Overview of Copper DSL and FTTN Solutions

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Product Manager
November 16-17, 2010
Agenda

- Drivers for Access Architecture Decisions
- FTTx Overview and Enabling Technologies
- CO/RT
- FTTN
- Hybrid Architectures
- FTTC
- Ultra Broadband Ethernet – A New Architecture
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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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)
• 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**
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**
- All Ethernet Core Product
  - Highly scalable Ethernet switch fabric
  - All services converted to Ethernet for maximum scalability

**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**

**Carrier Ethernet Services Migration**
- HDSL
- T1
- RPOTS
- Voice Gateway
- ADSL2+
- ADSL2+ Combo
- VDSL2
- VDSL2 Combo
- DS1
- DS1 MS
- DS3 1 port
- CH DS3 MS
- DS3 4 port
- OC3 1 port
- OC3 4 port
- GigE 8 port
- Quad OLT
- Active E
- GEPON
- DS1 PWE
- RPR
- GigE
- T-1
- HDSL
- ESHDSL
- DS1
- DS3
- CH DS3
- GigE 4 port
- CH DS3 MS
- DS3 4 port
- OC3 1 port

**Carrier Ethernet**
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
Residential and Broadband Solutions

- **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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Access Network: Pushing Fiber Deeper

Central Office

Feeder Plant (F1)

FTTN (Remote Terminal)

FTTN (Remote Node)

Feeder - Distribution Interface

FTTC

Drop Plant

18,000 ft

12,000 ft

3,000-5,000 ft

15-40 Mbps

100+ Mbps

Up to 1.5 Mbps

1.5-6+ 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)
1148V Models

Total Access 1148V Host (Integrated SM)

Total Access 1148V Client (Single GE Uplink to Host )

*portion of chassis removed for clarity
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
• 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
- TDM Network
- Legacy RT or ORB
- HDSL4
- Total Access 1124P
- PSTN
- GR-303, TR-08
- 8 Line Power Loops
- ADSL2+ w/ POTS
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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
• 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

NxGE

Local xDSL Subscribers

Local xDSL Subscribers

Local ADSL2+ Subscribers

Distribution Area 1

75 Mbps @ 10 kft (8 Pairs)

75 Mbps @ 10 kft (8 Pairs)

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

NxGE

320-480 Mbps shared transport

Local VDSL2 Subscribers 40-60 Mbps

2000 ft

Local VDSL2 Subscribers 40-60 Mbps

2000 ft

4000 ft @ 15-20 Mbps
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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

- Distribution Plant (F2)
  - FTTN (Remote Node)
  - 3,000-5,000 ft
  - 1.5-6+ Mbps

- FTTC
  - 12,000 ft
  - 15-40 Mbps

- Drop Plant
  - 100+ Mbps
Total Access 1108VP Architecture

TA5000 COT

TA5000/5006 RT

TA1108VP Series
8 Ports VDSL2 & POTS

TA1108VP
8 Ports VDSL2 & POTS

GE

GE

(Chaining Option)

Line Power
Remote Power Node
Upgrade Option

LPU

Line Power Loops

Class 5 Switch or Softswitch

GR-303, GR-08
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)
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Central Office

- **Feeder Plant (F1)**
- **FTTN (Remote Terminal)**
- **FTTN (Remote Node)**
- **Distribution Plant (F2)**
- **FTTC**
- **Drop Plant**

- **Remote Terminal**
- **FTTN (Remote Terminal)**
- **Feeder - Distribution Interface**

- **18,000 ft**
- **12,000 ft**
- **15-40 Mbps**
- **3,000-5,000 ft**
- **100+ Mbps**

- **Up to 1.5 Mbps**
- **1.5-6+ Mbps**

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A common FTTH scenario

Want to deliver super fast internet here

Note the road and sidewalk
FTTH in Challenging Environments

FTTH Cost prohibitive in such a scenario

- Trench fiber in sidewalk to home ($$$)
- Add New Optical Access Point ($)
Today's Customer Network

Distribution Point (DP)
[Subscriber Drop Pedestal]
- 8-16 homes per DP
- Drop length < 200ft
- Pole mount or below ground mount in hand hole

Problem Area $$$
Customer Premises

Network Termination

Overhead DP

Underground DP

Final Drop (av. 30m)

M side (av. 1.8km)

D side (av. 500m)
FTTH vs Ultra Broadband Ethernet

This Type of FTTH Deployment often cost prohibitive

Ultra Broadband Ethernet ONT ($)

Ethernet over Existing Subscriber Drops

Sidewalk/Road

ONT

ONT

ONT

ONT

ONT

ONT

ONT

ONT

Sean Balmer: Easy Install ($)

Delivers 100Mbps or more at a fraction of the cost and time of FTTH
Ultra Broadband Ethernet - Details

Point-point Ethernet or PON

Existing Copper

Existing subscriber drop

Min 100Mbps x 100Mbps Ethernet

Low voltage backpower

Ultra Broadband Ethernet ONT

- Sealed and submersible
  - install anywhere, zero maintenance
- Very low power
  - less than 10W for 8 ports
- Extremely small
  - 4” x 14”

Up to 100 meters (300ft)

Minimum 100Mbps in both directions, very fast to deploy, very low CAPEX & OPEX
Ultra Broadband Ethernet Meets Aggressive Goals

✓ **Fast Downstream**: Minimum 100Mbps
✓ **Fast Upstream**: Minimum 100Mbps
✓ **Low CAPEX & OPEX**:
  - leverages existing subscriber drop & **easy install**
  - No maintenance ONT – install it and forget about it
  - Low cost CPE option – simple media adapter
✓ **Accelerate Revenue**: hours not months
  - No fiber trenching and network power delays
  - Easy install
✓ **Flexible**
  - Very small, sealed and submersible – install anywhere
  - Can leverage GbE, GPON and Active Ethernet on uplink
  - Small port granularity (8 port)
✓ **Ultra Green**: ~1 Watt per subscriber
## Ultra Broadband Ethernet vs FTTH

<table>
<thead>
<tr>
<th>FTTH in Challenging Environment (road/sidewalk)</th>
<th>UBE in Any Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costly &amp; disruptive fiber trenching in road/sidewalk</td>
<td>Use existing subscriber drop (up to 200m)</td>
</tr>
<tr>
<td>Truck Roll to install outdoor ONT for every subscriber</td>
<td>No outdoor ONT required</td>
</tr>
<tr>
<td>Truck Roll to run Ethernet from ONT into home</td>
<td>Easy Install in home – no need to run cables from ONT</td>
</tr>
<tr>
<td>Takes months and sometimes years to roll-out</td>
<td>Complete install and turn up in days</td>
</tr>
</tbody>
</table>

Ultra Broadband Ethernet enables Network Wide Deployment

*Superior Performance at a fraction of the Cost*
Ultra Broadband Ethernet is Real

• Ultra Broadband Ethernet solves some real problems for carriers and consumers
• It provides a great alternative solution to FTTH in many scenarios
• Trials underway with Tier 1 Operators in Europe, North America and the Middle East
• Commercial Availability first half 2011
A toolbox with all the right tools

- **ADSL2+:** basic internet access & SD video – up to 25Mbps
- **FTTN/Cabinet w VDSL2:**
  - Up to 100Mbps DS, 50Mbps US (1,400 ft to 2,700ft depending on vectoring and bonding)
  - Appropriate for cross connects with short loops
- **FTTC [Fiber To The Curb]:**
  - Appropriate for Greenfield in certain cases
- **FTTP: Greenfield and select brownfield**
  - Can easily do 100Mbps and beyond
  - Only cost effective in greenfield or certain brownfield scenarios
- **Ultra Broadband Ethernet (cont’d)**
• Ultra Broadband Ethernet
  – Brownfield region where fiber installation is difficult
    • Super fast internet is desired but FTTP doesn’t prove in due to high cost of fiber installation
  – Highly competitive region where time to market is critical
    • Regaining a lost customer is very expensive. Ultra Broadband Ethernet can be deployed quickly and tactically as defense against cable providers
  – Where likely take rate is uncertain
    • Can deploy an 8 port Ultra Broadband Ethernet solution for same price as one FTTH customer!
  – Multi-dwelling units: leverage existing wiring and capitalize on easy install advantage
  – Others?
Wrapping Up: Complete Access Solutions

Broadband Product Suite for Copper and Fiber Delivery

Central Office

FTTN

FTTC

Customer Premises
BACKUP
VDSL2 Rate/Reach

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

30M to 35M 24AWG; 25M to 30M 26AWG
xDSL Performance Comparison

- **VDSL2** Superior for:
  - Very High Rates
  - Very Short Loops

- Bonded ADSL2+ offers lower cost per port and provides better 10 Mbps reach compared to VDSL2.

- Bonded ADSL2 and Bonded VDSL2 8a provide similar reach at ~30 Mbps.

- Target range for enhanced broadband services is indicated on the graph.

Graph shows the rate (Mbps) vs. distance (km) with various xDSL technologies compared.
VDSL2 Profiles & Band Plan 998

- 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
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

Data

8xT1 IMA

1148 IMA-Fed Host and 3 Clients

ADSL2+

Data/Video

Ethernet Switch

ADSL2+

Total Access 1100F and 1148 Clients

ADSL2+

NxGE

NxGE
Transitioning 1248 Systems to FTTN with the Total Access 1200F

1248 IMA-Fed Host and 3 Clients

8xT1 IMA

Data

Ethernet Switch

 NxGE

NxGE

Data/Video

Total Access 1200F and 1248 Clients

ADSL2+

ADSL2+

ADSL2+