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To: **Serial Attached SCSI Protocol Working Group**
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Subject: **SAS SSP transport layer state machines**

Introduction

This proposal is for the SAS transport layer state machines for the SSP protocol. This proposal
represents a significant change in tack from previous proposals for these state machines. Earlier
proposals focused on SAM objects (e.g., application client). This proposal names new objects unique to
SAS, but has the goal of being consistent with the SAM layering model. Revision 2 of this proposal
includes input from the SAS Protocol Working Group meetings held September 9th and 10th, 2002, and
moves elements from earlier in clause 9 into these clauses.

9.2.6   SSP transport layer state machines

9.2.6.1   Overview

The SSP transport layer contains state machines that perform the following functions:

  a) receive protocol service and other SAS connection management requests from the SCSI initiator
      application layer;
  b) send protocol service indications to the SCSI target application layer;
  c) receive data delivery service requests, other SAS connection management requests, and
      protocol service responses from the SCSI target application layer;
  d) send data delivery service confirmations to the SCSI target application layer;
  e) send protocol service confirmations to the SCSI initiator application layer;
  f) send requests to the SSP port layer state machines to transmit frames and manage SAS
      connections;
  g) receive confirmations from the SSP port layer state machines;

The SSP transport state machines are as follows:

  a) Initiator Send Frame (ISF state machines);
  b) Initiator Receive Data (IRD state machines);
  c) Initiator Process Response (IPR state machine);
  d) Initiator Frame Router (IFR state machine);
  e) Target Frame Router (TFR state machine); and
  f) Target Transport Server (TTS state machine).

9.2.6.2   SSP transport layer initiator device state machines

9.2.6.2.1   SSP transport layer initiator device state machines overview

The ISF (initiator send frame) state machine receives protocol service requests from the SCSI initiator application layer, receives XFER_RDY Arrived parameters from the IFR (initiator frame router) state machine, and constructs COMMAND, TASK, or data-out DATA frames. The service request may be to process either a command or task management function. This state machine also communicates with the port layer state machine via several requests and confirmations regarding frame transmission, and may communicate to the IPR (initiator process response) state machine regarding service delivery subsystem failures.

The ISF state machine contains the following states:

  a)   Initial state. ST_ISF1:Initiator_Send_Frame state;
  b)   ST_ISF2:Prepare_Command_Request state,
  c)   ST_ISF3:Prepare_Send_Data_Out state;

The IRD (initiator receive data) state machine receives and processes a parameter from the IFR (initiator frame router) state machine containing a DATA frame.

The IRD state machine contains the following states:

  a)   Initial state. ST_IRD1:Receive_Data_In state;
  b)   ST_IRD2:Process_Received_Data_In state.

The IPR (initiator process response) state machine receives a parameter from the IFR (initiator frame router) state machine containing a RESPONSE frame or a parameter containing a service delivery subsystem failure from the ISF (initiator send frame) state machine. The IPR state machine processes the RESPONSE information unit or the service delivery subsystem failure and sends a protocol service confirmation to the SCSI initiator application layer.

The IPR state machine contains the following state:

  a)   Initial state. ST_IPR1:Process_Received_Response state.

The IFR (initiator frame router) state machine receives confirmations from the port layer state machine and, depending on the confirmation, may send a parameter to the ISF (initiator send frame), IRD (initiator receive data), or the IPR (initiator process response) state machines. The IFR state machine receives connection information from the port layer state machine. The IFR state machine also receives Accept_Reject OPENs requests from the SCSI initiator application layer and sends these requests to the port layer state machine.

The IFR state machine contains the following state:

  a)   Initial state. ST_IFR1:Initiator_Frame_Router state.

The ISF (initiator send frame) state machine receives one of the following protocol service requests from the SCSI initiator application layer:

  a)   Send SCSI Command; or
  b)   Send Task Management Request.

The IPR (initiator process response) state machine sends one of the following protocol service confirmations to the SCSI initiator application layer:

  a)   Command Complete Received; or

    b)   Received Task Management Function - Executed.

The IFR (initiator frame router) state machine may receive one of the following requests from the SCSI initiator application layer:

    a)   Accept_Reject OPENs (Accept); or
    b)   Accept_Reject OPENs (Reject).

Requests to and confirmations from the port layer state machines are described in x.x.

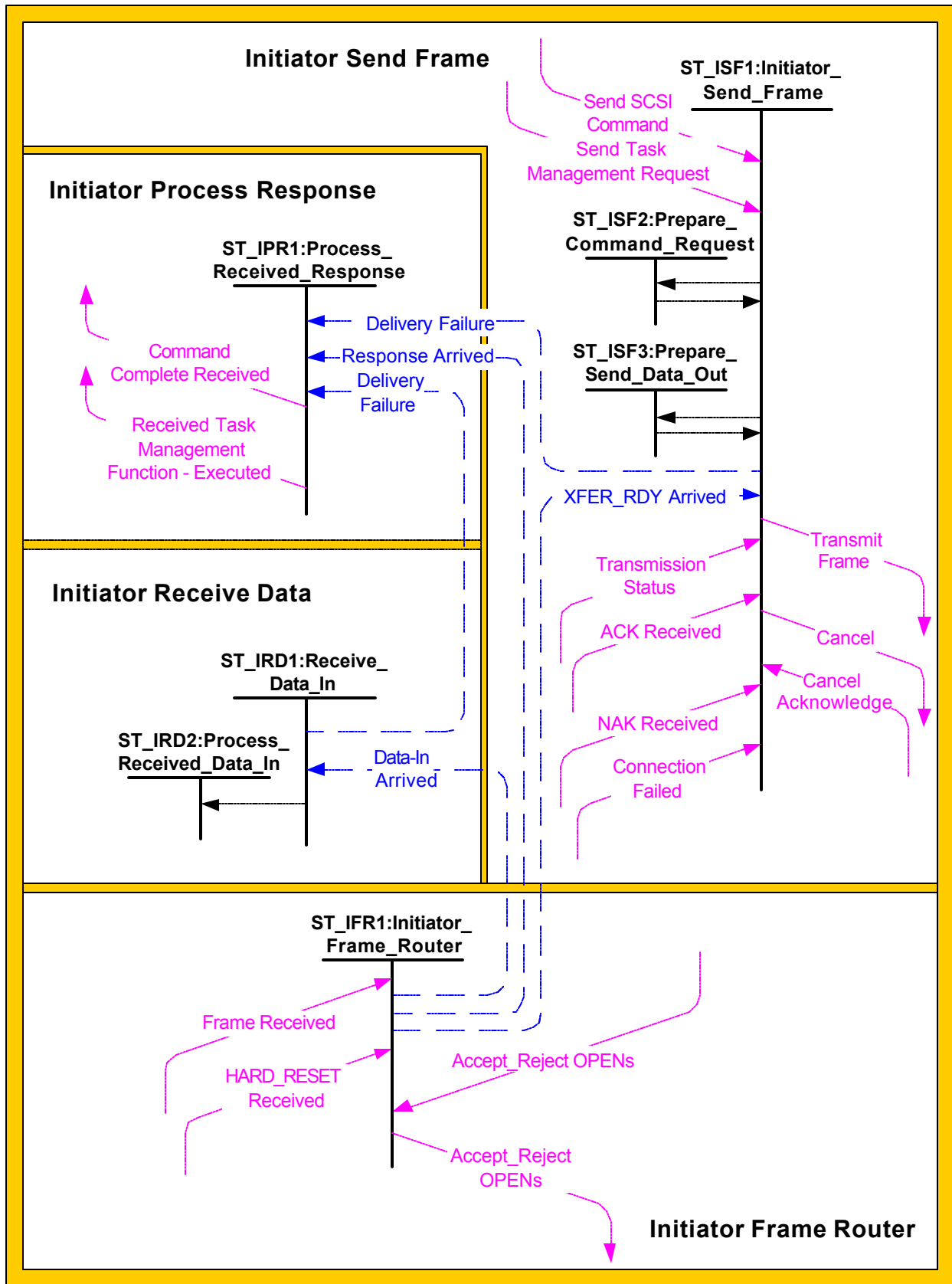Figure 1 describes the SSP transport layer initiator device state machines.

Initiator Send Frame

**ST_ISF1:Initiator_
Send_Frame**

Send SCSI
Command

Send Task
Management Request

Initiator Process Response

**ST_ISF2:Prepare_
Command_Request**

**ST_IPR1:Process_
Received_Response**

Delivery Failure

Response Arrived

Command
Complete Received

Delivery
Failure

**ST_ISF3:Prepare_
Send_Data_Out**

Received Task
Management
Function - Executed

XFER_RDY Arrived

Transmit
Frame

Initiator Receive Data

Transmission
Status

ACK Received

Cancel

**ST_IRD1:Receive_
Data_In**

Cancel
Acknowledge

**ST_IRD2:Process_
Received_Data_In**

Data-In
Arrived

NAK Received

Connection
Failed

**ST_IFR1:Initiator_
Frame_Router**

Frame Received

HARD_RESET
Received

Accept_Reject OPENs

Accept_Reject
OPENs

Initiator Frame Router

Figure 1. SSP transport layer initiator device state machines

9.2.6.2.2 ST_ISF1:Initiator_Send_Frame state

9.2.6.2.2.1 ST_ISF1:Initiator_Send_Frame state description

The ISF state machine shall be initiated when a Send SCSI Command or a Send Task Management Request protocol service request is received from the SCSI initiator application layer or when an XFER_RDY Arrived parameter is received from the IFR (initiator frame router) state machine.

This state shall be entered when either a COMMAND or TASK frame is received from the ST_ISF2:Prepare_Command_Request state, or when a DATA frame is received from the ST_ISF3:Prepare_Send_Data_Out state.

A Send SCSI Command or a Send Task Management Request protocol service request includes the following to be used in any OPEN address frames required to service the request:

  a) link rate;
  b) initiator connection tag;
  c) destination SAS address; and,
  d) source SAS address.

The request may also contain the initiator connection tag to be used in any OPEN address frame.

A Send SCSI Command protocol service request also includes the following to be used in any SSP frame for the request:

  a) tag;
  b) logical unit number;
  c) task attribute;
  d) additional CDB length;
  e) CDB; and,
  f) additional CDB bytes.

If the request is for a data-out command, then the request also includes the number of bytes for the first burst size for the logical unit.

A Send SCSI Send Task Management Request protocol service request includes the following to be used in the TASK frame:

  a) tag;
  b) task management function; and,
  c) tag of the task to be managed.

If the ISF state machine was initiated as the result of receiving a protocol service request, then this state shall transition to the ST_ISF2:Prepare_Command_Request state.
If the ISF state machine was initiated as the result of receiving an XFER_RDY Arrived parameter, then this state shall check the length of the XFER_RDY information unit. If the length of the information unit is not 12 bytes, then this state shall send a Delivery Failure parameter to the ST_IPR:Process_Received_Response state. This state machine shall terminate after sending the parameter. If the length of the XFER_RDY information unit is 12 bytes, then this state shall check the write data length in the XFER_RDY information unit. If the write data length exceeds the amount of data remaining to be transfered for the data-out command, then this state shall send a Delivery Failure parameter to the ST_IPR:Process Received_Response state. This state machine shall terminate after sending the parameter. If the length of the XFER_RDY frame and the write data length is correct, then this state shall transition to the ST_ISF3:Prepare_Send_Data_Out state.

If this state is entered from the ST_ISF2:Prepare_Command_Request state, then this state shall send a Transmit Frame (Interlocked) request to the port layer state machine.

If this state is entered from the ST_ISF3:Prepare_Send_Data_Out state, then this state shall send a Transmit Frame (Non-interlocked) request to the port layer state machine.

A Transmit Frame request from this state (either interlocked or non-interlocked) shall include the SSP frame and the following to be used for any OPEN address frame:

   a)   the initiator bit set to one;
   b)   link rate;
   c)   initiator connection tag;
   d)   destination SAS address; and,
   e)   source SAS address.

After sending a Transmit Frame request this state shall receive a Transmission Status confirmation from the port layer state machine. If the confirmation is not Transmission Status (Frame Transmitted), then this state shall send a Delivery Failure (Service Delivery Subsystem Failure) parameter to the IPR (initiator process response) state machine. The Delivery Failure attribute shall include:

   a)   any argument received from the port layer state machine; and,
   b)   I_T_L_x nexus information (i.e., destination SAS address and tag);

After sending a Delivery Failure parameter to the IPR state machine, the ISF state machine shall terminate.

After receiving a Transmission Status (Frame Transmitted) confirmation, this state shall then receive one of the following confirmations from the port layer state machine.

   a)   ACK Received;
   b)   NAK Received; or
   c)   Connection Failed.

If the confirmation is not ACK Received, then this state shall send a Delivery Failure (Service Delivery Subsystem Failure) parameter to the IPR (initiator process response) state machine including any argument received from the port layer state machine. After sending the Delivery Failure parameter to the IPR state machine, the ISF state machine shall terminate.

If the confirmation is ACK Received and the number of data bytes that has been transferred for a data-out request is less than the first burst size or the write data length, then this state shall transition to the ST_ISF3:Prepare_Send_Data_Out state.

This state may also send a Cancel request to the port layer state machine to cancel a previous Transmit Frame request. The ISF state machine shall terminate upon receipt of a Cancel Acknowledge confirmation from the port layer state machine.

9.2.6.2.2.2 Transition ST_ISF1:Initiator_Send_Frame to ST_ISF2:Prepare_Command_Request

This transition shall occur after a Send SCSI Command or Send Task Management Request protocol service request has been received from the SCSI initiator application layer.

9.2.6.2.2.3 Transition ST_ISF1:Initiator_Send_Frame to ST_ISF3:Prepare_Send_Data_Out

This transition shall occur after:

   a)   an ACK Received confirmation has been received from the port layer state machine for a COMMAND frame for a data-out operation and the first burst size is not zero;
   b)   an XFER_RDY Arrived parameter has been received from the IFR state machine and all required values are present and correct; or,

    c)   an ACK Received confirmation for a Transmit Frame (Non-interlocked) request has been received from the port layer state machine and the number of data bytes that has been transmitted for the request is less than the first burst size or the write data length.

9.2.6.2.3 ST_ISF2:Prepare_Command_Request state

9.2.6.2.3.1 ST_ISF2:Prepare_Command_Request state description

This state shall construct either a COMMAND or TASK frame.

If the frame to be constructed is a COMMAND frame, then this state shall include the following received from the SCSI initiator application layer in the frame:

    a)   tag;
    b)   logical unit number;
    c)   task attribute;
    d)   additional CDB length;
    e)   CDB; and,
    f)   additional CDB bytes.

If the frame to be constructed is a TASK frame, then this state shall include the following received from the SCSI initiator application layer in the frame:

    a)   tag;
    b)   task management function; and,
    c)   tag of task to be managed.

This state shall generate and include the following in either a COMMAND or TASK frame:

    a)   information unit type;
    b)   hashed destination SAS address;
    c)   hashed source SAS address;
    d)   timeout bit set to zero; and,
    e)   number of fill bytes.

9.2.6.2.3.2 Transition ST_ISF2:Prepare_Command_Request to ST_ISF1:Initiator_Send_Frame

This transition shall occur after the ST_ISF2:Prepare_Command_Request state has constructed a COMMAND or TASK frame.

9.2.6.2.4 ST_ISF2:Prepare_Send_Data_Out state

9.2.6.2.4.1 ST_ISF2:Prepare_Send_Data_Out state description

This state shall construct a DATA frame. This state shall include the following in the frame (these were received either from the SCSI initiator application layer or included in an XFER_RDY Arrived parameter):

    a)   tag; and,
    b)   target port transfer tag.

This state shall generate and include the following in the frame:

    a)   information unit type;
    b)   hashed destination SAS address;
    c)   hashed source SAS address;
    d)   timeout bit set to zero;
    e)   number of fill bytes; and,

    f)   fill bytes.

This state shall include requested data in the frame. If all of the data for the request is not included in the frame, the number of data bytes in the frame shall be a multiple of four, and the number of fill bytes shall be zero.

9.2.6.2.4.2 Transition ST_ISF2:Prepare_Send_Data_Out to ST_ISF1:Initiator_Send_Frame

This transition shall occur after the ST_ISF2:Prepare_Send_Data_Out state has constructed a DATA frame.

9.2.6.2.5 ST_IRD1:Receive_Data_In state

9.2.6.2.5.1 ST_IRD1:Receive_Data_In state description

The IRD state machine shall be initiated when a Data-In Arrived parameter is received from the IFR (frame router) state machine.

This state shall check the length of the DATA information unit. If the length of the information unit exceeds the amount of data remaining to be transfered for the data-in command, then this state shall send a Delivery Failure parameter to the ST_IPR:Process_Received_Response state. This state machine shall terminate after sending the parameter.

9.2.6.2.5.2 Transition ST_IRD1:Receive_Data_In to ST_IRD2:Process_Received_Data_In

This transition shall occur after any value to be checked by the ST_IRD1:Receive_Data_In has been checked.

9.2.6.2.6 ST_IRD2:Process_Received_Data_In state

9.2.6.2.6.1 ST_IRD2:Process_Received_Data_In state description

This state shall process the data-in data received by the ST_IRD1:Receive_Data_In state.

The IRD state machine shall terminate after the data-in data is processed.

9.2.6.2.7 ST_IPR1:Process_Received_Response state

9.2.6.2.7.1 ST_IPR1:Process_Received_Response state description

The IPR state machine shall be initiated when a Response Arrived parameter is received from the IFR state machine or a Delivery Failure parameter is received from the ISF state machine.

This state shall check the length of the RESPONSE information unit (see 9.2.3.5). If the length of the information unit is not correct, then this state shall send a Received Task Management Function – Executed confirmation to the SCSI initiator application layer with a protocol service response of Service Delivery Subsystem Failure. The confirmation shall include the tag. This state shall terminate after sending the confirmation.

This state shall, depending on the content of the RESPONSE information unit or Delivery Failure parameter, send either a Command Complete Received or Received Task Management Function – Executed protocol service confirmation to the SCSI initiator application layer.

The IPR state machine shall terminate after sending the confirmation.

9.2.6.2.8   ST_IFR1:Initiator_Frame_Router state

9.2.6.2.8.1   ST_IFR1:Initiator_Frame_Router state description [this one is done]

The IFR state machine shall be initiated when an Accept_Reject OPENs request is received from the SCSI initiator application layer or one of the following confirmations is received from the port layer state machine:

    a)   Frame Received; or,
    b)   HARD_RESET Received.

If the IFR state machine was initiated as the result receiving an Accept_Reject OPENs (Accept) or Accept_Reject OPENs (Reject) request from the SCSI initiator application layer, then this state shall send an Accept_Reject OPENs request along with the received argument to the port layer state machine. The IFR state machine shall terminate after sending an Accept_Reject OPENs request to the port layer state machine.

If the IFR state machine was initiated as the result of receiving a Frame Received (Frame failed), or HARD_RESET Received confirmation from the port layer state machine, then the IFR state machine shall terminate.

If the IFR state machine was initiated as the result of a Frame Received (ACK/NAK balanced) or Frame Received (ACK/NAK Not Balanced) confirmation from the port layer state machine, then this state shall check the information unit type in the received frame. If the confirmation was Frame Received (ACK/NAK Balanced) and the information unit type is not XFER_RDY, RESPONSE, or DATA, then the IFR state machine shall terminate. If the confirmation was Frame Received (ACK/NAK Not Balanced) and the information unit type is not DATA, then the IFR state machine shall terminate.

If the information unit type is correct relative to the confirmation, then this state may check that the hashed SAS source address and the hashed destination address in the frame match the SAS source address and SAS destination address used to open the connection. If this state checks these addresses and they do not match, then the IFR state machine shall terminate.
If the information unit type is XFER_RDY, then this state shall send a XFER_RDY Arrived parameter to the ST_ISF1:Initiator_Send_Frame state specified by the tag. If the information unit type is RESPONSE, then this state shall send a Response Arrived parameter to the ST_IPR1:Process_Received_Response state specified by the tag. If the information unit type is DATA then this state shall send a Data-in parameter to the ST_IRD1:Receive_Data_In state specified by the tag. Each of these parameters shall contain the content of the SAS frame. If the tag does not specify an existing state machine, then this state may discard the frame and the task or task set corresponding to the tag may be aborted.

The IFR state machine shall terminate after sending a parameter to another state machine.

9.2.6.3   SSP transport layer target device state machines

9.2.6.3.1   SSP transport layer target device state machines overview

The TFR (target frame router) state machine receives confirmations from the port layer state machine and sends a protocol service indication to the SCSI target application layer or a Data-Out Received parameter to the TTS (target transport server) state machine.   The TFR state machine also receives Accept_Reject OPENs requests from the SCSI target application layer and sends these requests to the port layer state machine.

The TFR state machine contains the following state:

    a)   Initial state. ST_TFR1:Target_Frame_Router state.

The TTS (target transport server) state machine performs the following functions:

a) receives and processes data-in and data-out delivery service requests from the SCSI target application layer;
b) processes and sends data-in and data-out delivery service confirmations to the SCSI target application layer;
c) receives and processes protocol service responses from the SCSI target application layer; and
d) communicates with the port layer state machine via several requests and confirmations regarding frame transmission.

The TTS state machine contains the following states:

a) Initial state. ST_TTS1:Request_Response_Router;
b) ST_TTS2:Target_Send_Frame state;
c) ST_TTS3:Prepare_Send_Data_In state;
d) ST_TTS4:Receive_Data_Out;
e) ST_TTS5:Prepare_XFER_RDY;
f) ST_TTS6:Process_Received_Data_Out; and
g) ST_TTS7:Prepare_Response.

The TFR state machine sends one of the following protocol service indications to the SCSI target application layer:

a) SCSI Command Received; or
b) Task Management Request Received.

The TFR state machine may receive one of the following requests from the SCSI target application layer:

a) Accept_Reject OPENs (Accept); or
b) Accept_Reject OPENs (Reject).

The TTS state machine receives one of the following protocol service responses from the SCSI target application layer:

a) Send Data-In; or
b) Receive Data-Out.

The TTS state machine sends one of the following protocol service confirmations to the SCSI target application layer:

a) Data-In Delivered; or
b) Data-Out Received.

Requests to and confirmations from the port layer state machines are described in x.x.

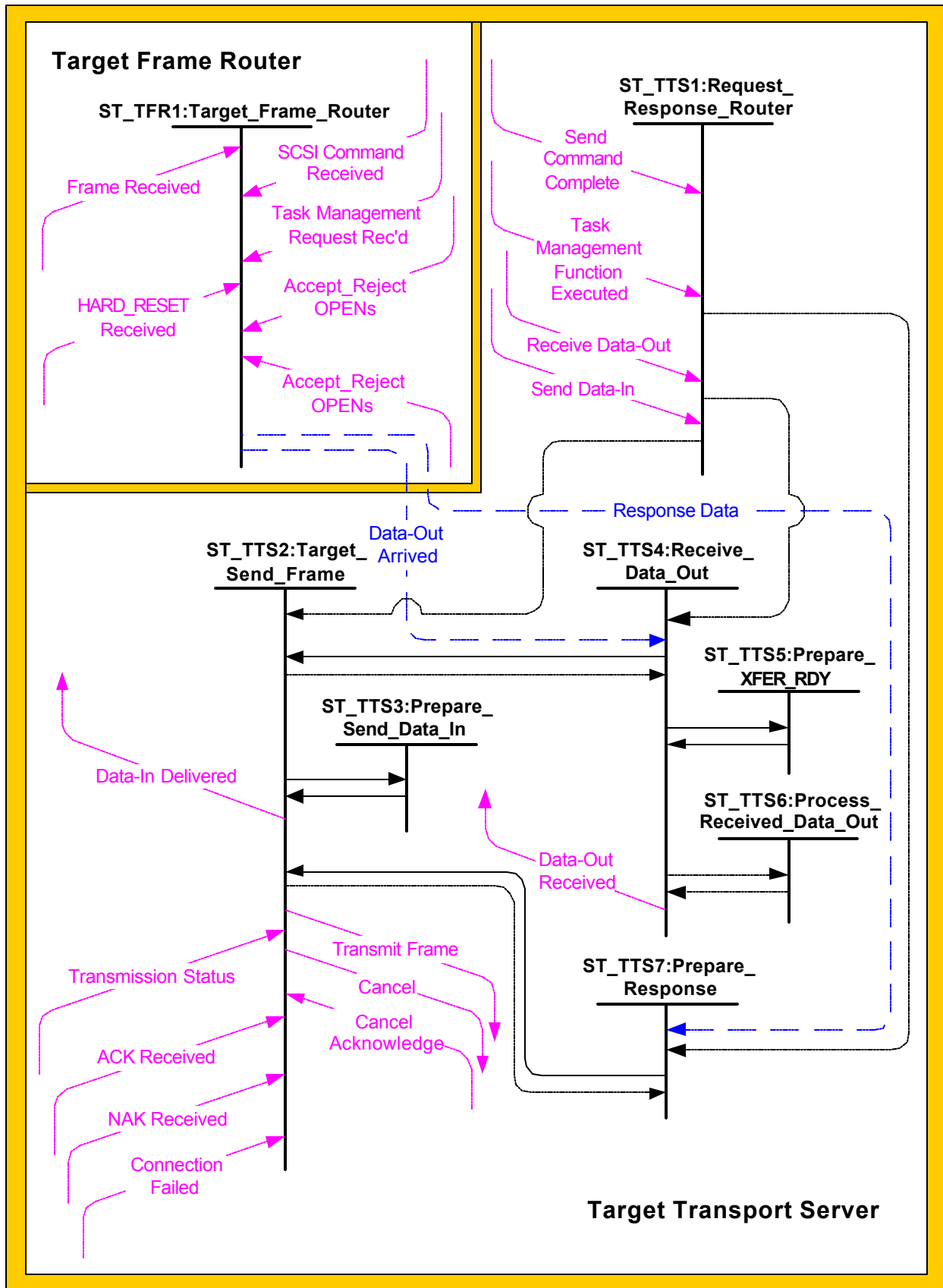Figure 2 describes the SSP transport layer target device state machines.

Figure 2. SSP transport layer target device state machines

9.2.6.3.2   ST_TFR1:Target_Frame_Router state

9.2.6.3.2.1   ST_TFR1:Target_Frame_Router state description

The TFR state machine shall be initiated when an Accept_Reject OPENs request is received from the SCSI target application layer or one of the following confirmations is received from the port layer state machine:

    a)   Frame Received; or,
    b)   HARD_RESET Received.

If the TFR state machine was initiated as the result of receiving an Accept_Reject OPENs (Accept) or Accept_Reject OPENs (Reject) request from the SCSI target application layer, then this state shall send an Accept_Reject OPENs request along with the received attribute to the port layer state machine. The TFR state machine shall terminate after sending an Accept_Reject OPENs request to the port layer state machine.

If the TFR state machine was initiated as the result of receiving a HARD_RESET Received confirmation from the port layer state machine, then the TFR state machine shall terminate.

If the TFR state machine was initiated as the result of receiving a Frame Received (ACK/NAK balanced) or Frame Received (ACK/NAK Not Balanced) confirmation from the port layer state machine, then this state shall check the information unit type in the received frame. If the information unit type is not COMMAND, TASK, or DATA, then this state may send a SCSI Command Received protocol service indication to the SCSI target application layer indicating a Service Delivery Subsystem Failure. This indication shall include the tag.

If the confirmation was Frame Received (ACK/NAK Balanced), the information unit type is not COMMAND, TASK, or DATA, and this state does not send an indication to the SCSI target application layer, then the TFR state machine shall terminate. If the confirmation was Frame Received (ACK/NAK Not Balanced), the information unit type is not DATA, and this state does not send an indication to the SCSI target application layer, then the TFR state machine shall terminate.

If the information unit type is correct relative to the confirmation, then this state may check that the hashed SAS source address and the hashed destination address in the frame match the SAS source address and SAS destination address used to open the connection. If this state checks these addresses and they do not match, then the TFR state machine shall terminate.

If the information unit type is DATA, and the tag does not match a tag for the outstanding data-out command, then the TFR state machine shall discard the frame.If the information unit type is COMMAND, then this state shall check that the length of the information unit is [28 + (4 x additional CDB length)] bytes. If the length of the information unit is less than the calculated length, then this state shall send a Response Data parameter to the ST_TTS7:Prepare_Response state with the argument INFORMATION UNIT TOO SHORT. If the length of the information unit is greater than the calculated length, then this state shall send a Response Data parameter to the ST_TTS7:Prepare_Response state with the attribute INFORMATION UNIT TOO LONG.

If the information unit type is TASK, then this state shall check that the length of the information unit is 32 bytes. If the length of the information unit is not 32 bytes, then this state shall send a Response Data parameter to the ST_TTS7:Prepare_Response state with the argument COMMAND OR TASK FIELDS INVALID.

If the information unit type is DATA, then this state shall check that the target port transfer tag corresponds to a target port transfer tag sent in a previous XFER_RDY frame. If the target port transfer tag in the frame does not correspond, then this state shall send a SCSI Command Received protocol service indication to the SCSI target application layer indicating a Service Delivery Subsystem Failure. This indication shall include the tag.

If the information unit type is COMMAND and the length of the information unit is correct, then this state shall send a SCSI Command Received protocol service indication to the SCSI target application layer. If the information unit type is TASK and the length of the information unit is correct, then this state shall send a Task Management Request Received protocol service indication to the SCSI target application layer. If the information unit type is DATA, then this state shall send a Data-Out Arrived parameter to the ST_TTS4:Receive_Data_Out state. Each indication or parameter shall contain the content of the SAS frame.

The TFR state machine shall terminate after sending a Data-Out Arrived parameter or protocol service indication.

9.2.6.3.3 ST_TTS1:Target_Request_Response_Router state

9.2.6.3.3.1 ST_TTS1:Target_Request_Response_Router state overview

The TTS state machine shall be initiated when one of the following is received from the SCSI target application layer:

 a) a Send Data-In data-in delivery service request;
 b) a Receive Data-Out protocol service request;
 c) a Task Management Function Executed protocol service response; or,
 d) a Send Command Complete protocol service response.

The request or response includes the following to be used in any OPEN address frames required to service the request or response:

 a) link rate;
 b) initiator connection tag;
 c) destination SAS address; and,
 d) source SAS address.

A Send Data-In data-in protocol service request also includes the following:

 a) I_T_L_x nexus (e.g., tag);
 b) device server buffer (e.g., starting logical block address); and,
 c) request byte count (e.g., transfer length).

A Receive Data-Out data-out delivery service request also includes the following:

 a) I_T_L_x nexus (e.g., tag);
 b) device server buffer (e.g., starting logical block address); and,
 c) request byte count (e.g., transfer length).

A Task Management Function Executed protocol service response or Send Command Complete protocol service response also includes the following:

 a) I_T_L_x nexus (e.g., tag);
 b) task management function; and,
 c) tag of task to be managed.

9.2.6.3.3.2 Transition ST_TTS1:Target_Request_Response_Router to ST_TTS2:Target_Send_Frame

This transition shall occur after the ST_TTS1:Target_Request_Response_Router state has received a Send Data-In data-in delivery service request from the SCSI target application layer.

9.2.6.3.3.3 Transition ST_TTS1:Target_Request_Response_Router to ST_TTS4:Receive_Data_Out

This transition shall occur after the ST_TTS1:Target_Request_Response_Router state has received a Receive Data-Out data-out delivery service request from the SCSI target application layer.

9.2.6.3.3.4 ST_TTS1:Target_Request_Response_Router to ST_TTS7:Prepare_Response

This transition shall occur after the ST_TTS1:Target_Request_Response_Router state has received a Task Management Function Executed protocol service response or a Send Command Complete protocol service response from the SCSI target application layer.

9.2.6.3.4 ST_TTS2:Target_Send_Frame state

9.2.6.3.4.1 ST_TTS2:Target_Send_Frame state description

This state is entered when a DATA frame is received from the ST_TTS3:Prepare_Send_Data_In state, when an XFER_RDY frame is received from the ST_TTS4:Receive_Data_Out state, when a RESPONSE frame is received from the ST_TTS7:Prepare_Response state, or after the ST_TTS7:Prepare_Response state has determined that the number of retries for a RESPONSE frame has been exceeded.

If the TTS state machine was initiated as the result of this state receiving a Send Data-In data-in delivery service request and the specified values are included with the request, then this state shall transition to the ST_TTS3:Prepare_Send_Data_In state.

If this state is entered from the ST_TTS2:Prepare_Send_Data_In for transmission of a DATA frame, then this state shall send a Transmit Frame (Non-interlocked) request to the port layer state machine.

If this state is entered from the ST_TTS4:Receive_Data_Out state for transmission of an XFER_RDY frame, then this state shall send a Transmit Frame (Interlocked) request to the port layer state machine.

If this state is entered from the ST_TTS7:Prepare_Response state for transmission of a RESPONSE frame, then this state shall send a Transmit Frame (Interlocked) request to the port layer state machine.

A Transmit Frame request from this state (either interlocked or non-interlocked) shall include the SSP frame and the following to be used for any OPEN address frame:

  a) the initiator bit set to zero;
  b) link rate;
  c) initiator connection tag;
  d) destination SAS address; and,
  e) source SAS address.

After sending a Transmit Frame request this state shall receive a Transmission Status confirmation from the port layer state machine.

If the confirmation is Transmission Status (Frame Transmitted) confirmation, then this state shall receive one of the following confirmations from the port layer state machine.

  a) ACK Received;
  b) NAK Received; or,
  c) Connection Failed.

If the confirmation is ACK Received, the transmitted frame was a DATA frame, and the number of bytes moved for the Send Data-In data-in delivery service request is less than the Request Byte Count, then this state shall transition to the ST_TTS3:Prepare_Send_Data_In state.

If the confirmation is ACK Received and the transmitted frame was an XFER_RDY frame, then this state shall transition to the ST_TTS4:Receive_Data_Out state.

This state shall send a Data-In Delivered data-in delivery service confirmation to the SCSI target application layer with a delivery result argument of DELIVERY SUCCESSFUL after one of the following:

    a) If a confirmation transmission status parameter for a DATA frame was Transmission Status (Frame Transmitted) followed by an ACK Received confirmation and the number of bytes moved for the Send Data-In data-in delivery service request is equal to the Request Byte Count; or,

    b) If a confirmation transmission status parameter for a RESPONSE frame was Transmission Status (Frame Transmitted) followed by an ACK Received confirmation.

This state shall send a Data-In Delivered data-in delivery service confirmation to the SCSI target application layer with a delivery result argument of DELIVERY FAILURE after one of the following:

    a) If the received transmission status confirmation parameter for a DATA or XFER_RDY frame was not Transmission Status (Frame Transmitted);

    b) If the received transmission status confirmation parameter for a DATA or XFER_RDY frame was Transmission Status (Frame Transmitted) followed by a confirmation of NAK Received or Connection Failed; or,

    c) If this state was entered as the result of the ST_TTS7:Prepare_Response state determining that the number of retries for a RESPONSE frame has been exceeded.

A Data-In Delivered data-in delivery service confirmation to the SCSI target application layer confirmation shall include the following:

    a) any argument received from the port layer state machine (e.g., Transmission Status (Frame Transmitted) or Service Delivery Subsystem Failure; and,

    b) I_T_L_x nexus information (i.e., destination SAS address and tag).

The TTS state machine shall terminate after sending the Data-In Delivered confirmation.

This state may also send a Cancel request to the port layer state machine to cancel a previous Transmit Frame request. The TTS state machine terminates upon receipt of a Cancel Acknowledge confirmation from the port layer state machine.

9.2.6.3.4.2 Transition ST_TTS2:Target_Send_Frame to ST_TTS2:Prepare_Send_Data_In

This transition shall occur after either a Send Data-In data-in delivery service request is received by the ST_TTS2:Target_Send_Frame state from the SCSI target application layer, or the ST_TTS2:Target_Send_Frame state has received a Transmission Status (Frame Transmitted) confirmation and an ACK Received confirmation for a DATA frame and the number of bytes moved for the Send Data-In data-in delivery service request is less than the Request Byte Count.

9.2.6.3.4.3 Transition ST_TTS2:Target_Send_Frame to ST_TTS4:Receive_Data_Out

This transition shall occur after the ST_TTS2:Target_Send_Frame state has received a Transmission Status (Frame Transmitted) confirmation and an ACK Received confirmation for an XFER_RDY frame.

9.2.6.3.4.4 Transition ST_TTS2:Target_Send_Frame to ST_TTS7:Prepare_Response

This transition shall occur if the ST_TTS2:Target_Send_Frame state receives one of the following confirmations for a RESPONSE frame from the port layer state machine:

    a) Transmission Status with an attribute other than (Frame Transmitted);

    b) NAK Received; or,

    c) Connection Failed.

9.2.6.3.5   ST_TTS3:Prepare_Send_Data_In state

9.2.6.3.5.1 ST_TTS3:Prepare_Send_Data_In state description

This state fetches the data from the Device Server Buffer and constructs a DATA frame. This state shall use the tag received from the ST_TTS2:Target_Send_Frame state to construct the frame.

This state shall generate the following to be used in the frame:

   a) information unit type;
   b) hashed destination SAS address;
   c) hashed source SAS address;
   d) timeout bit set to zero;
   e) number of fill bytes; and,
   f) fill bytes.

9.2.6.3.5.2 Transition ST_TTS3:Prepare_Send_Data_In to ST_TTS2:Target_Send_Frame

This transition shall occur after the ST_TTS3:Prepare_Send_Data_In state has constructed a DATA frame.

9.2.6.3.6   ST_TTS4:Receive_Data_Out state

9.2.6.3.6.1 ST_TTS4:Receive_Data_Out state description

This state is entered after one of the following occurs:

   a) a Receive Data-Out service request is received from the ST_TS1:Request_Response_Router
       state;
   b) a DATA frame is received from the TFR (target frame router) state machine;
   c) an ACK Received confirmation for an XFER_RDY frame was received from the
       ST_TTS2:Target_Send_Frame state;
   d) an XFER_RDY frame has been constructed by the ST_TTS5:Prepare_XFER_RDY state; or,
   e) data-out data has been processed by the ST_TTS6:Process_Received_Data_Out state.

If this state was entered as the result of receiving a Receive Data-Out service request from the ST_TS1:Request_Response_Router state then this state shall transition to the ST_TTS5:Prepare_XFER_RDY state.

If this state was entered as the result of receiving a DATA frame from the TFR state machine, then this state shall check the target transport tag value in the DATA frame. If the value does not match, then this state shall send a Data-Out Received data-out delivery service confirmation to the SCSI target application layer with a delivery result argument of DELIVERY SUCCESSFUL (ILLEGAL TARGET PORT TRANSFER TAG RECEIVED). This confirmation shall include the tag. The TTS state machine shall terminate after sending the confirmation.

If this state was entered as the result of receiving a DATA frame from the TFR state machine, then this state shall check the length of the data. If the length of the data exceeds that specified by the XFER_RDY frame that requested the data, then this state shall send a Data-Out Received data-out delivery service confirmation to the SCSI target application layer with a delivery result argument of DELIVERY SUCCESSFUL (TOO MUCH WRITE DATA). This confirmation shall include the tag. The TTS state machine shall terminate after sending the confirmation.

If the target transport tag value matches the value sent with the corresponding XFER_RDY frame, and the length of the data does not exceed that specified by the XFER_RDY frame that requested the data, then this state shall transition to the ST_TTS6:Process_Received_Data_Out state.

If this state is entered as the result of the ST_TTS2:Target_Send_Frame state receiving an ACK Received confirmation from the port layer state machine for an XFER_RDY frame, then this state shall wait for a Data-Out Arrived parameter from the TFR state machine.

If this state is entered from the ST_TTS5:Prepare_XFER_RDY state, then this state shall transition to the ST_TTS2:Target_Send_Frame state.

If this state is entered from the ST_TTS6:Process_Received_Data_Out state and the number of bytes moved for the Receive Data-Out data-out delivery service request is less than the Request Byte Count, then this state shall wait for a Data-Out Arrived parameter from the ST_TFR1:Target_Frame_Router state.

If this state is entered from the ST_TTS6:Process_Received_Data_Out state and number of bytes moved for the Receive Data-Out data-out delivery service request is equal to the Request Byte Count, then this state shall send a Data-Out Received data-out delivery service confirmation to the SCSI target application layer. This confirmation shall include the tag. The TTS state machine shall terminate after sending the confirmation.

9.2.6.3.6.2 Transition ST_TTS4:Receive_Data_Out to ST_TTS5:Prepare_XFER_RDY

This transition shall occur after a Receive Data-Out data-out delivery service request has been received by the ST_TTS4:Receive_Data_Out state from the ST_TTS1:Request_Response_Router state.

9.2.6.3.6.3 Transition ST_TTS4:Receive_Data_Out to ST_TTS2:Target_Send_Frame

This transition shall occur after this state has received an XFER_RDY frame from the ST_TTS5:Prepare_XFER_RDY state.

9.2.6.3.6.4 Transition ST_TTS4:Receive_Data_Out to ST_TTS6:Process_Received_Data_Out

This transition shall occur after the ST_TTS4:Receive_Data_Out state receives a Data-Out Arrived parameter from the TFR (target frame router) state machine.

9.2.6.3.7   ST_TTS5:Prepare_XFER_RDY state

9.2.6.3.7.1 ST_TTS5:Prepare_XFER_RDY state description

This state shall construct an XFER_RDY frame. This state shall use the following received from the Receive Data-Out data-out delivery service request to construct the frame:

    a) tag;
    b) target port transfer tag; and,
    a) write data length.

This state shall generate the following to be used in the frame:

    a) information unit type;
    b) hashed destination SAS address;
    c) hashed source SAS address;
    d) timeout bit set to zero; and,
    e) number of fill bytes.

9.2.6.3.7.2 Transition ST_TTS5:Prepare_XFER_RDY to ST_TTS4:Receive_Data_Out

This transition shall occur after the ST_TTS5:Prepare_XFER_RDY state has constructed an XFER_RDY frame.

9.2.6.3.8   ST_TTS6:Process_Received_Data_Out state

9.2.6.3.8.1 ST_TTS6:Process_Received_Data_Out state description

This state shall process the data received in a Data-Out parameter using the Device Server Buffer (e.g., logical block address) to which the data is to be transferred.

9.2.6.3.8.2 Transition ST_TTS6:Process_Received_Data_Out to ST_TTS4:Receive_Data_Out

This transition shall occur after data received in a Data-Out parameter has been processed.

9.2.6.3.9   ST_TTS7:Prepare_Response state

9.2.6.3.9.1 ST_TTS7:Prepare_Response state description

If not already running, the TTS state machine shall be initiated when a Response Data parameter is received by this state from the TFR state machine.

This state is entered after one of the following occurs:
- a) a Response Data parameter is received by this state from the TFR state machine;
- b) a Task Management Function Executed protocol service response was received by the ST_TTS1:Target_Request_Response_Router state from the SCSI target application layer;
- c) a Send Command Complete protocol service response was received by the ST_TTS1:Target_Request_Response_Router state from the SCSI target application layer; or,
- d) the ST_TTS2:Target_Send_Frame state receives something other than a Transmission Status (Frame Transmitted) confirmation followed by an ACK Received confirmation for a RESPONSE frame from the port layer state machine (i.e., the frame transmission was unsuccessful).

If this state was entered as the result of receiving a Response Data parameter from the TFR state machine, or a Task Management Function Executed protocol service response or a Send Command Complete protocol service response from the ST_TTS1:Target_Request_Response_Router state, then this state shall construct a RESPONSE frame.

If this state was entered as the result of receiving a Response Data parameter from the TFR state machine, this state shall use the tag received in the parameter. If the argument for the Response data parameter was INFORMATION UNIT TOO SHORT or INFORMATION UNIT TOO LONG, then this state shall set the status in the RESPONSE frame to CHECK CONDITION and the sense data to be the argument. If the argument was COMMAND OR TASK FIELDS INVALID, then this state shall set the response code to be the argument.

This state shall use the following received from the SCSI target application layer to construct the frame:

- a) tag;
- b) status
- c) response data; and,
- d) sense data.

This state shall generate the following to be used in the frame:

- a) information unit type;
- b) hashed destination SAS address;
- c) hashed source SAS address;
- d) timeout bit set to zero;
- e) number of fill bytes;
- f) fill bytes;
- g) data present;
- h) sense data list length; and,

i)   response data list length.

If this state was entered as the result of the ST_TTS2:Target_Send_Frame state receiving something other than a Transmission Status (Frame Transmitted) confirmation followed by an ACK Received confirmation for a RESPONSE frame from the port layer state machine (i.e., the frame transmission was unsuccessful), then this state shall check to see if the number of retries for the RESPONSE frame has been exceeded.

If the number of retries has not been exceeded, the this state generate a RESPONSE frame using all of the values for the previous RESPONSE frame except that the timeout bit shall be set to one.

9.2.6.3.9.2 Transition ST_TTS7:Prepare_Resp onse to ST_TTS2:Target_Send_Frame

This transition shall occur after the ST_TTS7:Prepare_Response state has constructed a RESPONSE frame or if the number of retries for transmission of a RESPONSE frame has been exceeded.