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Requirements for the Conversion between Permanent Connections and Switched Connections in a Generalized Multiprotocol Label Switching (GMPLS) Network

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Abstract

From a carrier perspective, the possibility of turning a permanent connection (PC) into a soft permanent connection (SPC) and vice versa, without actually affecting data plane traffic being carried over it, is a valuable option. In other terms, such operation can be seen as a way of transferring the ownership and control of an existing and in-use data plane connection between the management plane and the control plane, leaving its data plane state untouched.

This memo sets out the requirements for such procedures within a Generalized Multiprotocol Label Switching (GMPLS) network.

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1. Introduction

In a typical, traditional transport network scenario, data plane connections between two end-points are controlled by means of a Network Management System (NMS) operating within the management plane (MP). The NMS/MP is the owner of such transport connections, being responsible of their setup, teardown, and maintenance. Provisioned connections of this type, initiated and managed by the management plane, are known as permanent connections (PCs) [G.8081].

When the setup, teardown, and maintenance of connections are achieved by means of a signaling protocol owned by the control plane (CP), such connections are known as switched connections (SCs) [G.8081].

In many deployments, a hybrid connection type will be used. A soft permanent connection (SPC) is a combination of a permanent connection segment at the source-user-to-network side, a permanent connection segment at the destination-user-to-network side, and a switched connection segment within the core network. The permanent parts of the SPC are owned by the management plane, and the switched parts are owned by the control plane [G.8081].

Note, some aspects of a control-plane-initiated connection must be capable of being queried/controlled by the management plane. These aspects should be independent of how the connection was established.

1.1. Conventions Used in This Document

Although this requirements document is an informational document, not a protocol specification, 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] for clarity of requirement specification.

2. Label Switched Path Terminology

A Label Switched Path (LSP) has different semantics depending on the plane in which the term is used.

In the data plane, an LSP indicates the data plane forwarding path. It defines the forwarding or switching operations at each network entity. It is the sequence of data plane resources (links, labels, cross-connects) that achieves end-to-end data transport.

In the management plane, an LSP is the management plane state information (such as the connection attributes and path information) associated with and necessary for the creation and maintenance of a data plane connection.

In the control plane, an LSP is the control plane state information (such as the RSVP-TE [RFC3473] Path and Resv state) associated with and necessary for the creation and maintenance of a data plane connection.

A permanent connection has an LSP presence in the data plane and the management plane. A switched connection has an LSP presence in the data plane and the control plane. An SPC has an LSP presence in the data plane for its entire length, but has a management plane presence for part of its length and a control plane presence for part of its length.

In this document, when we discuss the LSP conversion between management plane and control plane, we mainly focus on the conversion of control plane state information and management plane state information.

3. LSP within GMPLS Control Plane

GMPLS ([RFC3471], [RFC3473], and [RFC3945]) defines a control plane architecture for transport networks. This includes both routing and signaling protocols for the creation and maintenance of LSPs in networks whose data plane is based on different technologies, such as Time Division Multiplexing (SDH/SONET, G.709 at ODUk level) and Wavelength Division Multiplexing (G.709 at OCh level).

3.1. Resource Ownership

A resource used by an LSP is said to be 'owned' by the plane that was used to set up the LSP through that part of the network. Thus, all the resources used by a permanent connection are owned by the management plane, and all the resources used by a switched connection are owned by the control plane. The resources used by an SPC are divided between the management plane (for the resources used by the permanent connection segments at the edge of the network) and the control plane (for the resources used by the switched connection segments in the middle of the network).

The division of resources available for ownership by the management and control planes is an architectural issue. A carrier may decide to pre-partition the resources at a network entity so that LSPs under management plane control use one set of resources and LSPs under control plane control use another set of resources. Other carriers may choose to make this distinction resource-by-resource as LSPs are established.

It should be noted, however, that even when a resource is owned by the control plane it will usually be the case that the management plane has a controlling interest in the resource. For example, consider the basic safety requirements that management commands must be able to put a laser out of service.

3.2. Setting Up a GMPLS-Controlled Network

The implementation of a new network using a Generalized Multiprotocol Label Switching (GMPLS) control plane may be considered as a green field deployment. But in many cases, it is desirable to introduce a GMPLS control plane into an existing transport network that is already populated with permanent connections under management plane control.

In a mixed scenario, permanent connections owned by the management plane and switched connections owned by the control plane have to coexist within the network.

It is also desirable to transfer the control of connections from the management plane to the control plane so that connections that were originally under the control of an NMS are now under the control of the GMPLS protocols. In case such connections are in service, such conversion must be performed in a way that does not affect traffic.

Since attempts to move an LSP under GMPLS control might fail due to a number of reasons outside the scope of this document, it is also highly desirable to have a mechanism to convert the control of an LSP back to the management plane.

Note that a permanent connection may be converted to a switched connection or to an SPC, and an SPC may be converted to a switched connection as well (PC to SC, PC to SPC, and SPC to SC). So the reverse mappings may also be needed (SC to PC, SPC to PC, and SC to SPC).

Conversion to/from control/management will occur in MIBs or in information stored on the device (e.g., cross-connect, label assignment, label stacking, etc.) and is identified as either initiated by a specific control protocol or by manual operation (i.e., via an NMS). When converting, this hop-level owner information needs to be completed for all hops. If conversion cannot be done for all hops, then the conversion must be done for no hops, the state of the hop-level information must be restored to that before the conversion was attempted, and an error condition must be reported to the management system.

In either case of conversion, the management plane shall initiate the change. When converting from a PC to an SC, the management system must indicate to each hop that a control protocol is now to be used, and then configure the data needed by the control protocol at the connection endpoints. When converting from an SC to a PC, the management plane must change the owner of each hop. Then the instance in the control plane must be removed without affecting the data plane.

The case where the CP and/or MP fail at one or more nodes during the conversion procedure must be handled in the solution. If the network is viewed as the database of record (including data, control, and management plane elements), then a solution that has procedures similar to those of a two-phase database commit process may be needed to ensure integrity and to support the need to revert to the state prior to the conversion attempt if there is a CP and/or MP failure during the attempted conversion.

4. Typical Use Cases

4.1. PC-to-SC/SPC Conversion

A typical scenario where a PC-to-SC (or SPC) procedure can be a useful option is at the initial stage of control plane deployment in an existing network. In such a case, all the network connections, possibly carrying traffic, are already set up as PCs and are owned by the management plane.

At a latter stage, when the network is partially controlled by the management plane and partially controlled by the control plane (PCs and SCs/SPCs coexist) and it is desired to extend the control plane, a PC-to-SC procedure can be used to transfer a PC or SPC to a SC.

In both cases, a connection, set up and owned by the management plane, needs to be transferred to control plane control. If a connection is carrying traffic, its control transfer has to be done without any disruption to the data plane traffic.

4.2. SC-to-PC Conversion

The main need for an SC-to-PC conversion is to give an operator the capability of undoing the action of the above introduced PC-to-SC conversion.

In other words, the SC-to-PC conversion is a back-out procedure and as such is not specified as mandatory in this document, but it is still a highly desirable function.

Again, it is worth stressing the requirement that such an SPC-to-PC conversion needs to be achieved without any effect on the associated data plane state so that the connection continues to be operational and to carry traffic during the transition.

5. Requirements

This section sets out the basic requirements for procedures and processes that are used to perform the functions of this document. Notation from [RFC2119] is used to clarify the level of each requirement.

5.1. Data Plane LSP Consistency

The data plane LSP MUST stay in place throughout the whole control transfer process. It MUST follow the same path through the network and MUST use the same network resources.

5.2. No Disruption of User Traffic

The transfer process MUST NOT cause any disruption of user traffic flowing over the LSP whose control is being transferred or over any other LSP in the network.

SC-to-PC conversion and vice-versa SHALL occur without generating alarms towards the end users or the NMS.

5.3. Transfer from Management Plane to Control Plane

It MUST be possible to transfer the ownership of an LSP from the management plane to the control plane.

5.4. Transfer from Control Plane to Management Plane

It SHOULD be possible to transfer the ownership of an LSP from the control plane to the management plane.

5.5. Synchronization of State among Nodes during Conversion

It MUST be assured that the state of the LSP is synchronized among all nodes traversed by it before the conversion is considered complete.

5.6. Support of Soft Permanent Connections

It MUST be possible to segment an LSP such that it can be converted to or from an SPC.

5.7. Failure of Transfer

It MUST be possible for a transfer from one plane to the other to fail in a non-destructive way, leaving the ownership unchanged and without impacting traffic.

If during the transfer procedure issues arise causing an unsuccessful or unexpected result, it MUST be assured that:

1. Traffic over the data plane is not affected.

2. The LSP status is consistent in all the network nodes involved in the procedure.

Point 2, above, assures that even in case of some failure during the transfer, the state of the affected LSP is brought back to the initial one and is fully under the control of the owning entity.

6. Security Considerations

Allowing control of an LSP to be taken away from a plane introduces a possible way in which services may be disrupted by malicious intervention.

A solution to the requirements in this document will utilize the security mechanisms supported by the management plane and GMPLS control plane protocols, and no new security requirements over the general requirements described in [RFC3945] are introduced. It is expected that solution documents will include an analysis of the security issues introduced by any new protocol extensions.

The management plane interactions MUST be supported through protocols that can offer adequate security mechanisms to secure the configuration and protect the operation of the devices that are managed. These mechanisms MUST include at least cryptographic security and the ability to ensure that the entity giving access to configuration parameters is properly configured to give access only to those principals (users) that have legitimate rights to read/create/change/delete the parameters. IETF standard management protocols (Netconf [RFC4741] and SNMPv3 [RFC3410]) offer these mechanisms.

Note also that implementations may support policy components to determine whether individual LSPs may be transferred between planes.

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