Network Architecture

BT100G Coherent IPoDWDM / Alien Wavelength Trial

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Agenda

- **Overview of BT Architecture**
- What is Coherent – quick overview.
- IPoDWDM / Alien Wavelengths - What is it ?
- Potential Benefits of Approach
- Trial Aims and Configuration
- Key Results and Findings
- Challenges (Areas for Further Exploration)
- Acknowledgements

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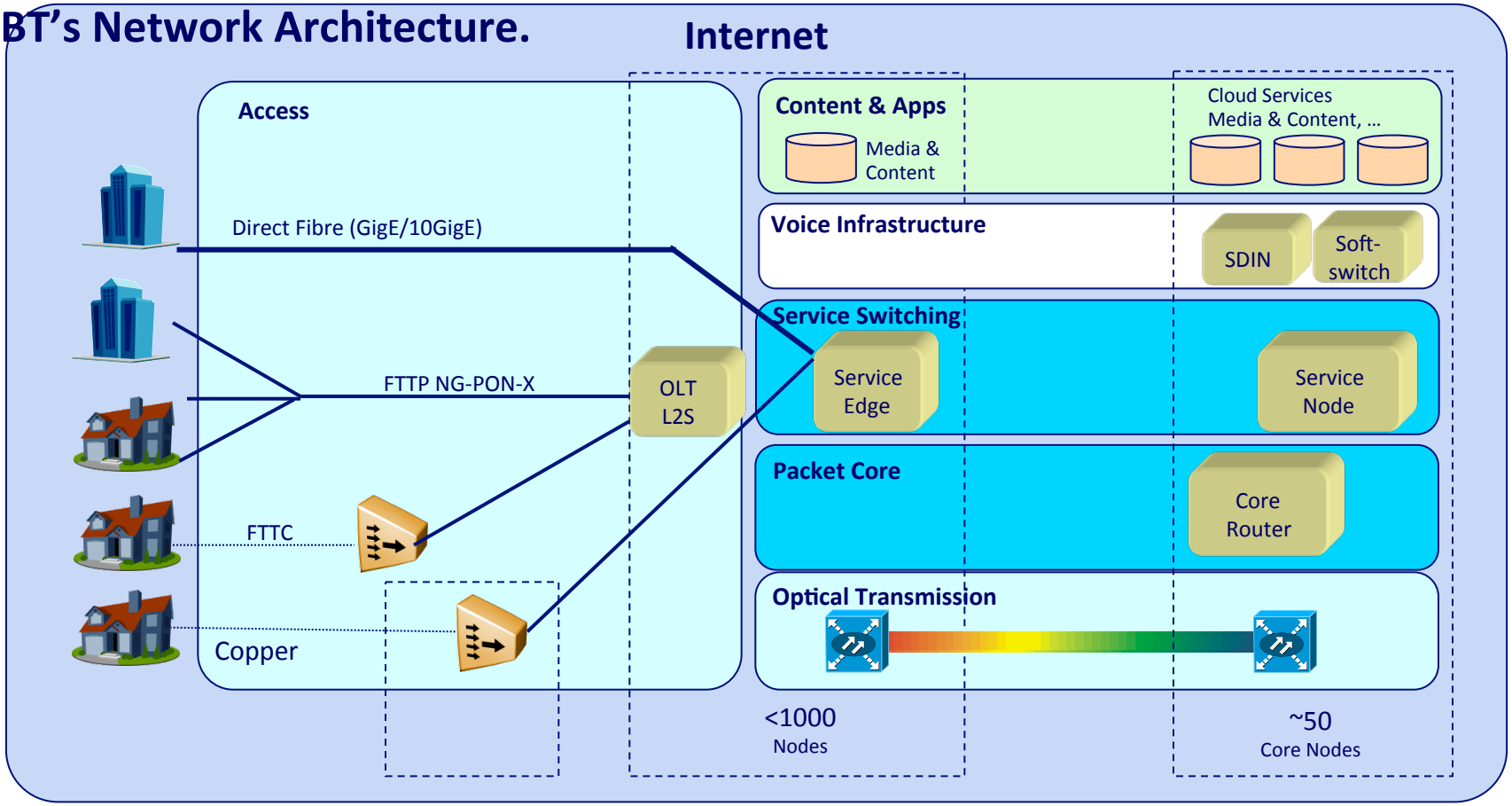
BT's Network Architecture.



Driving Principles

- Simpler network architecture with reduced duplication and avoidance of parallel networks
- Concentrate on strategic platforms reducing cost of operations and new service enablement
- Drive rationalisation of legacy infrastructure based on service led migrations, avoiding replication of old services on new infrastructure
- Technology investment focussed on meeting service/volume demand and unit cost reduction

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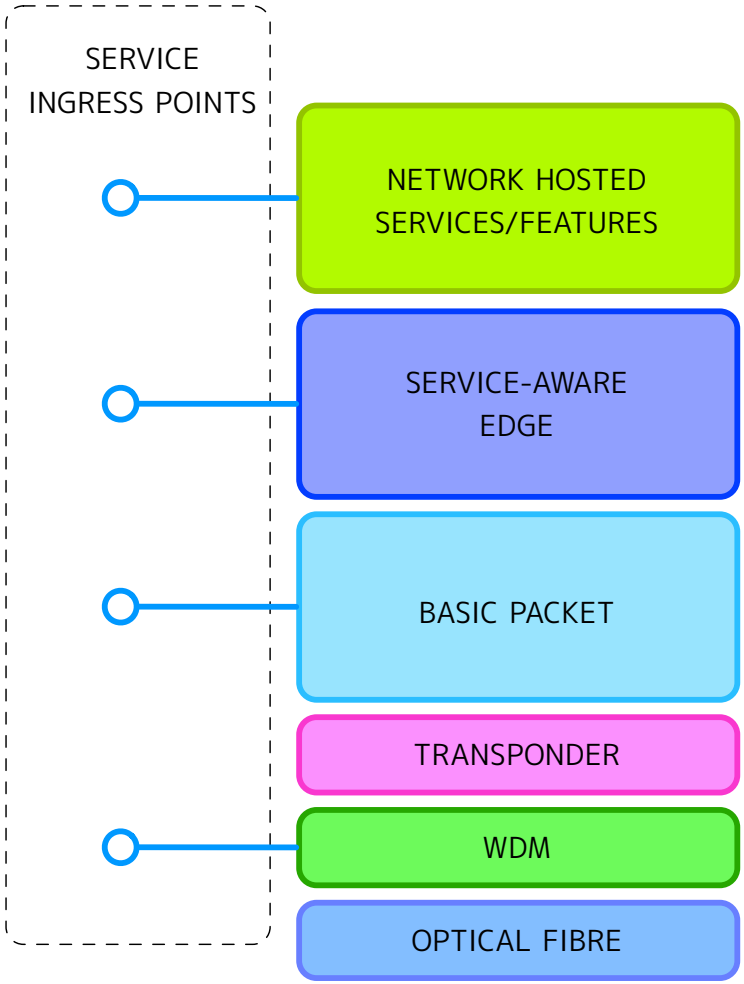
BT's Network Technology Vision.



- Vision for core and service edge functions.
- Foundation on optical transport – using WDM to optimise efficiency of use of this asset.
- Separation of the transponder from being an element of the optical system.
- Single converged packet-based multiplexing layer onto optical capacity.
- Set of edge devices switching on customer/service specific information.
- Higher-layer (L4+) functions provided acting on a subset of packets within a service.

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What is Coherent Technology?

Non-Coherent Systems use Intensity Modulated Direct Detection

Analogous to Morse Code:

Dumb receiver
Power or Amplitude (on/off) carries traffic info (1 bit/symbol))

Coherent System
Receiver works with local oscillator to tune into frequency of interest

Analogous to Digital Radio:

Intelligent receiver with access to amplitude, phase, and polarization information
Practical scaling to 40G, 100G, and beyond

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Why Coherent?

Challenges when moving to higher rates using TDM

Increased design, component complexity & cost

- Components must operate at faster speeds -> Increased system cost
- Limited supply of components -> Yield and Reliability issues

Inferior performance to 10G

- 75% reach lost at 40G, 90% lost at 100G
- Addition of RAMAN amplifiers and/or REGENs required (CAPEX)

Cannot operate over existing optimized network

- Replace some ROADMs with Regens (£££)
- Increased time to revenue

Increased sensitivity to chromatic dispersion

- 16 x worse at 40G, 100 x worse at 100G
- Addition of compensator equipment, amplifiers (£££) and more complex engineering (£££££££)

Increased sensitivity to Polarization Mode Dispersion

- 4 x worse at 40G, 10 x worse at 100G
- Rip and replace bad fiber, addition of compensator equipment (£££), and complex engineering (£££££££)

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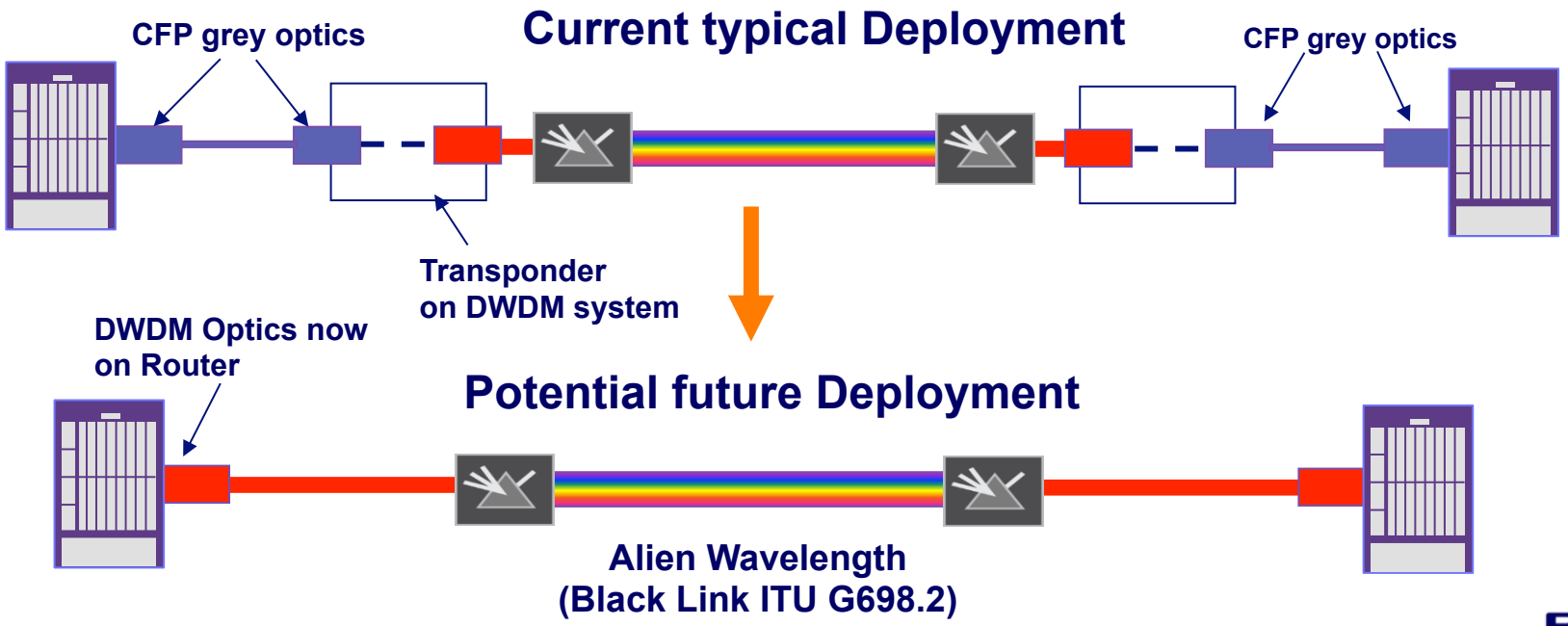
What is it ?

- Two Fundamental Technology Enablers
  - Emerging availability of DWDM interfaces on core router platforms (IPoDWDM interfaces)
    - 100G (and 40G) coherent coloured optics
  - Alien wavelength Transport or Black Link (ITU G698.2)
- A simplified architecture for the Core IP Network



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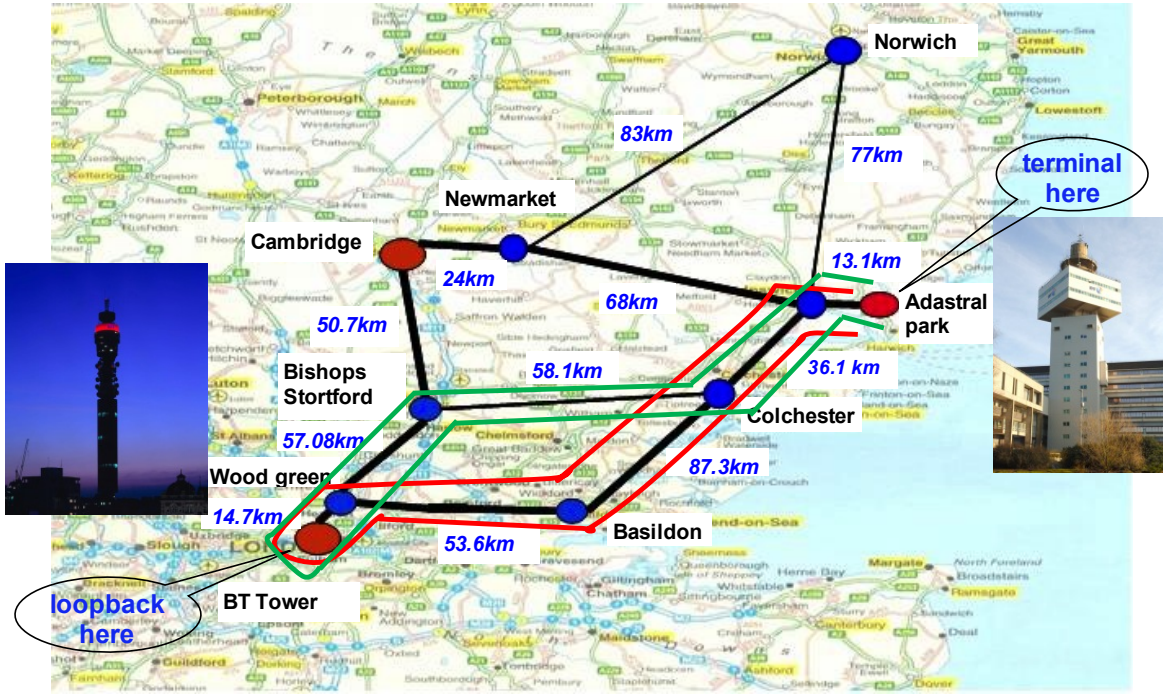
Field Trial DWDM Infrastructure



- WDM terminals located at Adastral Park
- Field fibres: Standard G652 SMF
- In line amplifiers located at intermediate BT exchanges (Colchester, Basildon, Bishops Stortford and BT Tower)

Link 1: Adastral Park – Colchester – Basildon – BT Tower and loop back ➔ 410km, mean link PMD of 14.2ps (Ciena)

Link 2: Adastral Park – Colchester – Bishops Stortford – BT Tower and loop back ➔ 359km, mean link PMD of 1.7ps (Huawei)

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Key Results and Findings

- Successfully demonstrated the feasibility of an IPoDWDM 100G alien wavelength approach over BT's existing DWDM systems (Ciena and Huawei)
- Cisco coherent 100G IPoDWDM optics is 'Transport-grade'
  - Robust performance with good OSNR performance and high dispersion and PMD tolerance
  - Comparable to leading Transport vendors
- Validated Cisco IPoDWDM 100G as an alien wavelength over NG-WDM (410km)
  - Error-free performance
  - Co-propagation with multiple native wavelengths (40G and 100G)
- Successfully demonstrated IPoDWDM alien wavelength over multiple DWDM systems (769km)
  - Stable error-free performance
  - Demonstration of optical router by-pass application
- Network Simplification
  - Space consolidation (removes transponder requirement from DWDM equipment – 3 slots)
  - Power reduction (185W vs. 555W → ~69% reduction)

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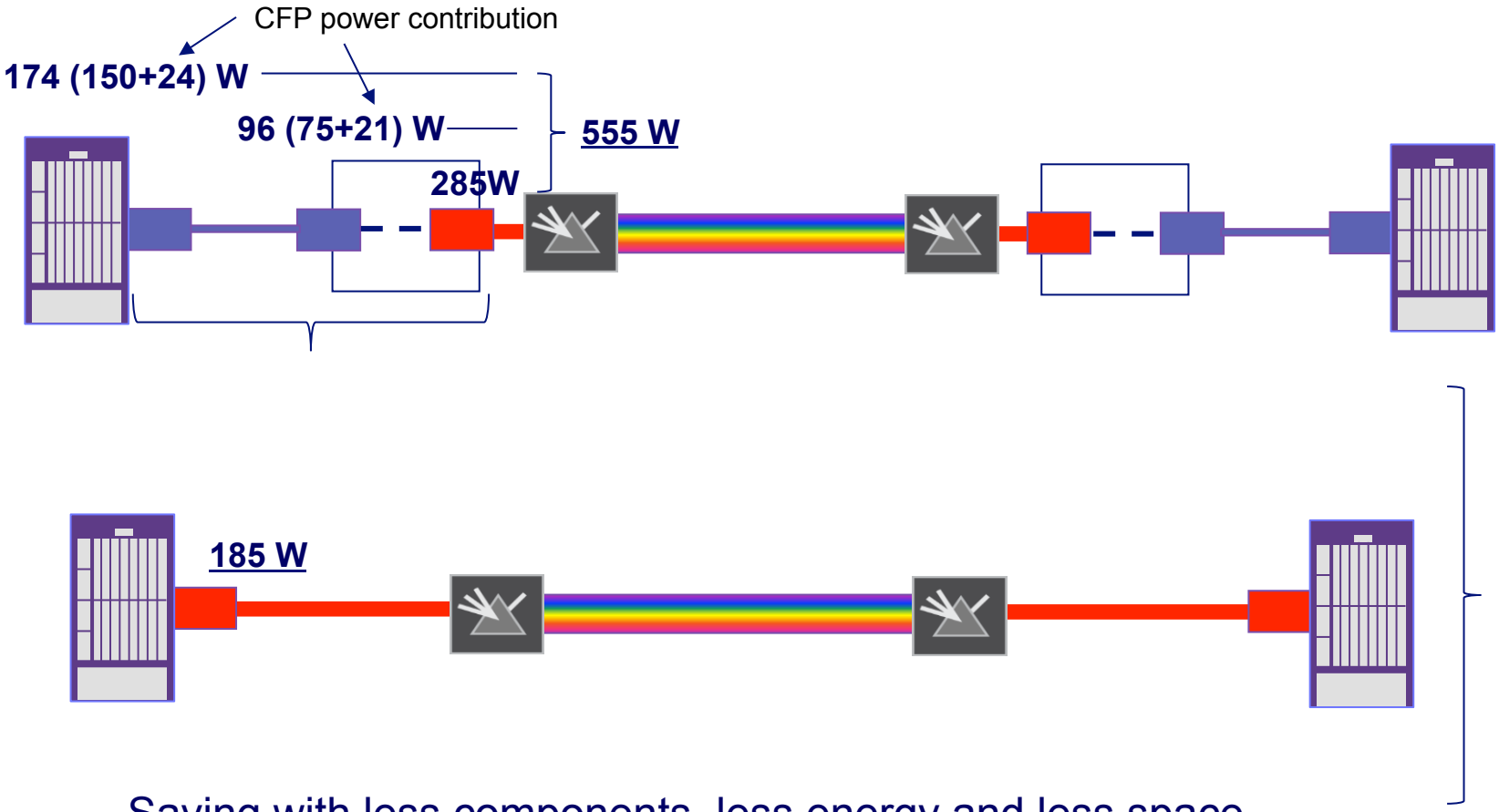
100G IPoDWDM/Alien vs. Grey Comparison



Saving with less components, less energy and less space.

Using LR4 CFP's but even if CFP optics are free, alien approach is still cheapest.
more adoption coming on LR10 and SR10(mm) but even so alien still cheapest.

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Key Challenges (Areas for Further Exploration)

- 100G IPoDWDM Optical Port Density
  - Disparity between electronic processing speeds and optical port density
  - New photonic integration technology (Cisco's acquisition of Lightwire) should begin to address this issue (http://www.lightreading.com/document.asp?doc_id=217915)
  - Alternative approach is to use optical extender shelf
- Management of IPoDWDM and Alien wavelengths
  - Could be implemented 'now' using separate management systems for IP and Transport domains
  - A 'Black Link Framework' for management of IP and alien wavelengths is being defined (IETF / ITU)
    - IETF CCAMP WG Informational Draft (draft-kunze-black-link-management-framework-00) is exploring differing management models which may offer operational advantages
- IPoDWDM means that routers now have visibility of optical performance data
  - E.g. Pre-FEC errors rates give early indication of system degradation
  - Early prevention of faults and improved resilience ?

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PRESS RELEASE: “BT and Cisco Complete Landmark 100G DWDM Trial” – Aug. 2012

To prepare its advanced global telecommunications network for the ongoing growth in Internet-enabled devices, services and applications – global IP traffic has increased eightfold in the last five years, and will increase threefold over the next five years, according to the most recent Cisco® Visual Networking Index Forecast – BT has successfully completed a landmark technology trial with Cisco intended to increase available bandwidth, simplify network operations, reduce capital expenses, and help usher in a new generation of consumer and business services.

BT and Cisco successfully completed an Internet protocol over dense wave division multiplexing (IPoDWDM) trial by integrating coherent 100G optical interfaces with the Cisco CRS-3 Carrier Routing System (CRS-3), the first known trial of its kind, to prepare BT’s BT 21CN network for future growth and services.

With the explosive growth of IP traffic on the network driven by video, mobile and cloud applications, service providers are looking for innovative ways to increase network capacity while increasing network availability and reliability. The trial, completed in the summer of 2012, used Cisco’s CRS-3 core router generating a standards-compliant 100G “alien wavelength” directly into BT’s existing network over a 770 kilometer span consisting of DWDM systems from multiple vendors.

Integrating the DWDM components into the router eliminated the need for a costly external transponder. Furthermore, the use of Cisco’s coherent technology eliminated the need for additional dispersion compensation units and electrical and optical regeneration equipment, providing a path for BT to further reduce capital and operational expenses.

“Using an IPoDWDM and alien wavelength solution whilst leveraging our existing DWDM investment allows BT to scale its 21C Network to a new level. Fulfilling demand for Super Fast Broadband and reducing the unit cost for bandwidth at the same time allows us to invest for the future and is key to BT's strategy. Working with Cisco on this trial has been highly productive in demonstrating the viability of this approach” said Neil McRae, BT’s Chief Network Architect.

IPoDWDM provides service providers with an opportunity to increase operational efficiencies, realize significant cost savings in power and real estate through equipment reduction while deploying an eco-friendly solution that helps reduce the overall network carbon footprint.

“Integrating long-haul transport interfaces such as coherent 100Gb/s IPoDWDM into routers to reduce cost while addressing bandwidth demands on service provider core networks is key step forward for the industry,” said David Ward, vice president and chief technology officer, Cisco Service Provider Networks. “In addition, as service providers increase the capacity of their core networks to 100G and beyond, the CRS-3 ensures continued growth and investment protection with its ability to manage 400 Gbps per slot.”

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Bringing it all together

Thank You

Acknowledgements

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  - Andrew Lord, Dave Johnson, Andrew Hastie, Bob Feuerstein, Rob Shakir, Glenn Whalley, Tony Dann, Andrew Sutton, Dave Noble, Rob Butler, Robert Higlett, Mark Saw, Kenneth Whitter & Dinesh Vasu, **Roger Payne, Yu Rong Zhou, Kevin Smith**
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  - Walid Wakim, John Keens, Lars Hanson & Matteo Pierpaoli
- Ciena

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