Network Working Group   YF. Ji
Internet-Draft   WW. Bian
Intended status: Informational   HX. Wang
Expires: April 21, 2012   SG. Huang
                                                             BUPT
                                                        GY. Zhang
                                                             CATR
                                                October 19, 2011

   **Performance Measurement Metrics of Label Switched Path (LSP)
      Establishment in Multi-Layer and Multi-Domain Networks
                    draft-jiyf-ccamp-lsp-02**

Abstract

   As the increment of network scale, optical networks need to be
   partitioned into multi-layer and multi-domain networks for the
   purpose of better management. Meanwhile, as the variety of user
   requests, different LSPs need to be established. In order to meet
   different requirements of users, the LSP establishment performance is
   necessary to be measured in multi-layer and multi-domain networks.
   For this reason, typical performance measurement metrics need to be
   proposed. In this document, the LSP establishment delay and bit
   error ratio (BER), which are both as the performance measurement
   metrics, are illustrated, and the definition and methodologies are
   proposed.

Status of this Memo

Copyright Notice

Table of Contents

1. Introduction

   As the increment of network scale and the variety of user request,
   optical networks need to be partitioned into multi-layer and multi-
   domain networks for the purpose of better management and different
   LSPs need to be established in order to meet different requirements
   of users. To measure whether a LSP establishment meets a user
   requirement or not in multi-layer and multi-domain networks, some
   objective performance measurement metrics and methodologies are
   proposed, which are the delay and the BER in this document. In
   previous IETF documents, RFC 5814 provided a series of performance
   metrics to evaluate the dynamic LSP provisioning performance in GMPLS
   networks, specifically the dynamic unidirectional and bidirectional
   LSP setup/release delay, while in this document, the measurement of
   LSP setup delay is extended into multi-layer and multi-domain
   networks and the path computation delay and the LSP setup BER are
   supplemented as the performance measurement metrics in the LSP
   establishment process.

   This document defines the performance measurement metrics and
   methodologies that can be used to measure the LSP establishment
   quality in multi-layer and multi-domain networks.

1.1. Requirements Language

   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].

1.2. Terminology

   BER: Bit Error Ratio.

   BRPC: Backward-Recursive PCE-Based Computation.

   GMPLS: Generalized Multiprotocol Label Switching.

   LID: Local Information Database.

   LSP: Label Switched Path.

   PCE: Path Computation Element.

   VSPT: Virtual Shortest Path Tree.

2. **Overview of the Performance Measurement Metrics of LSP Establishment**

2.1. **Overview of the LSP Establishment Delay**

   In the LSP establishment process, delay is considered as one of the
   main performance measurement metrics. In this document, the LSP
   establishment delay is divided into two parts, which are the path
   computation delay and the LSP setup delay.

   In multi-layer and multi-domain networks, owing to the complexity of
   path computation, the PCE-based path computation scheme is
   considered. Furthermore, as the optimal inter-domain LSP can not be
   obtained from a per-domain way, so the BRPC method is considered to
   accomplish the inter-domain path computation in this document. The
   path computation delay is approximately defined from the time that
   source node sends the path computation request to the time that
   source node receives the optimal path computation result.

   In multi-layer and multi-domain networks, the end-to-end LSP setup is
   considered in this document. In GMPLS networks, multiple LSPs that
   have different granularities are set up. Therefore, two typical LSP
   setup methods are employed: LSP nesting and LSP stitching. The LSP
   setup delay is approximately defined from the time that source node
   sends the LSP setup message to the time that source node receives the
   confirmation message of switch reversing function of all nodes.

2.2. **Overview of the LSP Establishment BER**

   There is a possibility that the physical link is not established
   successfully after signaling accomplishes the LSP setup owing to the
   optical signal quality degradation, so in order to measure the LSP
   establishment performance more completely, the physical impairment
   parameter is also considered in this document. BER is the epitome of
   all of physical impairment parameters, so BER is considered as one of
   the main performance measurement metrics in the LSP establishment
   process.

   In the measurement process of the LSP establishment BER, BRPC method
   is used for the path computation and end-to-end way is used for the
   LSP setup, and BER is evaluated in the LSP setup process. The
   approximate procedure is as follows: the signaling collects some
   physical parameter information from source node to destination node
   in the first place, and then the destination node evaluates the LSP
   establishment performance. If the computed BER meets the requirement
   of a user and is lower than specific threshold, then destination node
   returns Resv message to set up the LSP, otherwise, LSP setup fails.

3. Motivation

   The LSP establishment delay in multi-layer and multi-domain networks
   is useful for several reasons:

   o Average LSP establishment delay is an important performance
      measurement metric that MAY reflect the scalability of a multi-
      layer and multi-domain network to a certain extent. Longer LSP
      establishment delay with the increasing numbers of domains and
      nodes or traffic loads will most likely show that the network
      scalability is not good, especially when the delay curve of LSP
      establishment surpass linear change with the increasing numbers of
      domains and nodes or traffic loads.

   o The LSP establishment delay is an important performance
      measurement metric that MAY reflect the LSP establishment quality
      in multi-layer and multi-domain networks. Longer LSP
      establishment delay will most likely show that the LSP
      establishment quality is not good.

   o The values of LSP establishment delay in the samples MAY serve as
      an early indicator to provide references on whether to accept a
      service request that has the stringent requirement of LSP
      establishment delay or not.

   The LSP establishment BER in multi-domain networks is useful for
   several reasons:

   o The LSP establishment BER can decide whether the physical path is
      established successfully or not. If the values of LSP
      establishment BER are higher than specific threshold, then the
      physical path establishment still fails even though the LSP
      establishment succeeds.

   o The LSP establishment BER is an important performance measurement
      metric that MAY reflect the LSP establishment quality in multi-
      domain networks. Higher LSP establishment BER will most likely
      show that the LSP establishment quality is not good.

   o The values of LSP establishment BER in the samples MAY serve as an
      early indicator to provide references on whether to accept a
      service request that has the stringent requirement of LSP
      establishment BER or not.

[4](#). **The LSP Establishment Delay in Multi-Layer and Multi-Domain Networks**

   This section integrally defines a performance measurement metric
   named the LSP establishment delay in multi-layer and multi-domain
   networks.

[4.1](#). **Measurement Metric Parameters**

   o ID0, the source node ID.

   o ID1, the destination node ID.

   o T0, a time when the path computation is attempted.

   o T1, a time when the LSP setup is attempted.

[4.2](#). **Definition**

[4.2.1](#). **A Definition in Single Layer and Multi-Domain Networks**

   In single layer and multi-domain networks, the LSP establishment
   delay is collected from two parts: the path computation delay and the
   LSP setup delay.

   The detailed path computation process from source node ID0 to
   destination node ID1 is as follows: ID0 sends a Req message of path
   computation to the PCE which is responsible for the path computation
   of source domain. This request is forwarded between PCEs, domain-by-
   domain, until to the PCE which is responsible for the path
   computation of destination domain. The PCE in the destination domain
   computes a set of optimal paths from all of the domain ingress nodes
   to the destination node. This set is represented as a tree of
   potential paths called the VSPT, and the PCE in the destination
   domain passes it back to the previous PCE in a Rep message. Each PCE
   in turn adds the computed set of optimal paths to the VSPT and passes
   it back until the PCE in the source domain uses the VSPT to select an
   optimal end-to-end path from the tree, and returns the path to the
   source node. The above BRPC procedure makes an assumption that the
   sequence of domains is known in advance. The path computation delay
   from source node ID0 to destination node ID1 is dT means that ID0
   sends the Req message of path computation to the PCE which is
   responsible for the source domain at time T0, and that ID0 receives
   the path computation results from the PCE which is responsible for
   the source domain at time T0+dT.

   The detailed LSP setup process from source node ID0 to destination
   node ID1 is as follows: ID0 sends the LSP setup message, which
   includes two steps: establishing the service layer and sending the

Path message, that is, ID0 firstly establishes a service layer
through using signaling function, then ID0 sends Path message to
determine an available wavelength until this Path message arrives at
ID1. If the available wavelength exists, then ID1 returns Resv
message to ID0 to reserve available resources and the switch
reversing function of corresponding nodes is also carried out
simultaneously, otherwise, PathErr message is returned to ID0. When
a service layer exists, if any node which Path message traverses
detects the unavailable service layer, then PathErr message is also
returned to ID0. The LSP setup delay from source node ID0 to
destination node ID1 is dT means that ID0 sends the LSP setup message
at time T1, and that ID0 receives the LSP confirmation message of
switch reversing function of all nodes at time T1+dT.

The value of LSP establishment delay in single layer and multi-domain
networks is a real number of milliseconds.

There is another case in which source node ID0 does not receive the
optimal path computation result or the LSP confirmation message of
switch reversing function of all nodes within a reasonable period of
time, then the value of LSP establishment delay in this case is
marked undefined.

4.2.2. A Definition in Multi-Layer and Multi-Domain Networks

In multi-layer and multi-domain networks, LSP can be established
using the LSP nesting and stitching methods. In this process, the
LSP establishment delay is collected from two parts: the path
computation delay and the LSP setup delay.

The detailed path computation process from source node ID0 to
destination node ID1 is as follows: ID0 sends a Req message of path
computation to the PCE which is responsible for the source domain.
This request is forwarded between PCEs, domain-by-domain, until to
the PCE which is responsible for the destination domain. The PCE in
the destination domain computes a set of optimal paths from all of
the domain ingress nodes to the destination node. This set is
represented as a tree of potential paths called the VSPT, and the PCE
in the destination domain passes it back to the previous PCE in a Rep
message. Each PCE in turn adds the computed set of optimal paths to
the VSPT and passes it back until the PCE in the source domain uses
the VSPT to select an optimal end-to-end path from the tree, and
returns the optimal path to ID0. The above BRPC procedure makes an
assumption that the sequence of domains is known in advance. The
path computation delay from source node ID0 to destination node ID1
is dT means that ID0 sends the Req message of path computation to the
PCE which is responsible for the source domain at time T0, and that
ID0 receives the path computation results from the PCE which is

responsible for the source domain at time T0+dT.

The detailed LSP setup process from source node ID0 to destination
node ID1 is as follows: ID0 sends the LSP setup message, which
includes two steps: determining if the service layer exists and
sending the Path message, that is, ID0 firstly determines if service
layers exist. If service layers exist, ID0 sends Path message to the
next node to collects available wavelength resources, and the next
node carries out the same function like ID0 until Path message
arrives at ID1, which selects any available wavelength. If any
available wavelength exists, ID1 returns Resv message to the ID0 in
order to accomplish the process of resource reservation, and
meanwhile, the switch reversing function of corresponding nodes are
also carried out, otherwise, PathErr message is returned to the ID0.
If the capacity of existing service layer is not fully occupied, then
the fine granularity service that capacity is no more than remaining
capacity of existing service layer can still be accepted in this
service layer. If service layers do not exist, ID0 firstly
establishes a service layer through using signaling function, then
ID0 sends Path message to determine an available wavelength until
this Path message arrives at destination node. If the available
wavelength exists, then ID1 sends Resv message to ID0 to reserve
available resources and the switch reversing function of
corresponding nodes are also carried out simultaneously, otherwise,
PathErr message is returned to ID0. When a service layer exists, if
any node which Path message traverses detects the unavailable service
layer, then PathErr message is also returned to ID0. If the capacity
of new established service layer is not fully occupied, then the fine
granularity service that capacity is no more than remaining capacity
of new established service layer can still be accepted in this
service layer. The complete LSP nesting and stitching processes can
be obtained from RFC 4206 and RFC 5150, respectively. The LSP setup
delay from source node ID0 to destination node ID1 is dT means that
ID0 sends the LSP setup message at time T1, and that ID0 receives the
LSP confirmation message of switch reversing function of all nodes at
time T1+dT.

The value of LSP establishment delay in multi-layer and multi-domain
networks is a real number of milliseconds.

There is another case in which source node ID0 does not receive the
optimal path computation result or the LSP confirmation message of
switch reversing function of all nodes within a reasonable period of
time, then the value of LSP establishment delay in this case is
marked undefined.

4.2.3. A Definition in Other Networks

   There are still two forms of other networks: single layer and single
   domain networks and multi-layer and single domain networks. The
   definition in single layer and single domain networks is similar to
   the definition in single layer and multi-domain networks, and the
   difference is that the inter-domain LSP establishment process in
   single layer and single domain networks is not considered.
   Correspondingly, the definition in multi-layer and single domain
   networks is similar to the definition in multi-layer and multi-domain
   networks, and the difference is that the inter-domain LSP
   establishment process in multi-layer and single domain networks is
   not considered.

   The value of LSP establishment delay in single layer and single
   domain networks and multi-layer and single domain networks is a real
   number of milliseconds.

   There is another case in which ID0 does not receive the optimal path
   computation result or the LSP confirmation message of switch
   reversing function of all nodes within a reasonable period of time,
   then the value of LSP establishment delay in this case is marked
   undefined.

4.3. Discussion

   The reason that the LSP establishment delay is set to undefined not
   only lies in that source node ID0 never receives the corresponding
   reply message within a reasonable period of time, but also consists
   in that source node ID0 receives the PathErr message. There are many
   possible reasons for receiving the PathErr message, for example, the
   network does not have enough resources to establish the service layer
   for the user requests or the network element failure occurs.

5. The LSP Establishment BER in Multi-Domain Networks

   This section integrally defines a performance measurement metric
   named the LSP establishment BER in multi-domain networks.

5.1. General Assumptions

   o ID0, the source node ID.

   o ID1, the destination node ID.

   o Every node has a LID which stores the node physical information.

   o Destination node has a performance evaluation module which can
      evaluate the LSP establishment BER through combining corresponding
      physical parameter information.

5.2. Definition

   In the measurement process of the LSP establishment BER, whether the
   network is single domain or multi-domain, the evaluation method is
   the same, meanwhile, only the wavelength lightpath has physical
   parameters, so the single layer and multi-domain network is
   considered.

   In multi-domain networks, the physical parameters are collected and
   measured in the LSP setup process, so only the LSP setup process is
   considered in this section.

   The detailed LSP setup process from source node ID0 to destination
   node ID1 is as follows: ID0 firstly establishes a service layer
   through using signaling function, then ID0 sends Path message to
   determine an available wavelength until Path message arrives at ID1.
   Meanwhile, signaling message collects physical information of nodes
   and links. If the available wavelength exists and the computed BER
   by ID1 is within the tolerable range, then ID1 sends Resv message to
   ID0 to reserve available resources and the switch reversing function
   of corresponding nodes are also carried out simultaneously,
   otherwise, PathErr message is returned to ID0 and LSP setup fails.
   When the service layer exists, if any node which Path message
   traverses detects the unavailable service layer, then PathErr message
   is also returned to ID0 and LSP setup fails.

6. Methodologies

6.1. Definition

   o T0, a time when the path computation is attempted.

   o T1, a time when the LSP setup is attempted.

   o T2, a time when the optimal path computation result is returned.

   o T3, a time when the LSP confirm message of successful reservation
      is returned.

6.2. Methodologies

6.2.1. The LSP Establishment Delay

   o Make sure that the PCE has enough computation ability to compute
      the path that conforms to user request.

   o Make sure that the network has enough resources to establish the
      requested path.

   o At the source node, the Req message of path computation is formed.
      A timestamp (T0) may be stored locally on the source node when the
      Req message of path computation is sent towards the PCE which is
      responsible for the source domain, and a timestamp (T1) may be
      stored locally on the source node when the LSP setup message is
      sent.

   o If the corresponding end-to-end path computation results and the
      Resv message arrive at source node within a reasonable period of
      time, taking the timestamp (T2) and timestamp (T3) upon receipt of
      the messages. By subtracting the two timestamps, the estimation
      value of the delay of path computation (T2-T0) and the delay of
      LSP setup (T3-T1) can be computed.

   o If the corresponding end-to-end path computation results and the
      Resv message fail to arrive at source node within a reasonable
      period of time, the path computation delay and the LSP setup delay
      are considered to be undefined.

   o If the corresponding response is the PathErr message, then the
      path computation delay and the LSP setup delay are considered to
      be undefined.

6.2.2. The LSP Establishment BER

   o Make sure that the PCE has enough computation ability to compute
      the path that conforms to user request.

   o Make sure that the network has enough resources to establish the
      requested path.

   o In the path computation process, BRPC is used as the computation
      method.

   o In the LSP setup process, when Path message arrives at the
      destination node, the destination node computes the BER through
      combining the corresponding physical parameter information which
      is collected from the traversing nodes and links. If the computed

BER is within the tolerable range, then Resv message is returned
to the source node.

o If the computed BER is outside the tolerable range, then the
PathErr message is returned to the source node and the LSP
establishment fails.

7. Protocol Extension Requirements

o In the measurement process of the LSP establishment delay, the
start time of LSP establishment and the stop time need to be
determined using corresponding protocol. In the path computation
process, a new object that includes time stamp needs to be added
in routing protocol in order to record the start time of path
computation and the stop time of path computation; In the process
of LSP setup, a new object that includes time stamp needs to be
added in signaling protocol in order to record the start time of
LSP setup and the stop time of LSP setup.

o In the measurement process of the LSP establishment BER, the
physical information of nodes and links needs to be collected
using signaling protocol, and BER is evaluated in the destination
node through combining corresponding physical parameter
information, so a new object that includes network physical
parameters needs to be added in signaling protocol in order to
collect the physical information of nodes and links.

8. Security Considerations

This document involves some information collection about network
physical parameters. Such information would need to be protected
from intentional or unintentional disclosure.

9. Acknowledgments

We wish to thank Yongli Zhao, Linna Xia, Haoyuan Lin, Hongrui Han for
their comments and help.

The RFC text was produced using Marshall Rose's xml2rfc tool.

10. References

10.1. Normative References

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

    [RFC3473]   Berger, L., "Generalized Multi-Protocol Label Switching
                (GMPLS) Signaling Resource ReserVation Protocol-Traffic
                Engineering (RSVP-TE) Extensions", RFC 3473, January 2003.

    [RFC3945]   Eric, M., "Generalized Multi-Protocol Label Switching
                (GMPLS) Architecture", RFC 3945, October 2004.

    [RFC4206]   Kompella, K. and Y. Rekhter, "Label Switched Path (LSP)
                Hierarchy with Generalized Multi-Protocol Label Switching
                (GMPLS) Traffic Engineering (TE)", RFC 4206, October 2005.

    [RFC4655]   Farrel, A., Vasseur, J., and J. Ash, "A Path Computation
                Element (PCE)-Based Architecture", RFC 4655, August 2006.

    [RFC5150]   Ayyangar, A., Kompella, K., Vasseur, JP., and A. Farrel,
                "Label Switched Path Stitching with Generalized
                Multiprotocol Label Switching Traffic Engineering (GMPLS
                TE)", RFC 5150, February 2008.

    [RFC5440]   Vasseur, J. and JL. Le Roux, "Path Computation Element
                (PCE) Communication Protocol (PCEP)", RFC 5440,
                March 2009.

    [RFC5441]   Vasseur, J., Zhang, R., Bitar, N., and JL. Le Roux, "A
                Backward-Recursive PCE-Based Computation (BRPC) Procedure
                to Compute Shortest Constrained Inter-Domain Traffic
                Engineering Label Switched Paths", RFC 5441, April 2009.

    [RFC5814]   Sun, W. and G. Zhang, "Label Switched Path (LSP) Dynamic
                Provisioning Performance Metrics in Generalized MPLS
                Networks", RFC 5814, March 2010.

10.2. Informative References

    [I-D.ietf-ccamp-wson-impairments]
                Lee, Y., Bernstein, G., Li, D., and G. Martinelli, "The
                Application of the Path Computation Element Architecture
                to the Determination of a Sequence of Domains in MPLS &
                GMPLS", July 2010.

    [Interdomain-LSP]
                Aslam, F., Uzmi, ZA., and A. Farrel, "Interdomain Path
                Computation: Challenges and Solutions for Label Switched

                Networks", IEEE Communications Magazine, October 2007.

   [RFC5212]   Shiomoto, K., Papadimitriou, D., Le Roux, JL., Vigoureu,
               M., and D. Brungard, "Requirements for GMPLS-Based Multi-
               Region and Multi-Layer Networks (MRN/MLN)", RFC 5212,
               July 2008.

Appendix A. Other Authors

   1. Min Zhang

   BUPT

   No.10,Xitucheng Road,Haidian District

   Beijing 100876

   P.R.China

   Phone: +8613910621756

   Email: mzhang@bupt.edu.cn

   URI: http://www.bupt.edu.cn/

   2. Yunbin Xu

   CATR

   No.52 Hua Yuan Bei Lu,Haidian District

   Beijing 100083

   P.R.China

   Phone: ++8613681485428

   Email: xuyunbin@mail.ritt.com.cn

   URI: http://www.bupt.edu.cn/

Authors' Addresses

    Yuefeng Ji
    BUPT
    No.10,Xitucheng Road,Haidian District
    Beijing 100876
    P.R.China

    Phone: +8613701131345
    Email: jyf@bupt.edu.cn
    URI: http://www.bupt.edu.cn

    Weiwei Bian
    BUPT
    No.10,Xitucheng Road,Haidian District
    Beijing 100876
    P.R.China

    Phone: +8615210837998
    Email: bianweiwei2008@163.com
    URI: http://www.bupt.edu.cn/

    Hongxiang Wang
    BUPT
    No.10,Xitucheng Road,Haidian District
    Beijing 100876
    P.R.China

    Phone: +8613683683550
    Email: wanghx@bupt.edu.cn
    URI: http://www.bupt.edu.cn/

    Shanguo Huang
    BUPT
    No.10,Xitucheng Road,Haidian District
    Beijing 100876
    P.R.China

    Phone: +86 1062282048
    Email: shghuang@bupt.edu.cn
    URI: http://www.bupt.edu.cn/

      Guoying Zhang
      CATR
      No.52 Hua Yuan Bei Lu,Haidian District
      Beijing 100083
      P.R.China

      Phone: +86 1062300103
      Email: zhangguoying@mail.ritt.com.cn
      URI: http://www.catr.cn/