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OSPF Extensions in Support of Routing and Wavelength Assignment (RWA) in Wavelength Switched Optical Networks (WSONs)

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Status of this Memo

Abstract

This document describes OSPF routing protocols extensions to support
Routing and Wavelength Assignment (RWA) in Wavelength Switched
Optical Networks (WSON) under the control of Generalized MPLS (GMPLS).

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

[WSON-Frame] provides a framework for applying GMPLS [RFC3945] and
the Path Computation Element (PCE) architecture [RFC4655] to the
control of WSONs to address the RWA problem. [WSON-Info] describes an
information model that specifies the information needed at various
points in a WSON in order to compute paths and establish Label
Switched Paths (LSPs). Based on the information model of [WSON-Info],
[GEN-Encode] and [RWA-Encode] provide efficient protocol-independent
encodings of the information needed by the RWA process in a WSON.
Such encodings can be used to extend GMPLS signaling and routing
protocols.

This document provides RWA OSPF extensions based on [GEN-Encode]
which provides encodings of the information needed by the routing and
label assignment process in technologies such as WSON but that are

potentially applicable to a wider range of technologies. Additional
RWA OSPF extensions based on [RWA-Encode] which provides encodings of
the information specific to WSON technologies such as signal
compatibility and wavelength resource encodings are addressed in the
other document [WSON-COM-OSPF].

This document defines extensions to the OSPF routing protocol to
enhance the Traffic Engineering (TE) properties of GMPLS TE which are
defined in [RFC3630], [RFC4202], and [RFC4203]. The enhancements to
the Traffic Engineering (TE) properties of GMPLS TE links can be
announced in OSPF TE LSAs. The TE LSA, which is an opaque LSA with
area flooding scope [RFC3630], has only one top-level
Type/Length/Value (TLV) triplet and has one or more nested sub-TLVs
for extensibility. The top-level TLV can take one of three values (1)
Router Address [RFC3630], (2) Link [RFC3630], (3) Node Attribute
[OSPF-Node]. In this document, we enhance the sub-TLVs for the Link
TLV and Node Attribute TLV in support of RWA in WSON under the
control of GMPLS.

The detail encoding of OSPF extensions is not redefined in this
document. [GEN-Encode] provides encoding detail.

No consideration of optical impairment routing related information is
included in this document.

2. Node Information

According to [WSON-Info] and [GEN-Encode], the node information about
WSON nodes includes Node ID, connectivity matrix. Except for the Node
ID which should comply with Routing Address described in [RFC3630],
the other pieces of information are defined in this document.

[OSPF-Node] defines a new top TLV named the Node Attribute TLV which
carries attributes related to a router/node. This Node Attribute TLV
contains one or more sub-TLVs.

Per [GEN-Encode], we have identified the following new Sub-TLVs to
the Node Attribute TLV. Detail description for each newly defined
Sub-TLV is provided in subsequent sections:

Sub-TLV Type	Length	Name
TBD	variable	Connectivity Matrix

In WSON networks, generally the sub-TLVs above is optional, which
depends on the control plane implementations. Usually, Connectivity
Matrix sub-TLV may appear in the LSAs because WSON switches are

asymmetric at present. It is assumed that the switches are symmetric switching, if there is no Connectivity Matrix sub-TLV in the LSAs.

2.1. Connectivity Matrix

It is necessary to identify which ingress ports and wavelengths can be connected to (the same wavelength on) a specific egress port, because the switching devices in a WSON are highly asymmetric.

The Connectivity Matrix is used to identify these restrictions, which can represent either the potential connectivity matrix for asymmetric switches (e.g. ROADMs and such) or fixed connectivity for an asymmetric device such as a multiplexer as defined in [WSON-Info].

The Connectivity Matrix is a sub-TLV (the type is TBD by IANA) of the Node Attribute TLV. The length is the length of value field in octets. The meaning and format of this sub-TLV are defined in Section 5.3 of [GEN-Encode]. One sub-TLV contains one matrix. The Connectivity Matrix sub-TLV may occur more than once to contain multi-matrices within the Node Attribute TLV.

3. Link Information

The most common link sub-TLVs nested to link top-level TLV are already defined in [RFC3630], [RFC4203]. For example, Link ID, Administrative Group, Interface Switching Capability Descriptor (ISCD), Link Protection Type, Shared Risk Link Group Information (SRLG), and Traffic Engineering Metric are among the typical link sub-TLVs.

For WSONs, per [WSON-Info] and [GEN-Encode], we add the following additional link sub-TLVs to the link-TLV in this document.

Sub-TLV Type	Length	Name
TBD	variable	Port Label Restrictions
TBD	variable	Available Labels
TBD	variable	Shared Backup Labels

In WSON networks, generally all the sub-TLVs above are optional, which depends on the control plane implementations. It is default no restrictions on wavelength, so Port Label Restrictions sub-TLV may not appear in the LSAs. In order to be able to compute RWA, Available

Labels sub-TLV may appear in the LSAs. Without available wavelength
information, path computation need guess what lambdas may be
available (high blocking probability or distributed wavelength
assignment may be used). Shared Backup Labels sub-TLV SHOULD not
appear in the LSAs, if there is no wavelength backup functionality in
the WSON networks.

3.1. Port Label Restrictions

Port Label Restrictions describes the wavelength restrictions that
the link and various optical devices such as OXCs, ROADMs, and
waveband multiplexers may impose on a port in WSON. These
restrictions represent what wavelength may or may not be used on a
link and are relatively static. The detailed information about Port
label restrictions is described in [WSON-Info].

The Port Label Restrictions is a sub-TLV (the type is TBD by IANA) of
the Link TLV. The length is the length of value field in octets. The
meaning and format of this sub-TLV are defined in Section 5.4 of
[GEN-Encode]. The Port Label Restrictions sub-TLV may occur more than
once to specify a complex port constraint within the link TLV.

3.2. Available Labels

Available Labels indicates the wavelengths available for use on a
link as described in [GEN-Encode] in WSON. The Available Labels is a
sub-TLV (the type is TBD by IANA) of the Link TLV. The length is the
length of value field in octets. The meaning and format of this sub-
TLV are defined in Section 5.1 of [GEN-Encode]. The Available Labels
sub-TLV may occur at most once within the link TLV.

Note that there are five approaches for Wavelength (Label) Set which
is used to represent the Available Labels described in [GEN-Encode].
Considering that the continuity of the available or unavailable
wavelength set can be scattered for the dynamic wavelength
availability, so it may burden the routing to reorganize the
wavelength set information when the Inclusive (/Exclusive) List
(/Range) approaches are used to represent Available Wavelengths
information. Therefore, it is RECOMMENDED that only the Bitmap Set be
used for representation Available Wavelengths information.

The "Base Label" and "Last Label" in label set defined in [GEN-Encode]
corresponds to base wavelength label and last wavelength label in
WSON, the format of which is described as follows:

```
  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
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |Grid | C.S. |      Reserved    |    n                          |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The detailed information related to wavelength label can be referred
to [Lambda-Labels]

3.3. Shared Backup Labels

Shared Backup Labels indicates the wavelengths available for shared
backup use on a link as described in [GEN-Encode] in WSON.

The Shared Backup Labels is a sub-TLV (the type is TBD by IANA) of
the Link TLV. The length is the length of value field in octets. The
meaning and format of this sub-TLV are defined in Section 5.2 of
[GEN-Encode]. The Shared Backup Labels sub-TLV may occur at most once
within the link TLV.

4. Routing Procedures

All the sub-TLVs are nested to top-level TLV(s) and contained in
Opaque LSAs. The flooding of Opaque LSAs must follow the rules
specified in [RFC2328], [RFC2370], [RFC3630], [RFC4203] and [OSPF-
Node].

In the WSON networks, the node information and link information can
be classified as two kinds: one is relatively static information such
as Node ID, Connectivity Matrix information; the other is dynamic
information such as Available Wavelengths information. [GEN-Encode]
give recommendations of typical usage of previously defined sub-TLVs
which contain relatively static information and dynamic information.
An implementation SHOULD take measures to avoid frequent updates of
relatively static information when the relatively static information
is not changed. A mechanism MAY be applied such that static
information and dynamic information are contained in separate Opaque
LSAs to avoid unnecessary updates of static information when dynamic
information is changed.

Note that as with other TE information, an implementation SHOULD take
measures to avoid rapid and frequent updates of routing information
that could cause the routing network to become swamped. A threshold
mechanism MAY be applied such that updates are only flooded when a
number of changes have been made to the wavelength availability

information within a specific time. Such mechanisms MUST be
configurable if they are implemented.

5. Security Considerations

This document does not introduce any further security issues other
than those discussed in [RFC 3630], [RFC 4203].

6. IANA Considerations

[RFC3630] says that the top level Types in a TE LSA and Types for
sub-TLVs for each top level Types must be assigned by Expert Review,
and must be registered with IANA.

IANA is requested to allocate new Types for the sub-TLVs as defined
in Sections 2.1, 3.1, 3.2 and 3.3 as follows:

6.1. Node Information

This document introduces the following sub-TLVs of Node Attribute TLV
(Value TBD, see [OSPF-Node])

Type   sub-TLV

TBD   Connectivity Matrix

6.2. Link Information

This document introduces the following sub-TLVs of TE Link TLV (Value
2)

Type   sub-TLV

TBD   Port Label Restrictions

TBD   Available Labels

TBD   Shared Backup Labels

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