Configure MPLS Routing

This chapter describes how Cisco Crosswork Planning configures MPLS routing. All LSPs other than SR (segment routed) LSPs are routed like RSVP LSPs. For MPLS simulation information specific to these types of LSPs, see Configure RSVP-TE Routing and Configure Segment Routing.

- LSPs are established under normal operation: that is, with failures not taken into account.
- Any LSPs that are affected by the failures are rerouted. Depending on the LSP path settings, reroutes might involve moving to a secondary path, dynamically rerouting the LSPs, or rerouting based on a segment list.
- Demands are routed using the established LSPs using the specified IGP protocols given the specified failure scenarios.
- LSP utilizations are calculated from the demand traffic using the specified traffic level.

This section contains the following topics:

Supported LSP Types

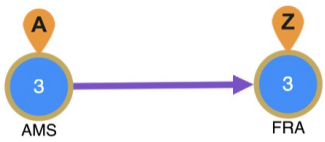
Cisco Crosswork Planning supports the following LSP types:

- SR LSPs—Segment Routing LSPs, which do not use RSVP for routing. You can create SR LSPs using the Cisco Crosswork Planning UI. They are identified with a **Type** property of **SR**. For more information, see Configure Segment Routing.
- RSVP LSPs—LSPs that are established through RSVP. These are commonly known as MPLS TE tunnels. Cisco Crosswork Planning discovers RSVP LSPs, and you can also create them using the Cisco Crosswork Planning UI. They are identified with a **Type** property of **RSVP**. For more information, see Configure RSVP-TE Routing.

Note Cisco Crosswork Planning does not model LDP tunnels as LSPs.

Create and Visualize LSPs

When selected in the **LSPs** table, LSPs appear in the plot as a violet arrow.



Follow these steps to create and visualize LSPs.

Procedure

Step 1 Open the plan file (see Open Plan Files). It opens in the **Network Design** page.

Step 2 From the toolbar, choose **Actions** > **Insert** > **LSPs** > **LSP**

OR

In the Network Summary panel on the right side, click + > **LSPs** in the **LSPs** tab.

The LSPs tab is available under the **More** tab. If it is not visible, then click the **Show/hide tables** icon ( ) and check the **LSPs** check box.

Step 3 Choose the **Type**, which determines whether this is an RSVP LSP or an SR LSP.

Step 4 In the **Name** field, enter the name of the LSP.

Step 5 Select the **Active** or **FRR enabled** check box.

Step 6 Expand the **Source & destination** panel. Choose the appropriate source and destination site and node details.

Step 7 (Optional) Expand the other panels (Routing, CSPF, and Other) and enter the relevant parameters.

Step 8 Click **Save**.

Step 9 To visualize the LSP in the network plot, select the LSP from the LSPs table. LSPs appear in the plot as a violet arrow.

You can also add a mesh of LSPs between the selected nodes using any of the following options:

- From the toolbar, choose **Actions** > **Insert** > **LSPs** > **LSP mesh**
- In the Network Summary panel on the right side, click + > **LSP mesh** in the **LSPs** tab.

What to do next

Filter to related information, such as related interfaces, source and destination nodes, or demands. To do this, select the LSP, click the **Cross table filter** icon ( ), and choose the appropriate option.

LSP Paths

LSPs can be assigned one or more LSP paths. Like LSPs, LSP paths have properties that vary depending on whether the path is for an RSVP LSP or SR LSP. If these properties are omitted, then they are inherited from the LSP. If these properties are set in the LSP path, they override the LSP settings. For information on these properties, see Configure RSVP-TE Routing and Configure Segment Routing.

Path Options and Active Path

Each LSP path has a **Path option** property in the Add/Edit LSP Path window. The LSP is routed using the first LSP path that can successfully be established. LSP paths are established in increasing order of their path option, where path option 1 is established first.

Alternatively, in the **Active path** field under the **Routing** section (Add/Edit LSP page), you can enter which LSP path to use.

Create LSP Paths

To create LSP paths, do the following:

Procedure

Step 1 Open the plan file (see Open Plan Files). It opens in the **Network Design** page.

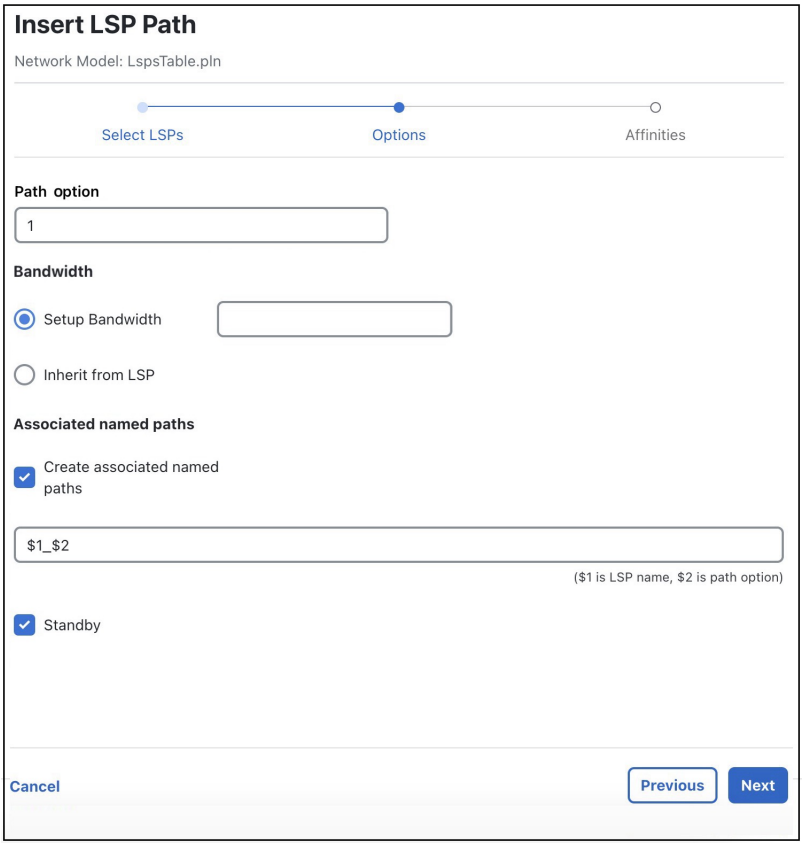
Step 2 In the Network Summary panel on the right side, from the **LSPs** table, choose the LSPs to which you are adding LSP paths.

Step 3 From the toolbar, choose **Actions > Insert > LSPs > LSP Paths**, or click + in the **LSP Paths** table.

The Insert LSP Path window appears.

Step 4 If you are satisfied with the LSPs that you selected in Step 2, click **Next**. Make changes to the selection, if required.

Step 5 In the **Path option** field, enter the order in which the LSP path is activated. Lower numbers have preference over higher numbers.



Step 6 If you are creating an LSP path from SR LSPs, proceed to Step 7. If this is an RSVP LSP path, optionally set these properties. For information on these properties, see Configure RSVP-TE Routing.

a) To set the bandwidth, specify the **Setup Bandwidth** for the LSP path, or specify that it should inherit the bandwidth from the LSP.

b) To create associated named paths, check this option and complete the name using $1 for the LSP name and $2 for the path option.

c) If this is a standby LSP path, check **Standby**, which ensures the paths are always active.

Step 7 Click **Next**.

Step 8 Make the required changes in the **Affinities** page to associate the LSP path with affinities.

a. For each rule (Include, Include any, Exclude), choose whether the LSP path should inherit the LSP affinity rule or whether it should be based on rules defined in the table below these options.

b. If you chose to use the table, choose the rule for each affinity you are associating with the LSP path.

Step 9 Click **Submit**.

Path Latency Calculations

Cisco Crosswork Planning calculates shortest latency paths for LSPs and demands as follows:

- By default, Cisco Crosswork Planning uses the shortest path from the source to the destination of the LSP or demand, where the weight on each interface is the delay value for that interface.
- If the delay for any interface is zero (as it is by default), a small (0.00001 ms) delay is used instead. This means that if all the delays for the interfaces in the plan are zero, the path with the smallest number of hops is selected.
- If two paths have the same latency, paths with the smaller number of hops are preferred.

Route Demands through LSPs

Route Demands through Intra-Area LSPs

Intra-area LSPs are modeled as IGP shortcuts. That is, the source of the demand using the LSP can be a node other than the ingress node into the IGP, and the destination node of the LSP can be a node other than the egress node from the IGP. A demand through intra-area LSPs does not require the LSP to traverse the full demand path.

Each intra-area LSP has a metric that helps determine which traffic is routed through the LSP. By default, autoroute LSPs have a metric equal to the shortest IGP distance from the source to the destination. However, you can configure static metrics for these LSPs that override this default. Static metrics can also be defined as relative to the shortest IGP distance, but these relative metrics are not currently supported in Cisco Crosswork Planning.

Forwarding adjacency LSPs always have a metric. If not specified, the default is 10. Forwarding adjacency LSP metrics are injected into the IGP so that nodes other than the source node of the LSP are aware of the path length through the forwarding adjacency LSP, and use it in their shortest path calculations.

To edit Autoroute and Forwarding adjacency (FA) settings, choose one or more LSPs from the LSP table, click  to open the Edit window, and edit the values in the **Routing** section.

Route Demands through Inter-Area LSPs

Because it is not possible to define metrics distances across ISP areas, there can be no well-defined metric for inter-area LSPs. Therefore, in Cisco Crosswork Planning, a demand only routes through an inter-area LSP if the demand's endpoints are nodes matching the source and destination of the LSP, interfaces on these nodes, or external ASes whose ingress and egress points through the IGP are these nodes. This requirement is true regardless of the network option settings.

To be routed, these demands must also match the privacy requirements. Autoroute, Forwarding adjacency (FA) properties, and LSP metrics are ignored. For information on privacy, see Route Demands through Specific LSPs (Private LSPs), on page 6.

Routing Inter-Area LSPs

In Cisco Crosswork Planning, all nodes in a single AS are assumed to belong to a single IGP. If the plan file contains more than one AS, all IGPs defined in these ASes are of the same type. For information on how nodes are assigned to areas or levels, see Simulate Traffic Flow from Source to Destination Using Demands.

An inter-area LSP is an LSP whose source node and destination node have no areas in common. If available, inter-area LSPs follow actual paths, regardless of whether doing so violates the required order of routing through areas. For example, if following an actual path, an inter-area can enter and leave an OSPF area 0 more than once.

Other factors that determine how the inter-area LSPs are routed include whether the LSP type is RSVP or SR, and whether you have selected to require explicit hops at ABRs. (See Explicit Versus Dynamic Inter-Area LSP Routing, on page 6.)

Note Inter-area Fast Reroute LSPs and inter-area IGP shortcut LSPs are not supported. If the source and destination nodes of a Fast Route LSP are in different areas, the LSP is not routed.

Order of Routing Through Areas

Regardless of the LSP type and whether explicit hops are required, inter-area LSPs route through the backbone areas, as follows, where "backbone" means area 0 for OSPF or the Level 2 area for IS-IS.

- If there are three or more areas, backbone areas must be between the source and destination nodes. Typically, there are no more than three areas and therefore, the backbone area must be in the middle. For example, an OSPF inter-area LSP would route from area 1 to area 0 (backbone) and then to area 2.
- If there are only two areas, there can only be one backbone area, and either the source or the destination node must be in the backbone area.

Explicit Versus Dynamic Inter-Area LSP Routing

An OSPF ABR is a node that belongs to both area 0 and other OSPF areas. An IS-IS ABR is a node that belongs to both the Level 2 area and another IS-IS level.

There are two modes of routing inter-area LSPs. One requires that explicit hops be set on ABR nodes. This mode correctly simulates actual router behavior where ABR explicit hops are required. The other mode does not require explicit hops at ABR nodes and can route an LSP fully dynamically across multiple areas. While this mode does not simulate actual router behavior, it is useful for planning inter-area LSP routes. These modes are specified using the network option labeled **LSP routing requires ABR explicit hops** under the **Label switched paths** section.

If this option is selected, inter-area LSPs are routed based on explicit hops set on the ABR nodes.

- An inter-area RSVP LSP must contain a named path, and the named path must contain explicit hops at ABRs for each required area crossing.
- An inter-area SR LSP must contain a segment list, and the segment list must contain explicit node hops at ABRs for each required area crossing.

If this option is not selected, inter-area LSPs are routed dynamically and explicit hops at ABRs are not required. To leave one area and enter another, the inter-area LSP routes to the closest ABR in the current area that also borders the area it is entering.

Route Demands through Specific LSPs (Private LSPs)

Cisco Crosswork Planning provides two ways to route selected traffic demands through specific LSPs. One way is to dedicate the traffic for specific demands to a private LSP, which is a special LSP that carries those

demands only. This type of LSP models an MPLS Layer 2 VPN, providing an exclusive route for the associated demands. If the LSP goes down, all traffic associated with the LSP is interrupted.

To configure LSPs that simulate Layer 2 VPNs, use one of these two tools.

- One tool creates dedicated demands for existing LSPs. The created demands will match the LSPs in source and destination. For details, see Create Private Demands for Existing LSPs, on page 7.
- One tool creates private LSPs from existing demands. The created LSPs will match the existing demands in source and destination. For details, see Create Private LSPs for Demands, on page 8.

The LSP **Private** column is set to true in the LSPs table, and the **Private LSP Name** and **Private LSP Source** columns in the Demands table are set.

Create Private Demands for Existing LSPs

Before you begin

Ensure that LSPs currently exist in the network model.

To create private demands for existing LSPs, do the following:

Procedure

Step 1 Open the plan file (see Open Plan Files). It opens in the **Network Design** page.

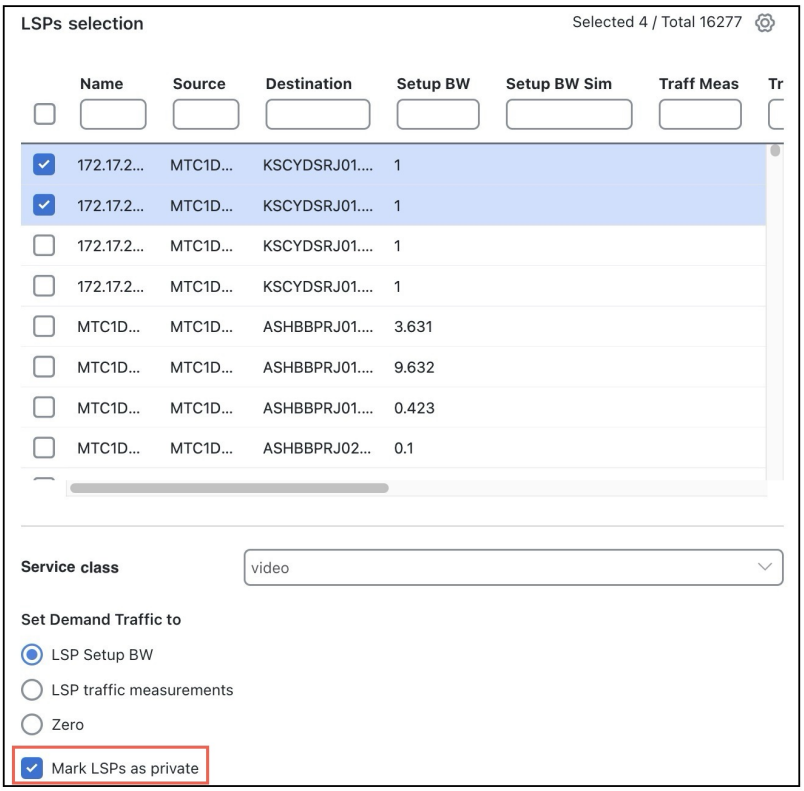
Step 2 From the toolbar, choose **Actions > Insert > LSPs > Demands for LSPs**.

OR

In the Network Summary panel on the right side, click  > **Demands for LSPs** in the **LSPs** tab.

The **LSPs** tab may be available under the **More** tab. If it is not visible, then click the **Show/hide tables** icon () and check the **LSPs** check box.

Figure 1: Create Demand for LSPs Page



Step 3 From the LSPs list, select the LSPs for which you want to create demands.

Step 4 Select the service class to which these LSPs belong.

Step 5 Set the demand traffic to equal the LSP setup bandwidth, the LSP traffic measurements, or zero.

Step 6 Check the **Mark LSPs as private** check box.

Step 7 Click **Submit**. The newly created demands are highlighted in the Demands table.

Create Private LSPs for Demands

Before you begin

Ensure that demands currently exist in the plan file. See Simulate Traffic Flow from Source to Destination Using Demands.

To create private LSPs for demands, do the following:

Procedure

Step 1 Open the plan file (see Open Plan Files). It opens in the **Network Design** page.

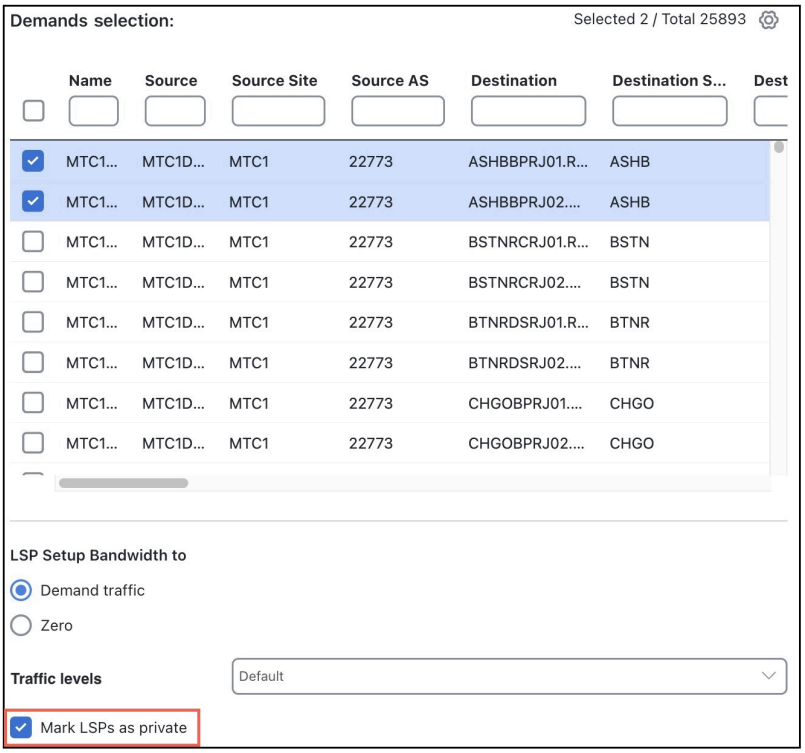
Step 2 From the toolbar, choose **Actions > Insert > LSPs > LSPs for demands**.

OR

In the Network Summary panel on the right side, click + > **LSPs for demands** in the **LSPs** tab.

The **LSPs** tab may be available under the **More** tab. If it is not visible, then click the **Show/hide tables** icon ( ) and check the **LSPs** check box.

Figure 2: Create LSPs for Demands Page



Step 3 In the list of demands, select the demands for which you want to create LSPs.

Step 4 Set the bandwidth traffic to a specific demand traffic or to zero.

Step 5 Check the **Mark LSPs as private** check box.

Step 6 Click **Submit**. The newly created LSPs are highlighted in the LSPs table.

Delete Demands When Deleting Private LSPs

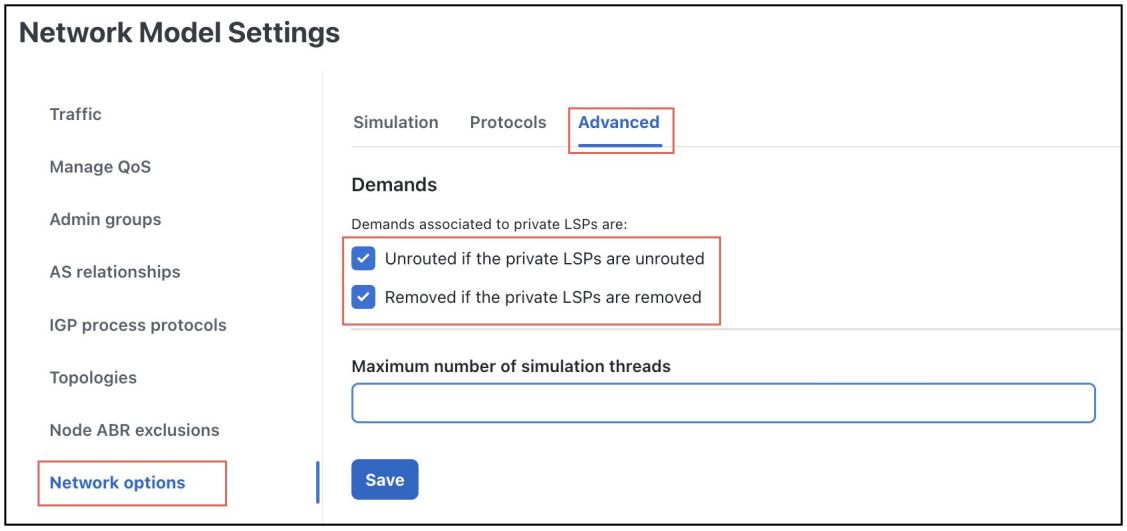
You can choose to delete a demand when deleting a Private LSP. By default, when a private LSP is deleted, the corresponding demand is not deleted.

Procedure

Step 1 Open the plan file (see Open Plan Files). It opens in the **Network Design** page.

Step 2 In toolbar, click **Network options** or choose **Actions > Edit > Network options**. The Network Model Settings page opens.

Step 3 Click the **Advanced** tab.



Step 4 In the **Demands** section, choose:

- Unrouted if the private LSPs are unrouted
- Removed if the private LSPs are removed

Step 5 Click **Save**.

Configure Load Sharing between LSPs

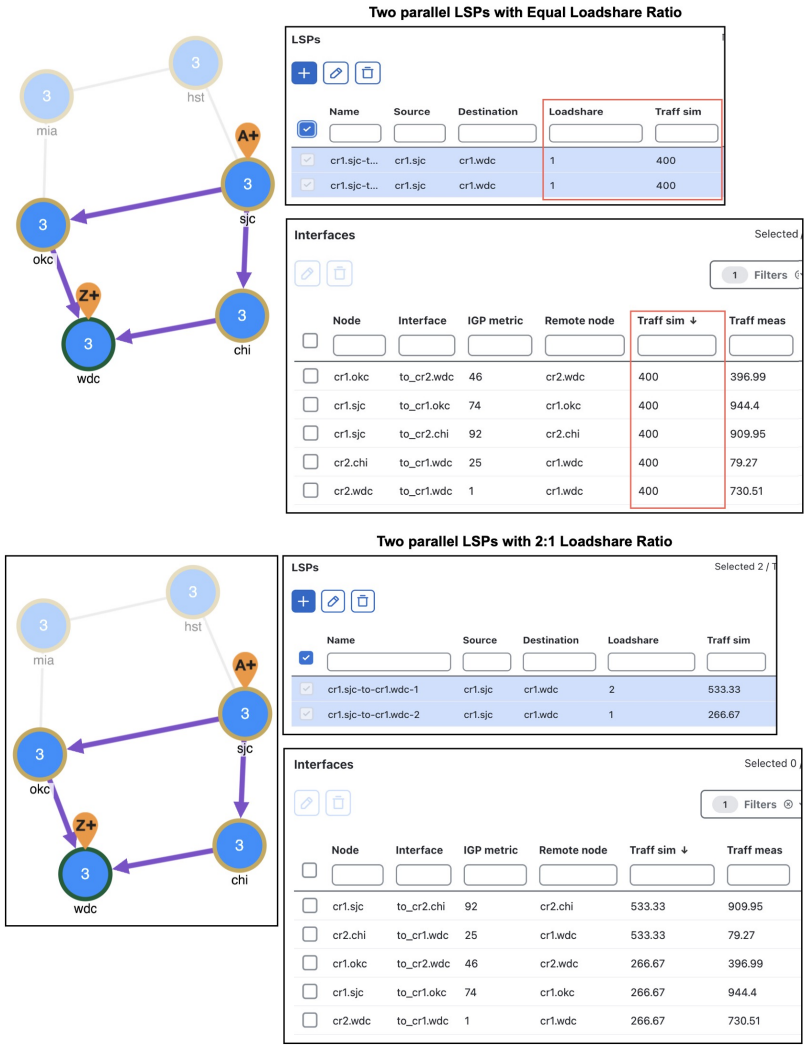
Two or more LSPs with the same source and destination (and metrics, if these are defined) loadshare traffic between them. How the load is shared between the LSPs is determined by the LSP Loadshare property. By default, LSPs have a Loadshare property of 1, and thus route traffic between them in equal proportions. Changing the Loadshare value changes the distribution of LSP traffic and interface traffic in proportion to these values.

Example: If two LSPs are parallel, and one has a Loadshare property of 2 and one has a Loadshare property of 1, there will be a 2-to-1 ratio of traffic shared between them. The top half of Figure 3: Examples of Two Parallel LSPs with Equal Loadsharing and 2:1 Loadsharing, on page 11 shows an example of two parallel LSPs that are routed using strict explicit paths. Each has a Loadshare value of 1, which means the traffic is routed using a 1:1 loadshare ratio so that each LSP carries 50% of the traffic. In contrast, the lower half shows the same parallel LSPs with a 2:1 ratio. That is, one LSP has a Loadshare value of 2, and one has a Loadshare property value of 1. The LSP with a Loadshare value of 2 carries 67% of the traffic, while the other carries 33%.

Note that in Cisco Crosswork Planning 7.0, you cannot visualize the change in the network plot. You can view the differences in the Network Summary tables.

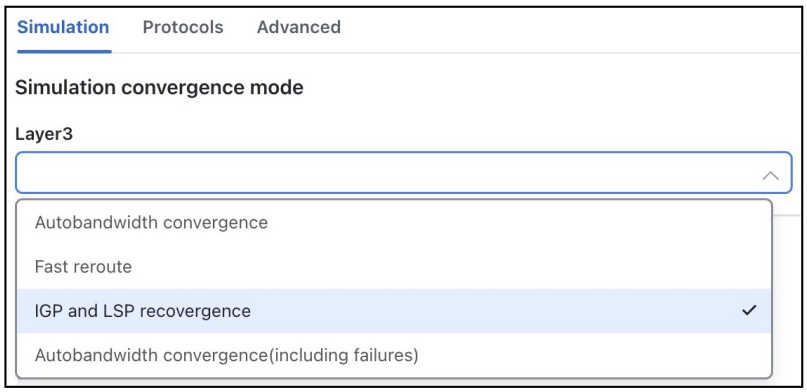
To optimize these Loadshare values, use the LSP Loadshare Optimization tool. For information, see Optimize LSP Loadshare .

Figure 3: Examples of Two Parallel LSPs with Equal Loadsharing and 2:1 Loadsharing



Set Global Simulation Parameters

Cisco Crosswork Planning lets you set global parameters that affect how LSPs are routed or rerouted. To access these options, click **Network options** or choose **Actions** > **Edit** > **Network options** in the toolbar. Then click the **Simulation** tab.



By default, Cisco Crosswork Planning simulates the state of the network once it has fully responded to a failure. Specifically, this is the network state after LSPs have re-established new routes around the failure, and the IGP has fully reconverged. This is called the *IGP and LSP reconvergence* simulation mode.

Other simulation modes include Fast reroute (FRR), Autobandwidth convergence, and Autobandwidth convergence (including failures). For information, see Configure RSVP-TE Routing.

The Optimization tools only work in IGP and LSP reconvergence mode. If you try to run one while in a different convergence mode, you are prompted whether to continue, and if you do, the simulation changes to IGP and LSP reconvergence mode.

Set LSP Establishment Order

Cisco Crosswork Planning establishes LSPs in the order in which they appear in the plan. The routing of a specific LSP might depend on previously established LSP routes. You can modify this order by changing a random seed. Cisco Crosswork Planning then establishes LSPs in a random order that is determined by this number. Although you cannot predict the order based on the number, if you use the same number multiple times, Cisco Crosswork Planning establishes the LSPs in the same order each time. Varying the LSP establishment order lets you check, for example, whether certain orders result in higher utilizations.

Procedure

Step 1 In the toolbar, click **Network options** or choose **Actions > Edit > Network options**. The Network Model Settings page opens.

Step 2 Click the **Simulation** tab.

Step 3 In the **Label switched paths** section, enter a number in the **LSP establishment order seed** field. The default is 0.

Step 4 Click **Save**.

Troubleshoot LSP Simulation

To help troubleshoot RSVP LSP and LSP path simulations, Cisco Crosswork Planning analyzes simulation routes and provides reasons for certain types of routing behavior. The simulation diagnostics tool identifies

why an LSP is not routed, why an LSP is routed away from its actual path, and why an LSP is not following the shortest TE path.

These routing diagnostics assume that all other LSPs, except for the one being tested, have been routed. That is, Cisco Crosswork Planning calculates whether an LSP can route on the actual path after all other routed LSPs have had their bandwidth reserved.

Note that running a report overwrites the previous report of the same type. For example, an LSPs diagnostic report would overwrite the previous LSPs report, but not the LSP path diagnostic report.

Run LSP Simulation Diagnostics

To run LSP simulation diagnostics, do the following:

Procedure

Step 1 Open the plan file (see Open Plan Files). It opens in the **Network Design** page.

Step 2 From the toolbar, choose **Actions > Tools > Diagnostics > LSP simulation** or **LSP path simulation**.

Step 3 Select the LSPs or the LSP paths you want to optimize.

Step 4 Click **Submit**.

A diagnostic report is automatically generated. You can access this report at any time by choosing **Actions > Reports > Generated reports**, and then clicking the **LSP Routing Diagnostics** or **LSP Path Routing Diagnostics** link in the right panel.

What to do next

See Use Simulation Diagnostics to Troubleshoot, on page 13.

Use Simulation Diagnostics to Troubleshoot

The following information is provided to help you troubleshoot LSP and LSP path issues.

Reason	Description
Affinities	The affinity settings prevent the LSP or LSP path from routing.
Available BW	There is insufficient bandwidth to route the LSP or LSP path.
Explicit Hops	The route is determined by a named path that contains one or more explicit hops.
Hop Limit	The hop limit is too low.
Invalid Actual Path	The actual path is invalid and cannot be interpreted as an LSP route.
No Actual Path	The LSP does not have an actual path.
No Attempt	The LSP path is not routed because it is not a standby path and it is not the lowest routable path option for the LSP.

Reason	Description
No Destination	There is no destination defined. The collected network might not contain the destination node of the LSP.
Simulation Option	The simulation option for following actual paths is not enabled.
TE not enabled	There are interfaces that the LSP or LSP path traverses that are not TE enabled.
Topology	The source and destination are disconnected.