

Bandwidth Virtualization with Digital Optical Networks

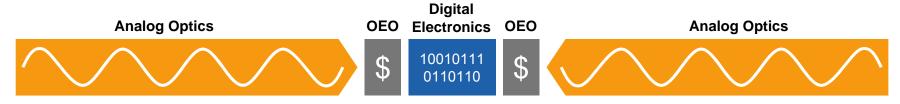
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Infinera Summary

- Optical communications systems
- Core innovation: **Photonic Integrated Circuits**
- A contrarian approach
 - "Digital Optical Networks"
 - PICs allow pervasive use of electronics in the optical layer to improve network economics and virtualize bandwidth
 - Infinera vertically integrates the PIC
- Rapidly winning footprint
 - Carriers, Cable operators, Internet content providers, Gov't, R&E, and others
 - 1H07 sales: \$135.7M
 - 300% Y-Y growth vs. 1H06



Inside the Optical Network: Three Key Functions



Analog Optics

- Photonic transmission
- Move lots of traffic across long distances
- Analog only

OEO Conversion

- Convert signals between optics and electronics
- Required for digital processing

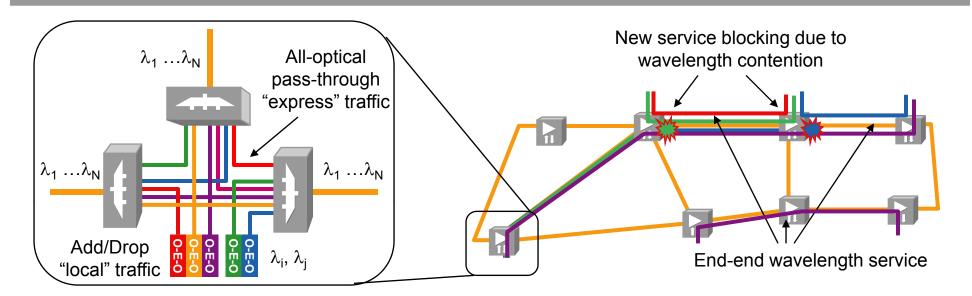
The most costly function

Digital Electronics

- Digital processing
- Add/drop traffic
- Manage bandwidth
- Service provisioning
- Performance monitoring



All-Optical Networking with ROADMs



- All-optical wavelength switching using filters, ROADM, WSS, etc.
- OEO only for local add/drop
- No sub-wavelength add/drop
- No wavelength inter-wavelength
- No digital PM or OAMP

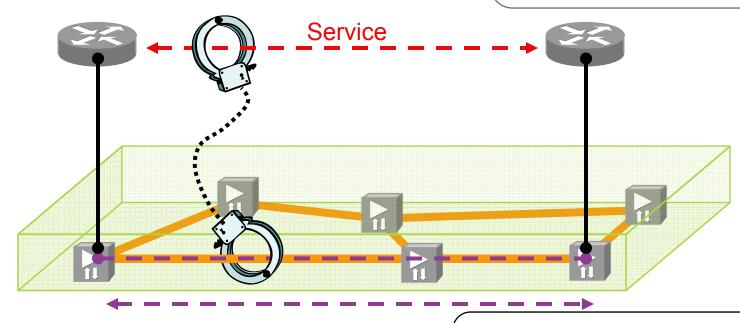
- End-end services over wavelengths
- Wavelength contention and blocking
 - **Incremental** OEO for λ -conversion = hidden CapEx premium
- Service limited by wavelength path
 - Optical reach
 - Number of (R)OADM nodes passed
 - Fiber characteristics

ROADMs limited by all-optical implementation

Conventional DWDM Couples Services to Waves

The service is coupled to the wave, and *inherits the* associated problems

Can the network handle the datarate? Wave blocking? Dispersion? Optical power? Regen? Protection? etc.



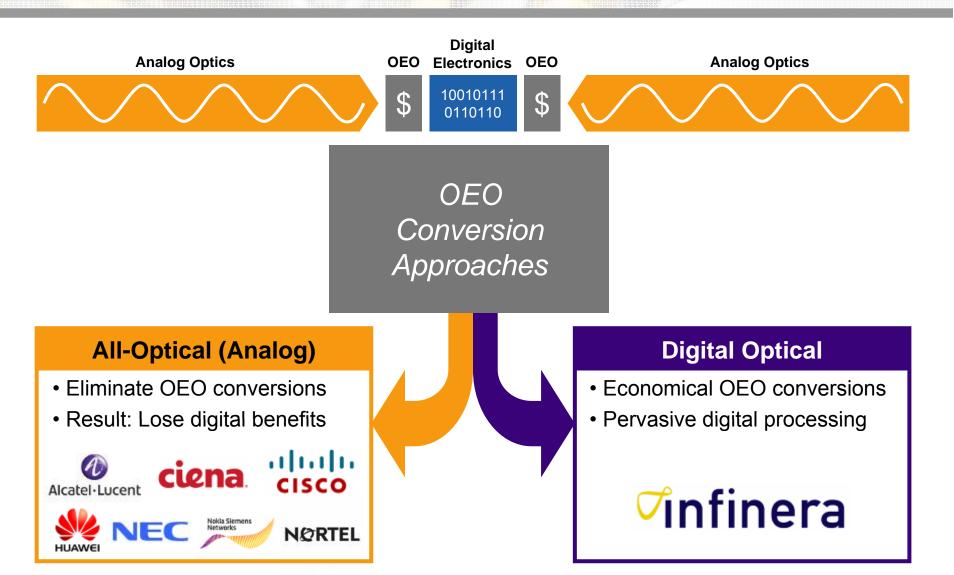
Wave



= ROADM or WSS

- 2.5G service needs 2.5G wave
- 10G service needs 10G wave
- 100G service needs...???

Infinera's Contrarian Approach to OEO



GENI Concerns Digital Optical Network Solutions

Photonic Integration

Bandwidth Virtualization

Software Intelligence







Cost -Effective Capacity



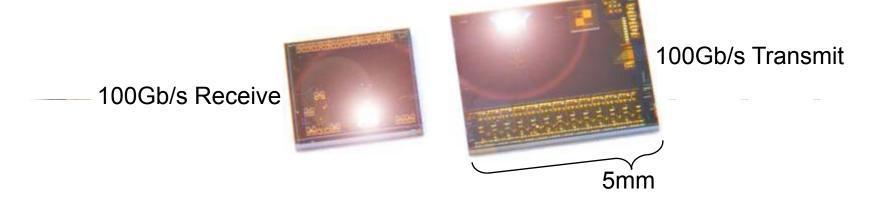
Network Flexibility



Network Manageabilitiy

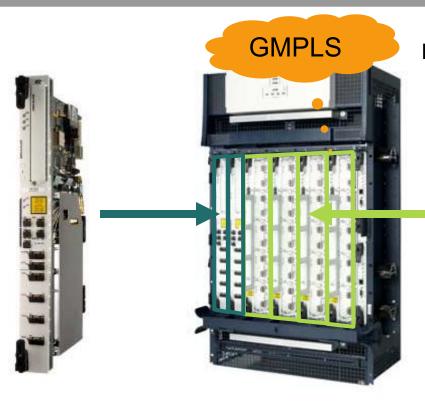


How to Reduce OEO Costs? Photonic Integration



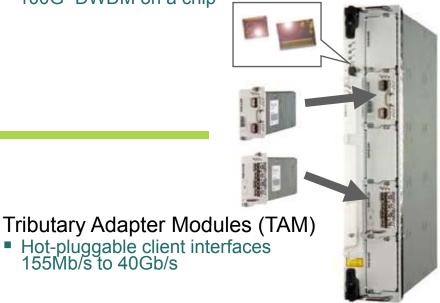
- Improves cost, space, power, reliability
- Makes digital processing economical

Infinera DTN Overview



Photonic Integrated Circuits (PICs):

■ 100G "DWDM on a chip"



Band Multiplexing Module (BMM)

40 or 80 λ options

Infinera DTN Chassis (DTC)

Electrical connectivity between DLMs for multi-direction digital switching.

IQ Network Operating System

- GMPLS automated service provisioning
- Digital protection & GMPLS restoration

Digital Line Module (DLM):

- 100Gb/s DWDM line module
- G.709 and enhanced FEC
- ODU1 Digital ROADM switch
- Add/drop & grooming at 2.5Gb/s granularity

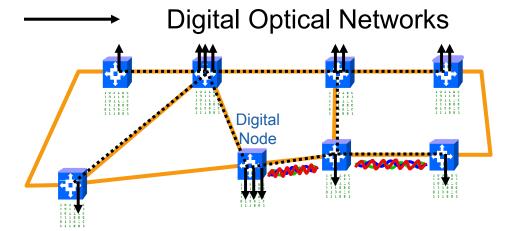
Photonic Integration and Digital Optical Networks

Photonic Integrated Circuits



100Gb/s Receive

100Gb/s Transmit



Don't Eliminate OFO. Make it Cheaper

> Photonic Integrated Circuits

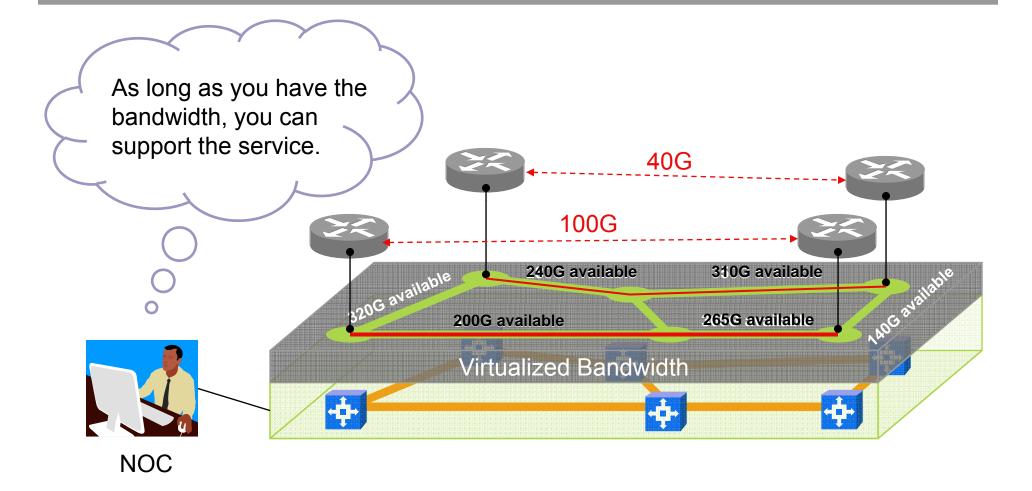
Direct Benefits:

- Lower cost OEO
- Lower power
- Higher density
- More reliable
- Fewer line cards
- Simpler system design

Strategic Benefits:

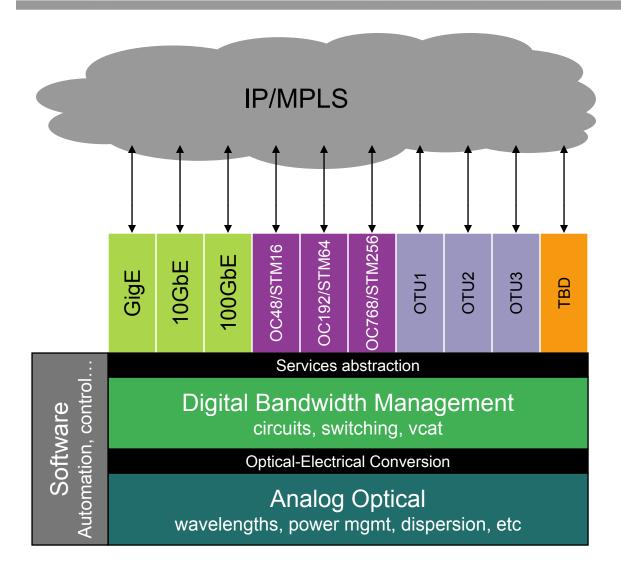
- Maximize service access
- Digital feature richness at every node
- Software intelligence
- Simplify operations
- Increase flexibility

Decoupling Transport Services from Waves



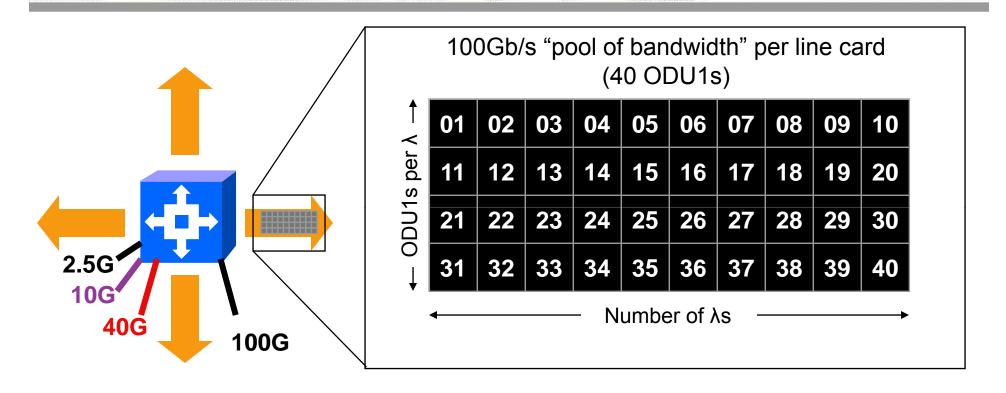
All sites are connected; GMPLS enables Operational simplicity

Open Service Architecture



- "Services" not "Wavelengths"
- Decouple the transport infrastructure from the services
 - Sub-lambda
 - Lambda
 - Super-lambda
 - Ethernet (GigE → 100GbE), SDH/SONET, OTN

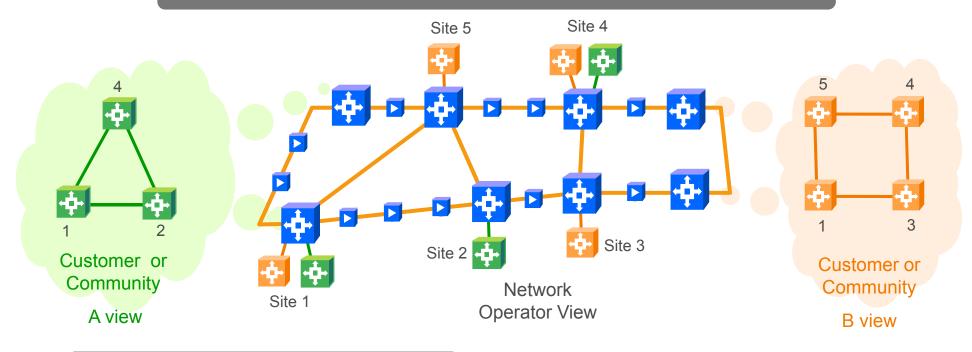
Digital Bandwidth Management w/ GMPLS



- Enables fractional services (e.g., Fractional 100 GbE)
- GMPLS fully automates bandwidth management

Layer1 VPN - Overview

Multiple virtual transport networks on a shared physical network



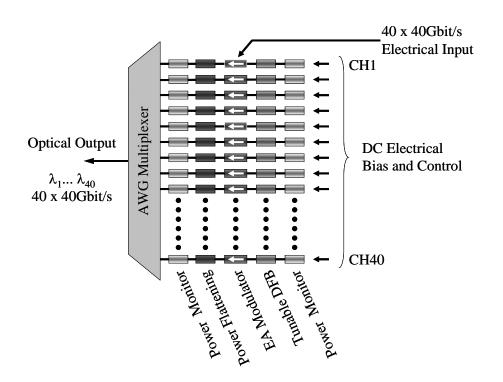
L1VPN - Characteristics

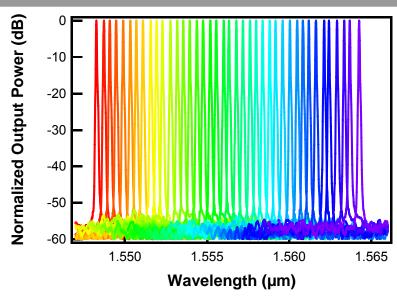
- Data plane isolation from other customers
- Management and control plane separation
- User-controlled circuit provisioning

Key Applications

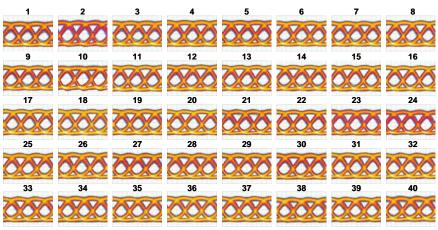
- Alternative to separate networks
- Separate administrative domains within user community

PIC Allow Scaling Beyond 100G: 1.6Tbit/s DWDM Large-Scale PIC Transmitter

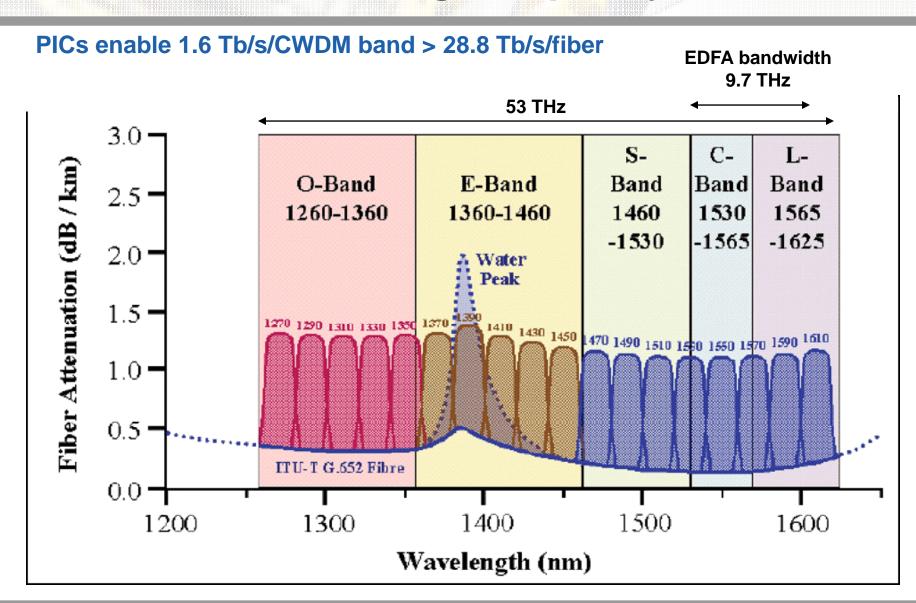




...40 channels x 40 Gb/s



PICs Enable Ultra High Capacity Networks





Thank you!

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