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Extensions to OSPF/IS-IS for Optical Routing

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Abstract

Real-time optical path setup is the fundamental requirement for agile optical networks and dynamic routing is a mechanism to propagate optical state information and calculate the available paths. OSPF/IS-IS are defined in [OSPF][ISIS]as an IGP routing protocol and this draft specifies the extensions to OSPF/IS-IS for support optical path routing computation.

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1. Introduction

Recently, there has been an increasing interest in agile optical networks. An agile optical network is an optical network with fast end-to-end optical path setup and restoration. One way to quickly set up an optical path through an agile optical network is to use dynamic routing together with signaling. The routing is used to collect network resource and connectivity information, pass state information around and compute the paths from one node to the other nodes. The signaling is used to setup, maintain and tear down the paths. OSPF is defined in [OSPF] and has been widely deployed throughout the Internet as an Interior Gateway Protocol (IGP). IS-IS is defined in [ISIS] and has been deployed in many large networks as an IGP. OSPF/IS-IS has been extended to allow for the future extensibility [OPA] and add traffic engineering capability [OSPFTE][ISISTE][Metric]. This draft extends the optical Link State Advertisement (LSA) to OSPF/IS-IS for support optical path routing computation. Note: For the purpose of this document, an LSA is synonymous with an IS-IS Link State Protocol Data Unit or (LSP). Since this acronym is easily confused with a Label Switched Path, we will use the term LSA to mean generically both OSPF and IS-IS advertisements. In the OSPF case the optical LSA makes use of type 10 opaque LSA.

The components that make up the Optical path selection are illustrated in Figure 1.

```
+--------+       +--------+       +--------+
|        |<----->|Path    |       |OSPF    |
| CR-LDP |   +-->|Selector|       |        |
|        |   |   |        |       |TE EXT  |
+--------+   |   +---+----+   +---|OPT EXT |
             |       |        |   +--------+
             |       v        |
             |   +--------+   |   +--------+
+--------+   |   |TE      |   |   |IS-IS   |
|        |   |   |Database|   |   |        |
| RSVP   |<--+   |        |   |   |TE EXT  |
|        |       |        |<--+---|OPT EXT |
+--------+       +--------+       +--------+
```

Figure 1 Optical Path Routing Functional Diagram

The optical path routing system is modeled after the Traffic Engineering systems for MPLS Constraint Based Routing. These systems consist of signaling protocols [CR-LDP][RSVP] that signal MPLS paths. These protocols can source route if they first consult a traffic engineering (TE) database using a path selection algorithm. The TE database can be maintained as an extension of one of the IGP protocols. This database contains information that is transported opaquely by the IGP for the purpose of constraint based routing.

This document deals with additional opaque information for the purpose of instantiating optical Lambda paths. A companion draft [Signal] deals with extensions to CR-LDP and RSVP to signal optical Lambda paths.

1.1 Agile Optical Networks

An optical network consists of Optical Label Switching Routers (OLSR) and point-to-point links. The OLSRs are interconnected by links. Although any topologies of interconnection, mesh, sparse mesh, or ring etc. are supported, we refer to the nodes as being meshed.

There are two interfaces in this network: Optical Node-to-Node Interface (ONNI) between two OLSRs and Optical User-Network Interface (OUNI) between customer premise equipment (CPE) and OLSRs. See Figure 2. An agile optical network, all of its OLSRs having a combination of <OSPF/ISIS, CR-LDP/RSVP> control component, is an optical network with fast Optical Label Switched Path (OLSP) setup

and failure recovery. The internal link is a link through an ONNI and an external link is a link cross an OUNI.

```
+--------+       +--------+       +--------+
|        | OUNI  |        | ONNI  |        |
|  CPE   +-------+  OLSR  +-------+  OLSR  |
|        |       |        |       |        |
+--------+       +--------+       +--------+
```

Figure 2 Optical Network Interfaces

1.2 Optical Path Granularity

The granularity of an optical path can be multiple Lambdas, single Lambdas, different levels of sub-Lambda, and groups at all Lambda and sub-Lambda levels.

2. Optical LSA

The optical Link State Advertisement (LSA) advertises the optical resource information. The resource information, especially the number of available Lambdas and their encoding protocols, are used by each node to compute accurate and consistent optical paths. This LSA is aligned with the traffic engineering LSA in [OSPFTE][ISISTE].

2.1 Optical LSA Header

The optical LSA begins with the standard LSA header. The LSA ID is as the following:

```
0               7               15                             31
+---------------+---------------+------------------------------+
|       2       |   Reserved    |         Instance ID          |
+---------------+---------------+------------------------------+
```

Instance ID - A maximum of 65536 Resource LSAs may be issued by a system

2.2 Optical LSA Payload

The optical LSA contains one top-level TLV. There are two top-level TLVs defined: OLSR Address TLV and Link TLV.

OLSR Address TLV

The OLSR address TLV is the same as Router Address TLV defined in

[OSPFTE][ISISTE].

Link TLV

The Link TLV describes a single unidirectional link. The Link TLV is a superset of the Link TLV defined in [OSPFTE][ISISTE] except some sub-TLV additions where noted below. The Link TLV contains the following sub-TLVs and there are no order requirements for the sub-TLVs:

1. Link type (mandatory)
2. Link ID (mandatory)
3. Local interface IP address (mandatory)
4. Remote interface IP address (mandatory)
5. Traffic engineering metric (mandatory)
6. Available Link resource (mandatory)
7. Resource class/Color (mandatory)

The TLVs, Link type, Link ID, Local interface IP address, Remote interface IP address, Traffic engineering metric, Resource class/Color, are defined in the spirit of [OSPFTE][ISISTE][Metric] with the following exceptions.

2.2.1 Link type

Link type identifies the type of link. There are two new link types introduced by this draft.

3.
  Service transparent
A service transparent is a point to point physical optical link.

4.
  Service aware
A service aware link is a point-point logical optical link.

By using this link type, plus the encoding type, we can represent both physical and logical link and their connection type in optical domain.

2.2.2 Link ID

Link ID is an identifier. It identifies the optical link exactly as the point to point case for TE extensions.

2.2.3 Local interface IP address

This interface address may be omitted in which case it defaults to the router address of the local node.

2.2.4 Remote interface IP address

This address may be specified as an IP address on the remote node or as the router address of the remote node.

2.2.5 TE Metric

This is a metric value that can be assigned for path selection. The TE metric in the TE extensions is a single value. Extensions to make this metric multiple values have been suggested to allow for more diverse path selection. [METRIC].

2.2.6 Available Link Resource

Note: This TLV represents the total classified bandwidth to be available over one link. One way to visualize this resource is the pool of available Lambdas and their associated bandwidth between two nodes. Each resource component represents a group of Lambdas with the same line encoding rate, and total current available bandwidth for all these Lambdas. Encoding rate could be extended to include more types.

This TLV specifies all Lambdas that can be used on this link in this direction (from the switch originator the LSA to its neighbour) grouped by the encoding protocol. There is one resource component per encoding type per fiber. If multiple fibers are used per link there will be a resource component per fiber to support fiber bundling.

```
0                              15                              31
+-------------------------------+-------------------------------+
|           Type = 6            |           Length              |
+-------------------------------+-------------------------------+
|                        Resource Component 1                   |
+---------------------------------------------------------------+
|                              ...                              |
+---------------------------------------------------------------+
|                        Resource Component 1                   |
+---------------------------------------------------------------+
```

Length - Specifies the length of value field in bytes.

The encoding for a resource component is:

```
0                             15                              31
+-------------------------------+-------------------------------+
|          Encoding Type        |          No of Lambda         |
+-------------------------------+-------------------------------+
|                           Bandwidth                           |
+---------------------------------------------------------------+
```

Encoding Type	Description
1	reserved
2	Transparent
3	GE
4	10 GE
5	OC-3/STM-1
6	OC-3c
7	OC-12/STM-4
8	OC-12c
9	OC-48/STM-16
10	OC-48c
11	OC-192/STM-64
12	OC-192c
13	OC-768/STM-256
14	OC-768c

Encoding Type   Specifies the encoding protocol,

No. of Lambda   Specifies the number of Lambdas with the same encoding type indicated by encoding type.

Bandwidth   Specifies the total bandwidth of this component in M bits/s.

For the encoding type "Transparent", the bandwidth of each Lambda is assumed to be equal and can be determined by dividing the Bandwidth value by the number of Lambdas in this link.

2.2.7 Resource Class

Resource class is essentially identical to the TE extensions draft. This allows for exclusion/inclusion of a link based on a configured 32 bit value.

3. Significant Change

In addition to normal OSPF/IS-IS operation, OLSRs shall originate optical LSAs when the LSA contents change significantly.

One way to control the protocol overhead introduced by optical LSAs is to trigger optical LSAs only when there is a significant change in the value of metrics since the last advertisement. Significant change allows the flexible trade-off between protocol overhead of frequent updates and the accuracy of the network state information that path selection algorithm depends on. A significant change is defined as when the difference between the current available bandwidth and the last advertised available bandwidth crosses a threshold. It could also be defined as a percentage change in the bandwidth used. When the threshold is crossed due to any set-up (tear down) of a new (existing) path, it will trigger an optical LSA for the affected link. The thresholds are configurable. The frequency of these updates can be decreased dramatically using event driven feedback as proposed in [Feedback].

4. Path Selection

Upon receipt an optical LSA update, the OLSR should update its optical routing database. No route or path calculation is necessary.

The OLSR that receives path set-up request over optical user-network interface computes the complete path from itself to the destination. The path selection will be performed upon receiving a path setup request, since path selection is a constraint-based routing, and the attributes of the optical path are unknown until the path set-up request arrives. The algorithm that will be used for the path selection is normally proprietary and vendor-specific.

5. For Further Study

In an Optical Transport Network, the signaling network may not be isomorphic with the traffic network. This is partly due to the nature of optical services (e.g., SONET paths) in there is limited "in band" control bandwidth which is not mixed with user data (like IP is). In extending OSPF/IS-IS for optical routing, it is probable that additional modifications are needed to accommodate a separate network for routing control traffic (adjacency discovery, database initialization, and topology updates). This is also suggested in [Sigarch] and [OLXC].

Additional modifications to OSPF/ISIS are needed to support functions for computing physical diversity in path setup.

6. Security Considerations

This document raises no new security issues for OSPF or IS-IS.

7. References

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