Introduction to Traditional Networks

This chapter provides insight into the business challenge, components of a network, and the current challenges faced by IP and optical networks.

Business Challenge

Today's networks, such as optical and packet networks, consist of multiple layers which are stitched together from many domains and vendors. Provisioning services in such complex environments requires intricate coordination between different management systems and organizations. It is challenging to operate these networks and the total cost of ownership (TCO) is rising. Service providers must simplify and reimagine the architecture to curtail the rising operational costs and fast-track the delivery of new services.

Solution

The Routed Optical Networking solution aims to simplify networks by removing the complexities inherent to the infrastructure. This simplification allows service providers to leverage their assets more effectively by:

- unifying the IP and optical layers of the network using a single control plane
- using high-speed coherent pluggable modules that offer reach and performance at appropriate cost points and power profiles
- simplifying the network life-cycle management by leveraging automation in all phases of the lifecycle

Changing the paradigm, the Cisco Routed Optical Networking solution improves operational efficiency and reduces network TCO. The transformed network also increases service agility.

Traditional Multilayer Network Architectures

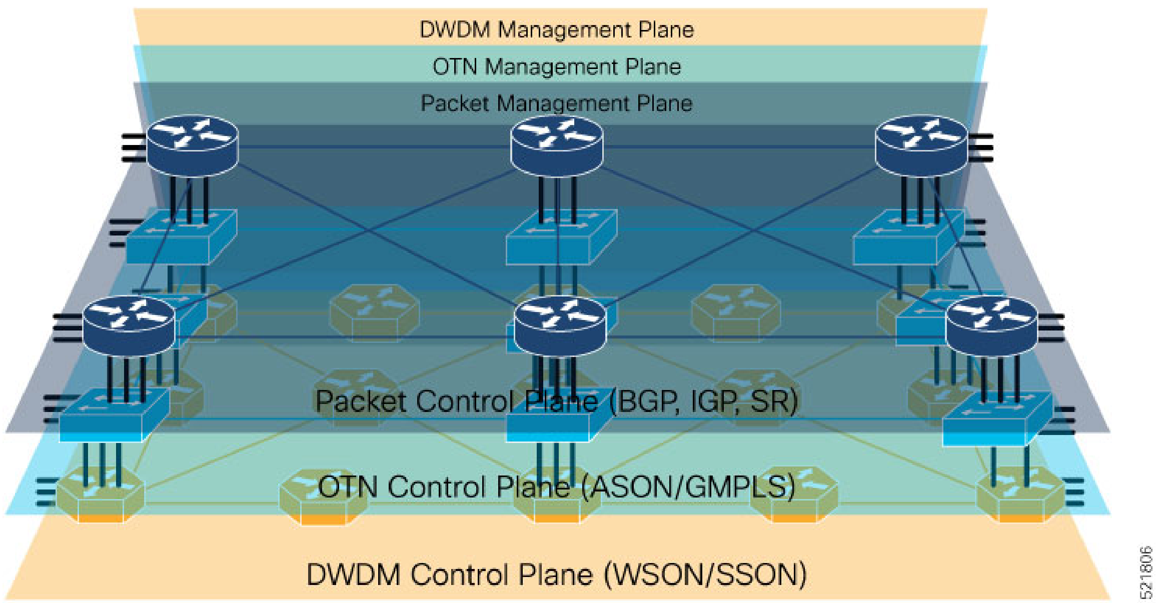
Traditional network infrastructure consists of an IP layer and an optical transport layer. The optical layer consists of a Dense Wavelength Division Multiplexing (DWDM) layer, and optionally an Optical Transport Network (OTN) switching layer. Each layer has its own independent control and management planes.

A distributed control plane communicates network information between network elements to enable end-to-end communication between network clients. Distributing routing information is the responsibility of the IP control plane. Resource and connection management between optical endpoints is the responsibility of the optical control plane.

The following table lists network layers and their corresponding control planes:

Layer	Control Plane
Packet layer/IP layer	BGP, IGP, Segment routing
Optical Transport Network layer	ASON/GMPLS
Dense Wavelength Division Multiplexing layer	WSON/SSON

Figure 1: Traditional Network Architecture



Each layer operates independently with separate redundancy and life cycles. Logically different teams are necessary to establish and maintain each layer.

Network Building Blocks

Traditional hierarchical networks consists of an IP layer and an optical transport layer.

IP Layer

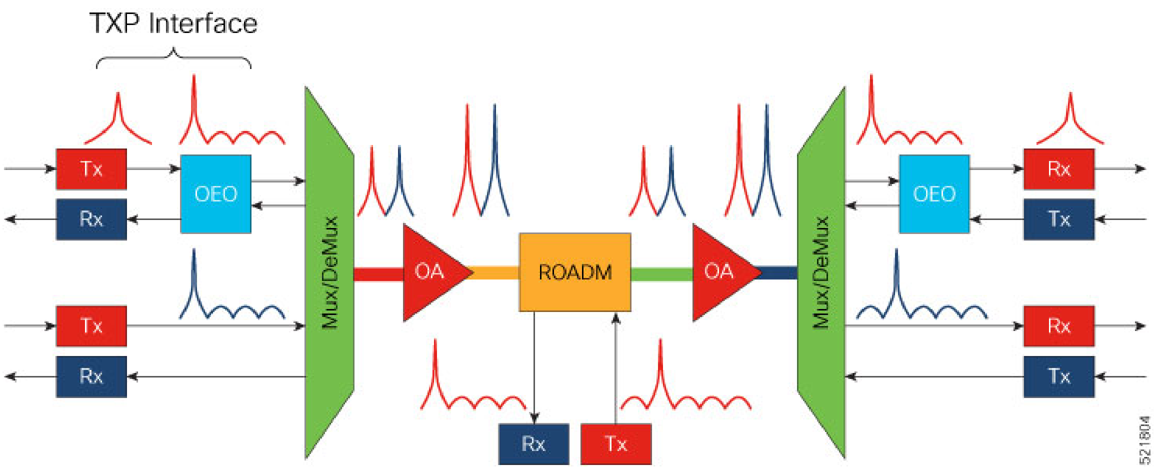
The IP layer is responsible for creating and maintaining the routing table and forwarding packets according to the routing table. The IP layer of traditional networks consists of interconnected routers.

Routers are the building blocks of packet networks and are responsible for efficiently forwarding IP or MPLS packets. Routers are used to create any to any fabrics used to carry virtually all networking traffic today, including the global Internet. Routers are also responsible for providing different functions based on their role in the network. Two examples are core and Provider Edge routers. Core routers use a simplified set of implemented features and supply high capacity interconnect between different regions in a network. Provider Edge (PE) routers support high scale overlay VPN services.

Optical Layer

The following diagram shows a typical DWDM network:

Figure 2: Typical DWDM Network



This table lists the abbreviations in the preceding image and their expansions:

TXP	Transponder
OEO	Optical-electrical-optical
Mux	Multiplexer
DeMux	Demultiplexer
OA	Optical amplifier
ROADM	Reconfigurable optical add/drop multiplexer

The building blocks of a typical DWDM network are:

- **Optical Transmitters and Receivers**: Transmitters provide source signals. They convert digital electrical signals into a light stream of a specific wavelength. Optical receivers detect pulses of light on optical fibers and convert optical signals to electrical signals.
- **Transponders**: Transponders take signals on gray wavelengths and send them in colored wavelengths. Colored wavelengths are wavelengths in the WDM standard. Gray wavelengths are wavelengths not in the WDM standard. A bidirectional transponder also receives a WDM standard bit-stream and converts the signals back to the wavelength used by the client device.
- **Muxponders**: Muxponders are similar to transponders. Muxponders take multiple gray wavelength signals and send them in a single colored-wavelength using Time Division Multiplexing (TDM).
- **Multiplexers/Demultiplexers**: Multiplexers take multiple wavelengths on separate fibers and combine them into a single fiber. The output of a multiplexer is a composite signal. Demultiplexers take composite

signals that compatible multiplexers generate and separate the individual wavelengths into individual fibers.

- **Optical Amplifiers**: Optical amplifiers amplify an optical signal. Optical amplifiers increase the total power of the optical signal to enable the signal transmission across longer distances. Without amplifiers, the signal attenuation over longer distances makes it impossible to coherently receive signals. We use different types of optical amplifiers in optical networks. For example: preamplifiers, booster amplifiers, inline amplifiers, and optical line amplifiers.
- **Optical add/drop multiplexers (OADMs)**: OADMs are devices capable of adding one or more DWDM channels into or dropping them from a fiber.
- **Reconfigurable optical add/drop multiplexers (ROADMs)**: ROADMs are programmable versions of OADMs. With ROADMs, you can change the wavelengths that are added or dropped. ROADMs make optical networks flexible and easily modifiable.

Challenges with Current IP and Optical Networks

Current hierarchical service provider networks have up to three different layers, IP, OTN, and DWDM, each with separate control planes. These networks have a layered and siloed architecture relying on dedicated hardware to exchange traffic between layers. The siloed architecture also often results in separate opaque redundancy mechanisms at each layer, increasing complexity and reducing overall network efficiency. The large number of devices used to interconnect the layers increases power utilization and drives up the overall carbon footprint of the network.

The layered and siloed architecture warrants manual service-stitching across network domains. The necessity for manual intervention hinders end-to-end automation and results in higher time to resolution and loss of efficiency.

Traffic runs over too many elements. The need for separate management of these elements by different departments and the lack of automated management increases the complexity and cost of the network.

Current service provider networks have immense complexities and face challenges in:

- Network planning
- Provisioning
- Path and network optimization
- Network monitoring
- Fault correction

These complexities and overlapping redundancies present bottlenecks to scaling the service provider networks efficiently.