Cisco Network Convergence System®
DWDM, OTN and Management Test Report

Introduction

Since OTN has started to take over the helm from SDH and SONET, it has aimed to combine the best of both worlds. To date, OTU specifications have been defined and implemented up to 100 Gbit/s. To relieve the burden of increasing demand for bandwidth, advanced DWDM solutions can be used to multiplex and transport densely grouped pipes of traffic across the fiber. In parallel, higher-bandwidth optical channel technologies are under development.

This report summarizes EANTC's test of Cisco's converged optical network solution from OTN aggregation, Flex Spectrum and CDC-capable DWDM transport to the planning and management platforms.

Test Highlights

- → **Colorless, directionless and contentionless DWDM architecture**
- → **400 Gbit/s transported over Flex Spectrum media channel**
- → **10 milliseconds path protection at the OTN layer**
- → **Multi-layered network planning combines layers 1 and 3**
- → **Interoperable with previous modules on software release 10.5**

DWDM Layer Tests

Test Bed Setup

The test bed consisted of four multi-chassis nodal locations. The sites were connected in a ring topology as shown in Figure 1 on page 2. The fiber links between the four sites spanned 50–200 kilometers using fiber spools. To view and manage network elements, we used the Cisco Transport Controller (CTC). Optical spectrum analysis and traffic generation was performed using JDSU 6000, JDSU 8000 and JDSU ONT-503 test sets.

Tested Devices

The DWDM network setup included different multi-chassis configurations of Cisco's NCS-2000 family. One of the sites combined one NCS-2006 chassis with one NCS-2015 chassis. Another site used four NCS-2006 chassis. The third had two NCS-2006 while the last used a single NCS-2006 chassis. Node-1 and Node-2 were 3-degree nodes interconnected by two fiber pairs.

With brownfield deployment in mind, the Cisco engineers combined the most recent modules (such as the SMR9-FS) with previous models (16WXC-FS) distributed across the different sites. All sites ran Cisco's 10.5 software release.

Colorless, Directionless and Contentionless Properties (CDC)

We tested the non-blocking contentionless property by creating two bidirectional circuits from Node-4 to Node-2 via two different directions (Directions A and B from Node-4 illustrated in Figure 1) using the same wavelength (1530.33 nm). We verified the two circuits by sending traffic and observed no traffic loss.

We asked Cisco how the contentionless property was achieved. Cisco's engineers answered that the NCS-2000 gets its contentionless nature from the 12-AD-FS module that features three 4x4 optical multicast switches. The 4x16 multicast switch module (16-AD-FS) was not part of the setup.

Now that both circuits were running over two separate paths, the Cisco team used CTC to reroute the second circuit from direction B to A. By doing that, we wanted to check how the system will deal with routing the lambda over a path that already had the same lambda configured. The system automatically detected this limitation and switched the lambda to another lambda then rerouted the circuit successfully. Traffic was fully restored after 157 seconds.

By running this sequence of events, we verified the directionless and colorless properties of the solution as well as the manual reroute triggering capability.

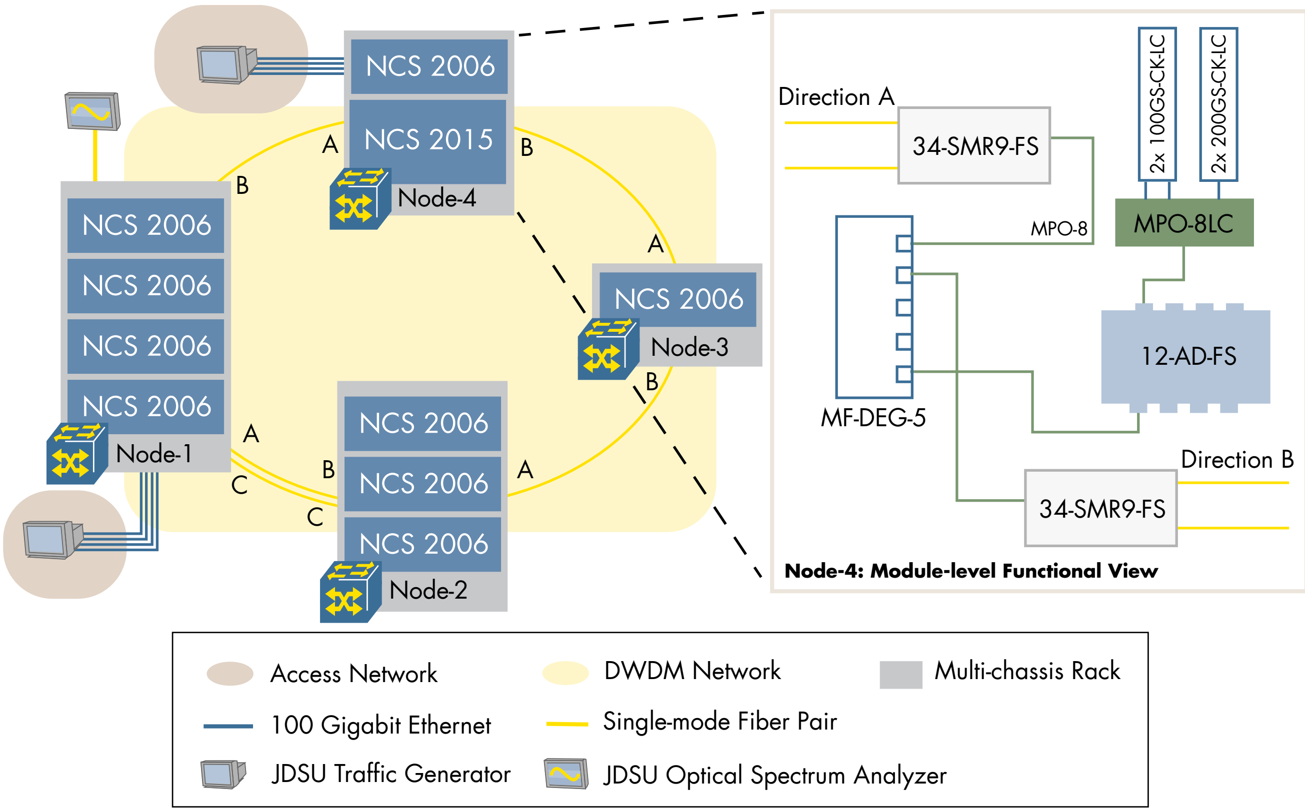

Figure 1: DWDM Network Topology

Automatic Restoration

Using the CTC tool, we created a circuit from Node-4 to Node-2. Then using the GUI, we limited the possible paths that the circuit can take to pass via Node-1. We then disconnected one of the two fibers connecting (Node-1 to Node-2), triggering an automatic restoration. The system automatically restored the circuit over a second link connecting Node-1 and Node-2 (Direction C) and avoided routing the circuit over Node-3 as we instructed it to do. The full traffic restoration process took 123 seconds.

Flex Spectrum

When the DWDM technology was developed, the ITU-T provided a grid that defines wavelength ranges. However, with Flex Spectrum, wavelength selection can be performed in software. In our setup, Cisco explained that the media channel can be defined in multiplications of 12.5 GHz. This should allow better utilization of the optical spectrum.

To test the flex spectrum capability of the solution, Cisco engineers reserved one 87.5 GHz media channel between Node-1 and Node-4 using Translation Language 1 (TL1). Over that media channel, Cisco sent two 200 Gbit/s channels sized at 32.17 GHz each and spaced with 6 GHz.

To send 400 Gbit/s of traffic over the resulting superchannel, Cisco mapped four 100GE ports into two 200 Gbit/s 16QAM carriers. On the client side, two 200G-CK-LC modules coupled with two MR-MXP modules were used.

To generate the traffic, we used three JDSU test sets; JDSU 8000, 6000 and ONT503. Each of the test sets generated one 100 Gbit/s stream. The traffic frame size was a mixture of fixed 256 Bytes, fixed 1518 Bytes and random IMIX split over the three test sets. To achieve our throughput target of 400 Gbit/s, we looped back the traffic from one of the test sets. We started sending the traffic and left the setup overnight for a little over 14 hours. No transmission errors or traffic loss were observed. Latency was around 1ms over the approximate distance of 200 kilometers between the two nodes.

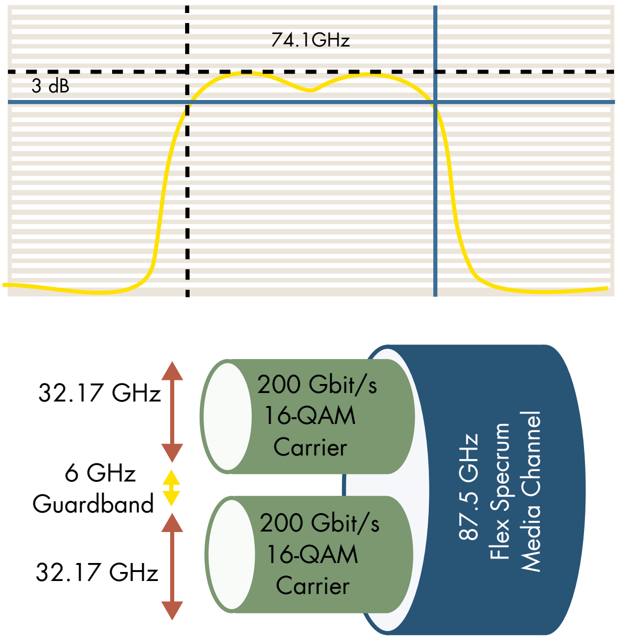

Figure 2: Flex Spectrum Configuration and Optical Spectrum Analysis

Backward-Compatibility and Interoperability

DWDM technology has been deployed by many service providers. Therefore, our setup intended to include multiple existing Cisco DWDM modules. The setup displayed in Figure 1 contained the RAMAN CTP, EDFA 17 and EDFA 24. It also included 100G and 200G cards, 16-WXC, plugables, controllers (TNC and TNCE), 4x4 COFS, MPO-8 and DEG-5 passive units. These units were combined with more recent "10.5 release" units like the FS-SMR, 12-AD-FS and MPO-16 passive unit.

To further verify client modules backward compatibility, we tested one 10x10G card paired with a 100G card as well as one OTU2-XP card. We emulated 1x 10 GE and 1x STM-16 client traffic using JDSU-5800 tester and kept the traffic running for 15 hours. No traffic loss or transmission errors were observed. All tests were performed running Cisco's 10.5 software release.

OTN Layer Tests

Test Bed Setup

Our test bed consisted of two NCS 4009 and two NCS 4016 in a mesh topology, shown in Figure 3. The access network was emulated using one JDSU-6000 traffic generator. The test traffic consisted of one 10 Gbit/s IMIX L2 traffic stream.

OTN Protection and Restoration

Using CTC, we created one 10GE (wrapped in ODU2) between Node-1 and Node-3 going through the direct link. We protected the circuit via another path that we instructed to strictly go through Node-2. We generated 10 Gbit/s traffic between both ends and no traffic loss or errors were observed.

To test circuit protection, we disconnected the direct link between Node-1 and Node-3. The circuit fell back to the back up path through Node-2 as expected. Traffic interruption duration in both directions was under ten milliseconds.

We used the same setup to test circuit automatic restoration. We created another circuit between Node-1 and Node-3 passing through the direct link between both nodes. However, this time round, we protected the circuit using 1+R restoration mechanism and allowed the system to choose the best alternative path upon failure. Subsequently, we disconnected the direct link between Node-1 and Node-3 and waited as the system found an alternative path. The circuit was restored in 800 ms.

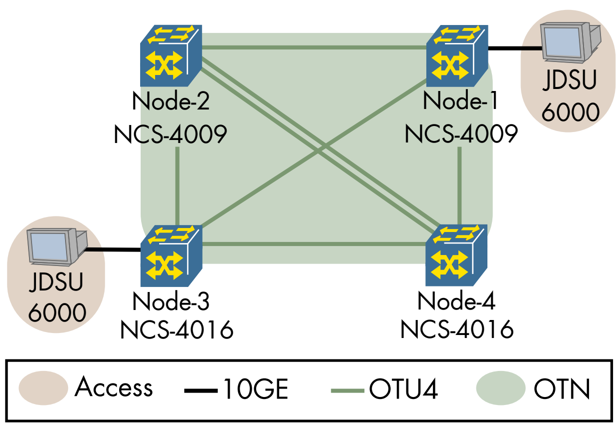

Figure 3: OTN Network Setup

In conjunction with the recovery tests, Cisco configured an option to revert back traffic to the original path 5 minutes after the original path is restored. We reconnected the link to the direct path between Node-1 and Node-3 and as expected the circuit was reverted to the original path after 5 minutes. Traffic loss period was 2.9 milliseconds.

Management and Planning Layer

Cisco MATE Demonstration

MATE is a centralized controller that provides a holistic and detailed view of the network on multiple layers. This demonstration intended to showcase how MATE adds the DWDM layer into the network planning perspective.

In this demonstration, Cisco used a third setup which consisted of two CRS routers (head-end and a tail-end) connected via six partially meshed DWDM nodes. OSPF adjacency was configured between both CRS routers. We started by creating two circuits between the nodes connected to the CRS routers. MATE generated the configuration code and prompted us if we wanted to push the configuration to the nodes automatically which is what we did. When MATE completed the circuit creation process, we verified the OSPF adjacency table on both CRS routers and saw the IP address of the peer on the other side.

Cisco team then demonstrated how to create two diverse path circuits protecting layer 3 traffic. We performed a fiber cut between the two nodes causing a path failure. The GMPLS restoration was triggered recovering the layer 3 OSPF adjacency.

We then asked the Cisco engineers to create two circuits over a single path and force both circuits to use the same lambda. Automatic lambda reversion was disabled. As expected, MATE alerted us that the path will be down due to that.

Cisco EPN Manager Test

Cisco introduced the EPN Manager (or EPN-M) as a web-based tool that combines the configuration and monitoring of packet and optical network elements in a single intuitive tool. Used in the optical network space, Cisco explained that while EPN-M shares many of its DNA with CTC, it is targeted at large optical networks.

We used EPN-M to replicate a selection of tests that we performed using CTC, such as circuit creation and deletion. We were able to verify the success of both operations by sending and monitoring traffic over the created circuits.

We also used EPN-M to manage software inventory and upgrade and downgrade the software release on a NCS-2002 device. The tool gave us the option to download only, or to download and activate the new software release. In order to put the feature through its paces, we tried to download the same software version that was originally loaded on the NCS-2002 device. The tool detected the abnormal request and rejected the software download operation. We then used a different software release and successfully downloaded and activated it on the NCS-2002.

The EPN-M was also used by us to backup the configuration of NCS-4016. The tool can also compare two configurations and highlight the differences, in case the user wants to know what has changed since the last backup. Cisco explained that EPN-M can be used to backup NCS-2000 family devices too, but the configuration comparison would not be possible due to the binary nature of the configuration file.

Summary

The results of our tests demonstrate that Cisco NCS provides a highly resilient, backward-compatible, and high-capacity optical transport solution. We verified that the system is supported by multiple Cisco management tools and uses the latest optical technologies such as CDC and Flex Spectrum.

About EANTC

The European Advanced Networking Test Center (EANTC) offers vendor-neutral network test services for manufacturers, service providers and enterprise customers. Primary business areas include interoperability, conformance and performance testing for IP, MPLS, Mobile Backhaul, VoIP, Carrier Ethernet, Triple Play, and IP applications.

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