Metro Optical Aggregation for ILEC Networks

Doug Starr and Mike Nielsen
Service Provider Consulting Systems Engineering

Optical Aggregation Services

Services

Voice Video Cisco IOS Data

ATM Core IP Core MPLS TDM

Wavelength Routing DWDM
Optical Aggregation
Generic Architecture

Access
POP/Metro
Core/Long Haul

Optical Aggregation
Access Alternatives

- Tributary Access
  DS1, DS3
- High Speed Access
  OC3/12/48
- LAN Access
  10BT, 100BT, 1000BT (GE)
- Wavelength Access
Optical Aggregation
Metro Access Architecture

Optical Aggregation
Broadband and Wideband SONET

Payload
POS/ATM/SRP

DS3

STS-1 SPE (51 Mbps)

STS-3c SPE (155 Mbps)

STS Envelope

STS-1 SPE

STS Envelope

STS-N Facility

STS

“N”

Multiplex
Optical Aggregation
Add/Drop Payload Grooming

SONET Network Element (NE or Node)

Matrix (Synchronous)

- Blue Facility Dropped
- Orange Facility Added

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Low-Speed TDM Access

DS1 maps directly to VT1.5
8 DS1s supported per chassis
UPSR OC-3 supported on egress interface
28 VTs dropped per node

US Applications Only
Optical Aggregation
Ethernet Access

Data: IP/PPP/HDLC/DS1/VT1.5

- Eight ethernet ports per device
- MLPPP binding of VT1.5 mapped HDLC frames for IP Payloads
- Not based on POS standard

Routing
- Static routes: one LAN port-to-port (scalable)
- WAN port (Release 1.0)
- Dynamic routing: "N" LAN ports to "M" (scalable)
- WAN ports (Release 2.0)
- Multiple premises customer support
- Packet throughput 50,000 pps

US Applications Only

Optical Aggregation
ONS15303 Introduction

- Cisco ONS15303
  - Bellcore/ANSI/ITU standards
  - OC-3 optics (UPSR and terminal)
  - 8 T1, 8 Ethernet ports
  - Port-to-SONET/SDH mapping
  - Dynamic routing for data services
Optical Aggregation
Data + SONET Functionality

- SONET OC-3 UPSR and linear modes
  Up to 24 VT1.5 channels can be allocated to IP data services
  Up to eight VT1.5 channels can be allocated to DS1 services

- Eight redundant DS1 interfaces
  Near-end PM with single grade of service (Bellcore defined)
  DS1 retiming and distribution
  Integrated BER testing on facilities

Optical Aggregation
ONS15303 Speeds and Feeds

- High speed: OC-3 (155M)
  Supports mixed STS-SPE and STS-VT mapped payloads
  Node drops up to 28 total of possible 84 VTs within OC-3
  Designed for edge applications
    - Full BW ADM or multiple Cisco ISRs at hub
    - Full BW 33xx hub node on roadmap
  Access/drop any VT in OC-3
    - Do not need to be consecutive VTs

- Drop interfaces (via crossconnect)
  DS1s can access up to 8 VTs
  DS1 #8 can be used for timing system
  10BaseT’s map into N x “Serial DS1s”
    - 1–8 SDS1s per 10BaseT (to VT)
    - 24 SDS1s available for data mapping
    - \(24 + 8 = 32\), not 28?
  Last four DS1s and last four SDS1s are set for “either or” mappings
Optical Aggregation

Generic Metro Architecture

Access Aggregation POP

Bandwidth Constrained POP

OC-12/48 Metropolitan Ring

Long Haul/Core

Optical Aggregation

Metro TDM Architecture

Packet/cell over TDM

TDM-based access to metropolitan area networks
Pure TDM transport (higher layer protocol ignorance) in metro
TDM Grooming functions granular to STS/VT, not packet
Cost effective and widely deployed architecture

Long Haul/Core

Intra-LATA Metro POP
Optical Aggregation
Metro POP Design

Optical Aggregation
ONS15454 System Architecture

SONET Plane

Data Plane

Packet/Cell Switching and Statistical Multiplexing onto SONET

All card slots access the TDM cross-connect

And
Optical Interfaces

- 4 port OC-3 card
  - 1310nm IR (16dB)

- 1 port OC-12 card
  - 1310nm IR (14dB)
  - 1310nm LR (26dB)
  - 1550nm LR (26dB)

- 1 port OC-48 card
  - 1310nm IR (13dB)
  - 1550nm LR (26dB)
  - 1550 ITU-T (27dB)

- 1+1 Protection optional

Electrical Interfaces

- 14 ports DS1
  - 1:1 and 1:N protection optional

- 12 ports DS3
  - 1:1 and 1:N protection optional

- 12 ports EC-1 (STS-1e)
  - 1:1 protection optional

- 6 ports DS3 Transmux
  - 1:1 protection optional
Cross Connect Family

- **XC Card**
  - 288 STS1 Ports or 144 STS level circuits

- **XC-VT Card**
  - 288 STS1 Ports or 144 STS level circuits
  - 672 VT1.5 Ports via 24 STS logical ports or 336 VT level circuits

Fully Redundant - Hot / Standby

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Optical Aggregation
ONS15454 Cross Connect Modules

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Extensive Bandwidth Management
288x288 STS switch matrix
672x672 VT switch matrix
Optical Aggregation
VT Cross Connect (XC-VT)

1 STS1 to carry 28 DS1s
no wasted bandwidth as in traditional DCS function

Optical Aggregation
Linear Add/Drop

Unidirectional and bidirectional SONET APS protection supported.
Optical Aggregation
SONET Ring Support

Maximum of 5 rings/chassis
Maximum 1 BLSR
Any combination UPSR

Central Office

Figure 1: Sample Meshed Network
A-B-C-H-G-J-L form a UPSR ring for circuit

Figure 2: Working and Protect Traffic Routed through a Meshed Network
Primary Path (Working Traffic)
Secondary Path (Protect Traffic)

Figure 3: Failure on Primary Path in Meshed Network
Secondary Path carries Working Traffic
Failure on Primary Path
Any Line Rate
Optical Aggregation
POS Transport Architecture

OC3/12/48 POS interfaces available
SONET APS supported

OC48 SONET UPSR or BLSR
MM 1261-1360nm
4xOC3: SM IR 1261-1360nm
SM LR 1261-1360nm
MM 1261-1360nm (SC)
1xOC12: SM IR 1261-1360nm (SC)
SM SR 1310nm (SC/FC)
1xOC48: SM LR 1310nm (SC/FC)

SONET APS redundant links
Topology can be linear point to point, ring, or mesh.

MM SR and SM IR 7x00 OC3

Optical Aggregation
CHOC12 POS Architecture

DS-3 IP/HDLC/PPP/FR Services offered on many Cisco platforms
Connectivity varies depending on application

Site A: IP router with DS3 I/F
Site B: IP router with DS3 I/F

GSR1200x
Channelized OC12 (DS3) POS Line Card(s)

Site: IP router with DS3 I/F

OC12/48 UPSR or BLSR

CH OC12
12xDS3 access

SM-IR, PB: 12dB
xmit pwr: -15 to -8 dB
rx pwr: -28 to -8 dB
1270nm - 1380nm

No APS on CHOC I/Fs!
Optical Aggregation
Ethernet Mapping

Traditional Data Over SONET

- 1-to-1 Mapped Circuits
- To Internet
- NAP
- Backbone Router
- Router
- 10/100 Mbps Ethernet Interface
- Multiple STS1
- 10/100 Mbps Ethernet Interface
- Brand x
- DSLAM
- Access Routers
- Customer Premise

Cisco 15454 Data Over SONET

- 3 STS1s to support 3 ethernet links
- 3 backbone router interfaces
- Unfilled STS1s from bursty traffic

- 1 STS1 to support 3 ethernet links
- 1 backbone router interface
- Efficient bandwidth utilization

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Ethernet Transport

Ethernet Interfaces
10/100 Mbps Ethernet
12 ports
10/100BaseT
Auto-sensing, full duplex support
IEEE 802.3x Flow Control
IEEE 802.1q VLAN compliant

VLAN ID=1 mapped to STS3c (STS 1-3)
VLAD ID=2 mapped to STS3c (STS 4-6)

Catalyst Switch

Ethernet mapped onto STS-3c
1.2Gbps BW on each Enet card
Customer receives multiple DS3s (DS1 mapped) from carriers. DS1 payloads include private line DS1’s, DS1’s from PBX’s and ATM mapped DS1’s. DS1s groomed into multiple DS3s to feed ATM switches, Voice Switches and hand-offs to other carriers.

Multiple DS3s (M13 Mapped) from Carrier Entrance Facility

M13 Mapped DS3s Containing Mixed Payloads
- Switched
- ATM
- IP Traffic

OPTICAL AGGREGATION

Transmux Card

Each DS1 is broken down into 28 DS1s
Each DS1 is mapped into a VT1.5
28 VT1.5s are packaged into an STS1

28 DS1s → 28 VT1.5s → STS1 Payload

STS1s are routed to cross connect for grooming

To XC-STS and XC-VT

STST1

To XC-STS
Optical Aggregation

STM-1 Transport over SONET

Transport STM-1 over SONET OC-n architecture
STM-01 encapsulation into STS-3c -- no add/drop functionality on subrate STM-1

- STM-1 SDH Customer Site
- ONS15454
- OC3/12/48 SONET UPSR or BLSR
- Handoff of STM-1 to customer
- STM-1 carried within SONET network as STS-3c

SDCC Tunneling

- ONS15454
- Tunnel 1
- Tunnel 2
- Terminal

SDCC from Red and Blue 3rd party ADMS are tunneled over the ONS15454. Separate LDCC tunnel for each SDCC path. Max of 3 tunnels between LTEs.

Legend
- Single SDCC Tunnels
- Two SDCC Tunnels
- Fiber Pair
Optical Aggregation

Metro WDM

- Key Features
  - Integration of SONET & DWDM layer
  - 18 ITU-T compliant OC-48 interfaces
  - Red and Blue ONS 15516 Passive DWDM Mux/Demux
  - Optimized for point-to-point fiber gain

Optical Aggregation

OC48 ITU-T DWDM Optics

- 18-\lambda OC48 ITU-T DWDM Optics
  - 16 working plus 2 spare wavelengths*
    - Red Band: 1547.72 1549.32 1550.92 1552.52 1554.13
      1555.75 1557.36 1558.98 1560.61* (nm)
    - Blue Band: 1530.33* 1531.90 1533.47 1535.04 1536.61
      1538.19 1539.77 1541.35 1542.94 (nm)
  - 24dB reach without optical amplification
  - +/- 0.25nm (200GHz) stabilized transmitter
  - Dispersion allowance of 3600ps/nm
  - Consistent with GR-2918-CORE and ITU-T G.692
  - Tx Power: 0 to -2 dBm
  - Rx Sensitivity: -9 to -27 dBm @ BER=10E-12
  - Transmit Laser Type: DFB/EA
Optical Aggregation

200GHz Channel Plan

OC48 ITU Optics

Dense WDM Plan

16λ Solution:

18λ Solution:

ITU-T wavelength grid

196.1 1528.77
195.9 1530.33
195.7 1531.90
195.5 1533.47
195.1 1536.61
194.9 1538.19
194.7 1539.77
194.5 1541.30
194.3 1542.90
194.1 1544.50
193.9 1546.10
193.7 1547.72
193.5 1549.32
193.3 1550.92
193.1 1552.52
192.9 1554.13
192.7 1555.75
192.5 1557.36
192.3 1558.98
192.1 1560.61

Solution:

Spare

195.3 1535.04

Solution:

Spare

1.75" high 9” deep
19” or 23” Rack Mountable (reversible ears)
SC Connectors

Optical Aggregation

Passive Filter Design

(Base Red DWDM)

(Uprade Blue DWDM)
200 GHz Channel Spacing
- Pass Band @ 1.0dB = 0.5nm min.
- Pair Insertion Loss (end-to-end, including 2 connector losses) = 9.0 dB max.
- Demux Isolation, adjacent channels = 25 dB min., non-adjacent channels = 40 dB min.
- Channel Uniformity @ 23°, excl. spares, = 1.5 dB max., incl. Spares = 2.0 dB
- Directivity = 35 dB min.
- Return Loss = 40 dB min.
- Chromatic Dispersion = 10ps max.
- PMD = 0.1 ps max.
- Operating Temp = 0 to 70° C
**Optical Aggregation**

**ONS Metro DWDM Applications**

- OC-48c SR Optics from router or switch
- ONS15454
- OC-48 ITU Optics
- ONS15516 or third party

Multiple applications
- transpond OC-48 router or switch optics for narrowband
- aggregate low speed interfaces for narrowband

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**Optical Aggregation**

**Storage Area Networking**

- ESCON
- Fiber Channel
- Gig Ethernet
- 100Mb Ethernet
- OC-3/12

16×BiDirectional system

- 8× per chassis
- 200GHz spacing
  - Channels 1-8: 1547.72nm to 1558.98nm
  - Channels 9-16: 1537.90nm to 1542.94nm

ITU Transponders and Passive Mux on same chassis

MINI SC (MU) Connectors Only!
Optical Aggregation
Metro 1500 DWDM

- Ethernet, Fast Ethernet, Gigabit Ethernet (10/100/1250 Mbps)
- FDDI (100 Mbps)
- ATM (155/622 Mbps)
- ESCON (200 Mbps)
- Fibre Channel (1.062 Gbps)
- Coupling Link (1.062 Gbps)
- Ficon (1.062 Gbps)
- PDH (34/140/565 Mbps)
- SONET/SDH (155/622/2488 Mbps)
- Various Proprietary Protocols

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Metro 1500 DWDM Specifications

- 32 channel system
- 8 channels/shelf
- Point-to-Point and Point-to-MultiPoint
- Up to 2.5Gbps/channel, bit rate and protocol independent
- 1:1 line level protection
- SNMP manageable
### Optical Aggregation

#### Metro 1500 Interface Types

<table>
<thead>
<tr>
<th>Name</th>
<th>Speed</th>
<th>TX λ</th>
<th>RX λ</th>
<th>Link Budget</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Speed Module</td>
<td>1250Mbps</td>
<td>850nm</td>
<td>770-860nm</td>
<td>19dB/12dB</td>
<td>Fiber Channel</td>
</tr>
<tr>
<td>Transparent HSM</td>
<td>1250Mb 850nm</td>
<td>1260-1360nm</td>
<td>19/12</td>
<td>All in speed range</td>
<td></td>
</tr>
<tr>
<td>2.5Gb Module</td>
<td>2.488Gbps 1310</td>
<td>1260-1360nm</td>
<td>19/12</td>
<td>OC48 and STM16</td>
<td></td>
</tr>
<tr>
<td>High Speed 622</td>
<td>622Mbps 1310</td>
<td>1260-1360nm</td>
<td>19/12</td>
<td>OC12/STM4</td>
<td></td>
</tr>
<tr>
<td>Transparent LSM</td>
<td>200Mbps 10-200Mbps</td>
<td>1310 1260-1360nm</td>
<td>19/12</td>
<td>All in speed range</td>
<td></td>
</tr>
</tbody>
</table>

### Optical Aggregation

#### Cisco Transport Manager

- TL1: Alarm and event reporting, Configuration and PM, NMA support, SNMP, Trap and Gets support, IETF standard MIBs, SNMP v2c, Tested with HP Openview, CORBA, Alarm and event notifications, Performance management, Connection management, Equipment Inventory, CORBA 2.1

- NMS/OSS:

  - TL1
  - SNMP
  - CORBA

- CMS: CORBA
Cisco Systems

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