Overview of Copper DSL and FTTN Solutions

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Agenda

- Drivers for Access Architecture Decisions
- FTTx Overview and Enabling Technologies
- CO/RT
- FTTN
- Hybrid Architectures
- FTTC
FTTx Access Architectures

• **What Drives Access Architecture Decisions?**
  – Bandwidth demands
  – Political/Regulatory requirements
  – Time to market constraints
  – Competitive threats
  – Capex Constraints

• **Access Architecture Options**
  – CO/RT-based DSL
  – Fiber to the Node (FTTN)
    – ADSL2+
    – VDSL2
    – Bonded xDSL
  – Fiber to the Curb (FTTC)
  – Fiber to the Premise (FTTP)
    – GPON
    – Active Ethernet
Bandwidth Drivers: Political/Regulatory
FCC’s National Broadband Plan

• Goals
  – 2015
    • 50 Mbps down / 20 Mbps up actual data rates to 100 million homes
  – 2020
    • 100 Mbps down / 50 Mbps up actual data rates to 100 million homes
    • 4 Mbps down / 1 Mbps up actual data rates to all homes

• Components
  – Last mile Access
  – 2nd /Middle Mile Aggregation

• Properties
  – Peak Rates
  – Capacity to deliver “actual rates”
    • (95% percentile rate returned by speed test)
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Access Network: Pushing Fiber Deeper

Central Office

Feeder Plant (F1)

FTTN (Remote Terminal)

18,000 ft

Up to 1.5 Mbps

12,000 ft

1.5-6+ Mbps

FTTN (Remote Node)

3,000-5,000 ft

15-40 Mbps

Distribution Plant (F2)

FTTC

Drop Plant

50+ Mbps

15-40 Mbps

Remote Terminal
ADTRAN EFM Bonding Features

- VDSL2 DSLAMs leverage same EFM Bonding engine used in ADTRAN Carrier Ethernet solutions
- G.998.2-compliant
- Any-port bonding across the line card
- Up to 12 pairs per bonding group for business-class NCTE
- High-speed bonding engine allows for ultra high-speed service deployment (up to 200M over 2 pairs with Profile 17a)
Advancements in FTTN: VDSL2 Vectoring

• What Vectoring Provides
  – Eliminates self cross-talk on short copper loops
  – Significant gains on short loops (< 3 kft)

• Deployment Guidelines for Vectoring
  – Short loop nature of this technology leads to smaller node sizes
  – Need small-form-factor, remote DSLAMs to take advantage of cross-talk cancellation capabilities of vectoring

VDSL2 with vectoring is ideally suited for remote node deployments
OSP Innovation – the OSP DSLAM

- Sealed DSLAM design eliminates the need for:
  - Expensive cabinet enclosures
  - Noisy, power hungry heat exchangers
  - Costly site construction
- 3rd generation sealed DSLAM design
  - 8+ years of engineering expertise in sealed DSLAM design
  - Over 50,000 units deployed in the field today
- Lower total landed cost for a sealed DSLAM changes the broadband business case
Changing the Total Cost of Deployment

• Deployment is greatly simplified using OSP DSLAMs
  – No new right of way
  – No new pad work
  – Significantly lower shipping costs
  – Installation doesn’t require a crane
  – Smaller crew onsite for installation
  – No expensive heat exchanger solutions
  – Lower power requirements

• Electronics costs keep falling but total deployment costs aren’t getting any cheaper
  – Metal (i.e. cabinets) keeps climbing
  – Lower density areas can’t prove in due to first cost turn-ups
Pedestal Mounting

Sealed OSP DSLAMs in pedestals save thousands in site, prep, and placement costs when compared to traditional cabinets.

Up to 192 Ports with Emerson CoolPed Pedestal
Line Powering

- Simplifies installation and reduces cost
- No AC pedestal or meter required
- No local DC rectifier or battery backup required
- Cleaner, more compact remote footprint
- Centralizes DC power and battery backup plant
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Complete Access Solutions

Broadband Product Suite for Copper and Fiber Delivery

Central Office
FTTN
FTTC
Customer Premises
Breadth of Services

Broadband Access
- ADSL2+
- ADSL2+ Combo
- VDSL2

Carrier Ethernet Services Migration
- Carrier-class platform
- Performance
- Redundancy
- Hardened

Supports legacy and advanced packet services

Services are moving to IP and Ethernet is the most efficient transport medium

Broadband Access Services Migration
- Carrier Ethernet
- HDSL
- T-1
- RPOTS
- Voice Gateway
- ADSL2+
- ADSL2+ Combo
- VDSL2
- DS1
- DS1 PWE
- ESHDSL
- GigE
- Quad OLT
- RPR
- DS3
- DS3 1 port
- DS3 4 port
- GPON
- CH DS3 MS
- OC3 1 port
- OC3 4 port
- CH DS3
- 8 port
- CH DS3 MS
- GigE
- DS3
High Density Solution

- Feature-rich Ethernet MSAP
  - Standard GE network ports
    - 802.1Q, 802.1p
    - PPPoA to oE
    - DHCP Opt 82
    - IGMP aware
  - LAG / LACP for redundant uplink
- IP DSLAM or BBDLC
  - Feature-rich ADSL2+ or VDSL2
    - Bonding, oA to oE, backwards compatible
  - Long loop POTS – 1850 Ohm
    - VoIP transport
    - SIP, GR-303, TR008
  - Density
    - Up to 504 Combo/POTS ports per shelf
    - 2,016 Combo ports per rack
    - 1,280 ADSL2+/VDSL2 with splitters
- Simple network scale
  - No additional slots for scale (SM)
  - Utilize copper or fiber GE SFPs
  - 1, 2.5, and 10Gb options

Redundant GigE
Or 10 GigE
• ADSL2+ 32-Port with Splitter Access Module
  – Full compliance with all standard ADSL modes
  – Auto-negotiation to CPE
  – “Make before break” POTS connectivity
  – 10 year warranty splitter
  – Bond any 2 ports
  – Annex M for symmetric service offering

• Combo 24-Port Access Module
  – POTS, ADSL2+ and splitters
  – High density solution
  – 504 ports per TA5000
    • 2,016 per rack

• Copper will continue to be leveraged
  – Easy migration to fiber when ready
  – Swap a module…
**VDSL2 Solutions**

- **VDSL2 32-Port with Splitter Access Module**
  - Support for multiple profiles
  - Fallback to ADSL modes
  - Completely G.993.2 compliant
  - Support for “5 Band” VDSL2: Profiles 8a, 8b, 8c, 8d, 12a, 12b, 17a
  - EFM bonding

- **VDSL2 Combo 24-Port Access Module**
  - POTS, VDSL2 and splitters
  - Early market entry
  - 504 ports per TA5000
    - 2,016 per rack
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- FTTN (Remote Terminal)
- FTTN (Remote Node)
- Distribution Plant (F2)
- FTTC
- Drop Plant

- 18,000 ft
- 12,000 ft
- 3,000-5,000 ft
- 15-40 Mbps
- 15-6 Mbps
- 100+ Mbps
- Up to 1.5 Mbps
- 1.5-6+ Mbps
- 100+ Mbps
• Standard Gigabit Ethernet uplinks
• 48 ADSL2+ ports per unit
  – Support for G.998.1 Bonded ADSL2+ (ATM Bonding)
  – Support for PTM mode of operation to remove ATM overhead (future)
• GR-487 compliant (sealed and weatherproof)
• -40 to +70 C (-40 to +158 F) operating temperature range
• Universal Power Supply (AC, DC, Span with a single power supply)
• Standard Gigabit Ethernet uplinks
• 48 ports of G.993.2-compliant VDSL2 in a single compact OSP DSLAM
  – Support for “5 Band” VDSL2: Profiles 8a, 8b, 8c, 8d, 12a, 12b, 17a
  – Backwards compatible with ADSLx Modems
• GR-487 compliant (sealed and weatherproof)
• -40 to +70 C (-40 to +158 F) operating temperature range
• Universal power supply (AC, DC, and span powering in a single part number)
Total Access 1148V Host (Integrated SM)

Total Access 1148V Client (Single GE Uplink to Host)
Standard 25-pair amp champ connectors and integrated SFP cages allow for flexible cabling options and field replacement without the need for re-splicing.
Total Access 1148A/V Application

Scalable from 48 to 192 ports per node
Total Access 1248A

- 1248A Host: 2 x GE uplink, 3 x GE ports for subtending
- 1248A Client: Single GE uplink (RJ45 or SFP)
- 48 ADSL2+ ports with integrated splitters
- Single IP address management of 192 ports
Total Access 1248V

- 1248V Host: 4 x GE uplink, 3 x 1/2.5GE ports for subtending
- 1248V Client: Single 1/2.5 GE uplink (RJ45 or SFP)
- 48 VDSL2 ports with integrated splitters
- Single IP address management for 192 ports
Total Access 1248A/V Application

Scalable solutions from 48 to 192 ports per node
Total Access 1124P

- 24 ADSL2+ plus POTS ports
- GigE or 8xHDSL4 EFM network connection
- 8xHDSL4 EFM host version has integrated GigE for future migration to fiber
- Capable of subtending additional 1124Ps (2nd-gen HW early 2011)
- VoIP to Total Access 5000 VG which converts to GR-303 (software upgradeable to SIP)
- Supports both span and DC power
- GR-487 compliant (environmentally sealed and weatherproof)
Total Access 1124P via Legacy RT

Total Access 5000 COT

Legacy RT or ORB

Total Access 1124P

TDM Network

HDSL4

PSTN

GR-303, TR-08

8 Line Power Loops

ADSL2+ w/ POTS
Fiber Fed Total Access 1124Ps

Total Access 5000 COT

Total Access 5006 RT

Total Access 1124P

ADSL2+ w/ POTS

ADSL2+ w/ POTS

GR-303, TR-08

PSTN

Class 5 Switch or Softswitch

GE
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Total Access 1148A-DMT

Best-in-Class Carrier Ethernet Products

Market-leading Sealed FTTN DSLAMs

Industry’s First Sealed DSLAM with > 100 Mbps Bonded Copper Backhaul

- Total Access 5000
- EoTDM (DS1, E1, DS3)
- EoF (Pt-Pt, ERPS, PON)
- EoCu (VDSL2, ADSL2+)
- Enhanced Protection
- Off-net Businesses
- Effective SMB Capture
- 3G/4G Mobile Backhaul
- Large On-net Enterprises

Ethernet over Bonded Copper

NxGE

1148A-DMT

ADSL2+
Total Access 1148A-DMT
Sealed FTTN DSLAM w/ Bonded Copper Uplink

- Bonded DSL copper transport to sealed Total Access 1148A-DMT DSLAMs located closer to the subscriber to drive higher bandwidth services
- Integrated bonded DSL copper transport on existing pairs eliminates multiple components and reduces pair requirements, delaying the expense of fiber deployment
Total Access 1148A-DMT

- 8xADSL2+ Bonded EFM or 2xGE Uplink Options
- 48 ADSL2+ subscriber interfaces
- Integrated GE switch for expansion
- Universal Power Supply (AC, DC, Span with a single power supply)

<table>
<thead>
<tr>
<th>Bonded Copper Backhaul Pair Requirements</th>
<th>Backhaul Bandwidth Capabilities</th>
<th>Copper Bonding Method</th>
<th>Fiber Upgrade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legacy Bonded T1 IMA 1148s</td>
<td>16 pairs for local power, 24 pairs for line powering</td>
<td>12 Mbps symmetric</td>
<td>IMA Bonding (ATM Based)</td>
</tr>
<tr>
<td>Total Access 1148A-DMT</td>
<td>8 pairs (includes line powering pairs)</td>
<td>100+ Mbps down, 10-20 Mbps up</td>
<td>EFM Bonding (Ethernet Based)</td>
</tr>
</tbody>
</table>
Extending Coverage Area for High Speed Services Over Copper

- Fiber-fed DSLAM w/ Multi-pair DSL Bonding
- Copper-fed DSLAM w/ Multi-pair DSL Bonding
- Copper-fed DSLAM w/ Multi-pair DSL Bonding

N xGE

75 Mbps @ 10 kft (8 Pairs)

Local xDSL Subscribers

Distribution Area 1

Distribution Area 2

Distribution Area 3

Extended High Speed Service Range Over Copper
1148V-DMT: The Next Generation
Bonded Copper to Mid-Distribution

Fiber-fed DSLAM w/ Multi-pair DSL Bonding

Copper-fed DSLAM w/ Multi-pair DSL Bonding

Local VDSL2 Subscribers 40-60 Mbps

320-480 Mbps shared transport

2000 ft

Local VDSL2 Subscribers 40-60 Mbps

4000 ft @ 15-20 Mbps
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Central Office

- **Feeder Plant (F1)**
  - 3,000-5,000 ft
  - 15-40 Mbps

- **FTTN (Remote Terminal)**
  - 18,000 ft
  - Up to 1.5 Mbps

- **FTTN (Remote Node)**
  - 12,000 ft
  - 1.5-6+ Mbps

- **FTTC**

- **Drop Plant**
  - 100+ Mbps
Total Access 1108VP Features

- Small form factor: (16” H x 10” W x 4” D)
- Designed for above or below ground deployment
- 12-pair copper cable (8 POTS+VDSL2 plus 4 powering pairs)
- IP68-compliant RJ45 Ethernet interface for management
- Fixed optical interface (two single-fiber connections – 1310nm Tx/1490nm Rx on fiber 1, 1490nm Tx/1310nm Rx on fiber 2) with quick disconnect fiber connector
Total Access 1108VP Features

• Network and Subscriber Interfaces
  – 2 single fiber GE ports (uplink & expansion)
  – 8 POTS plus VDSL2 interfaces

• VDSL2 Capabilities
  – G.993.2-compliant VDSL2 support
  – Profile 17a provides 75+ Mbps down, 45+ Mbps up @ 500 ft
  – VDSL2 bonding support in future software release

• POTS Capabilities
  – GR-08, GR-303, and SIP (future) capabilities
  – TA5000 VG utilized for TR-08 and GR-303 functionality

Utilizes functionality of TA5k VDSL2 Combo Card
The Total Access 1108VP is a single box solution for all FITL ONU deployment scenarios

(ADTRAN has developed mounting kits for each deployment option)
Wrapping Up: Complete Access Solutions

Broadband Product Suite for Copper and Fiber Delivery

Central Office

FTTN

FTTC

Customer Premises
Backup
VDSL2 Downstream and Upstream (Profile 17a - 24 Self, 24 AWG)

- Downstream: 30M to 35M 24AWG; 25M to 30M 26AWG
- Upstream: 20M to 25M 26AWG
xDSL Performance Comparison

- Bonded ADSL2+ provides lower cost per port.
- Bonded VDSL2 8a and Bonded ADSL2+ provide similar reach at ~30 Mbps.
- VDSL2 is superior for:
  - Very high rates
  - Very short loops

Target range for enhanced broadband services.
- D3 usable out to 610 m (1968 ft)
- U2 usable out to 900 m (2953 ft)
- D2 usable out to 1200 m (3937 ft)
- U1 usable out to 1300 m (4265 ft)
- HAM Bands: 1.81-2 Mhz, 3.5-4 MHz, 7-7.3 MHz

Loop lengths must be reduced in order to take advantage of high frequency VDSL2 bands.
Reach for NBP Target Rates

Nominal Rates based on measured Profile 17a performance with 12 disturber w.c. self crosstalk, V-denotes measured performance in -140 dBm/Hz white noise, approximately the limit that can be achieved with vectoring. Profile 30a may boost upstream reach at high rates.
Transitioning 1148 Systems to FTTN with the Total Access 1100F

- 1148 IMA-Fed Host and 3 Clients
- 8xT1 IMA
- ADSL2+

- Ethernet Switch
- NxGE
- Total Access 1100F and 1148 Clients
- ADSL2+

Data/Video

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Transitioning 1248 Systems to FTTN with the Total Access 1200F

1248 IMA-Fed Host and 3 Clients

Data/Video

Ethemet Switch

Data

NxGE

Total Access 1200F and 1248 Clients

ADSL2+

ADSL2+