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Subject: SAS port layer description modifications

Introduction

The following proposal is a replacement for the clause describing the SAS port layer. This revision includes input from the SAS Protocol Working Group meetings, March 10th and 11th, 2003.

1 Port layer

1.1 Overview

The SAS port layer interfaces with the SAS transport layer and the SAS link layer.

1.2 PL (port layer) state machines

1.2.1 PL state machines overview

The PL (port layer) consists of state machines that run in parallel and perform the following functions:

- a) receive requests from the SSP, SMP, and STP transport layer state machines for connection management (e.g., requests to open or close connections) and frame transmission;
- b) send requests to the SAS link layer state machines for connection management and frame transmission;
- c) receive confirmation from the SAS link layer state machines; and
- d) send confirmations to the SSP, SMP, and STP transport layer state machines.

The port layer state machines are as follows:

- a) PL_OC (port layer overall control) state machines (see 1.2.2); and
- b) PL_PM (port layer phy manager) state machines (see 1.2.3).

There is one PL_OC state machine per port. There is one PL_PM state machine for each phy contained in the port. Phys are assigned to ports by the management application layer.

Figure 1 shows examples of the port layer state machines and their interaction with the transport and link layers.

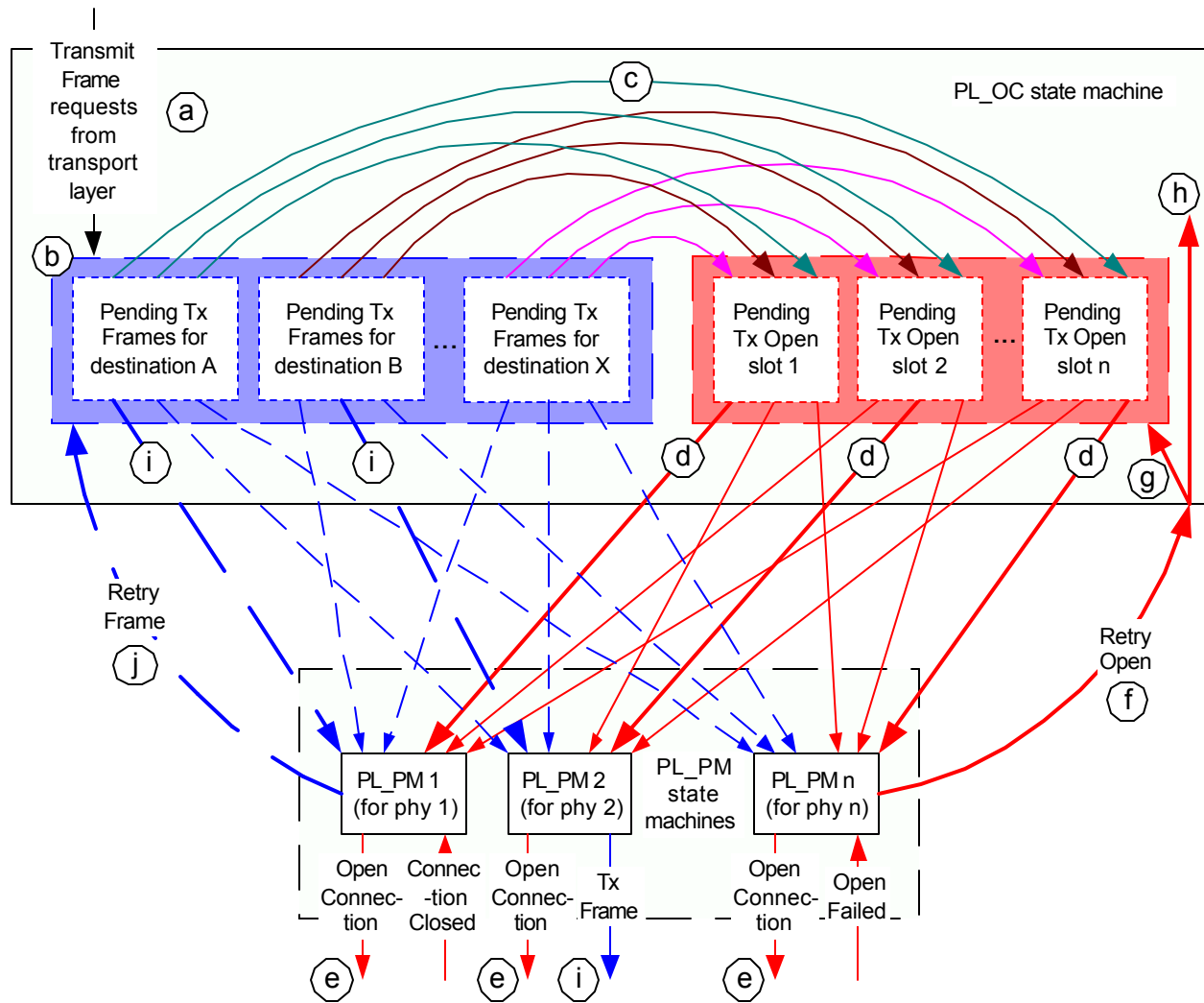


Figure 1 — Port layer examples

The following is a description of the processes in figure 1:

- Transmit Frame requests are received by the PL_OC state machine;
- the PL_OC state machine converts Transmit Frame requests into pending Tx Frame messages associated with the destination SAS address;
- the PL_OC state machine may generate a pending Tx Open message for a pending Tx Frame message when there is a pending Tx Open slot available (i.e., the number of pending Tx Open messages is less than or equal to the number of phys);
- the PL_OC state machine sends a pending Tx Open message as a Tx Open message to a PL_PM state machine as soon as a PL_PM machine is available; a slot is then available for a new pending Tx Open message;
- when a PL_PM state machine receives a Tx Open message, the PL_PM state machine attempts to establish a connection with the destination SAS address through the link layer;
- if a PL_PM state machine is unable to establish a connection with the destination SAS address, then the PL_PM state machine sends a Retry Open message to the PL_OC state machine.
- the PL_OC state machine should convert a Retry Open message to a pending Tx Open message if there is a pending Tx Open slot available; if the PL_OC state machine converts a Retry Open message into a pending Tx Open message, then the pathway blocked count and arbitration wait time context from the Retry Open message may be applied to the pending Tx Open message;

- h) if the PL_OC state machine does not convert a Retry Open to a pending Tx Open frame, then the PL_OC discards the Retry Open message. The PL_OC state machine may create a new Retry Open message for the same pending Tx Frame at a later time. If the PL_OC state machine discards a Retry Open message, then the pathway blocked count and arbitration wait time context from the Retry Open message are also discarded;
- i) after a PL_PM state machine establishes a connection with a destination SAS address, the PL_OC state machine sends pending Tx Frame messages for the destination to the PL_PM state machine as Tx Frame messages;
- j) if a PL_PM state machine is unable to send a Tx Frame message to the link layer as a Tx Frame request (e.g., due to a credit timeout), then the PL_PM state machine sends a Retry Frame message to the PL_OC state machine, and the PL_OC state machine converts the Retry Frame message into a pending Tx Frame message;
- k) if the PL_PM state machine is able to send a Tx Frame message as a Tx Frame request to the link layer, then the PL_PM state machine sends a Transmission Status confirmation to the transport layer.

1.2.2 PL_OC (port layer overall control) state machine

1.2.2.1 PL_OC overview

A PL_OC state machine:

- a) receives requests from the SSP, SMP, and STP transport layers;
- b) sends messages to the PL_PM state machine;
- c) receives messages from the PL_PM state machine;
- d) selects frames to transmit;
- e) selects phys on which to transmit frames;
- f) receives confirmations from the link layer;
- g) sends confirmations to the transport layer;
- h) has Arbitration Wait Time timers; and
- i) has I_T Nexus Loss timers.

This state machine consists of the following states:

- a) PL_OC1:Idle (see 1.2.2.2) (initial state); and
- b) PL_OC2:Overall_Control (see 1.2.2.3).

After power on this state machine shall start in the PL_OC1:Idle state.

This state shall maintain the timers listed in table 1.

Table 1 — PL_OC state machine timers

Timer	Initial value
I_T Nexus Loss timer	The value in the I_T NEXUS LOSS TIME field in the Protocol Specific Port Control mode page (see 10.1.6.2)
Arbitration Wait Time timer	Zero, a vendor specific value less than 8000h (see 7.12.3), or the value received with a Retry Open message

[illegible]

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If this state receives a HARD_RESET Received confirmation or if this state is entered from the PL_OC2 state as the result of a HARD_RESET Received confirmation, then this state shall send a HARD_RESET Received confirmation to the transport layer.

If this state receives a Transmit Frame request, then this state shall send a Transmission Status (No Phys In Port) confirmation to the transport layer.

1.2.2.2.2 Transition PL_OC1:Idle to PL_OC2:Overall_Control

This transition shall occur after a Phy Enabled confirmation is received for at least one phy assigned to the port.

1.2.2.3 PL_OC2:Overall_Control state

1.2.2.3.1 PL_OC2:Overall_Control state overview

This state may receive Transmit Frame requests from the transport layers (i.e., SSP and SMP) and Retry frame messages from PL_PM state machines. This state shall create a pending Tx Frame message from each Transmit Frame request and Retry Frame message. There may be more than one pending Tx Frame message at a time for each SSP transport layer. There shall be only one pending Tx Frame message at a time for each SMP transport layer.

This state selects PL_PM state machines through which connections are established. This state shall only attempt to establish connections through PL_PM state machines whose phys are enabled. This state selects PL_PM state machines on which connections are established to transmit frames. This state shall receive a response to a message from a PL_PM state machine before sending another message to that PL_PM state machine.

This state also:

- a) receives connection management requests from the transport layers;
- b) sends connection management messages to PL_PM state machines;
- c) receives connection management messages from PL_PM state machines; and
- d) sends connection management confirmations to the transport layers.

After receiving a Transmit Frame request for a destination SAS address for which there is no connection established and no I_T Nexus Loss timer has been created, this state shall create an I_T Nexus Loss timer for that SAS address if:

- a) the protocol is SSP;
- b) this state machine is an SSP target port; and
- c) the Protocol Specific Port Control mode page is implemented by the SSP target port.

When this state creates an I_T Nexus Loss timer it shall:

- a) initialize the I_T Nexus Loss timer; and
- b) not start the I_T Nexus Loss timer.

If this state machine is an SSP initiator port, then this state may create an I_T Nexus Loss timer for the SAS address. If a state machine an SSP initiator port creates an I_T Nexus Loss timer, it should use the value in the I_T NEXUS LOSS TIME field in the Protocol Specific Port Control mode page for the SSP target port (see 10.1.6.2).

Other SAS ports may detect an I_T nexus loss in a vendor-specific manner.

If there are no pending Tx Frame messages for a destination SAS address and an I_T Nexus Loss timer has been created for that destination SAS address, then this state shall delete the I_T Nexus Loss timer for that destination SAS address.

If this state receives a HARD_RESET Received confirmation, then this state shall discard all pending Tx Frame messages and delete all I_T Nexus Loss timers.

1.2.2.3.2 PL_OC2:Overall_Control state establishing connections

This state receives Phy Enabled confirmations from the link layer indicating when a phy is available.

This state receives Retry Open messages from a PL_PM state machine.

This state creates pending Tx Open messages based on pending Tx Frame messages and Retry Open messages. Pending Tx Open messages are sent to a PL_PM state machine as Tx Open messages.

If this state receives a Retry Open (No Destination) or a Retry Open (Open Timeout Occurred) message and an I_T Nexus Loss timer has not been created for the destination SAS address (e.g., an SSP target port does not support the I_T NEXUS LOSS TIME field in the Protocol Specific Port Control mode page), then this state shall process the Retry Open message as either a Retry Open message or an Unable To Connect message.

If this state receives a Retry Open (No Destination), Retry Open (Open Timeout Occurred), or Retry Open (Pathway Blocked) message, and the I_T Nexus Loss timer was initialized to zero, then this state shall process the Retry Open message.

If this state receives a Retry Open (No Destination) or a Retry Open (Open Timeout Occurred) message, an I_T Nexus Loss timer has been created for the destination SAS address, and there is no connection established with the destination SAS address, then this state shall check the I_T Nexus Loss timer, and:

- a) if the I_T Nexus Loss timer is not running, then this state shall start the timer;
- b) if the I_T Nexus Loss timer is running, then this state shall not stop the timer; and
- c) if the I_T Nexus Loss timer has expired, then this state shall process the Retry Open message as if it were an Unable To Connect message (see 1.2.2.3.4).

If this state receives a Retry Open (Pathway Blocked) message, an I_T Nexus Loss timer has been created for the SAS address, and there is no connection established with the destination SAS address, then this state shall check the I_T Nexus Loss timer, and:

- a) if the I_T Nexus Loss timer is running, then this state shall not stop the timer; and
- b) if the I_T Nexus Loss timer has expired, then this state shall process the Retry Open message as if it were an Unable To Connect message (see 1.2.2.3.4).

If this state receives a Retry Open (Retry) and an I_T Nexus Loss timer is running for the destination SAS address, then this state shall:

- a) stop the I_T Nexus Loss timer (if the timer has been running); and
- b) initialize the I_T Nexus Loss timer.

This state shall create a pending Tx Open message if:

- a) this state has a pending Tx Frame message or this state has received a Retry Open message;
- b) this state has fewer pending Tx Open messages than the number of PL_PM state machines (i.e., the number of phys in the port);
- c) there is no pending Tx Open message for the destination SAS address; and
- d) there is no connection established with the destination SAS address.

This state may create a pending Tx Open message if:

- a) this state has a pending Tx Frame message, or this state has received a Retry Open message and has not processed the message by sending a confirmation; and
- b) this state has fewer pending Tx Open messages than the number of PL_PM state machines.

This state shall have no more pending Tx Open messages than the number of PL_PM state machines.

If this state receives a Retry Open message and there are pending Tx Frame messages for which pending Tx Open messages have not been created, then this state should create a pending Tx Open message from the Retry Open message.

If this state does not create a pending Tx Open message from a Retry Open message (e.g., the current number of pending Tx Open messages equals the number of phys), then this state shall discard the Retry

Open message. A new pending Tx Open message may be created at a later time for the pending Tx Frame message that resulted in the Retry Open message.

If this state receives a Retry Open (Opened By Destination) message and the initiator and protocol arguments match those in the Tx Open messages that resulted in the Retry Open message, then this state may discard the Retry Open message and use the established connection to send pending Tx Frame messages as Tx Frame messages to the destination SAS address. If this state receives a Retry Open (Opened By Destination) message, then, if this state has a pending Tx Open slot available, this state may create a pending Tx Open message from the Retry Open message.

Note: if a connection is established by another port as indicated by a Retry Open (Opened By Destination) message, credit may not be granted for frame transmission. In this case this state may create a pending Tx Open message from a Retry Open message in order to establish a connection where credit is granted.

This state shall send a pending Tx Open message as a Tx Open message to a PL_PM state machine that has an enabled phy and does not have a connection established. If there is more than one pending Tx Open message, this state should send a Tx Open message for the pending Tx Open message that has been pending for the longest time first.

If this state creates a pending Tx Open message from one of the following messages:

- a) a Retry Open (Opened By Destination);
- b) a Retry Open (Opened By Other); or
- c) a Retry Open (Pathway Blocked).

then this state shall:

- a) create an Arbitration Wait Time timer for the pending Tx Open message;
- b) set the Arbitration Wait Time timer for the pending Tx Open message to the arbitration wait time argument from the Retry Open message; and
- c) start the Arbitration Wait Time timer for the pending Tx Open message.

When a pending Tx Open message is sent to a PL_PM state machine as a Tx Open message, the Tx Open message shall contain the following arguments to be used in an OPEN address frame:

- a) the initiator bit from the Transmit Frame request;
- b) the protocol from the Transmit Frame request;
- c) the connection rate from the Transmit Frame request;
- d) the initiator connection tag from the Transmit Frame request;
- e) the destination SAS address from the Transmit Frame request;
- f) the source SAS address from the Transmit Frame request;
- g) the pathway blocked count; and
- h) the arbitration wait time.

If a pending Tx Open message was created as the result of this state receiving a Transmit Frame request or a Retry Open (No Destination), Retry Open (Open Timeout Occurred), or Retry Open (Retry) message, then this state shall:

- a) set the pathway blocked count argument in the Tx Open message to zero; and
- b) set the arbitration wait time argument in the Tx Open message to zero or a vendor-specific value less than 8000h (see 7.12.3).

If a pending Tx Open message was created as the result this state receiving a Retry Open (Pathway Blocked) message, then this state shall set the pathway blocked count argument in the Tx Open message to the value of the pathway blocked count argument received with the message plus one, unless the pathway blocked count received with the argument is FFh.

If a pending Tx Open message was created as the result of this state receiving one of the following:

- a) a Retry Open (Opened By Destination) message;
- b) a Retry Open (Opened By Other) message; or
- c) a Retry Open (Pathway Blocked) message;

then this state shall set the arbitration wait time argument in the Tx Open message to be the value from the Arbitration Wait Time timer created as a result of the Retry Open message.

After this state sends a Tx Open message, this state shall discard the pending Tx Open message from which the Tx Open messages was created. After this state discards a pending Tx Open message, this state may create a new pending Tx Open message.

If this state receives a Connection Opened message and the initiator and protocol arguments match those in any pending Tx Frame messages, then this state may use the established connection to send pending Tx Frame messages as Tx Frame messages to the destination SAS address.

1.2.2.3.3 PL_OC2:Overall_Control state connection established

If this state receives a Connection Opened message or a Retry Open (Opened By Destination) message for a SAS address, and an I_T Nexus Loss timer has been created for the SAS address, then this state shall:

- a) stop the I_T Nexus Loss timer for the SAS address (if the timer has been running); and
- b) initialize the I_T Nexus Loss timer.

1.2.2.3.4 PL_OC2:Overall_Control state unable to establish a connection

If this state receives an Unable To Connect message or processes a Retry Open message as an Unable to Connect message then this state shall send a Transmission Status confirmation. Table 2 defines the confirmation to be sent for each message.

Table 2 — Confirmations from Unable To Connect or Retry Open messages

Message received	Confirmation to be sent
Retry Open (No Destination) ¹	Transmission Status (No Destination)
Retry Open (Open Timeout Occurred) ¹	Transmission Status (Open Timeout Occurred)
Retry Open (Open Timeout Occurred)	Transmission Status (Bad Destination)
Unable To Connect (Break Received)	Transmission Status (Break Received)
Unable To Connect (Connection Rate Not Supported)	Transmission Status (Connection Rate Not Supported)
Unable To Connect (Port Layer Request)	Transmission Status (Cancel Acknowledge)
Unable To Connect (Protocol Not Supported)	Transmission Status (Protocol Not Supported)
Unable To Connect (STP Resources Busy)	Transmission Status (STP Resources Busy)
Unable To Connect (Wrong Destination)	Transmission Status (Wrong Destination)
Note 1 if the Retry Open message was processed as an Unable To Connect message.	

If this state receives a Retry Open (No Destination), Retry Open (Open Timeout Occurred), or Retry Open (Pathway Blocked) message and the I_T Nexus Loss timer for the SAS address has expired, then this state shall perform the following:

- a) delete the I_T Nexus Loss timer for the SAS address;
- b) discard the Retry Open message;
- c) send a Transmission Status (I_T Nexus Loss) confirmation for the pending Tx Frame message from which the Retry Open message resulted;
- d) discard the pending Tx Frame message from which the Retry Open message resulted;

- e) if this state has any pending Tx Frame messages with the same destination SAS address and protocol as the Retry Open message, and this state has not sent a Tx Open message to a PL_PM state machine for the messages, then this state shall send a Transmission Status (I_T Nexus Loss) confirmation for each pending Tx Frame message and discard the pending Tx Frame messages and any corresponding pending Tx Open messages; and
- f) if this state has any pending Tx Frame messages with the same destination SAS address and protocol as the Retry Open message, and this state has sent a Tx Open message to a PL_PM state machine for a message, then this state shall send a Cancel message to each PL_PM state machine to which it has sent a Tx Open message. After receiving an Unable To Connect (Cancel Acknowledge) message from a PL_PM state machine in response to the Cancel message, then this state shall send a Transmission Status (I_T Nexus Loss) confirmation for each pending Tx Frame message and discard the pending Tx Frame messages and any corresponding pending Tx Open messages.

If this state receives an Unable To Connect (Connection Rate Not Supported), Unable To Connect (Protocol Not Supported), or Unable To Connect (STP Resources Busy) message and an I_T Nexus Loss timer is running for the SAS address, then this state shall:

- a) stop the I_T Nexus Loss timer (if the timer has been running); and
- b) initialize the I_T Nexus Loss timer.

The Transmission Status confirmation shall include the following as arguments:

- a) the tag;
- b) the destination SAS address; and
- c) the source SAS address.

This state shall discard the pending Tx Frame message for which the Transmission Status confirmation was sent.

1.2.2.3.5 PL_OC2:Overall_Control state connection management

If this state receives an Accept_Reject Opens request, then this state shall send an Accept_Reject Opens message to all phys in the port.

If this state receives an SMP Transmit Break request, then this state shall send an SMP Transmit Break message to the PL_PM state machine associated with the corresponding SMP transport state machine. If there is no PL_PM state machine associated with the request, the PM_OC state shall ignore the request.

If this state receives a Connection Closed message indicating that a connection with a destination SAS address is no longer open and this state has pending Tx Open messages, then this state may send a Tx Open message to the PL_PM state machine that sent the Connection Closed message.

If this state is a wide SSP port, then this state shall not reject an incoming connection request on one phy because it has an outgoing connection request on another phy.

If this state has no pending Tx Frame messages for a destination SAS address with which a PL_PM state machine has established a connection or this state has received a Disable Tx Frame message from a PL_PM state machine, then this state should send a Close Connection message to the PL_PM state machine.

1.2.2.3.6 PL_OC2:Overall_Control state frame transmission

In order to prevent live locks, If this state is a wide SSP port, has multiple connections established, and has a pending Tx Frame message, then this state shall send at least one Tx Frame message to a PL_PM state machine before sending a Close Connection message to the PL_PM state machine.

After this state receives a Connection Opened message from a PL_PM state machine, this state selects pending Tx Frame messages for the destination SAS address with the same initiator bit and protocol arguments, and, optionally, the same connection rate argument, and sends the messages to the PL_PM state machine as Tx Frame messages.

This state may send a Tx Frame message to any PL_PM state that has established a connection with the destination SAS address when the initiator and protocol arguments match those in the Tx Frame message.

This state may send a Tx Frame message containing a COMMAND frame for a destination SAS address to a PL_PM state machine while waiting for acknowledgement from the link layer for Tx Frame messages containing COMMAND frames for the same destination SAS address from different PL_PM state machines.

This state shall not send a Tx Frame message containing a TASK frame for a task that only affects an I_T_L_Q (e.g., an ABORT TASK or QUERY TASK task management function (see SAM-3)) until this state has received acknowledgement from the link layer for all Tx Frame messages with the same I_T_L_Q.

The following arguments shall be included with the Tx Frame message:

- a) the frame to be transmitted; and
- b) Balance Required or Balance Not Required.

A Balance Not Required argument may only be included if:

- a) the request was a Transmit Frame (Non-interlocked) request (i.e., the request included a DATA frame); and
- b) the last Tx Frame message sent to this PL_PM state machine while this connection has been established was for a DATA frame having the same logical unit number and tag value as the DATA frame in this Tx Frame message.

If a Balance Not Required argument is not included in the Tx Frame message, then a Balance Required argument shall be included.

Once this state has sent a Tx Frame message containing a DATA frame to a PL_PM state machine, this state shall not send a Tx Frame message containing a DATA frame with the same I_T_L_Q to another PL_PM state machine until this state receives acknowledgement from the link layer for all Tx Frame messages containing DATA frames with the same I_T_L_Q. Read DATA frames and write DATA frames for the same I_T_L_Q nexus maybe transmitted and received simultaneously on the same or different phys.

If this state is an SMP initiator port, then this state shall send the Tx Frame message containing the SMP REQUEST frame to the PL_PM state machine on which the connection was established for the Tx Open message. If this state is an SMP target port, then this state shall send the Tx Frame message containing the SMP REQUEST frame to the PL_PM state machine on which the connection was established for the Tx Open message. See 7.17 for additional information about SMP connections.

Characteristics of STP connections are defined by SATA (also see 7.16).

If this state receives a Disable Tx Frames message from a PL_PM state machine, then this state should send no more Tx Frame messages to that state machine.

1.2.2.3.7 PL_OC2:Overall_Control state frame transmission cancellations

Cancel requests received from the transport layer are used by this state to cancel previous Transmit Frame requests. A Cancel request shall include the following arguments:

- a) the destination SAS address; and
- b) the tag.

If this state receives a Cancel request and a Tx Frame message for the Transmit Frame request has not been sent to a PL_PM state machine, then this state shall:

- a) discard the Transmit Frame request; and
- b) send a Transmission Status (Cancel Acknowledge) confirmation to the transport layer.

If this state receives a Cancel request and a Tx Frame message for the Transmit Frame request has been sent to a PL_PM state machine, then this state shall send a Cancel message to the PL_PM state machine.

1.2.2.3.8 Transition PL_OC2:Overall_Control to PL_OC1:Idle

This transition shall occur after:

- a) all pending Tx Frame messages have been discarded and I_T Nexus Loss timers have been deleted as the result of receiving a HARD_RESET Received confirmation; or
- b) a Phy Disabled confirmation is received from all of the link layers in the port;

1.2.3 PL_PM (port layer phy manager) state machine

1.2.3.1 PL_PM overview

A PL_PM state machine:

- a) receives messages from the PL_OC state machine;
- b) sends requests to the link layer;
- c) receives confirmations from the link layer;
- d) sends confirmations to the transport layer;
- e) sends messages to PL_OC state machine;
- f) has an Arbitration Wait Time timer;
- g) may have a Bus Inactivity Time Limit timer; and
- h) may have Maximum Connect Time Limit timer.

This state machine consist of the following states:

- a) PL_PM1:Idle (see 1.2.3.2) (initial state);
- b) PL_PM2:ReqWait (see 1.2.3.3);
- c) PL_PM3:Connected (see 1.2.3.4); and
- d) PL_PM4:Wait_For_Close (see 1.2.3.5).

After power on this state machine shall start in the PL_PM1:Idle state.

This state shall maintain the timers listed in Table 3.

Table 3 — PL_PM state machine timers

Timer	Initial value
Bus Inactivity Time Limit timer	The value in the BUS INACTIVITY TIME LIMIT field in the Disconnect-Reconnect mode page (see 10.1.6.1)
Maximum Connect Time Limit timer	The value in the MAXIMUM CONNECT TIME LIMIT field in the Disconnect-Reconnect mode page (see 10.1.6.1)

Figure 3 and figure 4 show the PL_PM state machine.

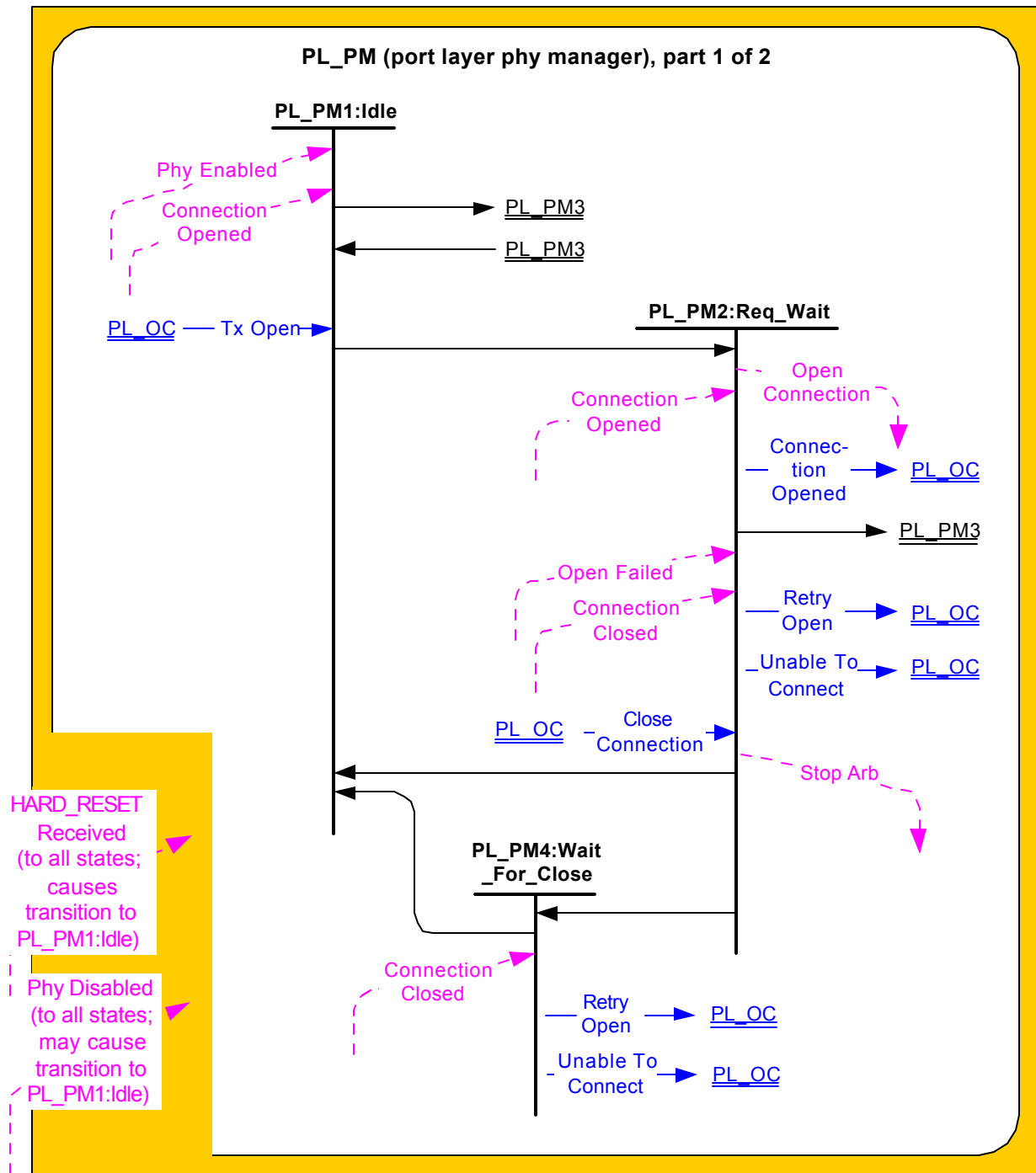


Figure 3 — PL_PM (port layer phy manager) state machine (part 1)

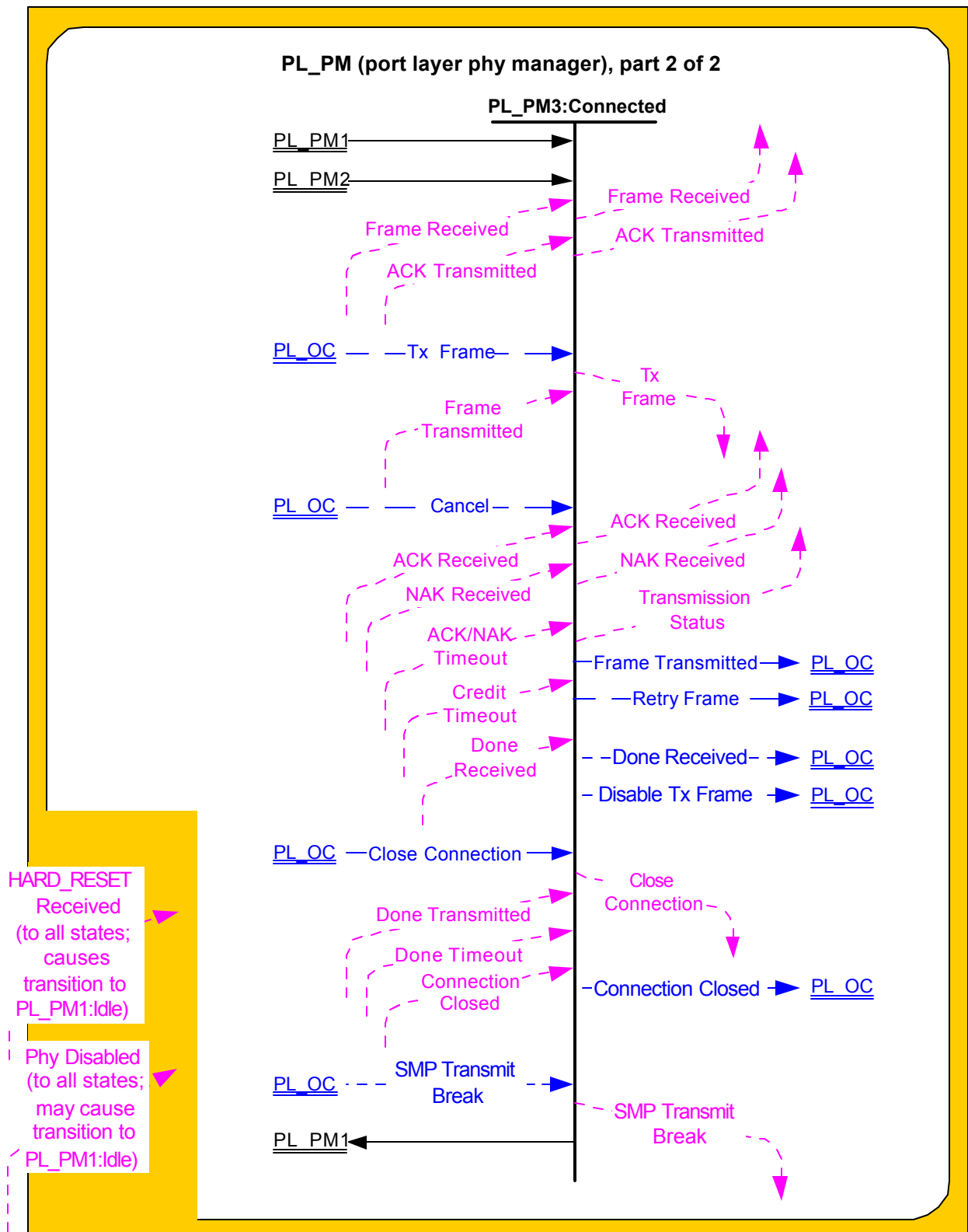


Figure 4 — PL_PM (port layer phy manager) state machine (part 2)

1.2.3.2 PL_PM1:Idle state

1.2.3.2.1 PL_PM1:Idle state description

This is the initial state of the PL_PM state machine.

1.2.3.2.2 Transition PL_PM1:Idle to PL_PM2:Req_Wait

This transition shall occur after:

- a) a Phy Enabled confirmation is received; and
- b) a Tx Open message is received from the PL_OC state machine.

1.2.3.2.3 Transition PL_PM1:Idle to PL_PM3:Connected

This transition shall occur after a Connection Opened confirmation is received.

1.2.3.3 PL_PM2:Req_Wait state

1.2.3.3.1 PL_PM2:Req_Wait state overview

This state sends an Open Connection request to the link layer and waits for a confirmation. This state sends and receives connection management messages to and from the PL_OC state machine.

If this state receives a HARD_RESET Received confirmation, then this state shall terminate all operations.

1.2.3.3.2 PL_PM2:Req_Wait establishing a connection

After this state receives a Tx Open message, this state shall:

- a) create an Arbitration Wait Time timer;
- b) initialize the Arbitration Wait Time timer to the arbitration wait time argument received with the Tx Open message;
- c) start the Arbitration Wait Time timer; and
- d) send an Open Connection request to the link layer.

The Open Connection request shall contain the following arguments from the Tx Open message to be used in an OPEN address frame:

- a) the initiator bit;
- b) the protocol;
- c) the connection rate;
- d) the initiator connection tag;
- e) the destination SAS address;
- f) the source SAS address; and
- g) the pathway blocked count;
- h) the arbitration wait time.

1.2.3.3.3 PL_PM2:Req_Wait connection established

If this state receives a Connection Opened confirmation, then this state shall send a Connection Opened message to the PL_OC state machine.

If this state receives a Connection Opened confirmation and the confirmation was not in response to an Open Connection request from this state (i.e., the connection was established in response to an OPEN address frame from another device), then this state shall discard any Open Connection request and send a Retry Open message to the PL_OC state machine. If the Connection Opened confirmation was from the destination of the Open Connection request, then this state shall send a Retry Open (Opened By Destination) message. If the Connection Opened confirmation was from a destination other than the destination of the Open Connection request, then this state shall send a Retry Open (Opened By Other) message.

A Retry Open (Opened By Destination) or Retry Open (Opened By Other) message shall contain the following arguments:

- a) the initiator bit received with the Tx Open message;
- b) the protocol received with the Tx Open message;
- c) the connection rate received with the Tx Open message;
- d) the initiator connection tag received with the Tx Open message;
- e) the destination SAS address received with the Tx Open message;
- f) the source SAS address received with the Tx Open message;
- g) the pathway blocked count argument received with the Tx Open message; and
- h) the content of the Arbitration Wait Time timer as an arbitration wait time argument.

1.2.3.3.4 PL_PM2:Req_Wait unable to establish a connection

If this state receives an Open Failed confirmation, then this state shall send either a Retry Open message or an Unable To Connect message to the PL_OC state machine.

Table 4 defines the message to be sent for each Open Failed confirmation.

Table 4 — Messages from Open Failed confirmations

Confirmation received	Message to be sent
Open Failed (Pathway Blocked)	Retry Open (Pathway Blocked)
Open Failed (Retry)	Retry Open (Retry)
Open Failed (Bad Destination)	Unable To Connect (Bad Destination)
Open Failed (Break Received)	Unable To Connect (Break Received)
Open Failed (Connection Rate Not Supported)	Unable To Connect (Connection Rate Not Supported)
Open Failed (No Destination)	Unable To Connect (No Destination)
Open Failed (Protocol Not Supported)	Unable To Connect (Protocol Not Supported)
Open Failed (STP Resources Busy)	Unable To Connect (STP Resources Busy)
Open Failed (Wrong Destination)	Unable To Connect (Wrong Destination)

A Retry Open message shall include the following arguments:

- a) the initiator bit received with the Tx Open message;
- b) the protocol received with the Tx Open message;
- c) the connection rate received with the Tx Open message;
- d) the initiator connection tag received with the Tx Open message;
- e) the destination SAS address received with the Tx Open message;
- f) the source SAS address received with the Tx Open message;
- g) the pathway blocked count argument received with the Tx Open message; and
- h) the content of the Arbitration Wait Time timer as an arbitration wait time argument.

An Unable To Connect message shall include the following arguments:

- a) the initiator connection tag received with the Tx Open message;
- b) the destination SAS address received with the Tx Open message; and
- c) the source SAS address received with the Tx Open message.

1.2.3.3.5 PL_PM2:Req_Wait connection management

If this state receives a Close Connection message from the PL_OC state machine and a Connection Opened confirmation has not been received from the link layer, then this state shall send a Stop Arb request to the link layer.

If this state receives a Close Connection message from the PL_OC state machine and a Connection Opened confirmation has been received from the link layer, then this state shall send a Close Connection request to the link layer.

If this state receives a Connection Closed confirmation, then this state shall send a Connection Closed message to the PL_OC state machine.

If this state receives a Done Timeout confirmation, then this state shall send a Connection Closed message to the PL_OC state machine.

1.2.3.3.6 Transition PL_PM2:Req_Wait to PL_PM1:Idle

This transition shall occur after:

- a) a Retry Open message is sent to the PL_OC state machine;
- b) an Unable To Connect message is sent to the PL_OC state machine;
- c) all operations have been terminated after a HARD_RESET Received confirmation is received; or
- d) a Phy Disabled confirmation is received.

1.2.3.3.7 Transition PL_PM2:ReqWait to PL_PM3:Connected

This transition shall occur after a Connection Opened confirmation is received.

1.2.3.3.8 Transition PL_PM2:Req_Wait to PL_PM4:Wait_For_Close

This transition shall occur after one of the following confirmations is received:

- a) an Open Failed (Open Timeout Occurred); or
- b) an Open Failed (Port Layer Request).

1.2.3.4 PL_PM3:Connected state**1.2.3.4.1 PL_PM3:Connected state description**

If the protocol for the connection is SSP, and this state is an SSP target port, and the value in the MAXIMUM CONNECT TIME LIMIT field in the Disconnect-Reconnect mode page (see 10.1.6.1) is not zero, then, upon entry into this state, this state shall:

- a) create a Maximum Connect Time Limit timer;
- b) initialize the Maximum Connect Time Limit timer; and
- c) start the Maximum Connect Time Limit timer.

If the protocol for the connection is SSP, and this state is an SSP target port, and the value in the MAXIMUM CONNECT TIME LIMIT field in the Disconnect-Reconnect mode page (see 10.1.6.1) is zero, then this state shall not create a Maximum Connect Time Limit timer (i.e., there is no maximum connect time limit).

Other SAS ports may implement a Maximum Connect Time Limit timer in a vendor-specific manner.

If the protocol for the connection is SSP, and this state is an SSP target port, and the value in the BUS INACTIVITY TIME LIMIT field in the Disconnect-Reconnect mode page (see 10.1.6.1) is not zero, then, upon entry into this state, this state shall:

- a) create a Bus Inactivity Time Limit timer;
- b) initialize the Bus Inactivity Time Limit timer; and
- c) not start the Bus Inactivity Time Limit timer.

If the protocol for the connection is SSP, and this state is an SSP target port, and the value in the BUS INACTIVITY TIME LIMIT field in the Disconnect-Reconnect mode page (see 10.1.6.1) is zero, then this state shall not create a Bus Inactivity Time Limit timer (i.e., there is no maximum bus inactivity time limit).

Other SAS ports may implement a Bus Inactivity Time Limit timer in a vendor-specific manner.

If a Bus Inactivity Time Limit timer has been created and this state receives a Tx Frame message from the PL_OC state machine, then this state shall:

- a) stop the Bus Inactivity Time Limit timer, if it is running; and
- b) initialize the Bus Inactivity Time Limit timer.

If this state receives a Tx Frame message from the PL_OC state machine, this state shall send a Tx Frame request to the link layer. The following arguments from the Tx Frame message shall be included with the Tx Frame request:

- a) the frame to be transmitted; and
- b) if this state is an SSP port, Balance Required or Balance Not Required.

For STP connections, this state connects the STP transport layer to the STP link layer.

If a Bus Inactivity Time Limit timer has been created and this state receives an ACK Received or NAK Received confirmation, then this state shall start the Bus Inactivity Time Limit timer. If the Bus Inactivity Time Limit timer expires before this state receives a Tx Frame message from the PL_OC state machine, then this state shall send a Close Connection request.

If a Maximum Connect Time Limit timer has been created and this state receives an ACK Received or NAK Received confirmation, then this state shall check the Maximum Connect Time Limit timer. If the Maximum Connect Time Limit timer has expired, then this state shall send a Close Connection request.

If this state receives a Tx Frame message from the PL_OC state machine after sending a Close Connection request but before receiving a Connection Closed confirmation, then this state shall send a Retry Frame message to the PL_OC state machine.

If this state receives a Frame Received confirmation, then this state shall send a Frame Received confirmation to the transport layer. The confirmation shall include the arguments received with the confirmation (e.g., the frame).

If this state receives an ACK Transmitted confirmation, then this state shall send an ACK Transmitted confirmation to the transport layer.

If this state receives a Frame Transmitted confirmation, then this state shall send a Transmission Status (Frame Transmitted) confirmation to the transport layer and a Frame Transmitted message to the PL_OC state machine.

If this state receives an ACK Received confirmation, then this state shall send an ACK Received confirmation to the transport layer.

If this state receives a NAK Received confirmation, then this state shall send an NAK Received confirmation to the transport layer.

If this state receives an ACK/NAK Timeout confirmation, then this state shall send a Transmission Status (ACK/NAK Timeout) confirmation to the transport layer.

If this state receives a Connection Closed confirmation after sending a Transmission Status (Frame Transmitted) confirmation, but before this state receives an ACK Received or NAK Received confirmation, then this state shall send a Transmission Status (Connection Lost Without ACK/NAK) confirmation to the transport layer.

If this state receives a Connection Closed confirmation after sending a Transmit Frame request but before receiving a Frame Transmitted confirmation, then this state shall send a Retry Frame message to the PL_OC state machine.

If this state receives a Cancel message from the PL_OC state machine, then this state shall discard the Tx Frame message and send a Transmission Status (Cancel Acknowledge) confirmation to the transport layer.

If this state receives a Credit Timeout confirmation, then this state shall send a Retry Frame message to the PL_OC state machine.

A Retry Frame message shall include the following arguments from the Tx Frame message:

- a) the initiator bit;
- b) the protocol;
- c) the connection rate;
- d) the initiator connection tag;
- e) the destination SAS address;
- f) the source SAS address; and
- g) the frame.

If this state receives a Done Received (ACK/NAK Timeout) or Done Transmitted, then this state shall send a Disable Tx Frames message to the PL_OC state machine.

If this state receives a HARD_RESET Received confirmation, then this state shall terminate all operations.

1.2.3.4.2 Transition PL_PM3:Connected to PL_PM1:Idle

This transition shall occur after:

- a) a Connection Closed confirmation is received; or
- b) all operations are terminated after a HARD_RESET Received confirmation is received.

1.2.3.5 PL_PM4:Wait_For_Close state

1.2.3.5.1 PL_PM4:Wait_For_Close state description

After this state receives a Connection Closed confirmation, and if this state was entered as the result of the PL_PM2:Req_Wait state receiving an Open Failed (Open Timeout Occurred) confirmation, then this state shall send a Retry Open (Open Timeout Occurred) message to the PL_OC state machine. The Retry Open message shall include the following arguments:

- a) the initiator bit received with the Tx Open message;
- b) the protocol received with the Tx Open message;
- c) the connection rate received with the Tx Open message;
- d) the initiator connection tag received with the Tx Open message;
- e) the destination SAS address received with the Tx Open message;
- f) the source SAS address received with the Tx Open message;
- g) the pathway blocked count argument received with the Tx Open message; and
- h) the content of the Arbitration Wait Time timer as an arbitration wait time argument.

After this state receives a Connection Closed confirmation, and if this state was entered after the PL_PM2:Req_Wait state received an Open Failed (Port Layer Request) confirmation (i.e., as the result of the PL_PM2:Req_Wait state sending a Stop Arb request), then this state shall send an Unable to Connect (Port Layer Request) message to the PL_OC state machine.

The Unable To Connect message shall include the following arguments:

- a) the initiator connection tag received with the Tx Open message;
- b) the destination SAS address received with the Tx Open message; and
- c) the source SAS address received with the Tx Open message.

If this state receives a HARD_RESET Received confirmation, then this state shall terminate all operations.

1.2.3.5.2 Transition PL_PM4:Wait_For_Close to PL_PM1:Idle

This transition shall occur after:

- a) a Retry Open or Unable To Connect message is sent to the PL_OC state machine; or
- b) all operations are terminated after a HARD_RESET Received confirmation is received.