Astr★l Point™

Will DWDM Make Bandwidth Cheap?

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Twenty-Five Million to One

- **A state of the art DWDM system could provide about 25.000.000 times the bandwidth of a typical point-point digital circuit of five years ago.**

Twenty-five Million to One

- **That'd be like having a car that goes at 75.000.000 kph, stuck on Bangkok's city streets (or Manila… or New York)**

Reality Check

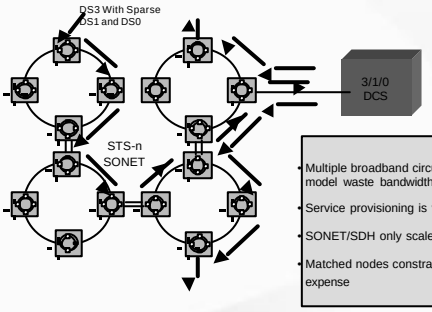
- **No "cars" need to travel at an individual speed of 7 million kph.**
- **It's not enough to have great highway. There mu be on-ramps and off-ran and clear *instructions* h direct traffic**

⇨ ***It's not about highway size. It's about the* traffic.**

The Presentation

- ✓ **Address implementation challenges in growing existing fibre networks**
- ✓ **Discuss DWDM, in concept**
- ✓ **Talk about approaches to these challenges in the metro environment**

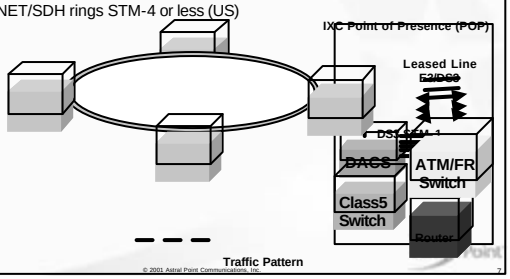
Drawbacks of SONET/SDH



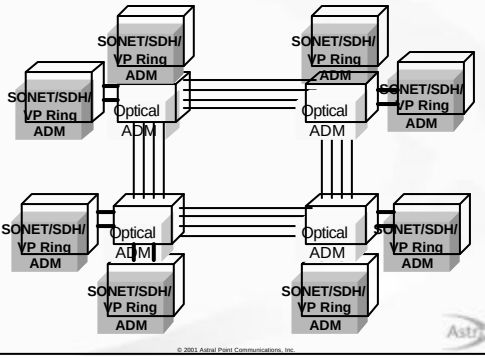
- Multiple broadband circuits and backhaul model waste bandwidth
- Service provisioning is very tedious
- SONET/SDH only scales by adding more rings
- Matched nodes constrain capacity, add expense

Today's Metro SONET/SDH Transmission implementation

- Ring topology for protection
- Data services backhauled to POP
- >70% of SONET/SDH rings STM-4 or less (US)



Today's Scalability Approach Only Addresses Bandwidth



CTO of a Major US Competitive Carrier

"The fibe spaghetti thrown tabl

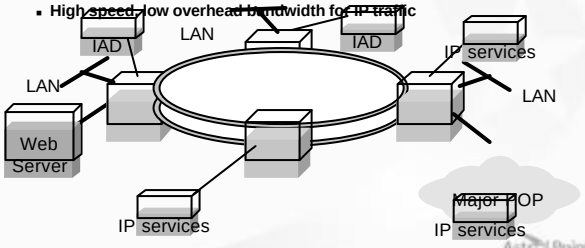
I can't possibly build rings out of it."

SONET/SDH/OADM Solution is Costly and Difficult to Manage

- **High initial cost**
  - Ring topology restricts rights of way and fiber runs
  - Too many systems needed
  - Too many optical interfaces (lasers on SADMs , OADM,s optical supervisory channels)
- **Ongoing life cycle cost - no integrated network view**
  - Provisioning
    - Multiple domains, Multiple rings and Multiple steps
    - Manual mapping of services to wavelengths
  - Fault Management
    - Numerous loopbacks and connection associations
  - Protection
    - Careful coordination of protection among systems
    - Centralized provisioning systems don't help protection

Meanwhile, New Traffic Patterns Dictate Distributed Bandwidth

- **Fine Grain Bandwidth Distribution**
  - Local T1/E1 and IMA ATM Services
  - LAN Services
- **High speed, low overhead bandwidth for IP traffic**



New Metropolitan Multi-Services Environment

- **Continued need for traditional circuit transmission**
- **Rapidly increasing use of IAD's for voice and data aggregation and NxT1/E1 services**
- **LAN Interfaces**
  - Transparent LAN services
  - Distributed Network Access Point (NAP)
- **Lambda (opaque wavelength) Services**
  - STM-1 to STM-64 Leased lines

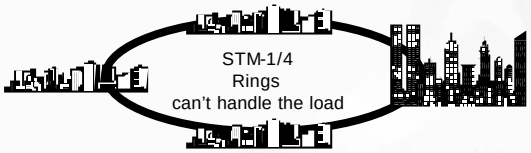
The “Last 15km Problem”?

Local CO/Wire Center

- DSL
- Cable Internet
- IAD
- LAN Services
- Requires numerous E3, STM1 and LAN rate connections

Serving Wire Center/POP

- Big Fast Routers
- Bigger ATM Switches
- DWDM/Inter-city Bandwidth Managers
- Requires numerous STM4 and STM16 connections



Next-gen Metro Needs

Current SONET/SDH Limits

- **Voice - centric**
- **Leased line service only**
- **Topology limits**
  - 16 Node Rings
- **Provisioning constraints**
  - Span level STS-1 mapping
  - Multi-element process for data
- **Cumbersome bandwidth upgrades**
  - SONET/SDH bandwidth is fixed at line rate
  - Simultaneous removal/replacement of all ADMs

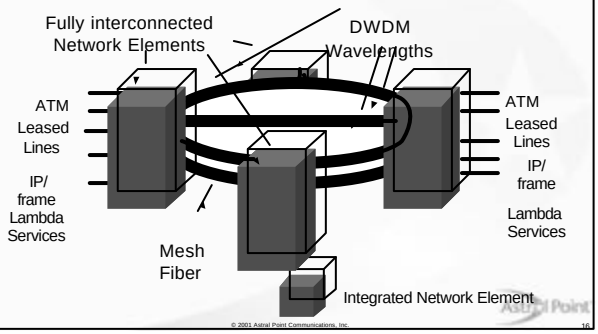
Next Generation Metropolitan Needs

- **Data - centric**
- **Multi-Service networks**
  - Leased line
  - ATM
  - IP/LAN, POS, MPλS, OIF?
- **Flexible topology support**
  - Ring for backward compatibility
  - Mesh for economical buildouts
- **“Point and Click” Provisioning**
- **Use of DWDM for non-obtrusive SONET/SDH overlay**
- **Scalability**
  - DWDM-Ease of adding bandwidth
  - Larger networks
  - Add network capacity beyond line rate

Next-gen metro needs - summary

- **“Data aware” – no presumption that SDH envelope is voice by default**
- **Multi-service. Not everything is IP, yet. SANs comes to mind. And voice.**
- **Growth is massive**
- **SONET/SDH systems are unscaleable and designed for stability, not growth**
- **Both “coarse” (STM-4+) and “fine” bandwidth granularity is needed**

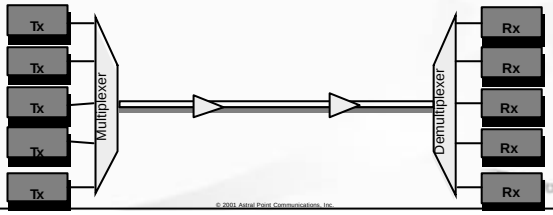
Getting to Next-Gen Needs



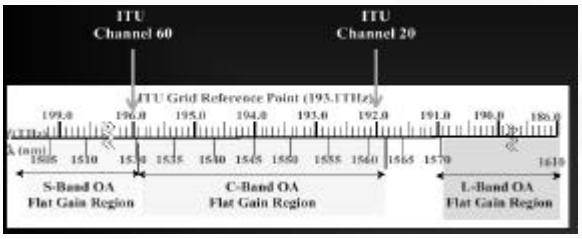
DWDM defined

- **Dense Wave Division Multiplexing: method for placing multiple lightstreams on a single fibre, and managing them independently**

Ten's of wavelengths/fiber over 100 – 1000 km

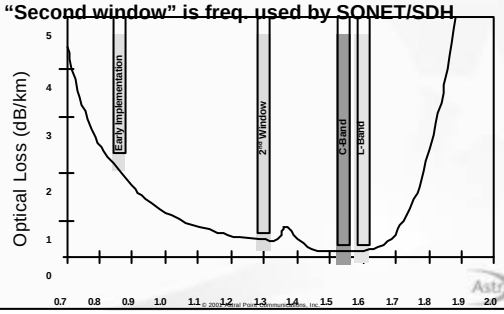


ITU "C", "L" and "S" Band

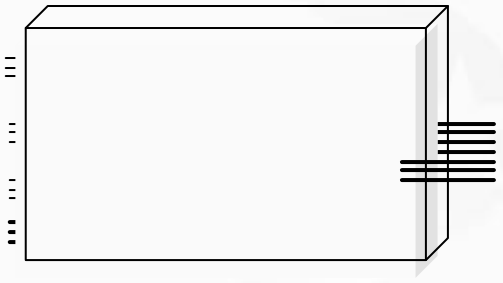


DWDM Wavelength utilisation

- **Attenuation and dispersion characteristics make C-band and L-band optimal**
- **"Second window" is freq. used by SONET/SDH**

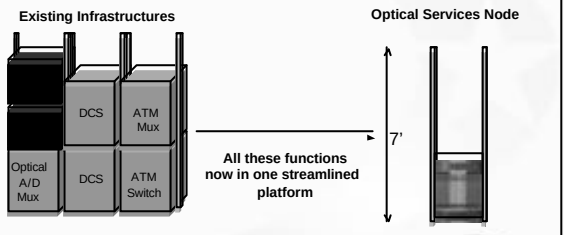


A New Integrated Electrical/Optical Network Element

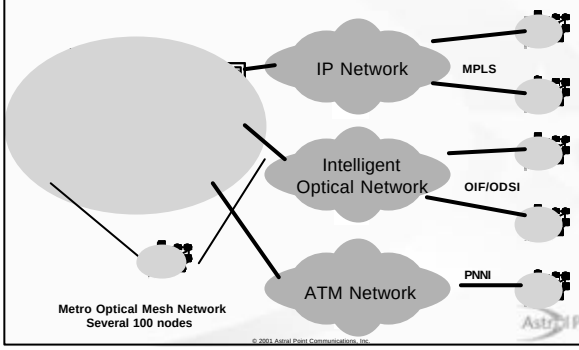


Astral Point ON5000 Block Diagram

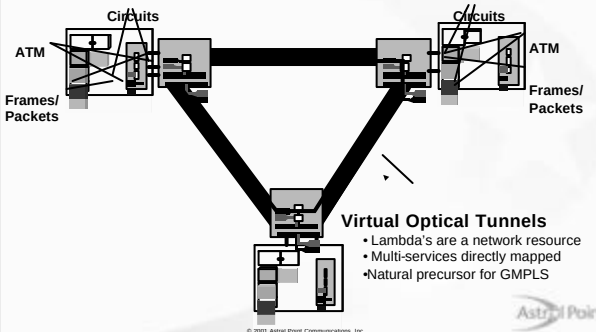
Rack Space Comparison
Space & power savings



Mesh Network Scalability and Dynamic Provisioning



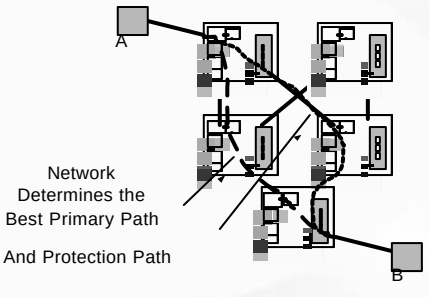
Virtual Optical Tunnels



Virtual Optical Tunnels

- Lambda's are a network resource
- Multi-services directly mapped
- Natural precursor for GMPLS

Single Step, End to End Service Provisioning



Network Determines the Best Primary Path

And Protection Path

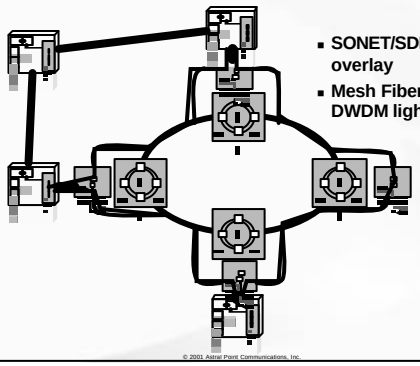
Mesh protection

- **Uses OSPF-based "Self-Healing Mesh" to overcome SONET/SDH limitations**
- **Enables first-ever SONET/SDH-quality protection and restoration in mesh networks**
  - Provides sub-50 ms protection and restoration in mesh networks that scale to hundreds of nodes
  - Allows for variable protection levels
    - Guaranteed Protection
    - Guaranteed Protection with reduced bandwidth
    - Pre-emptable services utilizing protection bandwidth

Applications

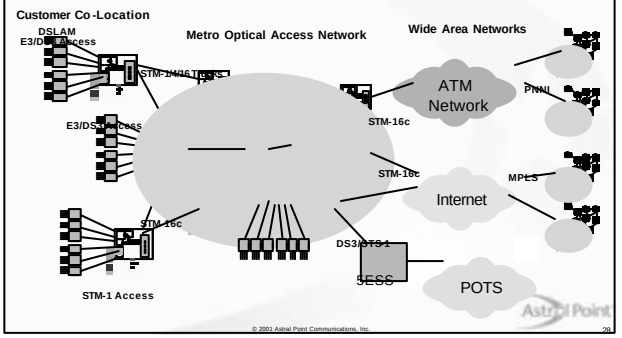
- **Bandwidth relief**
- **DSLAM aggregation**
- **Leased line transport**
- **"Fat pipe" services**

Optical Overlay for Fiber Span Relief

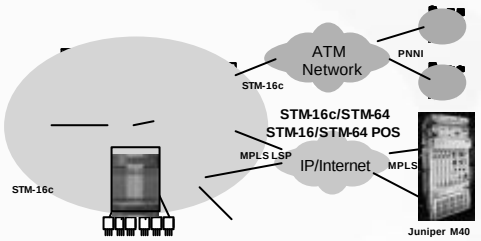


- **SONET/SDH optical overlay**
- **Mesh Fiber or DWDM lightpaths**

DSLAM Aggregation

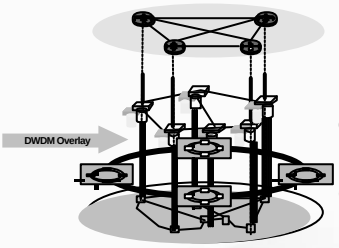


Big Pipes



Putting it All Together

Optical + ATM Mesh Network: Provides reliable optical channel protection and layer protection (IP, TDM, ATM, etc.)



Service Layer
(ATM Mesh Protection)

1550 DWDM Overlay
(32 Wave Optical Mesh Protection)

1310 SONET Ring Fiber Connection

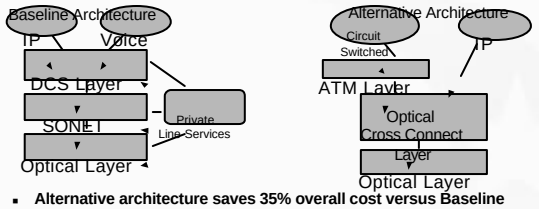
Physical Optical Fiber

ATM & IP/MPLS – Not mutually Exclusive

"It is ironic that even as the service-provider industry is … building its new services on Internet Protocol, based on its ubiquity and increasing maturity, the technology IP would displace — ATM … is finally getting its foothold in the public network at large… even as IP matures with … [MPLS], DiffServ and … other protocols that let IP do what ATM was built to do: *handle different types of traffic differently, each according to its needs.*"

– Carol Wilson in "The Network Economy" 20/2/01 www.theneteconomy.com

ATT Labs-Research Study



- **Alternative architecture saves 35% overall cost versus Baseline**
- **Contributors to savings are:**
  - Mesh network restoration 60% of the savings
  - ATM switching consolidation 40% of the savings

Source: IEEE Communications Magazine, "Future Transport Network Architectures", R. Doverspike, S. Phillips, J. Westbrook, ATT Labs-Research, August 1999 Vol. 37 No. * pp 96-101

Returning to the presentation brief:

"Although most… would agree DWDM… can make bandwidth cheap and plentiful…

… A number of issues remain that limit deployment

… what is DWDM really, what are the opportunities… where do we go from here?"

How'd we do?

"Will DWDM Make Bandwidth Cheap?"

- ***…Cheap and plentiful?*** **Yes and no. Complications are "last 15km", competitive forces, installed base and cost**
- ***…technical issues?*** **Existing rings, scalability limitations, management and provisioning nightmare**
- ***… solutions?*** **"Next Generation" "SONET/SDH replacement" platforms, mixing transparent and opaque services.**
  - *High bandwidth where its needed*
  - *Managed, high density bandwidth where* its *needed*
  - *Fostering interoperability for the next-gen IP platforms.*

Thank you.

Bibliography & Shameless Self-Reference

For those interested in learning more about the *technology* – write the *speaker* at sblessley@astralpoint.com.
A bibliography/recommended reading list is available.

For those interested in Astral Point products… www.astralpoint.com