# Chapter 20
# GMPLS Overview

Generalized Multiprotocol Label Switching (GMPLS) is the next-generation implementation of Multiprotocol Label Switching (MPLS). GMPLS extends the functionality of MPLS to include a wider range of label-switched path (LSP) options for a variety of network devices.

This chapter includes the following topics:

## GMPLS Standards

The JUNOS software supports the following RFC and Internet drafts related to GMPLS:

RFC 3471, *Generalized Multi-Protocol Label Switching (GMPLS)-Signaling Functional Description*

Describes the supported GMPLS label types: MPLS, Generalized, SONET/SDH, Suggested, and Upstream.

*Generalized Multi-Protocol Label Switching Extensions for SONET and SDH Control*, draft-ietf-ccamp-gmpls-sonet-sdh-08.txt

*Link Management Protocol (LMP)*, draft-ietf-ccamp-lmp-09.txt

*OSPF Extensions in Support of Generalized MPLS*, draft-ietf-ccamp-ospf-gmpls-extensions-09.txt (interface switching only)

The interface switching capability descriptor described in Section 6.4 is implemented.

*Routing Extensions in Support of Generalized MPLS*, draft-ietf-ccamp-gmpls-routing-06.txt

The interface switching capability descriptor described in Section 6.4 is implemented; however, it is currently packet-switch capable only.

## Terms and Acronyms

The following is a list of GMPLS-related terms:

Generalized Multiprotocol Label Switching (GMPLS)—An extension to MPLS that allows data from multiple layers to be switched over LSPs. GMPLS LSP connections are possible between similar Layer 1, Layer 2, and Layer 3 devices.

Forwarding adjacency—A forwarding path for sending data between GMPLS-enabled devices.

GMPLS label—Layer 3 identifiers, fiber port, TDM time slot, or DWDM wavelength of a GMPLS-enabled device used as a next-hop identifier.

GMPLS LSP types—There are four types of GMPLS LSPs:

Fiber-switched capable (FSC)—LSPs are switched between two fiber-based devices, such OXCs that operate at the level of individual fibers.

Lambda-switched capable (LSC)—LSPs are switched between two DWDM devices, such as such as OXCs that operate at the level of individual wavelengths.

TDM-switched capable (TDM)—LSPs are switched between two TDM devices, such as SONET ADMs.

Packet-switched capable (PSC)—LSPs are switched between two packet-based devices, such as routers or ATM switches.

Link Management Protocol—A protocol used to define a forwarding adjacency between peers and to maintain and allocate resources on the TE links.

Traffic Engineering (TE) Link—A logical connection between GMPLS-enabled devices. TE links can have addresses or IDs and are associated with certain resources or interfaces. They also have certain attributes (encoding-type, switching capability, bandwidth, and so on). The logical addresses can be routable, although this is not required because they are acting as link identifiers. Each TE link represents a forwarding adjacency between a pair of devices.

## Overview

Traditional MPLS is designed to carry Layer 3 IP traffic using established IP-based paths and associating these paths with arbitrarily assigned labels. These labels can be configured explicitly by a network administrator, or be dynamically assigned by means of a protocol such as the Label Distribution Protocol (LDP) or the Resource Reservation Protocol (RSVP).

GMPLS generalizes MPLS in that it defines labels for switching varying types of Layer 1, Layer 2, or Layer 3 traffic. GMPLS nodes can have links with one or more of the following switching capabilities:

- Fiber-switched capable (FSC)
- Lambda-switched capable (LSC)
- Time-division multiplexing (TDM) switched-capable (TSC)
- Packet-switched capable (PSC)

Label-switched paths (LSPs) must start and end on links with the same switching capability. For example, routers can establish packet-switched LSPs with other routers. The LSPs might be carried over a TDM-switched LSP between Synchronous Optical Network (SONET) add/drop multiplexers (ADMs), which in turn might be carried over a lambda-switched LSP.

The result of this extension of the MPLS protocol is an expansion in the number of devices that can participate in label-switching. Lower layer devices, such as optical cross-connects (OXCs) and SONET ADMs, can now participate in GMPLS signaling and set up paths to transfer data. A router can participate in signaling optical paths across a transport network.

Two service models determine the visibility that a client node (a router, for example) has into the optical core or transport network. The first is through a user-to-network interface (UNI), which is often referred to as the overlay model. The second is known as the peer model. Juniper Networks supports both models.

GMPLS signaling requires strict paths. Also, you must disable Constrained Shortest Path First (CSPF) with the no-cspf statement.

**NOTE:** There is not necessarily a one-to-one correspondence between a physical interface and a GMPLS interface. If a GMPLS connection uses a non-channelized physical connector, the GMPLS label can use the physical port ID. However, the label for channelized interfaces often is based on a channel or time slot. Consequently, it is best to refer to GMPLS labels as identifiers for a resource on a TE link.

To establish LSPs, GMPLS uses the following mechanisms:

An out-of-band control channel and a data channel—RSVP messages for LSP setup are sent over an out-of-band control network. Once the LSP setup is complete and the path is provisioned, the data channel is up and can be used to carry traffic. The Link Management Protocol (LMP) is used to define and manage the data channels between a pair of nodes.

RSVP-TE extensions for GMPLS—RSVP-TE is already designed to signal the setup of packet LSPs. This has been extended for GMPLS to be able to request path setup for various kinds of LSPs (non-packet) and request labels like wavelengths, time slots, and fibers as label objects.

Bidirectional LSPs—Data can travel both ways between GMPLS devices over a single path, so non-packet LSPs are signaled to be bidirectional.

## GMPLS Operation

The basic functionality of GMPLS requires close interaction between RSVP and LMP. It works in the following sequence:

1. LMP notifies RSVP of the new:

   TE link (forwarding adjacency)

   Resources available for the TE link

   Control peer

2. GMPLS extracts the LSP attributes from the configuration and requests RSVP to signal one or more specific paths, which are specified by the TE link addresses.

3. RSVP determines the local TE link, corresponding control adjacency and active control channel, and transmission parameters (such as IP destination). It requests that LMP allocate a resource from the TE link with the specified attributes. If LMP finds a resource matching the attributes, label allocation succeeds. RSVP sends a PathMsg hop-by-hop until it reaches the target router.

4. When the target router receives the PathMsg, RSVP again requests that LMP allocate a resource based on the signaled parameters. If label allocation succeeds, it sends back a ResvMsg.

5. If the signaling is successful, a bidirectional optical path is provisioned.

## GMPLS and OSPF

You can configure the Open Shortest Path First (OSPF) protocol for GMPLS. OSPF is an interior gateway protocol (IGP) that routes packets within a single autonomous system (AS). OSPF uses link-state information to make routing decisions.

## GMPLS and CSPF

GMPLS introduces extra constraints for computing paths for GMPLS LSPs that use CSPF. These additional constraints affect the following link attributes:

- Signal type (minimum LSP bandwidth)
- Encoding type
- Switching type

These new constraints are populated in the traffic engineering database (TED) with the exchange of an interface switching capability descriptor type length value (TLV) through an IGP.

The ignored constraints that are exchanged through the interface switching capability descriptor include:

- Maximum LSP bandwidth
- Maximum transmission unit (MTU)

The CSPF path computation is the same as in non-GMPLS environments, except that the links are also limited by GMPLS constraints.

Each link can have multiple interface switching capability descriptors. All the descriptors are checked before a link is rejected.

The constraints are checked in the following order:

1. The signal type configured for the GMPLS LSP signifies the amount of bandwidth requested. If the desired bandwidth is less than the minimum LSP bandwidth, the interface switching descriptor is rejected.

2. The encoding type of the link for the ingress and the egress interfaces should match. The encoding type is selected and stored at the ingress node after all the constraints are satisfied by the link and is used to select the link on the egress node.

3. The switching type of the links of the intermediate switches should match that of the GMPLS LSP specified in the configuration.

## GMPLS Features

The JUNOS software includes the following GMPLS functionality:

- Out-of-band control plane for signaling LSP path setup.
- RSVP-TE extensions support additional objects beyond Layer 3 packets, such as ports, time slots, and wavelengths.
- The LMP protocol creates and maintains a database of TE links and peer information. Only the static version of this protocol is supported in the JUNOS software.
- Bidirectional LSPs are required between devices.
- Several GMPLS label types that are defined in RFC 3471, *Generalized MPLS - Signaling Functional Description*, such as MPLS, Generalized, SONET/SDH, Suggested, and Upstream, are supported. Generalized labels do not contain a type field, because the nodes should know from the context of their connection what type of label to expect.
- Traffic parameters facilitate GMPLS bandwidth encoding and SONET/SDH formatting.
- Other supported attributes include Interface Identification and Errored Interface Identification, UNI-style signaling, and secondary LSP paths.