Overall **MPLS Course** Objectives

- The drivers for MPLS
- MPLS control and data plane operation
- MPLS terminology and uses in an Alcatel-Lucent environment
- LDP and RSVP protocol operation and configuration
- Options available for TE in an MPLS network, including configuration and operation
- How to traffic engineer in a hierarchical network using LDP-over-RSVP
- The available options for achieving resiliency with MPLS networks
- The implementation of fast re-route in a Nokia environment

Mod 1, Sec 1: MPLS drivers – the role of MPLS in:

- Improving forwarding performance
- Traffic Engineering applications
- Building High Available Networks
- Consolidation of Services over a common infrastructure
- Delivering Layer 2 and Layer 3 Services
- Triple Play Solutions
- Building a BGP Free Core

Mod 1, Sec 2: Intro to MPLS – a brief definition of MPLS and provide RFC references.

- Offer a brief definition of MPLS and provide RFC references.
- Introduce the concept of a label.
- Introduce the data plane operation of MPLS (Push, POP, Swap)
- Define the basic terminology used in MPLS (P/PE/CE, LER, LSR, FEC)
- Present the requirements for label signaling protocols in MPLS and relate the LIB/LFIB relationship to the RIB/FIB of IP routing protocols.

Mod 2, Sec 1: MPLS data plane operation

- Explain the MPLS Label Stack Operation
- Explain the MPLS Label structure in detail (label values, EXP, S, TTL fields)
- Explain pipe vs. uniform mode operation with respect to TTL, EXP; the impact to a label stack
- Explain frame vs. cell mode label implementation

Mod 2, Sec 2: MPLS control plane operation

- Explain the requirement for IGP and label distribution protocols.
- Discuss the various label distribution and control and retention modes.
- Introduce the various label space implementation modes.
- Introduce the various MPLS signaling protocols.
- Explain the use of MPLS reserved labels (0-15).
- Explain the Nokia Service Router support for the various presented modes and features.

Mod 3, Sec 1: LDP operation

- Explain the LDP peer discovery and session establishment processes.
- Describe the prerequisites and parameters to establish LDP sessions.
- Investigate the label distribution process for Link LDP and explain how the label databases are populated.

Mod 3, Sec 2: Additional LDP features
- ECMP for LDP
- LDP Export and Import Policy Implementation
- Label Withdraw and Release Actions
- LDP aggregate-prefix-match feature
- Targeted LDP
- LDP Authentication

Mod 4, Sec 1: RSVP control plane operation
- Introduce the Resource Reservation Protocol (RSVP).
- Introduce RSVP with Traffic Engineering (TE) extensions.
- Explain LSP signaling using RSVP.
- Explain RSVP session establishment process for an LSP.
- Introduce RSVP message types to establish or clear LSPs, and to signal error conditions.
- LSP-Ping and LSP-Trace for RSVP-TE based LSPs.

Mod 4, Sec 2: RSVP session refresh optimization
- RSVP-TE Hello Protocol
- Refresh-Time Randomization (RFC 2205 – Section 3.7)
- RSVP Refresh Overhead Reduction
  - Reliable message delivery using MESSAGE-ID and MESSAGE-ACK
  - Summary Refresh messages

Mod 5, Sec 1: MPLS Traffic Engineering Fundamentals
- Review the drivers for Traffic Engineering (TE)
- Discuss the additional information required in TE (administrative constraints).
- Understand how these attributes are signaled via IGP (OSPF and IS-IS TE extensions)
- Discuss the operation of CSPF (Constraint-Based Shortest Path First) algorithm.
- Discuss the use of ERO (Explicit Route Object) for signaling TE-based LSP paths.

Mod 5, Sec 2: Configuring TE in a single-area (flat) network
- Configure administrative constraints on the links (administrative group, TE-metric)
- Configure path definitions using strict and loose hops
- Specify constraints in LSP path configuration
- Use CLI show commands, demonstrate how to monitor an LSP path configuration
- Explain possible configuration errors and failure scenarios
- Explain the CSPF path-check tool with an example

Mod 5, Sec 3: Bandwidth (Not covered in the course; skip this section)

Mod 5, Sec 4: TE in a multi-area network
- The LDP-over-RSVP solution

Mod 5, Sec 5: MPLS Shortcuts
- LDP-Shortcut for BGP next-hops
- RSVP-TE Shortcut for BGP next-hops
- LDP-Shortcut for IP forwarding
- RSVP-TE Shortcut for IP forwarding
- 6PE – IPv6 tunnels over MPLS

Mod 6, Sec 1: MPLS Convergence Overview
Discuss the factors that influence total network convergence times for the following scenarios:
- Plain IGP network
- Secondary LSP-Path protection with RSVP-TE
- Fast-Reroute protection
- Using LDP based tunnels
- LDP-IGP Sync feature

Mod 6, Sec 2: Secondary LSP-Path Protection
- MPLS resiliency using:
  - Standby Secondary Paths
  - Non-Standby Secondary Paths
- Secondary LSP Path Selection Rules using:
  - Default path-preference values
  - Customized path-preference values
- Maintaining LSP Path Diversity using:
  - Strict Hop LSP Path Definitions
  - Administrative Groups
  - Shared Risk Link Groups

Mod 6, Sec 3: MPLS Fast Reroute (slides 76-85)
- Introduce Fast Reroute (FRR)
- Define FRR operational modes
  - One-to-one (detour paths)
  - Facility (bypass tunnels)
- Define FRR protection types
- Node protection
- Link protection

Overall **SA Course** Objectives
- Demonstrate the significance of Nokia services
- List the different service types available and their components
- Explain the encapsulation of service data with a service label and transport label
- Explain the concept of SAP and SDP and how they are used
- Describe the operation of VPWS services
- Configure, verify and troubleshoot an epipe service
- Recognize the interworking capabilities of the different VPWS
- Explain the operation of Virtual Private LAN Service (VPLS)
- Configure and verify a VPLS
- Use the correct operations, administration and maintenance (OAM) tools to analyze, manage, and troubleshoot IP/MPLS service networks
- Describe mirror service; differentiate between local & distributed mirror service
- Explain the operation of Internet enhanced services (IES)
- Describe the operation of the basic VPRN architecture
- Configure, verify, and troubleshoot an IPv4 VPRN
- [Not covered; skip this section] Configure, verify, and troubleshoot an IPv6 VPRN

Mod 1, Sec 1: Introduction to Services
- Describe the features of a service router
- List the differences between a service router and a traditional router
- Define the concept of a “service”
- Describe the types of services offered by the Nokia 7750 SR

Mod 1, Sec 2: Transport and Service Label Signaling
- Explain how customer data is transmitted across the service provider network (MPLS versus GRE tunnels)
- Explain the encapsulation of customer payload with transport and service labels
- Explain how transport labels and service labels are signaled

Mod 1, Sec 3: Service Components
- Describe the main components required for Nokia services (SAP, service ID, VC-ID, SDP)
- Explain the concept of SAP and encapsulation identifier
- Describe the operation of a local service
- Configure and verify a local service
- Describe the operation of a distributed service
- Define a service distribution point (SDP) and list its characteristics
- Configure and verify a ~~distributed~~ local service

Mod 1, Sec 4: Distributed Service Configuration
- Review of service configuration requirements
- Review of service configuration presented in previous section
- Configuring SDPs, usage of SDPs in spoke (and mesh) mode
- Example of complete configuration, verification, and testing

Mod 2, Sec 1: ePipe
- Describe the different types of Ethernet SAP encapsulation (null, dot1q, qinq) and the concept of VLAN tag
- Differentiate between the supported SAP values (default, null, and so on, among others)
- Explain the use of Ethertype value in identifying tagged frames
- Identify the types of MTUs that must be considered when designing a Layer 2 service (access port MTU/SAP MTU, Service-MTU and VC MTU/ip-MTU, SDP MTU/path-MTU, network port MTU)
- Explain the relationship between the different types of MTUs
- Describe the difference between VC-types for ePipe: tagged mode (VLAN) versus raw mode (Ether)
- Identify the different possible combinations of frame transmission for null, dot1q, and qinq encapsulation SAP with different egress encapsulation
- Configure and verify a distributed ePipe service

Mod 2, Sec 2: Other VPWS (Coverage only to a depth for general awareness)
- Describe the main characteristics of fPipe service
- Describe the main characteristics of aPipe service
- Describe the two modes of operation supported on the Nokia 7750 SR for aPipe (N:1 cell mode, AAL5 (e.g. for IP payloads)
- Describe the main characteristics of cPipe service

Mod 2, Sec 3: VPWS Interworking Capabilities (Mainly for general awareness)
- Identify the 7750 SR interworking capabilities provided with VPWS
- Define iPipe service and explain its main characteristics

Mod 3, Sec 1: Intro to VPLS operation
- Define a VPLS and list its features
- Explain the similarities and differences between ePipe and VPLS
- List the advantages of a VPLS from the perspective of both the customer & service provider
- Explain VPLS flooding behavior
- Identify the difference between mesh SDP and spoke SDP
- Describe the MAC learning process in VPLS

Mod 3, Sec 2: Intro to VPLS operation
- Identify the steps to configure a VPLS
- Configure and verify a VPLS
- Complete Lab 3 — Configuring a VPLS

Mod 3, Sec 3: VPLS Network Topologies
- Explain the operation of a hub and spoke VPLS
- Explain the operation of a hierarchical VPLS
- Explain the operation of a spoke termination on a VPLS
- Configure and verify a spoke SDP termination on a VPLS
- Complete Lab 4 — Spoke Termination to a VPLS

Mod 4, Sec 1: Operations, Administration and Maintenance (OAM)
- Provide an overview of OAM tools
- Utilize the tools available for managing and troubleshooting a service network (lsp-ping, lsp-trace, SDP-ping, SDP-MTU, SVC-ping)
- [Covered throughout previous weekly labs] Complete Lab 5 – OAM tools

Mod 4, Sec 2: Mirroring Service
- Describe mirroring service
- Differentiate between local and distributed mirror service
- Configure and verify the operation of a local and remote mirror service
- [Omitted] Complete Lab 6 – Mirror Service

Mod 5, Sec 1: Internet Enhanced Service (IES) Overview
- Describe customer access to IES
- Explain IES characteristics
- Configure and verify an IES
- Complete Lab 7 — Configuring an IES

Mod 5, Sec 2: Layer 3 Service Spoke Termination to Layer 2 VPN
- Describe the application or use of Layer 3 service spoke termination to a Layer 2 VPN
- Highlight the MTU issues that can arise when configuring a Layer 3 service spoke termination to a Layer 2 VPN service
- Describe the steps for configuring IES spoke termination to VPLS
- Complete Lab 8 – VPLS Spoke Termination on IES

Mod 5, Sec 3: VPRN Overview
- Define VPRN and explain its features
- Describe the key mechanisms and features that make up the VPRN architecture
- Explain the implementation of label stack in VPRN
- Describe the usage of the VPN routing and forwarding (VRF) table in VPRN
- Describe the distribution of VPRN routing information between CE-PE and PE-PE routers
- Describe data packet forwarding across a service provider network from a CE router to a remote CE

Mod 5, Sec 4: VPRN Control Plane Details
- Explain the role of virtual routing and forwarding instances (VRFs) in establishing a VPRN service
- Identify a VPN-IPv4 address family and explain its usage in VPRN
- Define a route distinguisher (RD) and explain its function
- Explain how the VPRN routing information is distributed among PE routers through the use of Multiprotocol BGP extensions
- Define a route target (RT) and explain how it is used to identify the set of VPNs in which a particular VRF participates
- Explain the requirements for distributing VPRN routing information between PE-CE routers
- List transport tunnel creation options and explain how they are used in VPRN
- Demonstrate VPN label signaling using MP-BGP

Mod 5, Sec 5: VPRN Case Study
- Identify the requirements for a successful operation of a VPRN service
- Configure a MP-BGP for the provider network and verify its operation
- Configure VPRN service instances and verify their operations
- Configure a PE-CE routing protocol (BGP) and verify its operation
- Demonstrate an end-to-end route exchange for a given VPRN network.
- Demonstrate an end-to-end data flow for a given VPRN network.
- Verify that the VPRN service is operational using OAM tools (oam vprn ping, oam vprn trace)
- Complete Lab 9 – Configure and verify basic IPv4 VPRN using LDP.

Mod 5, Sec 6: IPv6 VPRN
[Omitted from this course]