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Data Channel Status Confirmation Extensions for the Link Management Protocol

Abstract

This document defines simple additions to the Link Management Protocol (LMP) to provide a control plane tool that can assist in the location of stranded resources by allowing adjacent Label-Switching Routers (LSRs) to confirm data channel statuses and provide triggers for notifying the management plane if any discrepancies are found. As LMP is already used to verify data plane connectivity, it is considered to be an appropriate candidate to support this feature.

Status of This Memo

This is an Internet Standards Track document.

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1. Introduction

Generalized Multiprotocol Label Switching (GMPLS) networks are constructed from Traffic Engineering (TE) links connecting Label Switching Routers (LSRs). The TE links are constructed from a set of data channels. In this context, a data channel corresponds to a resource label in a non-packet technology (such as a timeslot or a lambda).

A data channel status mismatch exists if the LSR at one end of a TE link believes that the data channel is assigned to carry data, but the LSR at the other end does not. The term "ready to carry data" means cross-connected or bound to an end-point for the receipt or delivery of data.

Data channel mismatches cannot be detected from the TE information advertised by the routing protocols [RFC4203], [RFC5307]. The existence of some data channel mismatch problems may be detected by a mismatch in the advertised bandwidths where bidirectional TE links and bidirectional services are in use. However, where unidirectional services exist, or where multiple data channel mismatches occur, it is not possible to detect such errors through the routing protocol-advertised TE information. In any case, there is no mechanism to isolate the mismatches by determining which data channels are at fault.

If a data channel mismatch exists, any attempt to use the data channel for a new Label Switched Path (LSP) will fail. One end of the TE link may attempt to assign the TE link for use, but the other end will report the data channel as unavailable when the control plane or management plane attempts to assign it to an LSP.

Although such a situation can be resolved through the use of the Acceptable Label Set object in GMPLS signaling [RFC3473], such a procedure is inefficient since it may require an additional signaling exchange for each LSP that is set up. When many LSPs are to be set up, and when there are many data channel mismatches, such inefficiencies become significant. It is desirable to avoid the additional signaling overhead, and to report the problems to the management plane so that they can be resolved to improve the efficiency of LSP setup.

Correspondingly, such a mismatch situation may give rise to misconnections in the data plane, especially when LSPs are set up using management plane operations.

Resources (data channels) that are in a mismatched state are often described as "stranded resources". They are not in use for any LSP, but they cannot be assigned for use by a new LSP because they appear to be in use. Although it is theoretically possible for management plane applications to audit all network resources to locate stranded resources and to release them, this process is rarely performed because of the difficulty of coordinating different Element Management Systems (EMSs) and the associated risks of accidentally releasing in-use resources. It is desirable to have a control plane mechanism that detects and reports stranded resources.

This document defines simple additions to the Link Management Protocol (LMP) [RFC4204] to provide a control plane tool that can assist in the location of stranded resources by allowing adjacent LSRs to confirm data channel statuses and provide triggers for notifying the management plane if any discrepancies are found. As LMP is already used to verify data plane connectivity, it is considered to be an appropriate candidate to support this feature.

2. Specification of Requirements

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].

3. Problem Explanation

Examples of data channel mismatches are described in the following three scenarios.

In all of the scenarios, the specific channel resource of a data link will be unavailable because of the data channel status mismatch, and this channel resource will be wasted. Furthermore, a data channel status mismatch may reduce the possibility of successful LSP establishment, because a data channel status mismatch may result in failure when establishing an LSP.

So it is desirable to confirm the data channel statuses as early as possible.

3.1. Mismatch Caused by Manual Configuration

The operator may have configured a cross-connect at only one end of a TE link using an EMS. The resource at one end of the data channel is allocated, but the corresponding resource is still available at the other end of the same data channel. In this case, the data channel may appear to be available for use by the control plane when viewed from one end of the TE link but, will be considered to be unavailable

by the other end of the TE link. Alternatively, the available end of the data channel may be cross-connected by the management plane, and a misconnection may result from the fact that the other end of the data channel is already cross-connected.

Figure 1 shows a data channel between nodes A and B. The resource at A's end of the TE link is allocated through manual configuration, while the resource at B's end of the TE link is available, so the data channel status is mismatched.

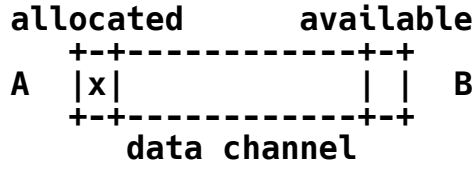


Figure 1. Mismatch Caused by Manual Configuration

3.2. Mismatch Caused by LSP Deletion

The channel status of a data link may become mismatched during the LSP deletion process. If the LSP deletion process is aborted in the middle of the process (perhaps because of a temporary control plane failure), the cross-connect at the upstream node may be removed while the downstream node still keeps its cross-connect, if the LSP deletion was initiated by the source node.

For example, in Figure 2, an LSP traverses nodes A, B, and C. Node B resets abnormally when the LSP is being deleted. This results in the cross-connects of nodes A and C being removed, but the cross-connect of node B still being in use. So, the data channel statuses between nodes A and B, and between nodes B and C are both mismatched.

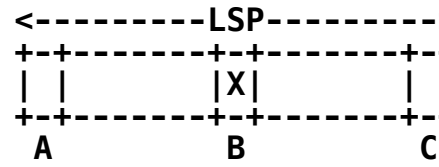


Figure 2. Mismatch Caused by LSP Deletion

In [RFC2205] and [RFC3209], a "soft state" mechanism was defined to prevent state discrepancies between LSRs. Resource ReSerVation Protocol-Traffic Engineering (RSVP-TE) restart processes ([RFC3473], [RFC5063]) have been defined: adjacent LSRs may resynchronize their control plane state to reinstate information about LSPs that have persisted in the data plane. Both mechanisms aim at keeping state consistency among nodes and allow LSRs to detect mismatched data

plane states. The data plane handling of such mismatched states can be treated as a local policy decision. Some deployments may decide to automatically clean up the data plane state so it matches the control plane state, but others may choose to raise an alert to the management plane and leave the data plane untouched just in case it is in use.

In such cases, data channel mismatches may arise after restart and might not be cleared up by the restart procedures.

3.3. Failed Resources

Even if the situation is not common, it might happen that a termination point of a TE link is seen as failed by one end, while on the other end it is seen as OK. This problem may arise due to some failure either in the hardware or in the status detection of the termination point.

This mismatch in the termination point status can lead to failure in the case of bidirectional LSP setup.

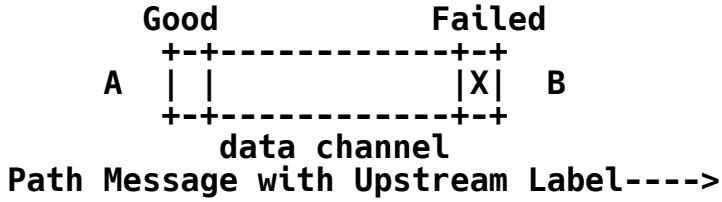


Figure 3. Mismatch Caused by Resource Failure

In this case, the upstream node chooses to use termination point A in order to receive traffic from the downstream node. From the upstream node's point of view, the resource is available and thus usable; however, in the downstream node, the corresponding termination point (resource B) is broken. This leads to a setup failure.

4. Motivation

The requirement does not come from a lack in GMPLS specifications themselves but rather from operational concerns because, in most cases, GMPLS-controlled networks will co-exist with legacy networks and legacy procedures.

The protocol extensions defined in this document are intended to detect data plane problems resulting from misuse or misconfigurations triggered by user error, or resulting from failure to clean up the data plane after control plane disconnection. It is anticipated that human mistakes are probably the major source of errors to deal with.

This document is not intened to provide a protocol mechanism to deal with broken implementations.

The procedures defined in this document are designed to be performed on a periodic or on-demand basis. It is NOT RECOMMENDED that the procedures be used to provide a continuous and on-line monitoring process.

As LMP is already used to verify data plane connectivity, it is considered to be an appropriate candidate to support this feature.

5. Extensions to LMP

A control plane tool to detect and isolate data channel mismatches is provided in this document by simple additions to the Link Management Protocol (LMP) [RFC4204]. It can assist in the location of stranded resources by allowing adjacent LSRs to confirm data channel statuses.

Outline procedures are described in this section. More detailed procedures are found in Section 6.

The message formats in the subsections that follow use Backus-Naur Form (BNF) encoding as defined in [RFC5511].

5.1. Confirm Data Channel Status Messages

Extensions to LMP to confirm a data channel status are described below. In order to confirm a data channel status, the new LMP messages are sent between adjacent nodes periodically or driven by some event (such as an operator command, a configurable timer, or the rejection of an LSP setup message because of an unavailable resource). The new LMP messages run over the control channel, encapsulated in UDP with an LMP port number and IP addressing as defined in "Link Management Protocol (LMP)" [RFC4204].

Three new messages are defined to check data channel status: ConfirmDataChannelStatus, ConfirmDataChannelStatusAck, and ConfirmDataChannelStatusNack. These messages are described in detail in the following subsections. Message Type numbers are found in Section 8.1.

5.1.1. ConfirmDataChannelStatus Messages

The ConfirmDataChannelStatus message is used to provide the remote end of the data channel with the status of the local end of the data channel and to ask the remote end to report its data channel. The message may report on (and request information about) more than one data channel.

```
<ConfirmDataChannelStatus Message> ::= <Common Header>
                                       <LOCAL_LINK_ID>
                                       <MESSAGE_ID>
                                       <DATA_LINK>[<DATA_LINK>...]
```

When a node receives the ConfirmDataChannelStatus message, and the data channel status confirmation procedure is supported at the node, the node compares its own data channel statuses with all of the data channel statuses sent by the remote end in the ConfirmDataChannelStatus message. If a data channel status mismatch is found, this mismatch result is expected to be reported to the management plane for further action. Management plane reporting procedures and actions are outside the scope of this document.

If the message is a Confirm Data Channel Status message, and the MESSAGE_ID value is less than the largest MESSAGE_ID value previously received from the sender for the specified TE link, then the message SHOULD be treated as being out-of-order.

5.1.2. ConfirmDataChannelStatusAck Messages

The ConfirmDataChannelStatusAck message is sent back to the node that originated the ConfirmDataChannelStatus message to return the requested data channel statuses.

When the ConfirmDataChannelStatusAck message is received, the node compares the received data channel statuses at the remote end with those at the local end (the same operation as performed by the receiver of the ConfirmDataChannelStatus message). If a data channel status mismatch is found, the mismatch result is expected to be reported to the management plane for further action.

```
<ConfirmDataChannelStatusAck Message> ::= <Common Header>
                                          <MESSAGE_ID_ACK>
                                          <DATA_LINK>[<DATA_LINK>...]
```

The contents of the MESSAGE_ID_ACK objects MUST be obtained from the ConfirmDataChannelStatus message being acknowledged.

Note that the ConfirmDataChannelStatusAck message is used both when the data channel statuses match and when they do not match.

5.1.3. ConfirmDataChannelStatusNack Messages

When a node receives the ConfirmDataChannelStatus message, if the data channel status confirmation procedure is not supported but the message is recognized, a ConfirmDataChannelStatusNack message

containing an ERROR_CODE indicating "Channel Status Confirmation Procedure not supported" MUST be sent.

If the data channel status confirmation procedure is supported, but the node is unable to begin the procedure, a ConfirmDataChannelStatusNack message containing an ERROR_CODE indicating "Unwilling to Confirm" MUST be sent. If a ConfirmDataChannelStatusNack message is received with such an ERROR_CODE, the node that originated the ConfirmDataChannelStatus message MAY schedule the ConfirmDataChannelStatus message retransmission after a configured time. A default value of 10 minutes is suggested for this timer.

```
<ConfirmDataChannelStatusNack Message> ::= <Common Header>
                                           [<LOCAL_LINK_ID>]
                                           <MESSAGE_ID_ACK>
                                           <ERROR_CODE>
```

The contents of the MESSAGE_ID_ACK objects MUST be obtained from the ConfirmDataChannelStatus message being rejected.

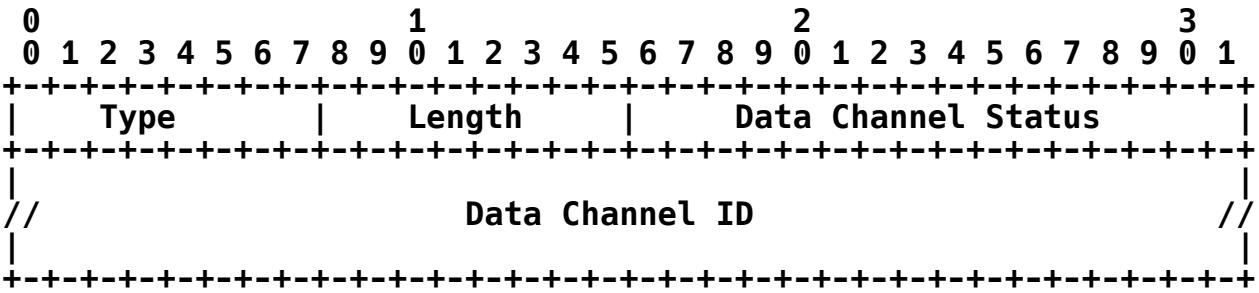
The ERROR_CODE object in this message has a new Class Type (see Section 8.3), but is formed as the ERROR_CODE object defined in [RFC4204]. The following Error Codes are defined:

```
0x01 = Channel Status Confirmation Procedure not supported
0x02 = Unwilling to Confirm
```

5.2. Data Channel Status Subobject

A new Data Channel Status subobject type is introduced to the DATA LINK object to hold the Data Channel Status and Data Channel ID.

See Section 8.2 for the Subobject Type value.



Data Channel Status:

This is a series of bit flags to indicate the status of the data channel. The following values are defined.

0x0000 : The channel is available/free.
0x0001 : The channel is unavailable/in-use.

Data Channel ID

This identifies the data channel. The length of this field can be deduced from the Length field in the subobject. Note that all subobjects must be padded to a four-byte boundary with trailing zeros.

If such padding is required, the Length field MUST indicate the length of the subobject up to, but not including, the first byte of padding. Thus, the amount of padding is deduced and not represented in the Length field.

Note that the Data Channel ID is given in the context of the sender of the ConfirmChannelStatus message.

The Data Channel ID must be encoded as a label value. Based on the type of signal (e.g., Synchronous Optical Network/Synchronous Digital Hierarchy (SONET/SDH), Lambda, etc.), the encoding methodology used will be different. For SONET/SDH, the label value is encoded as per [RFC4606].

5.3. Message Construction

Data_Link Class (as defined in Section 13.12 of [RFC4204]) is included in ConfirmDataChannelStatus and ConfirmDataChannelStatusAck messages.

The status of the TE link end MUST be carried by the Data Channel Status subobject, which is defined in Section 5.2 of this document. The new subobject MUST be part of Data_Link Class.

In the case of SONET/SDH, the Data Channel ID in the new subobject SHOULD be used to identify each timeslot of the data link.

5.4. Backward Compatibility

Some nodes running in the network might only support the LMP Message Types, which are already defined in [RFC4204]. The three new types of LMP messages defined in this document cannot be recognized by these nodes. The behavior of an LMP node that receives an unknown

message is not specified in [RFC4204] and will be clarified in a separate document.

Since the behavior of legacy nodes must be assumed to be unknown, this document assumes that a deployment intended to support the function described in this document will consist completely of nodes that support the protocol extensions also described in this document.

In the future, it may be the case that LMP will be extended to allow function support to be detected. In that case, it may become possible to deploy this function in a mixed environment.

6. Procedures

Adjacent nodes MAY send data channel status confirmation-related LMP messages. Periodical timers or some other events requesting the confirmation of channel status for the data link may trigger these messages. It's a local policy decision to start the data channel status confirmation process. The procedure is described below:

- Initially, the SENDER constructs a ConfirmDataChannelStatus message that MUST contain one or more DATA_LINK objects. The DATA_LINK object is defined in [RFC4204]. Each DATA_LINK object MUST contain one or more Data Channel Status subobjects. The Data Channel ID field in the Data Channel Status subobject MUST indicate which data channel needs to be confirmed, and MUST report the data channel status at the SENDER. The ConfirmDataChannelStatus message is sent to the RECEIVER.

- Upon receipt of a ConfirmDataChannelStatus message, the RECEIVER MUST extract the data channel statuses from the ConfirmDataChannelStatus message and SHOULD compare these with its data channel statuses for the reported data channels. If a data channel status mismatch is found, the mismatch result SHOULD be reported to the management plane for further action. The RECEIVER also SHOULD send the ConfirmDataChannelStatusAck message, which MUST carry all the local end statuses of the requested data channels to the SENDER.

- If the RECEIVER is not able to support or to begin the confirmation procedure, the RECEIVER MUST send a ConfirmDataChannelStatusNack message containing the ERROR_CODE that indicates the reason for rejection.

- Upon receipt of a ConfirmDataChannelStatusAck message, the SENDER MUST compare the received data channel statuses at the remote end with the data channel statuses at the local end. If a data

channel status mismatch is found, the mismatch result SHOULD be reported to the management plane for further action.

The data channel status mismatch issue identified by LMP may be automatically resolved by RSVP restart. For example, the restarting node may also have damaged its data plane. This leaves the data channels mismatched. However, RSVP restart will re-install the data plane state in the restarting node. The issue may also be resolved via RSVP soft state timeout.

If the ConfirmDataChannelStatus message is not recognized by the RECEIVER, the RECEIVER ignores this message and will not send out an acknowledgment message to the SENDER.

Due to the message loss problem, the SENDER may not be able to receive the acknowledgment message.

ConfirmDataChannelStatus SHOULD be sent using LMP [RFC4204] reliable transmission mechanisms. If, after the retry limit is reached, a ConfirmDataChannelStatusAck message or a ConfirmDataChannelStatusNack message is not received by the SENDER, the SENDER SHOULD terminate the data channel confirmation procedure and SHOULD raise an alert to the management plane.

7. Security Considerations

[RFC4204] describes how LMP messages between peers can be secured, and these measures are equally applicable to the new messages defined in this document.

The operation of the procedures described in this document does not of itself constitute a security risk because it does not cause any change in network state. It would be possible, if the messages were intercepted or spoofed, to cause bogus alerts in the management plane, and so the use of LMP security measures described in [RFC4204] is RECOMMENDED.

Note that performing the procedures described in this document may provide a useful additional security measure to verify that data channels have not been illicitly modified.

8. IANA Considerations

8.1. LMP Message Types

IANA maintains the "Link Management Protocol (LMP)" registry, which has a subregistry called "LMP Message Type". IANA has made the following three new allocations from this registry.

Value	Description
32	ConfirmDataChannelStatus
33	ConfirmDataChannelStatusAck
34	ConfirmDataChannelStatusNack

8.2. LMP Data Link Object Subobject

IANA maintains the "Link Management Protocol (LMP)" registry, which has a subregistry called "LMP Object Class name space and Class type (C-Type)". This subregistry has an entry for the DATA_LINK object, and there is a further embedded registry called "DATA_LINK Sub-object Class name space". IANA has made the following allocation from this embedded registry.

Value	Description
9	Data Channel Status

8.3. LMP Error_Code Class Type

IANA maintains the "Link Management Protocol (LMP)" registry, which has a subregistry called "LMP Object Class name space and Class type (C-Type)". This subregistry has an entry for the ERROR_CODE object. IANA has allocated the following new value for an ERROR_CODE class type.

C-Type	Description	Reference
4	ConfirmDataChannelStatusNack	[This RFC]

9. Acknowledgments

The authors would like to thank Adrian Farrel, Dimitri Papadimitriou, and Lou Berger for their useful comments.

10. References

10.1. Normative References

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10.2. Informative References

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