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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 GMPLS OSPF routing enhancements to support signal compatibility constraints associated with WSON network elements. These routing enhancements are required 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.

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 RFC-2119 [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 allow 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 required 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.

1.1. Revision History

From 00 to 01: The details of the encodings for compatibility moved from this document to [WSON-Encode].

From 01 to 02: Editorial changes.

From 02 to 03: Add a new Top Level Node TLV, Optical Node Property TLV to carry WSON specific node information.

From 03 to 04: Add a new sub-TLV, Block Shared Access Wavelength Availability TLV to be consistent with [WSON-Encode] and editorial changes.

From 04 to 05: Add a new section that discusses OSPF scalability and timeliness and editorial changes.

From 05 to 06: Change the title of the draft to "GMPLS OSPF Enhancement" from "OSPF Enhancement" to make sure the changes apply to the GMPLS OSPF rather than the base OSPF. Add specific OSPF procedures on how sub-TLVs are packaged per [RFC3630] and editorial changes.

From 06 to 07: Add clarifying texts on how to sub-divide the Optical Node TLV in case it exceeds the IP MTU fragmentation limit. Delete Section 3.2. to avoid multiple rules so as to avoid confusion.

From 07 to 08: Clean some old texts in Section 3. Align with [WSON-Encode] on the modulation and FEC type.

From 08 to 09: Added ISCD extensions for available labels and shared backup labels.

From 09 to 10: Revised for OIC changes consistent with encoding document.

From 10 to 11: Editorial clean-up only.

From 11 to 12: Revived the expired version.

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 constructed of a set of sub-TLVs. There are no ordering requirements for the sub-TLVs. Only one Optical Node 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 Pool Accessibility
TBA	variable	Resource Block Wavelength Constraints
TBA	variable	Resource Pool State
TBA	variable	Block Shared Access Wavelength Availability

The detail 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	5.1
Resource Pool Accessibility	4.1
Resource Block Wavelength Constraints	4.2
Resource Pool State	4.3
Block Shared Access Wavelength Availability	4.4

All sub-TLVs defined here may occur at most once in any given Optical Node TLV. "At most once" means that if there is sub-TLV related information, it should be always included. These restrictions need not apply to future sub-TLVs. Unrecognized sub-TLVs are ignored.

2.1. Sub-TLV Details

Among the sub-TLVs defined above, the Resource Pool State sub-TLV and 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]. Resource Block Information

Resource Block Information sub-TLVs are used to convey relatively static information about individual resource blocks including the resource block properties and the number of resources in a block.

There are five nested sub-TLVs defined in the Resource Block Information sub-TLV.

Value   Length   Sub-TLV Type

TBA	variable	Optical Interface Class List
TBA	variable	Input Client Signal List
TBA	variable	Processing Capability List

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

Name	Section [WSON-Encode]
Optical Interface Class List	5.2
Input Client Signal List	5.3
Processing Capability List	5.4

2.1.1. Resource Pool 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.

2.1.2. Resource Block 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. Resource Block Wavelength Constraints sub-TLV describe these properties.

2.1.3. Resource Pool State

This sub-TLV describes the usage state of a resource that can be encoded as either a list of 16 bit 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.

2.1.4. 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. ISCD format extensions

The Interface Switching Capability Descriptor describes switching capability of an interface [RFC 4202]. 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. Switch 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 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].

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 exceed 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 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 of the additional types of 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.

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].

6. IANA Considerations

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

Value	TLV Type
TBA	Optical Node Property

IANA is to allocate a new TLV Type and its Value for this Top Level Node TLV.

This document also introduces the following sub-TLVs associated with the Optical Node Property TLV as defined in Section 2.1 as follows:

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

IANA is to allocate new sub-TLV Types and their Values for these sub-TLVs defined under the Optical Node Property TLV.

There are three nested sub-TLVs defined in the Resource Block Information sub-TLV as follows:

Value	Length	Sub-TLV Type
TBA	variable	Optical Interface Class List
TBA	variable	Input Client Signal List
TBA	variable	Processing Capability List

IANA is to allocate new Sub-TLV Types and their Values for these Sub-TLVs defined under the Resource Block Information Sub-TLV.

Upon approval of this document, IANA will make the assignment of a new Switching Capability value for the existing ISCD located at http://www.iana.org/assignments/ospf-traffic-eng-tlvs/ospf-traffic-eng-tlvs.xml:

15   Interface Switching Capability Descriptor   [RFC4203]

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

This document defines the following sub-TLVs of the ISCD TLV:

Value	Sub-TLV
1	Available Labels
2	Shared Backup Labels

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.

[RFC3630] Katz, D., Kompella, K., and Yeung, D., "Traffic Engineering (TE) Extensions to OSPF Version 2", RFC 3630, September 2003.

[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.

[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.

[Gen-Encode] G. Bernstein, Y. Lee, D. Li, W. Imajuku, "General Network Element Constraint Encoding for GMPLS Controlled Networks", draft-ietf-ccamp-general-constraint-encode, 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.

[RFC6250] T. Otani, Ed., D. Li, Ed., "Generalized Labels for G.694 Lambda-Switching Capable Label Switching Routers", RFC 6250, March 2011.

[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.

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