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GMPLS OSPF Enhancement for Signal and Network Element Compatibility for Wavelength Switched Optical Networks

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Abstract

This document provides Generalized Multiprotocol Label Switching (GMPLS) Open Shortest Path First (OSPF) routing enhancements to support signal compatibility constraints associated with Wavelength-Switched Optical network (WSON) elements. These routing enhancements are applicable in common optical or hybrid electro-optical networks where not all of the optical signals in the network are compatible with all network elements participating in the network.

This compatibility constraint model is applicable to common optical or hybrid electro optical systems such as Optical-Electronic-Optical (OEO) switches, regenerators, and wavelength converters since such systems can be limited to processing only certain types of WSON signals.

Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

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1. Introduction

The documents [RFC6163, WSON-Info, WSON-Encode] explain how to extend the Wavelength Switched Optical Network (WSON) control plane to support both multiple WSON signal types and common hybrid electro optical systems as well hybrid systems containing optical switching and electro-optical resources. In WSON, not all of the optical signals in the network are compatible with all network elements participating in the network. Therefore, signal compatibility is an important constraint in path computation in a WSON.

This document provides GMPLS OSPF routing enhancements to support signal compatibility constraints associated with general WSON network elements. These routing enhancements are applicable in common optical or hybrid electro-optical networks where not all of the optical signals in the network are compatible with all network elements participating in the network.

This compatibility constraint model is applicable to common optical or hybrid electro optical systems such as OEO switches, regenerators, and wavelength converters since such systems can be limited to processing only certain types of WSON signals.

Related to this document is [GEN-OSPF] which provides GMPLS OSPF routing enhancements to support the generic routing and label assignment process that can be applicable to a wider range of technologies beyond WSON.

2. The Optical Node Property TLV

[RFC3630] defines OSPF TE LSA using an opaque LSA. This document adds a new top level TLV for use in the OSPF TE LSA: the Optical Node Property TLV. The Optical Node Property TLV describes a single node. It is comprised of a set of sub-TLVs. There are no ordering requirements for the sub-TLVs. Only one Optical Node Property TLV shall be advertised in each LSA.

The Optical Node Property TLV contains all WSON-specific node properties and signal compatibility constraints. The detailed encodings of these properties are defined in [WSON-Encode].

The following sub-TLVs of the Optical Node Property TLV are defined:

Value	Length	Sub-TLV Type
TBA	variable	Resource Block Information
TBA	variable	Resource Accessibility
TBA	variable	Resource Wavelength Constraints
TBA	variable	Resource Block Pool State
TBA	variable	Resource Block Shared Access Wavelength Availability

The detailed encodings of these sub-TLVs are found in [WSON-Encode] as indicated in the table below.

Sub-TLV Type	Section [WSON-Encode]
Resource Block Information	4.1
Resource Accessibility	3.1
Resource Wavelength Constraints	3.2
Resource Block Pool State	3.3
Resource Block Shared Access Wavelength Availability	3.4

All sub-TLVs defined here may occur at most once in any given Optical Node TLV. If more than one copy of a sub-TLV is received, only the first one of the same type is processed and the rest are ignored upon receipt. These restriction need not apply to future sub-TLVs. Unrecognized sub-TLVs are ignored.

Among the sub-TLVs defined above, the Resource Block Pool State sub-TLV and Resource Block Shared Access Wavelength Availability are dynamic in nature while the rest are static. As such, they can be separated out from the rest and be advertised with multiple TE LSAs per OSPF router, as described in [RFC3630] and [RFC5250].

2.1. Resource Accessibility

This sub-TLV describes the structure of the resource pool in relation to the switching device. In particular, it indicates the ability of an ingress port to reach a resource block and of a resource block to reach a particular egress port.

2.2. Resource Wavelength Constraints

Resources, such as wavelength converters, etc., may have a limited input or output wavelength ranges. Additionally, due to the structure of the optical system, not all wavelengths can necessarily reach or leave all the resources. The Resource Wavelength Constraints sub-TLV describes these properties.

2.3. Resource Block Pool State

This sub-TLV describes the usage state of a resource that can be encoded as either a list of integer values or a bit map indicating whether a single resource is available or in use. This information can be relatively dynamic, i.e., can change when a connection is established or torn down.

2.4. Resource Block Shared Access Wavelength Availability

Resources blocks may be accessed via a shared fiber. If this is the case, then wavelength availability on these shared fibers is needed to understand resource availability.

3. Interface Switching Capability Descriptor (ISCD) Format Extensions

The ISCD describes switching capability of an interface [RFC4202]. This document defines a new Switching Capability value for WSON as follows:

Value	Type
151 (TBA by IANA)	WSON-LSC capable (WSON-LSC)

Switching Capability and Encoding values MUST be used as follows:

Switching Capability = WSON-LSC

Encoding Type = Lambda [as defined in RFC3471]

When Switching Capability and Encoding fields are set to values as stated above, the Interface Switching Capability Descriptor MUST be interpreted as in [RFC4203] with the optional inclusion of one or more Switching Capability Specific Information sub-TLVs.

3.1. Switching Capability Specific Information

The technology specific part of the WSON ISCD may include a variable number of sub-TLVs called Bandwidth sub-TLVs. Two types of Bandwidth sub-TLV are defined (TBA by IANA):

- Type 1 - Available Labels

- Type 2 - Shared Backup Labels

The format of the SCSI MUST be as depicted in the following figure:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Type = 1 (Available)   |            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|                 Available Label Sub-TLV                       |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                              ...                              ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type = 2 (Shared backup)  |            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|                 Shared Backup Label Sub-TLV                   |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1: SCSI format

Where the Available Label Sub-TLV and Shared Backup Label sub-TLV are defined in [Gen-Encode].

The label format defined in [RFC6205] MUST be used when advertising interfaces with a WSON-LSC type Switching Capability.

4. WSON Specific Scalability and Timeliness

This document has defined five sub-TLVs specific to WSON. The examples given in [WSON-Encode] show that very large systems, in terms of channel count, ports, or resources, can be very efficiently encoded.

There has been concern expressed that some possible systems may produce LSAs that exceeds the IP Maximum Transmission Unit (MTU). In a typical node configuration, the optical node property TLV will not exceed the IP MTU. In a rare case where the TLV exceed the IP MTU, IP fragmentation/reassembly can be used, which is an acceptable method.

If the size of this LSA is greater than the MTU, then these sub-TLVs can be packed into separate LSAs. From the point of view of path computation, the presence of the Resource Block Information sub-TLV indicates that resources exist in the system and may have signal compatibility or other constraints. The other four sub-TLVs indicate constraints on access to, and availability of those resources.

Hence the "synchronization" procedure from a path computation point of view is quite simple. Until a Resource Block Information sub-TLV is received for a system, path computation cannot make use of the other four sub-TLVs since it does not know the nature of the resources, e.g., are the resources wavelength converters, regenerators, or something else. Once this sub-TLV is received, path computation can proceed with whatever sub-TLVs it may have received (there use is dependent upon the system type).

If path computation proceeds with out of date or missing information from these sub-TLVs, then there is the possibility of either (a) path computation computing a path that does not exist in the network, (b) path computation failing to find a path through the network that actually exists. Both situations are currently encountered with GMPLS, i.e., out of date information on constraints or resource availability.

In case where the new sub-TLVs or their attendant encodings are malformed, the proper action would be to log the problem and ignore

just the sub-TLVs in GMPLS path computations rather than ignoring the entire LSA.

Note that the connection establishment mechanism (signaling or management) is ultimately responsible for the establishment of the connection, and this implies that such mechanisms must insure signal compatibility.

5. Security Considerations

This document does not introduce any further security issues other than those discussed in [RFC3630], [RFC4203].

For general security aspects relevant to Generalized Multiprotocol Label Switching (GMPLS)-controlled networks, please refer to [RFC5920].

6. IANA Considerations

6.1. Optical Node Property TLV

This document introduces a new Top Level Node TLV (Optical Node Property TLV) under the OSPF TE LSA defined in [RFC3630].

New IANA registry will be created for the Optical Node Property TLV to allocate a new TLV Type and its Value for this Top Level Node TLV in the "Top Level Types in TE LSAs" section of the "OSPF Traffic Engineering TLVs" registry located at http://www.iana.org/assignments/ospf-traffic-eng-tlvs/ospf-traffic-eng-tlvs.xhtml. The following TLV is allocated in this specification.

Value	TLV Type	Reference
6 (suggested)	Optical Node Property	[This.I-D]

6.1.1. Optical Node Property Sub-TLV

Additionally, new IANA registry will be created for sub-TLVs of the Optical Node Property TLV to create a new section named "Types of sub-TLVs of Optical Node Property TLV (Value TBA)" in the "OSPF Traffic Engineering TLVs" registry located at http://www.iana.org/assignments/ospf-traffic-eng-tlvs/ospf-traffic-eng-tlvs.xml, and allocate new sub-TLV Types and their Values for these sub-TLVs defined under the Optical Node Property TLV as follows:

Value	Length	Sub-TLV Type	Reference
0		Reserved	
1 (suggested)	variable	Resource Block Information	[This.I-D]
2 (suggested)	variable	Resource Accessibility	[This.I-D]
3 (suggested)	variable	Resource Wavelength Constraints	[This.I-D]
4 (suggested)	variable	Resource Block Pool State	[This.I-D]
5 (suggested)	variable	Resource Block Shared Access Wavelength Availability	[This.I-D]
6-65535		Unassigned	

6.2. WSON-LSC Switching Type TLV

A new IANA registry will be created to make the assignment of a new value for the existing "Switching Types" TLV of the "GMPLS Signaling Parameters" registry located at http://www.iana.org/assignments/gmpls-sig-parameters as follows:

Switching capability	Description	Reference
151 (suggested)	WSON-LSC capable (WSON-LSC)	[This.I-D]

6.2.1. WSON-LSC SCSI Sub-TLVs

Additionally, a new IANA registry will be created for sub-TLVs of the WSON-LSC SCSI sub-TLV to create a new section/sub-registry named "Types for sub-TLVs of WSON-LSC SCSI (Switch Capability-Specific Information)" section under the "OSPF Traffic Engineering TLVs" registry, with the following sub-TLV types:

Value	Sub-TLV	Refenrence
0	Reserved	
1 (suggested)	Available Labels	[This.I-D]
2 (suggested)	Shared Backup Labels	[This.I-D]
3-65535	Unassigned	

Types are to be assigned via Standards Action as defined in [RFC5226].

7. References

7.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

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[G.694.1] ITU-T Recommendation G.694.1, "Spectral grids for WDM applications: DWDM frequency grid", June, 2002.

[RFC4203] Kompella, K., Ed., and Y. Rekhter, Ed., "OSPF Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS)", RFC 4203, October 2005.

[RFC6205] T. Otani, Ed. and D. Li, Ed., "Generalized Labels for Lambda-Switch-Capable (LSC) Label Switching Routers", RFC 6205, March 2011.

[WSON-Encode] G. Bernstein, Y. Lee, D. Li, W. Imajuku, "Routing and Wavelength Assignment Information Encoding for Wavelength Switched Optical Networks", draft-ietf-ccamp-rwa-wson-encode, work in progress.

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[GEN-OSPF] F. Zhang, Y. Lee, J. Han, G, Bernstein and Y. Xu, "OSPF-TE Extensions for General Network Element Constraints", draft-ietf-ccamp-gmpls-general-constraints-ospf-te, work in progress.

7.2. Informative References

[WSON-Info] Y. Lee, G. Bernstein, D. Li, W. Imajuku, "Routing and Wavelength Assignment Information Model for Wavelength Switched Optical Networks", draft-ietf-ccamp-rwa-info, work in progress.

[RFC6163] Y. Lee, G. Bernstein, W. Imajuku, "Framework for GMPLS and PCE Control of Wavelength Switched Optical Networks", RFC 6163, April 2011.

[RFC5250] Berger, L., et al., "The OSPF Opauqe LSA option", RFC 5250, July 2008.

[RFC5226] Narten, T. and H. Alvestrand, "Guidelines for Writing an IANA Considerations Section in RFCs", BCP 26, RFC 5226, May 2008.

[RFC5920] Luyuan Fang(Ed.), "Security Framework for MPLS and GMPLS N Networks", RFC5920, July 2010.

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