Economic Feasibility

Sam Sambasivan, AT&T
Martin Carroll, Verizon
Osamu Ishida, NTT
Andrew Ambrose, Alcatel-Lucent
John D'Ambrosia, Force10 Networks
Pete Anslow, Nortel
Gary Nicholl, Cisco
Steve Trowridge, Alcatel-Lucent
Jon Anderson ,Opnext

Subject : 40Gb/s Ethernet Single-mode Fibre PMD Study Group

Supporters (*Contributor)

Hidenori Takashashi , KDDI Labs *
Martin Birk , ATT Labs *
Kathy Tse , ATT Labs *
Jeffery Maki , Juniper Networks
John McDonough , NEC Corporation of America
Chris Cole , Finisar *
Sashi Thiagarajan, Ciena
Song Quan Shang, Semtech Corporation.
Brad Booth , AMCC
Koichiro Seto, Hitachi Cable
Hidehiro Toyoda, Hitachi
Satoshi Obara, Fujitsu Limited
Hideki Isono, Fujitsu Optical Components
Kazuyuki Mori, Fujitsu Optical Components
Frank Chang, Vitesse

Yann Loussouarn, FT
Christophe Betoule, FT
Erwan Pincemin , FT
(FT = France Telecom)

Outline

- Carrier Background
- Example
- 40G Deployment
- Key Carrier Cost Contributors for optical networks
- Carrier Operating Expense (OpEx)
- Installation & Maintenance
- Placeholder
- Economic Feasibility

Carrier Background

- Carrier networks represent a unique operational environment.
  - Geographically diverse network with sparsely distributed equipment locations.
  - Serve numerous customers and carry multiple services over the same network
- For Example: **AT&T Network** (**Source: Young_01_1106 (updated 11/09**))

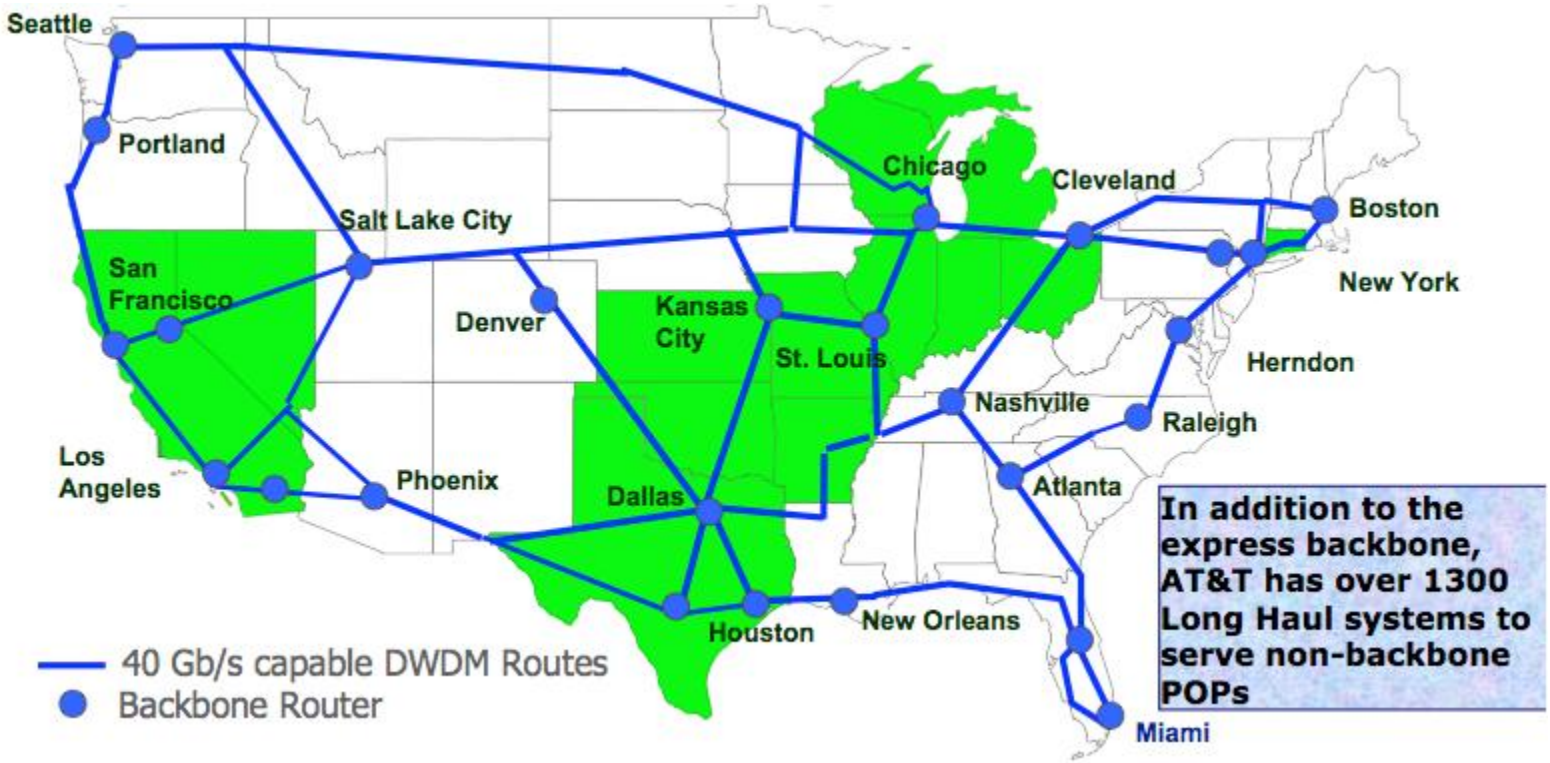
AT&T Global network

- 38 Internet data centres on 4 continents
- >980k fiber route miles
- >4100 MPLS access nodes (143 countries)
- >1450 Ethernet access nodes (21 countries)

AT&T Domestic network

- 26 Core data centers in US
- US area is ~3.5M sq miles covered by 40 Gb/s
- core backbone with >22k fiber route miles
- >1800 additional non-core backbone links

Example – AT&T Network (Source: Young_01_1106 (updated 11/09))



40 G Deployment

- Carrier deployment of 40G technology started in 2004.
- Initial deployed technologies were OC-768 or STM-256 standards (40G NRZ).
- Deployment of OTU3 technology started to support OTN service.
- Dual protocol OTU3/OC-768 modules were deployed in order to minimize costs. Both based on 40G NRZ optical technology.
- Currently there is a significant installed base of these interfaces.
- Future 40G clients will additionally be based on a 40GE standard to support Ethernet services.
- As currently defined in 802.3ba, 40GBASE-LR4 is optically incompatible with installed base preventing development of a single multi-protocol 40G module (ex. CFP) that supports 40GE and the installed base of OC-768 or STM-256, and OTU3 services.
  - This has significant cost implications for carrier networks

Contributors to cost of optical networks for carriers – client optics

Two major cost contributors for carriers with respect to client optics .

- Capital Expense (CapEx) is the acquisition cost of optics.
  - Similar for both carriers and data center operators.
  - Focus of 802.3ba debate in 2008 about 40GE standards alternatives.
- Operating Expense (OpEx) is the operational cost of optics.
  - It is significantly higher for carriers than data center operators.
  - Multiple services need to be supported in equipment centers distributed across large geographic areas that have lower equipment densities compared to data centers.
- Conclusion – 40 G deployment & cost
  - backward compatibility is required to support 40G networks
  - there is a higher cost of optics for carriers.
  - a 40 G Single Mode Fiber PMD would enable Carriers transition Ethernet services .

Carrier Operating Expense (OpEx) considerations due to client optical interfaces

- Higher carrier OpEx contributors due to client optics (vs. data center operator OpEx):
  - Shipping, Installation, Bring-up, Configuration, Sparing, Training, Life-cycle length.
  - Multi-protocol support.
- Carrier OpEx is proportional to the number of module types that have to be supported.
- A single module type minimizes OpEx by allowing configuration of same module for different services.
- Today, the OpEx of providing 10G client services (Ethernet, SONET or SDH, and OTN) is minimized through use of a single multi-protocol 10G SMF module (ex. XFP) that complies with 10GE, OC-192 or STM-64, and OTU2 standards

Carrier Perspective - Installation & Maintenance

Carrier OpEx is proportional to the number of module types supported

Installation - Single module decreases installation process & time

- **Shipping** - ship module in transponder before order details known, software provision later
- **Bring-up** - single module type for 40G with NRZ modulation, no confusion between 1 and 4 wavelengths
  - No confusion between modules and incompatible formats
- **Configuration** - single module type, can be shipped slotted in transponder and later remotely configured via software only
- **Training** - fewer pieces in the network, vastly reduced training for installation and maintenance staff.

Maintenance - Single module in network leads to less maintenance

- **Shipping** - order modules in bulk and ship pre-slotted in equipment, software configure later
- **Sparing** - single part to spare – note spares required in most locations
- **Training** - single part to train on
- **Multi Protocol Support** - single part supports all needs, customers can be disconnected and new customer can be reconnected without changing hardware or databases
- **Life Cycle Support** - single versus multiple modules to keep track off and keep the components alive

Economic Feasibility

a) Known cost factors, reliable data.
b) Reasonable cost for performance.
c) Consideration of installation costs.

- The cost factors for Ethernet components and systems are well known. The proposed project will reduce cost for carrier applications, enable Ethernet services transition and increase global Ethernet footprint & penetration. For carrier applications a 40G Single Mode Fiber PMD would enable a single module type which minimizes Operating Expense (OpEx) by allowing configuration of the same module for different services. This also provides backwards compatibility with deployed technology in carrier networks.
- For carrier applications the preferred carrier approach would be to utilize a 40G Serial PMD & deploy multi-protocol 40GE/OC-768/STM-256/OTU3 modules to provide the best balance of performance and cost:
  - provide backwards compatibility with deployed technology.
  - minimize OpEx costs due to simplified deployment.
  - leverage combined volumes to achieve lower Capital Expense (CapEx) for serial modules.
- In consideration of installation costs, the project is expected to use the proven and familiar medium of single mode fiber. A 40G Serial PMD would enable a single multi-protocol 40G module for carrier applications – this would simplify and reduce installation cost.
- Network design, installation and maintenance costs are reduced by preserving carrier network architecture, management, and software. A single module reduces cost as there is no need to individually support and maintain multiple modules to cover the required protocols.