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Routing Extensions to Support Network Elements with Switching Constraint

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Abstract

This document shares problem statements of the routing of optical Label Switched Paths(LSPs) over network elements with blocking switch architecture in fiber port selectivity. Also, this document provides a direction of solution to take into account the switching constraint within the scope of GMPLS Traffic Engineering (TE) over network elements with blocking switch architecture in fiber port selectivity in addition to wavelength selectivity.

Table of Contents

1. Introduction 2
2. Conventions used in this document 2
3. Problem Statements 3
3.1. Problem Statements 3
3.2. Problem Example 3
3.3. Comments on Necessity of Extension 4
4. Proposal for GMPLS Routing Enhancement 5
4.1. Possible Routing Enhancement 5
4.2. Comments on Other Possible Solutions 5
5. Compatibility and Inter-domain Issues 5
6. Security Considerations. 6
7. IANA Considerations 6
8. References 6
8.1. Normative references 6
8.2. Informative references 6
9. Acknowledgements 7
10. Authors' Addresses 7
Intellectual Property and Copyright Statements 7
Copyright Statement. 8

1. Introduction

The routing protocol extensions so far have been developed for Generalized Multi-Protocol Switching (GMPLS)[OSPF-TE],[GMPLS-ROUTING], [GMPLS-OSPF]. This document explains the necessity of routing extensions required to support GMPLS Traffic Engineering (TE) over network elements with blocking switch architecture in fiber port selectivity in addition to wavelength selectivity.

A reconfigurable optical add/drop multiplexer (ROADM) is a network element that employs the blocking switch architecture widely used in commercialized networks. The ROADM has switching constraints with respect to selecting the fiber port when adding/dropping a lambda path from/to a tributary port. The lambda path added from each tributary port is restricted to either east or west fiber port of the ROADM ring. Similarly, the dropping of a lambda path connected to the tributary port also has a constraint with respect to the selection of the tributary port.

The objective of this document is to share problem statement within this community and to provide a direction of solution to support the routing of Optical Label Switched Paths with blocking switch architecture having the constraint of selecting fiber ports.

2. 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].

3. Problem Statements

3.1. Problem Statements

Many lambda switch capable (LSC) nodes such as ROADM and Optical Cross-Connects (OXC) employ the blocking switch architecture to reduce the cost of the switch fabric or wavelength converters. In particular, the ROADM, which was already commercially deployed, employs a unique switch architecture that has a constraint with respect to the TE link selectivity, while the OXC without wavelength converters has a constraint with respect to wavelength label selectivity.

For the wavelength label selectivity constraint, GMPLS has a specification to control the label allocation mechanism for Label Switch Paths (LSPs) based on the signaling mechanism [RFC3471], [RFC3473]. On the contrary, for the TE link selectivity constraint, there is currently no specification.

To address this issue regarding the TE link selectivity constraint, it is clear that an extension to the GMPLS routing mechanism is essential for all network elements in a domain in order to understand which TE link can be selected to forward LSPs at the network elements that have the constraint.

3.2. Problem Example

Figure shows a typical example using ROADM systems and ROADM ring network architecture to illustrate the TE link selectivity constraint. In this example, we assume that each ROADM switches optical signals (LSPs) transparently and a ROADM system comprises four tributary interfaces, i.e., w1, w2, e1, and e2. Lambda LSPs from TE-Wx can only be dropped to w1 or w2, and lambda LSPs can only be added from e1 and e2, if these LSPs are forwarded to TE-Ex. Similarly, lambda LSPs from TE-Ex can only be dropped from e1 or e2, and lambda LSPs can only be added from w1 and w2 if these LSPs are forwarded to TE-Wx. Thus, the ports for each ROADM are grouped into "west" and "east" ports from the viewpoint of TE link selectivity.

```
      ________________________________________________
     | ROADM     __   __            __   __           |
     |          |Rx| |Rx|          |Tx| |Tx|          |
     |       w1 |__| |__|w2     e1 |__| |__|e2        |
     |          /|\  /|\           \|/  \|/           |
     |         __|____|___       ___|____|__          |
     |   /|->-|           |-->--|           |->-|\    |
     |  | |->-|   Drop    |-->--|    Add    |->-| |   |
--->----| |->-|           |-->--|           |->-| |---->----
     |  | |->-| switches  |-->--| switches  |->-| |   |
     |   \|->-|___________|-->--|___________|->-|/    |
```

```
        TE-Wx |          ___________       ___________         |  TE-Ex
              |    /|-<-|           |--<--|           |-<-|\   |
              |   | |-<-|    Add    |--<--|   Drop    |-<-| |  |
         ----<----| |-<-|           |--<--|           |-<-| |----<---
              |   | |-<-| switches  |--<--| switches  |-<-| |  |
              |    \|-<-|___________|--<--|___________|-<-|/   |
              |          /|\  /|\           \|/  \|/           |
              |           |_   |_            |_   |_           |
              |          |Tx| |Tx|          |Rx| |Rx|          |
              |          |__| |__|          |__| |__|          |
              |           w1   w2            e1   e2           |
              |________________________________________________|
```

In a ring network using ROADM systems, a lambda LSP added from a west tributary port cannot be dropped to a "west" tributary port at another node, and this is also true for the "east" bound case.
For example, a lambda LSP added from tributary port w1 of ROADM #1 cannot be dropped to tributary port w1 or w2 of ROADM #2, #3, or #4.
Similarly, a lambda LSP added from tributary port e1 of ROADM #1 Cannot be dropped to tributary port e1 or e2 of ROADM #2, #3, or #4.

```
                     _________                _________
                    |         | TE #1-E      |         | TE #2-E
          ==========|ROADM  #1|==============|ROADM  #2|==========
        ||  TE #1-W |_________|      TE #2-W |_________|          ||
        ||           | |   | |                | |   | |           ||
        ||Tributary w1 w2 e1 e2    Tributary w1 w2 e1 e2          ||
        ||                                                        ||
        ||                                                        ||
        ||           _________                _________           ||
        ||          |         | TE #4-W      |         | TE #3-W  ||
          ==========|ROADM  #4|==============|ROADM  #3|==========
            TE #4-E |_________|      TE #3-E |_________|
                     | |   | |                | |   | |
          Tributary e1 e2 w1 w2    Tributary e1 e2 w1 w2
```

3.3. Comments on Necessity of Extension

The problem described in the previous section is not so critical if the network comprises a single ROADM ring network. In such a case, the routing of LSPs can be performed based on static routing without using any routing protocols. Assignment of a destination node ID with a loose option in the Explicit Route Object (ERO) of the signaling message and execution of loose hop expansion [RFC3209] in each ROADM may result in successfully establishing an LSP.

Employing an inter-domain routing architecture can also be a solution [per-domain-calc]. By separating ROADM rings from a GMPLS routing domain, the nodes outside the ROADM domain assign a ROADM node ID or boundary node adjacent to the ROADM domain with a loose ERO to forward the Lambda LSP. Then, each ROADM node performs loose hop expansion to forward the lambda LSP toward the destination.

The case that essentially requires an extension of the GMPLS routing mechanism is the case in which the ROADM and other Lambda or Fiber Switch capable nodes co-exist in the same routing domain. Packet and TDM switch capable nodes attached to such a domain must also consider the TE link selectivity constraint at the ROADM nodes when creating a Lambda LSP.

4. Proposal for GMPLS Routing Enhancement

4.1. Possible Routing Enhancement

This section proposes advertising the TE link selectivity constraint as a solution. The extended sub-TLVs indicate the list of selectable and/or unselectable TE links from the TE link indicated in sub-TLV Type 2 (Link ID).

The possible extensions to sub-TLV are described below.

Sub-TLV Type	Length	Name
TBD	variable	Selectable numbered TE link list
TBD	variable	Unselectable numberd TE link list
TBD	variable	Selectable unnumberd TE link list
TBD	variable	Unselectable unnumberd TE link list

4.2. Comments on Other Possible Solutions

Employing a virtual TE link model as discussed in L1-VPN WG is also a possible solution [l1-vpn-frwk]. An optical network domain that has a switching constraint can be modeled as an abstract mesh network. Note that this routing architecture requires a hierarchical routing mechanism in each border node of the optical network domain.

5. Inter-domain and Compatibility Issues

Note that it is essential to share switching constraint information pertaining to each node in order for the border nodes to advertise abstract information to other network domains.

Also, note that it is essential to share switching constraint information pertaining to each node with the Path Computation Element (PCE), if the PCE based inter-domain routing architecture is employed.

There should be no interoperability issues with routers that do not implement these extensions, as the Opaque LSAs will be silently ignored.

6. Security considerations

TBD

7. IANA considerations

TBD

8. References

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