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Performance Measurement Metrics of Label Switched Path (LSP) Establishment in Multi-Layer and Multi-Domain Networks draft-jiyf-ccamp-lsp-03

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.

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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, for the purpose of utilizing network resource more efficiently, 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:

- 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.

- 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.

- 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:

- 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.

- 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.

- 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

- ID0, the source node ID.
- ID1, the destination node ID.
- T0, a time when the path computation is attempted.
- 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

- ID0, the source node ID.
- ID1, the destination node ID.
- Every node has a LID which stores the node physical information.

- 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

- T0, a time when the path computation is attempted.
- T1, a time when the LSP setup is attempted.
- T2, a time when the optimal path computation result is returned.
- T3, a time when the LSP confirm message of successful reservation is returned.

6.2. Methodologies

6.2.1. The LSP Establishment Delay

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

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

- 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.

- 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.

- 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.

- 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

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

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

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

- 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

available wavelength resource exists and the computed BER is within the tolerable range, then Resv message is returned to the source node.

- 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

- In the measurement process of the LSP establishment delay, the start time of LSP establishment and the end 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 end 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 end time of LSP setup.

- 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

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