechanism to increase/decrease capacity of a virtually concatenated group without incurring hits to active traffic.
- Rerouting of traffic due to current network conditions, such as failures or maintenance procedures.
- Defined for all high and low order SONET and SDH payloads.
Gb/10Gb Ethernet Advantages

- Big cost advantage over SONET/SDH and ATM
- Uses standard Ethernet frame format (no protocol conversion)
- Full duplex point-to-point links with long reach to 40-70 km
- Layer 2/3 switches
  - VLAN capacity (802.1Q)
  - Standard IP routing at layer 3 (e.g., OSPF, BGP)
  - Priority capability (aggregate flow QoS) provided by 802.1p at layer 2 and DiffServ at layer 3
  - Traffic policing, shaping and monitoring at edge

Gb/10Gb Ethernet Deficiencies

- Protection time ~ 1 sec >> 50 msec in SONET/ SDH
- QoS
  - Over-provisioning needed to provide delay/jitter sensitive apps.
  - QoS provided for traffic aggregates, not individual flow
  - Providing QoS across network boundaries is difficult
- PM and Fault management worse than SONET/ SDH
  - Ethernet provides no overhead for performance monitoring, alarms, protection signaling, etc.
  - Except for 10GbE WAN PHY, these functions must be performed at the management layer
  - Proprietary solutions (e.g., using the interframe gap) are being developed
- Accommodation of Legacy TDM Services $\rightarrow$ use TDMoIP technology
PON Evolution

- ATM-based PONs
- Early BPOPs tested and installed in limited quantities by carriers
- Supports Voice and Data
- 622 Mbps bandwidth ~70% Efficiency
- Adopted as ITU standard in 1999

- EPON—Ethernet-based PONs
- Emerging market, especially for Metro Ethernet
- Efficiency (for Voice and data services) ~49%
- 1Gbps bandwidth
- IEEE acceptance expected only in 2004

- GPON—Gigabit PON
- Evolution in FSAN Committee for Voice and Data in their native format
- Efficiency (for voice and data services) ~93%
- 2.5Gbps+ of bandwidth at 93% Efficiency
- ITU ratification in 2003
### EPON vs. APON, GPON

<table>
<thead>
<tr>
<th></th>
<th>EPON</th>
<th>APON</th>
<th>GPON</th>
</tr>
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<tbody>
<tr>
<td><strong>Standard body</strong></td>
<td>IEEE</td>
<td>ITU-T (FSAN)</td>
<td>ITU-T S515 (FSAN)</td>
</tr>
<tr>
<td><strong>Standardization</strong></td>
<td>2004.07</td>
<td>1998</td>
<td>2003.11 (G.GPON.GTC)</td>
</tr>
<tr>
<td><strong>Speed</strong></td>
<td>1G</td>
<td>155/622</td>
<td>Up to 2.488 Gbps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>622/1244 Mbps (Amendment)</td>
<td></td>
</tr>
<tr>
<td><strong>Back protocol</strong></td>
<td>Ethernet</td>
<td>ATM</td>
<td>Ethernet/ ATM/ TDM</td>
</tr>
<tr>
<td><strong>Protocol overhead for IP</strong></td>
<td>Small</td>
<td>Large</td>
<td>Middle</td>
</tr>
<tr>
<td><strong>US MAC scheme</strong></td>
<td>TDMA</td>
<td>TDMA</td>
<td>TDMA</td>
</tr>
<tr>
<td><strong>Line Coding</strong></td>
<td>8B/10B</td>
<td>Scramble NRZ</td>
<td>Scramble NRZ</td>
</tr>
<tr>
<td><strong>BER</strong></td>
<td>$10^{-12}$</td>
<td>$10^{-10}$</td>
<td>$10^{-12}$</td>
</tr>
<tr>
<td><strong>ODN Type</strong></td>
<td>Type1, Type2</td>
<td>Class A, B</td>
<td>Class A, B, C</td>
</tr>
<tr>
<td><strong>Max Reach</strong></td>
<td>Type1 $\leq$ 10 km</td>
<td>20 km</td>
<td>20 km</td>
</tr>
<tr>
<td></td>
<td>Type2 $\leq$ 20 km</td>
<td></td>
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### GPON TC Layer Options

- Comparative analysis will be made by the FSAN members
- One of the best solutions will be proposed to ITU-T from the members in FSAN
Interworking between TDM and IP Networks

TDMoIP / CESoP

- Encapsulate TDM Signal (T1, E1, T3, E3) in IP packets
- Transparent service delivery
  - In Band Signaling id preserved end-to-end
- End-to-End Delay in minimized
  - Low latency
- Tributary clock recovery id difficult
  - Adaptive clock method
  - Differential clocking method (similar to SRTS in AAL1)
**Edge Node and Local Exchange**

- Local Exchange may be replaced by
  - Multiservice access nodes
  - Media gateway
  - Telephony server
- Access Servers
  - Narrowband Access Server
  - Broadband Access Server
- Voice Gateway
  - VoIP gateway, H.323 / SIP
  - VoDSL gateway, (AAL2)
- Routers

**Next Generation Network**

- IP-Based and All IP in the Future
### Next Generation Network (NGN)

- Access Transport and Backbone Network → IP Network
- Server Layer and Edge Node → Server, Controller, Internetwork Gateway
- Access Node → Gateway
- CAU → Intelligent Access Unit

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<td>Gateway</td>
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<td>Access Transport</td>
<td>SDH, DWDM, PON, FTTx,</td>
<td>IP-Based Network</td>
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NGN Applications (VoIP-SIP Based)

3GPP Release 5 IP Multimedia Network
Conclusions

- Access Node Interfaces vary from NB to BB, to Multi services
- Access Transport can be SONET/SDH, Gb/XGb Ethernet, PON, RPR → Optical Communication Based
- An Evolution to NGN Driver is “IP”
  - Near term convergence: TDMoIP
  - Long term convergence: All IP
- Telecom and Data Com become IP Com