

To: T10 Technical Committee
 From: Rob Elliott, HP (elliott@hp.com)
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 Subject: 04-168r1 SAS-1.1 RRDY and CREDIT_BLOCKED clarifications

Revision history

Revision 0 (25 May 2004) First revision, split off from 04-115r1. Original proposal in 04-115r1 was to only allow CREDIT_BLOCKED when there were no outstanding RRDYs. May WG wanted to instead allow CREDIT_BLOCKED after RRDY, which this proposal does.
 Revision 1 (15 July 2004) Incorporated comments from July 2004 SAS protocol WG meeting.

Related documents

sas1r04 - Serial Attached SCSI 1.1 revision 4
 04-115 - SAS-1.1 Miscellaneous changes

Overview

Clarify handling of CREDIT_BLOCKED and RRDY.

1. CREDIT_BLOCKED may be sent while previous RRDY credits are still available for use [May SAS protocol WG request]. CREDIT_BLOCKED is just a promise that no further RRDYs are forthcoming in this connection. The frame receiver might choose to send this after it sent a DONE, or when it is busy doing some background task and temporarily cannot accept any more frames. After CREDIT_BLOCKED, it must still be ready to receive frames if previous RRDYs were outstanding.
2. The frame receiver shall not send any additional RRDYs after CREDIT_BLOCKED. CREDIT_BLOCKED is supposed to be a shortcut to DONE/DONE and closing the connection. There's no backing off the commitment.
3. If a frame transmitter sees RRDY after CREDIT_BLOCKED, it should ignore it. This is an error case.

Also, delete "Credit" from the argument names of Tx/Rx Credit Status (Credit Whatever) to make the usage consistent (usually they were sent with "Credit" in the name but received without it in the name).

Suggested changes

7.2.6.2 CREDIT_BLOCKED

CREDIT_BLOCKED indicates that no more credit is going to be sent during this connection.

See 7.16.4 for details on SSP flow control.

7.2.6.6 RRDY (Receiver ready)

RRDY is used to increase SSP frame credit.

The versions of RRDY representing different reasons are defined in table 66.

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[A phy shall not transmit RRDY after transmitting CREDIT_BLOCKED in a connection.](#) See 7.16.4 for details on SSP flow control.

7.16.4 SSP flow control

SSP phys [use RRDY to](#) grant credit for permission [for the other SSP phy in the connection](#) to transmit frames ~~with RRDY~~. Each RRDY increments credit by one frame. Frame transmission decrements credit by one frame. Credit of zero frames is established at the beginning of each connection.

SSP phys shall not increment credit past 255 frames.

To prevent deadlocks where an SSP initiator port and SSP target port are both waiting on each other to provide credit, an SSP initiator port shall never refuse to provide credit by withholding RRDY because it needs to transmit a frame itself. It may refuse to provide credit for other reasons (e.g., temporary buffer full conditions).

An SSP target port may refuse to provide credit for any reason, including because it needs to transmit a frame itself.

If credit is zero, SSP phys that are going to be unable to provide credit for 1 ms may send CREDIT_BLOCKED. The other phy may use this to avoid waiting 1 ms to transmit DONE (CREDIT_TIMEOUT) (see 7.16.7).

If credit is nonzero, SSP phys that are going to be unable to provide additional credit for 1 ms even if they receive frames per the existing credit may transmit CREDIT_BLOCKED.

After sending CREDIT_BLOCKED, an SSP phy shall not transmit any additional RRDYs in the connection.

7.16.5 Interlocked frames

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An SSP phy may transmit primitives responding to traffic it is receiving (e.g. an ACK or NAK to acknowledge an SSP frame, an RRDY to grant more receive credit, or a CREDIT_BLOCKED to indicate ~~credit is not forthcoming~~no more RRDYs are going to be transmitted) while waiting for an interlocked frame it transmitted to be acknowledged. These primitives may also be interspersed within an SSP frame.

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7.16.6 Closing an SSP connection

DONE shall be exchanged prior to closing an SSP connection (see 8.2.2.3.5). There are several versions of the DONE primitive indicating additional information about why the SSP connection is being closed:

- a) DONE (NORMAL) indicates normal completion; the transmitter has no more SSP frames to transmit;
- b) DONE (CREDIT TIMEOUT) indicates the transmitter still has SSP frames to transmit, but did not receive an RRDY granting frame credit within 1 ms or has received a CREDIT_BLOCKED and has consumed all RRDYs received; and
- c) DONE (ACK/NAK TIMEOUT) indicates the transmitter transmitted an SSP frame but did not receive the corresponding ACK or NAK within 1 ms. As a result, the ACK/NAK count is not balanced and the transmitter is going to transmit a BREAK in 1 ms unless the recipient replies with DONE and the connection is closed.

If the transmitter has no more SSP frames to transmit and receives a CREDIT_BLOCKED, it may transmit either DONE (NORMAL) or DONE (CREDIT_TIMEOUT).

After transmitting DONE, the transmitting phy initializes and starts a 1 ms DONE Timeout timer (see 7.16.7.5).

After transmitting DONE, the transmitting phy shall not transmit any more SSP frames during this connection.

However, the phy may transmit ACK, NAK, RRDY, and CREDIT_BLOCKED after transmitting DONE if the other phy is still transmitting SSP frames in the reverse direction. Once an SSP phy has both transmitted and received DONE, it shall close the connection by transmitting CLOSE (NORMAL) (see 7.12.7).

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7.16.7.4 SSP_TCM (transmit frame credit monitor) state machine

The SSP_TCM state machine's function is to ensure that transmit frame credit is available ~~from the originator~~ before a frame is transmitted. This state machine consists of one state.

This state machine shall keep track of the number of transmit frame credits ~~available~~ ~~received versus the number of transmit frame credits used~~. This state machine ~~adds~~ shall add one transmit frame credit for each RRDY Received message received and ~~subtracts~~ shall subtract one transmit frame credit for each Tx Credit Used message received. ~~This state machine shall remember any~~ The CREDIT_BLOCKED Received message ~~that is received~~ indicates that transmit frame credit is blocked. After receiving a CREDIT_BLOCKED Received message, this state machine may ignore additional RRDY Received messages until it receives a Request Close message or a Request Break message.

When transmit frame credit is available, this state machine shall send the Tx Credit Status (~~Credit~~ Available) message to the SSP_TF2:Tx_Wait state.

When transmit frame credit is not available and [transmit frame](#) credit is not blocked, this state machine shall send the Tx Credit Status (~~Credit~~ Not Available) message to the SSP_TF2:Tx_Wait state.

When transmit frame credit is not available and [transmit frame](#) credit is blocked, this state machine shall send the Tx Credit Status (~~Credit~~ Blocked) message to the SSP_TF2:Tx_Wait state.

When this state machine receives an Enable Disable SSP (Enable) message, [a](#) Request Close message, or [a](#) Request Break message, transmit frame credit shall be set to not available and [transmit frame](#) credit shall ~~not~~ ~~be~~ ~~set~~ ~~to~~ ~~not~~ blocked.

7.16.7.6.3 SSP_TF2:Tx_Wait state

7.16.7.6.3.1 State description

This state monitors the Tx Balance Status message and the Tx Credit Status message to ensure that frames are transmitted and connections are closed at the proper time.

If this state is entered from the SSP_TF1:Connected_Idle state with a Transmit Frame Balance Required argument or a Transmit Frame Balance Not Required argument, and:

- a) if the last Tx Credit Status message received had an argument of Not Available this state shall initialize and start the Credit Timeout timer; or
- b) if the last Tx Credit Status message had an argument other than Not Available this state shall stop the Credit Timeout timer.

7.16.7.6.3.2 Transition SSP_TF2:Tx_Wait to SSP_TF3:Indicate_Frame_Tx

This transition shall occur if this state was entered from the SSP_TF1:Connected_Idle state with an argument of Transmit Frame Balance Required if:

- a) the last Tx Balance Status message received had an argument of Balanced; and
- b) the last Tx Credit Status message received had an argument of ~~Credit~~ Available.

This transition shall occur if this state was entered from the SSP_TF1:Connected_Idle state with an argument of Transmit Frame Balance Not Required and if the last Tx Credit Status message received had an argument of ~~Credit~~ Available.

This transition shall occur after sending a Tx Credit Used message to the SSP_TCM state machine.

7.16.7.6.3.3 Transition SSP_TF2:Tx_Wait to SSP_TF4:Indicate_DONE_Tx

This transition shall occur and include an ACK/NAK Timeout argument if an ACK/NAK Timeout message is received.

This transition shall occur and include a Close Connection argument if:

- a) this state was entered from the SSP_TF1:Connected_Idle state with an argument of Close Connection; and
- b) the last Tx Balance Status message received had an argument of Balanced.

This transition shall occur and include a Credit Timeout argument if:

- a) this state was entered from the SSP_TF1:Connected_Idle state with a Transmit Frame Balance Required argument or a Transmit Frame Balance Not Required argument;
- b) the Credit Timeout timer expired before a Tx Credit Status message was received with an argument of Available, or the last Tx Credit Status message received had an argument of Blocked;
- c) a Tx Balance Status message was received with an argument of Balanced (i.e., the Credit Timeout argument shall not be included in this transition for this reason unless the ACK/NAK count is balanced); and
- d) an ACK/NAK Timeout message was not received.

7.16.7.7 SSP_RF (receive frame control) state machine

The SSP_RF state machine's function is to receive frames and determine whether or not those frames were received successfully. This state machine consists of one state.

This state machine:

- a) checks the frame to determine if the frame should be accepted or discarded;
- b) checks the frame to determine if an ACK or NAK should be transmitted; and
- c) sends a Frame Received confirmation to the port layer.

The frame (i.e., all the dwords between an SOF and EOF) shall be discarded if any of the following conditions are true:

- a) the number of data dwords between the SOF and EOF is less than 7;
- b) the number of data dwords after the SOF is greater than 263 data dwords;
- c) the Rx Credit Status (**Credit** Exhausted) message is received; or
- d) the DONE Received message is received.

If consecutive SOF Received messages are received without an intervening EOF Received message (i.e., SOF, data dwords, SOF, data dwords, and EOF instead of SOF, data dwords, EOF, SOF, data dwords, and EOF) then this state machine shall discard all dwords between those SOFs.

If the frame is discarded then no further action is taken by this state machine. If the frame is not discarded then this state machine shall:

- a) send a Frame Received message to the SSP_RCM state machine; and
- b) send a Frame Received message to the SSP_RIM state machine;

7.16.7.8 SSP_RCM (receive frame credit monitor) state machine

The SSP_RCM state machine's function is to ensure that there was credit given to the originator for every frame that is received. This state machine consists of one state.

This state machine monitors the receiver's resources and keeps track of the number of RRDYs transmitted versus the number of frames received.

Any time resources are released or become available, [if this state machine has not sent the Rx Credit Control \(Blocked\) message to the SSP_TC state machine and the SSP_D state machine](#), this state machine shall send the Rx Credit Control (Available) message to the SSP_TC state machine. This state machine shall only send the Rx Credit Control (Available) message to the SSP_TC state machine after frame receive resources become available. The specifications for when or how resources become available is outside the scope of this standard.

This state machine may send the Rx Credit Control (Blocked) message to the SSP_TC state machine and the SSP_D state machine [when no further receive frame credit is going to become available within a credit timeout \(i.e., less than 1 ms\), even if frames are received per the existing receive frame credit. indicating that no more credit is going to be sent during this connection.](#) After sending the Rx Credit Control (Blocked) message to the SSP_TC state machine and the SSP_D state machine, this state machine shall not send the Rx Credit Control (Available) message to the SSP_TC state machine or the SSP_D state machine for the duration of the current connection. ~~The Rx Credit Control (Blocked) message should be sent to the SSP_TC state machine and the SSP_D state machine when no further credit is going to become available within a credit timeout (i.e., less than 1 ms).~~

This state machine shall indicate through the Rx Credit Control message only the amount of resources available to handle received frames (e.g., if this state machine has resources for 5 frames the maximum number of Rx Credit Control requests with the Available argument outstanding is 5).

This state machine shall use the Credit Transmitted message to keep track of the number of RRDYs transmitted. This state machine shall use the Frame Received message to keep a track of the number of frames received.

Any time the number of Credit Transmitted messages received exceeds the number of Frame Received messages received this state machine shall send a Rx Credit Status (**Credit** Extended) message to the SSP_RF state machine and the SSP_D state machine.

Any time the number of Credit Transmitted messages received equals the number of Frame Received messages received this state machine shall send a Rx Credit Status (**Credit** Exhausted) message to the SSP_RF state machine and the SSP_D state machine.

If this state machine receives an Enable Disable SSP (Enable) message, Request Close message, or Request Break message the frame receive resources shall be initialized to the no credit value for the current connection.

7.16.7.10 SSP_TC (transmit credit control) state machine

The SSP_TC state machine's function is to control the sending of requests to transmit an RRDY or CREDIT_BLOCKED. This state machine consists of one state.

Any time this state machine receives a Rx Credit Control (Available) message it shall send a number of Transmit RRDY (Normal) messages to the SSP transmitter as indicated by the amount of resources available to handle received frames (e.g., if the Available argument indicates 5 RRDYs are to be transmitted this state machine sends 5 Transmit RRDY (Normal) messages to the SSP transmitter).

Any time this state machine receives a RRDY Transmitted message it shall send a Credit Transmitted message to the SSP_RCM state machine.

Any time this state machine receives a Rx Credit Control (Blocked) message it shall send a Transmit CREDIT_BLOCKED message to the SSP transmitter.