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

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## Status of this Memo



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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.

## 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 | 4.1 |
| Resource Pool Accessibility | 3.1 |
| Resource Block Wavelength Constraints | 3.2 |
| Resource Pool State | 3.3 |
| Block Shared Access Wavelength Availability | 3.4 |

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].

#### 2.1.1. 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 seven nested sub-TLVs defined in the Resource Block Information sub-TLV.

Value          Length       Sub-TLV Type

| | | |
|---|---|---|
| TBA | variable | Input Modulation Format List |
| TBA | variable | Input FEC Type List |
| TBA | variable | Input Bit Range List |
| TBA | variable | Input Client Signal List |
| TBA | variable | Processing Capability List |
| TBA | variable | Output Modulation Format List |
| TBA | variable | Output FEC Type List |

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

| Name | Section [WSON-Encode] |
|---|---|
| Input Modulation Format List | 4.2 |
| Input FEC Type List | 4.3 |
| Input Bit Range List | 4.4 |
| Input Client Signal List | 4.5 |
| Processing Capability List | 4.6 |
| Output Modulation Format List | 4.7 |
| Output FEC Type List | 4.8 |

### 2.1.2. 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.

### 2.1.3. 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.

### 2.1.4. 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.

2.1.5. 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. 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. However there has been concern expressed that some possible systems may produce LSAs that exceed the IP Maximum Transmission Unit (MTU) and that methods be given to allow for the splitting of WSON specific LSA into smaller LSA that are under the MTU limit. This section presents a set of techniques that can be used for this purpose.

3.1. Different Sub-TLVs into Multiple LSAs

Five sub-TLVs are defined in this document:

1. Resource Block Information
2. Resource Pool Accessibility
3. Resource Block Wavelength Constraints
4. Resource Pool State
5. Block Shared Access Wavelength Availability

All these are carried in an Optical Node Property TLV (see Section 2 for detail) of which there can be at most one in an LSA. Of these sub-TLVs the first three are relatively static, i.e., only would change with hardware changes or significant system reconfiguration. While the fourth and fifth are dynamic, meaning that they may change with LSP setup or teardown through the system. The most important technique for scalability and OSPF bandwidth reduction is to separate the dynamic information sub-TLVs from the static information sub-TLVs
and advertise them in OSPF TE LSAs, each with the Optical Node Property TLV at the top level ([RFC3630 and RFC5250]).

For LSA overhead reduction it is recommended to group as many of the three static sub-TLVs into the same LSA (within the Optical Node Property TLV). If the size of this LSA is greater than the MTU, then these sub-TLV 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.

### 3.2. Separating a Sub-TLV into Multiple OSPF TE LSAs

In the highly unlikely event that a WSON sub-TLV by itself would result in an LSA exceeding the MTU, all five WSON specific sub-TLVs in this document provide mechanisms that allow them to be subdivided into smaller sub-TLVs that can be sent in separate OSPF TE LSAs.

What is suggested as below is the only option allowed when dividing up the current set of sub-TLVs into separate OSPF TE LSAs. This means each sub-TLV will be packaged as the sole element in an OSPF TE LSA with a unique Link State ID. When such division is implemented, then the source node must flush the existing LSA (i.e., the original OSPF TE LSA with all sub-TLV's packaged together as described in Section 2). This will avoid duplicating the same information being advertised across multiple LSAs.

Sub-Division by Sets

All five sub-TLVs currently make use of one or more RB Set Fields [WSON-Encode] or Link Set Fields [Gen-Encode]. Long set fields can be decomposed into multiple smaller set fields resulting in multiple sub-TLVs that can be sent in multiple OSPF TE LSAs. The interpretation of the separate pieces is quite natural and reviewed in the following:

Resource Block Information
Information about different resources of similar types would get sent separately (LSAs). Path computation would not know a resource exists until it receives the instance of a sub-TLV that mentions that instance.

Resource Pool Accessibility
Information about accessibility to resources to/from ports would be in as separate pieces base on port or resource set separation. All pieces are combined to give complete resource/port accessibility view. Late/missing pieces would imply resources are not accessible to/from given ports.

Resource Block Wavelength Constraints
Information about resource wavelength constraints can be sent in separate pieces based on resource sub-sets. Late/missing pieces (LSAs) would imply resources accessible when they might not be.

Resource Pool State
Information about resource state can be sent in separate pieces based on resource sub-sets. Late/missing pieces (LSAs) could imply incorrect resources availability.

Block Shared Access Wavelength Availability
Information about resource shared access wavelength can be sent in separate pieces based on resource sub-sets. Late/missing pieces (LSAs) could imply incorrect shared wavelength availability.

Due to the reliability mechanisms in OSPF the phenomena of late or missing pieces for relatively static information (first three types of sub-TLVs) would be relatively rare.

## 4. Security Considerations

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

## 5. 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 seven nested sub-TLVs defined in the Resource Block Information sub-TLV as follows:

| Value | Length | Sub-TLV Type |
|---|---|---|
| TBA | variable | Input Modulation Format List |
| TBA | variable | Input FEC Type List |
| TBA | variable | Input Bit Range List |
| TBA | variable | Input Client Signal List |
| TBA | variable | Processing Capability List |
| TBA | variable | Output Modulation Format List |

| | | |
|---|---|---|
| TBA | variable | Output FEC Type List |

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

## 6. References

### 6.1. 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.

### 6.2. 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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