To: INCITS T10 Committee
From: Susan Gray, Quantum
Date: February 10, 2004
Document Number: T10/03-369r3
Subject: ADT State Diagrams

Revision History

Revision 3:
Incorporate comments from group meeting on February 9th. Change P3:Paused to a sub state of P2:Logged-In.

Revision 2:
Redraw state machines based on new convention (add messages between state machines)
Add state machine convention section
Remove transition labels
Only describe the transitions out for each state description.

Revision 1:
Incorporated comments from group meeting on November 3rd. Break it into 4 separate state machines. The text should only describe what the diagrams do not describe.

Revision 0:
Initial proposal

Discussion

Section 4.3 and 4.4 can be made more readable by providing state diagrams and describing the transitions.

This proposal applies to ADT Revision 10.

Changes

Globally change P2:Active to either P2:Logged-In, R0:Idle, TE0:Idle, or T0:Active as appropriate.
Globally change P3:Pending Recovery to R1:Pending Recovery
Globally change P4:Initiating Recovery toTE1:Initiating Recovery.
Globally change P5:Recovering to R2:Recovering.
Globally change P6:Paused to T1:Paused.
Globally change P7:Logged-Out to P3:Logged-Out.

The diagrams in Annex B need to be updated as well.

3.6 State machine conventions

3.6.1 State machine conventions overview

Figure x shows how state machines are described.

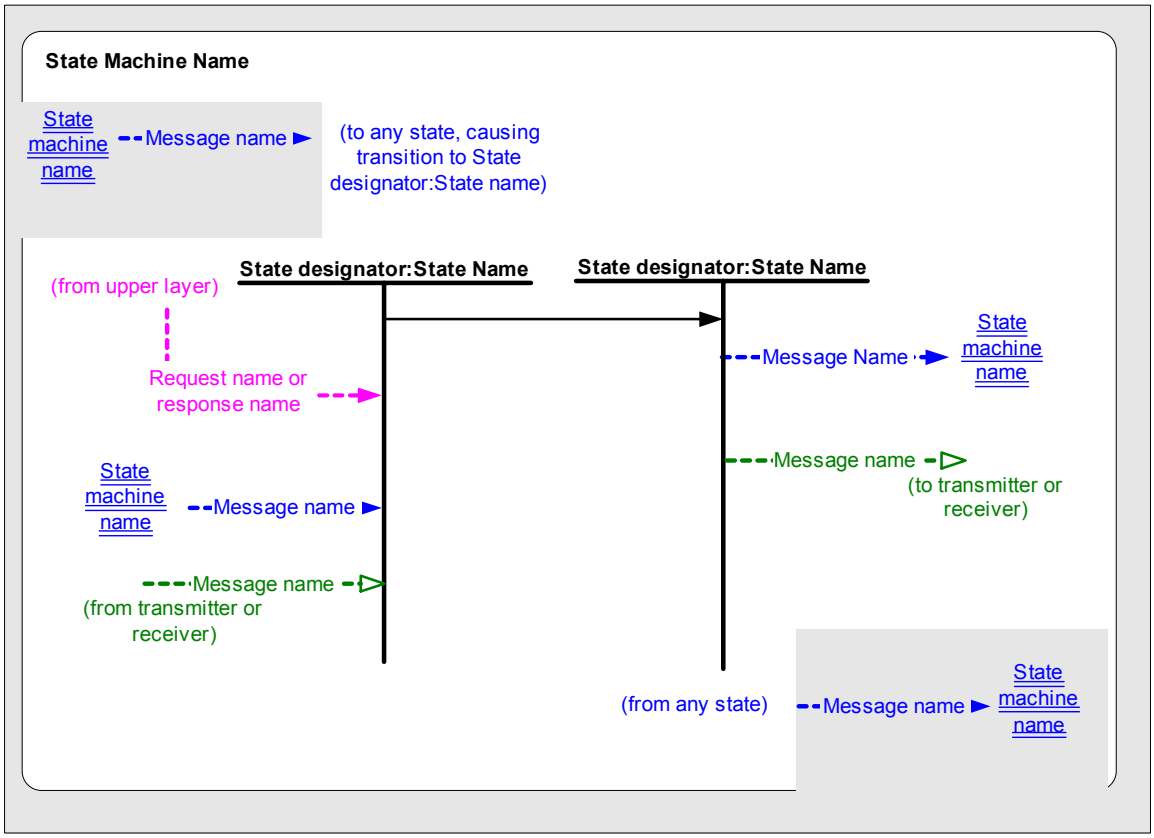

Figure x State machine conventions

State machines are enclosed in boxes with rounded corners. Each state is identified by a state designator and a state name. The state designator (e.g., P0) is unique among all state machines in this standard. The state name (e.g., Idle) is a brief description of the primary action taken during the state, and the same state name may be used by other state machines. Actions taken while in each state are described in the state description text.

3.6.2 Transitions

Transitions between states are shown with solid lines with an arrow pointing to the destination state. The conditions that cause a transition are fully described in the transition description text for each state.

Transitions between states are instantaneous.

3.6.3 Messages, requests, and event notifications

Messages passed between state machines are shown with dashed lines labeled with a message name. When messages are passed between state machines, they are identified by either a dashed line to or from a state machine name label with double underlines.

The meaning of each message is described in the state description text.

Requests and event notifications are shown with curved dashed lines originating from or going to the top or bottom of the figure. Each request and event notification is labeled. The meaning of each request and event notification is described in the state description text where it is used.

Messages with unfilled arrowheads are passed to or from the state machine's transmitter or receiver, not shown in the state machine figures, and are directly related to data being transmitted on or received from the physical link.

Messages, requests and event notifications that affect all states in the state machine are shown as touching the edge of the state machine enclosure. In this case, the meaning is described in the general state machine description subclause. Similarly, those that originate from all states are shown as exiting from the state machine enclosure.

(Replace the entire contents of section 4.3 and 4.4 with the following sections.)

4.3 ADT state machines

4.3.1 Introduction

The ADT transport layer contains five state machines to manage a connection between two ADT ports. These state machines reside in ADC devices. The state machines are as follows:

a) Port;
b) Link negotiation;
c) Transmitter;
d) Transmitter error recovery; and
e) Receiver error recovery.

The port state machine is the primary machine and always active while and the others are sub-state machines and only active to manage specific operations.

4.3.2 Port state machine

The port state machine consists of the following port states:

a) P0:Initial;
b) P1:Login;
c) P2:Logged-In; and
d) P3:Logged-Out.

This state machine shall start in P0:Initial state after a hard reset event.

The port shall transition to P1:Login after receiving a Port Login IU.

Figure x + 1 shows the port state machine. The following subclauses describe the transitions and the actions taken in each state.

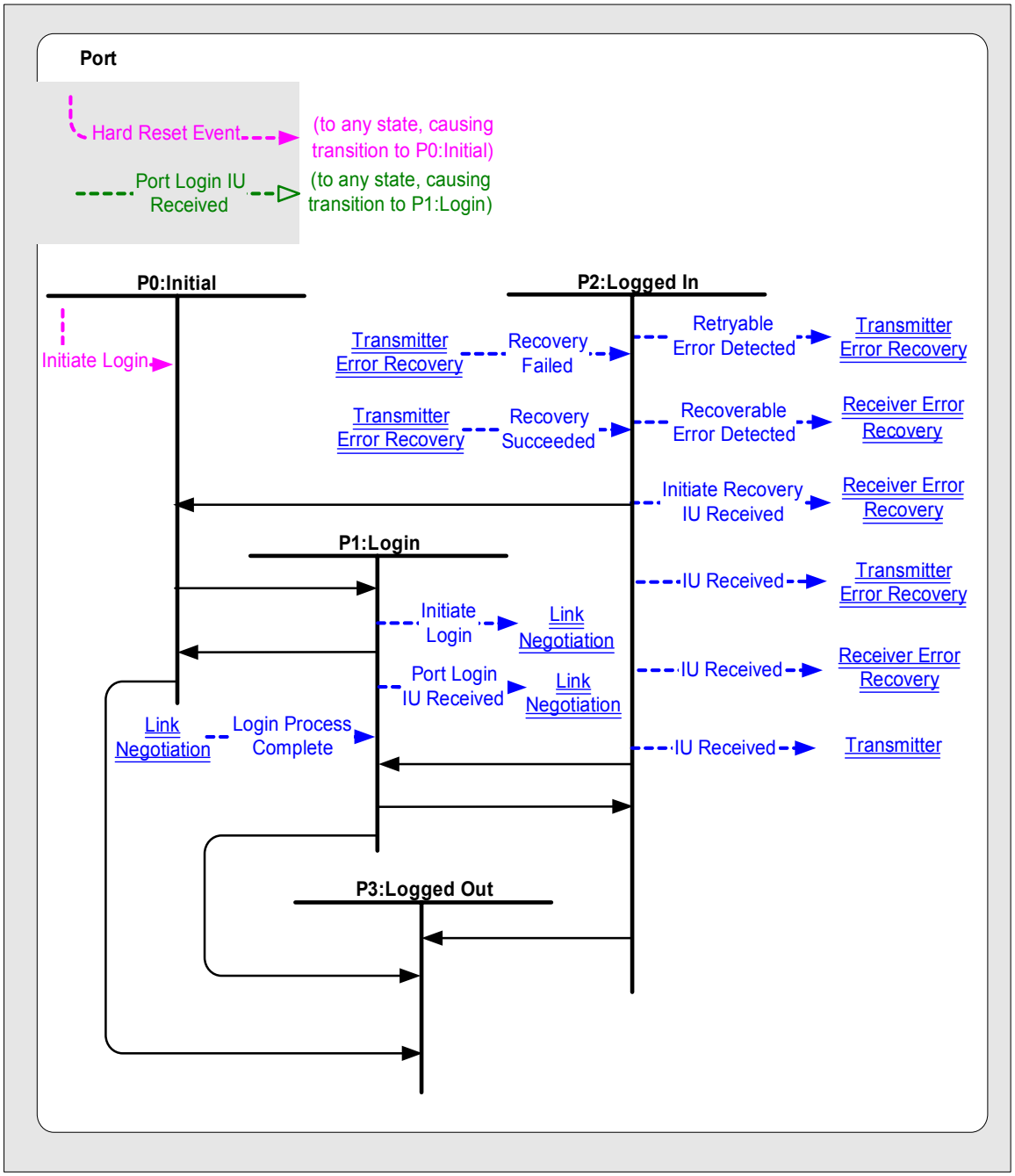

Figure X + 1 Port State Machine Diagram

4.3.2.1 P0:Initial state

4.3.2.1.1 State description

This is the initial state of the port state machine.

A port in P0:Initial state shall send a NAK IU with status value of REJECTED, PORT IS LOGGED OUT in response to any frame other than Port Login IU, Port Logout IU, NOP IU or acknowledgement IU. Upon entering this state, all other state machines are set to their initial states.

Since only an automation port can send a Logout IU, only an automation port can transition to this state after completing a port logout (see 6.5.5).

4.3.2.1.2 Transition P0:Idle to P1:Login

The port shall transition to P1:Login after receiving a Port Login IU or an Initiate Login request.

4.3.2.1.3 Transition P0:Idle to P3:Logged-Out

A port shall transition to P3:Logged-Out state after it receives a Port Logout IU and sends the corresponding ACK IU.

4.3.2.2 P1:Login state

4.3.2.2.1 State description

While in the P1:Login state, Port Login IUs are used to establish or change link parameters used by both ports on the link. The login process is a negotiation between the ports that shall result in the determination of a set of operating parameters that are acceptable to both ports. Following a hard reset or a Port Logout condition, the Port Login IU shall be sent using default parameters (see 4.2). If the port is already logged in, the Port Login IU shall be sent using current operating parameters unless the port is initiating the exchange as part of error recovery. The login process consists of a series of Port Login IUs all within a single exchange. The same X-Origin and Exchange ID values are used in all information units throughout the process (see 6.3).

A port in this state shall send a NAK IU with a status value of LOGIN IN PROCESS in response to any frame other than Port Login IU, Port Logout IU, NOP IU or acknowledgement IU.

While in this state, the port shall send a Port Login IU received message to the link negotiation state machine each time it receives a Port Login IU.

If the port enters this state as a result of an Initiate Login request, it sends an Initiate Login message to the link negotiation state machine.

After acknowledging a Port Login IU, transmission of frames for other exchanges shall either be suspended or aborted based on the setting of the AOE bit in the Port Login IU.

4.3.2.2.2 Transition P1:Login to P0:Initial

A port shall transition to P0:Initial state after it sends a Port Logout IU and receives the corresponding ACK IU.

4.3.2.2.3 Transition P1:Login to P2:Logged-In

A port shall set its operating parameters to the negotiated values and transition to P2:Logged-In state after receiving a Login Process Complete message.

4.3.2.2.4 Transition P1:Login to P3:Logged-Out

A port shall transition to P3:Logged-Out state after it receives a Port Logout IU and sends the corresponding ACK IU.

4.3.2.3 P2:Logged-In

4.3.2.3.1 State description

While in this state, the ports permission to transmit is managed through the use of the transmitter state machine.

While in this state, error recovery is managed through the use of the transmitter error recovery and receiver error recovery sub-state machines.

The port shall send a Retryable Error Detected message to the transmitter error recovery state machine when the port detects an error as defined in 4.7.1.2. In addition, the port shall suspend the transmission of all frames other than Port Login IU, Port Logout IU, Initiate Recovery IU, NOP IU or acknowledgment IU.

The port shall send a Recoverable Error Detected message to the receiver error recovery state machine when the port detects an error as defined in 4.7.1.3.

The port shall send an Initiate Recovery IU received message to the receiver error recovery state machine when the port receives an Initiate Recovery IU.

When a frame other than Port Login IU, Port Logout IU or NOP IU is received and the receiver error recovery state machine is not in R0:Idle, the port shall send an IU Received message to the receiver error recovery state machine.

When a frame other than Port Login IU, Port Logout IU or NOP IU is received and the transmitter error recovery state machine is not in R0:Idle, the port shall send an IU Received message to the transmitter error recovery state machine.

When the port receives a Recovery Succeeded message, the port shall resume the transmission of frames.

4.3.2.3.2 Transition P2:Logged-In to P0:Initial

A port shall transition to P0:Initial after receiving an ACK IU for a Port Logout IU.

4.3.2.3.3 Transition P2:Logged-In to P1:Login

A port shall transition to P1:Login and initiate a port login exchange after receiving a Recovery Failed message (see 4.7.2.2).

4.3.2.3.4 Transition P2:Logged-In to P3:Logged-Out

A port shall transition to P3:Logged-Out state after it receives a Port Logout IU and sends the corresponding ACK IU.

4.3.2.4 P3:Logged-Out state

4.3.2.4.1 State description

A port in P3:Logged-Out state shall not initiate an exchange. While in this state, upon receiving any frame other than a Port Login IU, the port shall send a NAK IU with a status value of REJECTED, PORT IS LOGGED OUT.

Since only a drive port can receive a Logout IU, only a drive port can transition to this state after completing a port logout.

4.3.3 Link negotiation state machine

The link negotiation state machine is used to manage the login process. It is a sub-state machine of the port state P1:Login. The states are as follows:

a) N0:Idle
b) N1: Negotiating;
c) N2:Accept Sent;
d) N3:Accept ACK Sent; and
e) N4:Complete.

This state machine becomes active when the port enters the P1:Login state.

Figure x + 2 shows the link negotiation state machine. The following subclauses describe the transitions and the actions taken in each state.

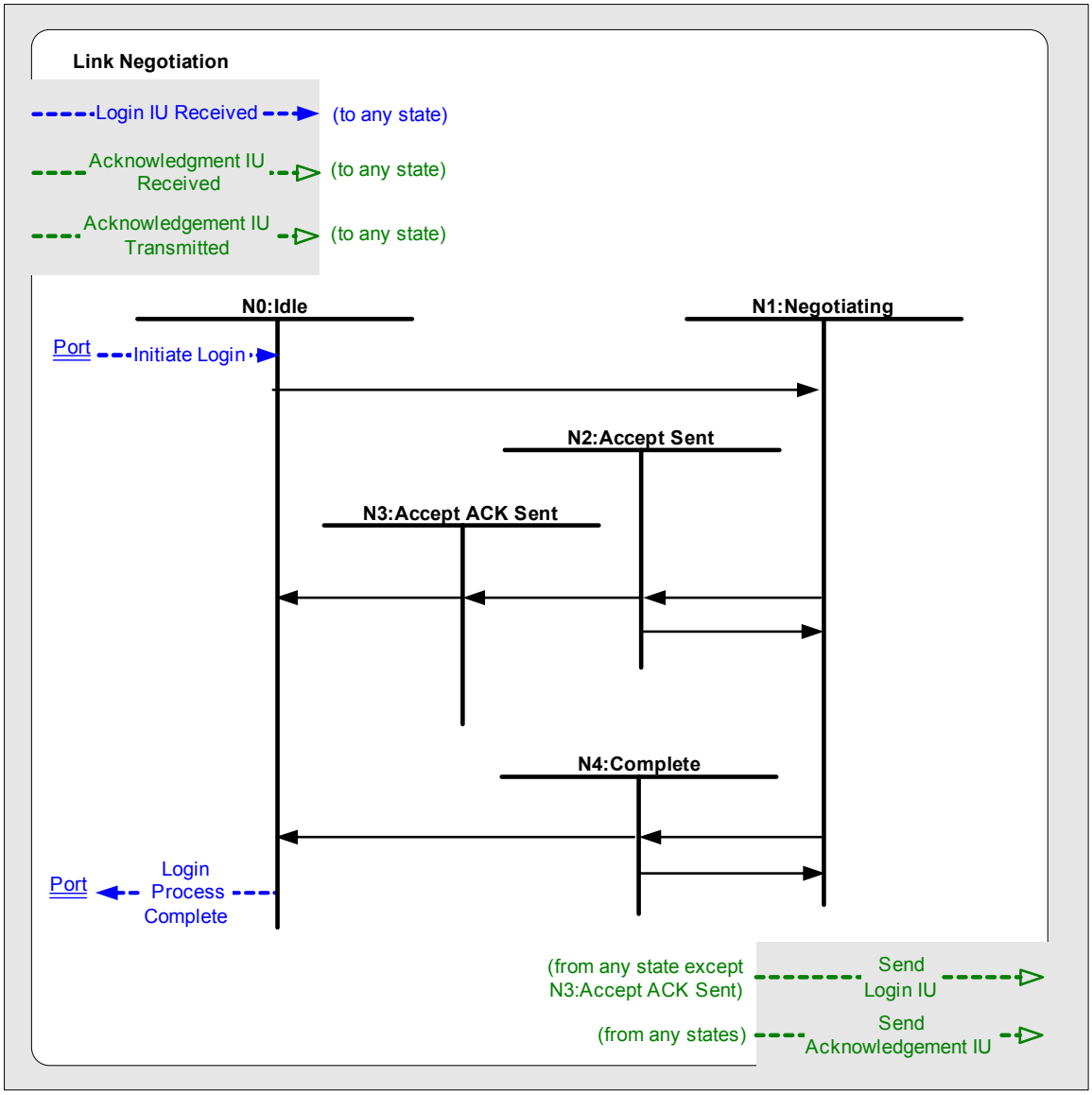

Figure x + 2 Link Negotiation State Diagram

4.3.3.1 Precedence of port login exchanges

To avoid a deadlock condition when both ports are attempting to initiate a Port Login exchange at the same time, the following rules shall apply. An automation device port that receives a Port Login IU with an exchange originated by the other port shall:

a) send an ACK IU and discard the Port Login IU from the other port if the automation device port has initiated a Port Login exchange that has not yet completed; or
b) send an ACK IU and discard the Port Login IU and initiate a Port Login exchange; or
c) complete the port login process using the exchange originated by the other port if no other Port Login exchange is open.

A Data Transfer Device that receives a Port Login IU in a new exchange shall abort all other Port Login exchanges, transition to N2:Negotiating, and process the Port Login IU as specified by that state.

4.3.3.2 N0:Idle state

4.3.3.2.1 State description

The N0:Idle states waits for the port to transition to P1:Login state.

If this state is entered from N3:Accept ACK Sent or N4:Complete, a Login Process Complete message shall be sent to the port state machine.

4.3.3.2.2 Transition N0:Idle to N1:Negotiating

This transition shall occur when an Initiate Login message is received or a Port Login IU Received message is received.

4.3.3.3 N1:Negotiating state

4.3.3.3.1 State description

If the port transitioned to this state due to an Initiate Login message, the port shall send a Port Login IU in a new exchange. If the AOE bit is set, the Port Login IU shall be sent with default starting parameters as the contents.

If the port transitioned to this state due to a negotiation error, the port shall send a Port Login IU in a new exchange with default starting parameters as the contents.

When a Port Login IU message is received, the parameters shall be inspected.

If the Port Login IU parameters are not acceptable, the port shall adjust all parameters that are unacceptable down to values that are acceptable to the port, and respond with a Port Login IU that contains these values. The ACCEPT bit shall be set to zero.

If the port receives a Port Login IU with the ACCEPT bit set to one with parameter values that are different from the last Port Login IU sent, the port shall send a NAK IU with a status value of NEGOTIATION ERROR. The port shall initiate a new Port Login exchange with default starting parameters as the contents.

If a port has not received a Port Login IU within 15 seconds after receiving the ACK IU for a Port Login IU that it has sent, the port shall consider this condition an error. It shall abort the Port Login exchange, set the port operating parameters to default, and initiate a new Port Login exchange.

4.3.3.3.2 Transition N1:Negotiating to N2:Accept Sent

If the ACCEPT bit is set to zero and the parameters in the received Port Login IU are acceptable, the port shall send a Port Login IU with the parameters unchanged and the ACCEPT bit set to one and transition to N2:Accept Sent.

4.3.3.3.3 Transition N1:Negotiating to N4:Complete

If the ACCEPT bit is set to one and the parameters in the received Port Login IU are unchanged from the values sent in the last Port Login IU, the port shall send a Port Login IU with the same values and the ACCEPT bit set to one and transition to N4:Complete.

4.3.3.4 N2:Accept Sent state

4.3.3.4.1 State description

A port enters this state if it has sent a Port Login IU with the ACCEPT bit set to one and unchanged parameters before it received a Port Login IU with the ACCEPT bit set to one (i.e. it is the first port to send a Port Login IU with the ACCEPT bit set to one).

4.3.3.4.2 Transition N2:Accept Sent to N1:Negotiating

If a port receives a Port Login IU with the ACCEPT bit set to zero or with parameter values that are different from the last Port Login IU sent, the port shall send a NAK IU with a status value of NEGOTIATION ERROR and transition to N1:Negotiating to initiate a new login exchange.

4.3.3.4.3 Transition N2:Accept Sent to N3:Accept ACK Sent

If a port receives a Port Login IU with the ACCEPT bit set to one and unchanged parameters, the port shall send an ACK IU and transition to N3:Accept ACK Sent.

4.3.3.5 N3:Accept ACK Sent state

4.3.3.5.1 State description

A port enters this state if it has sent a Port Login IU with the ACCEPT bit set to one and unchanged parameters and then received a Port Login IU with the ACCEPT bit set to one.

4.3.3.5.2 Transition N3:Accept ACK Sent to N0:Idle

When the ACK IU has finished transmitting, the port shall set its operating parameters to the negotiated values and transition to N0:Idle state.

4.3.3.6 N4:Complete state

4.3.3.6.1 State description

A port enters this state if it has received a Port Login IU with the ACCEPT bit set to one and unchanged parameters and then sent a Port Login IU with the ACCEPT bit set to one. In other words, it is the second port to accept the operating parameters.

4.3.3.6.2 Transition N4:Complete to N0:Idle

After receiving an ACK IU for the Port Login IU it sent, the port shall set its operating parameters to the negotiated values and transition to N0:Idle state.

4.3.3.6.3 Transition N4:Complete to N1:Negotiating

If a port receives a NAK IU it shall transition to N1:Negotiating to initiate a new login exchange.

4.3.4 Transmitter state machine

The transmitter state machine manages the ports permission to transmit. It is a sub-state machine of the port state P2:Logged-In. The transmitter state machine consists of the following states:

a) T0:Active; and
b) T1:Paused.

This state machine becomes active when the port enters P2:Logged-In state.

Figure x + 3 shows the transmitter state machine. The following subsclauses describe the transitions and the actions taken in each state.

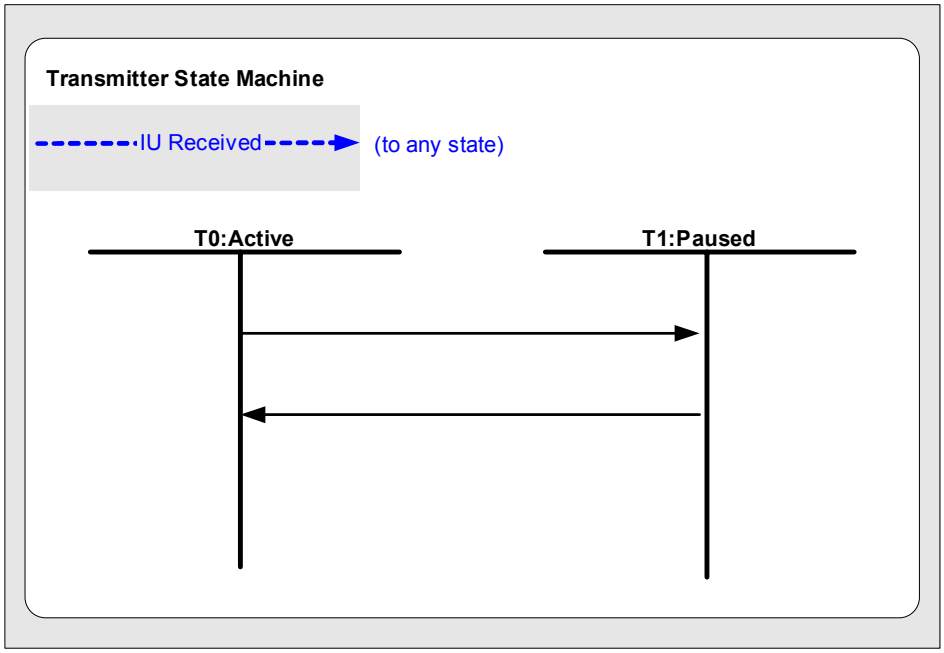

Figure x + 3 Transmitter State Diagram

4.3.4.1 T0:Active state

4.3.4.1.1 State description

A port in T0:Active state may transmit and receive all types of information units.

4.3.4.1.2 Transition T0:Active to T1:Paused

A port shall transition to T1:Paused state after it receives a Pause IU and sends the corresponding ACK IU.

4.3.4.2 T1:Paused state

4.3.4.2.1 State description

A port in T1:Paused state shall not initiate an exchange.

4.3.4.2.2 Transition T1:Paused to T0:Active

A port shall transition to T0:Active state after receiving any frame other than a Port Login IU, Port Logout IU, or acknowledgment IU.

4.3.5 Transmitter error recovery state machine

The transmitter error recovery state machine manages error recovery in the transmitting port. It is a sub-state machine of the port state P2:Logged-In. The transmitter error recovery state machine consists of the following states:

c) TE0:Idle;
d) TE1:Initiating recovery; and
e) TE2:Retry Initiate recovery.

This state machine becomes active when the port enters P2:Logged-In state.

Figure x + 4 shows the transmitter error recovery state machine. The following subsclauses describe the transitions and the actions taken in each state.

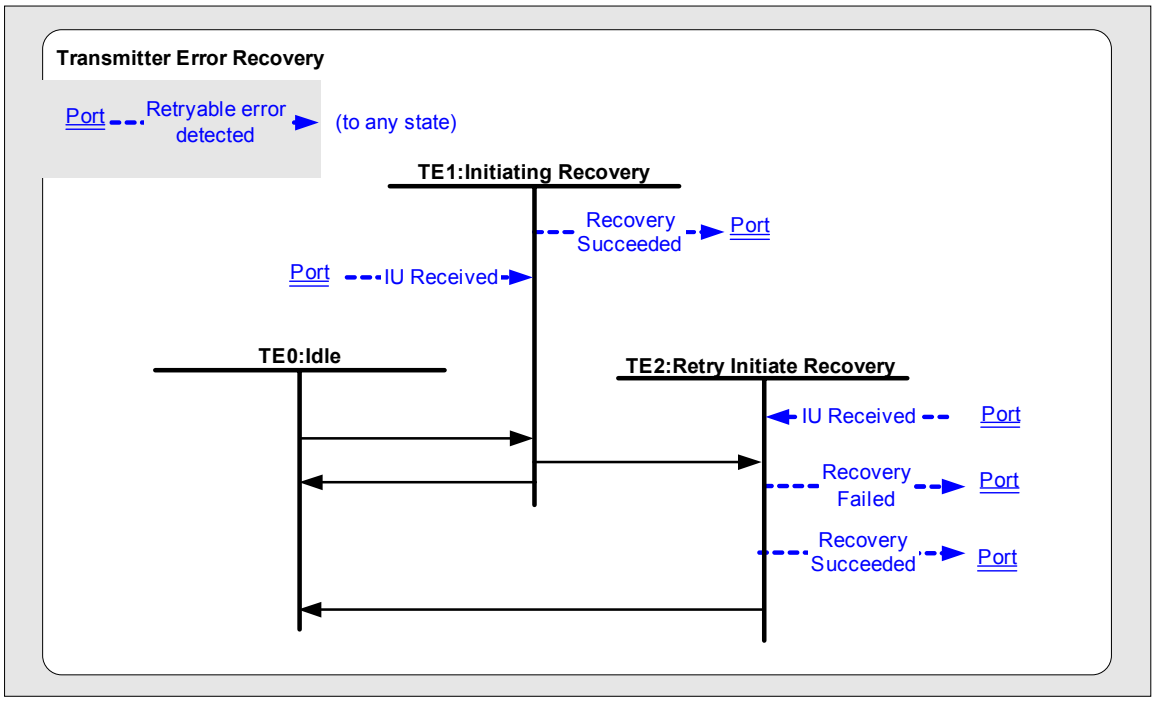

Figure x + 4 Transmitter Error Recovery State Diagram

4.3.5.1 TE0:Idle state

4.3.5.1.1 State description

The TE0:Idle states waits for the port to detect a retryable error.

4.3.5.1.2 Transition TE0:Idle to TE1:Initiating Recovery

Upon receiving a Retryable Error Detected message, the port shall send an Initiate Recovery IU and transition to TE1:Initiating Recovery.

4.3.5.2 TE1:Initiating Recovery state

4.3.5.2.1 State description

A port in TE1:Initiating Recovery state shall not send any frames other than acknowledgement IUs, Initiate Recovery IUs, Port Login IUs, NOP IU, Pause IU, or Port Logout IUs.

4.3.5.2.2 Transition TE1:Initiating Recovery to TE0:Idle

If an ACK IU for the Initiate Recovery IU is received, the port shall send a Recovery Succeeded message and transition to TE0:Idle.

4.3.5.2.3 Transition TE1:Initiating Recovery to TE2:Retry Initiate Recovery

If a Retryable Error Detected message or NAK IU for the Initiate Recovery IU is received, the port shall re-send the Initiate Recovery IU and transition to TE2:Retry Initiate Recovery.

4.3.5.3 TE2:Retry Initiate Recovery state

4.3.5.3.1 State description

A port in TE2:Retry Initiate Recovery state shall not send any frames other than acknowledgement IUs, Port Login IUs, NOP IU, Pause IU or Port Logout IUs.

4.3.5.3.2 Transition TE2:Retry Initiate Recovery to TE0:Idle

If an ACK IU for the Initiate Recovery IU is received, the port shall send a Recovery Succeeded message to the port state machine and transition to TE0:Idle.

If a Retryable Error Detected message or NAK IU for the Initiate Recovery IU is received, the port shall send a Recovery Failed message to the port state machine and transition to TE0:Idle.

4.3.6 Receiver error recovery state machine

The receiver error recovery state machine manages error recovery in the receiving port. It is a sub-state machine of the port state P2:Logged-In. The state machine consists of the following states:

a) R0:Idle;
b) R1:Pending recovery; and
c) R2:Recovering.

This state machine becomes active when the port enters P2:Logged-In state.

Figure x + 5 shows the receiver error recovery state machine. The following subsclauses describe the transitions and the actions taken in each state.

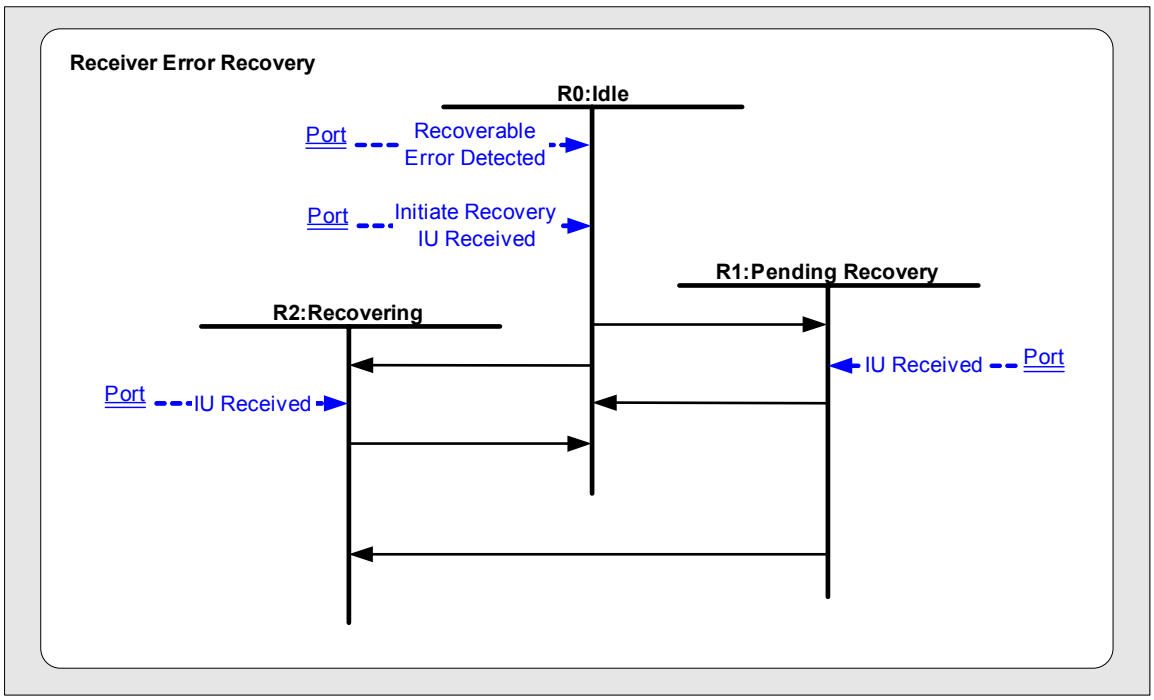

Figure x + 5 Receiver Error Recovery State Diagram

4.3.6.1 R0: Idle state

4.3.6.1.1 State description

The R0:Idle states waits for the port to detect a recoverable error or receive an Initiate Recovery IU indicating that the transmitter has detected a retryable error.

4.3.6.1.2 Transition R0:Idle to R1:Pending Recovery

The port shall transition to R1:Pending Recovery upon receiving a Recoverable Error Detected message.

4.3.6.1.3 Transition R0:Idle to R2:Recovering

The port shall transition to R2:Recovering upon receiving a Initiate Recovery IU received message and the FRAME NUMBER field value does not match the Expected Frame Number counter.

4.3.6.2 R1:Pending recovery state

4.3.6.2.1 State description

If a Recoverable Error Detected message was received, the port shall send the corresponding NAK IU.

While a port is in R1:Pending recovery state, receipt of a frame other than an Initiate Recovery IU, NOP IU, Port Login IU, Port Logout IU, or Pause IU is an error and the port shall send a NAK IU with a status of AWAITING INITIATE RECOVERY IU and PR bit set to one.

4.3.6.2.2 Transition R1:Pending Recovery to R0:Idle

A port shall transition to R0:Idle state after it receives a valid Initiate Recovery IU with a FRAME NUMBER field value that matches the Expected Frame Number counter.

4.3.6.2.3 Transition R1:Pending Recovery to R2:Recovering

A port shall transition to R2:Recovering state after it receives a valid Initiate Recovery IU with a FRAME NUMBER field value that does not match the Expected Frame Number counter.

4.3.6.3 R2:Recovering state

4.3.6.3.1 State description

A port in this state shall acknowledge and discard all frames that were previously processed. This is all frames with a FRAME NUMBER field value that does not match the Expected Frame Number counter.

4.3.6.3.2 Transition R2:Recovering to R0:Idle

When a frame with a FRAME NUMBER field value that matches the Expected Frame Number counter is received, the port shall transition to the R0:Idle state and continue with normal operations.