

Software-Defined Networking and Network Functions Virtualization

Redefining the Communications Network



shaping tomorrow with you

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Realizing the Potential of a Virtualized, Programmable Network

Imagine a network where services can be turned up in seconds rather than weeks or months. Imagine the cost savings from substituting inexpensive generic hardware for high-priced proprietary equipment. Imagine the revenue potential of a dynamic mesh architecture that eliminates the need for redundant protection paths. Imagine a network that can pinpoint and correct its own faults or automatically restore communications lifelines in a disaster situation.

These scenarios illustrate what the software-driven, virtualized network world will look like. From instantiating services on-the-fly to advanced capacity planning, the economic and operational efficiencies and benefits of SDN/NFV are far-reaching.

The virtualized, programmable network is not just "the next great thing." It is a prerequisite for the empowered, interconnected society of the near future.

Human-Centric Technology

At Fujitsu, these tangible benefits are what we aim to deliver. The virtualized, programmable network is not just "the next great thing." It is a prerequisite for the empowered, interconnected society of the near future. The network we envision will generate opportunities, foster collaboration and distribute knowledge. Our company vision is of "human-centric" innovation: technology that benefits individuals, businesses and society as a whole. This gives us unique insight into how and why people use networks and IT, and a clear focus on the desired outcome: a modernized, integrated network that delivers mobility, security, interconnectedness and cloud capabilities.

A Complete SDN/NFV Ecosystem from a Global ICT Leader

As a \$50 billion multinational corporation, Fujitsu is the world's third-largest Information/Communications Technology (ICT) services provider. We're one of a handful of companies with the knowledge, expertise and resources to build a complete multivendor, multilayer and modular SDN/NFV ecosystem.

Fujitsu also has an extensive network of strong relationships with technology and business partners, many of whom are household names. In North America, we're already engaged with our customers in architecting collaborative SDN solutions. In Japan, the Fujitsu Virtuora™ SDN platform has been deployed into live tier 1 carrier networks.

Fujitsu brings broad product, technology and service capabilities to the SDN/NFV arena. Our approach to SDN/NFV unites our optical networking leadership with our capabilities in data center, cloud/infrastructure services, and software applications. Today, we're building modular application components that answer the real business imperatives of real service providers. The advanced prototypes we have so far created enable us to demonstrate the unique value of Fujitsu SDN/NFV technology.

Trends and Challenges in a Changing Industry

The communications network industry has come a long way since the 1990s and business leaders expect ICT to be a prime driver of economic expansion. By 2017, service providers will be delivering 4.6 times the amount of mobile bandwidth they were in 2012 and 70% of companies will be using cloud services for some or all of their ICT function. Two years ago, the number of connected devices exceeded the world's population; this number will balloon to 50 billion by 2020.

Concurrent with these growth trends are challenges and associated costs that can best be addressed using existing assets, without costly investments in new equipment and proprietary Operations Support Systems (OSS):

- **Network to Cloud Interconnection** – Complex, customized methods are needed to connect between networks and the cloud. There is no distributed architecture: only a top-down structure.
- **OSS Agility** – There are no multilayer or multivendor OSS solutions, and these systems are expensive and time consuming to replace or augment.
- **Services Evolution** – New customer trends are driving demand for new, dynamic services that will require innovative modeling and open-standards approaches.
- **Time to Revenue** – Cumbersome, lengthy provisioning processes and services that lack resiliency increase time to revenue and reduce potential revenue.



Key Areas of Change

In response to the challenges it faces, the communications network industry is changing in several key areas that will have far-reaching effects on the network itself as well as service providers and their customers. In essence, the network and IT paradigms are colliding, with long-term disruptive effects. Instead of the monolithic, hardware-based implementations of the past, networks are becoming dynamic, virtualized and automated.

Equipment

The move towards commoditization of equipment is rapidly gathering momentum. At the low end of the equipment spectrum, many switching devices can be completely virtualized into x86-type platforms. Packet forwarding hardware is also becoming increasingly commoditized. Optical hardware is under increasing pressure to deliver simplified, more generic equipment, and the market favors small pluggable modules for delivering optical capacity without reliance on a specific vendor. Overall the industry is trending towards open standards and plug-and-play installation that make it easier and quicker to incorporate new equipment into a network.

Networks

Today's networks are very static and rely heavily on technology overlays as successive technologies and protocols have been introduced. These overlaid infrastructures, once built, are difficult and expensive to change. SDN/NFV aims to abstract a lot of those resources and virtualize the network to make it more dynamic.

Services

From the services point of view, the market is evolving away from traditional carrier services that were typically long-lived, slow to create, and manually activated. This is where separating the service functionality from the hardware implementation can enable a much more flexible, elastic approach to services, offering the benefits of scalability, programmability and automation.

Service Providers

For service providers, SDN/NFV technology changes the network into a service platform that breaks down the differences between carriers and over-the-top content providers. Carriers will be able to sell use of their networks to over-the-top providers such that the service becomes the network itself. This will enable stronger focus on applications and platforms. In sum, the networking and IT cloud paradigms are converging with the advent of SDN, NFV, and dynamic packet optical technologies.

Cornerstones of the New Architecture



This technology provides Layer 0-3 support and enables an interoperable multilayer, multivendor and modular infrastructure.

Foundational SDN Technology from Fujitsu

Fujitsu has developed a rich ecosystem of software and hardware as the basis for deploying SDN/NFV capabilities. The Fujitsu solution consists of software components that deliver essential orchestration, management, control, and analytical capabilities, in addition to releases of the FLASHWAVE CDS and 9500 platforms developed specifically for the SDN/NFV environment. This technology provides Layer 0-3 support and enables an interoperable multilayer, multivendor infrastructure.

Fujitsu SDN/NFV Capabilities:

- Support for up to 20,000 nodes
- Interfacing with legacy network infrastructure
- Logically centralized, physically distributed for resiliency and scalability
- Adaptable southbound interfaces (NETCONF, OpenFlow, CLI, and TL1)
- Open northbound interfaces (REST-based)
- User, service, and network levels of virtualization
- Active enablement for SDN functions (virtual topology maps, service chaining, traffic engineering)
- Data collection and analytics

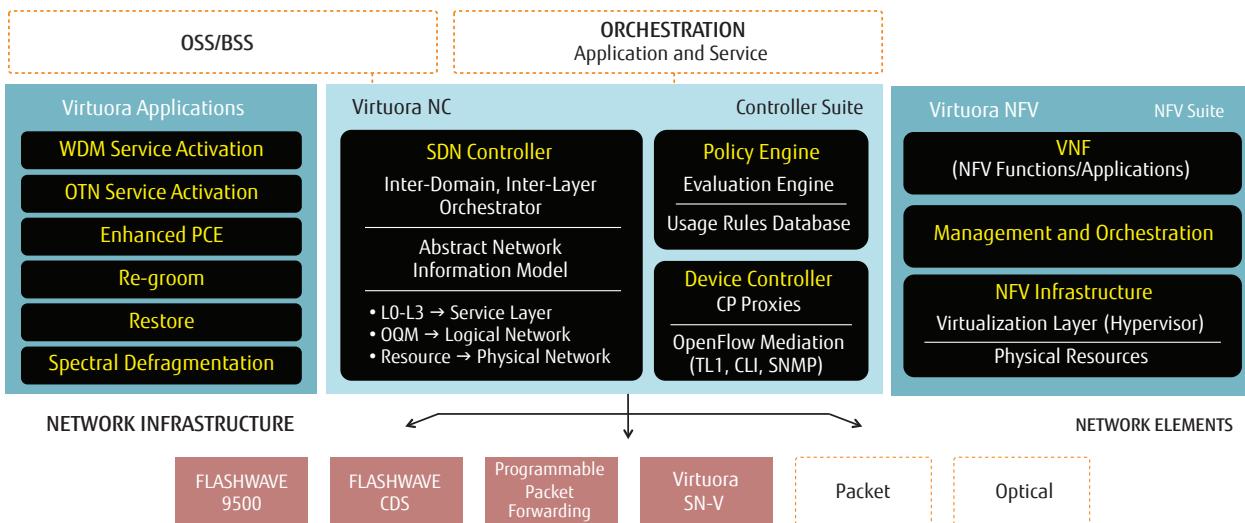
Network Functions Virtualization (NFV)

Fujitsu NFV technology supports VNF (Virtual Network Function) applications by enabling them to be tested and introduced rapidly and reliably. Multivendor VNFs can be implemented on our NFV management and policy platforms, and the overall solution validated in the Fujitsu NFV test environment.

Fujitsu NFV Technology Benefits

- Reduced capex by using commodity servers in place of proprietary network equipment
- Reduced opex by unifying hardware to enable simpler operation
- Efficient resource utilization by using fewer facilities
- Centralized resource management for both transmission equipment and network functions

Virtuora functional architecture



An Agile Multilayer, Multivendor Architecture

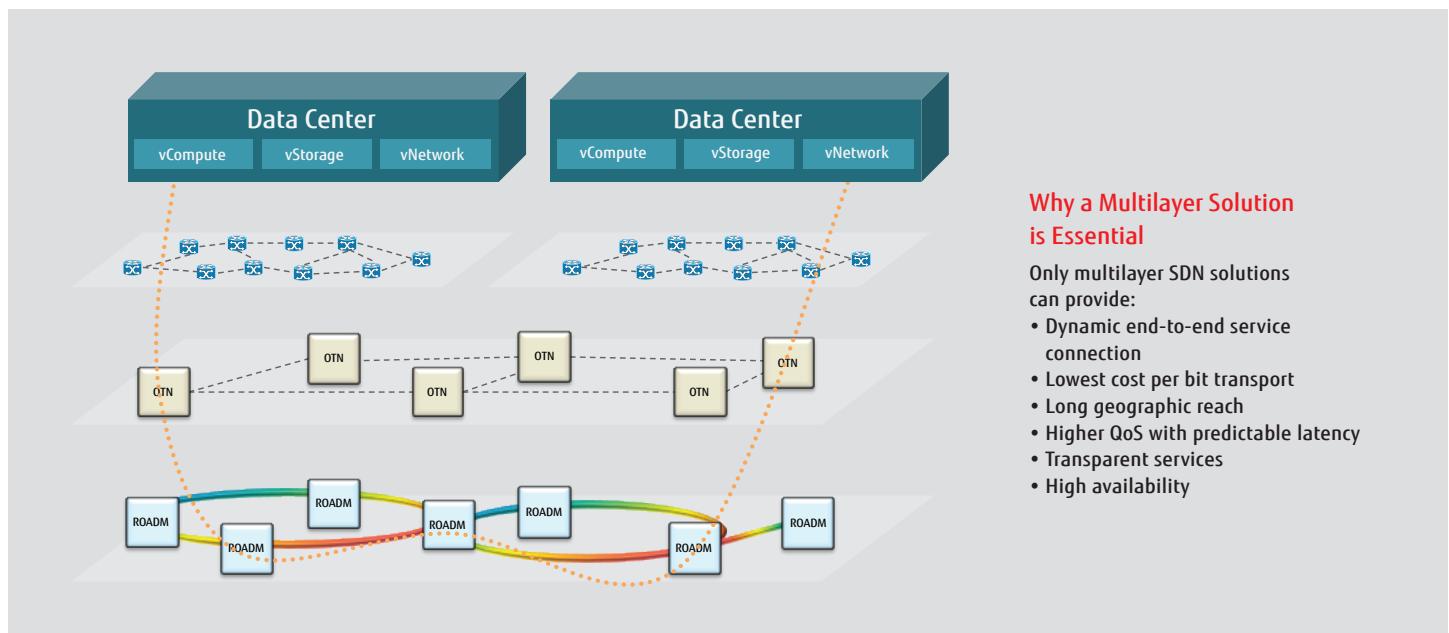
The vision for a multivendor, multilayer network that delivers truly agile, end-to-end, dynamic services demands a virtualized, multilayer packet optical architecture that is connected, converged, programmable, and interoperable. Ultimately, adding intelligence to multilayer management networks enables you to make decisions about how traffic will be routed based on the characteristics of the network itself.

The Fujitsu SDN/NFV architecture integrates OSS/BSS, OS, and EMS and provides control, orchestration, and virtualization intelligence to enable unified operation. On the hardware side, we are releasing optical technology alongside SDN that makes the optical transport layer truly dynamic as well. This Colorless, Directionless, Contentionless (CDC) next-generation ROADM provides the multilevel, dynamic modulation necessary to support the SDN/NFV vision of management and control.

Fujitsu Platform Components

Four components form the basis of the Fujitsu SDN/NFV ecosystem. These three components work in concert to deliver autonomous network design and control functionality:

- Fujitsu Network Virtuora NC
- Fujitsu Network Virtuora SN-V
- Fujitsu Virtuora NFV Manager
- Fujitsu and third-party applications



Participating in Open-Source Development

The Fujitsu FLASHWAVE® 9500 Packet Optical Networking Platform (Packet ONP) was successfully used with an open-source SDN controller in a 2014 series of tests sponsored by the Optical Interworking Foundation (OIF) and Open Networking Foundation (ONF). These industry groups are working to promote open-source SDN transport technologies.



In collaboration with the ONT's Optical Transport working group, Fujitsu participated in developing, prototyping and testing OpenFlow extensions in both Control Plane Data Interface (CPDI) and Control Virtual Network Interface (CVNI) forms.

Fujitsu Network Virtuora NC

Virtuora NC provides centralized control and management of network configuration information and provides a full-featured virtual network environment. Using a unique Fujitsu-developed intelligent routing design engine, Virtuora NC determines the optimal network route based on multiple types of information. Using these capabilities, WAN managers can deliver the best possible quality of service over complex networks. Virtuora NC also provides a service-chaining function that selects and connects to functions available on a WAN (such as firewalls and load balancers). The system depicts easy-to-read routing information for each service, simplifying virtual network operations that usually require a high level of specialist effort.

Key Features

- On-demand service activation and service chaining
- Automated operation and feedback control
- Centralized control and management of virtual network
- Real time quality measurement and data gathering
- Optimized path design when provisioning or restoring service

Fujitsu Network Virtuora SN-V

Virtuora SN-V is network virtualization node software that runs on a generic Intel® Architecture (IA) x86 server, enabling WAN operators to cut capital expenditure by reducing the need for specialized equipment. The software performs network virtualization and data transport processes using information from Virtuora NC. Virtuora SN-V employs intelligent execution-control technology to achieve high-speed data-communications processing as well as autonomous trouble monitoring and instant switchover when faults are detected.

Key Features

- Separate user and control planes
- VPN features (Layer 2 over Layer 3 tunneling and forwarding)
- WAN resource virtualization
- Autonomous route protection
- High-performance data forwarding
- Centrally controlled route protection
- Supports OpenFlow 1.3, an open programming interface for SDN

Fujitsu Network Virtuora NFV Manager

This component provides resource management and orchestration functions for VNFs based on ETSI NFV architecture. NFV Manager provides dynamic service chaining of virtualized or physical network functions, and thus simplifies the creation, deployment and management of differentiated network services. This simplifies integration between Fujitsu and third-party service software and supports an ecosystem of partners to offer services on top of the Virtuora SDN/NFV platform. The Fujitsu NFV manager also uses Virtual Machines (VMs) to operate multiple functions on a single physical server, improving resource utilization.

Key Features

- On-demand VNF deployment and network resource allocation
- Resource usage and operations status monitoring
- Logical and physical resource mapping
- Virtualized verification environment on commercial network with a VNF test and verification app
- High availability with distributed middleware
- Separate user and control planes

Virtuora SDN/NFV Applications

We are developing individual functions that offer unprecedented choices in service creation and operational efficiency. Several of these applications are available from Fujitsu today and more are in the planning stages. By using open software architecture, our approach provides the flexibility to select the best applications from any combination of Fujitsu and third parties.

Virtuora SDN/NFV Application Highlights

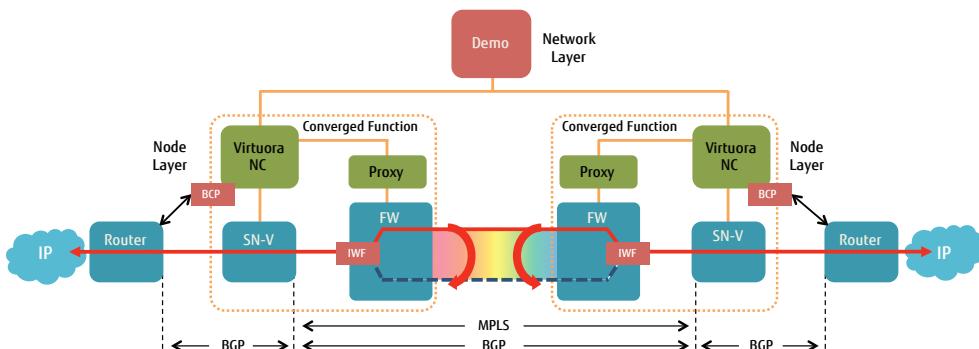
- Multilayer Path Computation Engine (PCE)
- Spectral defragmentation
- OTN/WDM service activation
- Multilayer design/planning/optimization, restore/re-groom
- Real-time network analytics
- Third-party partner apps

Applications and Capabilities

These applications and capabilities are examples of how the Fujitsu SDN/NFV portfolio can deliver real business benefits. They will mature into products that improve operational efficiency, cut costs, increase customer satisfaction, speed service velocity and make networks more flexible and agile in the face of continued change.

Multilayer Service Creation

Multilayer Service Creation makes it possible to create, activate, modify, and restore dynamic multilayer services in a fraction of the time required today. The technology includes a physically distributed, logically centralized, SDN controller that can interface with other systems such as the NETSMART® 2000 Planning and Design Tool to obtain provisioning and configuration data for both WDM and OTN traffic. These capabilities have been shown to reduce wavelength assignments by 25% in comparison with traditional optical networks.



Challenges Solved

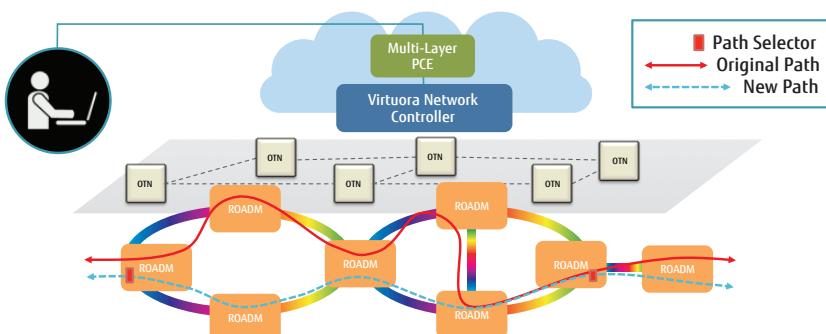
- Static network
- Single vendor
- Single layer
- Slow, manual service provisioning
- Complex path computation for WDM and OTN services
- Slow service restoration

Benefits

- Simplified operations through a "logically" centralized controller
- Improved circuit planning, recovery and re-optimization
- Automatic computation of optimal WDM spans
- Automatic path computation for OTN traffic based on two endpoints
- Automatic re-routing of paths where fiber breaks occur

Multilayer Traffic Optimization

The Virtuora NC policy-driven OTN Path Computation Engine (PCE) avoids congestion points and outages, boosting service quality and continuity and enabling fast recovery in multilayer, multivendor networks. The system can literally re-route traffic around congested areas or optimize re-use of the existing path to provision a better route.



Challenges Solved

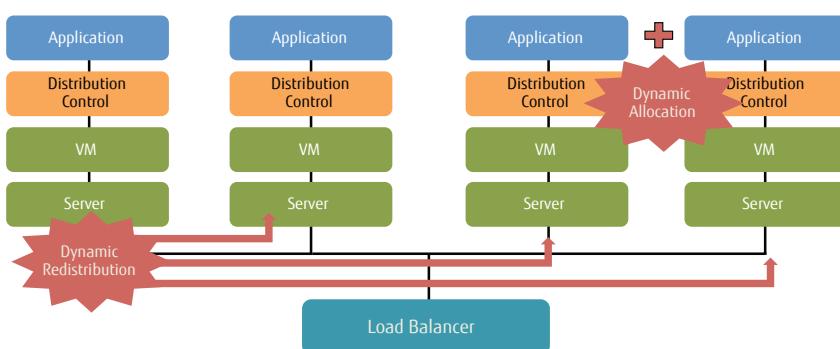
- New services progressively create congestion
- "Stranded" bandwidth
- Time-consuming, manual trouble resolution
- Inability to recover from large-scale failures

Benefits

- Re-grooming and optimization of OTN services
- Reduced service disruptions
- Reduced downtime

Dynamic Resiliency and Scalability

With dynamic ad-hoc virtual resource orchestration, the Fujitsu SDN/NFV systems automatically provision additional capacity or provide resiliency to ensure service continuity and quality even during times of sudden and/or unexpected peak demand. Virtuora NC offers a capacity view and report featuring a color-coded visual representation based on imported channel assignment data, and can perform spectral defragmentation to optimize wavelength assignments and free up resources. This capability is multivendor and new algorithms can be added on the fly.



Challenges Solved

- Sudden peaks in demand ("Mother's Day" events)
- Overhead caused by inactive/surplus infrastructure
- Underutilized investment
- Costly sustainment and business continuity efforts and investments

Benefits

- Clear information about congested links
- Improved flexibility to accommodate peak demand
- Reduced congestion
- Better use of bandwidth resources
- Improved failover protection

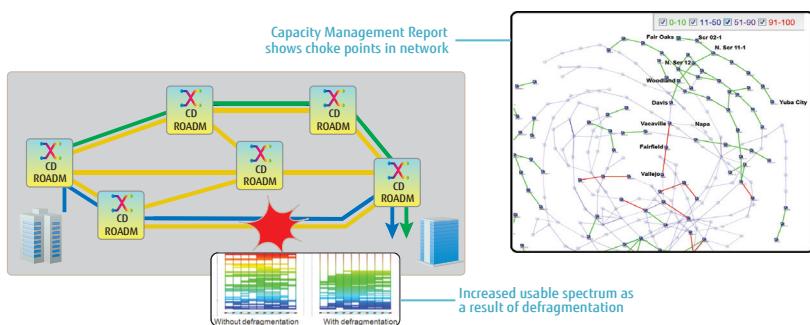
Transform your Business with our Disruptive Technology

Fujitsu SDN/NFV products can help you:

- Preserve and grow long-term profitability
- Develop new revenue opportunities
- Deliver new services faster
- Improve service quality and reliability
- Speed up troubleshooting and fault resolution
- Enable agile, flexible "pay as you grow" strategies
- Cut capital outlay and operational costs
- Reduce power and space consumption

Resource Planning and Utilization

Virtuora NC enables review of congestion and fragmentation levels and provides what-if analysis for re-grooming services or adding capacity. By providing reports in exportable formats, Virtuora NC also assists in future network planning.



Challenges Solved

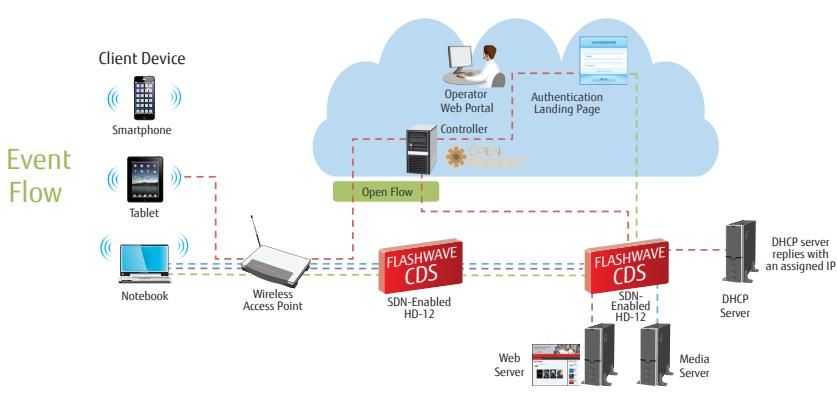
- Choke points in network
- Fragmentation of wavelength assignments over time
- Underutilized resources
- Unpredictable effects of changes to the network

Benefits

- Optimized wavelength assignments
- Better use of resources
- Easier detection of choke points
- Improved planning for future demand

Dynamic Service Activation

The Fujitsu SDN portfolio enables activation, restoration and protection of WDM and OTN services from a centralized, virtual, SDN network controller. By "logically" centralizing the controller, operations including service activation are greatly simplified. The Virtuora NC system collects reachability information from the NETSMART 2000 Design and Planning Tool, determines the optimal spans, and sends out the provisioning commands to activate the service. In situations such as a fiber break or equipment failure, the system is able to receive and process alarm data from the Element Management System (EMS) and use that information to determine the best possible new path, as well as automatically re-routing and restoring traffic.



Challenges Solved

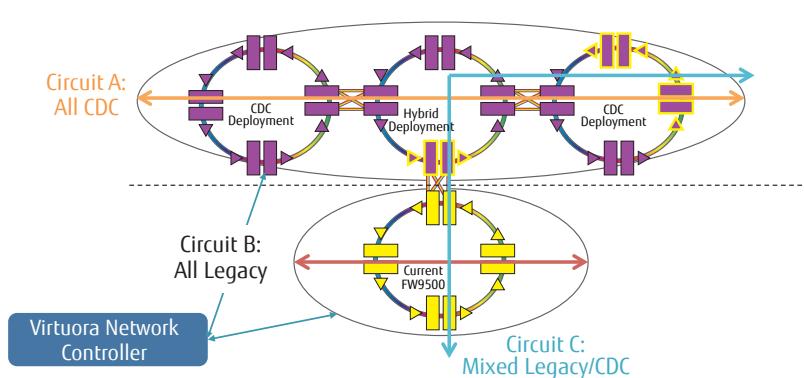
- Integration of new SDN technology into existing network
- Complex processes for making changes to existing network
- Static network with lengthy provisioning times

Benefits

- Improved circuit planning, recovery, and re-optimization
- Rapid service provisioning and activation
- Automatic restoration of traffic after service interruption

CDC and Traditional ROADM Integration

As the programmable, virtualized network takes shape, network equipment will evolve to support the new architecture. Virtuora NC integrates existing, new, and mixed lambda services, enabling longer life for legacy equipment and assisting service providers in controlling capital outlays. The Fujitsu FLASHWAVE 9500 and CDS platforms are moving towards CDC ROADM support, which is a prerequisite for SDN/NFV implementation. Virtuora NC provides integrated control for traditional and CDC networks managed by Virtuora NC-T.



Challenges Solved

- Bridging the gap between new and legacy hardware
- Managing physical constraints in a hybrid environment
- End-to-end circuit planning for both new and legacy optics

Benefits

- Integrates existing, new and mixed lambda services
- Prolongs profitable life of equipment
- Smaller overall footprint



IT and networking are converging on a wide scale and SDN/NFV and programmable packet optical are exerting major long-term disruptive influence. Fujitsu is actively investing in these technologies and engaging with customers in agile development projects that drive this transition forward.

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