Objectives for Service Provider Shared Transport of 802.3 Higher Speed Ethernet

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802.3 HSE MAN/WAN Transport Issues

- 802.3 HSE transport implementations will have a greater impact for end users who do not own or control dedicated physical facilities in a given environment.
- Service providers are now initially deploying shared infrastructure backbone transport networks to provide converged, aggregated MAN/WAN transport service needs, including future private-line transport of 802.3 HSE clients.
- HSSG needs to consider appropriate weighting of economic and functional factors in metropolitan and long haul WAN environments. This must consider adaptation to provider shared transport networks becoming established now and through to the time of prospective 802.3 HSE Task Force standard completion.

Provider Transport Network strategies are changing…

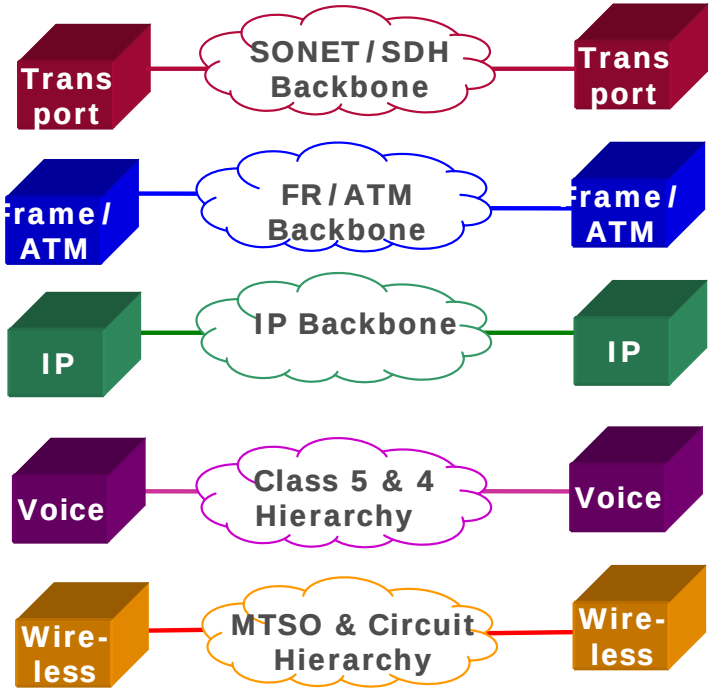
Old Model

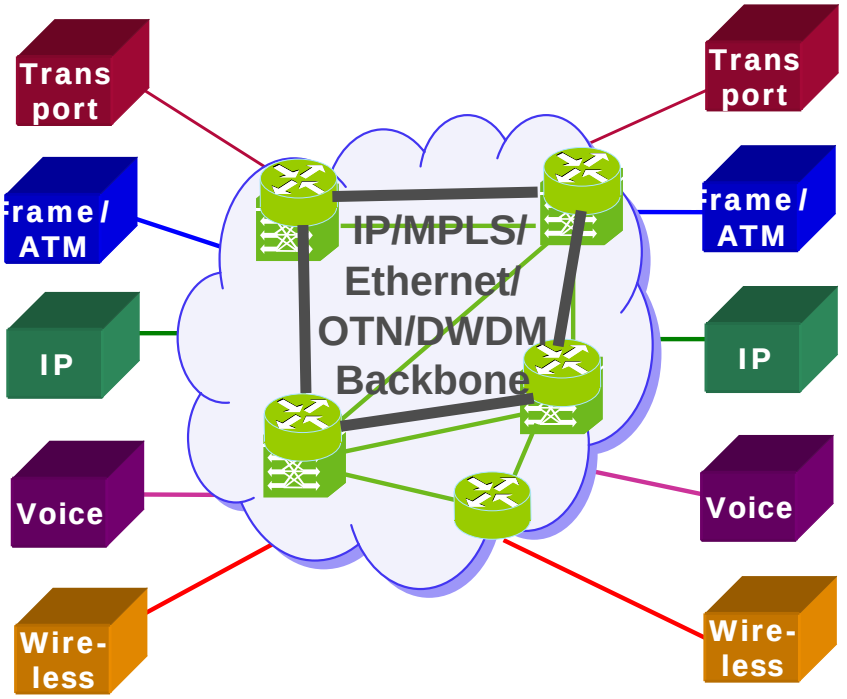
- Traffic growth steady and predictable onto multiple parallel backbones
- Client Access Rate << Backbone Rate
- Aggregation at ingress to backbone
- Backbone relatively static
- Separate domestic and global pieces

Today's reality

- Volatile Traffic growth onto a single converged network
- Client Access Channel Rate approaches or equals Backbone Channel Rate
- Greater amount of aggregation close to or done by the client
- Agile Backbone
- Seamless domestic/global network

Forces for Change: Technology & Service Convergence





The Past

Multiple backbones for each access technology or service

Today

Multiple access technologies & services on common IP/MPLS/Ethernet/OTN/DWDM transport backbone

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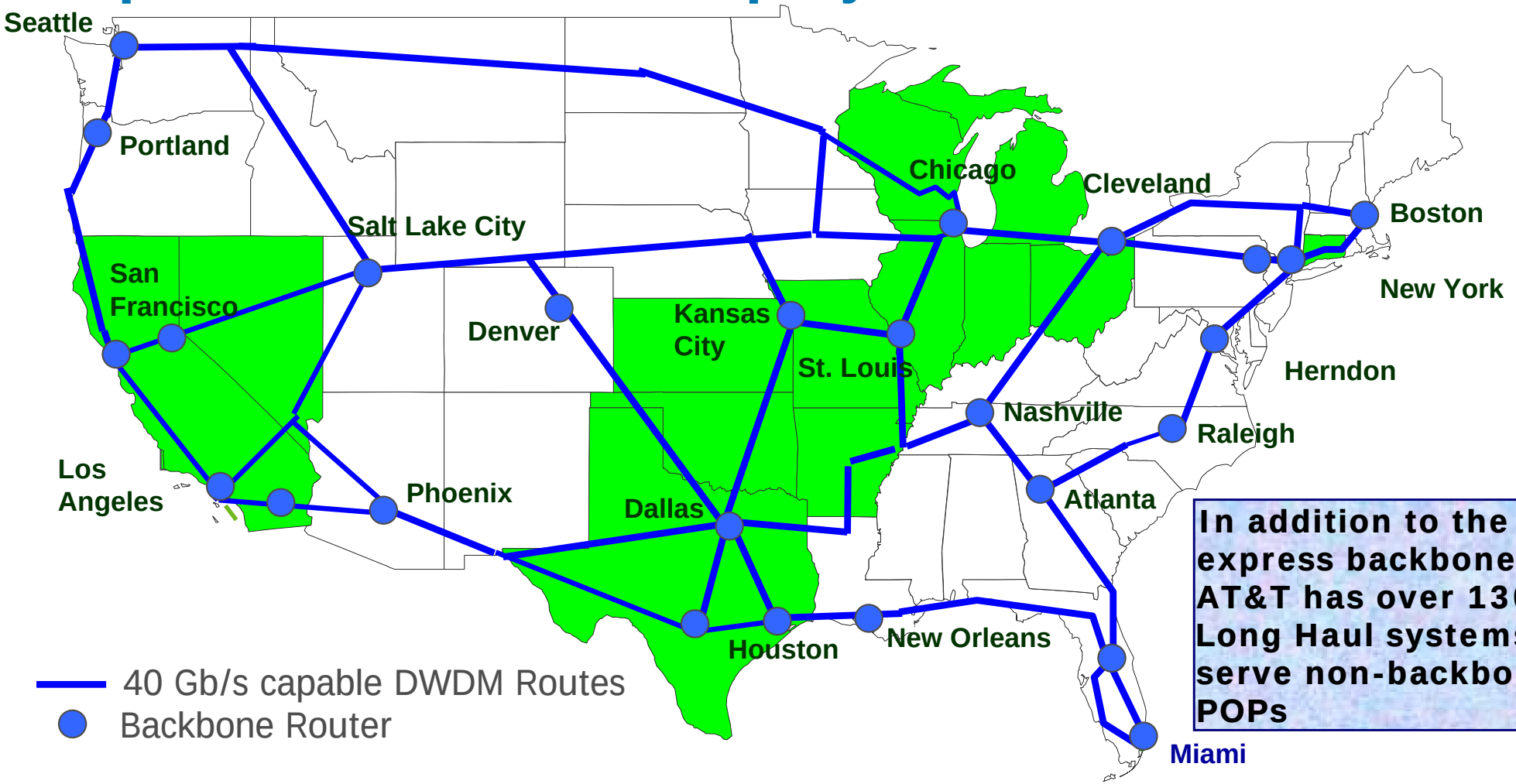
AT&T Global Network

Today, the Network Comprises:

- **535,000** fiber route miles globally
- 30 Internet data centers on **4** continents
- Dedicated MPLS access from over **1,600** nodes serving **137** countries
- Wired Ethernet from over **1,600** access points in **17** countries
- **7.0** petabytes of traffic on an average business day

AT&T US Domestic 40 Gb/s G.709 OTN/DWDM Express Backbone - Deployment Overview



In addition to the express backbone, AT&T has over 1300 Long Haul systems to serve non-backbone POPs

20,000 40 Gb/s OTN/DWDM Route Miles

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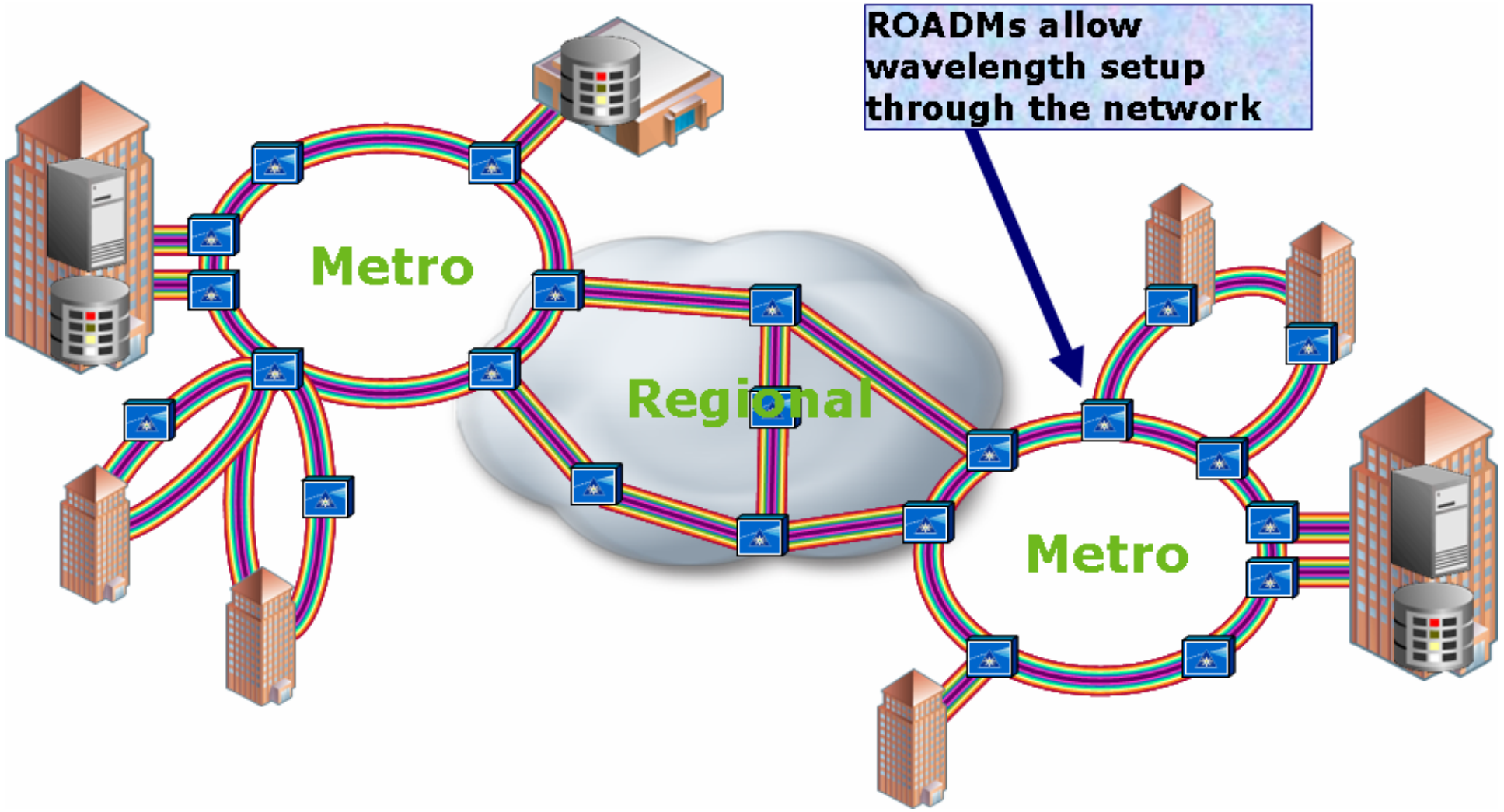
AT&T US Domestic OTN / DWDM Express Backbone - Initial Deployment Objectives

- Serves AT&T Converged IP Backbone and AT&T Enterprise customer base
  - Connects major US cities with express wavelengths
  - Complements extensive long haul and metropolitan networks for optical connectivity
- Provides low cost, high bandwidth pipes to support next-generation applications
  - 40 Gb/s G.709 OTN framing over 80 channel DWDM for most efficient multiplexing utilization and to support ultra-high rate client services such as 802.3 HSE
  - Ultra-long haul reach for rapid provisioning
  - ROADM-based enabling reconfiguration

AT&T US Metro/Regional Multi-Service Multi-Degree ROADM Networks: 10 to 40 Gb/s G.709 OTN/DWDM



AT&T US Domestic Express and Metro/Regional Backbones – Common Key Features

- ROADMs and Multi-degree ROADMs for optical express
- Tunable lasers for inventory and spares management
- Longest possible reach for both 10G and 40G to avoid touch points at regenerator locations
- Supports automated provisioning of bandwidth
- Growth path to tunable drops and ASON/G-MPLS for agility in wavelength provisioning

AT&T Domestic Express and Metro/Regional Backbones – Common Implementation

- C-band G.692 DWDM line haul with 80 channels (50 GHz grid) or 40 channels (100 GHz grid), both 10 and 40 Gb/s client payload rates per channel.
- G.709 OTN OTU2/ODU2/OPU2 (10 Gb/s) ↔ OTU3/ODU3/OPU3 (40 Gb/s) client payload multiplexing.
- Longitudinal single-span multi-supplier interoperability of G.709 adapted client signals across intra-domain interfaces.
- Optical modulation format is NRZ (10 Gb/s channel signalling) or advanced (duobinary, DQPSK, etc.) modulation (40 Gb/s channel signalling).
- OC-768 Packet over SONET is the current framing protocol employed for aggregated IP/MPLS/Ethernet client service interface at 40 Gb/s. (STS-768c payload capacity is 38.338560 Gb/s)

HSSG MAC Data Rate Objective – Implications for Service Provider OTN Shared Transport Networks

- 802.3 HSE will be considered as an ITU-T G.709 OTN ultra-rate client (client signalling rate > single OPUn channel payload capacity).
- Transport inverse multiplexing by means of Virtual Concatenation and Link Capacity Adjustment Scheme (LCAS) protocols are well established in transport service provider SONET/SDH networks for super-rate client Ethernet private line transport services. (client signalling rate > single STS-1 or STS-3c channel payload capacity)
- OTN Virtual Concatenation (OPU2-Xv, OPU3-Xv) and Link Capacity Adjustment Scheme defined in G.709 since November 2001. Details were introduced in 802.3 HSSG Interim Meeting (9/18/06) presentation: “Considerations for multi-lane implementations of higher rate Ethernet Interfaces”, S. Trowbridge/Lucent.
- Established G.709 OTN OPUn Payload Rates are:
  - OPU2 payload capacity = 9.995277 Gb/s
  - OPU3 payload capacity = 40.150519 Gb/s
- Client interface signalling rates may be higher due to transport framing/adaptation protocols (e.g., GFP - Generic Framing Procedure).

802.3 HSE MAC Data Rate –Mapping/Multiplex Options with OTN Virtual Concatenation

- Two primary 802.3 HSE client OTN mapping options (OPU2, OPU3)
  - OPU2-Xv virtual concatenation payload mapping -
    OPU2-10v offers 99.95277 Gb/s payload capacity
  - OPU3-Xv virtual concatenation payload mapping -
    OPU3-2v offers 80.301038 Gb/s payload capacity
    OPU3-3v offers 120.451557 Gb/s payload capacity
- With the first case of OPU2-Xv VCAT inverse multiplexing, G.709 also provides for the implementation of ODUk Time Division Multiplexing
  - As an option for operation with 40 Gb/s DWDM line rate systems, four ODU2 members out of a OPU2-Xv VCAT group may be multiplexed together and mapped into an OPU3 payload. This could be expected to provide overall higher bandwidth utilization and cost efficiencies for most 40 Gb/s line rate capable systems in metro to ultra long-haul shared provider transport environments.
- OTN Virtual Concatenation should be expected to be applicable to prospective consideration of both multi-lane and serial 802.3 HSE client PHY interfaces for adaptation to OTN shared transport networks. A range of joint client/network adaptation, mapping and multiplexing implementation options needs further definition and assessment with cost, utilization, functional architecture and operational aspects.

Service Provider Issues/Positions Summary

- Development of HSSG objectives for prospective 802.3 HSE PHYs must be considered for interfacing shared infrastructure networks of transport service providers.
- 802.3 HSE Signalling Rate choice(s) – should not functionally or economically disadvantage shared provider transport based on incumbent OTN/DWDM network operations. (Cost/bit or aggregate BW capacity*distance product across the entire spectral band)
  - Multi-lane PHY(s) options allocated to existing OTN virtual concatenation mappings
  - or Serial PHY operating with new adaptation to existing OTN virtual concatenation
- HSSG needs to properly weight appropriate relative costs for service provider shared transport network options serving customer 802.3 HSE EPL applications in both the metropolitan and long-haul WAN environments.
- Intend to bring in some shared infrastructure transport model relative costs:
  - Client-specific port attachment/adaptation/modulation costs
  - Common aggregation/multiplexing costs
  - Allocated line haul channel mileage costs (ultra long-haul, long-haul, metro)
- 802.3 needs to begin to liaise work with ITU-T Study Group 15 as HSSG positions begin to emerge/converge, before HSSG objectives are finalized.
  - Joint consideration of functional and implementation options for 802.3 HSE client adaptation to shared transport over OTN/DWDM networks
  - Broad spectrum of transport network service provider and supplier input

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Thank You!