

8 Port Layer Working Draft from SAS r00f

8.1 Overview

The port layer (PL) state machines interface with one or more SAS link layer state machines and one or more SSP, SMP, and STP transport layer state machines to establish port connections and disconnections. The port layer state machines also interpret or pass transmit and receive data, commands, and confirmations between the link and transport layers.

Figure 1 shows the relationship of the port layer to the transport and link layers.

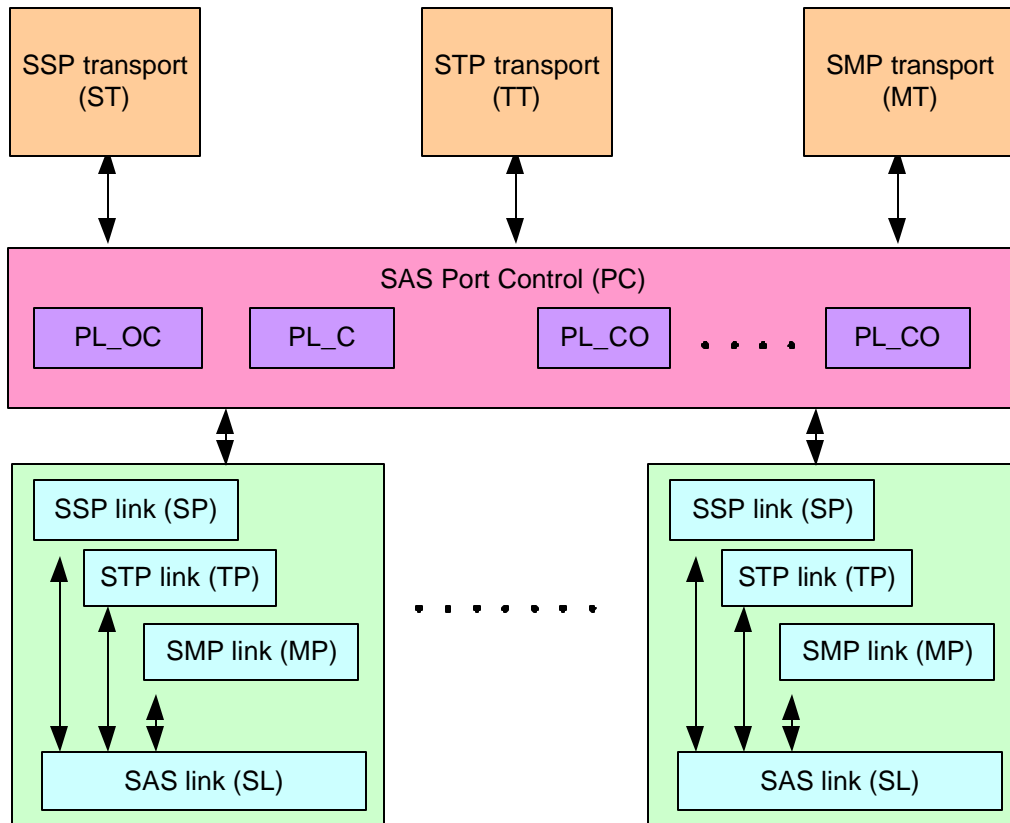


Figure 1. SAS port layer position

Three state machines running in parallel plus several commonly accessible counter/timers form the port layer.

The PL state machines are:

- Connection (PL_C state machine);
- Overall Control (PL_OC state machine); and
- Connected (PL_CO state machine).

The PL_C state machine's purpose is to:

- Request or retry a connection sequence via the link layer and handle exception conditions.

The PL_OC state machine's purpose is to:

- Receive Transmit Frame requests from the SSP, SMP and STP transport layers.
- If not connected, initiate a connection sequence;
- If /(When) connected, request a frame transmission by the PL_CO state machine and notify the transport layer when the frame has been transmitted (or an error occurred);
- For target devices only, monitor the bus inactivity time timer, the maximum connect time timer and the maximum burst size counter and initiate a port disconnection if specified limits are exceeded; and
- Execute the Cancel and Open_Reject Opens transport layer commands.

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The PL_CO state machine's purpose is to:

- a) Maintain a connected state for each phy (i.e., a different state machine for each phy);
- b) Request a frame transmission by the link layer, when requested by the PL_OC state machine, and notify the PL_OC when the frame has been transmitted (or an error occurred);
- c) Receive frame transmitted and frame received confirmation statuses from the link layer, and pass these statuses to the transport layer;
- d) Pass transmit and receive frames between the transport and the link layer; and
- e) Initialize and utilize the I_T nexus loss timer, the arbitration wait time timer, and the pathway blocked counter.

The port layer contains the following timers/counters for each phy which are accessible by all states:

- a) bus inactivity time timer;
- b) maximum connect time timer;
- c) maximum burst size counter;
- d) I_T nexus loss timer;
- e) arbitration wait time (AWT) timer; and
- f) pathway blocked counter.

The PL_OC state machine contains one state:

- a) PL_OC1:Overall Control

The PL_C state machine contains these states:

- a) PL_C1:Idle;
- b) PL_C2: SelectPhy;
- c) PL_C3: ReqWait;
- d) PL_C4:Check I_T Nexus Timer; and
- e) PL_C5:OpenFailed.

The PL_CO state machine contains two states:

- a) PL_CO1:Idle; and
- b) PL_CO2:Connected

Figure 2 shows the PL_C state machine.

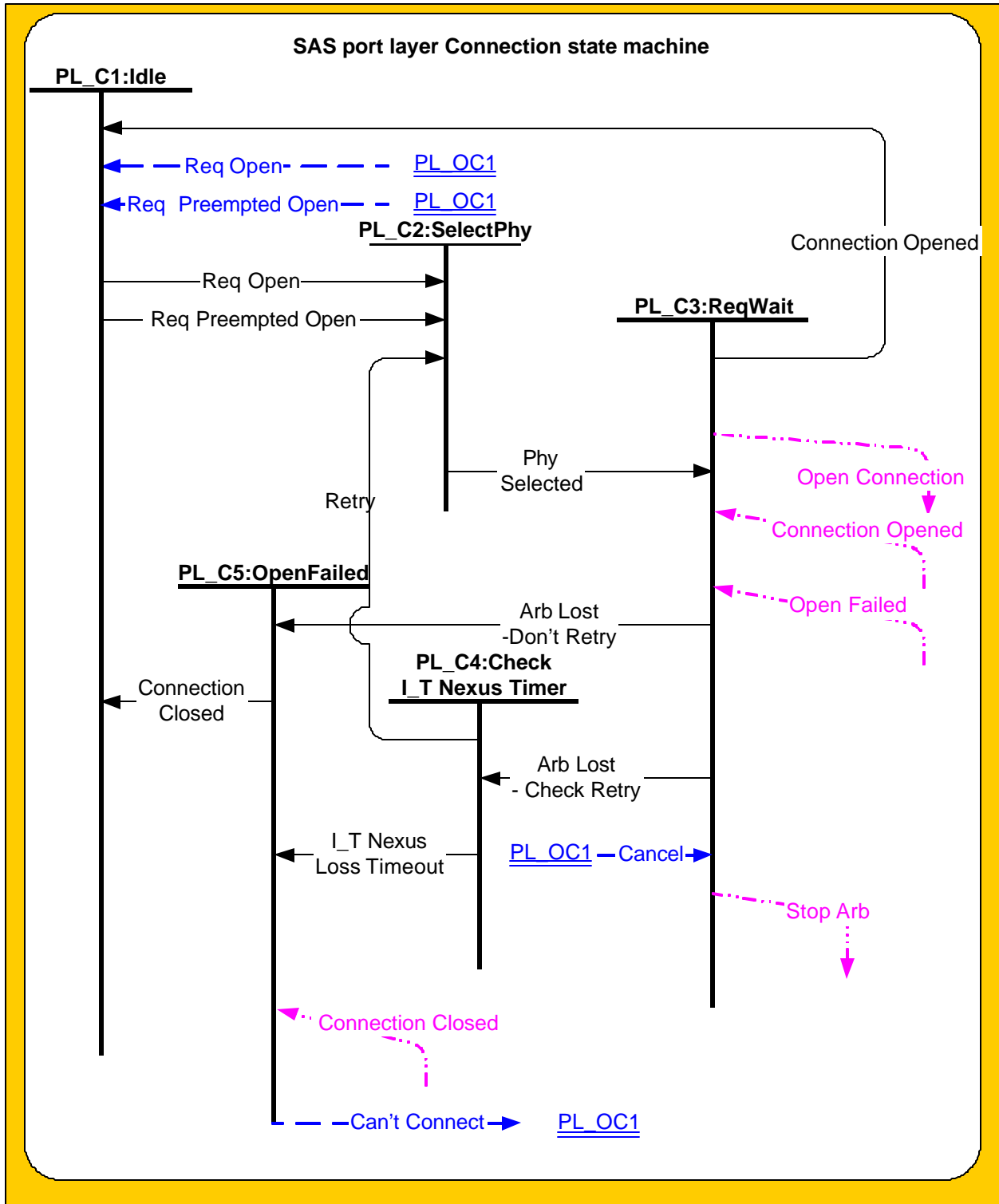


Figure 2. Port layer PL_C state machine

Figure 3 shows the PL_OC state machine.

SAS port layer Overall Control state machine

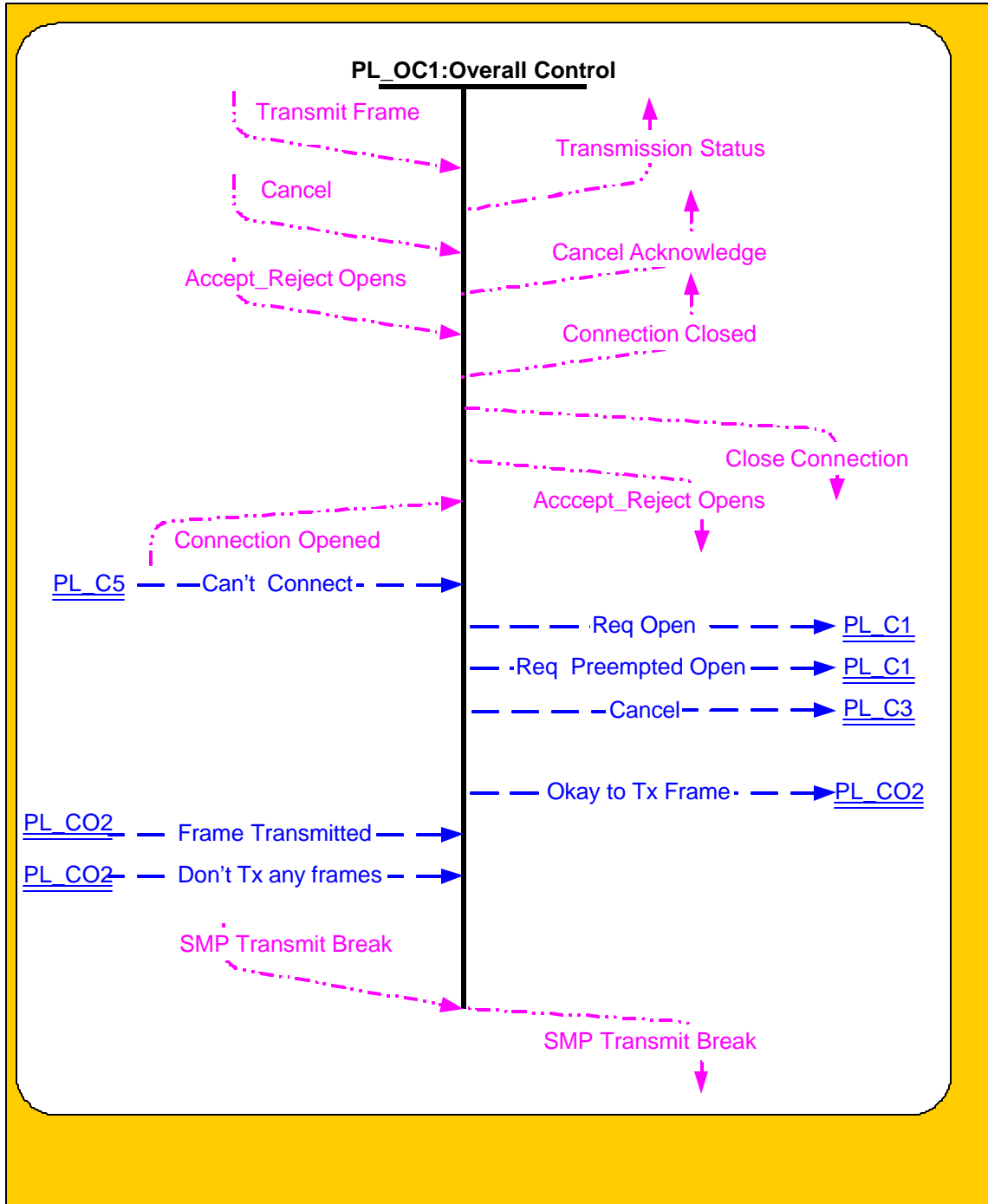


Figure 3. Port layer PL_OC state machine

Figure 4 shows the PL_CO state machine.

SAS port layer connected state machines

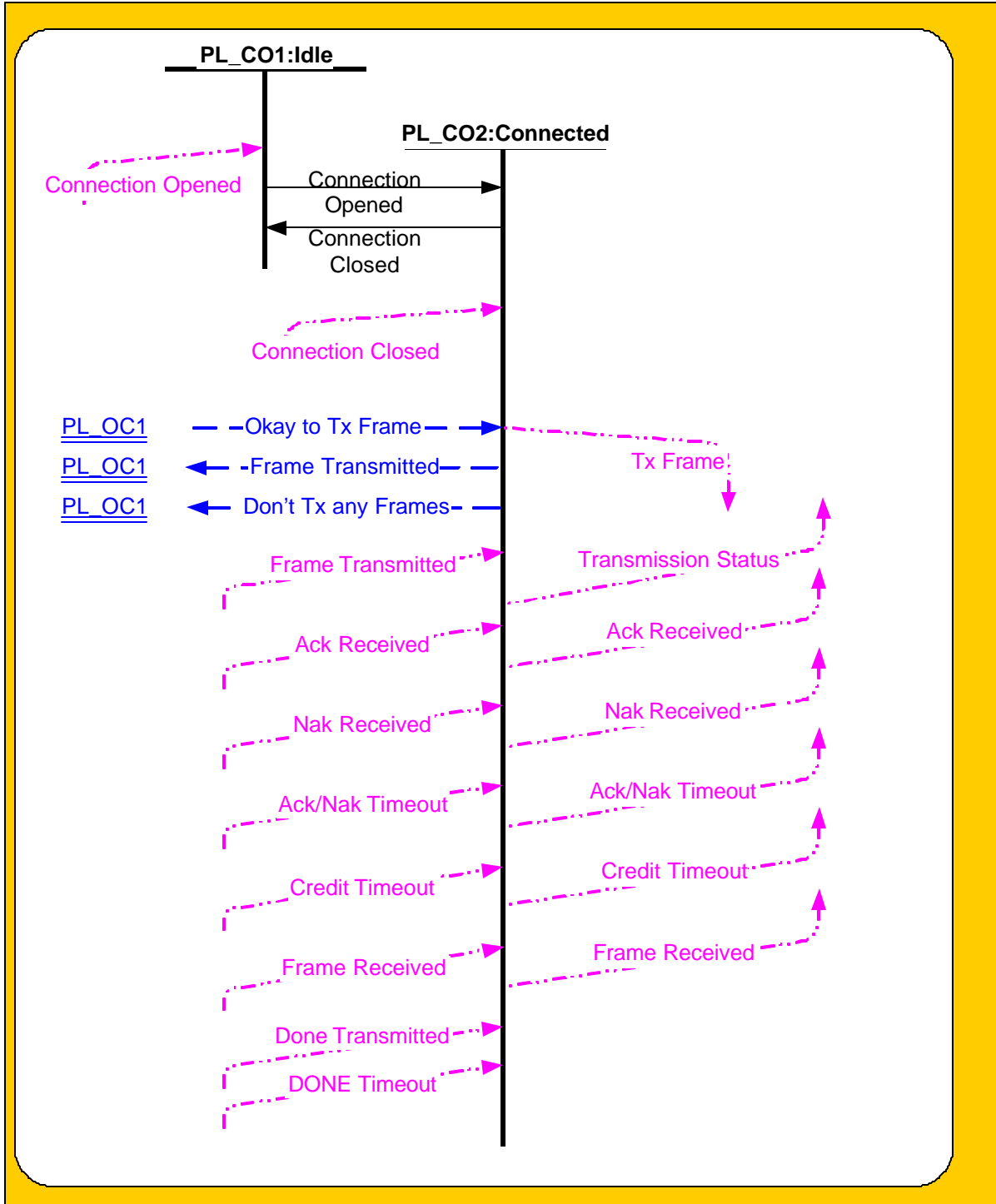


Figure 4. Port layer PL_CO state machine

8.2 Port Layer timers/counters descriptions

8.2.1 Bus inactivity time timer (see 10.1.1.2)

This timer is initialized and monitored by the PL_OC state machine during the current connection and before a DONE is transmitted.

8.2.2 Maximum connect time timer (see 10.1.1.3)

This timer is initialized and monitored by the PL_OC state machine during the current connection.

8.2.3 Maximum burst size counter (see 10.1.1.4)

This counter is initialized and monitored by the PL_OC state machine during the current connection. **Editors Note : who increments this counter**

8.2.4 I_T Nexus loss timer (see 10.1.2)

This timer is initialized and monitored by the PL_C state machine while trying to open a connection.

8.2.5 Arbitration wait time (AWT) timer (see 7.5.3 and 7.11.3)

This timer value is passed to the link layer by the PL_C state machine as an argument in its Open Connection request. The timer shall be initialized as described in 7.11.3.

8.2.6 Pathway blocked counter

The pathway blocked counter counts the number of Open Failed(Pathway Blocked) confirmations received from the link layer. This counter is initialized, and incremented by the PL_C state machine. The pathway blocked counter value is passed to the link layer by the PL_C state machine as an argument in its Open Connection request. The PL_C state machine shall not increment the pathway blocked counter past FFh.

8.3 PL_OC State Machine

8.3.1 PL_OC1:Overall Control state

8.3.1.1 State Description

This state shall receive multiple Transmit Frame requests from one or more transport layers. This state machine determines the order in which these requests are processed. This state machine shall service one Transmit Frame request per phy at a time. If multiple phys exist for this port, this state may establish multiple connections to different destination SAS addresses simultaneously and may transmit and receive via the different phys simultaneously.

This state receives either a Transmit Frame(Interlocked) or Transmit Frame(Non Interlocked) request that includes the following arguments:

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

If a Transmit Frame request was received from any transport layer and if a connection is open to the destination SAS address, this state determines which frame to transmit and sends an Okay to Tx Frame parameter to the PL_CO state machine.

This State machine shall generate a Okay to TX Frame parameter with a balance required argument to the PL_CO state machine when: **Editors note ; this is repeated in 7.14.5 Interlocked frames—should be here or both?**

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- a) A Transmit Frame(Interlocked) request is received from the transport layer or;
- b) Any Transmit Frame(Non Interlocked) request following a Transmit Frame(Interlocked) request from the transport layer; or
- c) Any Transmit Frame(Non Interlocked) request with a different Tag value in the Frame Header from the previous Transmit Frame(Non Interlocked) request

This state machine shall generate a Okay to TX Frame parameter with a balance not required argument to the PL_CO state machine when: **Editors note ; this is repeated in 7.14.5 –should be here or both?**

- a) A Transmit Frame(Non Interlocked) request is received from the transport layer that does not follow a Transmit Frame(Interlocked) request or has the same Tag value in the Frame Header that the preceding Transmit Frame(Non Interlocked) request had.

If multiple phy's exist, this state may then check for additional Transmit Frame requests to different destination SAS addresses.

After receiving a Frame Transmitted parameter from the PL_CO state machine, this state shall send a Transmission Status(Frame Transmitted) confirmation to the transport layer.

If a Connection Closed confirmation is received from the link layer after a Okay to Tx Parameter is sent but before a Frame Transmitted parameter is received, this state shall terminate the Transmit Frame request and send a Transmission Status(Connection Lost) confirmation to the transport layer.

After receiving a Frame Transmitted parameter from the PL_CO state machine, this state shall check if any additional Transmit Frame requests exist to this destination SAS Address. If no more Transmit Frame requests exist to the destination SAS Address, this state shall issue a Close Connection request to the link layer (see 7.14.7.7.2). If this is an initiator port and there is an additional Transmit Frame request to the destination SAS Address, then an Okay to Tx Frame parameter for this Transmit Frame request may be sent to the PL_CO state machine. If this is a target port and there is an additional Transmit Frame request to this destination SAS Address, this state shall check if any of the applicable timers/counters have exceeded the specified limits. If the timers/counters have not exceeded the specified limits, then an Okay to Tx Frame parameter may be sent to the PL_CO state machine. If the timers/counters have exceeded the specified limits, this state machine shall send a Close Connection request to the link layer.

The transport layer responses for any sequence of frame transmissions (e.g. multiple Non Interlocked data frame transmissions) is instantaneous (i.e., if continuous frame transmissions for the established I_T_L_Q connection is selected) then the next Transmit Request from the transport layer for that I_T_L_Q shall be available when the Transmission Status(Frame Transmitted) confirmation for the previous frame is sent to the transport layer by the port layer. **Editors note – do we need this statement**

If a Transmit Frame request was received from any transport layer and if a connection is not open to the destination SAS address, this state shall send either a Req Open or Req Preempted Open parameter to the PL_C state machine. The Req Open parameter shall cause the AWT timer to be initialized when the PL_C2 state is entered. The Req Preempted Open parameter shall cause no change to the AWT timer value when the PL_C2 state is entered. The Req Preempted parameter is used to establish a connection that had been previously requested but had been preempted by a connection opened to this SAS Address from another source SAS Address because of a selected (i.e, a Connection Opened(By SSP or SMP or STP Destination confirmation is received) path.

When the PL_C state machine sends an Open Connection request to the link layer. one of the following occurs:

- a) The connection is opened for this destination SAS Address as a result of the Open Connection request (i.e., a Connection Opened(By SSP or SMP or STP Source) confirmation is received) and as a result the requested frame transmission may occur;
- b) The connection is opened with this port from the destination SAS Address requested in the Open Connection request (i.e, a Connection Opened(By SSP or SMP or STP Destination) confirmation is received) and as a result the requested frame transmission may occur;

- c) The connection is opened with this port from a different destination SAS Address requested in the Open Connection request (i.e, a Connection Opened(By SSP or SMP or STP Destination) confirmation is received) and as a result the requested frame transmission shall not occur. This state may reexamine the Transmit Frame requests for this transport layer to determine if any transmit requests exist for this destination SAS Address. If transmit requests exist for this different destination SAS Address, these frames may be transmitted during this connection. The original requested frame transmission shall be saved with a Preempted status for priority and AWT control; or
- d) the connection is not established and as a result one of the following confirmations shall be sent to the transport layer based on the Can't Connect(Open Failed-xx) parameter received from the PL_C state machine:
 - a) Transmission Status (Open Failed – Wrong Destination);
 - b) Transmission Status (Open Failed – Protocol Not Supported);
 - c) Transmission Status (Open Failed – Pathway Blocked);
 - d) Transmission Status (Open Failed – Open Timeout Occurred);
 - e) Transmission Status (Open Failed – Port Layer Request);
 - f) Transmission Status (Open Failed – Break Received);
 - g) Transmission Status (Open Failed – No Destination);
 - h) Transmission Status (Open Failed – Bad Destination);
 - i) Transmission Status (Open Failed – STP Resources Busy);
 - j) Transmission Status (Open Failed – I_T Nexus Loss Timeout); or
 - k) Transmission Status (Open Failed – Physical Not Ready)

When a connection is closed, this state shall send a Connection Closed confirmation to the transport layer.

If a Don't Tx any frames parameter is received from the PL_CO2 state, this state shall not send another Okay to Tx Frame parameter to the PL_CO state machine until after a Connection Closed confirmation has been received from the link layer.

If this state receives a Connection Opened confirmation from the link layer and there are no pending Transmit Frame requests to this source SAS address, this state shall send a Close Connection request to the link layer (see 7.14.7).

If this state receives a Cancel request for a specific Transmit Frame request from the transport layer and if this specified Transmit Frame request has not been initiated by this state, this state will terminate this Transmit Frame request and send a Cancel Acknowledge(No Transmit Frame) confirmation to the Transport layer.

If this state receives a Cancel request for a specific Transmit Frame request from the transport layer and if this specified Transmit Frame request has been initiated by this state and if a connection has been opened, this state will send a Close Connection request to the link layer. When the connection has been closed, this state will send a Cancel Acknowledge(Frame Canceled) confirmation to the transport layer for this Transmit Frame request.

If this state receives a Cancel request for a specific Transmit Frame request from the transport layer and if this specified Transmit Frame request has been initiated by this state and if a connection sequence is in process, this state will send a Cancel parameter to the PL_C state machine. When the PL_C state machine has terminated the connection sequence and returned a Can't Connect(Open Failed – Port Layer Request) parameter, this state will terminate processing of this Transmit Frame request, and send a Cancel Acknowledge(Open Failed – Port Layer Request) confirmation to the transport layer for this Transmit Frame request.

If this state receives a Accept_Reject Opens request from the transport layer, this state will send this request to the link layer.

This state initializes the following counters/timers for each phy when a Connection Opened confirmation is received from the link layer:

- a) maximum connect time timer;
- b) maximum burst size counter; and
- c) bus inactivity timer

After each Frame Transmitted parameter received from the PL_CO state machine, if any of these counter/timers reaches the specification limit a Close Connection sequence will be initiated if an additional frame is to be transmitted to this destination SAS address. The PL_OC state machine will later open a connection to continue with the frame transmissions.

8.4 PL_C state machine

8.4.1 PL_C1:Idle state

8.4.1.1 State description

The PL_C1:Idle state is the idle state for the port layer Connection state machine.

This state is entered when a connection is opened or when a connection is closed.

This state is exited when the PL_OC state machine initiates a connection sequence via a Req Open or Req Preempted Open parameter transfer to the PL_C1 state.

8.4.1.2 Transition PL_C1:Idle to PL_C2:SelectPhy

The PL_C1:PL_C2 transition shall occur after the PL_OC state machine initiates a connection sequence via a Req Open or Req Preempted Open parameter transfer to the PL_C1 state.

8.4.2 PL_C2:SelectPhy state

8.4.2.1 State description

When this state is entered from the PL_C1:Idle state, this state shall:

- e) Select the phy through which the connection request is to be made;
- f) Initialize this phy's I_T nexus loss time timer;
- g) Initialize this phy's arbitration wait timer (AWT) if a Req Open parameter was sent from the PL_OC state machine;
- h) Not initialize this phy's AWT if a Req Preempted Open parameter was sent from the PL_OC state machine; and
- i) Initialize the pathway blocked count counter

When this state is entered from the PL_C4 state, this state may select a different phy (if the port is a wide port) to attempt another Open Connection request. If only one phy exists, the same phy shall be re-specified.

8.4.2.2 Transition PL_C2:SelectPhy to PL_C3:ReqWait

The PL_C2:PL_C3 transition shall occur after the counters identified in 8.4.2.1 have been initialized and the phy for the Open Connection request has been set up or switched to.

8.4.3 PL_C3:ReqWait state

8.4.3.1 State description

This state:

- a) Sends an Open Connection request to the selected link layer and interprets the resultant responses; or
- b) Sends a Stop Arb request to the link layer in response to a Cancel parameter transfer from the PL_OC state machine and interprets the resultant response.

The Open Connection request includes these arguments:

- a) destination SAS address;
- b) protocol;
- c) arbitration wait time (current AWT timer value)
- d) pathway blocked count (current pathway blocked count counter value);
- e) phy;
- f) link rate;
- g) Initiator bit; and
- h) initiator connection tag.

This state shall monitor the link layer confirmations to determine if;

- a) The connection was opened due to the Open Connection Request;
- b) A receive connection occurred, overriding the Open Connection request;

- c) Arbitration was lost and a retry is warranted ; or
- d) Arbitration was lost and no retry is warranted.

This state will increment the pathway blocked counter if a Open Failed(Port Layer Request) confirmation is received from the link layer. This state will reinitialize the pathway blocked counter if any confirmation other than Open failed(Pathway Blocked) is received.

8.4.3.2 Transition PL_C3:ReqWait to PL_C1:Idle

The PL_C3:PL_C1 transition shall occur after a Connection Opened confirmation is received from the link layer.

8.4.3.3 Transition PL_C3:ReqWait to PL_C4: Check I_T Nexus Timer

If a Cancel parameter has not been received from the PL_OC1 state, the PL_C3:PL_C4 transition shall occur after receiving one of the following confirmations from the link layer:

- a) Open Failed(Retry);
- b) Open Failed(No Destination);
- c) Open Failed(Pathway Blocked); or
- d) Open Failed(Open Timeout Occurred).

8.4.3.4 Transition PL_C3:ReqWait to PL_C5:OpenFailed

If a Cancel parameter has not been received from the link layer, the PL_C3:PL_C5 transition shall occur after receiving one of the following confirmations from the link layer:

- a) Open Failed(Bad Destination);
- b) Open Failed(Wrong Destination);
- c) Open Failed(Link Rate Not Supported);
- d) Open Failed(Protocol Not Supported);
- e) Open Failed(STP Resources Busy);
- f) Open Failed(Port Layer Request); or
- g) Open Failed(Break Received).

If a Cancel parameter has been received from the link layer, the PL_C3:PL_C5 transition shall occur after receiving any confirmation from the link layer.

8.4.4 PL_C4:Check I_T Nexus Timer state

8.4.4.1 State description

This state shall either set up for a connection retry or exit to the PC_C5 state to terminate connection retries.

This state shall first check if the link layer sent a Open Failed(Retry) or Open Failed(Pathway Blocked) conformation. If yes , a connection retry shall be set up. If no, this State shall check to see if the I_T nexus loss timer has exceeded the specified limit . If no, a connection retry shall be set up. If yes, this state shall exit to the PC_C5 state.

This state shall initialize the I_T nexus loss timer if a Open Failed(Retry) or Open Failed(Pathway Blocked) confirmation is received from the link layer.

This state shall delay 15 microseconds before it is exited.

8.4.4.2 Transition PL_C4:Check I_T Nexus Timer to PL_C2:Select Phy

The PC_C4: PC_C2 transition shall occur after:

- a) A Open Failed(Retry) or Open Failed(Pathway Blocked) conformation is received from the link layer; or
- b) A Open Failed(No Destination) or Open Failed(Open Timeout Occurred) confirmation is received and if the I_T nexus loss timer has not exceeded the specified limit.

8.4.4.3 Transition PL_C4:Check I_T Nexus Timer to PL_C5:OpenFailed

The PC_C4: PC_C5 transition shall occur after:

- a) A Open Failed(No Destination) or Open Failed(Open Timeout Occurred) confirmation is received and if the I_T nexus loss timer has exceeded the specified limit

8.4.5 PL_C5:OpenFailed state

8.4.5.1 State description

When this state shall is entered a Can't Connect parameter with one of the following reasons codes will be sent to the PL_OC state machine depending on the confirmation received from the link layer:

Can't Connect(Open Failed – Wrong Destination);
Can't Connect(Open Failed – Link Rate Not Supported);
Can't Connect(Open Failed – Protocol Not Supported);
Can't Connect(Open Failed – Pathway Blocked);
Can't Connect(Open Failed – Open Timeout Occurred);
Can't Connect(Open Failed – Port Layer Request);
Can't Connect(Open Failed – Break Received);
Can't Connect(Open Failed – No Destination);
Can't Connect(Open Failed – Bad Destination);
Can't Connect(Open Failed – STP Resources Busy);
Can't Connect(Open Failed – I_T Nexus Loss Timeout); or
Can't Connect(Open Failed – Physical Not Ready)

After sending a Can't Connect parameter, this state shall then wait for a Connection Closed confirmation to be received from the link layer.

Exception; A Can't Connect(Open Failed_Port layer Request) parameter will be sent to the PL_OC state machine if a Cancel parameter was pending when any Open Failed(XXX) confirmation was received from the link layer.

8.4.5.2 Transition PL_C5:OpenFailed to PL_C1:Idle

The PL_C5:PL_C1 transition shall occur after a Connection Closed confirmation is received from the link layer.

8.5 PL_CO state machine

8.6 PL_CO1:Idle State

8.5.1.1 State description

This state shall exist with each phy layer when no connection exists. When in this state, no frame transmissions or receptions may occur.

8.5.1.2 Transition PL_CO1:Idle to PL_CO2:Connected

The PL_CO1:PL_CO2 transition shall occur after a Connection Opened confirmation is received from the link layer.

8.5.2 PL_CO2:Connected State **Editors note – why not bold numbers**

8.5.2.1 State description

This state exists for each phy when a connection exists. When in this state, frame transmissions and receptions may occur.

When in this state and a frame is to be transmitted, the PL_OC state machine may send the Okay to Tx Frame parameter to the PL_CO state machine. Arguments shall include whether to transmit with Balance Required or Not, and the Frame to be transmitted.

This state machine shall generate a TX Frame(Balanced Required) request to the link layer when a Okay to Tx Frame parameter with a balance required argument is received.

This state machine shall generate a TX Frame(Balance Not Required) request to the link layer when a Okay to Tx Frame parameter with a balance not required argument is received.

After a Tx Frame request has been sent to the link layer and when the frame has been transmitted by the link Layer , a Frame Transmitted confirmation shall be sent to this state from the link layer. This state shall then send the PL_OC state machine a Frame Transmitted parameter which shall notify the PL_OC state that another frame may be transmitted.

This state shall also pass the following transmit confirmations regarding the previous Frame transmissions from the link layer to the transport layer:

- 1) Ack Received;
- 2) Nak Received;
- 3) ACK/NAK Timeout; or
- 4) Credit Timeout;

This state shall pass the received frame along with the Frame Received(Ack/Nak Balanced) or Frame Received(Ack/Nak Not Balanced) confirmations from the link layer to the transport layer.

This state shall generate a Don't Tx any Frames parameter for the PL_OC state machine if a Done Received confirmation is sent by the link layer.

8.5.2.2 Transition PL_CO2:Connected to PLCO1:Idle

The PL_CO2 transition shall occur after a Connection Closed confirmation is received from the link layer.

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