TCX Series Optical Transport System Feature Guide

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The information in this document is current as of the date on the title page.

YEAR 2000 NOTICE

Juniper Networks hardware and software products are Year 2000 compliant. Junos OS has no known time-related limitations through the year 2038. However, the NTP application is known to have some difficulty in the year 2036.

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About the Documentation

Documentation and Release Notes

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Documentation Conventions

Table 1 on page xvi defines notice icons used in this guide.

Table 1: Notice Icons

Icon	Meaning	Description
	Informational note	Indicates important features or instructions.
	Caution	Indicates a situation that might result in loss of data or hardware damage.
	Warning	Alerts you to the risk of personal injury or death.
	Laser warning	Alerts you to the risk of personal injury from a laser.
	Tip	Indicates helpful information.
	Best practice	Alerts you to a recommended use or implementation.

Table 2 on page xvi defines the text and syntax conventions used in this guide.

Table 2: Text and Syntax Conventions

Convention	Description	Examples
Bold text like this	Represents text that you type.	To enter configuration mode, type the **configure** command: user@host> **configure**
`Fixed-width text like this`	Represents output that appears on the terminal screen.	`user@host>` **show chassis alarms** `No alarms currently active`
Italic text like this	• Introduces or emphasizes important new terms. • Identifies guide names. • Identifies RFC and Internet draft titles.	• A policy *term* is a named structure that defines match conditions and actions. • *Junos OS CLI User Guide* • RFC 1997, *BGP Communities Attribute*
Italic text like this	Represents variables (options for which you substitute a value) in commands or configuration statements.	Configure the machine's domain name: [edit] root@# **set system domain-name** *domain-name*

Table 2: Text and Syntax Conventions (continued)

Convention	Description	Examples
Text like this	Represents names of configuration statements, commands, files, and directories; configuration hierarchy levels; or labels on routing platform components.	• To configure a stub area, include the **stub** statement at the **[edit protocols ospf area area-id]** hierarchy level. • The console port is labeled **CONSOLE**.
< > (angle brackets)	Encloses optional keywords or variables.	**stub <default-metric *metric*>;**
| (pipe symbol)	Indicates a choice between the mutually exclusive keywords or variables on either side of the symbol. The set of choices is often enclosed in parentheses for clarity.	**broadcast | multicast** **(*string1* | *string2* | *string3*)**
# (pound sign)	Indicates a comment specified on the same line as the configuration statement to which it applies.	**rsvp { # Required for dynamic MPLS only**
[ ] (square brackets)	Encloses a variable for which you can substitute one or more values.	**community name members [*community-ids*]**

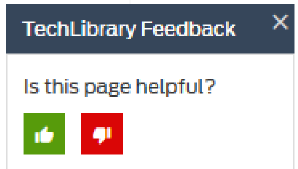
Indention and braces ({ })	Identifies a level in the configuration hierarchy.	[edit]
		routing-options {
		  static {
		    route default {
		      nexthop *address*;
		      retain;
		    }
		  }
		}

; (semicolon)	Identifies a leaf statement at a configuration hierarchy level.	
GUI Conventions		
Bold text like this	Represents graphical user interface (GUI) items you click or select.	• In the Logical Interfaces box, select **All Interfaces**. • To cancel the configuration, click **Cancel**.
> (bold right angle bracket)	Separates levels in a hierarchy of menu selections.	In the configuration editor hierarchy, select **Protocols>Ospf**.

Documentation Feedback

We encourage you to provide feedback so that we can improve our documentation. You can use either of the following methods:

- Online feedback system—Click TechLibrary Feedback, on the lower right of any page on the Juniper Networks TechLibrary site, and do one of the following:



  - Click the thumbs-up icon if the information on the page was helpful to you.
  - Click the thumbs-down icon if the information on the page was not helpful to you or if you have suggestions for improvement, and use the pop-up form to provide feedback.

- E-mail—Send your comments to techpubs-comments@juniper.net. Include the document or topic name, URL or page number, and software version (if applicable).

Requesting Technical Support

Technical product support is available through the Juniper Networks Technical Assistance Center (JTAC). If you are a customer with an active J-Care or Partner Support Service support contract, or are covered under warranty, and need post-sales technical support, you can access our tools and resources online or open a case with JTAC.

- JTAC policies—For a complete understanding of our JTAC procedures and policies, review the *JTAC User Guide* located at https://www.juniper.net/us/en/local/pdf/resource-guides/7100059-en.pdf.
- Product warranties—For product warranty information, visit https://www.juniper.net/support/warranty/.
- JTAC hours of operation—The JTAC centers have resources available 24 hours a day, 7 days a week, 365 days a year.

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For quick and easy problem resolution, Juniper Networks has designed an online self-service portal called the Customer Support Center (CSC) that provides you with the following features:

- Find CSC offerings: https://www.juniper.net/customers/support/
- Search for known bugs: https://prsearch.juniper.net/
- Find product documentation: https://www.juniper.net/documentation/
- Find solutions and answer questions using our Knowledge Base: https://kb.juniper.net/
- Download the latest versions of software and review release notes: https://www.juniper.net/customers/csc/software/
- Search technical bulletins for relevant hardware and software notifications: https://kb.juniper.net/InfoCenter/

- Join and participate in the Juniper Networks Community Forum: https://www.juniper.net/company/communities/
- Create a service request online: https://myjuniper.juniper.net

To verify service entitlement by product serial number, use our Serial Number Entitlement (SNE) Tool: https://entitlementsearch.juniper.net/entitlementsearch/

Creating a Service Request with JTAC

You can create a service request with JTAC on the Web or by telephone.

- Visit https://myjuniper.juniper.net.
- Call 1-888-314-JTAC (1-888-314-5822 toll-free in the USA, Canada, and Mexico).

For international or direct-dial options in countries without toll-free numbers, see https://support.juniper.net/support/requesting-support/.

CHAPTER 1

Getting Started

About the TCX1000 Series Optical Transport System

This topic introduces you to the TCX1000 Optical Transport System and all of the products in the portfolio.

TCX1000 Optical Transport System Portfolio

The TCX1000 Optical Transport System is a portfolio of products that provide the foundation of a comprehensive, open, and programmable optical transport network. The TCX1000 Series enables service providers, cloud providers, enterprises, and other high capacity network providers to handle the demand of the immense traffic growth on their networks driven by cloud services including, mobile traffic, and high definition entertainment services. These demands are being seen at every part of the network including the Access, Metro and Core. These ultra high capacity networks require a new generation of coherent optimized, highly flexible and open dense wavelength division multiplexed (DWDM) line systems. Photonics is the ultimate enabler of capacity on fiber, which is the medium of choice in high capacity networks.

TCX1000 Programmable ROADM

At the foundation of the TCX1000 Optical Transport System is the TCX1000 Programmable ROADM, a standalone, 20-port advanced reconfigurable add-drop multiplexer (ROADM). You can use the TCX1000 Programmable ROADM, also called the TCX1000-RDM20, to form up to a 20-degree ROADM node and it scales to 19.2 Tbps when used with 96 x 200 Gbps coherent channels. The TCX1000-RDM20 has an integrated high power variable gain amplifier for line amplification and supports both total power monitoring and channel power monitoring.

TCX1000-2D8CMD

The TCX1000-2D8CMD is a colorless, two-directional optical multiplexer-demultiplexer that provides eight colorless client ports and two line ports. You can use the TCX1000-2D8CMD to add and drop up to eight colorless channels to and from a single universal port on a TCX1000-RDM20. In addition, connecting the line ports on the TCX1000-2D8CMD to two separate TCX1000-RDM20s in a multi-degree node, enables you to provide 1 + 1 redundancy for the channels on the TCX1000-2D8CMD. You can control which channels are switched to which direction through the proNX Optical Director. The TCX1000-2D8CMD module is a fully passive optical module, with no power, that is packaged in a standard LGX cassette.

TCX1000 Inline Amplifier

The TCX1000 Inline Amplifier or TCX1000-ILA is a standalone erbium-doped fiber (EDFA) amplifier that supports dual optical inline amplification — two functionally separate amplifiers. The TCX1000-ILA provides periodic optical amplification of a dense wavelength-division multiplexing (DWDM) signal to enable long-distance transmission as it propagates along the fiber-optic cable. You can use the TCX1000-ILA in all TCX1000-RDM20 network configurations described in this guide.

proNX Optical Director

The proNX Optical Director control and management software is disaggregated from the optical hardware and executed by a centralized server cluster in a high availability DCN connected environment. The proNX Optical Director abstracts the optical control layer from the TCX1000 Series hardware and creates a disaggregated programmable optical layer for the TCX1000 Series hardware.

Disaggregation of the software management and optical controls from the underlying hardware provides multiple benefits to the network operators including flexible deployment, scalability, enhanced automation, best-of-breed hardware support and multi-layer optimization.

It is the combination of the TCX1000 Series hardware and proNX Optical Director control and management software that provide the full TCX1000 Optical Transport System solution.

Combining TCX1000 Series products with the integrated coherent optics within Juniper Networks routing and switching platforms enables a powerful and comprehensive end-to-end packet-optical solution. The proNX Optical Director can manage and control the TCX1000 Series devices in your optical network, as well as optical interfaces in Juniper Networks routers and switches and BTI7800-FM96.

The proNX Optical Director controls and manages the optical control layer for all TCX1000 managed devices as well as the compatible optical interfaces in your Juniper Networks routers and switches.

If you are using the Juniper Networks BTI7800 platform, the proNX Optical Director can control and manage the optical control layers on the Universal Forwarding Modules (UFM3 and UFM6) and the 96-port optical multiplexer-demultiplexer (FMD96).

Related Documentation

- TCX1000-RDM20 Overview on page 31
- TCX1000-RDM20 Features on page 32
- TCX1000-2D8CMD Colorless Multiplexer-Demultiplexer Overview on page 36
- TCX1000-ILA Inline Amplifier Overview on page 40

Understanding TCX Series Terminology

To understand the TCX Series ring, mesh, and linear multi-hop capabilities, you need to understand certain terms. Throughout this document we use the following reconfigurable optical add drop multiplexer (ROADM) terms:

- *ROADM Element* — A ROADM element is a TCX Series device that provides a designated function as a constituent part of a ROADM node. This function can include switching channels to or from another ROADM degree using a pass-through connection or adding/dropping physically connected channels onto the associated ROADM degree's fiber span. Examples of ROADM elements are the TCX1000-RDM20 or a combination of the TCX1000-RDM20 and a compatible multiplexer such as the TCX1000-2D8CMD or the BTI7800-FMD96. A ROADM node is built from a number of ROADM elements. The TCX1000-ILA is both a network element and a node.
- *ROADM Degree* — ROADM degrees are groups of elements that are specifically and exclusively assigned to a given network line direction. The term ROADM degree can also be used to simply describe the TCX1000-RDM20 element.
- *ROADM Node* — A ROADM node is a configuration of ROADM elements that together provide a specific role in an optical network. A ROADM node is conceptual only, and exists purely to convey the type of role that the constituent ROADM elements provide. Examples of ROADM nodes are single-degree terminal nodes and multi-degree add/drop nodes.

In addition the following packet optical ROADM node characteristics and terms appear throughout this document:

- *Colorless* — The colorless property of a ROADM node is the ability of the ROADM node to have a multiplex port in which the channel center frequency (or wavelength: they are the same thing) is initially unassigned. This flexibility can be achieved with a broadband multiplexer or a programmable/tunable multiplexer, for example the TCX1000-RDM20. The operational center frequency of the port is determined through provisioning.

  The important points are that colorless is a property of the multiplexer (universal) ports, not the line ports, and that the center wavelengths used on the multiplexer port channels must be provisioned. That is, the multiplexer port is colorless until a wavelength (or wavelengths) are assigned to that port.
- *Directionless* — The directionless property is not something that a single ROADM degree, such as a standalone TCX1000-RDM20, can have. There is only one direction (or destination) for the line port on a single ROADM degree. The universal port traffic on the TCX1000-RDM20 can only go in one line direction.

The directionless property is a characteristic of the ROADM node rather than each individual degree.

In multi-degree ROADM node configurations, directionless refers to the ability of the ROADM node to have a multiplexer port that is initially unassigned to a line port direction. Obviously, it would take at least two line ports to offer any choice of line direction, but the choices are not limited to two as long as there are multiple degrees to the ROADM node.

In its simplest form, a directionless configuration consists of two ROADM elements connected to each other and to an add/drop device in common.

In summary, directionless operation is a characteristic of the ROADM node and not the individual element. Directionless operation can be achieved with a direction-switchable or broadcast multiplexer, such as the TCX1000-2D8CMD, where the line port direction used is determined through provisioning.

- *Contentionless* — Contentionless operation refers to the ability to reuse wavelengths within a directionless ROADM node.

  In a directionless but non-contentionless architecture, after a wavelength is configured on a multiplexer port (to go in one line direction), the same wavelength cannot be configured on another multiplexer port of the same multiplexer (even if going in a different line direction). This is a blocking architecture.

  In a directionless and contentionless architecture, the same wavelength can be reused on different multiplexer ports of the same multiplexer as long as the wavelength on one port uses a different line direction from the wavelength on the other port.

  This is a non-blocking architecture.

  If the multiplexer element is designed to provide a fully non-blocking solution, then the solution is contentionless (as well as directionless).

- *Flex Grid* — In flex grid operation, not only is the channel center frequency or wavelength provisionable for the multiplexer port, but the channel width is provisionable as well. This capability is important because the channel width can now be optimized to match the spectral width of the channel. For example, a 32 Gbps Baud channel, previously operated in a 50 GHz window aligned with a 50 GHz-spaced grid, can now operate in a 37.5 GHz window, and a 64 Gbps Baud channel can be accommodated with the provisioned 75 GHz channel width.

  As with colorless operation, this flexibility can be achieved with a broadband multiplexer or a programmable/tunable multiplexer. The operational width and center frequency of the port is determined through provisioning.

  The important point here is that flex grid ports are all colorless, but all colorless ports are not necessarily flex grid ports.

  NOTE: The hardware of the TCX1000-RDM20 is flex grid ready. However the proNX Optical Director does not yet support the ability to configure the channel width.

Related Documentation

- About the TCX1000 Series Optical Transport System on page 21
- TCX1000-RDM20 Overview on page 31
- TCX1000-RDM20 Features on page 32

CHAPTER 2

Safety

Optical Precautions

NOTE: Refer to the TCX1000 Programmable ROADM Quick Start Guide for your initial configuration of the TCX1000 Programmable ROADM and the TCX1000 Programmable ROADM Hardware Guide whenever you work with the TCX1000 Programmable ROADM hardware.

In general, use the following precautions when working with the TCX Series devices:

- Handle glass fiber with care. Glass fiber can be broken if mishandled.
- Protect skin from exposed glass fiber. It can penetrate the skin.
- The TCX Series equipment should be used in a controlled access area. Limit the number of personnel who have access to the optical transmission systems. Personnel should be properly trained on laser safety and authorized, if access to laser emissions is required.
- Limit the use of laser test equipment to authorized, trained personnel during installation and service. This precaution includes using optical loss test (OLT) set, optical spectrum analyzer (OSA), and optical time domain reflectometer (OTDR) equipment.
- Exclude any unauthorized personnel from the immediate laser radiation area during service and installation when there is a possibility that the system might become energized. Consider the immediate service area to be a temporary laser-controlled area.
- The TCX Series system functions in the 850 nm to 1620 nm wavelength window that is considered invisible radiation. Laser light being emitted by a fiber, a pigtail, or a bulkhead connector cannot be seen by the naked eye. Use appropriate eye protection during fiber-optic system installation or maintenance whenever there is potential for laser radiation exposure, as recommended by the company's health and safety procedures. Observe this precaution whether or not warning labels have been posted.

- During installation or service, a broken optical fiber or non-terminated connector should only be viewed with an indirect image converter or with a filtered optical instrument of optical density sufficient to reduce the exposure levels below the appropriate maximum permissible exposure, unless it has been verified that all optical transmitters are turned off and will remain off during the installation or service operation.
- During all splicing operations that require viewing the end of a fiber of an SG3a, SG3b or SG4 optical-fiber communication systems, the laser source on the fiber involved shall be de-energized or viewing the systems incorporating personal protection shall be employed. A responsible person(s) shall verify that the system is de-energized before splicing proceeds. Where applicable, ensure compliance with lockout/tagout requirements of OSHA Standard 29 CFR Part 1910.147.

Related Documentation

- About the TCX1000 Series Optical Transport System on page 21
- TCX1000-RDM20 Overview on page 31
- TCX1000 Programmable ROADM Quick Start Guide
- TCX1000 Programmable ROADM Hardware Guide

TCX1000 Automatic Laser Shutdown

This topic describes how the automatic laser shutdown safety mechanisms work on TCX1000 devices.

TCX1000 Automatic Laser Shutdown Overview

Due to the potential safety hazard that is posed by the high power optical outputs, the TCX1000-RDM20 and TCX1000-ILA have an automatic laser shutdown (ALS) mechanism that guards against the risk of direct human exposure to high-powered lasers.

ALS applies only to **Line Out** port connections between adjacent TCX1000 devices. The ALS mechanism acts to detect a fiber disconnection or fiber cuts along the span, and upon doing so, causes the shutdown of the high-powered WDM composite signal.

This topic discusses the automatic laser shutdown (ALS) mechanisms on the TCX1000-RDM20 and TCX1000-ILA.

NOTE: The ALS mechanisms discussed here apply to the **Line Out** ports on interconnected TCX1000 devices including:

- TCX1000-RDM20 to TCX1000-RDM20
- TCX1000-RDM20 to TCX1000-ILA
- TCX1000-ILA to TCX1000-ILA

Automatic Line Shutoff

Automatic line shutoff is one of the main safety mechanisms on TCX1000-RDM20 and TCX1000-ILA. Automatic line shutoff is implemented on the **Line Out** ports of the TCX1000-RDM20 and TCX1000-ILA. Automatic line shutoff identifies fiber breaks or disconnects between two interconnected TCX1000 device **Line Out** ports.

Table 3 on page 29 describes the automatic line shutoff logic for the TCX1000-RDM20 and the TCX1000-ILA:

Table 3: Automatic Line Shutoff Logic for TCX1000-RDM20 and TCX1000-ILA

Automatic line shutoff	Conditions	Notes
Enabled	When: Line In LOS is true + OSC link state is down	If this condition is true, on the TCX1000-RDM20, the line output power on the TCX1000-RDM20 is automatically disabled. If this condition is true, on either **Line In** port on the TCX1000-ILA, the line output power is automatically disabled on both **Line Out** ports.
Disabled	When: Line In LOS is false *or* OSC link state is up and **OSC In** LOS is false	Line output power on the TCX1000-RDM20 or TCX1000-ILA is normal under this condition.

TCX1000-RDM20 Automatic Power Reduction

On the TCX1000-RDM20, automatic power reduction (APR) of the booster is triggered if the reported output return loss (ORL) is less than 17 dB. Normal operation resumes when the ORL exceeds 20 dB. APR limits output power to +3 dBm regardless of current provisioned settings and input power. It does not prevent operating at lower output powers. The primary intent of APR is to reduce output power to eye safe levels in the event the **Line Out** fiber is disconnected.

APR engagement occurs in less than 500 ms after disconnection of the **Line Out** fiber.

TCX1000-ILA Automatic Power Reduction

On the TCX1000-ILA, automatic power reduction (APR) reduces the output power level on open line out (**Line A Out** and Line B Out) ports to a safe eye level. If either line output port on the TCX1000-ILA is open or becomes disconnected, the output power of the port is attenuated by 2 dB to bring it to safe level, if it is not already at safe level.

NOTE: Automatic power reduction (APR) is implemented on both line output ports of the TCX1000-ILA — **Line A Out** and **Line B Out**.

The TCX1000-ILA APR mechanism monitors the back-reflection ratio (OBR) of each line output port and uses it as a gauge. If the back-reflection ratio goes above -17 dB (indicative of a fiber cut) on either output port, *and* the total output power is higher than 19 dBm, the amplifier enters the APR state and an APR alarm (“EDFAABRFL” or “EDFABARFL”) is raised. The amplifier stays in APR state until the back-reflection ratio goes below -19 dB, at which point the target output signal power is restored and the APR alarm is cleared.

APR engagement occurs in less than 40 ms after disconnection of either line port fiber.

TCX1000-RDM20 Output Power Clamp

Preamplifier output power is clamped to a maximum power to ensure that the output is below Class 1M limits even if the full C-band is routed out a single **Ux Out** port with minimum insertion loss. This apply to the universal ports on the TCX1000-RDM20. You cannot disable or adjust this clamp.

Related Documentation

- Optical Precautions on page 27
- TCX1000-RDM20 Optical Monitoring Points on page 36
- TCX1000-RDM20 Overview on page 31

CHAPTER 3

TCX1000 Series Product Overviews

TCX1000-RDM20 Overview

At the center of the TCX Series portfolio is the TCX1000 Programmable ROADM or TCX1000-RDM20, which works along side the TCX1000-2D8CMD optical multiplexer and the TCX1000-ILA inline amplifier to form the foundation of an open, programmable, optical transport network. The TCX1000-RDM20 is also compatible with many of the optical interfaces in Juniper Networks routers and switches enabling you to form a complete end-to-end packet optical solution.

To complete that solution, the proNX Optical Director provides control and management of the optical layer on TCX1000 devices and optical interfaces in compatible Juniper Networks routers and switches.

The TCX1000-RDM20 is a standalone, 20-port, reconfigurable optical add-drop multiplexer (ROADM) that provides all features of a route and select ROADM degree in a compact, disaggregated, stackable, form factor. You can deploy the TCX1000-RDM20 in point to-point, ring, mesh and linear multi-span optical network configurations. You can configure multiple TCX1000-RDM20s in a single node to create a simple 2-degree ROADM and scaling up to a 20-degree ultra high-capacity multi-directional ROADM node in which traffic can be switched from any line direction to another. The TCX1000-RDM20 can provide this ultra-high capacity switching in the metro and between data centers, enabling you to dynamically add/drop channels onto your optical network through the proNX Optical Director in any direction.

The TCX1000-RDM20 scales to 19.2 Tbps on its line when used with 96 x 200 Gbps coherent channels. It is bit rate transparent and therefore agnostic to framing and modulation formats and enables scalable, agile and automated networks.

The TCX1000-RDM20 supports an extended C-band spectrum from 191.325 to 196.125 THz (1528.578 nm to 1566.928 nm) which is consistent with 96 channel operation (196.1 to 191.35 THz channel centers) on a 50 GHz ITU channel grid.

Combining the TCX1000-RDM20 with integrated coherent optics within Juniper Networks routing and switching platforms provides a powerful and comprehensive end-to-end packet-optical solution.

Related Documentation

- TCX1000-RDM20 Features on page 32
- TCX1000-RDM20 Optical Monitoring Points on page 36
- TCX1000-2D8CMD Colorless Multiplexer-Demultiplexer Overview on page 36

TCX1000-RDM20 Features

This topic describes the features supported by the TCX1000-RDM20.

20-Port Route and Select ROADM

The TCX1000-RDM20 is a reconfigurable add-drop multiplexer (ROADM) that multiplexes and demultiplexes wavelengths (channels) from the 20 universal ports to a single composite signal for transmission out its line port.

The TCX1000-RDM20 is a route and select ROADM element that is logically separated into two discrete paths:

- Multiplexing path — 20 universal input (Add) ports labeled **Ux In** are multiplexed, amplified by a booster and routed to the **Line Out** port. For shorter spans, a variable optical attenuator automatically provides short span line padding.
- Demultiplexing path — The multiplexed composite signal is received by the TCX1000-RDM20 on the **Line In** port. A preamplifier amplifies the composite signal, which is then fed to the demultiplexer. The signal is demultiplexed and the channels are dropped to the 20 universal output (Drop) ports labeled **Ux Out**.

Reconfiguring the channels on the universal ports is controlled through the proNX Optical Director, enabling you to reroute channels dynamically.

You can use the universal ports:

- To directly add/drop channels onto the optical network.

- To provide a secondary multiplexing function when connected to external optical multiplexer-demultiplexer devices for channel port expansion.

  For example, connecting the TCX1000-2D8CMD colorless multiplexer to a universal port, enables you to add an additional eight colorless ports for transceiver connections to the TCX1000-RDM20.

  Alternatively, connecting the Juniper Networks BTI7800-FMD96 fixed optical multiplexer-demultiplexer to a single universal port enables the TCX1000-RDM20 to support up to 96 x 200 Gbps coherent channels on a fixed 50 GHz grid.

- By configuring multiple TCX1000-RDM20s in a single node, you can form multi-directional or degree nodes and use the universal ports to cross-connect channels between the nodes. This is referred to as pass-through. You can create true ROADM sites that scale from a 2-degree ROADM node up to high degree solutions for multi-directional switching in point-to-point, ring, mesh, and linear multi-span network configurations.

Complete End-to-End Juniper Networks Coherent Packet-Optical Solution

In this release, the TCX1000-RDM20 scales to 19.2 Tbps when used with 96 x 200 Gbps coherent channels on the universal add/drop ports. It supports a diverse range of packet-optical network configurations, including point-to-point, ring, mesh and linear multi-span configurations for ultra high capacity connectivity in the metro and between data centers. It provides complete support for compatible 100 Gbps and 200 Gbps coherent interfaces across Juniper Networks routers and switches and BTI7800 platforms.

The proNX Optical Director controls and manages the optical control layer for all TCX1000 managed devices, as well as compatible optical interfaces in your Juniper Networks routers and switches and BTI7800 Universal Forwarding Modules (UFM3 and UFM6).

TCX1000-RDM20 Colorless, Directionless, Contentionless Operation

The TCX1000-RDM20 supports colorless, directionless and contentionless operation as follows:

- *Colorless* — The universal ports on the TCX1000-RDM20 have no assigned or fixed frequency; the universal ports are colorless until you provision a wavelength to that port. You can assign any wavelength to any universal port.
- *Directionless* — The TCX1000-RDM20 when used with an appropriate optical multiplexer, supports directionless operation. The TCX1000-2D8CMD is a colorless and two directional multiplexer. When TCX1000-RDM20 is used with TCX1000-2D8CMD, two directional selection is supported. More capable optical multiplexers can be added in-service to extend the capability of the node when they are available.
- *Contentionless* — The TCX1000-RDM20 when used with an appropriate multiplexer supports contentionless operation. When a directionless, contentionless multiplexer is available it can be placed in-service to extend the capability of the ROADM node.
- *Flex Grid* — The hardware of the TCX1000-RDM20 is flex grid ready. However the proNX Optical Director does not yet support the ability to configure the channel width.

Integrated Optical Amplification

The TCX1000-RDM20 integrates booster and pre-amplification to compensate for link and component losses.

Support for Multiple Fiber Types

The TCX1000-RDM20 supports the following fiber types:

- Single mode fiber (SMF)
- Enhanced large effective area fiber (ELEAF)
- Truewave
- Truewave Classic
- Non - zero dispersion shifted fiber (NZ-DSF)
- Dispersion shifted fiber (DSF)
- Single mode fiber-LEAF Submarine (SMF-LS)

Integrated Optical Service Channel

The TCX1000-RDM20 supports a 1511 nm Ethernet optical service channel (OSC) that provides management connectivity to the device over its line port and also assists in zero-channel turn-up and the optical safety for the system.

For remote sites that have limited access to your DCN HA and the proNX Optical Director, you can remotely manage the TCX1000-RDM20 over its line port using the OSC.

The TCX1000-RDM20 OSC is fully compatible with the TCX1000-ILA OSC.

Automatic Laser Shutdown

Due to the potential safety hazard that is posed by the high power optical outputs, the TCX1000-RDM20 has an automatic laser shutdown (ALS) mechanism that guards against the risk of direct human exposure to high-powered lasers.

The ALS mechanism acts to detect a fiber disconnection or fiber cuts along the span, and upon doing so, causes the shutdown of the high-powered WDM composite signal.

TCX1000 Performance Monitoring

The TCX1000-RDM20 and TCX1000-ILA both report performance metrics to the proNX Optical Director for all external ports on their systems. They also both have a number of internal monitors that provide information about the total optical powers and, for the TCX1000-RDM20, the per-channel powers (spectral information) at different points within the system. You can measure performance from these internal monitors at the external ports on both of these devices.

The proNX Optical Director also provides a number of performance monitoring and control functions including monitoring and compensating for span loss in the fiber spans between the line ports on the TCX1000-RDM20 and TCX1000-ILA. The proNX Optical

Director monitors this loss continuous and proactively and dynamically adjusts its amplifier settings to compensate for the loss in the fiber spans. It also provides alarming when it is unable to keep the span loss within the allowable dB levels.

In addition, the proNX Optical Director monitors the pass-through fiber connections between TCX1000-RDM20s universal ports in multi-degree ROADM nodes and provides alarming when the loss is out of range.

The proNX Optical Director also monitors and controls individual channel power over the entire channel path in the network.

TCX1000-RDM20 Management Features

All TCX Series hardware is managed by proNX Optical Director, Juniper Networks open, microservices-based optical control and management platform. The proNX Optical Director control and management software disaggregates the optical control layer from the device hardware, allowing you to configure the optical control plane settings on the managed device dynamically, including software upgrades and device updates, while maintaining services.

TCX1000-RDM20 Ports

The TCX1000-RDM20 has the following ports:

- Line port (duplex LC/UPC) to connect to system fiber
- Monitor port (duplex LC/UPC) to provide optical monitoring access in both directions
- 20 universal ports (duplex LC/UPC) that provide node side connections to optical multiplexers, coherent transceivers, and other TCX1000-RDM20 universal ports for pass-through traffic between multi-degree ROADM nodes.
- A 1511 nm and 1611 nm OSC port (duplex LC/UPC). The 1511 nm OSC connects to connects externally to an the SFP optical transceiver.

  NOTE: **In this release, we supply a 1511 nm SFP transceiver for the OSC function and the 1611 nm OSC port is not used. You can use the 1611 nm port (OSC 1) to connect external test equipment**

- Dual-DCN (**DCN 0** and **DCN 1**) Ethernet ports (RJ-45) that connect internally to a Layer 2 switch and the device's CPU. You use the dual-DCN ports to connect the TCX1000-RDM20 to your DCN HA management network for redundant management communications to the device.
- Ethernet Craft port (RJ-45) and the USB port connect internally to a Layer 2 switch and the device's CPU for local management communications. These ports are used only for initial configuration of the device before it is deployed to the optical network.

Related Documentation

- TCX1000-RDM20 Overview on page 31
- TCX1000-RDM20 Optical Monitoring Points on page 36

- TCX1000 Automatic Laser Shutdown on page 28

TCX1000-RDM20 Optical Monitoring Points

The TCX1000-RDM20 contains a number of internal monitor points that provide information about the total optical powers and per-channel powers (spectral information) at different points within the system. You can measure performance at the following ports:

- **Line In** and **Line Out** ports

  You can also measure the total back-reflected power at the **Line Out** port.

- **OSC 0 In**/**OSC 0 Out** and **OSC 1 In**/**OSC 1 Out** ports

You can also connect external instrumentation, for example an optical spectrum analyzer for spectral monitoring to the TCX1000-RDM20 to provide additional information at the following monitor ports:

- **Mon In** — provides an optical monitor port after the pre-amplifier
- **Mon Out** — provides an optical monitor port after the booster amplifier

In addition, in this release, the OSC 1 port is not used. As such, you can also connect an optical time-domain reflectometer (OTDR) to this port for characterization of the system fiber.

Related Documentation

- TCX1000-RDM20 Overview on page 31
- TCX1000-RDM20 Features on page 32
- TCX1000 Programmable ROADM Hardware Guide

TCX1000-2D8CMD Colorless Multiplexer-Demultiplexer Overview

The TCX1000-2D8CMD is a simple and low cost port expander that uses a combiner-splitter architecture. The TCX1000-2D8CMD is housed in industry standard LGX cassettes that you can flexibly mount in 1RU, 3RU, or 4RU passive chassis solutions.

TCX1000-2D8CMD Overview

The TCX1000-2D8CMD is a colorless, two-directional optical multiplexer-demultiplexer that provides eight colorless client ports and two line ports. You can use the TCX1000-2D8CMD to expand the number of channels you can support on the

TCX1000-RDM20. For example, by connecting the TCX1000-2D8CMD to a single universal port on the TCX1000-RDM20, you can switch an additional eight channels through the TCX1000-RDM20 using only a single universal port, while still maintaining the spectrally programmable (colorless) operation and using the minimum numbers of universal ports on the TCX1000-RDM20, allowing for future expansion.

Client Ports

You connect your transceivers to the eight client ports on the TCX1000-2D8CMD labeled **Cx In** and **Cx Out**.

NOTE: The combiner-splitter architecture of the TCX1000-2D8CMD requires you use only coherent transceivers.

Channels received from the line ports of the TCX1000-2D8CMD are broadcast to all eight client ports. The coherent transceivers connected to the client ports are responsible for selecting their corresponding wavelength and filtering out the impact of the unwanted broadcast channels.

The TCX1000-2D8CMD has no optical filtering. If channels with overlapping spectral usage are presented on the client ports of the same TCX1000-2D8CMD, interference occurs between the channels. You cannot add/drop multiple channels that are the same wavelength to the TCX1000-2D8CMD client ports. If two or more channels at the same wavelength are added to the TCX1000-2D8CMD, channels collide causing transmission impairment of the overlapping channels. You must take care to ensure that these collisions do not happen; this is not enforced by the hardware. However, if the proNX Optical Director detects this situation, it reports an alarm.

Line Ports

The TCX1000-2D8CMD has two line ports. Channels present on the client ports are combined and sent out both line ports simultaneously.

You can connect the line ports of the TCX1000-2D8CMD to the TCX1000-RDM20 universal ports to provide either:

- Single Direction Add/Drop Colorless Multiplexing on page 37
- 1 + 1 Redundancy on page 38

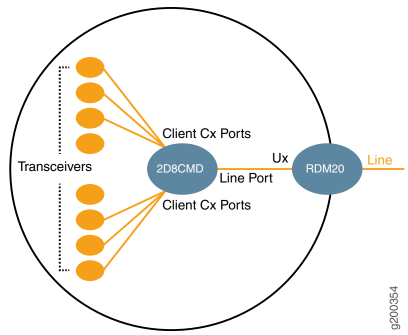
Single Direction Add/Drop Colorless Multiplexing

Figure 1 on page 38 shows a single direction ROADM node that supports single direction add/drop colorless multiplexing-demultiplexing. This example uses only one of the line ports on the TCX1000-2D8CMD.

Looking at Figure 1 on page 38 from left to right: transceivers connect to the client (**Cx In** and **Cx Out**) ports of the TCX1000-2D8CMD, whose line port (**L0 IN** and **L0 OUT**) connects to a single universal port on the TCX1000-RDM20.

All channels present on the TCX1000-2D8CMD are combined and sent out the line port to the universal port on the TCX1000-RDM20, which multiplexes these channels, along with any channels directly connected to its universal ports and sends them out the line port of the TCX1000-RDM20.

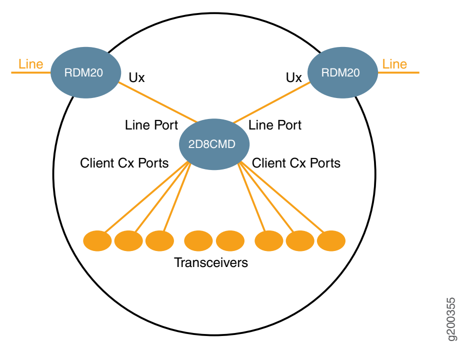
Figure 1: Single Direction ROADM Node Add/Drop Colorless Multiplexing



1 + 1 Redundancy

Figure 2 on page 38 shows a 2-degree ROADM node that provides 1 + 1 redundancy for the channels connected to the TCX1000-2D8CMD. The node consists of two TCX1000-RDM20s and one TCX1000-2D8CMD. The software configuration of the connecting TCX1000-RDM20s control the selection of which channels are routed to/from each ROADM line port.

Figure 2: Summary Colorless 1+1 Redundancy Multiplexing in ROADM Node



In this ROADM node, one of the line ports on the TCX1000-2D8CMD connects to TCX1000-RDM20 serving the west direction (degree) and the other line port connects to TCX1000-RDM20 serving the east degree. By connecting to both TCX1000-RDM20 devices, the TCX1000-2D8CMD has add/drop access to wavelengths in both directions, which is a prerequisite to setting up a service with redundant paths.

The TCX1000-2D8CMD broadcasts the identical composite line signal out both line ports simultaneously and the connecting TCX1000-RDM20 is responsible for selecting which channels are sent through to the TCX1000-RDM20 line ports. The selection and routing of the channels is dynamically controlled through the proNX Optical Director.

NOTE: The TCX1000-2D8CMD has no optical filtering; the identical composite line signal is broadcast out both Line ports of the TCX1000-2D8CMD simultaneously and it is the responsibility of the connected TCX1000-RDM20 to select and route the channels through to the Line port.

The drop (demultiplexing) side of the TCX1000-RDM20 is responsible for selecting the channels destined to the TCX1000-2D8CMD and routing the channels to the correct universal port and line port on the TCX1000-2D8CMD.

Both TCX1000-2D8CMD line port paths cannot be active at the same time because the TCX1000-2D8CMD does not perform any switching; it simply broadcasts the channels.

Operation

The Drop (demultiplexing) side of the TCX1000-RDM20 is responsible for selecting which channels are sent to the receiving TCX1000-2D8CMD line port. The TCX1000-2D8CMD broadcasts the received channels to all client ports where the connected transceivers are responsible for selecting their corresponding wavelength and filtering out the impact of the unwanted broadcast channels. As such, the TCX1000-2D8CMD is suitable for coherent *only* applications.

The Add (multiplexing) side of the TCX1000-RDM20 is responsible for receiving the composite line signals from the TCX1000-2D8CMD on its universal ports and multiplexing the composite line signal, along with any channels directly connected to the universal ports, and sending the composite WDM signal out its line port on to the fiber system.

NOTE: The TCX1000-2D8CMD has no optical filtering. If channels with overlapping spectral usage are presented on the client ports of the same TCX1000-2D8CMD, interference occurs between the channels. You cannot add/drop multiple channels that are the same wavelength to the TCX1000-2D8CMD client ports. If two or more channels at the same wavelength are added to the TCX1000-2D8CMD, channels collide causing transmission impairment of the overlapping channels. You must take care to ensure that these collisions do not happen; this is not enforced by the hardware. However, if the proNX Optical Director detects this situation, it reports an alarm.

Calculating the TCX1000-2D8CMDs Required for Your Configuration

This section is meant to help you understand and determine the number of devices you need for your particular configuration.

Example 1

For the first example, assume that you need to support 16 channels and you want to do so using the fewest number of universal ports on the TCX1000-RDM20 so that you can leave ports for future expansion. You can create this configuration using the TCX1000-2D8CMD as follows:

- Two TCX1000-2D8CMD (8 ports x 2=16 ports)
- One TCX1000-RDM20

In this example, you connect the 16 transceivers to the client ports on the two TCX1000-2D8CMD multiplexers and you connect only one of the line ports from each TCX1000-2D8CMD to a universal port on the TCX1000-RDM20. This leaves you 18 universal ports on the TCX1000-RDM20 for future expansion (20 ports total - 2 ports=18 ports). This enables the transport of 16 colorless channels while using only a single universal port.

Example 2

For the second example, assume that you need to support 48 channels and you want to do so using the fewest number of universal ports on the TCX1000-RDM20 so that you can leave ports for future expansion. You can create this configuration using the TCX1000-2D8CMD as follows:

- Six TCX1000-2D8CMD (8 ports x 6 = 48 ports)
- One TCX1000-RDM20

The six TCX1000-2D8CMDs provide a total of 48 ports for transceiver connections. One of the line ports from each TCX1000-2D8CMD connects to a universal port on the TCX1000-RDM20, using a total of 6 universal ports. This leaves you 14 free universal ports on the TCX1000-RDM20 for future expansion.

Related Documentation

- Understanding TCX1000-RDM20 and BTI7800-FMD96 Multiplexing Capabilities on page 98
- Understanding TCX1000-RDM20 and TCX1000-2D8CMD Multiplexing Capabilities on page 92
- TCX1000-RDM20 Overview on page 31
- Understanding Multi-Degree ROADM Nodes on page 70

TCX1000-ILA Inline Amplifier Overview

The TCX1000 Inline Amplifier or TCX1000-ILA is a standalone 1RU chassis that provides dual amplifiers, along with an embedded optical service channel (OSC) at 1511 nm, and AC or DC redundant hot-swappable power supplies and cooling units.

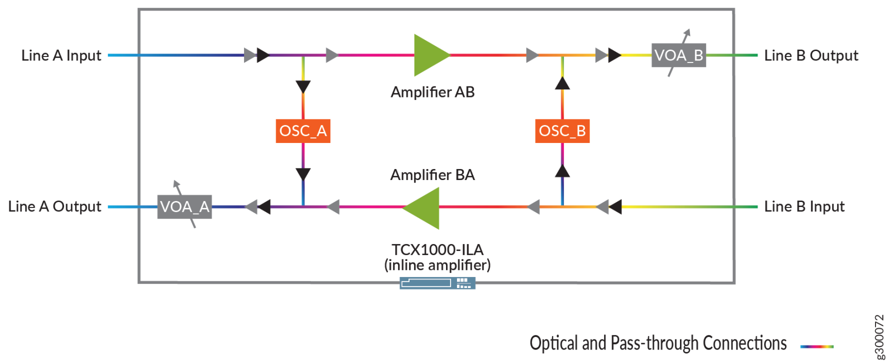
NOTE: *Compatibility* — The TCX1000-ILA is compatible with the proNX Optical Director, Release 2.2 and TCX1000-RDM20, Release 3.1.

- Amplifier on page 41
- proNX Optical Director Optical Control and Management on page 42

Amplifier

The TCX1000-ILA is a dual EDFA amplification solution that provides optical gain for the optical signal traversing the amplifier in the A-B direction, and the signal traversing the amplifier in the opposite B-A direction. Thus, it can be viewed as two amplifiers in one box. As shown in Figure 3 on page 41, functionally, the two amplifiers are totally separate (with the exception of the OSC) and are referred to as amplifier AB and amplifier BA. Line A is serviced by the input to amplifier AB and the output of amplifier BA. Line B is serviced by the input to amplifier BA and the output of amplifier AB.

Figure 3: TCX1000-ILA Functional View



The typical application of the TCX1000-ILA is between ROADM node sites to extend the reach of the optical network by using periodic amplification to maintain a high optical signal-to-noise ratio (OSNR).

The TCX1000-ILA connects to the two fiber spans through two sets of front panel ports (LC):

- Connect one line to the **Line A In** and **Line A Out** ports
- Connect the other line to the **Line B In** and **Line B Out** ports

Table 4 on page 41 summarizes these connections and describes the direction served by each amplifier in the TCX1000-ILA.

Table 4: TCX1000-ILA Line Ports Versus Direction

Amplifier	Physical Ports	Direction Served
AB	**Line A IN**	A to B input
	Line B OUT	A to B output

Table 4: TCX1000-ILA Line Ports Versus Direction (continued)

Amplifier	Physical Ports	Direction Served
BA	**Line B IN**	B to A input
	Line A OUT	B to A output

proNX Optical Director Optical Control and Management

Like all TCX Series products, the TCX1000-ILA is controlled and managed by the proNX Optical Director. The proNX Optical Director control and management software continuously receives data from the TCX1000-ILA and adjusts the optical controls on the unit to compensate for span loss. In addition, threshold crossing alerts and performance monitors from the TCX1000-ILA are sent and recorded in the proNX Optical Director, which alerts you to any associated alarms.

The proNX Optical Director fully manages and controls the TCX1000-ILA:

- The proNX Optical Director dynamically selects the optimum gain range for the amplifier to match the real-time measured span losses.
- The proNX Optical Director dynamically sets the gain tilt of the TCX1000-ILA to provide coarse gain equalization to maximize ONSR in the path.

You are therefore not required to configure the TCX1000-ILA; it is completely and automatically managed by the proNX Optical Director control and management software.

In-Service Upgrades

An in-service upgrade enables firmware and software to be updated without affecting traffic on the TCX1000-ILA.

Optical Service Channel

The TCX1000-ILA supports an embedded Ethernet optical service channel (OSC) that provides inter-site system communication for management purposes and is fully compatible with the TCX1000-RDM20 OSC.

Initial configuration of the TCX1000-ILA is performed through the front panel Ethernet connection as described in the TCX1000 Inline Amplifier Quick Start for instructions on how to configure the IP address on the TCX1000-ILA.. After you complete the steps in this document, you can remotely manage the TCX1000-ILA over the Ethernet OSC. This enables you to deploy the TCX1000-ILA in a site without direct access to your data communications network (DCN), but still maintain visibility and control of the TCX1000-ILA over the OSC. This remote OSC connection passes through the TCX1000-ILA to allow management and control of a chain of amplifiers in between TCX1000-RDM20 ROADM sites.

The embedded 100 Mbps Ethernet OSC is comprised of a 1511 nm signal. The TCX1000-ILA terminates and transmits this signal using small form-factor pluggable (SFP) optics. All control information is conveyed in Ethernet packets. Neighbor discovery on the line ports of the TCX1000-ILA is performed by LLDP on the Ethernet link.

TCX1000-ILA Features

The TCX1000-ILA supports the following features:

- Support for up to four cascaded TCX1000-ILA amplifiers between TCX1000-RDM20 ROADM nodes.
- The TCX1000-ILA functions as a C-Band amplifier. This means that the DWDM signal the TCX1000-ILA supports, occupies the spectrum known as the C-Band (1528 nm -1566 nm).
- The TCX1000-ILA supports a line-side back reflection monitor that allows for monitoring the back reflection of the output signal.
- The TCX1000-ILA supports two monitoring ports enabling you to monitor the output spectrum of both line A and line B output signals while the amplifier is in service. To monitor the output spectrum, connect an optical spectrum analyzer (OSA) to either the **MON A** or **MON B** monitor port.

Related Documentation

- TCX1000-ILA Hardware Alarms and Probable Causes on page 190
- TCX1000 Management Architecture on page 103
- Deployment Rules for TCX1000 Management Communications on page 109
- Best Practices for Using the TCX1000-ILA in Linear Multi-Span, Ring and Mesh Networks on page 85

CHAPTER 4

Optical Control and Management Overview

proNX Optical Director System and Optical Control Levels

This topic provides an overview of the optical control and management provided as part of the proNX Optical Director software. It includes the following sections:

Introduction

All products in the TCX Series Optical Transport System portfolio are controlled and managed by the proNX Optical Director. The proNX Optical Director is a highly available platform that runs on a three-node server cluster. It is an integral component of the TCX1000 Series Optical Transport System and it is the combination of the TCX1000 Series hardware and the proNX Optical Director control and management software platform that provide the full TCX Optical Transport System solution.

The proNX Optical Director control and management software abstracts the optical control layer from the TCX1000 Series managed device and moves control of the optical layer off of the managed device to a centralized and programmable optical control layer called the Juniper Programmable Photonic Layer. By disaggregating the optical control plane from the TCX1000 Series hardware, you can more regularly and flexibly modify control plane behavior while maintaining service continuity, lowering operational expense, and fine-tuning transport-layer performance.

In traditional optical networks, the optical control function resides on the device hardware and the devices exchange proprietary control messages with each other on an optical service channel (OSC). This makes interworking across vendor equipment difficult and often leads to the deployment of single-sourced networks. Moving the optical control layer to a centralized software controller makes heterogeneous networks with equipment from multiple vendors possible.

System Controls

The proNX Optical Director control and management software provides comprehensive systems control functions that:

- Prevent or eliminate degradation of any part of the system — TCX1000 Series managed devices constantly send streams of real-time optical link measurements to the proNX Optical Director, which then uses the data to build an always current view of the optical links in the network. This allows the proNX Optical Director to make real-time control decisions on all aspects of optical link management.
- Initiate immediate response to demands that are placed on the system — As demands are placed on the system, the proNX Optical Director evaluates the information it collects from the managed devices, calculates corrective actions and makes configurations changes to the device in order to compensate for the increased demands on the system.
- Respond to changes in the system to meet long term requirements, such as continuous control of equipment performance — The proNX Optical Director continuously collects information from the managed devices in the network, evaluates that information and automatically makes configurations changes that may be required to any of the managed devices in the network.

Optical Control Levels

The proNX Optical Director control and management software provides three additional level of optical controls:

- Device Control — Responsible for maintaining the optical configuration of a device. The proNX Optical Director receives streams of real-time optical link measurements from the TCX1000 Series managed device and builds an always current view of the optical links in the network. This allows the proNX Optical Director to make real-time control decisions on all aspects of optical link management. The proNX Optical Director discovers OLS network elements and reads and displays their configuration. You can change the configuration, view the equipment inventory, pull up a visual representation of the device, or view performance monitoring parameters and alarm details.
- Span Loss Compensation — Responsible for controlling the optical path over a span (between two sites). By abstracting the optical controls from the hardware, the proNX Optical Director can read optical power levels on devices at both ends of a span, decide whether changes need to be made to the device configuration to compensate for span loss and then send commands to the hardware to make the appropriate adjustments.
- Pass-Through Nodal Loss Measurement— Responsible for calculating the loss in the pass-through fiber connection between two TCX1000-RDM20s universal ports in a multi-degree ROADM node and reporting out-of-range (OOR) alarms to the proNX Optical Director. Pass-through nodal loss is the loss in power across the fiber between the two universal ports that form the pass-through connection between two degrees in a multi-degree ROADM node. The pass-though loss is measured within the total

optical power over the pass-through fiber connection and is represented mathematically as the difference between the transmitted dBm power on the **Ux Out** port of one TCX1000-RDM20 and the received dBm power on the **Ux In** port of the other TCX1000-RDM20.

NOTE: This release of the TCX Series Optical Transport System calculates pass-through nodal loss and reports nodal loss out-of-range alarms but does not control nodal loss. If the pass-through loss calculation is not within range, Nodal loss OOR alarms are raised at both ends of the pass-through fiber connection. If a Nodal loss OOR alarm occurs, inspect and verify the pass-through fiber connections.

- Network Control — Responsible for controlling the optical paths within an optical network (endpoint-to-endpoint). The proNX Optical Director supports A-to-Z provisioning and activation of optical services.

Related Documentation

- proNX Optical Director Overview on page 47
- proNX Optical Director Control and Management Software Components on page 48
- proNX Optical Director Performance Monitoring Metrics on page 165

- *About Juniper Optical Control Environment*

proNX Optical Director Overview

The proNX Optical Director receives streams of real-time optical link measurements from all the TCX1000 Series ROADM elements under management. From this data, the proNX Optical Director builds an always current view of the optical links in the network. This allows the proNX Optical Director to make real-time control decisions on all aspects of optical link management, including the following:

- Span loss compensation
- Pass-through nodal loss measurement and alarming
- Automatic per-channel power control through the entire network path

These control decisions are translated into commands that are communicated to the TCX1000 Series managed devices for execution. This ongoing control loop allows the proNX Optical Director to deliver optimal optical transmission performance for the managed devices by dynamically and automatically controlling all aspects of optical link output.

In traditional optical networks, this control function resides on the device hardware where the devices exchange proprietary control messages with each other on an optical service channel (OSC). Moving this function to a centralized software controller makes heterogeneous networks with equipment from multiple vendors possible.

The proNX Optical Director control and management software provides A-to-Z provisioning, dynamic real-time control of optical links, and activation of optical services. To create a channel service, you select the two service endpoints and the proNX Optical Director automatically creates the optical path for the service.

The proNX Optical Director also enables fault, configuration, accounting, performance and security (FCAPS) functionality and optical service activation on optical interfaces residing in Juniper Networks routers and switches.

Related Documentation

- proNX Optical Director System and Optical Control Levels on page 45
- proNX Optical Director Control and Management Software Components on page 48

proNX Optical Director Control and Management Software Components

This topic describes the software components of the proNX Optical Director. It includes the following subjects:

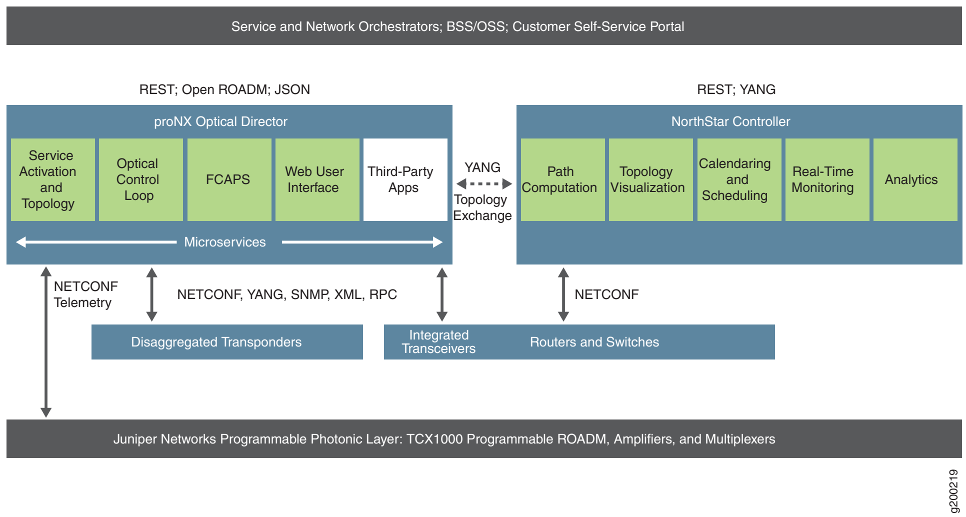
- proNX Optical Director Architecture and Software Components on page 48
- Orchestration Framework on page 49
- Browser-Based User Interface on page 50
- Software Applications on page 50

proNX Optical Director Architecture and Software Components

Each optical product in the TCX Series Optical Transport System is disaggregated and standalone. In addition, the proNX Optical Director control and management software disaggregates and abstracts the optical control layer from the managed devices.

With the TCX Series Optical Transport System, the optical control intelligence resides in the cloud with the proNX Optical Director control and management software enabling you to simply control the optical transport layer.

Figure 4: proNX Optical Director Microservice Architecture



NOTE: **The Northstar Controller functionality in Figure 4 on page 49 is not supported in this release.**

Juniper Programmable Photonic Layer

Figure 4 on page 49 illustrates the proNX Optical Director control and management software architecture. At the bottom of the stack is the Juniper Programmable Photonic Layer, which represents the TCX Series device hardware layer and embedded firmware. The proNX Optical Director control and management software communicates with the TCX Series Juniper Programmable Photonic Layer over the devices Netconf and telemetry interfaces. To control and manage compatible integrated (in Juniper Networks routers and switches) and disaggregated transponders, the proNX Optical Directors uses the Netconf interface and the XML, RPC and SNMP protocols.

Orchestration Framework

The proNX Optical Director control and management software is a Microservices Based Architecture (MSA) platform. Microservices are implemented using Docker containers and orchestration is provided by Kubernetes.

The infrastructure is responsible for the full lifecycle of the microservices including how they are commissioned, upgraded, managed and monitored, as well as how they are removed during decommissioning. You can easily upgrade a single microservice within the framework. The infrastructure also supports placement, healing, scaling and replication of the microservices.

Browser-Based User Interface

The proNX Optical Director control and management software includes a browser-based user interface for network, device, and service control and management. The user interface contains views for all supported features including:

- Dashboard with Modular Dashlets
- Active and historical alarms
- Device management, including discovery, system configuration, provisioning, backup/restore, and software upgrade
- Device logs
- Service activation and topology display
- User administration
- Tasks

Software Applications

The software applications included in the proNX Optical Director include:

FCAPS Application

The FCAPS application enables fault, configuration, accounting, performance, and security (FCAPS) functionality for the TCX1000 Series managed devices, as well as for compatible Juniper Networks routers and switches. FCAPS support on these devices includes:

- Device discovery, undiscovery
- Chassis visualization
- Inventory
- Configuration and provisioning
- Backup and restore
- Performance monitor collection and historical binning
- Log collection
- Software upgrade
- Alarm and historical alarms

Service Activation and Topology Application

An optical service provides channel connectivity between service endpoints and is defined by its wavelength and the endpoints that it interconnects. The proNX Optical Director service management across the optical network includes: service provisioning, service activation, and service monitoring and troubleshooting. The proNX Optical Director supports A-to-Z provisioning and activation of optical services. You select the two service endpoints and the proNX Optical Director automatically configures the optical path between the two service endpoints.

The proNX Optical Director learns and displays the topology of the network and provides various visual indicators that allow you to see the health of the network at a glance and deal with problem areas in a proactive manner. The topology application also enables you can also view links on a per-span basis.

Optical Control Layer Application

The optical control layer (OCL) application provides dynamic real-time control of optical links, provides A-to-Z provisioning and activation of optical services, and provides performance control and monitoring for automatic span loss compensation and automatic channel power control. The TCX1000 Series elements constantly send streams of real-time optical link measurements to the proNX Optical Director, which then uses the data to build an always current view of the optical links and services in the network. This allows the proNX Optical Director to make real-time control decisions on all aspects of optical link and service management.

The OCL application is a conglomerate of real-time control algorithms, which automatically configure TCX Series optical devices to provide optimal optical network transmission performance. Near-instant network-wide visibility of the services provided by the disaggregated infrastructure allows implementation of advanced control algorithms, which optimize the optical transmission for the whole service path or even a complete network.

The other functions of the OCL application include:

- Generating control-related performance monitors and alarms
- Zero-lambda turnup
- Short span support

NOTE: **For complete details on the proNX Optical Director, see:** proNX Optical Director User Guide.

Related Documentation

- proNX Optical Director User Guide
- proNX Optical Director System and Optical Control Levels on page 45
- proNX Optical Director Overview on page 47
- proNX Optical Director Performance Monitoring Metrics on page 165
- proNX Optical Director Alarms on page 178

CHAPTER 5

Product Applications

TCX1000 Series Product Applications

This topic provides an overview of the TCX1000 Series product applications and includes the following topics:

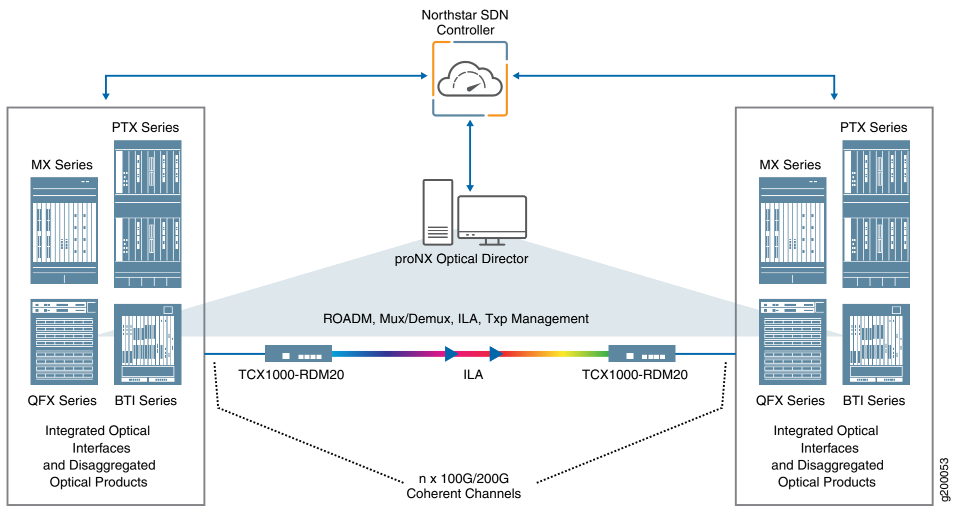
TCX1000-RDM20 Product Applications

The TCX1000-RDM20 is a highly flexible and open DWDM optical line system that provides reconfigurable optical add/drop multiplexing and pass-through of channels in a multi-degree node. The TCX1000-RDM20 enables multi-terabit wavelength switching capabilities to compliment the high capacity routing, switching and transport interfaces on Juniper Networks routing and switching platforms. The TCX1000-RDM20 is primarily for data center interconnect (DCI), access and aggregation, and metropolitan-area networks and can also be used in the core.

Figure 5 on page 54 shows an example of how you might pair the TCX1000-RDM20 and the TCX1000-ILA with your existing Juniper Networks routers and switches as well as our BTI7800 Series products to build an ultra, high capacity packet-optical network.

Transceivers integrated in the Juniper Networks routers and switches can connect directly to the universal ports on the TCX1000-RDM20 or can connect through an optical multiplexer such as the TCX1000-2D8CMD or BTI7800-FMD96, enabling you to route high-speed services over the optical network. The proNX Optical Director controls and manages the optical layer from the transceiver endpoints in the routers and switches all the way through your optical network.

Figure 5: TCX1000-RDM20 Overview



Regardless of your application, you can mix coherent services on the TCX1000-RDM20. For example, you can connect 100 Gbps services from an MX Series router, as well as connect 200 Gbps services running on a QFX Series switch to the same TCX1000-RDM20.

The TCX1000-RDM20 supports up to 96 x 200 Gbps coherent channels at 50 GHz spacing in a point-to-point link configuration by leveraging the BTI7800-FMD96. The TCX1000-RDM20 supports an extended C-band spectrum from 191.325 to 196.125 THz (1528.578 to 1566.928 nm) which is consistent with 96 channel operation (196.1 to 191.35 THz channel centers) on a 50 GHz ITU channel grid.

Data Center Applications

For data center interconnection (DCI) applications, you can pair the TCX1000-RDM20 and TCX1000-ILA with the following Juniper Networks routers and switches for a complete end-to-end solution:

- For Juniper Networks QFX10008 and QFX100016 Ethernet switches using the QFX10K-12C-DWDM line card (6 x 200 Gbps DWDM), the TCX1000-RDM20 enables an end-to-end solution with up to 19.2 Tbps per fiber.
- For Juniper Networks MX Series 5G Universal Routing Platforms including the MX240/MX480/MX960/MX2010/MX2020, using the MIC3-100G-DWDM interface card, the TCX1000-RDM20 enables an end-to-end solution with up to 9.6 Tbps per fiber.

  For MX Series routers, you can also use the MIC6-100G-CFP2, which is a 100-Gigabit Ethernet MIC with CFP2 ports.
- For Juniper Networks PTX3000 and PTX5000 routers using the PTX-5-100G-WDM physical interface card (PIC), the TCX1000-RDM20 enables an end-to-end solution with up to 9.6 Tbps per fiber.

  For PTX Series routers, you can also use the P2-100GE-OTN, which is a 100-Gigabit Ethernet OTN PIC with CFP2. Four ports that can be configured as 100-Gigabit Ethernet, 100-Gigabit OTN, or a combination of 100-Gigabit Ethernet and 100-Gigabit Ethernet OTN interfaces.

Access, Aggregation, and Metro Applications

For access, aggregation, and metro applications, you can pair the TCX1000-RDM20 with the following Juniper Networks routers and switches for a complete end-to-end solution:

- For Juniper Networks MX Series 5G Universal Routing Platforms including the MX240/MX480/MX960/MX2010/MX2020, using the using the MIC3-100G-DWDM interface card, the TCX1000-RDM20 enables an end-to-end solution with up to 9.6 Tbps per fiber.

  For MX Series routers, you can also use the MIC6-100G-CFP2, which is a 100-Gigabit Ethernet MIC with CFP2 ports.

Related Documentation

- TCX1000-RDM20 Universal Port Rules on page 63
- Understanding TCX Series Point-to-Point Topologies on page 65
- TCX Series Optical Transport System Capacities on page 61
- TCX1000-RDM20 Overview on page 31

CHAPTER 6

Juniper Networks Compatible Products

Juniper Networks Compatible Routers, Switches, Optical Multiplexers and Transponders

Table 5 on page 57 lists the Juniper Networks routers and switches and the associated optical interfaces that are compatible with the TCX1000-RDM20 and proNX Optical Director.

Table 6 on page 58 lists the Juniper Networks optical multiplexers, transponders and inline amplifiers that are compatible with the TCX1000-RDM20 and proNX Optical Director.

Table 5: TCX1000-RDM20 Compatible Devices

Juniper Networks Device	Supported Interfaces	TCX1000-RDM20 Enabled Solution
ACX6360	Ports on the CFP2-DCO pluggable transceiver (CFP2-DCO-T-WDM-1)	
MX Series 5G Universal Routing Platforms including: • MX240 • MX480 • MX960 • MX2010 • MX2020	MIC3-100G-DWDM—100-Gigabit DWDM OTN MIC supported on both the MPC3E (MX-MPC3E-3D) and MPC3E NG (MPC3E-3D-NG). The MIC3-100G-DWDM MIC provides a single 100-Gigabit Ethernet interface port that supports DP-QPSK with coherent reception and OTU4 and OTU4 (v) framing modes. See 100-Gigabit DWDM OTN MIC with CFP2-ACO	Enables an end-to-end solution with up to 9.6 Tbps per fiber for: • Data Center Interconnection (DCI) applications • Access, Aggregation, and Metro applications
	MIC6-100G-CFP2, a 100-Gigabit Ethernet MIC with CFP2 ports. Supports two 100-Gigabit Ethernet CFP2 ports. 100-Gigabit Ethernet MIC with CFP2	

Table 5: TCX1000-RDM20 Compatible Devices (continued)

Juniper Networks Device	Supported Interfaces	TCX1000-RDM20 Enabled Solution
PTX Series Packet Transport Routers including: • PTX3000 • PTX5000	PTX-5-100G-WDM— 5-port 100-Gigabit DWDM OTN PIC for both the PTX3000 and the PTX5000 routers. The PTX-5-100G-WDM PIC provides five 100-Gigabit Ethernet interface ports that support dual-polarization quadrature phase shift keying (DP-QPSK) modulation with coherent reception and OTU4 and OTU4 (v) framing modes. See, 100-Gigabit DWDM OTN PIC with CFP2-ACO (PTX Series)	Enables an end-to-end DCI solution with up to 9.6 Tbps per fiber.
	P2-100GE-OTN, a 100-Gigabit Ethernet OTN PIC with CFP2. Four ports that can be configured as 100-Gigabit Ethernet, 100-Gigabit OTN, or a combination of 100-Gigabit Ethernet and 100-Gigabit Ethernet OTN interfaces. 100-Gigabit Ethernet OTN PIC with CFP2	
QFX10000 line of modular Ethernet switches including: • QFX10008 • QFX100016	QFX10K-12C-DWDM line card: 6-port line card, with built-in optics, supports flexible rate modulation at 100 Gbps, 150 Gbps, and 200 Gbps speeds and is supported on both QFX10008 and QFX100016. See, QFX10K-12C-DWDM Coherent Line Card	Enables an end-to-end DCI solution with up to 19.2 Tbps per fiber using 200 Gbps coherent channels.

Table 6 on page 58 lists the Juniper Networks compatible optical multiplexers and transponders.

Table 6: Juniper Networks Compatible Optical Multiplexers, Transponders and Inline Amplifiers

Juniper Networks Device	How to Use It With the TCX1000-RDM20
TCX1000-ILA	The TCX1000-ILA is a dual inline amplifier you can use in your TCX Series optical network, along with the TCX1000-RDM20. The dual inline amplifiers supply amplification for two fiber spans. Optical control and management is dynamically controlled through the proNX Optical Director including managing the span loss for both lines and dynamically adjusting the amplification to compensate for loss of signal in the fiber.

Table 6: Juniper Networks Compatible Optical Multiplexers, Transponders and Inline Amplifiers (continued)

Juniper Networks Device	How to Use It With the TCX1000-RDM20
TCX1000-2D8CMD	The TCX1000-2D8CMD colorless multiplexer can be used to add/drop an additional 8 channels to the TCX1000-RDM20 and uses only a single universal port on the TCX1000-RDM20. The TCX1000-2D8CMD enables both single and multi-direction add/drop multiplexing, depending on how it is connected to the TCX1000-RDM20. The proNX Optical Director manages and controls the TCX1000-2D8CMD through the connected TCX1000-RDM20. Through the proNX Optical Director, you can dynamically configure what channels from the TCX1000-2D8CMD you want to add/drop onto the TCX1000-RDM20 Line port. NOTE: You must use coherent transceivers on the TCX1000-2D8CMD client ports.
BTI7800-FMD96 See, BTI7800 Packet Optical Transport Platform	Ports on the UFM3 (BT8A78UFM3) 100G Coherent CFP-M05 transceiver (CFP-100GBASE-CHRT) Ports on the UFM6 (BT8A78UFM6-I02) 400G Coherent MSA XCVR The BTI7800-FMD96 optical multiplexer-demultiplexer can be used to add/drop 96 channels to the TCX1000-RDM20 by connecting the common/line port of the BTI7800-FMD96 to a single universal port. This configuration supports up to 96 x 200 Gbps coherent channels with 50 GHz fixed channel spacing. The proNX Optical Director manages and controls the BTI7800-FMD96 through the connected TCX1000-RDM20. Through the proNX Optical Director, you can dynamically configure what channels from the BTI7800-FMD96 you want to add/drop onto the TCX1000-RDM20 Line port.

Related Documentation

- *proNX Optical Director Topology Support*
- proNX Optical Director Links and Services Overview on page 148
- Understanding TCX Series Point-to-Point Topologies on page 65Understanding Multi-Degree ROADM Nodes on page 70

CHAPTER 7

TCX Series Optical Transport System Capacities

TCX Series Optical Transport System Capacities

This topic describes the system capacities for the TCX Series Optical Transport System products including the proNX Optical Director. It includes the following subjects:

TCX1000-RDM20 System Capacities

The TCX1000-RDM20 system capacity is determined more by the transceiver capability and the expected reach of the network rather than by the TCX1000-RDM20 itself. The available capacity for any given configuration must be determined for each network design, but it is useful to outline the maximum capacities available on such links and the device parameters that drive these limits.

Table 7 on page 62 shows the maximum system capacity, for this release, that can be achieved with a full fill of channels for different transceiver capabilities.

For example, the direct connect capability is maximized with only 20 channels present (one on each universal port of the TCX1000-RDM20) but the fixed multiplexer (BTI7800-FMD96) allows for the whole available spectrum to be fully utilized as 96 x 200 Gbps coherent channels at 50 GHz spacing. Finally, this is not intended to show transceiver capability availability but rather to illustrate the system capacity available if and when that capability is available.

Required OSNR is smaller for lower capacity channels.

Table 7: Maximum System Capacity With a Full Fill of Channels for Different Transceiver Capabilities

Capacity in Tbps	100 Gbps QPSK 32 G Baud	150 Gbps 8QAM 32 G Baud	200 Gbps 16QAM 32G Baud
Direct Connect (20 ports)	2.0	3.0	4.0
BTI7800-FMD96	9.6	14.4	19.2

proNX Optical Director Capacities

Table 8 on page 62 lists the proNX Optical Director capacities.

Table 8: proNX Optical Director Capacities

Capacity	Values
Maximum number of supported ROADM nodes	1000
Maximum number of provisioned services	1000

Related Documentation

- TCX1000 Series Product Applications on page 53
- TCX1000-RDM20 Universal Port Rules on page 63
- Understanding TCX Series Point-to-Point Topologies on page 65
- TCX1000-RDM20 Overview on page 31

CHAPTER 8

TCX1000-RDM20 Universal Port Rules

TCX1000-RDM20 Universal Port Rules

In this release, you can use the universal ports on the TCX1000-RDM20 as follows:

1. Each and any universal port can be directly connected to a coherent transceiver.

   coherent transceivers can be:

   - Compatible integrated transceivers in a Juniper Networks router or switch
   - Juniper Networks disaggregated transceiver such as the BTI7800 Universal Forwarding Modules: UFM3 with coherent CFP and UFM6
   - Third-party transceiver

   The TCX1000-RDM20 supports up to 20 colorless channel connections — any channel can be added on any universal port of the TCX1000-RDM20. This is enabled in conjunction with tunable transceivers.

2. Each and any universal port can be connected to an optical multiplexer-demultiplexer.

   This enables you to use the fewest number of universal ports on the TCX1000-RDM20 and plan for future expansion.

   For example, connecting your transceivers to the TCX1000-2D8CMD client ports and connecting one of its line ports to a single universal port on the TCX1000-RDM20 enables you to switch an additional 8 colorless channels on the TCX1000-RDM20, while 19 universal ports are still available for direct add/drop traffic, pass-through connections, or for additional optical multiplexers-demultiplexers. The TCX1000-2D8CMD supports colorless single and multi-direction add/drop capability.

   The BTI7800-FMD96 fixed optical multiplexer-demultiplexer is also compatible with the TCX1000-RDM20. You can connect the line port of the BTI7800-FMD96 optical multiplexer to a single universal port on the TCX1000-RDM20 enabling you to support up to 96 x 200 Gbps coherent channels at 50 GHz spacing.

   NOTE: Ports on the BTI7800-FMD96 optical multiplexer are fixed in frequency and therefore not colorless.

3. Each and any universal port can be used for a pass-through connection in a multi-degree ROADM node. For a pass-through connection, you connect a universal port on one TCX1000-RDM20 ROADM degree to another universal on the another ROADM degree allowing you to pass channels from one degree to another in a multi-degree ROADM node.

Related Documentation

- TCX1000 Series Product Applications on page 53
- Understanding TCX Series Point-to-Point Topologies on page 65
- TCX Series Optical Transport System Capacities on page 61
- TCX1000-RDM20 Overview on page 31

CHAPTER 9

Understanding ROADM Node Configurations

Understanding TCX Series Point-to-Point Topologies

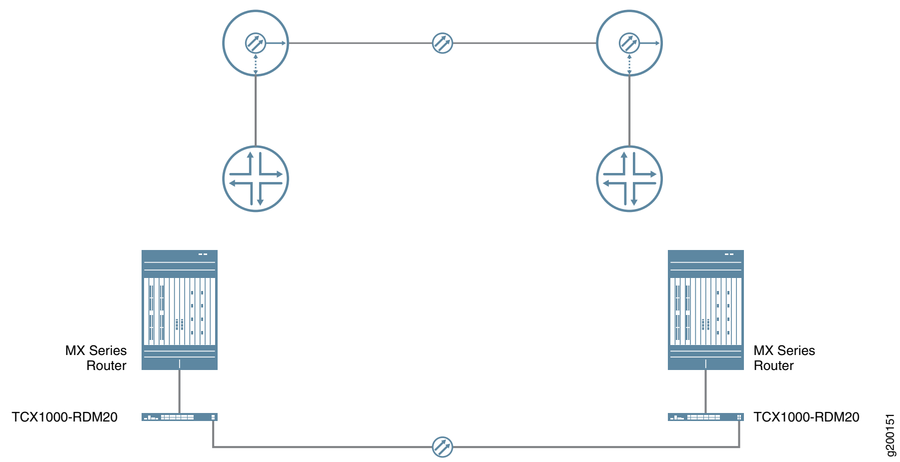
This topic describes and illustrates the supported point-to-point network configurations.

NOTE: The proNX Optical Director provides complete end-to-end optical control and management for all Juniper Networks products described in the following sections.

Simple Point-to-Point Direct Connect

The simplest network configuration you can create is with just two TCX1000-RDM20 units and coherent transceivers in the router connected directly to the universal ports as illustrated in Figure 6 on page 66.

Figure 6: TCX1000-RDM20 Point to Point — Direct Connect



This scenario enables you to transport channels from a Juniper Networks router over the high speed optical network. Integrated coherent transceivers in the router are directly connected to universal ports on the TCX1000-RDM20. On the transmit side, the TCX1000-RDM20 multiplexes the channels and transmits the composite signal out the **Line out** port to the fiber span. On the receive side, the TCX1000-RDM20 receives the composite signal from the fiber span on the **Line in** port, demultiplexes the channels, and routes them to the appropriate universal ports, which are directly connected to the transceivers in the router.

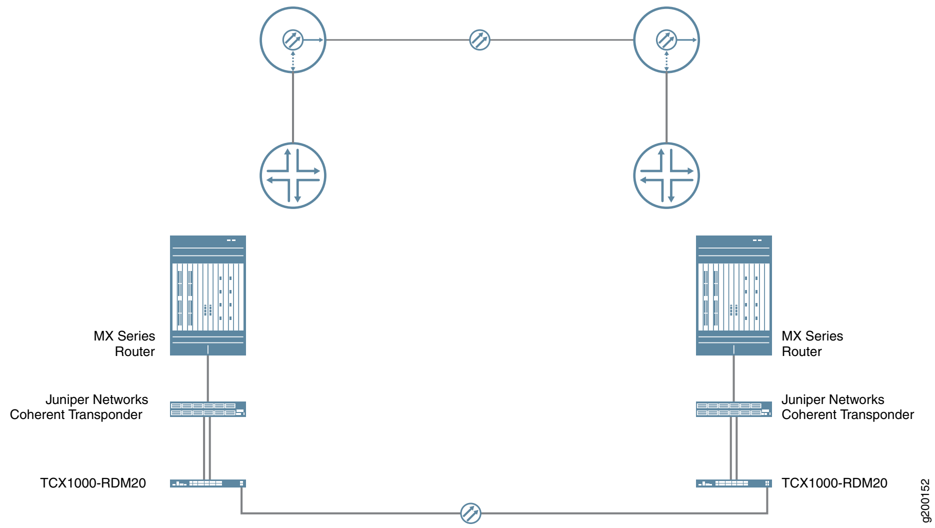
You can use the following Juniper Networks products in this configuration:

- As an amplifier solution for this configuration, you can use the TCX1000-ILA.
- For MX Series routers, you can use the MIC3-100G-DWDM, 100-Gigabit DWDM OTN MIC.
- For PTX Series routers, you can use the PTX-5-100G-WDM, 5-port 100-Gigabit DWDM OTN PIC.
- For QFX Ethernet switches, you can use the QFX10K-12C-DWDM line card, which is a 6-port line card, with built-in optics that supports flexible rate modulation at 100 Gbps, 150 Gbps, and 200 Gbps speeds. Both the QFX10008 or the QFX100016 support this line card.

Short Reach Router Interfaces with Disaggregated Transceivers

In scenarios where the router interfaces are short-reach, you can construct a similar configuration using disaggregated transceivers to generate the coherent channels, as illustrated in Figure 7 on page 67.

Figure 7: TCX1000-RDM20 Point to Point — Direct Connect with Disaggregated Transceivers



In this configuration, short reach optical interfaces on the router are connected to the client ports on a disaggregated transceiver, which connects the channels directly to the universal ports on the TCX1000-RDM20. On the transmit side, the TCX1000-RDM20 multiplexes the channels present on the universal ports and transmits the composite signal out the line port to the fiber span. On the receive side, the TCX1000-RDM20 receives the composite signal on the line port, demultiplexes the channels and routes them to the appropriate universal ports, which are directly connected to the disaggregated transceivers.

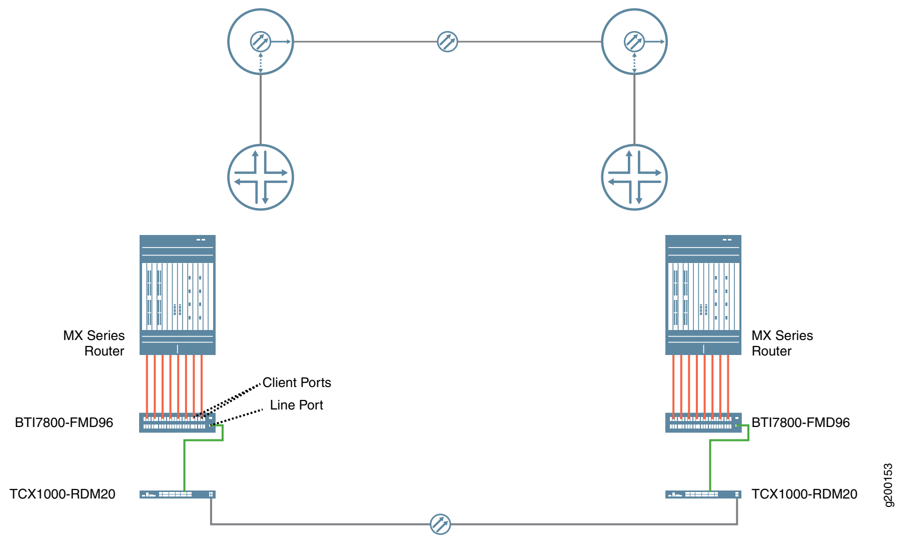
You can use the following Juniper Networks products in this configuration:

- As an amplifier solution for this configuration, you can use the TCX1000-ILA.
- For routers, you can use either the MX Series or PTX Series routers
- For disaggregated transceivers, you can use Juniper Networks BTI7800 with the Universal Forwarding Modules (UFM): UFM3 with coherent CFP and UFM6.

Simple High Capacity Point-to-Point Using TCX1000-RDM20 and Multiplexer/Demultiplexer

To limit the number of universal ports that you use so that you can have room for future expansion, you can connect an optical multiplexer to a universal port and connect your transceivers to the multiplexer. For this configuration, you can pair the TCX1000-RDM20 with either the TCX1000-2D8CMD or the Juniper Networks BTI7800-FMD96. The example in Figure 8 on page 68 uses the BTI7800-FMD96. This configuration supports up to 96 x 200 Gbps coherent channels with 50 GHz spacing using only a single universal port on the TCX1000-RDM20. This allows full fill of the spectrum for maximum system capacity while using the minimum number of universal ports on the TCX1000-RDM20 to allow for later system expansion.

Figure 8: TCX1000-RDM20 Point-to-Point with Fixed Multiplexer/Demultiplexer



On the transmit side, the coherent channels on the router interfaces connect directly to the client ports on the BTI7800-FMD96, which multiplexes the channels and sends them out the composite line port to the universal port on the TCX1000-RDM20. The TCX1000-RDM20 further multiplexes the channels and sends the composite signal out the line port of the TCX1000-RDM20 to the fiber span. At the receive side, the TCX1000-RDM20 receives the composite signal from the fiber span on the **Line In** port, demultiplexes the channels and routes the signal to the **Line In** port of the BTI7800-FMD96, which further demultiplexes the channels and routes them to the clients ports of the BTI7800-FMD96, which are directly connected to the transceivers in the router.

You can also build this configuration using coherent interfaces in the router (as shown in Figure 8 on page 68) or with disaggregated coherent transceivers between the router and the multiplexer/demultiplexer.

To build this configuration using coherent interfaces in the router, you can use:

- For MX Series routers, you can use the MIC3-100G-DWDM, 100-Gigabit DWDM OTN MIC.
- For PTX Series routers, you can use the PTX-5-100G-WDM, 5-port 100-Gigabit DWDM OTN PIC.
- For QFX switches, you can use the QFX10K-12C-DWDM line card, which is a 6-port line card, with built-in optics that supports flexible rate modulation at 100 Gbps, 150 Gbps, and 200 Gbps speeds. Both the QFX10008 or the QFX100016 support this line card.
- As an amplifier solution for this configuration, you can use the TCX1000-ILA.
- For the fixed multiplexer-demultiplexer, you can use the BTI7800-FMD96.
- For a colorless multiplexer-demultiplexer, you can use the TCX1000-2D8CMD.

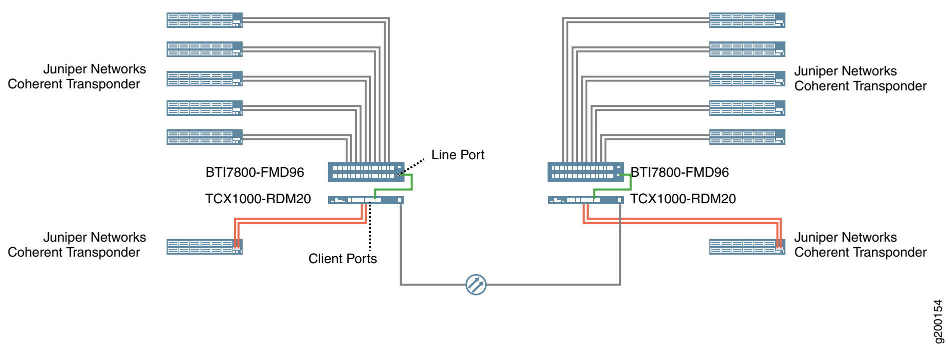
To build this configuration with disaggregated coherent transceivers between the router and the multiplexer/demultiplexer, you can use:

- The MX Series or the PTX Series routers or the QFX10008 or the QFX100016 switch
- As an amplifier solution for this configuration, you can use the TCX1000-ILA.
- For the fixed optical multiplexer-demultiplexer you can use the BTI7800-FMD96.
- For the disaggregated transceivers, you can use the BTI7800 Universal Forwarding Modules (UFM): UFM3 with coherent CFP and the UFM6.
- For a colorless multiplexer-demultiplexer, you can use the TCX1000-2D8CMD.

TCX1000-RDM20 Direct Connect with Fixed Multiplexer/Demultiplexer Deployed Simultaneously

The multiplexer and direct connect solution can also be deployed simultaneously as shown in Figure 9 on page 69.

Figure 9: Direct Connect with Fixed Multiplexer/Demultiplexer Deployed Simultaneously



In this topology, five channels from the disaggregated coherent transceivers, connect to the clients ports of the BTI7800-FMD96 fixed multiplexer. On the transmit side, the channels are multiplexed and sent out the composite line side of the BTI7800-FMD96, which is directly connected to a universal port on the TCX1000-RDM20. The TCX1000-RDM20 further multiplexes the channels, along with any directly connected channels, and routes the composite signal out the line port to the fiber span. At the receive side, the TCX1000-RDM20 receives the composite signal from the fiber span on the **Line In** port, demultiplexes the channels and routes them to the receive line side of the BTI7800-FMD96, which further demultiplexes the channels and routes them to the directly connected disaggregated transceivers.

This configuration provides a dense, low-loss solution for combining the channels, but the frequency of each channel is locked to the port of the fixed BTI7800-FMD96. The additional coherent transceiver directly connected to the TCX1000-RDM20 universal port is effectively on a colorless port and because it is tunable, you can use it as a standby channel for all the channels connected on the client ports of the BTI7800-FMD96. This configuration provides a remotely reconfigurable solution and the direct connect transceivers can be used to replace any of the channels on the BTI7800-FMD96 in the event of their failure.

You can use the following Juniper Networks products to build this configuration:

- As an amplifier solution for this configuration, you can use the TCX1000-ILA.
- For colorless applications, you can use the TCX1000-2D8CMD multiplexer to add/drop channels or you can connect channels directly to the TCX1000-RDM20 (as shown with the backup channel transponder).
- For the fixed optical multiplexer you can use the BTI7800-FMD96.
- For disaggregated transceivers, you can use Juniper Networks BTI7800 with the Universal Forwarding Modules (UFM): UFM3 with coherent CFP and the UFM6.

Related Documentation

- TCX1000 Series Product Applications on page 53
- TCX1000-RDM20 Universal Port Rules on page 63
- TCX Series Optical Transport System Capacities on page 61
- TCX1000-RDM20 Overview on page 31

Understanding Multi-Degree ROADM Nodes

Pass-through enables you to configure multi-degree ROADM nodes and pass express traffic between ROADM degrees. This topic provides an overview of the channel connectivity when using pass-through versus directly connected add/drop channels.

2-Degree ROADM Node Example

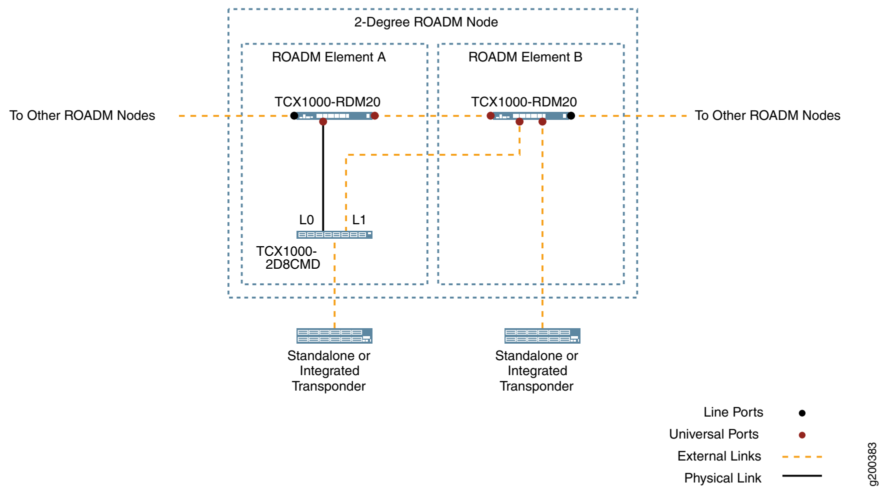
Figure 10 on page 71 shows an example of how devices can be connected together in a 2-degree ROADM node. A 2-degree ROADM node contains two ROADM elements, with each ROADM element connected to a line (or degree). These ROADM elements are labelled A and B in the example.

ROADM Element A consists of a TCX1000-RDM20 and a TCX1000-2D8CMD. The TCX1000-2D8CMD connects to a universal port on the TCX1000-RDM20 in ROADM Element A and to a universal port on the TCX1000-RDM20 in ROADM Element B. By connecting to both TCX1000-RDM20 devices, the 2D8CMD has add/drop access to wavelengths on both degrees, which is a prerequisite to setting up a service with redundant paths.

In contrast, ROADM Element B just consists of a TCX1000-RDM20, so it only has add/drop access to wavelengths on the line that it is attached to. The reason for this is that the TCX1000-RDM20 can only switch wavelengths between its universal ports and its line port. It cannot switch wavelengths from one universal port to another.

The external link shown between the TCX1000-RDM20 in ROADM Element A and ROADM Element B is the pass-through connection.

Figure 10: 2-Degree ROADM Node Example

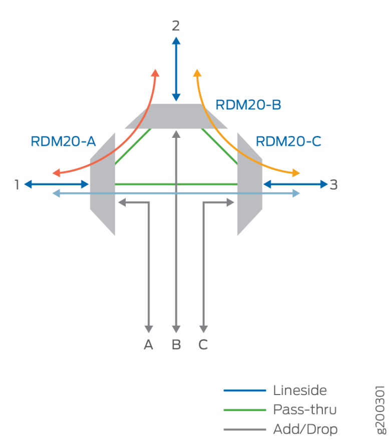


Understanding Pass-Through Connections

The TCX1000-RDM20 pass-through feature enables you to create multi-degree switching nodes and ring, mesh, and linear multi-span network configurations. Pass-through enables channels to be switched from one degree to another within the same ROADM node. Channels configured to take the pass-through path enter on one degree, are demultiplexed and routed to the designated pass-through universal port on the other ROADM degree, which multiplexes the channels and sends them out the line port of ROADM degree to the next node in the path.

Figure 11 on page 71 highlights the allowable channel connectivity for this pass-through configuration.

Figure 11: Allowable Channel Connectivity Using Pass-Through



In the configuration shown in Figure 11 on page 71, channels can be add/dropped to any of the three directions served by the node based on which ROADM element they are physically connected (see A, B, C) to or channels can be passed from one degree to another over the pass-through path between each degree in the node (see green lines between each node).

The multi-degree ROADM node in Figure 11 on page 71 consists of the following ROADM elements and degrees:

- 3 ROADM degrees:
  - Degree 1 is specific to the direction 1: RDM20-A
  - Degree 2 is specific to the direction 2: RDM20-B
  - Degree 3 is specific to the direction 3: RDM20-C
- 3 ROADM elements:
  - ROADM element: RDM20-A serves ROADM degree 1
  - ROADM element: RDM20-B serves ROADM degree 2
  - ROADM element: RDM20-C serves ROADM degree 3

Using pass-through connections, you can create a flexible connectivity map for the ROADM node. By interconnecting all ROADM degrees to all other ROADM degrees within the same node using pass-through, you can establish a fully non-blocking switching matrix.

In Figure 11 on page 71, a pass-through connection is configured between all three ROADM degrees in the node (see green lines), enabling full intra-ROADM mesh any-to-any connectivity between the ROADM degrees:

- Channels to/from direction 1 can connect to/from direction 2 (see red line)
- Channels to/from direction 1 can connect to/from direction 3 (see light blue line)
- Channels to/from direction 2 can connect to/from direction 3 (see orange line)

NOTE: **It is important to understand that the TCX1000-RDM20 only switches channels between its universal ports and its line port. It does not switch channels from one universal port to another universal on the same ROADM element. Channels connected to the universal ports of the TCX1000-RDM20 are always multiplexed by the ROADM and sent out the ROADM line port.**

Connecting and Configuring Pass-Through

To pass-through channels from one ROADM degree to another in a multi-degree node, you connect two universal ports on different ROADM degrees within a multi-degree node with a fiber cable and you create a logical link between the two universal ports. When you create a service, you simply select the two service endpoints and the proNX Optical Director automatically provisions the best path for the service.

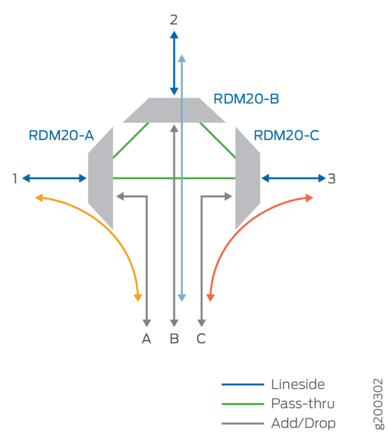
You can configure multiple channels to run over a single pass-through connection and you can create multiple pass-through connections between ROADM degrees in a multi-degree node.

Understanding Add/Drop Channel Connectivity in Multi-Degree ROADM Nodes

BEST PRACTICE: The ROADM node in Figure 12 on page 73 is capable of routing any directly connected channels to any degree the node serves as long as you connect your transceiver to the correct ROADM degree. In addition, it is important to take note of which ROADM degree you attach your transceivers to in multi-degree nodes (sites), to ensure the channel traverses the shortest path between source and destination.

Figure 12 on page 73 shows the same configuration but highlights the allowable add/drop channel connectivity of the ROADM node.

Figure 12: Allowable Channel Connectivity for Add/Drop Connections



In this configuration, channels (A, B, C) are add/dropped to the Line port of the ROADM element they are physically connected to. The allowable add/drop capabilities in this configuration are:

- Channel A can be switched only to/from RDM20-A degree 1 (orange line)
- Channel B can be switched only to/from RDM20-B degree 2 (red line)
- Channel C can be switched only to/from RDM20-C degree 3 (light blue line)

The following channel connectivity is *not allowed* on the ROADM node in Figure 12 on page 73:

- Channel A cannot be switched to/from degree 2
- Channel A cannot be switched to/from degree 3
- Channel B cannot be switched to/from degree 1
- Channel B cannot be switched to/from degree 3

- Channel C cannot be switched to/from degree 1
- Channel C cannot be switched to/from degree 2

The most important thing to understand about directly connecting channels to the universal (add/drop) ports in multi-degree ROADM nodes is that channels connected to the universal ports on the TCX1000-RDM20 are considered to be part of that ROADM degree that they are connected to and are sent or received to/from *only* that ROADM degree or line port. This capability is referred to as single direction colorless multiplexing. You can configure any wavelength you want on any universal port, that is the colorless operation and it is single direction because directly connected channels are always associated with the ROADM degree to which the channel transceiver is physically connected.

NOTE: **It is important to understand that the ROADM elements in** Figure 12 on page 73 **are completely capable of switching each channel in any direction by physically connecting the transceivers to the ROADM element serving the direction you want the channel switched.**

Related Documentation

- Creating Multi-Degree ROADM Nodes on page 74

Creating Multi-Degree ROADM Nodes

This topic describes how you can interconnect the TCX1000-RDM20 to deploy multi-degree ROADM nodes by using pass-through fiber connections on the universal ports of the TCX1000-RDM20 to interconnect ROADM degrees in multi-degree nodes. It includes the following subjects:

Refresher: Pass-Through Versus Directly Add/Drop Channels

Before we discuss how you create multi-degree ROADM nodes using pass-through, recall how pass-through and add/drop connections work:

- *Pass-Through Connections* — Enables you to pass through channels from one ROADM degree to another within a multi-degree node. Pass-through is therefore multi-directional. Pass-through is possible between any ROADM degrees that have universal port to universal port connectivity (which may not be every degree in every multi-degree ROADM node).
- *Add/Drop Connections* — Directly connected channels are always routed out the same ROADM element that they are physically connected to and are therefore, single direction.

BEST PRACTICE: TCX1000-RDM20 ROADM nodes are capable of switching any directly connected channels to any degree the node serves as long as you connect your transceiver to the correct ROADM element within the node.

In addition, it is important to take note of which ROADM degree you attach your transceivers to in multi-degree nodes (sites), to ensure the channel traverses the shortest path between source and destination.

In the following sections, we look at multi-degree ROADM node configurations and what their pass-through and add/drop capabilities are.

Creating 2-Degree ROADM Node Configurations

Using TCX1000-RDM20 pass-through, you can create 2-degree ROADM node configurations by interconnecting two ROADM degrees in a single node.

Figure 13: 2-Degree ROADM Node

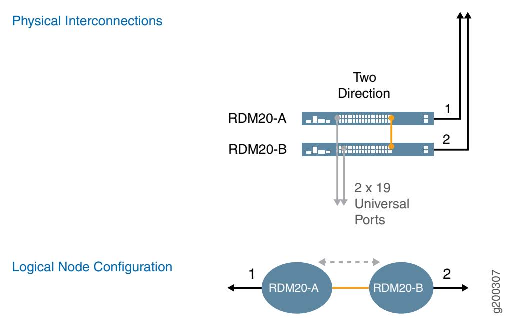


Figure 13 on page 75 shows a two-degree ROADM node. The top portion shows the physical interconnections needed to create the ROADM node. The bottom portion shows the logical node configuration.

To create this ROADM node configuration, you can use two TCX1000-RDM20 ROADM elements. In this example: RDM20-A and RDM20-B are interconnected with a fiber cable between a single universal port on each ROADM degree, allowing you to pass-through channels between direction 1 and 2. This creates a single ROADM node with two line directions (ROADM degree 1 and 2) and leaves 19 universal ports on RDM20-A and 19 universal ports on RDM20-B that you can use to directly add/drop traffic: 19 channels to/from degree 1 and 19 channels to/from degree 2.

Understanding the Pass-Through Capabilities in This Configuration

In Figure 13 on page 75, a single pass-through fiber connection exists between ROADM degrees: RDM20-A and RDM20-B. The proNX Optical Director automatically selects the pass-through path for services running between direction 1 and 2.

Understanding the Add/Drop Capabilities in This Configuration

The ROADM node configuration in Figure 13 on page 75 enables single direction colorless multiplexing:

- Channels connected to RDM20-A are always routed out degree 1.
- Channels connected to RDM20-B are always routed out degree 2.

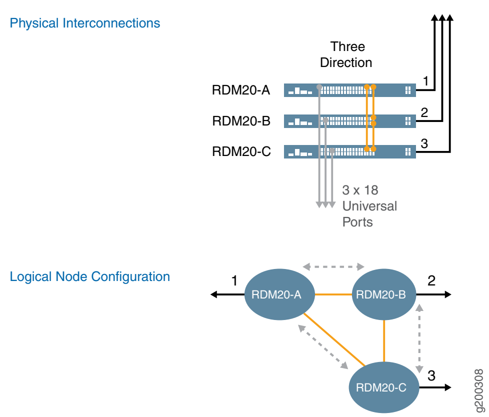
You can add/drop channels in either direction 1 or 2. However, you must physically connect the channel to the appropriate ROADM degree. Make sure to connect the channel to a universal port on the ROADM degree that is responsible for the direction in which you want the channel to be switched.

For example, to add/drop a channel to/from direction 1, you must connect the transceiver to a universal port on RDM20-A. Conversely, to add/drop a channel to/from direction 2, you must connect the transceiver to a universal port on RDM20-B.

Creating 3-Degree ROADM Node Configurations Using Pass-Through

Using the TCX1000-RDM20, you can create 3-degree nodes like the one shown in Figure 14 on page 76.

Figure 14: 3-Degree ROADM Node Using Pass-Through



In Figure 14 on page 76, shows a 3-degree ROADM node configuration. The top portion of this figure shows the physical interconnections needed to create the ROADM node and the bottom portion shows the logical node configuration.

To create this 3-degree ROADM node, you can use three TCX1000-RDM20s that are each interconnected with fiber cables between two universal ports on each ROADM degree, allowing you to pass-through channels between all three directions in the node. This leaves 18 universal ports on each ROADM element that you can use for add/drop traffic.

Understanding the Pass-Through Capabilities in This Configuration

Figure 14 on page 76 has three pass-through paths:

- Path between RDM20-A and RDM20-B
- Path between RDM20-A and RDM20-C
- Path between RDM20-B and RDM20-C

These pass-through paths enable any-to-any directional switching:

- Channels to/from direction 1 can be switched to/from direction 2
- Channels to/from direction 1 can be switched to/from direction 3
- Channels to/from direction 2 can be switched to/from direction 3

Understanding the Add/Drop Capabilities in This Configuration

In Figure 14 on page 76 you can add/drop channels in three possible directions: 1, 2, and 3. However, in order to do so, you must connect the channel transceiver to the appropriate ROADM degree within the node. Make sure to connect the channel transceiver to a universal port on the ROADM degree that is responsible for the direction in which you want the channel to be switched.

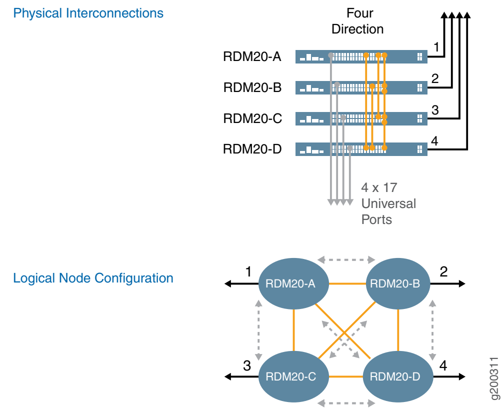
- To add/drop a channel to/from direction 1, connect the channel transceiver to a universal port on RDM20-A.
- To add/drop a channel to/from direction 2, connect the channel transceiver to a universal port on RDM20-B.
- To add/drop a channel to/from direction 3, connect the channel transceiver to a universal port on RDM20-C.

Creating 4-Degree ROADM Nodes Using Pass-Through

Using the TCX1000-RDM20, you can create 4-degree ROADM node configurations like the one in Figure 15 on page 78. The top portion of the figure shows the physical interconnections needed to create the ROADM node. The bottom portion shows the logical node configuration.

To create this node, you can use four TCX1000-RDM20s that are each interconnected with fiber cables between three universal ports on each ROADM degree, allowing you to pass-through channels between all four directions in the node. This leaves 17 universal ports on each ROADM degree that you can use to add/drop traffic.

Figure 15: 4-Degree ROADM Node Using Pass-Through



Understanding the Pass-Through Capabilities in This Configuration

The ROADM node in Figure 15 on page 78 has the following pass-through paths:

- Path between RDM20-A and RDM20-B
- Path between RDM20-A and RDM20-C
- Path between RDM20-A and RDM20-D
- Path between RDM20-B and RDM20-D
- Path between RDM20-B and RDM20-C
- Path between RDM20-C and RDM20-D

The ROADM node in Figure 15 on page 78 enables any-to-any directional switching including:

- Channels to/from direction 1 can connect to/from direction 2
- Channels to/from direction 1 can connect to/from direction 3
- Channels to/from direction 1 can connect to/from direction 4
- Channels to/from direction 2 can connect to/from direction 3
- Channels to/from direction 2 can connect to/from direction 4
- Channels to/from direction 3 can connect to/from direction 4

Understanding the Add/Drop Capabilities in This Configuration

In Figure 15 on page 78, you can add/drop channels in all four directions: 1, 2, 3 and 4. However, in order to do so, you must connect the channel transceiver to the appropriate ROADM degree within the node. Make sure to connect the channel transceiver to a universal port on the ROADM degree that is responsible for the direction you want the channel switched.

- To add/drop a channel to/from direction 1, connect the channel transceiver to a universal port on RDM20-A.
- To add/drop a channel to/from direction 2, connect the channel transceiver to a universal port on RDM20-B.
- To add/drop a channel to/from direction 3, connect the channel transceiver to a universal port on RDM20-C.
- To add/drop a channel to/from direction 4, connect the channel transceiver to a universal port on RDM20-D.

Related Documentation

- Understanding Multi-Degree ROADM Nodes on page 70
- TCX1000-RDM20 Universal Port Rules on page 63
- Supported Network Configurations on page 79

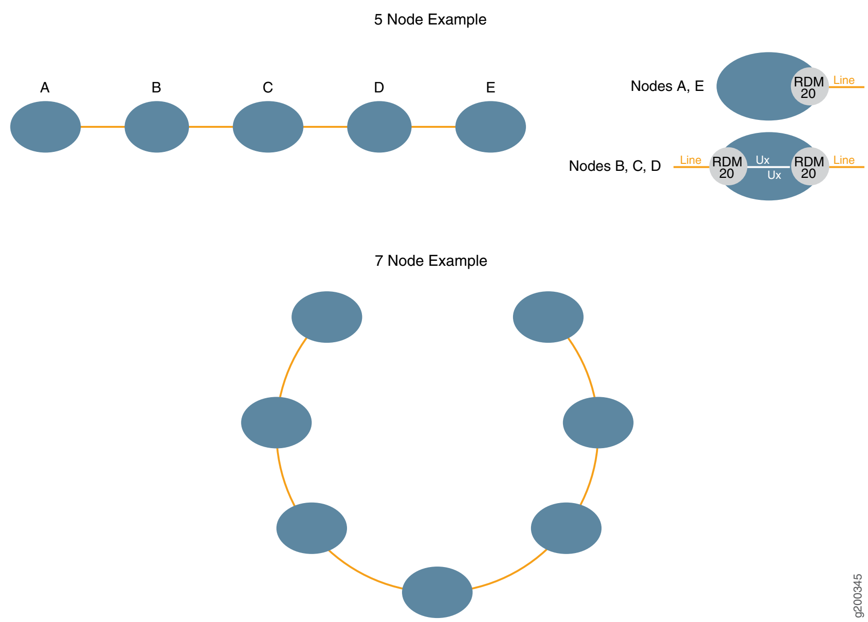
Supported Network Configurations

This topic describes and illustrates the various network configurations you can build with the TCX Series Optical Transport System.

Linear Multi-Span Multi-Access Network

Figure 16 on page 80 shows a five node linear multi-span, multi-access network configuration. In addition, a seven node configuration is shown that has two endpoints, which form a dual-homed configuration that is sometimes known as a horseshoe configuration.

Figure 16: Linear Multi-Span Multi-Access Network and Horseshoe Network Configuration



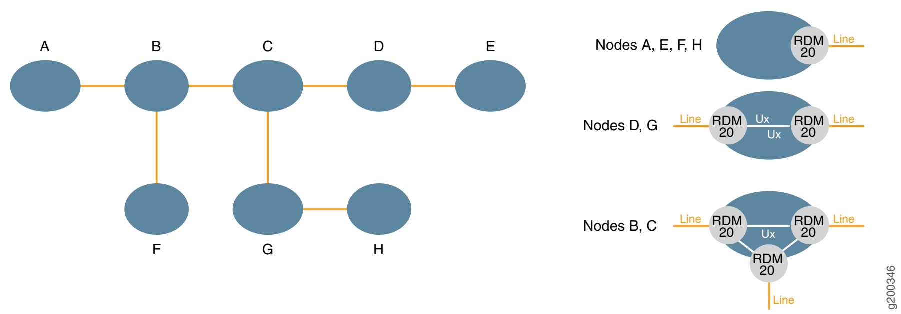
This network configuration uses the following:

- Each end node (A & E) is a single TCX1000-RDM20, 1-degree ROADM node.
- Middle nodes (B, C, D) consist of two TCX1000-RDM20s, which form a 2-degree ROADM node interconnected by fiber cables for passing channels to/from degrees.
- Line ports (duplex) connect to system fiber pairs.
- Pass-through fiber connections at 2-degree (middle) sites (B, C, D) uses universal ports.
- Transceivers can be directly connected the **Ux** ports on the TCX1000-RDM20 or can be connected to an optical multiplexer, which in-turn connects to a universal port on the TCX1000-RDM20.

Linear Multi-Span with Spurs

In Figure 17 on page 81 is a linear multi-span network with spurs.

Figure 17: Linear Multi-Span with Spurs



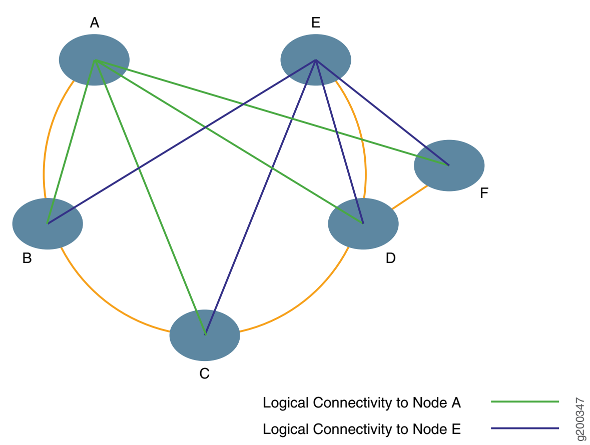
This network configuration uses the following:

- 1-degree sites (A,E,F,H) are formed with a single TCX1000-RDM20 at each end node.
- 2-degree sites (D,G) are formed with 2 x TCX1000-RDM20 at each pass-through node.
- 3-degree sites (B,C) are formed with 3 x TCX1000-RDM20 at each spur node.
- Line ports (duplex) are connected to system fiber pairs.
- Transceivers can be directly connected the **Ux** ports on the TCX1000-RDM20 or can be connected to an optical multiplexer, which in-turn connects to a universal port on the TCX1000-RDM20.

Horseshoe with Spur

In Figure 18 on page 81 is a linear horseshoe network configuration with dual homed hub sites (A and E).

Figure 18: Horseshoe with Spur



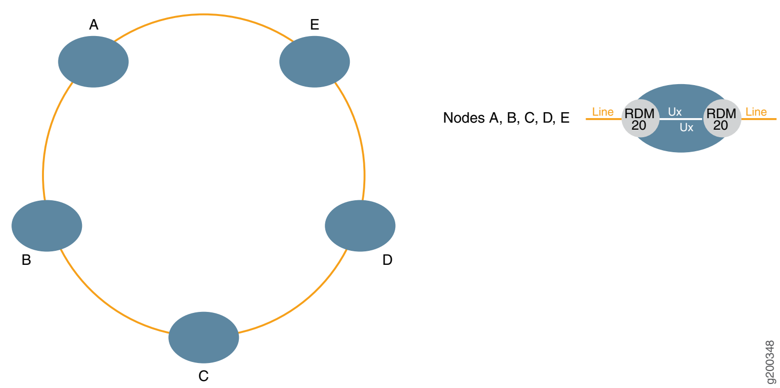
This network configuration uses the following:

- Sites B, C, D have redundant paths (and equipment) for connectivity to ROADM nodes A and E.
- Site F has a shared risk path between ROADM nodes F and D. Connection can then be optically switched by the ROADM node at D to either direction from nodes D to A and E.
- Protected sites (B,C,D) are preferred because they provide the most resilient connection.
- Sites with shared risk paths (F) are supported, but provide a less capable solution. However they may be used to collect additional traffic on to the network where limited fiber routes are available. If path from F to E is available it is the preferred path to extend horseshoe path.

Ring

In Figure 19 on page 82 is a ring network configuration.

Figure 19: Ring Network



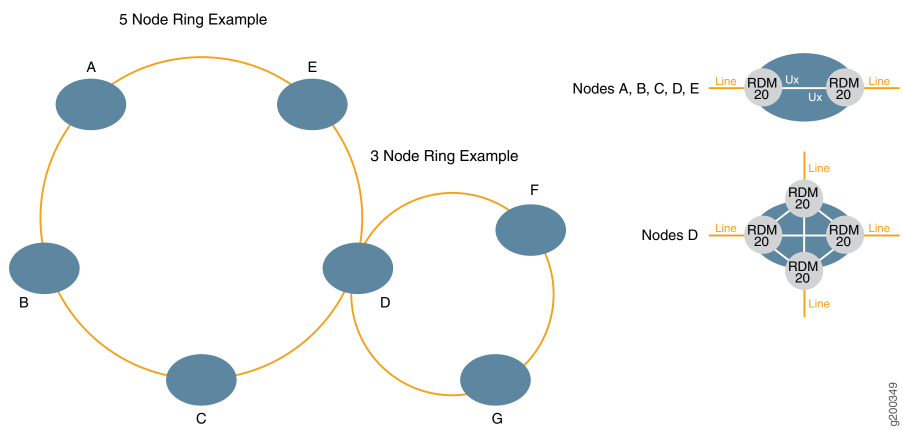
A ring network is composed of many 2-degree ROADM nodes. This example ring network configuration uses the following:

- All 2-degree sites (A,B,C,D,E) are formed with 2 x TCX1000-RDM20 at each pass-through node.
- Line ports (duplex) connected to system fiber pairs.
- Path forms closed optical ring.
- Transceivers can be directly connected the **Ux** ports on the TCX1000-RDM20 or can be connected to an optical multiplexer, which in-turn connects to a universal port on the TCX1000-RDM20.

Ring Interconnect

In Figure 20 on page 83 is a ring interconnect network configuration.

Figure 20: Ring Interconnect Network



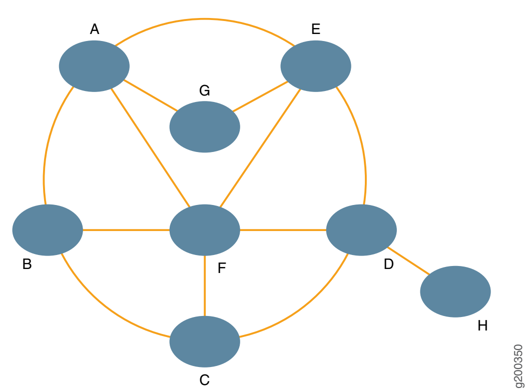
This network configuration uses the following:

- 2-degree sites (A,B,C,E,F,G) are formed with 2 x TCX1000-RDM20 at each pass-through node.
- 4-degree site (D) at ring interconnect is formed with 4 x TCX1000-RDM20.
- Line ports (duplex) connect to system fiber pairs.
- The 4-degree site (D) allows traffic to be switched from one ring to another.
- Transceivers can be directly connected the **Ux** ports on the TCX1000-RDM20 or can be connected to an optical multiplexer, which in-turn connects to a universal port on the TCX1000-RDM20.

Mesh

The mesh network in Figure 21 on page 83 combines characteristics of all previous network configurations.

Figure 21: Mesh Example 1

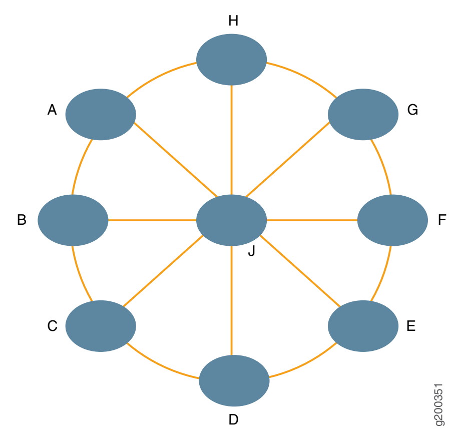


This network configuration uses the following:

- 1-degree site (H) is formed with a single TCX1000-RDM20
- 2-degree site (G) is formed with 2 x TCX1000-RDM20
- 3-degree sites (B,C) are formed with 3 x TCX1000-RDM20
- 4-degree sites (A,D, E) are formed with 4 x TCX1000-RDM20
- 5-degree site (F) is formed with 5 x TCX1000-RDM20
- Sites up to 20-degrees are supported by the TCX1000-RDM20
- Line ports (duplex) connect to system fiber pairs
- Transceivers can be directly connected the **Ux** ports on the TCX1000-RDM20 or can be connected to an optical multiplexer, which in-turn connects to a universal port on the TCX1000-RDM20.

Figure 22 on page 84 shows a high resilience mesh network configuration.

Figure 22: Mesh Example 2



This network configuration is highly resilient to multiple failures—each site has three independent paths to any other site:

- 3-degree sites (A,B,C,D,E,F,G,H) are formed with 3 x TCX1000-RDM20
- 8-degree site (J) is formed with 8 x TCX1000-RDM20
- Sites up to 20-degrees are supported by the TCX1000-RDM20
- Line ports (duplex) connect to system fiber pairs
- Transceivers can be directly connected the **Ux** ports on the TCX1000-RDM20 or can be connected to an optical multiplexer, which in-turn connects to a universal port on the TCX1000-RDM20.

Related Documentation

- Creating Multi-Degree ROADM Nodes on page 74
- Understanding Multi-Degree ROADM Nodes on page 70
- TCX1000-RDM20 Universal Port Rules on page 63

Best Practices for Using the TCX1000-ILA in Linear Multi-Span, Ring and Mesh Networks

You can use the TCX1000-ILA in point-to-point, linear multi-span, ring and mesh networks. This topic describes the best practices for using the TCX1000-ILA in these networks.

BEST PRACTICE: When planning your network, take into consideration whether sites will or will not require traffic access. If you know that a site will never require traffic access, deploy the TCX1000-ILA as a lower cost solution. However, if you know that in the future, the site will require traffic access, the best solution is to deploy a ROADM node (with a minimum of two TCX1000-RDM20 devices for two directional traffic). This strategy enables you to implement the future traffic access without disrupting traffic in your network. If you choose to upgrade from a TCX1000-ILA to a TCX1000-RDM20 in the future, be aware that this hardware change will be service disruptive to traffic in your network.

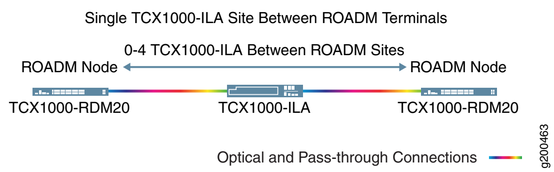
NOTE: We recommend no more than four TCX1000-ILA amplifiers be cascaded between two ROADM nodes.

TCX1000-ILA in Linear Multi-Span Networks

You can use the TCX1000-ILA in linear multi-span point-to-point networks. Although you can create multi-span point-to-point networks using all ROADM nodes, if there is no requirement to add or drop traffic at a node, a lower cost and higher performance solution is to use a dedicated inline amplifier (TCX1000-ILA) for this boosting application. The TCX1000-ILA provides lower noise amplification than the ROADM nodes, therefore it improves the OSNR and the reach of the optical network. However, by design, the TCX1000-ILA does not provide the spectral equalization capability that is delivered by the ROADM node and so transmission power disparity across the WDM wavelength complement can accumulate through the network. As a result, we recommend no more than four TCX1000-ILA amplifiers be cascaded in the amplifier chain between two ROADM nodes. The optical signal is re-equalized at the ROADM pass-through node and then additional amplifier sites can be used in the path. This ROADM node with TCX1000-ILA configuration is illustrated in the Figure 23 on page 86 and Figure 24 on page 86 below.

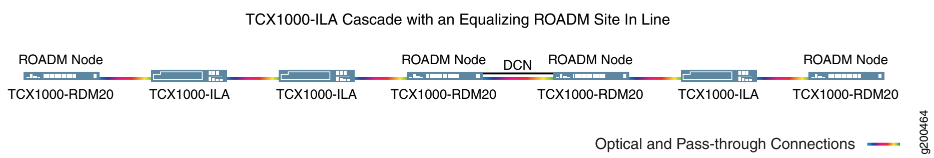
The first example in Figure 23 on page 86 shows a single TCX1000-ILA site between ROADM Terminals to increase the network reach (note that there is no add/drop at the TCX1000-ILA site).

Figure 23: Single TCX1000-ILA Site Between Two ROADM Terminals



The second example in Figure 24 on page 86 shows a TCX1000-ILA cascade with an equalizing ROADM node in line.

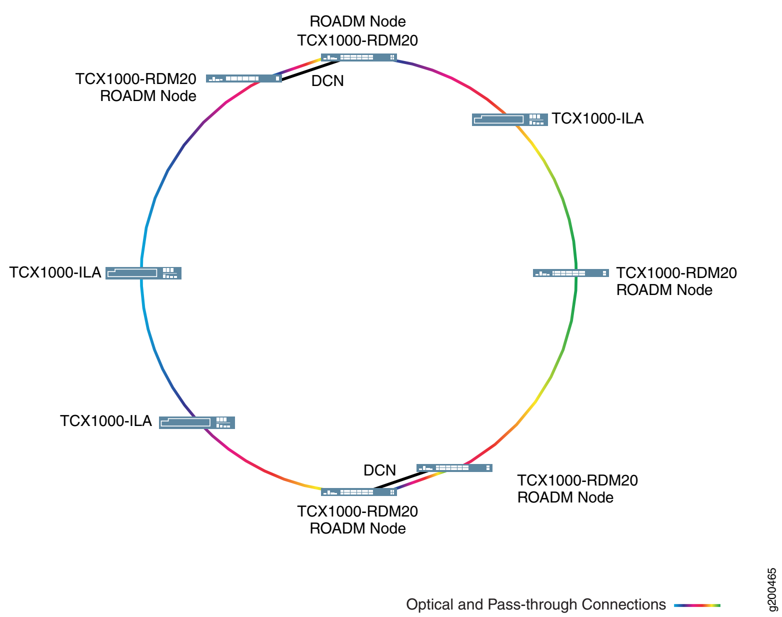
Figure 24: TCX1000-ILA Cascade With an Equalizing ROADM Site In Line



TCX1000-ILA in Ring and Mesh Networks

You can use the same reduced-cost TCX1000-ILA design placement when creating ring and mesh networks where traffic access is not required as the example shown in Figure 25 on page 86 shows.

Figure 25: TCX1000-ILA Ring Network



Related Documentation

- TCX1000-ILA Inline Amplifier Overview on page 40
- Management Communications Examples for TCX1000 Linear Multi-Span Networks on page 123

- Management Communications Examples for TCX1000 Ring Networks on page 133
- Understanding Multi-Degree ROADM Nodes on page 70

CHAPTER 10

Understanding ROADM Node Multiplexing Strategies

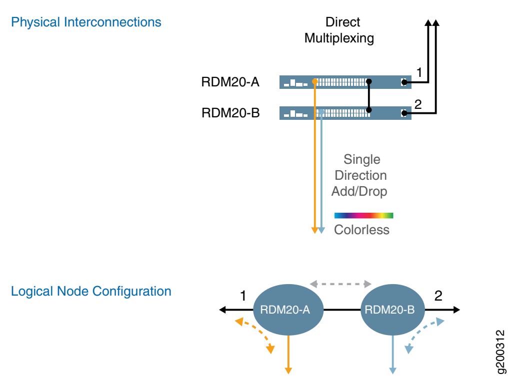
Understanding Direct Multiplexing on the TCX1000-RDM20 ROADM

This topic describes how you an use the universal ports on the TCX1000-RDM20 for direct multiplexing.

Direct ROADM Multiplexing With the TCX1000-RDM20

Figure 26 on page 89 shows a 2-degree linear multi-span ROADM node. The top portion shows the physical interconnections needed to create the ROADM node. The bottom portion shows the logical node configuration.

Figure 26: Single Direction Add/Drop Colorless Direct Multiplexing with TCX1000-RDM20 ROADM



The 2-degree ROADM node in Figure 26 on page 89 provides single direction add/drop colorless multiplexing and demultiplexing. A single universal port on each ROADM element is used for a pass-through connection, leaving 38 ports for direct add/drop traffic: 19 universal ports on RDM20-A and 19 universal ports on RDM20-B for directly connected, single direction add/drop traffic.

The following sections describe how multiplexing and demultiplexing works for directly connected add/drop channels and for pass-through connections in this configuration.

Multiplexing

Add/Drop Channels

The thing to keep in mind with channels that are directly connected to the TCX1000-RDM20 universal ports, is that they are always switched over the Line port of the TCX1000-RDM20 the channel is physically connected to.

Channels directly connected to the TCX1000-RDM20 are multiplexed and sent out the Line port of their respective ROADM degree:

- Channels directly connected to ROADM degree: RDM20-A are multiplexed and sent out direction 1.
- Channels directly connected to ROADM degree: RDM20-B are multiplexed and sent out direction 2.

Pass-Through Channels

Pass-through channels act differently than directly add/dropped channels. Channels that you configure to take a pass-through connection are multiplexed as:

- Pass-through channels coming in from direction 1 are demultiplexed by RDM20-A and passed to the RDM20-B pass-through port. The pass-through channels are then multiplexed by RDM20-B and sent out direction 2.
- Pass-through channels coming in from direction 2 are demultiplexed by RDM20-B and passed to the RDM20-A pass-through port. The pass-through channels are then multiplexed by RDM20-A and sent out direction 1.

In summary, pass-through channels are simply passed through the node, in one Line port and out a different Line port; they are never dropped at the node.

Demultiplexing

Add/Drop Channels

- Channels arriving from direction 1, arrive on the line port of RDM20-A and are demultiplexed by RDM20-A and dropped to their appropriate universal ports.
- Channels arriving from direction 2, arrive on the line port of RDM20-B and are demultiplexed by RDM20-B and dropped to their appropriate universal ports.

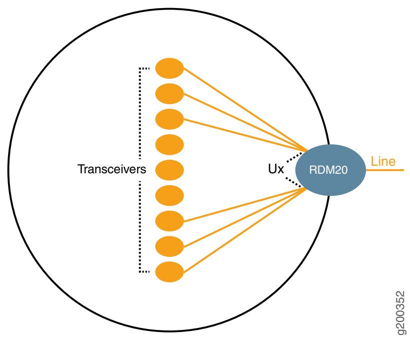
Pass-Through Channels

Channels that you configure to take the pass-through connection are demultiplexed as:

- Pass-through channels from direction 1 arrive on the line port of RDM20-A. The channels are demultiplexed and sent to the RDM20-A pass-through port and passed to the RDM20-B pass-through port. The pass-through channel is then multiplexed by RDM20-B and sent out direction 2.
- Pass-through channels from direction 2 arrive on the line port of RDM20-B. The channels are demultiplexed and sent to the RDM20-B pass-through port and passed to the RDM20-A pass-through port. The pass-through channel is then multiplexed by RDM20-A and sent out direction 1.

Summary of Direct ROADM Multiplexing

Figure 27: Summary of Direct ROADM Multiplexing



Referring to Figure 27 on page 91, coherent transceiver interfaces connect directly to the universal (**Ux**) ports on the TCX1000-RDM20. This provides channel ports which are:

- Colorless
- Single direction (defined by TCX1000-RDM20 direction)
- Supports non-coherent channels

The number of **Ux** ports available at a node depends on what is used for other connections. For example are pass-through connections configured on the universal ports. To calculate the available universal ports on each ROADM degree, use the following:

There are 20-(N-1) universal ports available on the ROADM degree, where *N* is the number of directions at a ROADM node.

For example:

- In a 1-degree site (terminal) there are 20 available universal ports on the ROADM
- In 2-degree site (terminal) there are 19 available universal ports on each ROADM degree for a total of 2x19=38 universal ports for the ROADM node
- In 3-degree site (terminal) there are 18 available universal ports on each ROADM degree for a total of 3x18=54 universal ports for the ROADM node

Related Documentation

- Understanding TCX1000-RDM20 and TCX1000-2D8CMD Multiplexing Capabilities on page 92
- Supported Network Configurations on page 79
- TCX1000-RDM20 Universal Port Rules on page 63

Understanding TCX1000-RDM20 and TCX1000-2D8CMD Multiplexing Capabilities

Introduction

The TCX1000-RDM20 has twenty universal ports that you can use for directly adding/dropping channels onto a ROADM degree, passing channels through from one ROADM degree to another, or for connecting an optical multiplexer-demutiplexer to add/drop more channels to the TCX1000-RDM20.

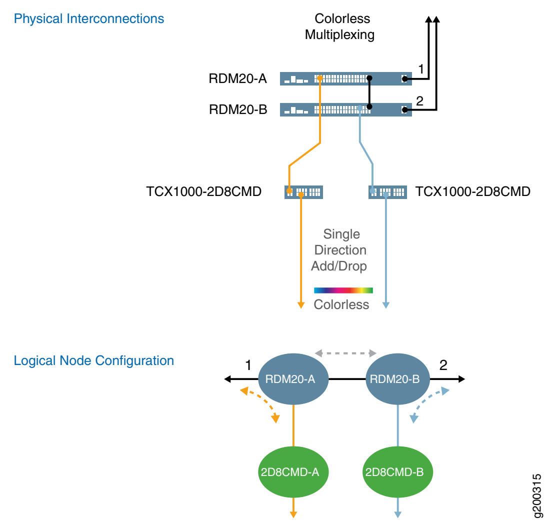
This section describes how you can use the TCX1000-2D8CMD multiplexer with the TCX1000-RDM20 for both single and multi-direction colorless add/drop multiplexing. This section also describes how multiplexing and demultiplexing works in this configuration for both directly added/dropped channels and pass-through channels.

NOTE: **The TCX1000-2D8CMD client ports require coherent transceivers.**

Single Direction Add/Drop Colorless Multiplexing with TCX1000-2D8CMD

Figure 28 on page 93 shows a 2-degree linear multi-span ROADM node. The top portion shows the physical interconnections needed to create the ROADM node. The bottom portion shows the logical node configuration.

Figure 28: Single Direction Add/Drop Colorless Multiplexing with TCX1000-2D8CMD



In Figure 28 on page 93 is a ROADM node that includes two elements, RDM20-A and 2D8CMD-A form one ROADM element serving degree 1 and RDM20-B and 2D8CMD-B form another ROADM element serving degree 2. This 2-degree node provides single direction colorless multiplexing for connected channels; connected channels are always routed out the ROADM degree that they are physically connected to. As such, in this configuration, you can add/drop channels for direction 1 by connecting your transceivers to either RDM20-A or 2D8CMD-A and you can add/drop channels for direction 2 by connecting your transceivers to either RDM20-B or 2D8CMD-B.

Also in this ROADM node configuration, a single universal port on each TCX1000-RDM20 is used to pass channels between the two ROADM degrees. Another universal port connects the line port of the TCX1000-2D8CMD multiplexer. This configuration leaves you 18 universal ports on RDM20-A and 18 universal ports on RDM20-B, as well as 8 additional ports on each TCX1000-2D8CMD.

The following sections describe how multiplexing and demultiplexing works for directly connected add/drop channels and for pass-through channels in this configuration.

Multiplexing

Add/Drop Channels

- Channels directly connected to the clients ports (**Cx**) on 2D8CMD-A are combined and broadcast out the **Lx Out** port(s) to the connected universal port on RDM20-A, which multiplexes the channels and routes them out degree 1.
- Channels directly connected to the clients ports (**Cx In**) on 2D8CMD-B are combined and broadcast out the **Lx Out** port(s) to the connected universal port on RDM20-B, multiplexes the channels and routes them out degree 2.

Pass-Through Channels

The configuration in Figure 28 on page 93 enables you to pass through channels between degree 1 and degree 2:

- Pass-through channels from direction 1 are received on the line port of RDM20-A, which demultiplexes the channels and sends it out the universal port on RDM20-A to the universal port on RDM20-B. RDM20-B multiplexes the pass-through channel and sends it out direction 2.
- Pass-through channels from direction 2 are received on the line port of RDM20-B, which demultiplexes the channel and sends it out the universal port on RDM20-B to the universal port on RDM20-A. RDM20-A multiplexes the pass-through channel and sends it out direction 1.

Demultiplexing

Add/Drop Channels

- Channels coming in from direction 1 are demultiplexed by RDM20-A and dropped to the appropriate universal port. Channels destined to 2D8CMD-A, now present at **Lx In** port of 2D8CMD-A , are broadcast to the 8 channel output ports (**Cx Out** ports) on 2D8CMD-A.
- Channels coming in from direction 2 are demultiplexed by RDM20-B and dropped to the appropriate universal port. Channels destined to 2D8CMD-B, now present at the **Lx In** port, are broadcast to the 8 channel output ports (**Cx Out** ports) on 2D8CMD-B.

NOTE: The connected coherent transceivers are responsible for selecting their corresponding wavelength and filtering out the impact of the unwanted broadcast channels. As such, the TCX1000-2D8CMD is suitable for coherent *only* applications.

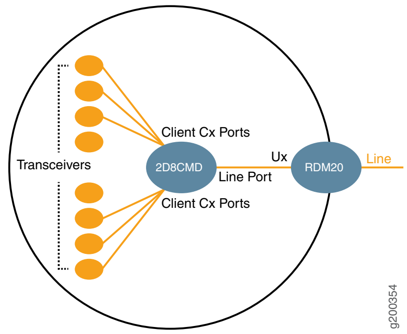
Pass-Through Channels

- A pass-through channel coming in from direction 1 is demultiplexed by ROADM element RDM20-A and sent out the **Ux Out** pass-through port on RDM20-A to the **Ux In** pass-through port on RDM20-B, which multiplexes the pass-through channel and sends it out direction 2.
- A pass-through channel coming in from direction 2 is demultiplexed by ROADM element RDM20-B and sent out the **Ux Out** pass-through port on RDM20-B to the **Ux In** pass-through port on RDM20-A, which multiplexes the pass-through channel and sends it out direction 1.

Summary of Colorless Single Direction Multiplexing

Figure 29 on page 95 summarizes colorless single direction multiplexing.

Figure 29: Colorless One-Direction Multiplexing



Coherent transceiver interfaces connect to the eight client ports on the TCX1000-2D8CMD. The line port of the TCX1000-2D8CMD connects to a single **Ux** port on the TCX1000-RDM20. The TCX1000-2D8CMD can be thought of as an 8:1 port expander. This configuration provides channel ports that are:

- Colorless
- Single direction (direction is defined by the connected TCX1000-RDM20 degree)

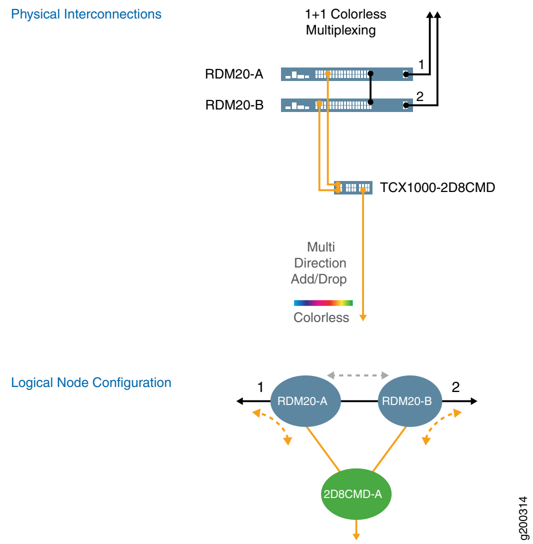
NOTE: There is no spectral policing on the TCX1000-2D8CMD, so that if the same channel is applied to two or more client ports of a single TCX1000-2D8CMD, interference can occur between the channels.

NOTE: This configuration does not work with non-coherent channels.

Multi-Direction Add/Drop Colorless Multiplexing with TCX1000-RDM20 and TCX1000-2D8CMD

Figure 30 on page 96 shows a 2-degree linear multi-span ROADM node that supports multi-direction add/drop capability. The top portion shows the physical interconnections needed to create the ROADM node. The bottom portion shows the logical node configuration.

Figure 30: Multi-Direction Add/Drop Colorless Multiplexing with TCX1000-RDM20 and TCX1000-2D8CMD



The 2-degree ROADM node in Figure 30 on page 96 provides multi-direction add/drop colorless multiplexing by leveraging the TCX1000-2D8CMD dual line ports. In this node configuration, a single universal port on each ROADM element (RDM20-A and RDM20-B) is used for a pass-through connection. Another universal port on each ROADM element connects to the two line ports (L*x*) of the TCX1000-2D8CMD. This configuration leaves you 36 universal ports for add/drop traffic: 18 universal ports on RDM20-A and 18 universal ports on RDM20-B, as well as 8 additional ports on the TCX1000-2D8CMD.

The following sections describe how multiplexing and demultiplexing works for directly connected add/drop channels and for pass-through channels in this configuration.

Multiplexing

Add/Drop Channels

Channels directly connected to the **Cx In** ports on ROADM element: 2D8CMD-A are combined and broadcast out both **Lx Out** ports to the connected universal ports on RDM20-A and RDM20-B. Channels configured to take the path to direction 1 are multiplexed by RDM20-A and sent out direction 1. Channels configured to take the path to direction 2 are multiplexed by RDM20-B and sent out direction 2.

The TCX1000-2D8CMD broadcasts the same composite signal out both line ports and the ROADM (TCX1000-RDM20) elements manage the channel selection. This allows a channel connected to the TCX1000-2D8CMD to be routed out either degree 1 or degree 2 of the ROADM node. This provides flexibility to re-configure the network remotely, allowing for rapid re-configuration of services, tidal traffic flow or automated optical restoration applications.

The TCX1000-2D8CMD provides the simplest form of a multi-direction solution where the output from the 8 to 1 combiner is broadcast in 2 directions. This is primarily intended for 1 + 1 redundancy applications.

NOTE: The TCX1000-2D8CMD broadcasts channels present on the **Cx In** ports out both **Lx Out** ports. You specify the path for these channels on the TCX1000-RDM20 when you define the channel service.

Pass-Through Channels

The 2-degree ROADM node in Figure 30 on page 96 enables you to pass through channels from degree 1 to degree 2 and from degree 2 to degree 1:

- Pass-through channels from direction 1 are received on the line port of ROADM element: RDM20-A, which demultiplexes the channel and sends it out the universal port on RDM20-A to the universal port on RDM20-B. RDM20-B multiplexes the pass-through channel and sends it out direction 2.
- Pass-through channels from direction 2 are received on the line port of ROADM element: RDM20-B, which demultiplexes the channel and sends it out the universal port on RDM20-B to the universal port on RDM20-A. RDM20-A multiplexes the pass-through channel and sends it out direction 1.

Demultiplexing

Add/Drop Channels

Channels coming in from direction 1 that are destined for ROADM element: 2D8CMD-A are demultiplexed by RDM20-A and sent over the universal port to the connected line port on 2D8CMD-A. 2D8CMD-A demultiplexes the channels and broadcasts them to the **Cx Out** ports.

Channels coming in from direction 2 that are destined for ROADM element: 2D8CMD-A are demultiplexed by RDM20-B and sent over the universal port to the connected line port on 2D8CMD-A. 2D8CMD-A demultiplexes the channels and broadcasts them to the **Cx Out** ports.

NOTE: The TCX1000-2D8CMD broadcasts channels present on the **Cx In** ports out both **Lx Out** ports. You specify the path for these channels on the TCX1000-RDM20 when you define the channel service.

Pass-Through Channels

- A pass-through channel coming in from direction 1 is demultiplexed by ROADM element RDM20-A and sent out the **Ux Out** port on RDM20-A to the **Ux In** port on RDM20-B, which multiplexes the pass-through channel and sends it out direction 2.
- A pass-through channel coming in from direction 2 is demultiplexed by ROADM element RDM20-B and sent out the **Ux Out** port on RDM20-B to the **Ux In** port on RDM20-A, which multiplexes the pass-through channel and sends it out direction 1.

Summary Colorless 1+1 Redundancy Multiplexing

Figure 31: Summary Colorless 1+1 Multiplexing

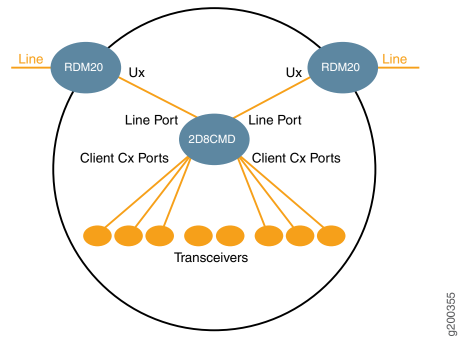


Figure 31 on page 98 summarizes colorless 1+1 redundancy multiplexing. Coherent transceiver interfaces connect to the eight TCX1000-2D8CMD client ports. The two line ports from the TCX1000-2D8CMD each connect to a single universal port on TCX1000-RDM20. This configuration provides channel ports that are:

- Colorless
- Multi-direction — channels can be sent/received in two directions, as determined by the TCX1000-RDM20 configuration

NOTE: The TCX1000-2D8CMD broadcasts channels present on the **Cx In** ports out both **Lx Out** ports. The configuration of the connected TCX1000-RDM20 is responsible for determining which channels are multiplexed by the TCX1000-RDM20 and sent out its line port.

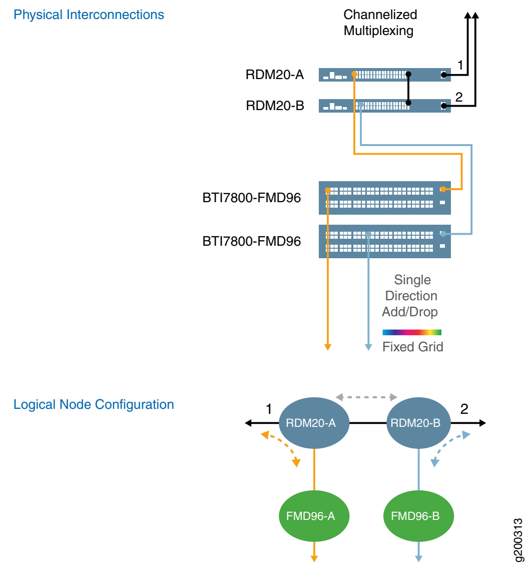
Related Documentation

- TCX1000-2D8CMD Colorless Multiplexer-Demultiplexer Overview on page 36
- Understanding Multi-Degree ROADM Nodes on page 70
- Supported Network Configurations on page 79
- Creating Multi-Degree ROADM Nodes on page 74

Understanding TCX1000-RDM20 and BTI7800-FMD96 Multiplexing Capabilities

Figure 32 on page 99 shows a 2-degree linear multi-span ROADM node that supports single direction fixed-grid add/drop capability. The top portion shows the physical interconnections needed to create the ROADM node. The bottom portion shows the logical node configuration.

Figure 32: Single Direction Channelized Multiplexing with TCX1000-RDM20 and BTI7800-FMD96 Fixed Multiplexer



The 2-degree linear multi-span ROADM node in Figure 32 on page 99 provides single direction fixed-grid add/drop multiplexing by using the Juniper Networks BTI7800-FMD96 optical multiplexer-demultiplexer. The BTI7800-FMD96 is a 96 channel fixed multiplexer-demultiplexer that provides fixed grid access to all 96 wavelengths in the DWDM 50 GHz channel plan. In this ROADM node configuration, a single universal port on each ROADM element (RDM20-A and RDM20-B) is used for a pass-through connection. Another universal port on each ROADM element connects to the line port of the BTI7800-FMD96: the universal port on RDM20-A connects to the line port of FMD96-A and the universal port on RDM20-B connects to the line of FMD96-B. This configuration enables 96 channels in direction 1 and 96 channels and direction 2.

The following sections describe how multiplexing and demultiplexing works for directly connected add/drop channels and for pass-through channels in this configuration.

Multiplexing

Add/Drop Channels

- Channels directly connected to the clients ports of FMD96-A are multiplexed and sent out the line port to the universal port on RDM20-A. RDM20-A further multiplexes the channels and sends them out the line port of RDM20-A to direction 1.

- Channels directly connected to the clients ports of FMD96-B are multiplexed and sent out the line port to the universal port on RDM20-B. RDM20-B further multiplexes the channels and sends them out the line port of RDM20-B to direction 2.

Pass-Through Channels

The 2-degree ROADM node in Figure 32 on page 99 enables you to pass through channels from direction 1 to direction 2 and from direction 2 to direction 1:

- Pass-through channels from direction 1 are received on the line port of ROADM element: RDM20-A, which demultiplexes the channels and sends them out the universal port on RDM20-A to the universal port on RDM20-B. RDM20-B multiplexes the pass-through channel and sends them out direction 2.
- Pass-through channels from direction 2 are received on the line port of ROADM element: RDM20-B, which demultiplexes the channels and sends them out the universal port on RDM20-B to the universal port on RDM20-A. RDM20-A multiplexes the pass-through channels and sends them out direction 1.

Demultiplexing

Add/Drop Channels

Channels coming in from direction 1 that are destined for ROADM element: FMD96-A are demultiplexed by RDM20-A and sent over the universal port to the connected line port on FMD96-A. FMD96-A demultiplexes the channels and sends them to the **Cx Out** ports.

Channels coming in from direction 2 that are destined for ROADM element: FMD96-B are demultiplexed by RDM20-B and sent over the universal port to the connected line port on FMD96-B. FMD96-B demultiplexes the channels and sends them to the **Cx Out** ports.

Pass-Through Channels

- A pass-through channel coming in from direction 1 is demultiplexed by ROADM element RDM20-A and sent out the **Ux Out** port on RDM20-A to the **Ux In** port on RDM20-B, which multiplexes the pass-through channel and sends it out direction 2.
- A pass-through channel coming in from direction 2 is demultiplexed by ROADM element RDM20-B and sent out the **Ux Out** port on RDM20-B to the **Ux In** port on RDM20-A, which multiplexes the pass-through channel and sends it out direction 1.

Summary of Single Direction Channelized Multiplexing with TCX1000-RDM20 and BTI7800-FMD96 Fixed Multiplexer

Figure 33: Summary of Single Direction Channelized Multiplexing with TCX1000-RDM20 and BTI7800-FMD96 Fixed Multiplexer

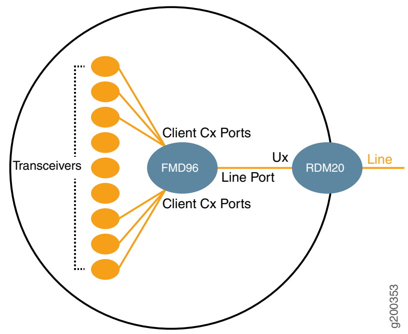


Figure 33 on page 101 summarizes single direction channelized multiplexing with the TCX1000-RDM20 and BTI7800-FMD96 fixed multiplexer. Coherent transceiver interfaces connect to the client ports of the BTI7800-FMD96, which provides 96 ports on a fixed 50 GHz grid. The BTI7800-FMD96 Line port connects to single universal port on the TCX1000-RDM20.

NOTE: Spectrum is *not* reserved on the TCX1000-RDM20. Channel slots on the Line port are only used if you provision them.

This provides a channel ports which are:

- Colored (fixed 50 GHz grid)
- Single direction (defined by the TCX1000-RDM20 direction)
- Supports non-coherent channels

Related Documentation

- Understanding Direct Multiplexing on the TCX1000-RDM20 ROADM on page 89
- Understanding TCX1000-RDM20 and TCX1000-2D8CMD Multiplexing Capabilities on page 92

CHAPTER 11

Deployment Rules for Network Management and Optical Service Channel

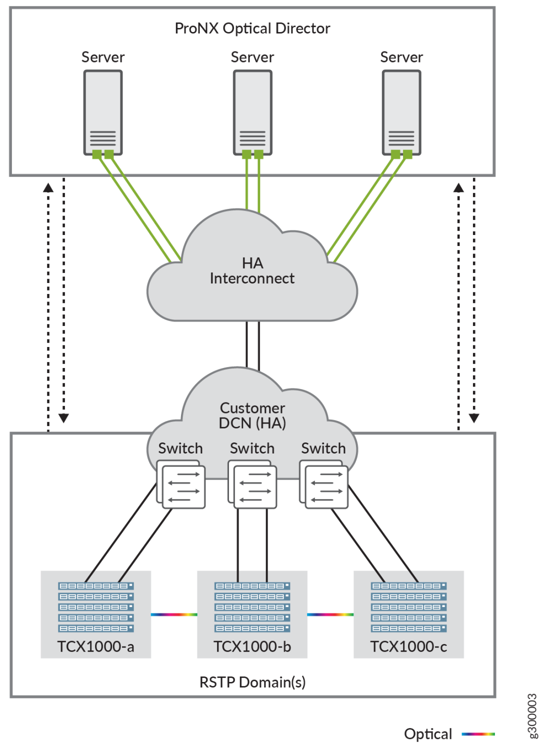
TCX1000 Management Architecture

This topic describes the TCX1000 management architecture including the hardware operation and management communication ports and port rules.

Understanding the TCX1000 Management Architecture

Figure 34 on page 104 shows the management network architecture for the TCX1000 Series, which is based on high availability (HA) communication or redundant paths between the proNX Optical Director and TCX1000 devices in the optical network. The management network that connects the proNX Optical Director to the devices that it manages is called the Data Communication Network (DCN).

Figure 34: TCX1000 Management Networking Architecture



Along with the management traffic, the DCN carries the optical control traffic that allows the proNX Optical Director to control the optical links on the devices that it manages. In this role, the proNX Optical Director processes streams of optical link metrics from the TCX1000 devices and constantly adjusts the attenuators and amplifiers within each device to ensure optimal link performance at all times even as optical wavelength services are added and deleted from the network. This real-time control loop requires a continuous and reliable communication path between the proNX Optical Director and each TCX1000 device under control and management, which places strict requirements on the DCN.

High Availability

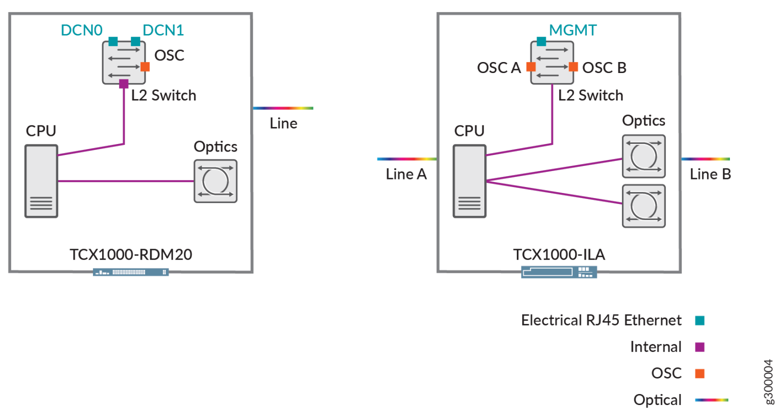
In order to provide the reliability required for the proNX Optical Director to act as an optical link controller, the DCN must be designed for high availability (HA). An HA network provides 99.999% availability, supports diverse links, and has no single point of failure. An HA system is intended for continuous operation and has redundant components and adequate backup and failover strategies. The DCN must be highly fault tolerant where a single failure does not isolate part of the network. The data center where the proNX Optical Director servers are situated must be hardened and be able to survive power outages and disastrous events.

Redundant Management Communications to Each TCX1000 Device

Similarly, every managed TCX1000 device (TCX1000-RDM20 and TCX1000-ILA must have redundant links to your Ethernet DCN HA for management communications. In Figure 34 on page 104, we can see that all TCX1000 nodes in the optical network are connected to the DCN HA through an external Layer 2 switch and the Ethernet management communication ports on the TCX1000 devices.

BEST PRACTICE: The fastest and best method to use for management communications to TCX1000 devices is to connect the device's Ethernet management communication ports to your Ethernet DCN HA using an external Layer 2 RSTP-enabled switch.

Figure 35: TCX1000-RDM20 and TCX1000-ILA Hardware Management Communication Architecture



TCX1000 IP Management Communications

TCX1000 devices uses two IP addresses for management communications:

- Local IP address — used only to communicate locally with the TCX1000 device.
- Remote IP address — used for all communications with the proNX Optical Director.

NOTE: The proNX Optical Director resides in your HA network and as such, the TCX1000 devices on your DCN HA are considered to be remotely managed.

For remotely managed TCX1000 devices, the proNX Optical Director always addresses management messages to the remote IP address of the TCX1000 device.

The protocol used to communicate with the proNX Optical Director is IP.

How the Communication Ports on TCX1000 Devices Work

Figure 35 on page 105 illustrates the internal hardware management communications architecture used by the TCX1000-RDM20 (on the left) and TCX1000-ILA (on the right).

Both the TCX1000-RDM20 (left) and TCX1000-ILA (left) have an internal CPU to which all management communications occur. The external ports on each device communicate with the CPU through an internal RSTP-enabled Layer 2 switch. The proNX Optical Director management messages are sent to and from the CPU over external ports to the internal Layer 2 switch.

If a management message is addressed to the local TCX1000 device, the CPU responds to the message out the same port the message was received on. If the message is not addressed to the local TCX1000 device, the CPU consults its address table to identify which port it has seen the address on previously. If it has received messages from the address previously, it will have a record of which port it received the message on, and it will forward the message out that port. If the CPU consults its address table and finds no record of the address, it will broadcast the message out all ports.

TCX1000-RDM20 Management Communication Port Rules

Rules — For redundant management communication paths, you must connect the TCX1000-RDM20 device to your DCN HA using at least two of three ports described in Table 9 on page 106.

Table 9: TCX1000-RDM20 Management Communications Port Rules

TCX1000-RDM20 Port	How Communications Work	Notes
DCN0 **DCN1**	Management messages received on either of the **DCN** ports are sent to the internal CPU. If the message is addressed to the local device, the CPU will act upon the message and respond over its **DCN** port. If the message is addressed to a remote TCX1000 device connected to the TCX1000-RDM20 **Line** port the TCX1000-RDM20 forwards the message out its **Line** port if OSC forwarding is enabled. If the message is addressed to a remote TCX1000 device connected through the TCX1000-RDM20's other **DCN** port such, as in a multi-degree ROADM node configuration or when the DCN ports are daisy-chained together, the message is forwarded out the other **DCN** port	BEST PRACTICE: The **DCN** ports shown in Figure 35 on page 105) are directly connected through the internal RSTP-enabled Layer 2 switch to the CPU and the DCN ports are connected to the DCN HA through an external RSTP-enabled Layer 2 switch. This is the recommended method of deployment.

Table 9: TCX1000-RDM20 Management Communications Port Rules (continued)

TCX1000-RDM20 Port	How Communications Work	Notes
Line	Management messages received on the **Line** port are sent to the internal CPU. If the message is addressed to the local TCX1000-RDM20, the CPU will act upon the message and respond over its **Line** port. If the message is addressed to a remote TCX1000 device connected through the TCX1000-RDM20's **DCN** ports such, as in a multi-degree ROADM node configuration or when the DCN ports are daisy-chained together, the message is forwarded out the appropriate **DCN** port.	NOTE: In order for the TCX1000-RDM20 to exchange management messages over its **Line** port, the OSC forwarding feature must be enabled on the device. When this feature is enabled, the OSC signal is combined with the line WDM signal and sent over the fiber span connected to the line port. The OSC is a point-to-point channel that allows optical devices to communicate with each other for management and control purposes. NOTE: TCX1000-RDM20 OSC forwarding is disabled by default. NOTE: You cannot use OSC forwarding if the TCX1000-RDM20 line port is connected to a TCX1000-RDM20 or TCX1000-ILA that is on a different IP subnet.
ETH CRAFT	This port is used for local management communications to the internal CPU of the TCX1000-RDM20.	NOTE: The **ETH CRAFT** port (not shown in Figure 35 on page 105) is directly connected to the internal CPU and the CPU uses a dedicated IP address to communicate with the **ETH CRAFT** port.

Remote Management Communications in Multi-Degree TCX1000-RDM20 Nodes

Multi-degree ROADM nodes have multiple TCX1000-RDM20 elements in a single node for multi-directional switching. Each TCX1000-RDM20 in the node can receive management messages over its line port, assuming you have enabled OSC forwarding on each device.

Daisy Chain the DCN Ports in Multi-Degree TCX1000-RDM20 Nodes for Redundant Management Communications

As a second path for management messages, in remotely connected multi-directional TCX1000-RDM20 nodes, you can daisy chain the **DCN** ports on the co-located TCX1000-RDM20s within the node in order to pass along management messages addressed to the co-located TCX1000-RDM20. If the management message is addressed to a TCX1000-RDM20 that is further down in the optical network, the co-located TCX1000-RDM20 forwards the message over its **Line** port as long as OSC forwarding is enabled.

TCX1000-ILA Management Communication Port Rules

The right-hand side of Figure 35 on page 105 shows the internal hardware architecture of the TCX1000-ILA. You can communicate with the TCX1000-ILA in several ways as described in Table 10 on page 108.

NOTE: The proNX Optical Director always addresses management messages to the IP address of the TCX1000-ILA internal CPU, regardless of whether the message arrives on one of the **Line** ports or the **MGMT** port.

The TCX1000-ILA has separate OSC signals for Line A and Line B that are used to exchange management messages addressed to remotely connected TCX1000-RDM20 and TCX1000-ILA devices. If the TCX1000-ILA receives a management message for a remotely connected TCX1000-RDM20 or TCX1000-ILA, it forwards the message out the appropriate **Line** port. This forwarding of management messages over its line ports is not configurable like it is on the TCX1000-RDM20; you cannot disable management message forwarding on the TCX1000-ILA.

For redundant management communication paths, you must connect the TCX1000-ILA to your DCN HA using at least two of three ports described in Table 10 on page 108.

Table 10: TCX1000-ILA Management Communication Port Rules

TCX1000-ILA Port	How Communications Work	Notes
MGMT (Ethernet) port	Management messages received on the **MGMT** port are sent to the internal CPU. If the message is addressed to the local device, the CPU will act upon the message and respond over its **MGMT** port. If the message is addressed to a remote TCX1000 device, the CPU consults its address table and forwards the message out either **Line A Out** or **Line B Out** port if the address is known, or broadcasts the message out both line ports.	BEST PRACTICE: Connecting the TCX1000-ILA **MGMT** port to an external Layer 2 switch that is connected to the same DCN HA as the proNX Optical Director is the best method for communicating with the TCX1000-ILA.
Line A	Management messages received on the **Line A In** port are sent to the internal CPU. If the message is addressed to the device, the CPU will act upon the message and respond over its **Line A Out** port. If the message is addressed to a remote TCX1000 device, the CPU consults its address table and forwards the message out either **Line B Out** port or the **MGMT** port.	
Line B	Management messages received on the **Line B In** port are sent to the internal CPU. If the message is addressed to the device, the CPU will act upon the message and respond over its **Line B Out** port. If the message is addressed to a remote TCX1000 device, the CPU consults its address table and forwards the message out either **Line A Out** port or the **MGMT** port.	

Related Documentation

- Management Communications Examples for TCX1000 Linear Multi-Span Networks on page 123
- Deployment Rules for TCX1000 Management Communications on page 109
- Management Communications Examples for TCX1000 Ring Networks on page 133

Deployment Rules for TCX1000 Management Communications

When deploying TCX1000 devices, there are rules and management communication considerations that you need to consider before you deploy the devices in your optical network.

This topic summarizes the deployment rules for TCX1000 management communications and the proNX Optical Director.

- Summary of Deployment Rules for the proNX Optical Director on page 109
- Summary of Deployment Rules for TCX1000-RDM20 and TCX1000-ILA on page 109

Summary of Deployment Rules for the proNX Optical Director

The servers running the proNX Optical Director must be enterprise class servers, and the server cluster must be installed in an HA data center that has redundant systems and uninterruptible power supplies (UPS).

When deploying your optical network, you must use the following rules for the proNX Optical Director:

1. Servers in the proNX Optical Director server cluster must reside in the same subnet.
2. All servers in the proNX Optical Director server cluster must redundant high-availability connectivity to your HA network.
3. Your DCN HA network must support HA connectivity between the proNX Optical Director servers and TCX1000 devices (TCX1000-RDM20 or TCX1000-ILA).

This guide does not describe the requirements for proNX Optical Director and its servers in detail. Refer to the proNX Optical Director Documentation for complete details.

Summary of Deployment Rules for TCX1000-RDM20 and TCX1000-ILA

Here are the hard rules to follow when deploying TCX1000 devices in your optical network:

1. Each TCX1000-RDM20 and TCX1000-ILA must have redundant paths for management communications with the proNX Optical Director. See, “Rule 1: Before Deploying Identify Redundant Paths for Management Communications to Each TCX1000 Device” on page 110.
2. Keep Layer 2 and Layer 3 management networks together and segregated from other L2/L3 IP subnets. See, “Rule 2: Keep Layer 2 and Layer 3 Management Networks Together and Segregated From Other L2/L3 IP Subnets” on page 114.

3. You must determine whether a TCX1000-RDM20 needs to have OSC forwarding enabled on it and configure the feature before you deploy the TCX1000-RDM20. See, “Rule 3: Configure OSC Forwarding on TCX1000-RDM20 Before Deploying” on page 116.
4. Configure IP set up before deploying TCX1000 devices. See, “Rule 4: Configure IP Management Before Deploying TCX1000 Devices” on page 118.
5. Switches that connect to the TCX Series devices to your DCN HA must participate in RSTP to prevent Layer 2 network loops and must be compatible with the IEEE 802.1w RTSP protocol. Both the TCX1000-RDM20 and TCX1000-ILA are compatible with the protocol. See, “Rule 5: RSTP Deployment Rules for TCX1000 Devices” on page 119.

Related Documentation

- Management Communications Examples for TCX1000 Ring Networks on page 133
- Management Communications Examples for TCX1000 Linear Multi-Span Networks on page 123
- TCX1000 Management Architecture on page 103
- TCX1000-RDM20 OSC Connection Overview on page 143

- *Enabling OSC Forwarding on the TCX1000-RDM20*

Rule 1: Before Deploying Identify Redundant Paths for Management Communications to Each TCX1000 Device

This topic describes deployment rule 1 for the TCX1000-RDM20 and TCX1000-ILA, which requires redundant paths for management communications.

Before You Deploy TCX1000 Devices

Before you deploy TCX1000 devices in your optical network, we recommend that you sketch out your network and identity how each TCX1000 device (TCX1000-RDM20 and TCX1000-ILA) in the network will handle redundant management communications.

NOTE: Every TCX Series device managed by the proNX Optical Director must have redundant links to your DCN HA network.

Your DCN HA design must include a fault tolerant management network design with redundant paths for management communications to each TCX1000 device and the proNX Optical Director. There are several ways to achieve this and it is your responsibility to design your own DCN HA network.

TCX1000-RDM20

BEST PRACTICE: The best way to provide redundant management communications to the TCX1000-RDM20 is to connect the TCX1000-RDM20 to your DCN HA is using a Layer 2 switch between the **DCN 0** and **DCN 1** ports and your DCN HA. In this case the TCX1000-RDM20 has redundant paths directly to your DCN HA with the proNX Optical Director.

If the deployment site has no DCN access, you can manage the TCX1000-RDM20 over its line port if you enable OSC forwarding on the device.

In remotely connected multi-directional ROADM nodes, you can daisy chain the DCN ports on the TCX1000-RDM20s within the node in order to pass along management messages addressed to the DCN port of a co-located TCX1000-RDM20. If the management message is addressed to a TCX1000 device that is further down in the optical network, the TCX1000-RDM20 will pass the message along over its line port as long as OSC forwarding is enabled.

As per our requirement for redundant paths for proNX Optical Director IP management communications to each TCX1000 device in your optical network, you must ensure that your TCX1000 optical network, at minimum, is homed at each end by a TCX1000-RDM20 connected through a Layer 2 switch on the same DCN HA as the proNX Optical Director. Enabling OSC forwarding on the homed TCX1000-RDM20s at each end of your optical network provides the second path for management communications—each homed TCX1000-RDM20 can forward proNX Optical Director management messages over their line ports to remotely connected TCX1000 devices using the OSC signal. The IP address used by the proNX Optical Director is the address of the remotely connected TCX1000 device. If the remotely connected device is a TCX1000-RDM20, it must also have OSC forwarding enabled in order to exchange IP management packets with the local TCX1000-RDM20 using the OSC signal over its line port.

In summary, this is one example of how a TCX1000 device can become unreachable. However, it demonstrates the need for redundant management communications to each TCX1000 device. We understand that in some deployments this may not always be possible. But you should be aware of the risks and take precautions. we recommend in all cases, that you provide redundant connections for management communications to the TCX1000 device.

Caution: Know the Risks When You Cannot Provide Redundant Management Communications to a TCX1000-RDM20

CAUTION: If there is no way to provide redundant paths for management communications to a remote TCX1000-RDM20, you can manage the device over its Line port using the OSC. In this case, the TCX1000-RDM20 is a 1D terminal and you should be aware that a break in the fiber span or a failure of the OSC signal on the remote TCX1000-RDM20 or the local TCX1000-RDM20 providing remote management connectivity to the remote

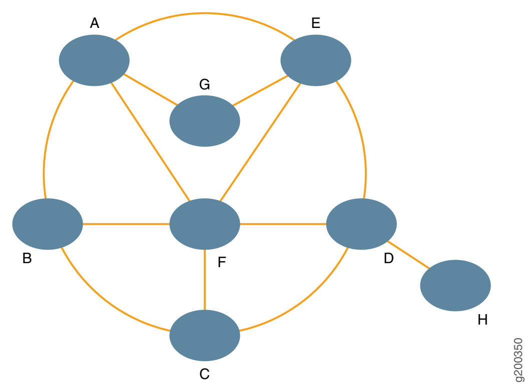
TCX1000-RDM20, can isolate the remote TCX1000-RDM20 making it unreachable and requiring you to go to the site to repair the problem.

Let us look at an example of this in Figure 36 on page 112. Specifically, look at the H node. At the H node, we have a single TCX1000-RDM20, which is connected through its Line port to Node D. The TCX1000-RDM20 at Node H receives its management messages over the OSC signal from the TCX1000-RDM20s at Site D. At site D we a 3-degree ROADM node, which is comprised of 3 TCX1000-RDM20s:

- One TCX1000-RDM20 connects to site H
- One TCX1000-RDM20 connects to site E
- One TCX1000-RDM20 connects to site C

These three TCX1000-RDM20s can exchange traffic with each other over their pass-through connections and switch traffic in any direction.

Figure 36: Node Isolation Example



Now let us look at what would happen to the TCX1000-RDM20 at node H if we had a break in the fiber span to site D or a failure of the OSC signal at either end of the span. There are three possible ways that site H can become unreachable and require you to go on site to correct the issue:

- Line fiber break between sites D and H

  In this case, all traffic would down at site H and the TCX1000-RDM20 would become unreachable. You can try to diagnose the problem from site D but if you find no reason for the issue, you would need to go on site to resolve the problem.

- OSC failure (fiber or SFP) on the TCX1000-RDM20 at site D that connects to site H

  In this case, all traffic would still be up between sites D and H but the TCX1000-RDM20 at site H would become unreachable by the proNX Optical Director. A device unreachable alarm is raised for the

TCX1000-RDM20 at site H after a timeout period. However, the fact that traffic is up between sites D and H confirms the line connection, so we can deduce that they issue is with either the OSC at site D or the OSC at site H. You can try correcting the problem at site D by swapping out the OSC cable or the SFP but if it does not fix the problem, then the issue is with the OSC at site H and you would need to go on site to resolve the problem.

- OSC failure (fiber or SFP) on the TCX1000-RDM20 at site H

  In this case, all traffic would still be up between sites D and H but the TCX1000-RDM20 at site H would become unreachable by the proNX Optical Director. A device unreachable alarm is raised for the TCX1000-RDM20 at site H after a timeout period. However, the fact that traffic is up between sites D and H confirms the line connection, so we can deduce that they issue is with the OSC between sites D and H. You can try to diagnose the problem from site D but if you find no reason for the issue, you would need to go to site H to resolve the problem.

You could solve the issue for site H by adding another TCX1000-RDM20 to sites D and H and having redundant paths at site H back to site D.

TCX1000-ILA

NOTE: For redundant management communication paths, you must connect the TCX1000-ILA to your DCN HA using at least two of three ports described in “TCX1000 Management Architecture” on page 103.

BEST PRACTICE: The best method for providing redundant management paths for the TCX1000-ILA is to connect TCX1000-ILA device to your DCN HA network is using a Layer 2 switch between the **MGMT** port and your DCN. In this case the device is directly connected to your DCN HA with the proNX Optical Director.

As the secondary path, the TCX1000-ILA also transmits and receives management messages over its Line ports using the OSCA and OSCB signals. This is not user configurable.

Related Documentation

- Deployment Rules for TCX1000 Management Communications on page 109
- Management Communications Examples for TCX1000 Ring Networks on page 133
- Management Communications Examples for TCX1000 Linear Multi-Span Networks on page 123
- TCX1000 Management Architecture on page 103

Rule 2: Keep Layer 2 and Layer 3 Management Networks Together and Segregated From Other L2/L3 IP Subnets

This topic describes deployment rule 2 for the TCX1000-RDM20 and TCX1000-ILA, which requires you to keep management networks together and segregated from other L2/L3 subnets.

Overview

By design, TCX1000 devices (TCX1000-RDM20 and TCX1000-ILA) act like Layer 2 devices in the optical network; all the management communication ports on TCX1000 devices are Layer 2 interfaces. However, TCX1000 devices are managed by the proNX Optical Director using IP, which is Layer 3 protocol. As such, when you design your DCN HA, each TCX1000-RDM20 and TCX1000-ILA in your optical network must be dedicated to a single Layer 2 (L2) and Layer 3 (L3) IP subnet and you must keep the TCX1000-RDM20 and TCX1000-ILA L2/L3 subnet together *and* segregated from other L2/L3 subnets in your network.

The **DCN** ports and **Line** port on the TCX1000-RDM20, and **MGMT** and **Line A** and **Line B** ports on the TCX1000-ILA must be on the same L2 RSTP domain. For L3 remote IP management connectivity to work over the L2 domain, the remote TCX1000 device must be on the same IP subnet as the local TCX1000 device. As L2 devices, TCX1000 devices cannot forward management messages to a remotely connected TCX1000 device on a different L2/L3 subnet. This rule keeps domains segregated to ensure no possible interactions with several IP subnets.

TCX1000-RDM20 L2/L3 Segregation

BEST PRACTICE: **If you need to deploy a TCX1000-RDM20 device on a different L2/L3 subnet, you must segregate the L2/L3 subnets. You can do this by connecting the TCX1000-RDM20 DCN ports through an external L2 switch and ensuring that OSC forwarding is disabled so that management messages are not forwarded over the TCX1000-RDM20 line port.**

If you have a multi-subnet node, you must connect the TCX1000-RDM20s in the node to your DCN HA using a dedicated L2 RSTP-enabled switch for each IP subnet so that the TCX1000-RDM20s can communicate directly over their DCN ports to the proNX Optical Director and you must also ensure that you do not enable OSC forwarding on a TCX1000-RDM20 in a multi-subnet node. As a L2 device, the TCX1000-RDM20 cannot forward management messages to remotely connected TCX1000 device on a different L2/L3 subnet..

NOTE: For Layer 3 connectivity to work over a Layer 2 network and to provide remote connectivity over its Line port, the local TCX1000-RDM20 must be on the same L2/L3 subnet as the remote TCX1000 device it provides remote management connectivity for regardless of whether the remote device is a TCX1000-RDM20 or TCX1000-ILA.

TCX1000-ILA L2/L3 Segregation

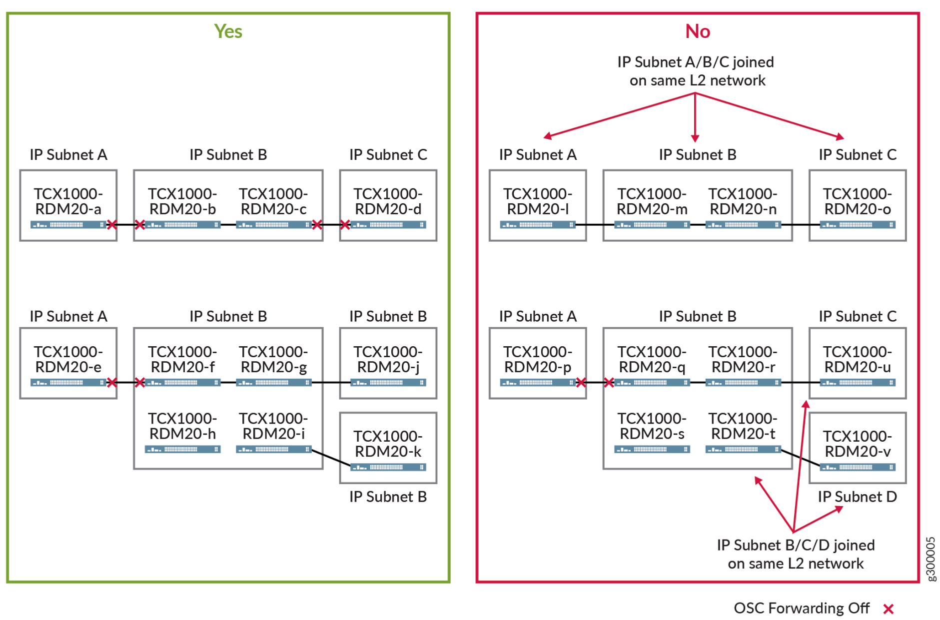
NOTE: You cannot deploy a TCX1000-ILA on a different L2/L3 subnet from its connecting TCX1000-RDM20 or TCX1000-ILA. If the TCX1000-ILA receives a management message addressed to a remote TCX1000 device it forwards the message out the appropriately line port.

Layer 2/Layer 3 Subnet Segregation Example

On the left of Figure 37 on page 115, we see two network examples showing the proper set up for Layer 2 and Layer 3 segregation and OSC forwarding.

On the right, we see the same two examples, with OSC forwarding improperly set up, causing management communications to fail.

Figure 37: TCX1000 Hardware Networking Architecture



The top-left network in Figure 37 on page 115 is a three site multi-span network. All three sites are on different IP subnets. TCX1000-RDM20-a is on IP subnet A, it is connected to a 2-degree ROADM node made up of TCX1000-RDM20-b and TCX1000-RDM20-c, which are on IP subnet B and finally to TCX1000-RDM20-d, which is on IP subnet C.

Because the three TCX1000-RDM20s are all on different IP subnets, OSC forwarding must be disabled. In this example, OSC forwarding is properly set to disabled.

However, if OSC forwarding was enabled as shown in the top-right example of Figure 37 on page 115, management communications would not work because they cannot cross IP subnets and this would effectively join IP subnets A, B, and C onto same L2 network, which is not allowed.

The bottom half of Figure 37 on page 115 shows a different optical network configuration. On the example network in the bottom-left of Figure 37 on page 115, we have a network with four sites. Three sites are on IP subnet B and one site is on IP subnet A. In this example, OSC forwarding must be disabled on TCX1000-RDM20-e at site A and also on TCX1000-RDM20-f at site B, thereby blocking management communications between IP subnets A and B. However, notice that all the other TCX1000-RDM20s in the network are on IP subnet B; because they are on the same L2/L3 subnet, you can enable OSC forwarding on these TCX1000-RDM20s including: TCX1000-RDM20-g, TCX1000-RDM20-h, TCX1000-RDM20-i, TCX1000-RDM20-j, and TCX1000-RDM20-k.

On the bottom-right in Figure 37 on page 115, we have the same network, however, in this example, all TCX1000-RDM20s are on different subnets and if OSC forwarding was enabled on any device, management communications would not work. TCX1000-RDM20-p on IP subnet A and TCX1000-RDM20-q on IP subnet B, are properly set with OSC forwarding disabled. However, all other TCX1000-RDM20s in this example have OSC forwarding enabled and as such, the L2/L3 subnets for sites B, C, and D are not segregated. As such, in the bottom-right example, proNX Optical Director communications would not work properly because they cannot cross IP subnets and this would effectively join IP subnets B, C, and D onto same L2 network, which is not allowed.

Related Documentation

- TCX1000 Management Architecture on page 103
- Deployment Rules for TCX1000 Management Communications on page 109
- Management Communications Examples for TCX1000 Ring Networks on page 133
- Management Communications Examples for TCX1000 Linear Multi-Span Networks on page 123

Rule 3: Configure OSC Forwarding on TCX1000-RDM20 Before Deploying

This topic describes deployment rule 3 for management communication on the TCX1000-RDM20 and TCX1000-ILA. It describes OSC forwarding and when and how to enable this feature.

- OSC Forwarding Overview on page 117
- When and When Not to Use OSC Forwarding on the TCX1000-RDM20 on page 117

OSC Forwarding Overview

BEST PRACTICE: Before you deploy a TCX1000-RDM20, you must determine how it will communicate with the proNX Optical Director and enable OSC forwarding if the TCX1000-RDM20 needs to forwarding IP management messages to the remote TCX1000 device.

NOTE: You configure OSC forwarding through the CLI of the TCX1000-RDM20 using the **stp-group** parameter under the RSTP DCN0/DCN1 settings. OSC forwarding can only be configured through the CLI on the TCX1000-RDM20.

If the TCX1000-RDM20 is using only direct dual-DCN connections to you DCN HA and is not responsible for communicating management messages over its line port to a remotely connected TCX1000 device, you do not need to configure OSC forwarding. It is disabled by default.

BEST PRACTICE: On the TCX1000-RDM20, by default, OSC forwarding is disabled. If you are using OSC management over the Line port on the TCX1000-RDM20 as a redundant path for management communications to the device, you must explicitly enable the OSC forwarding on the TCX1000-RDM20.

For more information on how to enable OSC forwarding on the TCX1000-RDM20, see Enabling OSC Forwarding on the TCX1000-RDM20.

CAUTION: If you deploy a TCX1000-RDM20 at a remote site that has no DCN access without OSC forwarding enabled, you will not be able to remotely manage the TCX1000-RDM20 through proNX Optical Director when a line break occurs in your optical network and the local or the remote TCX1000-RDM20 is not configured to forward OSC management messages over its line port.

You will need to go on site to enable the OSC forwarding on the device.

OSC forwarding must be enabled on the both the local and remote TCX1000-RDM20 devices to have remote connectivity to remote sites.

When and When Not to Use OSC Forwarding on the TCX1000-RDM20

When deploying TCX1000-RDM20 devices, you must identify whether the device needs to forward management messages to the TCX1000 device it will be remotely connected to. The TCX1000-RDM20 uses an OSC forwarding feature that determines whether or not the device forwards management messages over its Line port using the OSC signal.

You must enable OSC forwarding when the device is responsible for sending management messages to the device remotely connected to its Line port.

Table 11 on page 118 describes when and when not to use OSC forwarding on the TCX1000-RDM20.

Table 11: OSC Forwarding Conditions

Enable OSC Forwarding If:	Do Not Enable OSC Forwarding If:
The TCX1000-RDM20 line port is connected to a TCX1000-ILA.	The TCX1000-RDM20 line port is connected to a TCX1000-RDM20 or TCX1000-ILA that is on a different IP subnet.
The TCX1000-RDM20 line port is connected to a TCX1000-RDM20 without DCN access.	

Refer to the TCX1000 Programmable ROADM Quick Start Guide for instructions on how to configure OSC Forwarding.

Related Documentation

- *Enabling OSC Forwarding on the TCX1000-RDM20*
- TCX1000 Management Architecture on page 103
- Deployment Rules for TCX1000 Management Communications on page 109
- Management Communications Examples for TCX1000 Ring Networks on page 133
- Management Communications Examples for TCX1000 Linear Multi-Span Networks on page 123

Rule 4: Configure IP Management Before Deploying TCX1000 Devices

Before you deploy either the TCX1000-RDM20 and TCX1000-ILA in your optical network, you must configure IP address on the device so that you can remotely manage and configure it through the proNX Optical Director.

Regardless of which external port a management message is received on, the TCX1000 internal CPU either responds to the message over the port the message was received on, or it forwards the message out one or all of its management communication ports.

Refer to the TCX1000 Programmable ROADM Quick Start for instructions on how to configure the IP address on the TCX1000-RDM20.

Refer to TCX1000 Inline Amplifier Quick Start for instructions on how to configure the IP address on the TCX1000-ILA.

Related Documentation

- TCX1000 Management Architecture on page 103
- Deployment Rules for TCX1000 Management Communications on page 109
- Management Communications Examples for TCX1000 Ring Networks on page 133
- Management Communications Examples for TCX1000 Linear Multi-Span Networks on page 123

Rule 5: RSTP Deployment Rules for TCX1000 Devices

When deploying TCX1000 devices, there are rules that you must consider regarding rapid spanning tree (RSTP), which is used resolve loops in your DCN HA management network RSTP domain. This section describes these rules in more detail with some examples, as well as describes the concepts of RSTP.

Before We Begin, What is RSTP?

Before for look at the deployment rules for Rapid Spanning Tree Protocol (RSTP), we need to briefly look at what RSTP is all about. This section looks at RSTP concepts like tree, hops and RSTP maximum diameter.

The requirement for redundant management connections to each TCX1000 device in your DCN HA management network creates loops in the network and makes the network susceptible to broadcast storms. However, the DCN HA network needs to include loops because they provide redundant paths for management communications in case of a link failure in the network. RSTP addresses both of these issues because it provides link redundancy while simultaneously preventing undesirable loops.

RSTP resolves loops in a Layer 2 network by controlling the port states on the device and enabling or disabling the port from forwarding traffic. RSTP ensures that each Layer 2 device in the uses only a single path at a time for management communications.

NOTE: Layer 2 devices include switches, the TCX1000-RDM20 and TCX1000-ILA.

TCX1000 devices support RSTP IEEE 802.1w.

On the TCX1000-RDM20, the following ports participate in RSTP:

- DCN0
- DCN1
- Line

On the TCX1000-ILA, the following ports participate in RSTP:

- MGMT
- Line A
- Line B

RSTP enables or disables the ports on Layer 2 devices in the network and creates a *tree* to each device in the network over which management communications occur. If a break occurs in the network, RSTP automatically enables or disables ports on the Layer 2 devices in the tree and builds a new tree to reestablish management communications.

The tree includes a *root bridge*, which is at the top of the tree. Every other Layer 2 device in the tree knows the path the root bridge and uses it.

Going from one Layer 2 device in the network to another represents one *hop*.

The RSTP *diameter* is the number of Layer 2 devices from root bridge to the furthest Layer 2 device in the network. So, to determine the RSTP diameter of the network, you count the number of hops, then + 1. RSTP has limitations on maximum diameter, which is dictated by the Root Bridge Max-Age parameter.

NOTE: This guide does not go into detail on RSTP. Instead it focuses on RSTP in the context of connecting TCX1000 devices to your DCN HA. For more details on the concepts of RSTP you can reference the following documents, which are for Juniper Networks switches:

- This document provides a good general description of RSTP concepts: How Spanning Tree Protocols Work
- This document provides an example of RTSP on Juniper Networks EX Series Layer 2 Switches:Example: Faster Convergence and Improved Network Stability with RSTP on EX Series Switches

RSTP Network Deployment Rules

NOTE: Only TCX1000-RDM20 devices running software release 3.1 or higher support IEEE 802.1w RTSP protocol. TCX1000-RDM20 devices running software releases lower than release 3.1 do not support RSTP and do not support management communications over their Line port.

When deploying TCX1000 devices in your optical network, you must adhere to the following rules for your DCN HA RSTP domain:

- *RSTP Rule 1:* RSTP maximum diameter of 20 or less — This means that any Layer 2 device (TCX1000 or switch) in the DCN HA can be no more than 19 hops away from the proNX Optical Director because: RSTP diameter = number of hops to device +1.

  NOTE: It is important to remember that if you exceed the RSTP maximum diameter, RSTP could resolve a loop that would result in loss of communication with a TCX1000 device after only a single fault. This is why you must be sure to count hops and check the maximum diameter when designing your DCN HA. For an example, see “Example: Single Network Failure Isolates Device in Network” on page 122.

- *RSTP Rule 2:* RSTP maximum domain size of 100 Layer 2 devices (TCX1000 or switch) or less in a single RSTP domain — If this rule cannot be respected, you must break up your DCN HA RSTP domain by segregating L2/L3 RSTP domains and ensuring OSC forwarding is off between the RSTP domains, which is the default on the TCX1000-RDM20. This is likely only an issue for remote management communications in large DCN HA where the RSTP maximum diameter rule is exceeded.
- *RSTP Rule 3:* We recommend that you provision your RSTP network so that the one of your DCN Layer 2 switches is the RTSP root bridge of the network. The typical RSTP Bridge Priority is 32768 or below on DCN switches.

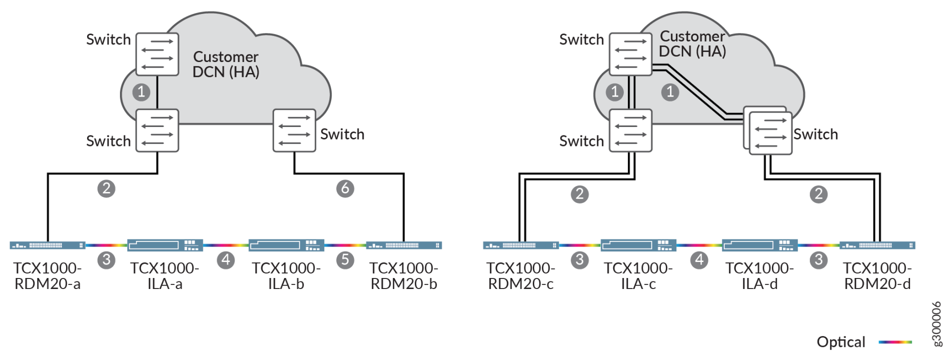
Counting RSTP Hops and Diameter

Figure 38 on page 121 shows an example of two DCN HA Ethernet networks.

The TCX1000 network on the left is homed to the DCN by a single Layer 2 switch at each end the network. The TCX1000 devices at each end of the network have a single connection to the Layer 2 switch.

The TCX1000 network on the right is homed to the DCN by the same single Layer 2 at each end the network. However the TCX1000 devices at each end of the network have redundant connections to the DCN.

Figure 38: Counting RSTP Hops



Let us take a look at how this one change impacts the hop count and the RSTP maximum diameter. But first, *RSTP Rule 1* says RSTP maximum diameter of 20 or less. — This means that any Layer 2 device in the DCN HA can be no more than 19 hops away from the DCN HA and hence the proNX Optical Director because: RSTP diameter = number of hops to device +1.

Looking at the network on the left of Figure 38 on page 121 we can see that there is a total of 6 hops from the first Layer 2 switch in the DCN HA to TCX1000-RDM20-b, making the RSTP maximum diameter: 6 +1=7.

1. Hop 1-from the first switch to the second
2. Hop 2-from the second switch to TCX1000-RDM20-a
3. Hop 3-from TCX1000-RDM20-a to TCX1000-ILA-a

4. Hop 4-from TCX1000-ILA-a to TCX1000-ILA-b
5. Hop 5-from TCX1000-ILA-b to TCX1000-RDM20-b
6. Hop 6-from TCX1000-RDM20-b to the third switch on the right

The second network example on the right of Figure 38 on page 121 shows the same network as on the left. However, in this network example, we have redundant paths for management communications by connecting both DCN ports on TCX1000-RDM20-c and TCX1000-RDM20-d to the DCN HA. This effectively decreases the number of hops required for management communications to 4 hops. The RSTP maximum diameter is decreased to: 4 hops +1=5. The redundant paths from the DCN to TCX1000-RDM20-c and TCX1000-RDM20-d enable management communications to go over either path in only 4 hops from either TCX1000-RDM20-c or TCX1000-RDM20-d:

Path 1

1. Hop 1-from the first switch the second switch
2. Hop 2-from the second switch to TCX1000-RDM20-c
3. Hop 3-from TCX1000-RDM20-c to TCX1000-ILA-c
4. Hop 4-from TCX1000-ILA-c to TCX1000-ILA-d

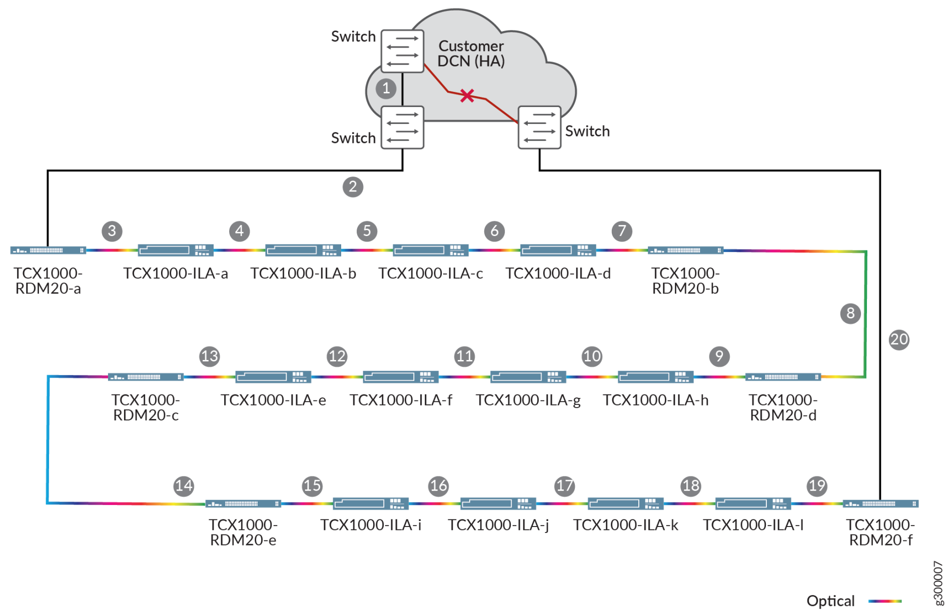
Path 2

1. Hop 1-from the first switch to the third switch (on the right in the DCN)
2. Hop 2-from the third switch to TCX1000-RDM20-d
3. Hop 3-from TCX1000-RDM20-d to TCX1000-ILA-d
4. Hop 4-from TCX1000-ILA-d to TCX1000-ILA-c

Example: Single Network Failure Isolates Device in Network

Figure 39 on page 123 shows an example network where we exceed the RSTP maximum diameter and a single link failure isolates a TCX1000 devices. This example network shows a 3 TCX1000-RDM20 x 4 TCX1000-ILA deployment, which is a linear multi-span network that consists of three point-to-point TCX1000-RDM20 networks that each have 4 TCX1000-ILAs in their amplifier chains. This example illustrates a worse case scenario, where there is a single failure at the worst location (x) between two switches in your DCN. This single failure, causes the switch between the DCN HA and TCX1000-RDM20-f to become unmanageable because the RSTP maximum diameter of the network exceeds 20. Due to the break at (x) it would take 20 hops to reach the switch, which exceeds RSTP guidelines.

Figure 39: Example: Single Network Failure Isolates Device in Network



Related Documentation

- RSTP Default Settings for TCX1000-RDM20 and TCX1000-ILA on page 207
- TCX1000 Management Architecture on page 103
- Deployment Rules for TCX1000 Management Communications on page 109
- Management Communications Examples for TCX1000 Ring Networks on page 133
- Management Communications Examples for TCX1000 Linear Multi-Span Networks on page 123

Management Communications Examples for TCX1000 Linear Multi-Span Networks

This sections describes management communications examples for linear multi-span networks. It focuses on network examples and describes how each device in the example handles management communications.

- Summary of Deployment Rules for TCX1000-RDM20 and TCX1000-ILA on page 123
- Linear Multi-Span Network: Example 1 on page 124
- Linear Multi-Span Network: Example 2 on page 125
- Linear Multi-Span Network – Dual Homed: Example 1 on page 126
- Linear Multi-Span Network – Dual Homed: Example 2 on page 129
- Linear Multi-Span Network – Dual Homed on page 131

Summary of Deployment Rules for TCX1000-RDM20 and TCX1000-ILA

Here are the hard rules to follow when deploying TCX1000 devices in your optical network:

1. Each TCX1000-RDM20 and TCX1000-ILA must have redundant paths for management communications with the proNX Optical Director. See, Rule 1: Before Deploying Identify Redundant Paths for Management Communications to Each TCX1000 Device in "Deployment Rules for TCX1000 Management Communications" on page 109.
2. Keep Layer 2 and Layer 3 management networks together and segregated from other L2/L3 IP subnets. See, Rule 2: Keep Layer 2 and Layer 3 Management Networks Together and Segregated From Other L2/L3 IP Subnets in "Deployment Rules for TCX1000 Management Communications" on page 109.
3. You must determine whether a TCX1000-RDM20 needs to have OSC forwarding enabled on it and configure the feature before you deploy the TCX1000-RDM20. See, Rule 3: Configure OSC Forwarding on TCX1000-RDM20 Before Deploying in "Deployment Rules for TCX1000 Management Communications" on page 109.
4. Configure IP set up before deploying TCX1000 devices. See Rule 4: Configure IP Management Before Deploying TCX1000 Devices in "Deployment Rules for TCX1000 Management Communications" on page 109.
5. Switches that connect to the TCX Series devices to your DCN HA must participate in RSTP to prevent Layer 2 network loops and must be compatible with the IEEE 802.1w RTSP protocol. Both the TCX1000-RDM20 and TCX1000-ILA are compatible with the protocol. See, "Rule 5: RSTP Deployment Rules for TCX1000 Devices" on page 119.

Linear Multi-Span Network: Example 1

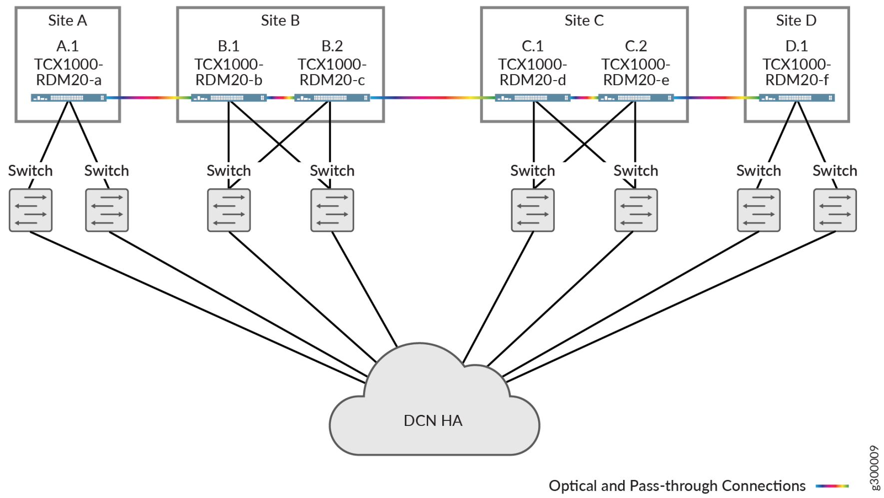
Figure 40 on page 125 shows a linear multi-span network that includes four sites: A, B, C, D.

Looking at our rules for segregating L2/L3 subnets, we can see that each site is on a different IP subnet:

- At site A, TCX1000-RDM20-a is on IP subnet A.1
- At site B, TCX1000-RDM20-b is on IP subnet and B.1 and TCX1000-RDM20-c is on IP subnet B.2
- At site C, TCX1000-RDM20-d is on IP subnet C.1 and TCX1000-RDM20-e is on IP subnet C.2
- At site D, TCX1000-RDM20-f is on IP subnet D.1

Therefore, we must segregate the L2/L3 networks by fronting them with a L2 switch connected to the DCN ports on each TCX1000-RDM20 in the network. In this example, proNX Optical Director management communications are always sent over the DCN network to the TCX1000 devices.

Figure 40: Direct Connect Linear Multi-Span Network: Example 1



NOTE: Due to the multiple IP subnets used in this network, OSC forwarding could never be used for management communications. Therefore, we can leave the default setting for OSC forwarding, which is off, on all TCX1000-RDM20s in this network.

In this example, we have clearly kept together the DCN HA L2 subnet and separated each L3 subnet between the sites by disabling OSC forwarding on each device and we have redundant management communications to each TCX 1000 over the DCN HA as required. This example meets all the rules required for this network. It uses quite a few Layer 2 switches but is simple way to deploy a linear multi-span network.

In summary, because all sites in this example are different L2/L3 subnets, all TCX1000-RDM20s in the example use only their dual-DCN ports for communicating management messages.

BEST PRACTICE: Figure 40 on page 125 uses all the best practice guidelines for redundant management communications, L2/L3 subneting and DCN HA design.

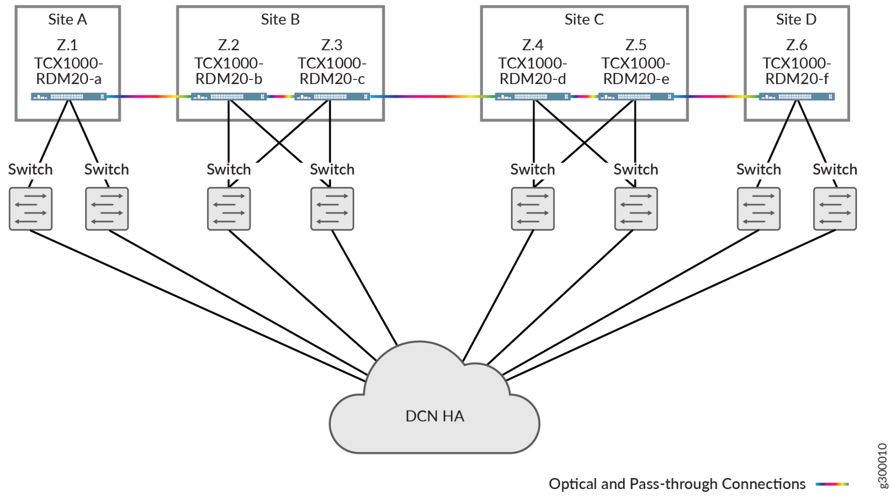
Linear Multi-Span Network: Example 2

Figure 41 on page 126 shows a linear multi-span network that includes four sites: A, B, C, D:

- At site A, TCX1000-RDM20-a is on IP subnet Z.1
- At site B, TCX1000-RDM20-b is on IP subnet and Z.2 and TCX1000-RDM20-c is on IP subnet Z.3

- At site C, TCX1000-RDM20-d is on IP subnet Z.4 and TCX1000-RDM20-e is on IP subnet Z.5
- At site D, TCX1000-RDM20-f is on IP subnet Z.6

Figure 41: Direct Connect Linear Multi-Span Network: Example 2



All sites in this example are on the Z IP subnet so we do not need to segregate L2/L3 subnets and, following our best practices, each TCX1000 device to an external Layer 2 RSTP-enabled switch for management communications to go over the DCN ports of the TCX1000-RDM20s.

In addition, because this network is all on one IP subnet, we can enable OSC forwarding on the TCX1000-RDM20s if we wanted to. However, there is no need to with the redundant DCN connections.

In summary, all TCX1000-RDM20s in this example use their dual-DCN ports and their Line ports to communicate management messages.

BEST PRACTICE: Figure 41 on page 126 uses all the best practice guidelines for redundant management communications, Layer 2 and Layer 3 subneting and DCN HA design.

This network complies with all of our deployment rules. We have redundant management communications to each TCX1000 device and we have to interactions with L2/L3 segregation because all devices are on the same L2/L3 subnet.

Linear Multi-Span Network – Dual Homed: Example 1

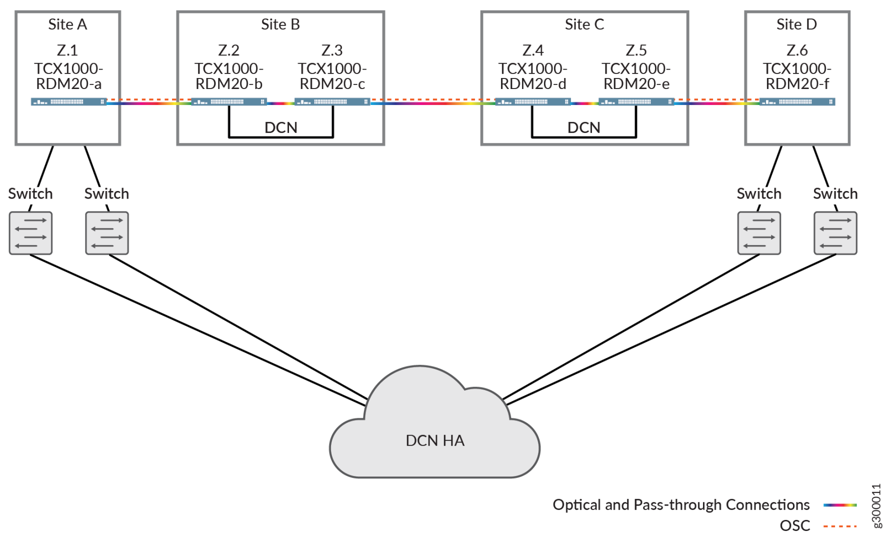
Figure 42 on page 127 shows a linear multi-span network that includes four sites: A, B, C, D:

- At site A, TCX1000-RDM20-a is on IP subnet Z.1
- At site B, TCX1000-RDM20-b is on IP subnet and Z.2 and TCX1000-RDM20-c is on IP subnet Z.3
- At site C, TCX1000-RDM20-d is on IP subnet Z.4 and TCX1000-RDM20-e is on IP subnet Z.5
- At site D, TCX1000-RDM20-f is on IP subnet Z.6

All sites in this example are on the Z IP subnet so we not need to segregate L2/L3 subnets. This also tells us that we can manage communication messages to remotely connected devices over the Line ports of TCX1000-RDM20s in the network.

NOTE: You must enable OSC forwarding on the device before deploying it.

Figure 42: Linear Multi-Span Network – Dual Homed: Example 1



Between the two TCX1000-RDM20s at sites B and C, there are two connections:

- The optical line shows the pass-through channels connected between the two TCX1000-RDM20s.
- The black line shows the DCN ports daisy-chained between the two TCX1000-RDM20s for management communications.

Let us look at how redundant management communications work for each TCX1000 device in Figure 42 on page 127:

- Looking at our redundant path rules, we can see that TCX1000-RDM20-a and TCX1000-RDM20-f at sites A and D respectively, are directly connected to the DCN through Layer 2 switches and therefore can communicate management messages over their DCN ports. However, we can also see in Figure 42 on page 127, that the TCX1000-RDM20s at sites A and D are responsible for providing management communications over their line ports to the TCX1000-RDM20s at sites B and C respectively and therefore, OSC forwarding must be enabled on the TCX1000-RDM20s at sites A, B, C and D so that they can exchange management messages over their Line ports.

- Looking at our redundant path rules for management communications for the TCX1000-RDM20s at sites B and C, we have already established that the first path is receiving management messages over their Line ports from the TCX1000 devices at site A or site D.

  The second path for remote management communications for the TCX1000-RDM20s at sites B and C is enabled by daisy chaining the DCN ports on the TCX1000-RDM20s at these sites.

  If we daisy DCN ports between TCX1000-RDM20-b and TCX1000-RDM20-c at site B:

  - Management communications for TCX1000-RDM20-b occur over either the line port from site A, or over the DCN port from TCX1000-RDM20-c, which receives management communications from site C.
  - Management communications for TCX1000-RDM20-c occur over either the Line port from site C, or over the DCN port from TCX1000-RDM20-b, which receives management communications from site A.

  If we daisy the DCN ports between TCX1000-RDM20-d and TCX1000-RDM20-e at site C:

  - Management communications for TCX1000-RDM20-d occur over either the Line port from site B, or over the DCN ports from TCX1000-RDM20-e, which receives management communications from site D.
  - Management communications for TCX1000-RDM20-e occur over either the Line port from site D, or over the DCN ports from TCX1000-RDM20-d, which receives management communications from site B.

This example uses fewer switches and complies with all of our management communication deployment rules. We have redundant paths for management communications to each TCX1000 device in the network. The network is on a single IP subnet so we do not worry about segregating any L2/L3 subnets.

In summary, all TCX1000-RDM20s in this example have redundant paths for management communications either through their DCN ports or Line ports and we have met all of our other deployment rule requirements.

BEST PRACTICE: Figure 42 on page 127 uses all the best practice guidelines for redundant management communications at sites A and D, Layer 2 and Layer 3 subneting and DCN HA design.

NOTE: Although the TCX1000-RDM20s at sites B and C have redundant management communication paths, they are not connected to the DCN HA through external Layer 2 switch, which is not the best practice method for management communications.

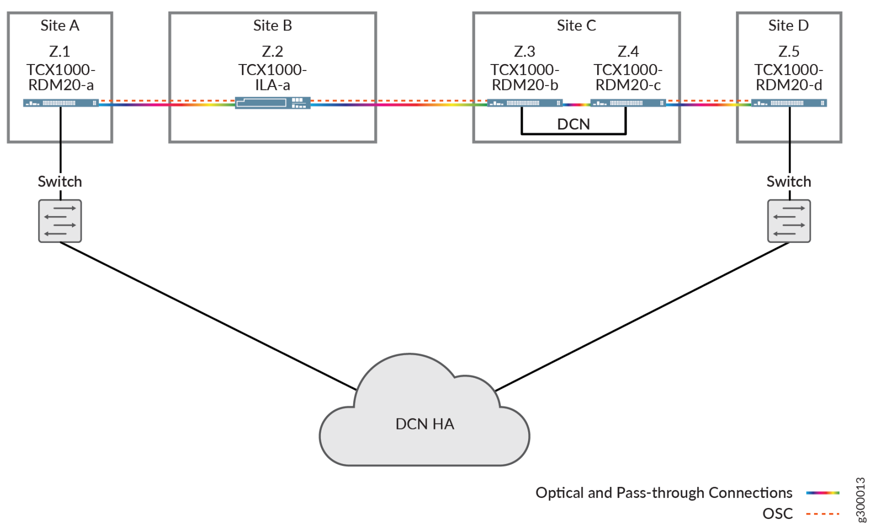
Linear Multi-Span Network – Dual Homed: Example 2

The example network deployment in Figure 43 on page 129 shows a linear multi-span network that includes four sites: A, B, C, D:

- At site A, TCX1000-RDM20-a is on IP subnet Z.1
- At site B, TCX1000-ILA-a is on IP subnet and Z.2
- At site C, TCX1000-RDM20-b is on IP subnet Z.3 and TCX1000-RDM20-c is on IP subnet Z.4
- At site D, TCX1000-RDM20-d is on IP subnet Z.5

All TCX1000 devices in the networks are on the same L2/L3 subnet so we do not need to worry about our L2/L3 segregation rule.

Figure 43: Linear Multi-Span Network – Dual Homed: Example 2



Between the two TCX1000-RDM20s at sites C, there are two connections:

- The optical line shows the pass-through channels connected between the two TCX1000-RDM20s.
- The black line shows the DCN ports daisy-chained between the two TCX1000-RDM20s for management communications.

Looking at our rules for redundant paths for management communications in Figure 43 on page 129, we can see that TCX1000-RDM20-a and TCX1000-RDM20-d at sites A and D respectively, are directly connected to the DCN through a single connection and can therefore communicate directly with the proNX Optical Director over the DCN. However, sites A and D each have only a single connection to the DCN and they require two paths for redundant management communications.

In addition, sites B and C have no direct access to the DCN. At site B we have a TCX1000-ILA, which is using it Line ports to send management communications.

At site C, there is no DCN access and therefore the TCX1000 devices at site C cannot send management communications over their DCN ports and instead must send them over their Line ports.

Table 12 on page 130 summarizes the management communications and methods for each TCX1000 device shown in Figure 43 on page 129.

Table 12: Summary of Management Communications

Site	Device	OSC Forwarding Enabled	Management Communications for proNX Optical Director
A	TCX1000-RDM20-a	Yes	Uses a single connection to the DCN port and as the secondary path uses its Line port to exchange management messages with the TCX1000-ILA-a at site B.
B	TCX1000-ILA-a	N/A	Uses its Line A port to exchange management messages with site A and uses its Line B port to exchange management messages with site C.
C	TCX1000-RDM20-b	Yes	Uses its Line port to exchange management messages with site B and has its DCN port daisy-chained to the DCN port of TCX1000-RDM20-c for management communications from site D.
	TCX1000-RDM20-c	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-d at site D and has its DCN port daisy-chained to the DCN port of TCX1000-RDM20-b to receive management communications from site B.
D	TCX1000-RDM20-d	Yes	Uses a single connection to the DCN and as the second path uses its Line port to exchange management messages with the TCX1000-RDM20-c at site C.

In summary, all TCX1000 devices in Figure 43 on page 129 have redundant paths for management communications either through their Ethernet management ports or their Line ports and we have met all of our other deployment rule requirements.

However, none of the TCX1000 devices in this example use the best practice management communications methods. The TCX1000-RDM20s use a single DCN port and or their Line ports but none of them have dual-DCN connections to the DCN HA. The TCX1000-ILA uses only its Line ports for management communications and not the MGMT port, which is the best method to use.

Linear Multi-Span Network – Dual Homed

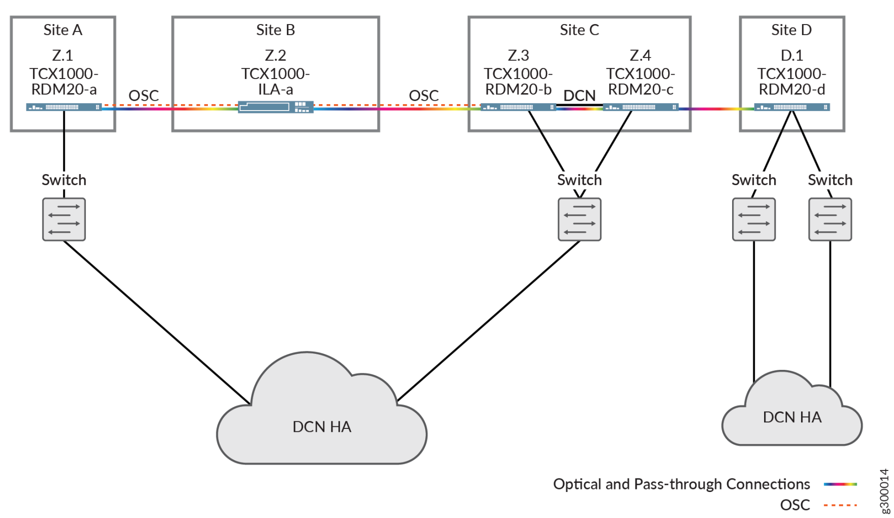
The example network deployment inFigure 44 on page 131 shows a linear multi-span network that includes four sites: A, B, C, D. Looking at our rules for L2/L3 subnets, we can see:

- At site A, TCX1000-RDM20-a is on IP subnet Z.1
- At site B, TCX1000-ILA-a is on IP subnet and Z.2
- At site C, TCX1000-RDM20-b is on IP subnet Z.3 and TCX1000-RDM20-c is on IP subnet Z.4
- At site D, TCX1000-RDM20-d is on IP subnet D.1

TCX1000-RDM20-d at site D is on a different IP subnet (subnet D) than the other sites in the network, which are all on IP subnet Z. This tells us that we must do several things on TCX1000-RDM20-d:

1. We need to segregate site D because it is on a different L2/L3 network subnet. This means that all management communications to TCX1000-RDM20-d at site D must are through the dual-DCN ports and the proNX Optical Director must be able to access the cloud at site D through L3 IP communications.
2. We also need to ensure we do not enable OSC forwarding on the line port of TCX1000-RDM20-d at site D because we do not want to forward management messages from one IP subnet to another since the TCX1000-RDM20 acts as a Layer 2 device in the network.

Figure 44: Linear Multi-Span Network – Dual Homed



Between the two TCX1000-RDM20s at sites C, there are two connections:

- The optical line shows the pass-through channels connected between the two TCX1000-RDM20s.
- The black line shows the DCN ports daisy-chained between the two TCX1000-RDM20s for management communications.

Looking at our rules for redundant network management communications in Figure 44 on page 131, we can see that TCX1000-RDM20-a at site A is directly connected to the DCN through a single DCN connection. The secondary path for management communications for TCX1000-RDM20-a is over its line port from the TCX1000-ILA-a at site B, therefore we must enable OSC forwarding on TCX1000-RDM20-a at site A.

At site B we have a TCX1000-ILA, which has no access to the DCN. Line A receives management communications over OSCA from TCX1000-RDM20-a at site A. Line B receives management communications over OSCB from TCX1000-RDM20-b at site C.

At site C, we have TCX1000-RDM20-b and TCX1000-RDM20-c, which each have only a single DCN connection for management communications. The OSCB from the TCX1000-ILA-a at site B serves as the second path for management communications to TCX1000-RDM20-b. However, TCX1000-RDM20-c cannot receive management communications from TCX1000-RDM20-d at site D because it is on a different IP subnet. Therefore, the second path for management communications to TCX1000-RDM20 c is over its DCN port, which must be daisy-chained to the DCN port of TCX1000-RDM20-b.

Table 13 on page 132 summarizes the management communications and methods for the example network shown in Figure 44 on page 131.

Table 13: Summary of Management Communications

Site	Device	OSC Forwarding Enabled	Management Communications for proNX Optical Director
A	TCX1000-RDM20-a	Yes	Uses a single connection to the DCN and as the second path uses its Line port to exchange management messages with the TCX1000-ILA-a at site B.
B	TCX1000-ILA-a	N/A	Uses its Line A port to exchange management messages with site A and uses its Line B port to exchange management messages with site C.
C	TCX1000-RDM20-b	Yes	Uses its Line port to exchange management messages with TCX1000-ILA-a at site B and has its DCN port daisy-chained to the DCN port of TCX1000-RDM20-c for management communications to the DCN.
	TCX1000-RDM20-c	Yes	Uses a direct DCN connect to the Layer 2 switch DCN and as a second path has its other DCN port daisy-chained to the DCN port on TCX1000-RDM20-b for redundant management communications.

Table 13: Summary of Management Communications (continued)

Site	Device	OSC Forwarding Enabled	Management Communications for proNX Optical Director
D	TCX1000-RDM20-d	No	All management communications to this device are through the dual-DCN ports on the device to the L2 switch.

In summary, all TCX1000 devices in Figure 43 on page 129 have redundant paths for management communications either through their Ethernet management ports or their Line ports and we have met all of our other deployment rule requirements.

However, only the TCX1000-RDM20 at site D is using the best practice management communication methods. The TCX1000-RDM20s use a single DCN port and or their Line ports but none of them have dual-DCN connections to the DCN HA. The TCX1000-ILA uses only its Line ports for management communications and not the MGMT port, which is the best method to use.

Related Documentation

- TCX1000 Management Architecture on page 103
- Deployment Rules for TCX1000 Management Communications on page 109
- TCX1000-RDM20 OSC Connection Overview on page 143
- Management Communications Examples for TCX1000 Ring Networks on page 133

Management Communications Examples for TCX1000 Ring Networks

This sections describes management communications examples for TCX1000 ring networks. It focuses on network examples and describes how each device in the example handles management communications.

- Ring ROADM Network – Single Homed Deployment Example 1 on page 133
- Ring ROADM Network – Single Homed Deployment Example 2 on page 136
- Ring ROADM Network – Dual Homed Example on page 139

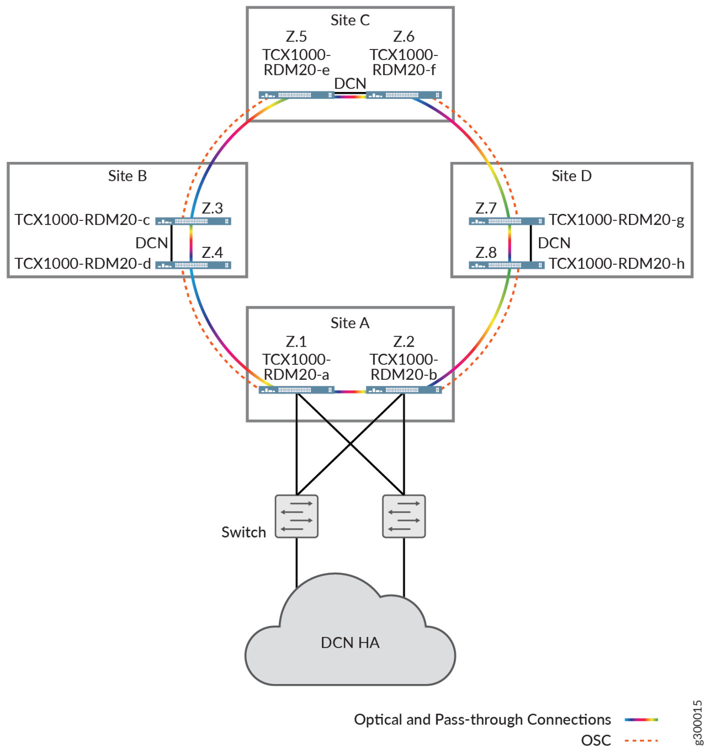
Ring ROADM Network – Single Homed Deployment Example 1

The example ring network Figure 45 on page 134 includes four sites: A, B, C, D.

- At site A, TCX1000-RDM20-a is on IP subnet Z.1 and TCX1000-RDM20-b is on IP subnet Z.2
- At site B, TCX1000-RDM20-c is on IP subnet and Z.3 and TCX1000-RDM20-d is on IP subnet and Z.4
- At site C, TCX1000-RDM20-e is on IP subnet Z.5 and TCX1000-RDM20-f is on IP subnet Z.6
- At site D, TCX1000-RDM20-g is on IP subnet Z.7 and TCX1000-RDM20-h is on IP subnet Z.8

Looking at our rules for L2/L3 subnets, we can see that all sites are on the Z subnet, so we do not need to worry about the L2/L3 segregation rule in this example.

Figure 45: Ring Network – Single Homed Deployment Example 1



Between the two TCX1000-RDM20s at sites B, C, D there are two connections:

- The optical line shows the pass-through channels connected between the two TCX1000-RDM20s.
- The black line shows the DCN ports daisy-chained between the two TCX1000-RDM20s for management communications.

Let us look at how each TCX1000 device in Figure 45 on page 134 communicates to the DCN HA.

One thing stands out looking at this network; the only site in the network that has direct access to the DCN is site A. This tells us several things:

- Site A is the hub for management communications and all management communications to sites B, C and D go through the TCX1000-RDM20s at site A.
- All TCX1000-RDM20s at sites B, C and D must have OSC forwarding enabled in order for them to exchange management messages with site A devices.
- We have no conflicts using OSC Forwarding because we know that all TCX1000 devices in the network are on the same L2/L3 subnet.

In this example, at site A both TCX1000-RDM20-a and TCX1000-RDM20-b are using their dual-DCN connections for management communications. However, they are also each responsible for communicating management messages over their Line ports to the TCX1000 devices at sites B and D and must therefore have OSC forwarding enabled. TCX1000-RDM20-a communicates management messages over its Line port to TCX1000-RDM20-d at site B and TCX1000-RDM20-b communicates management messages over its line port to TCX1000-RDM20-h at site D.

Table 14 on page 135 summarizes the management communications and methods for the example network shown in Figure 45 on page 134.

Table 14: Summary of Management Communications

Site	Device	OSC Forwarding Enabled	Management Communications for proNX Optical Director
A	TCX1000-RDM20-a	Yes	BEST PRACTICE: Uses its dual-DCN connections for management communications and its Line port to exchange management communications with TCX1000-RDM20-d at site B over its line port.
	TCX1000-RDM20-b	Yes	BEST PRACTICE: Uses its dual-DCN connections for management communications and its Line port to exchange management communications with TCX1000-RDM20-h at site D over its line port.
B	TCX1000-RDM20-c	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-e at site C and has its DCN port daisy-chained to TCX1000-RDM20-d within the same node so that it can receive management messages over its DCN port received from the TCX1000-RDM20-d Line port.
	TCX1000-RDM20-d	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-a at site A and has its DCN port daisy-chained to TCX1000-RDM20-c within the same node so that it can receive management messages over its DCN port received from the TCX1000-RDM20-c Line port.
C	TCX1000-RDM20-e	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-c at site B and has its DCN port daisy-chained to TCX1000-RDM20-f within the same node so that it can receive management messages over its DCN port received from the TCX1000-RDM20-f Line port connected to site B.
	TCX1000-RDM20-f	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-g at site D and has its DCN port daisy-chained to TCX1000-RDM20-e within the same node so that it can receive management messages over its DCN port received from the TCX1000-RDM20-e Line port connected to site D.

Table 14: Summary of Management Communications (continued)

Site	Device	OSC Forwarding Enabled	Management Communications for proNX Optical Director
D	TCX1000-RDM20-g	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-f at site C and has its DCN port daisy-chained to TCX1000-RDM20-h within the same node so that it can receive management messages over its DCN port received from the TCX1000-RDM20-h Line port connected to site A.
	TCX1000-RDM20-h	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-b at site A and has its DCN port daisy-chained to TCX1000-RDM20-g within the same node so that it can receive management messages over its DCN port received from the TCX1000-RDM20-g Line port connected to site C.

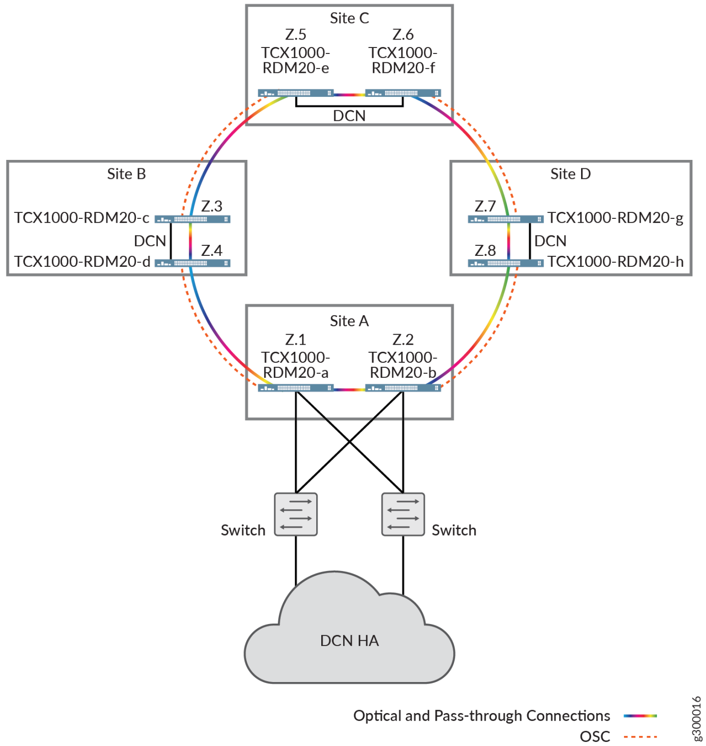
In summary, all TCX1000 devices in Figure 45 on page 134 have redundant paths for management communications either through their Ethernet management ports or their Line ports and we have met all of our other deployment rule requirements.

However, only the TCX1000-RDM20s at site A are using the best practice management communication methods. All other TCX1000-RDM20s use a single DCN port and their Line ports but none of them have dual-DCN connections to the DCN HA, which is the best method to use.

Ring ROADM Network – Single Homed Deployment Example 2

The example network in Figure 46 on page 137 is exactly the same as the example shown in the previous example Figure 45 on page 134. All the TCX1000 devices are on subnet Z, so we do not need to worry about IP segregating L2/L3 subnets.

Figure 46: Ring ROADM Network – Single Homed Example 2



Between the two TCX1000-RDM20s at sites A, B, C, D there are two connections:

- The optical line shows the pass-through channels connected between the two TCX1000-RDM20s.
- The black line shows the DCN ports daisy-chained between the two TCX1000-RDM20s for management communications.

Let us look at how each TCX1000 device in Figure 46 on page 137 communicates to the DCN HA.

The other thing that is similar is that the only site in the network that has direct access to the DCN is site A. Sites B, C and D have no direct DCN access and must be remotely managed over their Line ports. However, unlike the previous example, the TCX1000-RDM20s at site A have only a single connection to the DCN. This tells us several things:

- All management communications in the network go through site A
- All TCX1000-RDM20 devices at sites A, B, C and D must have OSC forwarding enabled, which we know is alright because the network is on one L2/L3 subnet.

At site A, each TCX1000-RDM20 at site A has only a single connection to the DCN for management communications and we need two paths to each device, so we must daisy-chained the other DCN port on each TCX1000-RDM20 at site A so that they can exchange management messages with each other as a second path.

Table 15 on page 138 summarizes the management communications and methods for the example network shown in Figure 46 on page 137.

Table 15: Summary of Management Communications

Site	Device	OSC Forwarding Enabled	Management Communications for proNX Optical Director
A	TCX1000-RDM20-a	Yes	Uses one DCN port to the switch and second DCN port is daisy-chained to TCX1000-RDM20-b so that the device can also communicate management messages over its second DCN port. Its also uses its Line port.
	TCX1000-RDM20-b	Yes	Uses one DCN port to the switch and second DCN port is daisy-chained to TCX1000-RDM20-a so that the device can also communicate management messages over its second DCN port. Its also uses its Line port.
B	TCX1000-RDM20-c	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-e at site C and has its DCN port daisy-chained to TCX1000-RDM20-d within the same node so that it can receive management messages over its DCN port received from the TCX1000-RDM20-d Line port.
	TCX1000-RDM20-d	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-a at site A and has its DCN port daisy-chained to TCX1000-RDM20-c within the same node so that it can receive management messages over its DCN port received from the TCX1000-RDM20-c Line port.
C	TCX1000-RDM20-c	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-c at site B and has its DCN port daisy-chained to TCX1000-RDM20-f within the same node so that it can receive management messages over its DCN port received from the TCX1000-RDM20-f Line port connected to site B.
	TCX1000-RDM20-d	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-g at site D and has its DCN port daisy-chained to TCX1000-RDM20-e within the same node so that it can receive management messages over its DCN port received from the TCX1000-RDM20-e Line port connected to site D.
D	TCX1000-RDM20-g	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-f at site C and has its DCN port daisy-chained to TCX1000-RDM20-h within the same node so that it can receive management messages over its DCN port received from the TCX1000-RDM20-h Line port connected to site A.
	TCX1000-RDM20-g	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-b at site A and has its DCN port daisy-chained to TCX1000-RDM20-g within the same node so that it can receive management messages over its DCN port received from the TCX1000-RDM20-g Line port connected to site C.

In summary, all TCX1000 devices in Figure 46 on page 137 have redundant paths for management communications either through their Ethernet management ports or their Line ports and we have met all of our other deployment rule requirements.

However, none of the TCX1000-RDM20s in this example are using the best practice management communication methods, which is connecting each TCX1000-RDM20 to its own external Layer 2 switch through the dual-DCN ports on the device.

Ring ROADM Network – Dual Homed Example

The example in Figure 47 on page 140shows a managed ring ROADM network that is dual-homed at sites A and D, providing complete redundancy for management communications.

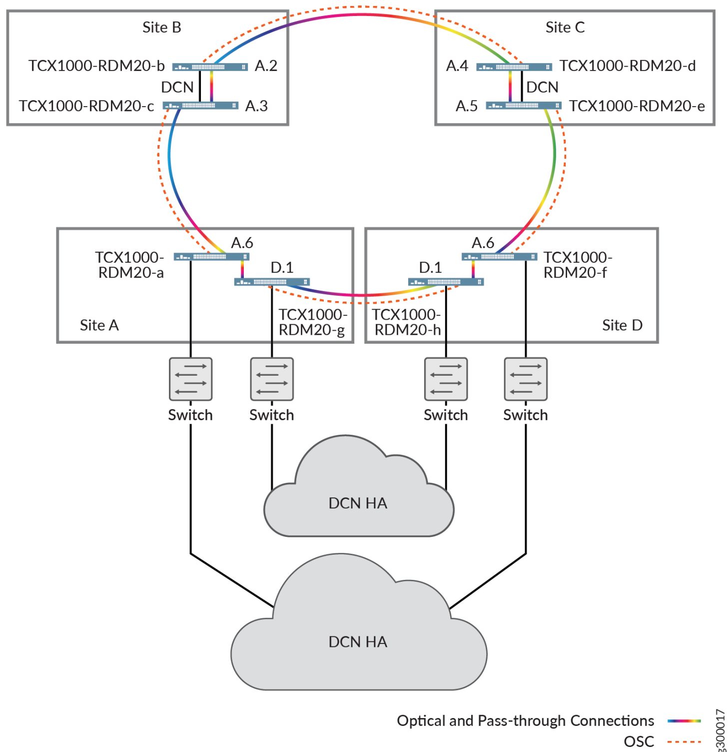
This network has four sites: A, B, C and D:

- At site A, TCX1000-RDM20-a is on IP subnet A.6 and TCX1000-RDM20-g is on IP subnet D.1
- At site B, TCX1000-RDM20-b is on IP subnet and A.2 and TCX1000-RDM20-c is on IP subnet and A.3
- At site C, TCX1000-RDM20-d is on IP subnet A.4 and TCX1000-RDM20-e is on IP subnet A.5
- At site D, TCX1000-RDM20-f is on IP subnet A.6 and TCX1000-RDM20-h is on IP subnet D.1

Based on our rules for L2/L3 subnets, we have segregated the L2/L3 subnets at sites A and D using dedicated L2 switches and L3 (IP) management communications are segregated through separate Ethernet DCNs for the D.1 and A.6 IP subnets.

So again, we have segregated L2/L3 subnets and kept them together. This example also has two RSTP domains, one for subnet D.1 and one for subnet A.6.

Figure 47: Ring ROADM Network – Dual Homed Example



Between the two TCX1000-RDM20s at sites B and C there are two connections:

- The optical line shows the pass-through channels connected between the two TCX1000-RDM20s.

NOTE: **If their is a failure with management communications at site A hub, you can dynamically activate the site D management communication hub and all management communications will reroute over the pass-through connections between the TCX1000-RDM20s at sites A and D.**

- The black line shows the DCN ports daisy-chained between the two TCX1000-RDM20s for management communications.

As we look at how each TCX1000 device in Figure 47 on page 140 communicates to its respective DCN, a couple of things are important to notice:

- The TCX1000 devices on subnet D.1 at sites A and D (TCX1000-RDM20-g and TCX1000-RDM20-h), each have a single connection to their DCN for management communications. The second path for management communications for TCX1000-RDM20-g and TCX1000-RDM20-h on subnet D.1 is their Line ports and therefore we must enable OSC forwarding on both of these devices.
- The TCX1000 devices on subnet A.6 at sites A and D (TCX1000-RDM20-a and TCX1000-RDM20-f), each have a single connection to their DCN for management

communications. The second path for management communications for TCX1000-RDM20-a and TCX1000-RDM20-f on subnet A.6 is their Line ports and therefore we must enable OSC forwarding on both of these devices.

- At sites B and C, each TCX1000-RDM20 uses its Line port for management communications and we therefore must enable OSC forwarding on them. We must also daisy chain the DCN port on the TCX1000-RDM20 at these sites so they can also receive management messages from each others Line ports.

NOTE: **What we must never do in this network is daisy chain the DCN ports between the TCX1000-RDM20s at sites A and D. Both of these sites include TCX1000-RDM20s that are different L2/L3 subnets.**

Table 16 on page 141 summarizes the management communications and methods for the example network shown in Figure 47 on page 140.

Table 16: Summary of Management Communications

Site	Device	OSC Forwarding Enabled	Management Communications for proNX Optical Director
A	TCX1000-RDM20-a	Yes	Uses a single connection to the DCN through the L2 switch for management communications and also exchanges management messages with TCX1000-RDM20-c at site B over its Line port.
	TCX1000-RDM20-g	Yes	Uses a single connection to the DCN through the L2 switch for management communications and also exchanges management messages with TCX1000-RDM20-h at site D over its Line port.
B	TCX1000-RDM20-b	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-d at site C and has its DCN port daisy-chained to TCX1000-RDM20-c within the same node so that it can receive management messages over its DCN port from the TCX1000-RDM20-c Line port.
	TCX1000-RDM20-c	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-a at site A and has its DCN port daisy-chained to TCX1000-RDM20-b within the same node so that it can receive management messages over its DCN port received from the TCX1000-RDM20-b Line port.

Table 16: Summary of Management Communications (continued)

Site	Device	OSC Forwarding Enabled	Management Communications for proNX Optical Director
C	TCX1000-RDM20-d	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-b at site B and has its DCN port daisy-chained to TCX1000-RDM20-e within the same node so that it can receive management messages over its DCN port received from the TCX1000-RDM20-e Line port.
	TCX1000-RDM20-e	Yes	Uses its Line port to exchange management messages with TCX1000-RDM20-f at site D and has its DCN port daisy-chained to TCX1000-RDM20-d within the same node so that it can receive management message over its DCN port received from the TCX1000-RDM20-d Line port connected to site D.
D	TCX1000-RDM20-f	Yes	Uses a single connection to the DCN through the switch and also exchange management messages over its Line port with TCX1000-RDM20-e at site C.
	TCX1000-RDM20-h	Yes	Uses a single connection to the DCN through the switch and also exchange management messages with TCX1000-RDM20-g at site A.

In summary, all TCX1000 devices in Figure 47 on page 140 have redundant paths for management communications either through their Ethernet management ports or their Line ports and we have met all of our other deployment rule requirements.

BEST PRACTICE: Although none of the TCX1000-RDM20s in this example are using the best practice management communication methods, which is connecting each TCX1000-RDM20 to its own external Layer 2 switch through the dual-DCN ports on the device, this example does meet best practices for management communications at site A, because it has completely duplicated the management communication hub at site D. If there is a failure with management communications at the site A hub, you can dynamically activate the site D hub in the proNX Optical Director.

Related Documentation

- TCX1000 Management Architecture on page 103
- Deployment Rules for TCX1000 Management Communications on page 109
- TCX1000-RDM20 OSC Connection Overview on page 143

TCX1000-RDM20 OSC Connection Overview

This topic provides an overview of the OSC kit and how you connect the OSC. To use OSC forwarding for management communications, you must install the TCX1000-RDM20 OSC optics.

What is the OSC Used For?

Both the TCX1000-RDM20 and TCX1000-ILA support an OSC, which is used for several purposes:

- To remotely manage TCX1000-RDM20 and TCX1000-ILA devices at sites with limited access to your DCN.
- Enables zero-channel turn-up by providing an optical link between the two managed devices allowing proNX Optical Director to measure span loss between the two managed devices without having any channels turned up.
- Assists with the optical safety for the system. If both the OSC Ethernet link state is down *and* the preamplifier is in active loss of signal (LOS) alarm, the booster is automatically disabled. Recovery is automatic when the fault is repaired.

NOTE: On the TCX1000-ILA, the OSC is passed along with the OMS line signal to the next TCX1000 device. The OSC optics on the TCX1000-ILA are internal to the device. You simply connect the Line ports to the device.

TCX1000-RDM20 OSC Kit

The TCX1000-RDM20 comes with an OSC kit that includes a 1511 nm SFP transceiver to provide the OSC channel.

On the TCX1000-RDM20, the 1511 nm OSC is multiplexed, along with the C-band DWDM channels present on the universal ports, and the composite signal is sent out the **Line Out** port to the fiber system. At the receiving TCX1000-RDM20, the composite line signal is received on the **Line In** port. The C-band channels are routed to the appropriate universal ports and the OSC is routed to the **OSC 0** port. The **OSC 0** port is connected to the OSC SFP transceiver which is connected to the internal CPU via an internal Ethernet Layer 2 switch.

NOTE: Although the TCX1000-RDM20 can support either a 1511 nm OSC on the **OSC 0** port or a 1611 nm OSC on **OSC 1** port we support only the use of the provided 1511 nm OSC. As a result, the **OSC 1** port is not used and you can use this port, to connect an instrumentation grade optical time-domain reflectometer (OTDR) at 1611 nm for optical fiber characterization.

Connecting the OSC

There are three ports associated with the OSC on the front panel of TCX1000-RDM20:

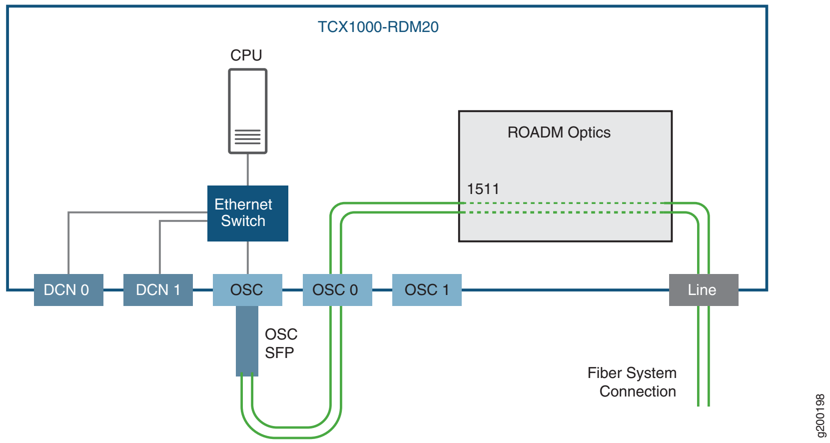
- **OSC** — Accepts an SFP optical transceiver that provides the transmit and receive functions of the OSC wavelength
- **OSC 0** — Optical port that multiplexes and demultiplexes the 1511 nm OSC signal on the Line port
- **OSC 1** — Optical port that multiplexes and demultiplexes the 1611 nm OSC signal on the Line port

These ports are used in the following manner:

- The **OSC 1** port is not used in this release. As a result, you can use the **OSC 1** port, to connect an instrumentation grade optical time-domain reflectometer (OTDR) at 1611 nm for optical fiber characterization.
- The **OSC 0** port is used for Line port management communications. You connect **OSC 0** port to the SFP in the **OSC** port with a patch cord provided in the OSC kit. It transmits and receives the 1511 nm channel from the SFP optical transceiver supplied in the OSC kit.
- The **OSC** port is an SFP cage that accepts an SFP optical transceiver for the OSC function. In this release, we provide an OSC kit with each TCX1000-RDM20 that includes a 1511 nm, 100 Mbps SFP optical transceiver that provides the OSC signal. You insert the transceiver into the **OSC** port and then use the provided patch cord to connect the 1511 nm channel to the **OSC 0** port.

These connections are illustrated in Figure 48 on page 145.

Figure 48: TCX1000-RDM20 OSC Connections



Because the OSC signal is coupled to the WDM signal after the integrated VOA, it does not receive any additional attenuation over the loss of the system fiber. As a result, when operating the TCX1000-RDM20 on short spans, additional external loss must be added. If the OSC power at the receive side of the SFP port is measured to be above -7 dBm, then you should install the fixed loss attenuators supplied in the OSC kit.

Related Documentation

- Deployment Rules for TCX1000 Management Communications on page 109
- proNX Optical Director Control and Management Software Components on page 48
- *Enabling OSC Forwarding on the TCX1000-RDM20*

CHAPTER 12

TCX1000-RDM20 Configuration Overview and Software Upgrades

TCX1000-RDM20 Port Administrative States

Port Administrative State and Operational State

The ports on the TCX1000-RDM20 have two possible states:

- Operational — The operational state is read-only and can be either **Up**, to indicate the port is operational, or **Down**, to indicate the port is not operational.
- Administrative — The administrative state is configurable and can be set to **In-service** or **Out-of-service**.

NOTE: **To enable a link, set the administrative state of the port to In-service.**

Placing a port **Out-of-service** automatically blocks all associated spectrum. It does not change any of the provisioned configuration parameters so that the connection automatically returns to the same state it was in when placed back to **In-service**, providing external conditions remain the same as well. An **Out-of-service** port continues to accept provisioning changes but will not optically apply any of them until it is placed back into service.

Input and output ports are initially specified during connection creation but can be also be changed at any time. This can be done without restriction, whether the connection is in or out-of-service and whether it is blocked or unblocked.

Auto Provisioning of Ports

By default, the following ports are set to **Out-of-service** on a new device:

- Line ports — When you define an external link for the line port, the administrative state on both the line port and the OSC 0 port are auto-provisioned to **In-service**.
- Universal ports — When you create a physical-link to a multiplexer-demultiplexer or to a Junos port, the universal port is auto-provisioned to **In-service**.
- OSC ports — Auto-provisioning of these ports works in the following manner:
  - The **OSC** port is the pluggable port and after the supplied optical SFP transceiver is plugged in, the administrative state is automatically changed to **In-service**.

Related Documentation

- TCX1000-RDM20 Overview on page 31
- TCX1000-RDM20 Optical Monitoring Points on page 36

proNX Optical Director Links and Services Overview

All TCX1000 Series devices are configured and managed by proNX Optical Director. This topic describes the basic concept of links and services for the TCX Series Optical Transport System. It includes the following subjects:

- Links on page 148
- Services on page 152

Links

Links Overview

Configuring and learning device links allows the proNX Optical Director to have a view of the topology of the optical network, which is a prerequisite for managing optical services. An accurate view of the topology allows the proNX Optical Director to dynamically control the optical links in your network and to determine the available service paths for the services that you subsequently create. In order to build the topology, the proNX Optical Director needs to know how devices are connected together, including knowledge of the device links within a ROADM node, the device links between ROADM nodes, the device links between amplifier sites, and the device links between ROADM nodes and amplifier sites. See Table 17 on page 148 for definitions of terms used in this section.

Table 17: Optical Network Glossary

Term	Definition
Amplifier site	A site containing a line amplifier device providing amplification of the incoming composite DWDM signals. An example of a line amplifier device is the TCX1000-ILA, which is an inline amplifier that provides amplification in both directions.
Device link	A link between any two managed devices. Device links represent the actual fibers installed between devices in your network.
Line span	A device link connecting the line ports of two devices together.

Table 17: Optical Network Glossary (continued)

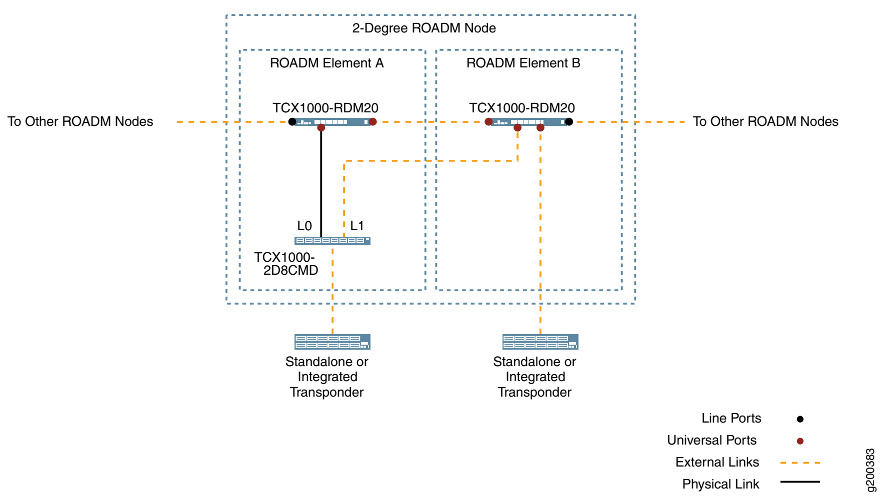
Term	Definition
Tail facility	The link from the optical network edge to the client transponder. See Table 20 on page 155 and Table 19 on page 154.
Topology	The ROADM topology, which is the topology concerned with how ROADM nodes are connected together, and consequently, how wavelengths are allocated in the network. NOTE: The ROADM topology models an amplifier site as part of a line because line amplifiers operate on the composite DWDM signal and not on the individual wavelengths.

Figure 49 on page 149 shows an example of how devices can be connected together in a 2-degree ROADM node. A 2-degree ROADM node contains two ROADM elements, with each ROADM element connected to a line (or degree). These ROADM elements are labelled A and B in the example.

ROADM Element A consists of a TCX1000-RDM20 and a 2D8CMD. The 2D8CMD connects to a universal port on the TCX1000-RDM20 in ROADM Element A and can optionally connect to a universal port on the TCX1000-RDM20 in ROADM Element B. By connecting to both TCX1000-RDM20 devices, the 2D8CMD has add/drop access to wavelengths on both degrees, which is a prerequisite to setting up a service with working and protection paths.

In contrast, ROADM Element B just consists of a TCX1000-RDM20, so it only has add/drop access to wavelengths on the line that it is attached to. The reason for this is that the TCX1000-RDM20 can only switch wavelengths between its universal ports and its line port. It cannot switch wavelengths from one universal port to another.

Figure 49: 2-Degree ROADM Node Example



The endpoint or client transponder can be a standalone device or integrated within a router or a switch. The endpoint transponder can connect to the ROADM node in a couple of different ways. One way is to connect the endpoint transponder to a client port on the 2D8CMD in ROADM Element A to provide add/drop access to both degrees. By doing this, you can then set up a service with both working and protection paths through the network. The second way is to connect the endpoint transponder directly to a universal port on the TCX1000-RDM20 in either ROADM Element A (not shown) or ROADM Element B to provide add/drop access to the degree to which the TCX1000-RDM20 is attached.

The device links to the endpoint transponders are known as tail facilities, which are the connections between the optical network edge and the client device. The proNX Optical Director can be used to provision tail facility links to supported ports on Juniper Networks equipment as well as to provision the endpoints themselves. See Table 19 on page 154 and Table 20 on page 155 for the list of the tail facility endpoints that the proNX Optical Director can configure.

Device links within a ROADM node and from a ROADM node to a tail facility endpoint must be manually provisioned.

Device links between ROADM nodes, between amplifier sites, and between ROADM nodes and amplifier sites, can be learned depending on which release of the proNX Optical Director and TCX1000-RDM20 you are running. These device links are called line spans because they connect to the line ports of the devices.

Provisioned Device Links

A provisioned device link is a device link that you explicitly create. A provisioned device link where both endpoints are within the same ROADM element is called a physical link. A provisioned device link where one endpoint resides outside the ROADM element is called an external link. For more information on external and physical links, see http://www.openroadm.org.

NOTE: In Juniper Networks' implementation, only device links that are provisioned have a physical or external type designation. Auto-learned device links are not associated with a link type.

It is important that your configured device links match the actual device links or unexpected behavior can occur.

NOTE: When you provision a device link to a ROADM port, the ROADM port is automatically placed in-service administratively. You do not need to manually place the port in-service.

Auto-Learned Device Links

Automatic learning of line spans is supported if you are running proNX Optical Director release 2.2 or higher and the devices in your network are running the following releases:

- TCX1000-RDM20 running release 3.1 or higher
- TCX1000-ILA running any release

The proNX Optical Director learns about the existence of line spans based on the Link Layer Discovery Protocol (LLDP) neighbor information that the devices report. While the proNX Optical Director can determine the neighbors from this data, it cannot determine the type of fiber used for the span because the type of fiber used cannot be automatically detected. Instead, the proNX Optical Director assumes a default fiber type for all line spans in the network.

NOTE: **If this default fiber type is different from the actual fiber type for a particular span, you will need to manually configure the fiber type for that span.**

To change the fiber type, you have to create an external link based on the auto-learned link and then change the fiber type of the external link. The proNX Optical Director does not allow you to change the fiber type of an auto-learned device link directly because auto-learned data originates from the device and is read-only. For convenience, the proNX Optical Director user interface lets you perform this task as if you are editing the fiber type.

Nevertheless, it is important for you to be aware that when you change the fiber type of an auto-learned device link, you are actually creating a separate external link and assigning a fiber type to that external link. When the proNX Optical Director sees an external link and an auto-learned link sharing the same two endpoints, the proNX Optical Director uses the fiber type provisioned for the external link.

If you later physically unplug the fiber associated with the auto-learned device link, the auto-learned designation disappears from the table (in the Device Links Current page), but the entry remains to represent the newly created external link. You can delete this external link just like you can delete any other external link.

NOTE: **Unlike a provisioned link, an auto-learned link to a ROADM port does not automatically place the ROADM port administratively in-service. You will need to manually place the port in-service or create the external link for the line span. One way of creating the external link is to edit the fiber type.**

Link Validation

The proNX Optical Director validates device links for network-wide consistency. The following provisioning inconsistencies are detected and alarmed:

- Two or more device links share the same endpoint (that is, a port has a link to more than one device). The proNX Optical Director displays the inconsistent links in the table in the Device Links Current page. The inconsistent links are considered invalid and are not considered part of the topology.
- An auto-learned line span does not match the provisioned (expected) line span. The proNX Optical Director displays the inconsistent links in the table in the Device Links Current page. The auto-learned line span is considered valid and part of the topology.

The provisioned (expected) line span is considered invalid and is therefore not part of the topology.

Supported Optical Links

Table 18 on page 152 describes the allowed link endpoint combinations.

The source and destination designations are used only to distinguish between the two link endpoints. They are assigned arbitrarily and are interchangeable.

Table 18: Supported Optical Links

Source Link Endpoint	Destination Link Endpoints	Notes
A line port on a TCX1000-RDM20 or a TCX1000-ILA	A line port on a TCX1000-RDM20 or a External TCX1000-ILA	NOTE: You can cascade up to four TCX1000-ILAs in an amplifier chain.
Universal port on TCX1000-RDM20	Universal port on a co-located TCX1000-RDM20 in a multi-degree note	NOTE: This is a fiber connection used for channel pass-through between ROADM elements in a multi-degree ROADM node.
Universal port on TCX1000-RDM20	A line port on a TCX1000-2D8CMD optical multiplexer-demultiplexer	Enables 8 channels from the TCX1000-2D8CMD to be multiplexed over a single universal port on the TCX1000-RDM20.
Universal port on TCX1000-RDM20	A line port on a BTI7800-FMD96 fixed optical multiplexer-demultiplexer	Enables up to 96 x 200 Gbps coherent channels from the BTI7800-FMD96 to be multiplexed over a single universal port. The FMD96 is a fixed channel multiplexer/demultiplexer, which means that each client port is associated with a hardcoded fixed wavelength. When you create a link between an FMD96 client port and a tail facility endpoint, you must ensure that the tail facility endpoint is configured with a wavelength that matches the wavelength of the client port on the FMD96.
A universal port on a TCX1000-RDM20	A supported tail facility endpoint on Juniper Networks equipment. See Table 20 on page 155.	
A client port on an FMD96 or on a 2D8CMD	A supported tail facility endpoint on Juniper Networks equipment. See Table 20 on page 155.	

Services

Services Overview

An optical service provides wavelength connectivity between optical service endpoints and exists as a series of individual optical cross-connects that route the service wavelength through the multiplexers/demultiplexers, ROADMs, and line amplifiers that make up the optical network. The proNX Optical Director encapsulates this series of cross-connects into a single entity for presentation to the user.

Attached to each end of the optical service is the endpoint transponder. The endpoint transponder can be a standalone transponder or a transponding function integrated on packet equipment.

The connection between the endpoint transponder and the optical network edge is called the tail facility. The tail facility endpoint (that is, transponder) is not part of the optical network, but you can use the proNX Optical Director to configure the tail facility endpoint if the tail facility terminates on a supported transceiver port on Juniper Networks equipment. This is called a supported tail facility endpoint.

If the tail facility does not terminate on a supported transceiver port, the tail facility endpoint is known as an external or alien endpoint. You can connect an alien endpoint to the optical network but you will need to configure the alien endpoint using the external equipment's management system.

When you create an optical service using the proNX Optical Director, you specify the wavelength and the two endpoints that the wavelength interconnects. The endpoint that you specify can be an optical service endpoint (that is, an optical port at the optical network edge) or a supported tail facility endpoint:

- If the service connects to a supported tail facility endpoint, then you can specify the tail facility endpoint directly when you create the service. The proNX Optical Director automatically determines where the optical service endpoints are based on the configured device links and sets up the optical service between the optical service endpoints.
- If the service connects to an alien endpoint, then the endpoint you specify is the optical port that attaches to the alien endpoint at the optical network edge. This can be a topologically-unconnected universal port on a TCX1000-RDM20 if the alien device is attached directly to that port, or a universal port on a TCX1000-RDM20 that is topologically connected to a multiplexer/demultiplexer. In this latter case, the alien device is attached to a client port on the multiplexer/demultiplexer.

Optical Service Endpoints and Tail Facility Endpoints

This section describes two types of endpoints: the optical service endpoint and the tail facility endpoint.

The optical service endpoint refers to the port at the optical network edge that connects to the client transponder. This endpoint is part of the optical network.

The tail facility endpoint is the port on the client transponder that connects to the optical network edge. This endpoint is a client or a user of the optical network.

Figure 50 on page 154 and Table 19 on page 154 describe the allowed endpoints when you create a service. You can create a service from endpoints A, B, C, or D to endpoints E, F, G, or H.

Figure 50: Optical Service Endpoints

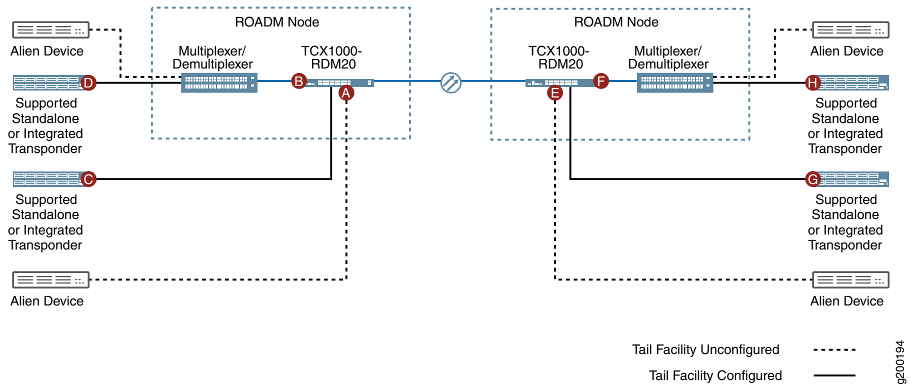


Table 19: Optical Service and Tail Facility Endpoints

Endpoint	Label	Usage
An optical service endpoint where the endpoint is a topologically-unconnected universal port on a TCX1000-RDM20. This is a universal port that does not have a link associated with it.	A or E	You typically use this endpoint when you set up a service to an alien device that is attached directly to a universal port on the TCX1000-RDM20.
An optical service endpoint where the endpoint is a universal port on a TCX1000-RDM20 that is topologically connected to a multiplexer/demultiplexer. This is a universal port that has a link to a multiplexer/demultiplexer.	B or F	You typically use this endpoint when you set up a service to an alien device that is attached to a client port on the multiplexer/demultiplexer.
A supported tail facility endpoint where the endpoint is topologically connected to a universal port on a TCX1000-RDM20. This is a transceiver port at the supported tail facility endpoint.	C or G	You typically use this endpoint when you set up a service to a supported tail facility endpoint that is attached directly to a universal port on the TCX1000-RDM20.
A supported tail facility endpoint where the endpoint is topologically connected to a client port on a multiplexer/demultiplexer. This is a transceiver port at the supported tail facility endpoint.	D or H	You typically use this endpoint when you set up a service to a supported tail facility endpoint that is attached to a client port on the multiplexer/demultiplexer.

The TCX1000-RDM20 has a pool of 20 universal ports that you can use to connect to other ROADM elements and/or to client transponders. For lower wavelength fan-out, you can deploy the TCX1000-RDM20 without a multiplexer/demultiplexer and use any available universal ports to connect directly to client transponders (labels A, C, E, G). For larger wavelength fan-out, you can deploy the TCX1000-RDM20 alongside a multiplexer/demultiplexer to give access to more wavelengths (labels B, D, F, H).

When creating a service to an alien tail facility endpoint, the endpoint you specify resides in the optical network (labels A, B, E, F) and does not include the tail facility itself. It is your responsibility to ensure that the alien endpoint is configured properly to connect to the optical network at those points.

When creating a service to a supported tail facility endpoint, the endpoint that you specify is the supported port on Juniper Networks equipment (labels C, D, G, H in Figure 50 on page 154). SeeTable 20 on page 155 for the list of supported tail facility endpoints.

Creating a service for a supported tail facility listed Table 20 on page 155 in:

- Includes control and configuration of endpoint transceiver(s)
- Sets up of the service, such a 100 Gbps Ethernet transport including wavelength
- Opens the optical path through network to allow transport of channel
- Opens the optical path and brings it under control for performance optimization
- Creates the service, for example from router port to router port

See Figure 50 on page 154 and Table 19 on page 154 for the allowed endpoints when you create a service. You can create a service from A, B, C, or D to E, F, G, or H.

For lower wavelength fan-out, you can deploy the TCX1000-RDM20 without a multiplexer-demultiplexer and use the universal ports to connect directly to client transponders (labels A, C, E, G in Figure 50 on page 154). For larger wavelength fan-out, you can deploy BTI7800-FMD96 fixed multiplexer-demultiplexer to give access to all 96 wavelengths concurrently (labels B, D, F, H in Figure 50 on page 154). Or, for a colorless, flex grid ready solution, you can use twelve TCX1000-2D8CMD colorless multiplexers with a single TCX1000-RDM20 to provide 96 wavelength access.

Table 20 on page 155 shows the Juniper Networks compatible tail-facility service endpoints that the proNX Optical Director supports.

Table 20: Juniper Networks Compatible Tail-Facility Service Endpoints

Client Device	Juniper Networks Compatible Service Tail Facility Endpoints
BTI7800	Ports on the UFM3 (BT8A78UFM3) 100G Coherent CFP-M05 transceiver (CFP-100GBASE-CHRT) Ports on the UFM6 (BT8A78UFM6-I02) 400G Coherent MSA XCVR
ACX6360	Ports on the CFP2-DCO transceiver (CFP2-DCO-T-WDM-1)
MX Series router	• Ports on MPC5E-100G10G, MPC5EQ-100G10G adapter cards that support QSFP+ • Ports on MPC6 (MX2K-MIC6-2CE-CFP2) adapter cards that support CFP2
PTX Series router	• Ports on the 100-Gigabit DWDM OTN PIC with CFP2-ACO (PTX-5-100G-WDM) • Ports on the P2-100GE-OTN PIC with the CFP2-DCO-T-WDM-1 pluggable transceiver
QFX Series switch	Ports on the QFX10K DWDM 1.2 Tbps line card (QFX10K-12C-DWDM)

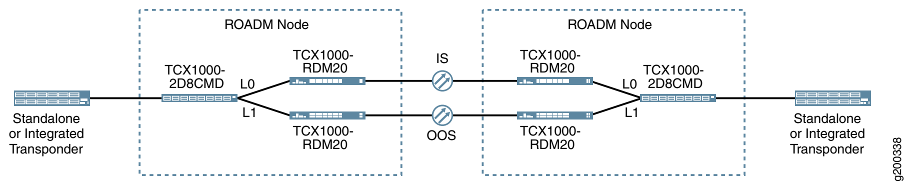
Single Path Service

A single path service is a service that has a single path set up between the two service endpoints. A fault on the path might cause the service to go down.

Protected Service

Figure 51 on page 156 shows a protected service using a pair of two-degree ROADM nodes connected in a basic two-node ring. More complex ring and mesh configurations are possible as well.

Figure 51: Protected Service



A protected service is a service that has a pair of paths set up between the two service endpoints. One path is placed administratively in-service (IS) and the other path is placed administratively out-of-service (OOS). Under normal conditions, the IS path provides the optical connectivity. If a fault occurs in the current IS path, you can manually restore service by administratively disabling the current IS path and administratively enabling the current OOS path so that the current OOS path becomes the new IS path. This is called manual restoration by changing a. service's administrative state.

NOTE: It is up to the operator to ensure that one path is administratively in-service and the other path is administratively out-of-service. The proNX Optical Director does not enforce this but will raise an alarm if both paths are in-service.

A multi-degree colorless multiplexer/demultiplexer such as the TCX1000 2-Degree 8-Channel Colorless Mux/Demux (2D8CMD) is required at each end as the common endpoint for the protected service. The 2D8CMD has two line ports (L0 and L1) that connect to the two different degrees in the ROADM node, thereby supporting two paths between the endpoints.

A protected service is modeled as a pair of services where each service in the pair takes a different path across the network. The individual services in the pair are effectively single path services that share a common wavelength and common endpoints.

There are two ways to set up a protected service in the proNX Optical Director:

- You can configure the IS path and let the proNX Optical Director determine and configure the OOS path. This is the easier method.
- You can configure a single path service for the IS path and separately configure a single path service for the OOS path. The proNX Optical Director is then able to determine

that you have created a protected service because the single path services that you created share the same wavelength and the same endpoints.

Orphan Service

An orphan service is a service without two add/drop endpoints. If you see an orphan service displayed, it is an indication that you have misconfigured the ROADM topology or otherwise altered the ROADM topology (such as unplugging and plugging fibers to different devices when LLDP is enabled) after the service is created.

The proNX Optical Director only allows you to create an optical service if a path exists between the two add/drop endpoints at the time that you create the service. If, after you create the service, you change the ROADM topology (such as by deleting links or undiscovering ROADM devices) such that the original path no longer exists between the two endpoints, the proNX Optical Director shows the service as two orphan services, one for each endpoint.

The reason for this is that, after the ROADM topology change, the proNX Optical Director cannot reconcile the intended service path with the new ROADM topology and therefore cannot display the full service path. It is only able to display the path from each endpoint to where the topology is broken. Note that this behavior can be different for a cut fiber. In the case of a cut fiber on a line span, the proNX Optical Director still knows where the intended path is as long as the associated external link is provisioned. In this case, the service is shown with a link that is down, and not as a pair of orphan services.

When you fix the ROADM topology, the proNX Optical Director will display the service correctly once again.

To prevent this from happening, ensure you do not change the ROADM topology after you create the service.

Related Documentation

- Juniper Networks Compatible Routers, Switches, Optical Multiplexers and Transponders on page 57
- *TCX1000-RDM20 Signal Band Specifications*
- TCX1000-RDM20 Port Administrative States on page 147

TCX1000 Third-Party Wavelength Support

This topic describes support for third-party wavelengths and the configuration information you need to configure a service on the TCX1000 to transport the third-party wavelength.

proNX Optical Director and Third Party Wavelengths

The proNX Optical Director does not control or manage third-party optical interfaces supplying the third-party wavelengths to the TCX1000-RDM20. As a result, the configuration of links and services for third-party wavelengths differs from the configuration of Juniper Networks compatible devices. For Juniper Networks compatible devices, you can simply select the service endpoints and proNX Optical Director automatically configures the entire service across the across the optical network.

The configuration of links and services for third-party optical interfaces supplying third-party wavelengths to the TCX1000-RDM20 is slightly different. Links are not applicable to third-party optical interfaces, because the proNX Optical Director cannot control or manage these optical interfaces and is completely unaware of them, you cannot select them as link source and destination endpoints.

Services are applicable to third-party wavelengths, but the configuration still differs from configuring services on Juniper Networks compatible optical interfaces. Because the proNX Optical Director is unaware of the third-party optical interface, you cannot select it as a service endpoint. Instead you must select the universal port to which the third-party optical interface is connected as the service endpoint and the proNX Optical Director creates the optical path for the third-party wavelength by:

- Opening the optical path through the network to allow transport of the third-party channel. The third-party channel is treated as any other channel on the TCX1000-RDM20. It is multiplexed and demultiplexed by the TCX1000-RDM20s and channel performance management is automatically applied to it.
- Creating the service from TCX1000-RDM20 universal port to universal port

NOTE: You are responsible for setting up the third-party transceiver optical services that run over the optical path.

Methods for Connecting Alien Transceivers to ROADM Nodes

You can connect alien transceivers to ROADM nodes in the following ways:

- By connecting the alien transceiver directly to a TCX1000-RDM20 universal port.
- By connecting the alien transceiver to a client port on a TCX1000-2D8CMD, which in turn, has its line port connected to a universal port on a TCX1000-RDM20.
- By connecting the alien transceiver to a client port on a BTI7800-FMD96, which in turn, has its line port connected to a universal port on a TCX1000-RDM20.
- By connecting the alien transceiver to a alien optical multiplexer-demultiplexer, which in turn, has its line port connected to a universal port on a TCX1000-RDM20.

NOTE: Alien transceivers and alien optical multiplexer-demultiplexers used with TCX1000 must be compatible with the 50 GHz ITU grid. Alien multiplexer-demultiplexers can be colorless, or of wider bandwidth, provided that they support 50 GHz channel centers.

Alien Transceiver Direct Connect to TCX1000-RDM20 Universal Port

Table 21 on page 159 describes the spectral characteristics required on the alien transceiver to connect it directly to a universal port on a TCX1000-RDM20.

Table 21: Spectral Characteristic Requirements for Direct Connection

Spectral Characteristic	Min	Max	Unit
Channel spacing	50	50	GHz
Channel center frequency	191.35	196.1	THz
Tx ONSR (out of band)	35		db/0.1 nm
Channel baud rate for direct connect		43	Gbaud

Table 22 on page 159 describes the TCX1000-RDM20 universal port operating levels. The operating levels of the alien transceiver must be compatible to directly attach the transceiver to a universal port.

Table 22: Operating Levels at TCX1000-RDM20 Universal Port

Operating Levels at TCX1000-RDM20 Ux Port	Min	Typ	Max	Unit
Channel Add power to **Ux In**	-10.7*		0.0*	dBm/50GHz
Channel Drop power to **Ux Out**	-5.5*		1.9*	dBm/50GHz

* You must ensure these levels are compatible with the alien transceiver interface.

Alien Transceiver to TCX1000-2D8CMD to TCX1000-RDM20

Table 23 on page 159 describes the spectral characteristics required to connect an alien transceiver to a client port on a TCX1000-2D8CMD, which in turn, has its line port connected to a universal port on a TCX1000-RDM20.

Table 23: Spectral Characteristic

Spectral Characteristic	Min	Typ	Max	Unit
Channel spacing		50		GHz
Channel center frequency	191.35		196.1	THz

Table 23: Spectral Characteristic (continued)

Spectral Characteristic	Min	Typ	Max	Unit
Tx ONSR (out of band)	45			db/0.1 nm
Channel baud rate for direct connect			43	Gbaud

Table 24 on page 160 describes the operating levels required to connect an alien transceiver to a client port on a TCX1000-2D8CMD, which in turn, has its line port connected to a universal port on a TCX1000-RDM20.

Table 24: Operating Levels at TCX1000-RDM20 Universal Port

Operating Levels at TCX1000-RDM20 Ux Port	Min	Typ	Max	Unit
Channel Add power to **Cx In** on TCX1000-2D8CMD	-0.5*		10.0*	dBm/50GHz
Channel Drop power to **Cx Out** on TCX1000-2D8CMD	-15.6*		- 8.0*	dBm/50GHz
* You must ensure these levels are compatible with the alien transceiver interface.				

Alien Transceiver to BTI7800-FMD96 to TCX1000-RDM20

Table 25 on page 160 describes the spectral characteristics required to connect an alien transceiver to a client port on a BTI7800-FMD96, which in turn, has its line port connected to a universal port on a TCX1000-RDM20.

Table 25: Spectral Characteristic

Spectral Characteristic	Min	Typ	Max	Unit
Channel spacing		50		GHz
Channel center frequency	191.35		196.1	THz
Tx ONSR (out of band)	35			db/0.1 nm
Channel baud rate for direct connect			34.5	Gbaud

Table 26 on page 160describes the operating levels required to connect an alien transceiver to a client port on a BTI7800-FMD96, which in turn, has its line port connected to a universal port on a TCX1000-RDM20.

Table 26: Operating Levels at TCX1000-RDM20 Universal Port

Operating Levels at TCX1000-RDM20 Ux Port	Min	Typ	Max	Unit
Channel Add power to **Cx In**	-5.1*		5.1*	dBm/50GHz
Channel Drop power to **Cx Out**	-11.1*		-3.1*	dBm/50GHz

Table 26: Operating Levels at TCX1000-RDM20 Universal Port (continued)

Operating Levels at TCX1000-RDM20 Ux Port	Min	Typ	Max	Unit
* You must ensure these levels are compatible with the alien transceiver interface.				

Alien Transceiver to Alien Mux-Demux to TCX1000-RDM20

Table 27 on page 161 describes the spectral characteristics required on the alien multiplexer that has its line port connected directly to a universal port on the TCX1000-RDM20.

Table 27: Alien 50 GHZ

Alien 50 GHZ	Min	Typ	Max	Unit
Channel spacing		50		GHz
Channel center frequency	191.35		196.1	THz
Tx ONSR (out of band) at Mux-Demux output port	35			db/0.1 nm
Alien filter 0.5 db bandwidth	20.0			GHz
Alien filter 1.0 db bandwidth	24.5			GHz
Alien filter 3.0 db bandwidth	35.0			GHz
Channel baud rate with alien filter			34.5	Gbaud
NOTE: The above guidelines on the alien filter bandwidth provide an estimate for the compatibility of the multiplexer-demultiplexer and transceiver. We recommend that you verify the filter penalty from the multiplexer-demultiplexer is acceptable for the system application.				

Table 28 on page 161 describes the operating levels required on the alien multiplexer to connect its line port to a universal port on the TCX1000-RDM20.

Table 28: Operating Levels at TCX1000-RDM20 Universal Port

Operating Levels at TCX1000-RDM20 Ux Port	Min	Typ	Max	Unit
Channel Add power to **Ux In**	-10.7*		0.0*	dBm/50GHz
Channel Drop power to **Ux Out**	-5.5*		1.9*	dBm/50GHz
* You must ensure these levels are compatible with the alien transceiver interface.				

Related Documentation

- proNX Optical Director Links and Services Overview on page 148
- TCX1000 Series Product Applications on page 53
- TCX1000-RDM20 Universal Port Rules on page 63

TCX1000 Series Software Upgrades

This topic provides an overview of how software upgrades work on the TCX1000 Series of devices and it includes the following subjects:

- Software Upgrade Overview on page 162
- Overview of Performing Software Upgrades on the TCX1000-RDM20 on page 162

Software Upgrade Overview

TCX1000 Series devices support nondisruptive software upgrades where the device retains the last known configuration and passes traffic uninterrupted. You can perform software upgrades on a single device or on multiple devices simultaneously. All software upgrades are initiated from the proNX Optical Director.

Software upgrades are delivered as a single file, which contains all the software for the various components of the device. The TCX1000-RDM20 uses a two bank boot structure which allows for the running load to remain in place while the new load is installed to, and run from, the other bank. This enables reversion to the original running load should an upgrade fail or you choose to revert before the process completes. Banks are referred to as A and B and either can function as the currently active bank.

There are two phases in the software upgrade process: Stage and Activate. After you select the proNX Optical Director SFTP server and filename in the management system, you can chose to either Stage or Activate the upgrade.

- Staging copies the software upgrade file to the TCX1000 Series device.
- Activate performs the upgrade on the device

After you initiate the software upgrade, the management system notifies you when the upgrade is complete.

Overview of Performing Software Upgrades on the TCX1000-RDM20

To upgrade the software on a TCX1000 device:

1. Download the TCX1000 software from the Juniper Networks website.
2. Save the TCX1000 software upgrade file to one of the proNX Optical Director SFTP servers.

   NOTE: The path of the software upgrade file must be relative to the directory you provided when the SFTP server was configured, or if no path was selected, then it must be relative to your SFTP home directory. You can also browse the SFTP server for the software upgrade file.

3. In proNX Optical Director:

a. Select the SFTP server on which the software upgrade file resides.

b. Select the name of the TCX1000 software upgrade file.

c. Select the Stage operation to copy the software upgrade file to the TCX1000 device. Ensure this tasks completes successfully before proceeding.

d. Select the Activate operation to upgrade the device software. Ensure this tasks completes successfully before proceeding.

Related Documentation

- *proNX Optical Director Device Backup and Restore Support*
- proNX Optical Director System and Optical Control Levels on page 45
- proNX Optical Director Control and Management Software Components on page 48

CHAPTER 13

TCX1000 Series Performance Monitoring and Metrics

proNX Optical Director Performance Monitoring Metrics

This topic describes the performance monitoring metrics provided by the proNX Optical Director. It includes the following topics:

proNX Optical Director Performance Monitoring Metrics Overview

The proNX Optical Director enables you to collect and view performance monitoring metrics and logs on the TCX1000-RDM20.

The proNX Optical Director collects historical performance monitoring metrics (PMs) from managed devices automatically, on a predefined schedule. Historical PMs are PMs that are collected and binned (aggregated over a measurement interval, timestamped, and discretely stored) by the device.

The proNX Optical Director stores collected PMs in a database for 30 days and makes them available for viewing. PM data points older than 30 days are purged from the database. The proNX Optical Director supports the collection and display of 1-minute, 15-minute, and 1-day bins. The actual bins collected and displayed depend on what the device supports. PM points in 15-minute bins are timestamped on the hour and at every 15 minutes thereafter. PM points for the 1-day bin are timestamped at midnight (local time of the machine running the web browser accessing the GUI).

proNX Optical Director Performance Monitors

The proNX Optical Director control and management software provides the following performance monitors:

Span Loss Management

The proNX Optical Director provides span loss management on the TCX1000-RDM20 and the TCX1000-ILA. span loss management determines the total optical loss of the span and makes automatic adjustments to the device hardware controls to compensate for the loss.

Channel Automatic Power Management

The proNX Optical Director provides channel automatic power management to compensate for individual channel power variations to maintain the optimal performance of the channel through the entire network path and to ramp-up channels to the correct line operating power, maintain that power within predefined tolerance levels throughout operation and provide graceful ramp-down of the channel during decommissioning.

Pass-Through Nodal Loss Measurement

Pass-through nodal loss is the loss in the fiber between the two TCX1000-RDM20s at a pass-through site, in other words the loss in the fiber between the two universal ports being used for pass-through.

Table 29 on page 166 describes the proNX Optical Director metrics for pass-through nodal loss.

Table 29: Pass-Through Nodal Loss Performance Metric

Performance Metric	Entity	Unit (dB)	Refresh rate	Fields	Binning
Nodal Loss	Tx and Rx Client side fiber connect	dB	Every time client data arrives from one of the managed device end-points of a fiber-connection (pass-through U*x* port	Current, Minimum, Maximum, Average	1-minute 15-minute 24-hr

Related Documentation

- proNX Optical Director Span Loss Management, Alarms and Metrics on page 166
- proNX Optical Director System and Optical Control Levels on page 45
- proNX Optical Director Control and Management Software Components on page 48

- *About Juniper Optical Control Environment*

proNX Optical Director Span Loss Management, Alarms and Metrics

The proNX Optical Director provides span loss management, which determines the total optical loss of the span and makes adjustment to the device hardware controls to compensate for the loss. This topic describes the span loss management capability provided by the proNX Optical Director on TCX1000 Series devices.

- Span Loss Management on page 167
- proNX Optical Director Span Loss Performance Metrics on page 168

Span Loss Management

What is Span Loss

Span loss can be defined as the total system attenuation between line ports of adjacent TCX1000 Series devices in the network. This includes the loss from the transmission fiber and any additional losses from optical connections within the path. An example of additional losses is the attenuation introduced when optical patch panels are used to manage cabling within an installation.

The proNX Optical Director measures the span loss by reading the output power (dBm) at the **Line Out** port at one end of the fiber and the input power (dBm) at **Line In** port at the other end of the fiber. These measurements are continuously read at both ends of the span and reported to the proNX Optical Director. After proNX Optical Director reads these power levels, it calculates the span loss and adjusts internal set points on one or both TCX1000 Series devices to compensate for the loss while minimizing the added noise. For example, based on the measured span loss, the proNX Optical Director may determine that the input level on the downstream device is too low. In this case, proNX Optical Director adjusts the output level on the **Line Out** port of the local TCX1000 Series device to compensate for the span loss.

Span loss management is performed on all links between these TCX1000 devices:

- TCX1000-RDM20 to TCX1000-RDM20
- TCX1000-RDM20 to TCX1000-ILA
- TCX1000-ILA to TCX1000-ILA

Short Span Support

On short spans, if the measured span loss is such that the maximum input powers to the downstream TCX1000 Series device may be exceeded, the span control feature adjusts the launch power at the upstream site to automatically compensate. In this way, the span control seamlessly manages span losses as low as 0 dB.

Span Control Over Time

The span control continuously monitors the span loss between the line ports of the TCX1000-RDM20 and TCX1000-ILA and adjusts the internal set points to compensate for the loss, while adding the minimum amount of noise. In this way the span control automatically adjusts for variations in span loss over time, for example, from seasonal variations in loss or for additional losses added after a cable repair.

How Span Loss Out-Of-Range (OOR) Alarms Work

When a span is first brought into service, the span control configures the internal components of the TCX1000 Series devices to be optimized for that loss. In cases of very large changes in span loss, the optimization cannot be maintained over the full operating specification of the managed device with full optical performance. The proNX Optical Director provides a Span Loss Out-Of-Range (OOR) alarm, which indicates that either the TCX1000 Series device is being operated outside of specification or that the internal configuration is no longer optimized.

If the measured span loss is outside the allowable range for the managed device, a Span Loss Out-Of-Range (OOR) alarm is raised and logged by the proNX Optical Director. The proNX Optical Director span loss management feature ensures that the OOR alarm is unlikely to be raised except in the rare event that the span loss changes by a very large amount after initial commissioning.

For example, let us assume that we have two TCX1000 Series devices connected point-to-point. The local device is “device A” and the remote device is “device B. The proNX Optical director reads the output dBm power level at the device A transmit port (**Line Out**) and the dBm power level received at the device B **Line In** port. If, after subtracting the receive line power measured at device B from the transmit line power measured at device A, the resulting value is not within the allowable range, two alarms are raised in proNX Optical Director:

- Tx Span Loss Out-Of-Range — This alarm is raised at the transmit end **Line Out** port on device A.
- Rx Span Loss Out-of-Range — This alarm is raised at the receive end **Line In** port on device B.

In the rare event that the OOR alarm is raised, you can remotely re-optimize the span by toggling the administrative state of the line port by setting the administrative state to **Out-of-Service** and then back to **In-Service**.

NOTE: This is traffic impacting and so is not automated. Normal control behavior ensures that internal configuration re-optimization is not required, however, in rare cases such as very large changes in span loss, this may occur.

If the reported span loss is outside of the TCX1000 device specification, the optical connections in the span should be verified to identify why the accumulated losses are now out of range.

proNX Optical Director Span Loss Performance Metrics

The span loss is always measured within the OSC-band (1510 nm), which allows for zero-lambda turn-up, whereby the optical path between TCX Series sites is confirmed without having to turn up any wavelength services. This is valuable during installation. When wavelength services are provisioned on the link, both the OMS Span Loss and the OSC Span Loss are reported as performance metrics in the proNX Optical Director as described in Table 30 on page 169.

Table 30: Span Loss Performance Metrics

Performance Metric	Entity	Unit (dB)	Refresh Rate	Fields	Binning
OMS Span loss	Tx and Rx Line side fiber connect	dB	Every time OMS (Line Port) data arrives from one of the managed device end-points of a fiber connection	Current, Minimum, Maximum, Average	1-minute 15-minute 24-hr
OSC Span loss NOTE: Used for zero lambda turn-up.	Tx and Rx Line side fiber connect	dB	Every time OSC (Line Port) data arrives from one of the managed device end-points of a fiber connection	Current, Minimum, Maximum, Average	1-minute 15-minute 24-hr

Related Documentation

- proNX Optical Director Alarms on page 178

TCX1000-RDM20 Performance Monitoring Metrics

This topic describes the TCX1000-RDM20 performance monitors and metrics. It includes the following subjects:

Types of Performance Monitors

The TCX1000-RDM20 has two types of performance monitors:

- *Device hardware performance monitors* — The TCX1000-RDM20 hardware provides comprehensive performance monitoring on all provisioned ports and interfaces. Performance metrics for the hardware are continually collected and archived by the proNX Optical Director software.
- *proNX Optical Director performance monitors* — provided by the proNX Optical Director optical control software

TCX1000-RDM20 Performance Monitoring Metrics

Table 31 on page 169 describes the performance monitoring metrics supported for the TCX1000-RDM20.

Table 31: TCX1000-RDM20 Performance Monitoring Metrics

Monitor	Reference Point	Description	Min	Max	Units
Line In (Total)	**Line In**	Total optical power at Line In port (dBm)	-35.3	13.2	dBm

Table 31: TCX1000-RDM20 Performance Monitoring Metrics (continued)

Monitor	Reference Point	Description	Min	Max	Units
Line Out (Total)	**Line Out**	Total optical power at Line Out port C-Band power only	-18	22.9	dBm
Booster In	Mux Out		-30.4	19.5	dBm
Booster Out	**Line Out** (VOA set to 0dB)	C-Band power only	-3	22.9	dBm
OSC 0 Out	**OSC 0 Out**	OSC 0 (1511 nm) power at OSC 0 Out port ()	-42	3	dBm
OSC 1 Out	**OSC 1 Out**	OSC 1 (1611 nm) power at OSC 1 Out port (dBm)	-42	3	dBm
Ux In	**Ux In**	Channel power at Ux In port, x=0 to 19 (dBm)	-22.4	23	dBm
Preamp Out	Demux In		-0.5	23	dBm
Booster In	Mux Out		31.65	-1.75	dBm
Booster Out	Line Out (VOA=0 dB)		-9.25	6.75	dBm
Line In	Line In		-34.25	-8.05	dBm
Pre-amp Out	Demux In		-6.75	6.75	dBm
Mux In	Ux In		-23.65	0.25	dBm
Chassis Temperature	N/A	Chassis temperature (degrees C)			
PSU 0 Voltage	PSU input	Power supply 0 input voltage (V)			
PSU 0 Current	PSU input	Power supply 0 input current (A)			
PSU 1 Voltage	PSU input	Power supply 1 input voltage (V)			
PSU 1 Current	PSU input	Power supply 1 input current (A)			
Fan Module 0, fan x speed	N/A	Fan module 0, fan unit x speed, x=1 to 3 (rpm)			

Table 31: TCX1000-RDM20 Performance Monitoring Metrics (continued)

Monitor	Reference Point	Description	Min	Max	Units
Fan Module 1, fan x speed	N/A	Fan module 1, fan unit x speed, x=1 to 3 (rpm)			

Related Documentation

- Binning and Intervals for Performance Monitoring Metrics on page 175
- TCX1000-RDM20 Overview on page 31
- proNX Optical Director Performance Monitoring Metrics on page 165

TCX1000-RDM20 Total Power Monitor Ranges

This topic describes the power ranges for total power monitoring.

- Power Ranges for Power Monitors on page 171

Power Ranges for Power Monitors

Two power ranges are defined for each power monitor:

- Operation — The operation range is the optical power range over which the channel monitoring and control is expected to meet all operating performance requirements.
- Alarm — The alarm range is the optical power range over which the monitoring is still required in order to have proper system alarming and fault detection. The alarm range maximum and minimum define the hardware limits (power readings outside of hardware limits are considered invalid).

Table 32 on page 171 describes the total power monitoring range for the universal ports.

Table 32: Universal Port Optical Power Monitor Ranges

Monitor Name	Reference Point	Alarm Range (dBm)		Operation Range (dBm)	
		Min	Max	Min	Max
Ux In	**Ux In**	-29	24	-22.4	23
Ux Out	**Ux Out**	-36.5	22.7	-23	20.5

Table 33 on page 171 lists the preamplifier optical power monitoring ranges.

Table 33: Preamplifier Optical Power Monitoring Ranges

Monitor Name	Reference Point	Alarm Range (dBm)		Operation Range (dBm)	
		Minimum	Maximum	Minimum	Maximum
Line In	Line In	-38	13.6	-33	13.2

Table 33: Preamplifier Optical Power Monitoring Ranges (continued)

Monitor Name	Reference Point	Alarm Range (dBm)		Operation Range (dBm)	
		Minimum	Maximum	Minimum	Maximum
OSC 0 Line In	Line In	-48.5	11.6	-43.9	2.5
OSC 1 Line In	Line In	-48.5	11.6	-43.9	2.5
OSC 0 Out	OSC 0 Out	-48	13.5	-42	3
OSC 1 Out	OSC 1 Out	-48	13.5	-42	3

Table 34 on page 172 lists the booster power monitoring ranges.

Table 34: Booster Optical Power Monitoring Ranges

Monitor Name	Reference Point	Alarm Range (dBm)		Operation Range (dBm)		Notes
		Min	Max	Min	Max	
Line Out	Line Out (VOA set to 0 dB)	-8.2	26.8	-3	22.9	C-Band power only
Line Out	Line Out	-24.4	25.2	-18	22.9	C-Band power only
OSC 0 Line Out	Line Out	-47.5	11.6	-11.9	9.5	OSC 0 power only
OSC 1 Line Out	Line Out	-47.5	11.1	-12.4	9.5	OSC 1 power only
OSC 0 In	OSC 1 In	-47	13.5	-10	10	OSC 0 power only
OSC 1 In	OSC 2 In	-47	13.5	-10	10	OSC 1 power only

Related Documentation

- TCX1000-RDM20 Performance Monitoring Metrics on page 169
- Binning and Intervals for Performance Monitoring Metrics on page 175

TCX1000-RDM20 Channel Power Monitoring Ranges

This topic describes the channel power monitoring ranges for the TCX1000-RDM20.

Two power ranges are defined for each monitor:

- Operation — The Operation range is the optical power range over which the channel monitoring and control is expected to meet all operating performance requirements.

- Alarm — The Alarm range is the optical power range over which the monitoring is still required in order to have proper system alarming and fault detection. The alarm range maximum and minimum define the hardware limits (power readings outside of hardware limits are considered invalid).

Table 35 on page 173 describes the channel power monitoring ranges.

Table 35: Channel Power Monitoring Ranges

Monitor Name	Alarm Range (dBm)		Operation Range (dBm)	
	Min	Max	Min	Max
Line In	-35.4	-3	-32.2	-3
U *x* In	-28.1	0.3	-23.6	0.3

Related Documentation

- TCX1000-RDM20 Performance Monitoring Metrics on page 169
- TCX1000-RDM20 Total Power Monitor Ranges on page 171
- Binning and Intervals for Performance Monitoring Metrics on page 175

TCX1000-ILA Performance Monitoring Metrics

Table 36 on page 173 lists the performance monitoring metrics supported on the TCX1000-ILA. All performance monitoring metrics support 15 minute and 24 hour binning.

NOTE: The TCX1000-ILA performance monitoring metrics are not associated with a specific line (Line A or Line B) port. All TCX1000-ILA performance monitors are shown regardless of which line port is selected in the proNX Optical Director.

Table 36: TCX1000-ILA Performance Monitoring Metrics

Monitor	Metric	Reference Point	Description	Min	Max	Units
OSC-A	RX power	LINE A IN	OSC (1511 nm) power at Line A In port	-55.5	5	dBm
OSC-A	TX power	LINE A OUT	OSC (1511 nm) power at Line A Out port	-44.2	16.1	dBm
OSC-B	RX power	LINE B IN	OSC (1511 nm) power at Line B In port	-55.5	5	dBm
OSC-B	TX power	LINE B OUT	OSC (1511 nm) power at Line B Out port	-44.2	16.1	dBm

Table 36: TCX1000-ILA Performance Monitoring Metrics (continued)

Monitor	Metric	Reference Point	Description	Min	Max	Units
EDFA-AB	Input Power	LINE A IN	Total signal power at Line A In port	-41.7	12.7	dBm
EDFA-AB	Output Power	LINE B OUT (VOA-B=0dB)	Total signal power at Line B Out port (dBm), not including Line B Output VOA attenuation	-8.6	21.1	dBm
EDFA-AB	Signal Output Power	LINE B OUT (VOA-B=0dB)	Total signal power at Line B Out port minus ASE power (dBm), not including Line B Output VOA attenuation	-8.6	21.1	dBm
EDFA-BA	Back Reflection Ratio	LINE A OUT	Ratio of Line A Output power over optical power reflected back into Line A Output port	N/A	N/A	dB
EDFA-BA	Input Power	LINE B IN	Total signal power at Line B In port	-41.7	12.7	dBm
EDFA-BA	Output Power	LINE A OUT (VOA-A=0dB)	Total signal power at Line A Out port (dBm), not including Line A Output VOA attenuation	-8.6	21.1	dBm
EDFA-BA	Signal Output Power	LINE A OUT (VOA-A=0dB)	Total signal power at Line A Out port minus ASE power (dBm), not including Line A Output VOA attenuation	-8.6	21.1	dBm
EDFA-AB-Pump0	Current	N/A	EDFA-AB pump0 drive current	N/A	N/A	mA
EDFA-AB-Pump0	Temperature	N/A	EDFA-AB pump0 temperature	N/A	N/A	degrees C
EDFA-AB-Pump1	Current	N/A	EDFA-AB pump1 drive current	N/A	N/A	mA
EDFA-AB-Pump1	Temperature	N/A	EDFA-AB pump1 temperature	N/A	N/A	degrees C
EDFA-BA-Pump0	Current	N/A	EDFA-BA pump0 drive current	N/A	N/A	mA
EDFA-BA-Pump0	Temperature	N/A	EDFA-BA pump0 temperature	N/A	N/A	degrees C

Table 36: TCX1000-ILA Performance Monitoring Metrics (continued)

Monitor	Metric	Reference Point	Description	Min	Max	Units
EDFA-BA-Pump1	Current	N/A	EDFA-BA pump1 drive current	N/A	N/A	mA
EDFA-BA-Pump1	Temperature	N/A	EDFA-BA pump1 temperature	N/A	N/A	degrees C
EDFA-AB	Back Reflection Ratio	LINE B OUT	Ratio of Line B Output power over optical power reflected back into Line B Output port	N/A	N/A	dB
VOA-A	Attenuation	N/A	Line A Output VOA (VOA-A) Attenuation	N/A	N/A	dB
VOA-B	Attenuation	N/A	Line B Output VOA (VOA-B) Attenuation	N/A	N/A	dB

Related Documentation

- TCX1000-ILA Inline Amplifier Overview on page 40
- TCX1000-ILA Hardware Alarms and Probable Causes on page 190
- TCX1000-ILA External and Amplifier Port Thresholds on page 204

Binning and Intervals for Performance Monitoring Metrics

Performance monitoring support for TCX1000 Series managed devices follows typical performance monitor conventions, including collecting data at 15-minute and 24-hour intervals, and supporting historical data.

TCX1000 Series devices retain the following historical bins:

- 15 x 1-minute historical bins
- 96 x 15-minute historical bins
- 7 x 1-day historical bins

TCX1000 devices support three historical PM intervals:

- 1 day
- 15 minutes
- 1 minute

You initiate the collection of performance metrics manually in proNX Optical Director, which then requests the metrics from the device. Once the task is complete you can go back to view the metrics on the desired port.

Related Documentation

- TCX1000-RDM20 Performance Monitoring Metrics on page 169
- proNX Optical Director Performance Monitoring Metrics on page 165
- proNX Optical Director Span Loss Management, Alarms and Metrics on page 166
- TCX1000-ILA Performance Monitoring Metrics on page 173

TCX1000-RDM20 and TCX1000-ILA Real-Time Telemetry Metrics

This topic describes the real-time telemetry metrics supported on the TCX1000-RDM20 and TCX1000-ILA.

You can view and graph real-time telemetry metrics for the optical ports and services running on the TCX1000-RDM20. The proNX Optical Director receives streams of telemetry data from optical devices in the network. This data is used by the proNX Optical Director Optical Control Layer to manage the optical controls of the optical ports on the devices. A subset of this data is available for viewing.

You can view telemetry data in the proNX Optical Director within the Services panel and within the Telemetry panel under Metrics for each port on the TCX1000-RDM20.

For services running on the TCX1000-RDM20, you can define the duration, in seconds, make a selection of A-Z or Z-A end points and view the corresponding telemetry data, by selecting the start button. As each data point is received from the telemetry stream, a chart is updated.

You can view telemetry data for the optical ports on the TCX1000-RDM20 including the universal ports, line ports, and OSC ports. To view the telemetry data, select an optical port, select the Telemetry option under Metrics, select a duration, in seconds and select the metric you want to view, and select start. As each data point is received from the telemetry stream, a chart is updated. You can view and graph the following telemetry metrics for the TCX1000-RDM20:

- Line and universal port telemetry metrics — OMS POWER IN/OUT
- OSC0/OSC1 port telemetry metrics — OSC POWER IN/OUT

OMS power is the combined total power of all the C-band channel powers. OSC power is the power of the 1510 nm optical service channel. The Line port power in/out is a combination of the OMS and OSC powers. The universal port power in/out is only the OMS power. OSC in is only between the Line ports.

On the TCX1000-ILA optical ports, you can view and graph: Rx OMS Power In, Rx Total Power In, Tx OMS Power Out, and Tx Total Power Out.

Related Documentation

- proNX Optical Director Performance Monitoring Metrics on page 165
- TCX1000-RDM20 Performance Monitoring Metrics on page 169
- TCX1000-ILA Performance Monitoring Metrics on page 173

CHAPTER 14

Alarms

TCX1000 Alarm Overview

In the TCX Series Optical Transport System, there are two different sources of optical alarms:

- TCX1000 managed device alarms — The TCX1000-RDM20 is responsible for all conditions that are validated on the device itself. Examples include any alarms associated with the port, connection, or amplifier.
- proNX Optical Director generated alarms — The optical control layer (OCL) application within proNX Optical Director generates alarms for conditions that cannot be validated by the managed device. Examples include span and pass-through nodal loss out-of-range (OOR) alarms.

An alarm is a persistent indication of a fault that clears only when the triggering condition has been resolved. A current list of problems occurring on the network component is kept in the form of an active alarm list.

A list of cleared faults is also maintained.

In general alarms are:

- Persistent indication
- Clear only when the triggering condition resolved
- Active alarm list
- Cleared faults list is maintained

- Filtering of alarms to severity levels
- Alarm severity: critical, major, minor warning

Current alarms are maintained along with historical alarms for a configurable period of time. This allows debugging of network issues after a fault has occurred.

By default, alarm event notification is turned off. Each user can choose to enable alarm event notification. If enabled, event notifications are sent for all alarms raised. There is also a throttling mechanism so that you are not inundated with notifications during alarm storms.

Related Documentation

- TCX1000-RDM20 Hardware Alarms and Probable Causes on page 182
- TCX1000-ILA Hardware Alarms and Probable Causes on page 190
- TCX1000-RDM20 Performance Monitoring Metrics on page 169
- proNX Optical Director Performance Monitoring Metrics on page 165
- proNX Optical Director Span Loss Management, Alarms and Metrics on page 166
- proNX Optical Director Alarms on page 178

proNX Optical Director Alarms

proNX Optical Director Alarms

The proNX Optical Director control and management software generates the alarms described in Table 37 on page 178.

Table 37: proNX Optical Director Generated Alarms

proNX Optical Director Alarm	Condition Cause	Example
Unreachable network element	This alarm is raised when an attempt to discover a device fails. The device will be pinged periodically to test whether it has become reachable again. If the device becomes reachable then the alarm is cleared.	NOTE: Length of time to raise or clear this alarm can be up to 15 minutes. Network element 10.10.10.10 is unreachable
Network link with farend undiscovered	Port on the TCX1000-RDM20 is pointing to a device that is not discoverable. This can be a line port, universal port, or a connection on the TCX1000-RDM20.	

Table 37: proNX Optical Director Generated Alarms (continued)

proNX Optical Director Alarm	Condition Cause	Example
Nodal loss out of range (OOR)	The nodal loss OOR alarm is raised against both ends of a universal port pass-through fiber connection to indicate the issue may be with the upstream TCX1000-RDM20 **Ux Out** port or the downstream TCX1000-RDM20 **Ux In** port, or the cross-connect fiber itself. Pass-through nodal loss is the loss in the fiber between two pass-through universal ports. The range is 0 dB to 5.2 dB. This alarm is raised when the pass-through nodal loss is out of operational range of the equipment between the two pass-through universal ports.	
Incomplete network link	Indicates an incomplete link configuration on the line ports between the two TCX1000-RDM20s. For example, if you configured the line port on one end of the link but did not configure the line port on the other end.	
Farend	Indicates an incompatible wavelength at a topology level. Applies only to universal ports connected to a Junos router transceiver and the frequencies do not match.	
Tx-span-loss-out-of-range Rx-span-loss out-of-range	The measured span loss on a network link is outside the range that the TCX1000 device can compensate for. The Span Loss OOR alarm is raised against both ends of the span to indicate the issue may be with the upstream managed device transmit (output) port, the downstream managed device receive input port, or the line fiber. The span loss performance monitor monitors both OSC and OMS can be queried in the proNX Optical Director, to determine which limits are being applied for the span loss OOR alarm. If the span loss OOR alarm persists after verifying the physical connections, we recommend you toggle the managed device's Line Port Admin State (**In Service** -> **Out Of Service** -> **In Service**) to reset the EDFA gain range NOTE: To toggle the line port on the TCX1000-ILA, the line port must be toggled on the upstream TCX1000-RDM20 since the TCX1000-ILA does not have a managed Line Port.	
OTI Communication Failure	If a managed device had been discovered and the OTI interface is supported, OCL checks that an OTI packet has been received periodically If no packet is received for 5 minutes, the OTI Communication Failure alarm is raised. You can verify the device is reachable with the proNX Optical Director by performing a re-sync.	

Table 37: proNX Optical Director Generated Alarms (continued)

proNX Optical Director Alarm	Condition Cause	Example
Topology mismatch	The proNX Optical Director generates a topology mismatch alarm if you select a multi-span channel path that runs over TCX1000-RDM20 hardware from TCX Series Optical Transport System, Release 1.0. The TCX1000-RDM20 hardware in TCX Series Optical Transport System, Release 1.0 requires a firmware upgrade to support multi-span capabilities. You can download the new TCX1000-RDM20 firmware here: TCX1000-RDM20 software download.	
Device port (Topology link)	Topology link has FE=%s. Device not found	
	Topology link has FE interface=%s. Interface not found	
	Topology link has FE=%s provisioned with fiber-type=%s. Expected %s	Applies to line spans only.
	Topology link has FE=%s which is already provisioned as FE for=%s	
	Topology link has expected FE=%s. Actual FE for=%s	LLDP auto-discovered FE does not match expected.
	Topology link has FE=%s which does not have reciprocal configuration	
	Topology link FE=%s is an incompatible software version for %s	ROADM to ROADM links must have devices with same major version. TCX1000-ILAs may be connected to each other or to a TCX1000-RDM20.
	Topology link=%s missing required circuit pack	The far end command referenced in an external-link that does not exist in that far end TCX1000-RDM20's book-keeping data.
	Topology link FE=%s has an incompatible internet protocol for %s	IPv4 to IPv6 not supported on a single span. Both devices should be discovered with the same IP-version.
	Topology link has FE=%s which is a CMD on a device connected by a line span.	Prevents crosstalk loop where L0 and L1 are in a loop
	Topology link has FE=%s with %s. Frequency mismatch for %s	Only applies to external links on MD channel ports.
service-cmd circuit-pack	Topology links from CMD with duplicate wavelengths	More than one Junos port to same CMD but with same frequency. The proNX Optical Director does not know which is okay so all are shown.
Service	Optical service has incompatible A=%s and Z=%s.	Service has incompatible tail configuration for FEC or/and modulation.

Related Documentation

- proNX Optical Director Span Loss Management, Alarms and Metrics on page 166
- proNX Optical Director Performance Monitoring Metrics on page 165
- proNX Optical Director System and Optical Control Levels on page 45
- proNX Optical Director Control and Management Software Components on page 48

TCX1000 Hardware Alarm Types and Behavior

This topic describes the various types of alarms and their behavior on TCX1000 devices.

- Optical Power Alarms on page 181
- Temperature Alarm Behavior on page 181

Optical Power Alarms

The TCX1000-RDM20 and TCX1000-ILA support the following optical power alarms.

Input/Output Low Degrade Alarms

These alarms indicate that the optical power measured on the port or interface *has dropped below* the Input/output Low Degrade Threshold value. To clear this fault, an optical input power equal to the Input/output Low Degrade Threshold plus the Input/Output Low Degrade Hysteresis must be restored at the port or interface.

Input/Output Overload Alarms

These alarms indicate that the optical power measured on the port or interface *has exceeded* the Input/output Overload Threshold value. To clear this fault, an optical input power equal to the Input/output Overload Threshold minus the Input Overload Hysteresis must be restored at the port or interface.

Loss of Output (LOO) Alarms

LOO alarms indicate that the optical power measured on the port or interface *has dropped below* the Loss of Output threshold value. To clear this fault, an optical power equal to the loss of output threshold plus the loss of output hysteresis must be restored at the port or interface.

Loss of Signal (LOS)

LOS alarms indicate that the optical power measured on the port or interface *has dropped below* the Loss of Signal Threshold value. To clear this fault, an optical input power equal to the Loss of Signal Threshold plus the Loss of Signal Hysteresis must be restored at the port or interface.

Temperature Alarm Behavior

When the card temperature Out-Of-Range alarm is asserted, it indicates that the TCX1000 ambient temperature sensor has gone significantly outside the design operating range. The TCX1000 will continue to remain fully operational on a best effort basis under these conditions, however performance may fall outside of specifications. No TCX1000 system will be automatically shut down under these circumstances, however if ambient temperature climbs high enough the power modules will eventually shut off. This can be expected to happen in the range of 65-70º C ambient.

The TCX1000-RDM20 and TCX1000-ILA contain internal heating elements for stabilizing various optical components. These have over-temperature protection on an individual basis that is not tied directly to the card temperature alarm. Overheating of any of these elements can lead to the affected heater being shut down. This will be alarmed as a service or non-service affecting hardware failure as appropriate.

Related Documentation

- TCX1000 Alarm Overview on page 177
- proNX Optical Director Alarms on page 178
- proNX Optical Director Span Loss Management, Alarms and Metrics on page 166
- TCX1000-ILA Hardware Alarms and Probable Causes on page 190
- TCX1000-RDM20 Hardware Alarms and Probable Causes on page 182

TCX1000-RDM20 Hardware Alarms and Probable Causes

Table 38 on page 182 describes the TCX1000-RDM20 hardware alarms and their probable causes and location.

Table 38: TCX1000-RDM20 Hardware Alarms and Probable Causes and Location

Entity	Alarm	Description Probable Cause/ Probable Location	Severity
fan 0	fru-missing	Fan module not present Probable-cause-direction= Not Applicable Probable-cause-location=Not Applicable	Major
fan 0	fru-fail	Fan module has failed Probable-cause-direction= Not Applicable Probable-cause-location=Not Applicable	Major
fan 1	fru-missing	Fan module not present Probable-cause-direction= Not Applicable Probable-cause-location=Not Applicable	Major
fan 1	fru-fail	Fan module has failed Probable-cause-direction= Not Applicable Probable-cause-location=Not Applicable	Major

Table 38: TCX1000-RDM20 Hardware Alarms and Probable Causes and Location (continued)

Entity	Alarm	Description Probable Cause/ Probable Location	Severity
power module 0	fru-missing	Power module not present Probable-cause-direction= Not Applicable Probable-cause-location=Not Applicable	Major
power module 0	fru-fail	Power module has failed Probable-cause-direction= Not Applicable Probable-cause-location=Not Applicable	Major
power module 0	input-power-fail	No input power to power module Probable-cause-direction= Not Applicable Probable-cause-location=Not Applicable	Minor
power module 0	fru-comms-failure	Communications failure to FRU Probable-cause-direction= Not Applicable Probable-cause-location=Not Applicable	Minor
power module 1	fru-missing	Power module not present Probable-cause-direction= Not Applicable Probable-cause-location=Not Applicable	Major
power module 1	fru-fail	Power module has failed Probable-cause-direction= Not Applicable Probable-cause-location=Not Applicable	Major
power module 1	input-power-fail	No input power to power module Probable-cause-direction= Not Applicable Probable-cause-location=Not Applicable	Minor
power module 1	fru-comms-failure	Communications failure to FRU Probable-cause-direction= Not Applicable Probable-cause-location=Not Applicable	Minor

Table 38: TCX1000-RDM20 Hardware Alarms and Probable Causes and Location (continued)

Entity	Alarm	Description Probable Cause/ Probable Location	Severity
card	hardware-fail-SA	Potentially service affecting hardware failure Probable-cause-direction= Not Applicable Probable-cause-location=Not Applicable	Critical
card	hardware-fail-NSA	Non service affecting hardware failure Probable-cause-direction= Not Applicable Probable-cause-location=Not Applicable	Minor
card	temperature-oor	Temperature outside operating limits Probable-cause-direction= Not Applicable Probable-cause-location=Not Applicable	Minor

Related Documentation

- TCX1000 Alarm Overview on page 177
- TCX1000 Hardware Alarm Types and Behavior on page 181
- TCX1000-RDM20 Port Alarms and Probable Causes on page 184
- TCX1000-RDM20 Internal Amplifier Alarms and Probable Causes on page 187
- TCX1000-RDM20 Connection Alarms and Probable Causes on page 189

TCX1000-RDM20 Port Alarms and Probable Causes

Table 39 on page 184 describes details the various port alarms the TCX1000-RDM20 can raise and their probable cause and location.

Table 39: TCX1000-RDM20 Port Alarms and Probable Causes and Locations

Port	Alarm	Description Probable Cause/ Probable Location	Severity
ETH CRAFT	ethernet-link-down	Port Ethernet link status is down Probable-cause-direction=bidirectional Probable-cause-location=FAREND	Minor

Table 39: TCX1000-RDM20 Port Alarms and Probable Causes and Locations (continued)

Port	Alarm	Description Probable Cause/ Probable Location	Severity
Ethernet DCN 0	ethernet-link-down	Port Ethernet link status is down Probable-cause-direction=bidirectional Probable-cause-location=FAREND	Minor
Ethernet DCN 1	ethernet-link-down	Port Ethernet link status is down Probable-cause-direction=bidirectional Probable-cause-location=FAREND	Minor
Line Port	optical-los	Loss of input Probable-cause-direction=rx Probable-cause-location=FAREND	Major
Line Port	input-low-degrade	Input power degraded Probable-cause-direction=rx Probable-cause-location=FAREND	Minor
Line Port	optical-loo	Loss of Output Probable-cause-direction=tx Probable-cause-location=NEAREND	Major
Line Port	attenuation-unattainable	Output VOA cannot achieve target attenuation Probable-cause-direction=rx Probable-cause-location=FAREND	Major
Line Port	optical-return-los	Low Optical Return Loss on Output Probable-cause-direction=bidirectional Probable-cause-location=FAREND	Minor
OSC 0	optical-los	Loss of input at OSC In Probable-cause-direction=rx Probable-cause-location=FAREND	Minor

Table 39: TCX1000-RDM20 Port Alarms and Probable Causes and Locations (continued)

OSC 0	optical-loo	Loss of OSC at Line In Probable-cause-direction=tx Probable-cause-location=NEAREND	Minor
OSC 1	optical-los	Loss of input at OSC In Probable-cause-direction=rx Probable-cause-location=FAREND	Minor
OSC 1	optical-loo	Loss of OSC at Line In Probable-cause-direction=tx Probable-cause-location=NEAREND	Minor
OSC SFP	pluggable-missing	No SFP installed Probable-cause-direction=bidirectional Probable-cause-location=NEAREND	Major
OSC SFP	receiver-overload	SFP receiver overload Probable-cause-direction=rx Probable-cause-location=FAREND	Major
OSC SFP	pluggable-fail	SFP internal fault Probable-cause-direction=bidirectional Probable-cause-location=NEAREND	Major
OSC SFP	pluggable-comms-failure	I2C link to SFP failed Probable-cause-direction=bidirectional Probable-cause-location=NEAREND	Major
OSC SFP	ethernet-link-down	Ethernet link status is down Probable-cause-direction=bidirectional Probable-cause-location=FAREND	Major
OSC SFP	optical-los	Loss of input, Rx LOS Probable-cause-direction=rx Probable-cause-location=FAREND	Minor

Related Documentation

- TCX1000 Alarm Overview on page 177

- TCX1000 Hardware Alarm Types and Behavior on page 181
- TCX1000-RDM20 Port Alarm Thresholds on page 201

TCX1000-RDM20 Internal Amplifier Alarms and Probable Causes

Table 40 on page 187 describes the TCX1000-RDM20 amplifier (booster and preamplifier) alarms and their probable causes and location.

Table 40: TCX1000-RDM20 Amplifier Alarms and Probable Causes and Locations

Entity	Alarm	Description Probable Cause/ Probable Location	Severity
booster	amp-gain-not-achieved	Amplifier cannot achieve gain target Probable-cause-direction="tx" Probable-cause-location="NEAREND"	Major
booster	amp-operating-outside-mask	Amplifier operating outside the mask Probable-cause-direction="tx" Probable-cause-location="NEAREND"	Minor
booster	optical-loo	Loss of output Probable-cause-direction="tx" Probable-cause-location="NEAREND"	Critical
booster	input-overload	Input power overload Probable-cause-direction="rx" Probable-cause-location="FAREND"	Minor
booster	input-low-degrade	Input power degraded Probable-cause-direction="rx" Probable-cause-location="FAREND"	Minor
booster	optical-los	Loss of input Probable-cause-direction="rx" Probable-cause-location="FAREND"	Major

Table 40: TCX1000-RDM20 Amplifier Alarms and Probable Causes and Locations (continued)

Entity	Alarm	Description Probable Cause/ Probable Location	Severity
booster	auto-power-reduction	Automatic output power reduction active due to high return loss or forced APR Probable-cause-direction="rx" Probable-cause-location="NEAREND"	Major
booster	automatic-shutdown	Automatic shutdown due to detected line break Probable-cause-direction="tx" Probable-cause-location="NEAREND"	Major
booster	laser-safety-disabled	Automatic Line Shutdown system disabled Probable-cause-direction="tx" Probable-cause-location="NEAREND"	Minor
Preamp	amp-gain-not-achieved	Amplifier cannot achieve gain target Probable-cause-direction="tx" Probable-cause-location="NEAREND"	Major
Preamp	amp-operating-outside-mask	Amplifier being operated outside the gain mask Probable-cause-direction="tx" Probable-cause-location="NEAREND"	Minor
Preamp	optical-loo	Loss of output Probable-cause-direction="tx" Probable-cause-location="NEAREND"	Critical
Preamp	input-overload	Input power overload Probable-cause-direction="rx" Probable-cause-location="FAREND"	Minor
Preamp	optical-line-failure	Line failure detected, possible fiber break Probable-cause-direction="rx" Probable-cause-location="FAREND"	Major

Related Documentation

- TCX1000 Alarm Overview on page 177
- TCX1000 Hardware Alarm Types and Behavior on page 181
- TCX1000-RDM20 Internal Amplifier Alarm Thresholds on page 202

TCX1000-RDM20 Connection Alarms and Probable Causes

Table 41 on page 189 describes the connection alarms and their probable causes.

Table 41: Connection Alarms and Probable Causes

Entity	Alarm	Description Probable Cause/ Probable Location	Severity
Ux In	optical-los	Loss of input on port Probable-cause-direction="rx" Probable-cause-location="FAREND"	Major
	input-low-degrade	Input channel power degraded Probable-cause-direction="rx" Probable-cause-location="FAREND"	Major
	input-overload	Input channel power overload Probable-cause-direction="rx" Probable-cause-location="FAREND"	Major
	optical-loo	Loss of output channel Probable-cause-direction="tx" Probable-cause-location="NEAREND"	Major
	output-overload	Output channel overload Probable-cause-direction="tx" Probable-cause-location="NEAREND"	Major
	output-low-degrade	Output channel degraded Probable-cause-direction="tx" Probable-cause-location="NEAREND"	Major

Table 41: Connection Alarms and Probable Causes (continued)

Entity	Alarm	Description Probable Cause/ Probable Location	Severity
Ux Out	optical-los	Loss of input channel Probable-cause-direction="rx" Probable-cause-location="FAREND"	Major
	input-overload	Input channel power overload Probable-cause-direction="rx" Probable-cause-location="FAREND"	Major
	input-low-degrade	Input channel power degraded Probable-cause-direction="rx" Probable-cause-location="FAREND"	Major

Related Documentation

- TCX1000 Alarm Overview on page 177
- TCX1000 Hardware Alarm Types and Behavior on page 181
- TCX1000-RDM20 Connection Alarm Thresholds on page 203

TCX1000-ILA Hardware Alarms and Probable Causes

Table 42 on page 190 describes the hardware alarms supported by the TCX1000-ILA and includes probable causes and corrective actions.

Table 42: TCX1000-ILA Hardware Alarms and Probable Cause

Alarms	Severity	Description and Raise Conditions	Probable Cause and Corrective Action
BoardTemperatureAbnormal	Major	Board temperature alarm. This alarm is raised if: (temperature > HighThr temperature < LowThr) This alarms clears when board temperature returns to normal range: (temperature < (HighThr– 1) and temperature > (LowThr + 1))	*Probable cause:* Environment or fan fail. *Corrective action:* Replace fan to recover the temperature to normal range:

Table 42: TCX1000-ILA Hardware Alarms and Probable Cause (continued)

Alarms	Severity	Description and Raise Conditions	Probable Cause and Corrective Action
CommunicationAbnormal	Critical	TCX1000-ILA internal alarm. This alarm is raised if communication between X86 and amplifier has problem.	*Probable cause:* Submodule communication exception. *Corrective action:* Perform a hard reset on the TCX1000-ILA. If the hard reset does not clear the alarm, the device may need to be replaced.
Fan0Missing	Critical	Fan 0 is missing.	*Probable cause:* Fan absent. *Corrective action:* Insert Fan in to fan slot 0.
Fan1Missing	Critical	Fan 1 is missing.	*Probable cause:* Fan absent. *Corrective action:* Insert Fan in to fan slot 1.
Fan2Missing	Critical	Fan 2 is missing.	*Probable cause:* Fan absent. *Corrective action:* Insert Fan in to fan slot 2.
Fan0SpeedAbnormal	Critical	Fan 0 speed below 768 rotate/minimum.	*Probable cause:* Fan damage. *Corrective action:* Clean the fan or replace it.
Fan1SpeedAbnormal	Critical	Fan 1 speed below 768 rotate/minimum.	*Probable cause:* Fan damage. *Corrective action:* Clean the fan or replace it.
Fan2SpeedAbnormal	Critical	Fan 1 speed below 768 rotate/minimum.	*Probable cause:* Fan damage. *Corrective action:* Clean the fan or replace it.
SoftwareVersionAbnormal	Critical	Module firmware version mismatch.	*Probable cause:* Upgrade failure. *Corrective action:* Repeat the upgrade.
Power1Abnormal	Critical	Power module 1 failed or missing.	*Probable cause:* Power failure or absent. *Corrective action:* Replace power module 1.

Table 42: TCX1000-ILA Hardware Alarms and Probable Cause (continued)

Alarms	Severity	Description and Raise Conditions	Probable Cause and Corrective Action
Power0Abnormal	Critical	Power module 0 failed or missing	*Probable cause:* Power failure or absent. *Corrective action:* Replace power module 0.
MgmtEth0Abnormal	Minor	Mgmt eth0 link down	*Probable cause:* Network cable is disconnected. *Corrective action:* Reconnect the network cable.
EDFAABCaseTemperature	Major	Amplifier AB case temperature alarm. This alarm raises if the amplifier case temperature is above 80° C.	*Probable cause:* Environment or fan failure. *Corrective action:* This alarm clears when amplifier case temperature is below 79° C.
EDFAABRFL	Critical	Amplifier AB module reflection alarm. This alarm raises if: ((LineAout/LineBout power >= 19 dBm) and (Back-reflection Power– LineAout/LineBout power) > -17dB))	*Corrective action:* This alarm clears when ((LineAout/LineBout power < 19 dBm) || (Back-reflection Power – LineAout/LineBout power < -19dB))
EDFAABOOG	Critical	Amplifier AB Out of gain alarm. This alarm raises if: (GainSetting - RealGain > 0.5dB)	This alarm clears when (GainSetting-RealGain < 0.5dB) *Corrective action:* Check optical path.
EDFAABPump0EOL	Critical	Amplifier AB Pump 0 current alarm.	*Corrective action:* To clear the alarm, reset module. If the alarm does not clear, the device may need to be replaced.
EDFAABPump1EOL	Critical	Amplifier AB Pump1 current alarm.	*Corrective action:* To clear the alarm, reset module. If the alarm does not clear, the device may need to be replaced.
EDFAABPump0Temperature	Major	Amplifier AB Pump0 temperature alarm. This alarm raises when pump temperature is out of threshold (20° to 30° C).	*Corrective action:* This alarm clears when pump temperature is within (21° to 29° C).

Table 42: TCX1000-ILA Hardware Alarms and Probable Cause (continued)

Alarms	Severity	Description and Raise Conditions	Probable Cause and Corrective Action
EDFAABPump1Temperature	Major	Amplifier AB Pump1 temperature alarm. This alarm raises when pump temperature is out of threshold (20º to 30º C).	*Corrective action:* This alarm clears when pump temperature is within (21º to 29º C).
EDFAABInputLOS	Critical	Amplifier AB Input (**Line A In**) power loss of signal (LOS) alarm. This alarm raises if (Input power < low threshold) Threshold= -39 dBm.	*Corrective action:* This alarm clears if (Input power > high threshold)
EDFAABOutputLOS	Critical	Amplifier AB Output (**Line B Out**) power loss of signal (LOS) alarm. This alarm raises if (Output total power < low threshold) Threshold= -6 dBm.	*Corrective action:* This alarm clears if (Output signal > high threshold)
EDFAABCaliTblerr	Critical	Amplifier AB calibration table error.	*Probable cause:* Amplifier internal alarm. *Corrective action:* Device may require replacement.
EDFAABVOA1AchieveFailed	Critical	Target VOA setting – Actual Achieved VOA setting >= 2dB and timefilter = 1s, (clear , <1dB)	*Probable cause:* Amplifier AB internal VOA failure. *Corrective action:* Device may require replacement.
EDFAABVOA2AchieveFailed	Critical	Target VOA setting – Actual Achieved VOA setting >= 2dB and timefilter = 1s, (clear , <1dB)	*Probable cause:* internal VOA failure. *Corrective action:* Device may require replacement.
EDFAABSwitchFailed	Critical	Amplifier switch failure alarm.	*Probable cause:* internal switch failure. *Corrective action:* Device may require replacement.
EDFABACaseTemperature	Major	This alarm raises when BA amplifier case temperature > 80º C.	*Corrective action:* This alarm clears when BA amplifier temperature < 79º C.

Table 42: TCX1000-ILA Hardware Alarms and Probable Cause (continued)

Alarms	Severity	Description and Raise Conditions	Probable Cause and Corrective Action
EDFABARFL	Critical	This alarm raises when ((VOA out power > APR Algorithm Activation Threshold) and (Back-reflection Power–VOA out power) > APR Trigger Ratio Threshold))	*Corrective action:* This alarm clears when ((Back-reflection Power - VOA out power) < APR Clear Threshold)
EDFABAOOG	Critical	This alarm raises when (|GainSetting- RealGain| > 0.5dB)	*Corrective action:* This alarm clears when (|GainSetting- RealGain| < 0.5dB) Check optical path.
EDFABAPump0EOL	Critical	Amplifier BA Pump0 current alarm.	*Corrective action:* To clear this alarm, reset the device. If the alarm does not clear device may need replacement.
EDFABAPump1EOL	Critical	Amplifier BA Pump1 current alarm.	*Corrective action:* To clear this alarm, reset the device. If the alarm does not clear it may need replacement.
EDFABAPump0Temperature	Major	Amplifier BA Pump0 temperature alarm. This alarm raises when pump temperature is out of threshold (20º to 30º C).	*Corrective action:* This alarm clears when pump temperature is within (21º to 29º C).
EDFABAPump1Temperature	Major	Amplifier BA Pump1 temperature alarm. This alarm raises when pump temperature is out of threshold (20º to 30º C).	*Corrective action:* This alarm clears when pump temperature is within (21º to 29º C).
EDFABAInputLOS	Critical	Amplifier BA loss of signal (LOS) input power alarm. This alarm raises if (Input power < low threshold) Threshold= -39 dBm.	*Corrective action:* This alarm clears if (input power > high threshold)
EDFABAOutputLOS	Critical	Amplifier BA loss of signal (LOS) output power alarm. This alarm raises if (Output total power < low threshold) Threshold= -6 dBm.	*Corrective action:* This alarm clears when if (Output signal power > high threshold)

Table 42: TCX1000-ILA Hardware Alarms and Probable Cause (continued)

Alarms	Severity	Description and Raise Conditions	Probable Cause and Corrective Action
EDFABACaliTblerr	Critical	This alarm raises if there is an Amplifier BA calibration table error.	*Probable cause:* Internal amplifier error. *Corrective action:* Device may need replacement.
EDFABAVOA1AchieveFailed	Critical	This alarm raises if the target VOA setting – actual achieved VOA setting >= 2dB and timefilter = 1s, (clear , <1dB)	*Probable cause:* Internal BA amplifier error. *Corrective action:* Device may need replacement.
EDFABAVOA2AchieveFailed	Critical	This alarm raises if the target VOA setting – actual achieved VOA setting >= 2dB and timefilter = 1s, (clear , <1dB)	Probable cause: Internal BA amplifier error. *Corrective action:* Device may need replacement.
EDFABASwitchFailed	Critical	This alarm raises there is a amplifier switch failure.	*Probable cause:* Internal switch failure. *Corrective action:* Device may need replacement.
OSCAAddPowerLOS	Critical	OSC A (for Line A) Add power loss of signal (LOS) alarm. This alarm raises if (add power < low threshold) Threshold= -42 dBm.	*Corrective action:* This alarm clears if (add power > high threshold)
OSCADropPowerLOS	Critical	OSC A drop power loss of signal (LOS) power alarm. This alarm raises if (drop power < low threshold) Threshold= -7 dBm.	*Corrective action:* This alarm clears if (drop power > high threshold)
OSCBAddPowerLOS	Critical	OSC B (for Line B) Add power loss of signal (LOS) alarm. This alarm raises if (add power < low threshold) Threshold= -42 dBm.	*Corrective action:* This alarm clears if (add power > high threshold)

Table 42: TCX1000-ILA Hardware Alarms and Probable Cause (continued)

Alarms	Severity	Description and Raise Conditions	Probable Cause and Corrective Action
OSCBDropPowerLOS	Critical	OSC B drop power loss of signal (LOS) power alarm. This alarm raises if (drop power < low threshold) Threshold= -7 dBm.	*Corrective action:* This alarm clears if (drop power > high threshold)
EDFAABOBRMinor	Minor	Amplifier AB optical back reflection minor alarm. (Optical Back Reflection High) (OBR-HT): Raise >= -24dB; Clear <= -26dB	*Probable cause:* High Back Reflection is caused by dirty fiber connectors or fiber plant downstream from Line-Out. *Corrective action:* Carefully clean all fiber connectors and patch-panels. Reflectometer/OTDR can be used to determine reflective event in fiber plant.
EDFAABOBRCritical	Critical	Amplifier AB optical back reflection critical alarm. (Optical Back Reflection High) (OBR-OS): Raise >= -18dB; Clear <= -20dB	*Probable cause:* High Back Reflection is caused by dirty fiber connectors or fiber plant downstream from Line-Out. *Corrective action:* Carefully clean all fiber connectors and patch-panels. Reflectometer/OTDR can be used to determine reflective event in fiber plant.
EDFAABALSO	Critical	Automatic line shutoff amplifier AB.	*Corrective action:* Check fiber connection and repair
EDFAABOLF	Critical	Optical line failure on amplifier AB.	*Corrective action:* Check fiber connection and repair
EDFABAOBRCritical	Critical	Amplifier AB optical back reflection critical alarm. (Optical Back Reflection High) (OBR-OS): Raise >= -18dB; Clear <= -20dB	*Probable cause:* High Back Reflection is caused by dirty fiber connectors or fiber plant downstream from Line-Out. *Corrective action:* Carefully clean all fiber connectors and patch-panels. Reflectometer/OTDR can be used to determine reflective event in fiber plant.

Table 42: TCX1000-ILA Hardware Alarms and Probable Cause (continued)

Alarms	Severity	Description and Raise Conditions	Probable Cause and Corrective Action
EDFABAOBRMinor	Minor	Amplifier AB optical back reflection minor alarm. (Optical Back Reflection High) (OBR-HT): Raise >= -24dB; Clear <= -26dB	*Probable cause:* High Back Reflection is caused by dirty fiber connectors or fiber plant downstream from Line-Out. *Corrective action:* Carefully clean all fiber connectors and patch-panels. Reflectometer/OTDR can be used to determine reflective event in fiber plant.
EDFABAALSO	Critical	Automatic line shutoff amplifier BA.	*Corrective action:* Check fiber connection and repair
EDFABAOLF	Critical	Optical line failure on amplifier BA.	*Corrective action:* Check fiber connection and repair

Related Documentation

- TCX1000 Alarm Overview on page 177
- TCX1000 Hardware Alarm Types and Behavior on page 181
- proNX Optical Director Alarms on page 178
- TCX1000-ILA Inline Amplifier Overview on page 40
- TCX1000-ILA Performance Monitoring Metrics on page 173

CHAPTER 15

Alarm Threshold References

Span Loss Out-of-Range Alarm Thresholds for TCX1000-RDM20 and TCX1000-ILA

The proNX Optical Director automatically monitors and adjusts for loss in the spans between TCX1000 devices. This topic describes the supported span loss out of range (OOR) thresholds for the TCX1000 devices.

TCX1000-RDM20 to TCX1000-RDM20 Span Loss Out-of-Range Alarm Thresholds

Table 43 on page 199 describes the supported span loss ranges for the TCX1000-RDM20.

Table 43: TCX1000-RDM20 to TCX1000-RDM20 Span Loss Out-of-Range Alarm Thresholds

Hardware	Fiber Type	Minimum (dB)	Maximum(dB)
TCX1000-RDM20	SMF	Range 1: 0.0	Range 1: 20.0
		Range 2: 4.8	Range 2: 32.8
	ELEAF Truewave Truewave Classic NZ-DSF	Range 1: 0.0	Range 1: 16.5
		Range 2: 4.8	Range 2: 32.8
	DSF SMF-LS	Range 1: 0.0	Range 1: 13.5
		Range 2: 4.8	Range 2: 32.8

Span Loss Out of Range (OOR) Thresholds TCX1000-RDM20 to TCX1000-ILA

Table 44 on page 200 describes the span loss out of range (OOR) thresholds between the TCX1000-RDM20 and a connected TCX1000-ILA.

Table 44: Span Loss Out of Range (OOR) Thresholds TCX1000-RDM20 to TCX1000-ILA

Hardware	Fiber Type	Minimum	Maximum
TCX1000-RDM20 to TCX1000-ILA	SMF	Range 1: 0 dB	Range 1: 21.0 dB
		Range 2: 4.8 dB	Range 2: 35.8 dB
	ELEAF Truewave Truewave Classic NZ-DSF	Range 1: 0 dB	Range 1: 17.5 dB
		Range 2: 4.8 dB	Range 2: 35.8 dB
	DSF SMF-LS	Range 1: 0 dB	Range 1: 14.5 dB
		Range 2: 4.8 dB	Range 2: 35.8 dB

Span Loss Out of Range (OOR) Thresholds for TCX1000 Devices

Table 45 on page 200 describes the span loss thresholds between two TCX1000-ILA amplifiers.

Table 45: Span Loss Out of Range Thresholds TCX1000-ILA to TCX1000-ILA

Hardware	Fiber Type	Minimum	Maximum
TCX1000-ILA to TCX1000-ILA	SMF	Range 1: 0 dB	Range 1: 20.0 dB
		Range 2: 5.0 dB	Range 2: 33.0 dB
	ELEAF Truewave Truewave Classic NZ-DSF	Range 1: 0 dB	Range 1: 17.5 dB
		Range 2: 5.0 dB	Range 2: 33.0 dB
	DSF SMF-LS	Range 1: 0 dB	Range 1: 14.5 dB
		Range 2: 5.0 dB	Range 2: 33.0 dB

Span Loss Out of Range Thresholds TCX1000-ILA to TCX1000-RDM20

Table 46 on page 201 describes the span loss out of range (OOR) thresholds between a TCX1000-ILA and a connected TCX1000-RDM20.

Table 46: Span Loss Out of Range Thresholds TCX1000-ILA to TCX1000-RDM20

Hardware	Fiber Type	Minimum	Maximum
TCX1000-ILA to TCX1000-RDM20	SMF	Range 1: 0 dB	Range 1: 19.0 dB
		Range 2: 5.0 dB	Range 2: 30.0 dB
	ELEAF Truewave Truewave Classic NZ-DSF	Range 1: 0 dB	Range 1: 16.5 dB
		Range 2: 5.0 dB	Range 2: 30.0 dB
	DSF SMF-LS	Range 1: 0 dB	Range 1: 13.5 dB
		Range 2: 5.0 dB	Range 2: 30.0 dB

Related Documentation

- proNX Optical Director Performance Monitoring Metrics on page 165
- proNX Optical Director Span Loss Management, Alarms and Metrics on page 166
- TCX1000-ILA Performance Monitoring Metrics on page 173
- proNX Optical Director Overview on page 47

TCX1000-RDM20 Port Alarm Thresholds

Table 47 on page 202 describes the external port alarm threshold values that are programmable through the proNX Optical Director for the TCX1000-RDM20.

NOTE: Hysteresis value is +/-1.0 dB for all ports and interfaces described in Table 47 on page 202. Hysteresis values are not user configurable.

Table 47: TCX1000-RDM20 External Port Thresholds

Port	Hardware Alarm	Description	Threshold (dBm)
Line In	Optical-los	Loss of signal	Range 1: -25.0
			Range 2: -36.0
	Input-low-degrade	Input Power Degraded	Range 1: -22.0
			Range 2: -33.0
Line Out	Optical-loo	Loss of output	-18.2
OSC 0/1 In	Optical-los	Loss of signal	-11
OSC 0/1 Out	Optical-loo	Loss of output	-41.60
Ux In	Optical-los	Loss of signal	-15.65
	Input-low-degrade	Input Power Degraded	12.65

Related Documentation

- TCX1000 Alarm Overview on page 177
- TCX1000 Hardware Alarm Types and Behavior on page 181
- TCX1000-RDM20 Port Alarms and Probable Causes on page 184

TCX1000-RDM20 Internal Amplifier Alarm Thresholds

Table 48 on page 202 describes the amplifier alarm threshold values that are programmable through the proNX Optical Director for the TCX1000-RDM20.

NOTE: **Hysteresis values for all amplifier thresholds is +/-1.0 dB. Hysteresis values are not user configurable.**

Table 48: Amplifier Alarm Thresholds

Amplifier	Hardware Alarm	Description	Threshold (dBm)
Booster	Optical-loo	Loss of output	-3.20
	Input-overload	Input Power Overload	2.1
	Input-low-degrade	Input Power Degraded	-26.2
	Optical-los	Loss of signal	-29.2

Table 48: Amplifier Alarm Thresholds (continued)

Amplifier	Hardware Alarm	Description	Threshold (dBm)
Preamp	Optical-loo	Loss of output	-6.4
	Input-overload	Input Power Overload	Range 1: 13.1
			Range 2: 5.1
	input optical overload		

Related Documentation

- TCX1000 Alarm Overview on page 177
- TCX1000 Hardware Alarm Types and Behavior on page 181
- TCX1000-RDM20 Internal Amplifier Alarms and Probable Causes on page 187

TCX1000-RDM20 Connection Alarm Thresholds

Table 49 on page 203 describes the connection alarm threshold values that are available through the proNX Optical Director for the TCX1000-RDM20.

NOTE: Hysteresis value for all connection thresholds is +/- 1.0 dB unless otherwise noted. Hysteresis values are not user configurable.

Table 49: TCX1000-RDM20 Connection Thresholds

Connection	Hardware Alarm	Description	Threshold (dBm)
Ux In	Optical-los	Loss of signal channel	-17.65
	Input-overload	Input Channel Power Overload	1.55
	Input-low-degrade	Input Channel Power Degraded	-14.65
	Optical-loo	Loss of output channel	-26.75
	Output-overload	Output Channel Power Overload	-15.75
	Output-low-degrade	Output Channel Power Degraded	-23.75
Ux Out	Optical-los	Loss of signal channel	-8.15
	Input-overload	Input Channel Power Overload	7.05
	Input-low-degrade	Input Channel Power Degraded	-0.95

Related Documentation

- TCX1000 Alarm Overview on page 177
- TCX1000 Hardware Alarm Types and Behavior on page 181
- TCX1000-RDM20 Connection Alarms and Probable Causes on page 189

TCX1000-ILA External and Amplifier Port Thresholds

Table 50 on page 204 describes the external port thresholds for the TCX1000-ILA.

NOTE: Hysteresis (dBm) is not applicable.

Table 50: TCX1000-ILA External Port Thresholds

Port	Hardware Alarm	Description	Threshold (dBm)
Line A In **Line B In**	OscRxLos	Receive Loss of signal	-42.00
Line A Out **Line B Out**	OscTxLos	Transmit Loss of signal	-7.00

Table 51 on page 204 describes the EDFA amplifier thresholds for the TCX1000-ILA.

NOTE: Hysteresis (dBm) is not applicable.

Table 51: TCX1000-ILA Amplifier Thresholds

Port	Hardware Alarm	Description	Threshold (dBm)
EDFA Amplifier AB	EdfaABInputLos	Input Loss of signal (LOS) on amplifier AB	-39.00
	EdfaABOutputLos	Output Loss of signal (LOS) on amplifier AB	-6.00
EDFA Amplifier BA	EdfaBAInputLos	Input Loss of signal (LOS) on amplifier BA	-39.00
	EdfaBAOutputLos	Output Loss of signal (LOS) on amplifier BA	-6.00

Related Documentation

- TCX1000-ILA Inline Amplifier Overview on page 40
- *TCX1000-ILA Amplifier Alarm Thresholds*

- TCX1000-ILA Hardware Alarms and Probable Causes on page 190
- TCX1000-ILA Performance Monitoring Metrics on page 173

CHAPTER 16

Appendix

RSTP Default Settings for TCX1000-RDM20 and TCX1000-ILA

This topic provides the default RSTP settings for the TCX1000-RDM20 and TCX1000-ILA for reference.

TCX1000-RDM20: Default Settings (for reference)

Here are the default settings for the TCX1000-RDM20 RTSP support:

- Bridge Priority = 40960
- Hello Interval = 2
- Max-age = 20
- Forwarding delay = 15
- Hold count = 3

DCN0/DCN1 settings:

- Port Cost = 20000
- Port Priority = 32
- stp-group = default_lan

OSC settings:

- Port Cost = 200000
- Port priority = 176
- stp-group = none (also known as “OSC forwarding” defaulted to OFF)

NOTE: **Depending on your network deployment, you may need to enable this option.**

TCX1000-ILA: Default Settings (for reference)

Here are the default settings for the TCX1000-ILA RSTP bridge:

- RSTP bridge settings:
  - Bridge Priority = 49152
  - Hello Interval = 2
  - Max-age = 20
  - Forwarding delay = 15
  - Hold count = 2

DCN0/DCN1 settings:

- Port Cost = 20000
- Port Priority = 32

OSC settings:

- Port Cost = 200000
- Port priority = 176

Related Documentation

- Rule 5: RSTP Deployment Rules for TCX1000 Devices on page 119
- TCX1000 Management Architecture on page 103
- Deployment Rules for TCX1000 Management Communications on page 109