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TWG Second Showing

Item 11-10-00001.006

Subject: Protocol enhancements for 3.0 Specifications

Background: There are a few protocol enhancements which should be made to improve the competitiveness of RapidIO. These include the efficiency of the retry and error recovery protocols.

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Comment Expiration Date:

Distribution: RapidIO TA Technical Working Group members

1.2 Discussion

The target markets for the 3.0 specification have expanded beyond telecom. To compete, RapidIO must be able to deliver superior quality of service and latency while remaining bandwidth efficient. This document proposes changes to the RapidIO control symbol protocol which will improve the bandwidth efficiency and latency characteristics of RapidIO.

1.2.1 Receiver Based Flow Control and Error Recovery Optimization

The RapidIO protocol operates well using receiver based flow control. Optimization of success path packet transfer, and recovery from retries, is the focus of this showing. It is proposed that the semantics of the Packet Accepted (PA), Packet Not Accepted (PNA) and Restart From Retry (RFR) control symbols be changed.

Currently, one PA control symbol must be sent for every packet. If long packets are sent in one direction on a link, and short packets in the other, the bandwidth devoted to acknowledging short packets reduces the bandwidth available for transmission of long packets. Additionally, the PA’s required for the short packets reduces the bandwidth efficiency of RapidIO significantly.

Ideally, it would be possible to combine PA’s with Start of Packet (SOP) and End of Packet (EOP) control symbols as packets are transferred in either direction, regardless of differences in packet size. It is proposed to optionally enhance the semantics of PA control symbols to acknowledge all outstanding unacknowledged packets up to and including the ackID found in the PA. This allows PA control symbols to be combined with SOP and EOP, improving the bandwidth efficiency of RapidIO without impairing the reliability of packet transfer. This capability would be optional for all Baud Rate Classes in the 3.0 specification in order to allow for backwards compatibility with existing Baud Rate Class 1 and 2 devices.

If a packet cannot be accepted due to lack of resources, there are two methods used to retry packets. If only VC0 is active, then a Retry control symbol is issued which indicates the ackID of the packet which is to be retried. In response, a Restart from Retry (RFR) control symbol is sent, followed shortly afterwards by an SOP for a packet. If any of VC1 through VC8 are also active, then a PNA is issued with a cause of “Packet not accepted due to lack of resources”. Upon receiving a PNA, the processing element issues a Link-Request/Input-Status (LR/IS) which should result in receiving a Link Response (LR) control symbol shortly thereafter. The LR indicates the ackID of the next packet which should be transmitted. A Status and VC_Status control symbol must be transmitted following the LR, enabling the receiver to know the buffer status of the link partner and choose a packet which can be accepted.

The change to the PA semantics proposed above would allow multiple packets to be outstanding at the time a Retry needs to be issued. If the Retry acknowledges all packets up to the ackID immediately before the retried ackID, less bandwidth is required to issue the Retry and the Retry can be issued with lower latency.

There are corner cases in which no packet is available for transmission after a Retry. For example, the previously transmitted packet may have outlived the current Time To Live period and been discarded. If this occurs, the standard error recovery procedure of LR/IS and LR can be followed.

Support for enhanced PA and Retry control symbols will be optional for devices operating at Baud Rate Class 1 and 2. Support for enhanced PA and Retry control symbols shall be mandatory for devices operating at Baud Rate Class 3.

The efficiency of retrying a packet using PNA, LR/IS and LR sequence can be improved significantly. The value for using the PNA, LR/IS and LR sequence is to inform the transmitter of the buffer status of the link partner, thus efficiently supporting receiver based flow control when multiple VCs are active. If the VC0 Retry protocol is used instead, a Status and VC_Status control symbol for each active VC must be transmitted after a Retry in order to inform the link partner of the buffer status to be used to choose a packet which the link partner can accept. Using a Retry control symbol is likely simpler than altering the PNA based protocol, however, it is not backward compatible with the Rev 2.2 specification and devices which support any VCs other than VC0. Enhancing the PNA, LR/IS, and LR sequence has the added benefit of improving the speed of recovery for bit errors on the link.

It is proposed that the PNA format be changed to incorporate the ackID of the next expected packet to make the PNA can act similarly to a Retry control symbol. To improve efficiency, a PNA must be followed by a Status and VC_Status control symbol for every active VC to inform the link partner of the buffer status to be used to choose a packet which the link partner can accept. The change in PNA contents and transmission of Status and VC_Status would be optional for all Baud Rate Classes in the 3.0 specification.

The 2.3 specification halts packet transmission until a LR is received. It is proposed that packet transmission optionally be allowed to start immediately after transmission of the LR/IS to remove the latency of waiting for a LR, since the PNA optionally indicates the ackID to be sent. This will also be optional for all Baud Rate Classes in the 3.0 specification.

1.2.2 VoQ Backpressure Optimization

VoQ Backpressure will be necessary in the new applications targeted by RapidIO to deliver superior quality of service. For Baud Rate Class 3 devices, the need to increase ackID size to 12 bits prevents linking VoQ Backpressure with VC_Status. VoQ Backpressure control symbols must therefore be sent as distinct control symbols. Optimization of VoQ Backpressure control symbols is therefore critical.

The number of ports in a system varies with switch size, but the need for VoQ backpressure remains. VoQ Backpressure control symbols have two fields, Port Status Bits and Port Group. The total number of ports supported by VoQ backpressure is $2^{\text{Port Group}}$*sizeof(Port Status Bits). As system size changes, the bandwidth required for VoQ backpressure can be optimized if the division between Port Status and Port Group is programmable.

1.3 Proposals

1.3.1 Receiver Based Flow Control and Error Recovery Optimization Proposal

Enhancements for the receiver based flow control and error recovery optimization are optional.

In Part 6, section 3.2, change the control symbol field definition table as indicated by the underlined text:

Table 1-1. Stype0 Control Symbol Encoding

stype0	Function	Contents of Parameter0	Contents of Parameter1	Reference
0b000	packet-accepted	packet_ackID	buf_status	Section 1.3.2
0b001	packet-retry	packet_ackID	buf_status	Section 1.3.3
0b010	packet-not-accepted	arbitrary, or ackID_status	cause	Section 1.3.4
0b011	reserved	—	—	—
0b100	status	ackID_status	buf_status	Section 3.4.4
0b101	VC_status	VCID	buf_status	Section 3.4.5
0b110	link-response	ackID_status	port_status	Section 3.4.6
0b111	implementation-defined *	implementation-defined	implementation-defined	—

Change the text for the Packet-Accepted, Packet-Retry, and Packet Not Accepted control symbol descriptive sections as indicated by underlined text:

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1.3.2 Packet-Accepted Control Symbol

The packet-accepted control symbol indicates that the port sending the control symbol has taken responsibility for sending the packet to its final destination and that resources allocated to the packet by the port receiving the control symbol can be released. This control symbol shall be generated only after the entire packet has been received and found to be free of detectable errors. The packet-accepted control symbol field usage and values are displayed in Table 1-2.

Table 1-2. Packet-Accepted Control Symbol field usage and values.

stype0	Parameter0	Parameter1
0b000	packet_ackID	buf_status

The buf_status value in the control symbol is for the VC of the packet being accepted. Since the VC of the packet is not carried in the control symbol, the port receiving the control symbol must reassociate the ackID in the packet_ackID field with the VC of the accepted packet to determine the VC to which the buf_status applies.

The buf_status shall be for the VC of the packet indicated by the packet_ackID.

1.3.3 Packet-Retry Control Symbol

A packet-retry control symbol indicates that the port sending the control symbol was not able to accept the packet due to some temporary resource conflict such as insufficient buffering and the packet must be retransmitted. The control symbol field usage and values are displayed in Table 1-3.

Table 1-3. Packet-Retry Control Symbol field usage and values.

stype0	Parameter0	Parameter1
0b001	packet_ackID	buf_status

The packet-retry control symbol is only used in single VC mode for compatibility with Rev. 1.x RapidIO devices. Packet retry is replaced with error recovery when multiple VCs are active. See Chapter 6, "LP-Serial Protocol", for more information.

The buf_status shall be for the VC of the packet indicated by the packet_ackID.

1.3.4 Packet-Not-Accepted Control Symbol

The packet-not-accepted control symbol indicates that the port sending the control symbol has either detected an error in the received character stream or, when operating in multiple VC mode, has insufficient buffer resources and as a result may have rejected a packet or control symbol. The control symbol contains an “arbitrary, or ackID_status” field and a “cause” field. The control symbol field usage and values are displayed in Table 1-4.

Table 1-4. Packet-Not-Accepted Control Symbol field usage and values.

Format	stype0	Parameter0	Parameter1
Control Symbol 24	0b010	arbitrary, or ackID_Status	cause
Control Symbol 48	0b010	arbitrary, or ackID_Status	0b0, cause
Control Symbol 64	0b010	arbitrary, or ackID_Status	0b0, cause

The "arbitrary, or ackID_Status" field may an arbitrary value, or may be the ackID_Status, indicating the ackID of the next packet expected by the link partner, depending on the capabilities and configuration of the device.

The "cause" field is used to provide information about the type of error that was detected for diagnostics and debug use. The content of the cause field is informational only.

The cause field shall be encoded as specified in Table 1-5 which lists a number of common faults and their encoding. If the port issuing the control symbol is not able to specify the fault, or the fault is not one of those listed in the table, the general error encoding shall be used.

Table 1-5. Cause Field Definition

Cause	Definition
0b00000	Reserved
0b00001	Received packet with an unexpected ackID
0b00010	Received a control symbol with bad CRC
0b00011	Non-maintenance packet reception is stopped
0b00100	Received packet with bad CRC
0b00101	Received invalid character, or valid but illegal character
0b00110	Packet not accepted due to lack of resources
0b00111	Loss of descrambler sync
0b01000 - 0b11110	Reserved
0b11111	General error

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Change the description of packets in Part 6, section 6.2 Packets as indicated by the underlined text:

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1.3.5 Acknowledgment Identifier

Each packet requires an identifier to uniquely identify its acknowledgment control symbol. This identifier, the acknowledge ID (ackID) is 5 bits long when using Control Symbol 24 and 6 bits long when using Control Symbol 48. This allows up to 2^N outstanding unacknowledged request and/or response packets where N is the number of bits in the ackID field. To eliminate the ambiguity between 0 and 2^N outstanding packets, a maximum of 2^N-1 outstanding unacknowledged packets shall be allowed at any one time.

The value of ackID assigned to the first packet transmitted after a reset shall be 0. The values of ackID assigned to subsequent packets shall be in increasing numerical order, wrapping back to 0 on overflow. The ackID assigned to a packet indicates the order of the packet transmission and is independent of the virtual channel assignment of the packet.

The acknowledgment control symbols are defined in Chapter 3, "Control Symbols". When acknowledgement control symbols are received containing VC specific information (e.g., buf_status), the transmitter side of the port must reassociate that information with the correct VC based on the returned ackID.

Devices which support Baud Rate Class 3 operation shall support configuration values whereby Packet Accepted controls symbols sent and/or received acknowledge multiple packets. The configuration shall be controlled by the Port n Latency Optimization CSRs. When transmitting control symbols, devices operating at Baud Rate Class 1 and 2 shall support a default configuration in which they send one Packet Accepted control symbol for each received packet. Devices operating at Baud Rate Class 1 and 2 may optionally support a configuration in which they may transmit one Packet Accepted control symbol for multiple received packets. Devices operating at Baud Rate Class 3 may transmit one Packet Accepted control symbol for multiple received packets.

Devices operating at Baud Rate Class 1 and 2 may optionally support reception of Packet Accepted control symbols which acknowledge all outstanding packets up to and including the packet ackID. Devices operating at Baud Rate Class 3 shall support reception of Packet Accepted control symbols which acknowledge all outstanding packets up to and including the packet ackID. It shall be possible to configure devices operating at Baud Rate Class 3 to transmit a Packet Accepted control symbol for each received packet.

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Change the description of the Link Maintenance, Packet Exchange, and Receiver-Controlled Flow Control protocol definition as indicated by the underlined text:

"

1.4 Link Maintenance Protocol

The link maintenance protocol involves a request and response pair between ports connected by a LP-Serial link. For software management, the request is generated through ports in the configuration space of the sending device. An external host write of a command to the link-request register with an I/O logical specification maintenance write transaction causes a link-request control symbol to be issued onto the output port of the device, but only one link-request can be outstanding on a link at a time.

The device that is linked to the sending device shall respond with an link-response control symbol if the link-request command required it to do so. The external host retrieves the link-response by polling the link-response register with I/O logical maintenance read transactions. A device with multiple RapidIO interfaces has a link-request and a link-response register pair for each corresponding RapidIO interface.

The automatic error recovery mechanism relies on the hardware generating packet-not-accepted and link-request/input-status control symbols under the transmission error conditions described in Section 6.13.2.1, "Recoverable Errors" and using the corresponding link-response information to attempt recovery.

Due to the undefined reliability of system designs, it is necessary to put a safety lockout on the reset function of the link-request/reset-device control symbol. A device receiving a link-request/reset-device control symbol shall not perform the reset function unless it has received four link-request/reset-device control symbols in a row without any intervening packets or other control symbols, except status control symbols. This will prevent spurious reset-device commands inadvertently resetting a device. The link-request/reset-device control symbol does not require a response.

The input-status command of the link-request/input-status control symbol is used by the hardware to recover from transmission errors. If the input port had stopped due to a transmission error that generated a packet-not-accepted control symbol back to the sender, the link-request/input-status control symbol acts as a link-request/restart-from-error control symbol, and the receiver is re-enabled to receive new packets after generating the link-response control symbol. The link-request/input-status control symbol may also be used to restart the receiving device if it is waiting for a restart-from-retry control symbol after retrying a packet. This situation can occur if transmission errors are encountered while trying to resynchronize the sending and receiving devices after the retry.

The link-request/input-status control symbol requires a response. A port receiving a link-request/input-status control symbol returns a link-response control symbol containing two pieces of information:

- port_status
- ackID_status

These status indicators are described in Table 3-12.

The retry-stopped state indicates that the port has retried a packet and is waiting to be restarted. This state is cleared when a restart-from-retry (or a link-request/input-status) control symbol is received. The error-stopped state indicates that the port has encountered a transmission error and is waiting to be restarted. This state is cleared when a link-request/input-status control symbol is received.

1.5 Packet Transmission Protocol

The LP-Serial protocol for packet transmission provides link level flow and error detection and recovery.

The protocol uses control symbols to delimit packets when they are transmitted across a LP-Serial link as specified in Section 1.4.1, “Packet Delimiting.

The link protocol uses acknowledgment to monitor packet transmission. With two exceptions, each packet transmitted across a LP-Serial link shall be acknowledged by the receiving port with a packet acknowledgment control symbol. Packets shall be acknowledged in the order in which they were transmitted (ackID order). The first exception occurs when a single packet-acknowledge symbol acknowledges multiple packets. The second exception is when an event has occurred that caused a port to enter the Input Error-stopped state. CT mode packets accepted by a port after the port entered the Input Error-stopped state and before the port receives a link-request/input-status control symbol shall not be acknowledged.

To associate packet acknowledgment control symbols with transmitted packets, each packet shall be assigned an ackID value according to the rules of Section 1.3.5, “Acknowledgment Identifier that is carried in the ackID field of the packet and the packet_ackID field of the associated acknowledgment control symbol. The ackID value carried by a packet indicates its order of transmission and the order in which it is acknowledged.

The LP-Serial link RT protocol uses retransmission to recover from packet transmission errors or a lack of receive buffer resources. To enable packet retransmission, a copy of each RT packet transmitted across a LP-Serial link shall be kept by the sending port until either a packet-accepted control symbol is received for the packet or the sending port determines that the packet has encountered an unrecoverable error condition.

The LP-Serial link CT protocol does not use packet retransmission. CT mode packets that are corrupted by transmission errors or that are not accepted because of a lack of receive buffer resources are discarded and lost. Therefore, a port need not retain a copy of a CT mode packet whose transmission has been completed.

The LP-Serial link protocol uses the ackID value carried in each packet to ensure that no RT mode packets are lost due to transmission errors. With one exception, a port shall accept packets from a LP-Serial link only in sequential ackID order, i.e. if the ackID value of the last packet accepted was N, the ackID value of the next packet that is accepted must be (N+1) modulo2^n where n is the number of bits in the ackID field. The exception is when an event has occurred that caused a port to enter the Input Error-stopped state. A CT mode packet received by a port after the port entered the Input Error-stopped state and before the port receives a link-request/input-status control symbol shall be accepted by the port without regard to the value of the packet's ackID field if the packet is otherwise error free and there are adequate receive buffer resources to accept the packet. The value that is maintained by the port of the ackID expected in the next packet shall not be changed by the acceptance of CT packets during this period.

A LP-Serial port accepts or rejects each error free packet that it receives with the expected ackID depending on whether the port has input buffer space available for the VC and/or priority level of the packet. The use of the packet-accepted, packet-retry, packet-not-accepted and restart-from-retry control symbols and the buf_status field in packet acknowledgment control symbols to control the flow of packets across a LP-Serial link is covered in Section 1.6, "Flow Control.

The LP-Serial link protocol allows a packet that is being transmitted to be canceled at any point during its transmission. Packet cancellation is covered in Section 6.10, "Canceling Packets".

The LP-Serial link protocol provides detection and recovery processes for both transmission errors and protocol violations. The enumeration of detectable errors, the detection of errors and the associated error recovery processes are covered in Section 6.13, "Error Detection and Recovery".

In order to prevent switch processing element internal errors, such as SRAM soft bit errors, from silently corrupting a packet and the system, switch processing elements shall maintain packet error detection coverage while a packet is passing through the switch. The simplest method for maintaining packet error detection coverage is to pass the packet CRC through the switch as part of the packet. This works well for all non-maintenance packets whose CRC does not change as the packets are transported from source to destination through the fabric. Maintaining error detection coverage is more complicated for maintenance packets as their hop_count and CRC change every time they pass through a switch. However, passing the packet CRC through the switch as part of the packet does not prevent packet loss due to soft errors within the switch. Recovery from soft errors within a switch requires that each packet passing through the switch be covered by some type of error correction of adequate strength.

In order to support transaction ordering requirements of the logical layer specifications, the LP-Serial protocol imposes packet delivery ordering requirements within the physical layer and transaction delivery ordering requirements between the physical layer and the transport layer in end point processing elements. These requirements are covered in Section 6.11, "Transaction and Packet Delivery Ordering Rules".

In order to prevent deadlock, the LP-Serial protocol imposes a set of deadlock prevention rules. These rules are covered in Section 6.12, "Deadlock Avoidance".

This specification provides both bandwidth reservation and priority based channels. Priority scheduling may or may not be included in the reservation of bandwidth. Whatever allocation of bandwidth is used for priority traffic, higher level flows will reduce the bandwidth available for lower level flows. It is possible that traffic associated with higher flow levels can starve traffic associated with lower flow levels. It is important to use the available flows properly for the transaction type, to insure the rules in Section 6.11, "Transaction and Packet Delivery Ordering Rules" and Section 6.12, "Deadlock Avoidance" are met. The actual mechanisms used to schedule traffic are beyond the scope of this specification.

1.6 Flow Control

This section defines RapidIO LP-Serial link level flow control. The flow control operates between each pair of ports connected by a LP-Serial link. The purpose of link level flow control is to prevent the loss of packets due to a lack of buffer space in a link receiver.

The LP-Serial protocol defines two methods or modes of flow control. These are named receiver-controlled flow control and transmitter-controlled flow control. Every RapidIO LP-Serial port shall support receiver-controlled flow control. LP-Serial ports may optionally support transmitter-controlled flow control.

1.6.1 Receiver-Controlled Flow Control

Receiver-controlled flow control is the simplest and basic method of flow control. In this method, the input side of a port controls the flow of packets from its link partner by accepting or rejecting packets on a packet by packet basis. The receiving port provides no information to its link partner about the amount of buffer space it has available for packet reception.

As a result, its link partner transmits packets with no *a priori* expectation as to whether a given packet will be accepted or rejected. A port signals its link partner that it is operating in receiver-controlled flow control mode by setting the buf_status field to all 1's in every control symbol containing the field that the port transmits. This method is named receiver-controlled flow control because the receiver makes all of the decisions about how buffers in the receiver are allocated for packet reception.

A port operating in receiver-controlled flow control mode accepts or rejects each inbound error free packet based on whether the receiving port has enough buffer space available for the VC and the priority level of the packet. If there is enough buffer space available, the port accepts the packet and transmits a packet-accepted control symbol to its link partner that contains the ackID of the accepted packet in its packet_ackID field. <u>The port optionally acknowledges multiple packets with a single packet-accepted control symbol. Transmission of </u>a packet-accepted control symbol informs the port's link partner that the packet<u> (or packets)</u> has been received without detected errors and that it has been accepted by the port. On receiving the packet-accepted control symbol, the link partner discards its copy of the accepted packet <u>(or packets) </u>freeing buffer space in the partner.

The remaining behavior is a function of the mode of the VC.

1.6.1.1 Reliable Traffic VC Receivers

If buffer space is not available, the port rejects the packet. If multiple VCs are active, and the VC is in reliable traffic mode, the rejected packet shall be acknowledged with the packet-not-accepted control symbol. The cause field of the control symbol should be set to "packet not accepted due to lack of resources". <u>The "arbitrary, or ackID_Status" field of the packet-not-accepted control symbol may be set to the ackID of the retried packet. In this case, the packets associated with ackIDs up to, but not including, the retried ackID are acknowledged by the packet-not-accepted control symbol. Reception of the packet-not-accepted control symbol</u> causes the entire "RT Group" to go through the same process used in error recovery to resequence and retransmit the RT packets. See Section 6.13, "Error Detection and Recovery" for details.

If the port is operating in single VC mode, the port may use the Packet Retry protocol described in Section 1.6.1.3, “Single VC Retry Protocol, or it may continue to use the packet-not-accepted protocol described above.

1.6.1.2 Continuous Traffic VC Receivers

If buffer space is not available, and the VC is in CT mode, the packet is acknowledged as accepted, and the packet is discarded. This preserves the order of the normal link response and does not impact performance. Receiver based flow control for CT channels will result in packet loss due to receiver overruns depending on bandwidth and buffering conditions. See Section 6.9.2, "Transmitter-Controlled Flow Control" for transmitter based flow control options.

1.6.1.3 Single VC Retry Protocol

When operating with a single VC (VC0), the receiver may use the retry protocol for handling receiver overruns. It is a requirement that implementers include this functionality in the channel design to be backward compatible with existing RapidIO interfaces.

When a port rejects a packet, it immediately enters the Input Retry-stopped state and follows the Input Retry-stopped recovery process specified in Section 1.7.1.4, “Input Retry-Stopped Recovery Process. As part of the Input Retry-stopped recovery process, the port sends a packet-retry control symbol to its link partner indicating that the packet whose ackID is in the packet_ackID field of the control symbol and all packets subsequently transmitted by the port have been discarded by the link partner and must all be retransmitted. <u>When the ability to acknowledge multiple packets with a single control symbol is enabled, the packet-retry control symbol shall acknowledge all packets up to, but not including, the ackID in the retry control symbol.</u> The control symbol also indicates that the link partner is temporarily out of buffers for packets of priority less than or equal to the priority of the retried packet.

<u>Devices may optionally support configuration values whereby Retry controls symbols sent and/or received acknowledge multiple packets. The configuration shall be controlled by the Port n Latency Optimization CSRs. When transmitting control symbols, devices operating at Baud Rate Class 1 and 2 shall support a default configuration in which the Retry control symbol does not acknowledge packets. Devices operating at Baud Rate Class 1 and 2 may optionally support a configuration in which Retry control symbols acknowledge all packets up to, but not including, the ackID_status in the Retry control symbol. Devices operating at Baud Rate Class 3 shall support a default configuration whereby a transmitted Retry control symbol</u>

acknowledges all packets up to, but not including, the ackID_status in the Retry control symbol.

Devices operating at Baud Rate Class 1 and 2 may optionally support reception of Retry control symbols which acknowledge all outstanding packets up to, but not including, the ackID_status. Devices operating at Baud Rate Class 3 shall support reception of Retry control symbols which acknowledge all outstanding packets up to, but not including, the ackID_status. It shall be possible to configure devices operating at Baud Rate Class 3 to transmit a Retry control symbol only when all packets up to the Retried packet have been acknowledged.

A port that receives a packet-retry control symbol immediately enters the Output Retry-stopped state and follows the Output Retry-stopped recovery process specified in Section 1.7.1.5, “Output Retry-Stopped Recovery Process. As part of the Output Retry-stopped recovery process, the port receiving the packet-retry control symbol sends a restart-from-retry control symbol which causes its link partner to exit the Input Retry-stopped state and resume packet reception. The ackID assigned to that first packet transmitted after the restart-from-retry control symbol is the ackID of the packet that was retried.

Figure 1-1 shows an example of single VC receiver-controlled flow control operation. In this example the transmitter is capable of sending packets faster than the receiver is able to absorb them. Once the transmitter has received a retry for a packet, the transmitter may elect to cancel any packet that is presently being transmitted since it will be discarded anyway. This makes bandwidth available for any higher priority packets that may be pending transmission.

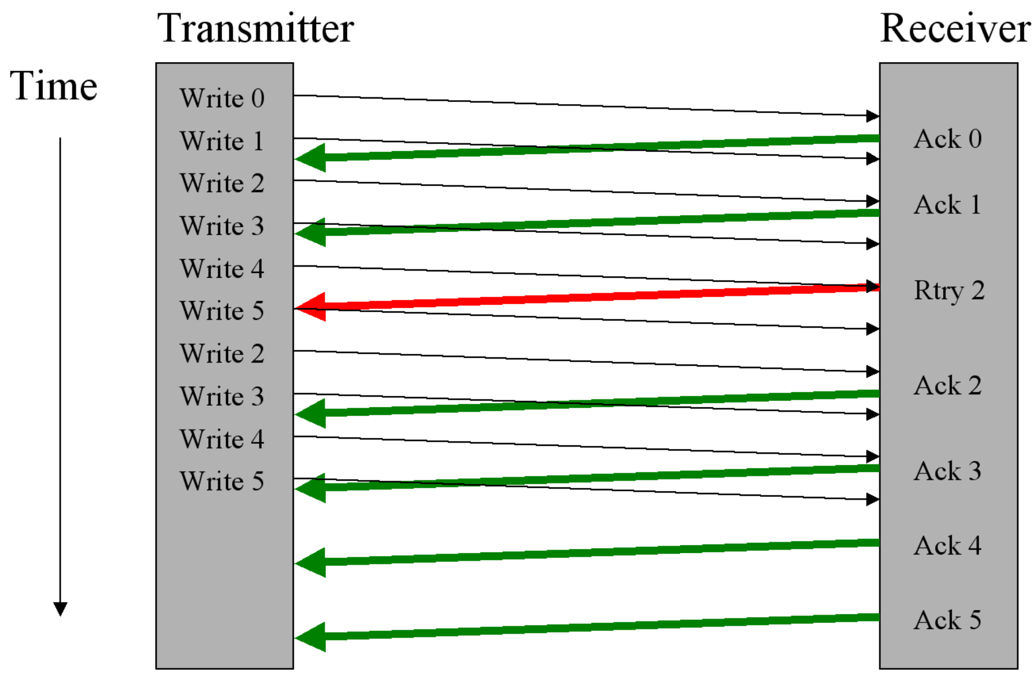

Figure 1-1. Single VC Mode Receiver-Controlled Flow Control

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Extend section 5.13.2 Link Behavior Under Error as follows:

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The LP-Serial link uses error detection and retransmission to protect RT packets against loss or corruption due to transmission errors. Transmission error detection is done at the input port, and all transmission error recovery is also initiated at the input port.

The packet transmission protocol requires that each RT packet transmitted by a port be acknowledged by the receiving port and that a port retain a copy of each RT packet that it transmits until the port receives a packet-accepted control symbol acknowledgment for the packet or the sending port determines that the packet has encountered an unrecoverable error. If the receiving port detects a transmission error in a packet, the port sends a packet-not-accepted control symbol acknowledgment back to the sender indicating that the packet was corrupted as received. After a link-request/input-status and link-response control symbol exchange, the sender begins retransmission with the next packet according to the priority/bandwidth scheduling rules. The RT VCs retransmit all packets that were unacknowledged at the time of the error. CT VCs continue with the next untransmitted packet.

All RT packets corrupted in transmission are retransmitted. The number of times a packet may be retransmitted before the sending port determines that the packet has encountered an unrecoverable condition is implementation dependent.

The primary mechanism for informing the link partner of a detected error is the Packet Not Accepted control symbol. Devices may optionally support a configuration in which they transmit Packet Not Accepted control symbols which contain an ackID_status, and support resumption of packet transmission using the next expected ackID found in received Packet Not Accepted control symbols. Packet Not Accepted control symbols which contain the ackID_status shall be interpretted as acknowledging all ackIDs up to, but not including, the ackID_status value. The configuration shall be controlled by the Port n Latency Optimization CSRs.

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Change the input-error stopped and output-error stopped recovery process as indicated by the underlined text:

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1.6.1.4 Input Error-Stopped Recovery Process

When the input side of a port detects a transmission error, it immediately enters the Input Error-stopped state. To recover from this state, the input side of the port takes the following actions.

- Record the condition(s) that caused the port to enter the Input Error-stopped state.
- If an error(s) was detected in a control symbol or packet, ignore and discard the corrupted control symbol or packet.
- Cause the output side of the port to issue a packet-not-accepted control symbol. (The packet-not-accepted control symbol causes the output side of the receiving port to enter the Output Error-stopped state and send a link-request/input-status control symbol.). If the packet-not-accepted control symbol contains the next expected ackID, cause the output side of the port to transmit Status and VC_Status control symbols for all active VCs subject to the following:

    The packet-not-accepted control symbol shall be transmitted either before any of the status and VC-status control symbols are transmitted or after all of the status and VC-status control symbols are transmitted.

    The status and VC-status control symbols that are transmitted shall be transmitted in the following order. If a status control symbol is transmitted it shall be transmitted first before any of the VC-status control symbols. Any VC-status control symbols that are transmitted shall be transmitted after the status control symbol and in order of increasing VCID.

    The buffer status found in the status and VC-status control symbols shall reflect buffer status up to, but not including, the packet associated with the ackID in the packet-not-accepted control symbol.

- Subsequent to the event that caused the port to enter the Input Error-stopped state and prior to the reception of a link-request/input-status control symbol,

  discard without acknowledgement or error report all packets that are received for VCs operating in RT mode,

  accept without acknowledgement (accept silently) all error free packets that are received for VCs operating in CT mode for which the VC specified in the packet has buffer space available and

  discard without acknowledgement all packets that are received for VCs operating in CT mode which are not error free or for which the VC specified in the packet does not have buffer space available.

- When a link-request/input-status control symbol is received from the connected port, cause the output side of the port to transmit a link-response control symbol and if the transmitter-controlled flow control is in use on the link, to also transmit a VC_Status control symbol for each of VC1-8 that is active. The transmission of a VC_Status control symbol for each of VC1-8 that is active is optional if receiver-controlled flow control is in use on the link, the input side of the port should also cause the output side of the port to transmit a status control symbol (for VC0). The input side of the port then exits the Input Error-stopped state and resumes normal packet reception. The actual transmission of the link-response, VC-status, and status control symbols may occur after the input side of the port exits the Input Error-stopped state and resumes normal packet reception.

- The transmission of the link-response, status and VC-status control symbols is subject to the following requirements.

  The link-response control symbol shall be transmitted either before any of the status and VC-status control symbols are transmitted or after all of the status and VC-status control symbols are transmitted.

  The status and VC-status control symbols that are transmitted shall be transmitted in the following order. If a status control symbol is transmitted it shall be transmitted first before any of the VC-status control symbols. Any VC-status control symbols that are transmitted shall be transmitted after the status control symbol and in order of increasing VCID.

  The link-response control symbol shall not be transmitted until the input side of the port is ready to resume packet reception and either the buffer consumption of all packets received by the port before the link-request/input-status control symbol has been determined or the port is able to maintain the distinction after packet reception resumes between packets received before the reception of the link-request/input-status control symbol and packets received after the reception of the link-request/input-status control symbol (as the processing of packets received before the link-request/input-status control symbol differs from the processing of packets received after the link-request/input-status control symbol).

The status or VC-status control symbol for a VC operating in RT mode shall indicate the number of receive buffers available for that VC inclusive of the buffer consumption of all packets received and accepted by the port for that VC before the event that caused the port to enter the Input Error-stopped state.

The VC-status control symbol for a VC operating in CT mode shall indicate the number of receive buffers available for that VC inclusive of the buffer consumption of all packets received and accepted by the port for that VC before the link-request/input-status control symbol was received.

The status and VC-status control symbols shall be transmitted before any packet acknowledgment control symbols are transmitted for packets received after the link-request/input-status control symbol was received.

An example state machine with the behavior described in this section is included in Section C.3, "Error Recovery".

1.6.1.5 Output Error-Stopped Recovery Process

To recover from the Output Error-stopped state, the output side of a port takes the following actions.

- Immediately stops transmitting new packets.
- Resets the link packet acknowledgment timers for all transmitted but unacknowledged packets. (This prevents the generation of spurious time out errors.)
- Transmits an input-status link-request/input-status (restart-from-error) control symbol. (The input status link-request/input-status control symbol causes the connected port to transmit a link-response control symbol that contains the input_status and ackID_status of the input side of the port. The ackID_status field contains the ackID value that is expected in the next packet that the connected port receives.)

- If the optional ability to perform error recovery with the ackID in the packet-not-accepted control symbol is enabled, and receipt of a Packet Not Accepted control symbol was the cause of entering the Output Error-Stopped state, then the port exits the output error-stopped state. VCs operating in RT mode back up to the first unaccepted packet in each VC. VCs operating in CT mode silently assume the unacknowledged packets were accepted and adjust their state accordingly.
- If the optional ability to perform error recovery with the ackID in the packet-not-accepted control symbol is disabled, or the port entered the Output Error-Stopped state for a reason other than receipt of a packet not accepted control symbol, the port waits until the link-response is received to exit the Output Error-stopped state. VCs operating in RT mode back up to the first unaccepted packet in each VC. VCs operating in CT mode silently assume the unacknowledged packets were accepted and adjust their state accordingly.
- The port resumes transmission with the next RT or CT packet according to the bandwidth allocation algorithm using the ackID value contained in the link-response control symbol.
- If the ability to perform error recovery using the ackID in the packet-not-accepted control symbol is enabled, and receipt of a Packet Not Accepted control symbol was the cause of previously entering the Output Error-Stopped state, then receipt of a link-response shall complete the outstanding link-request/input-status control symbol, allowing another link-request/input-status control symbol to be transmitted. The contents of the link-response control symbol shall be treated as informational in this case.

An example state machine with the behavior described in this section is included in Section C.3, "Error Recovery".

"

Add the following register definition to register blocks with blockIDs of 0x0012, 0x0013, and 0x0019 as defined in 3.0 PHY TG showing 11-11-00002:

"

1.6.2 Port *n* Latency Optimization CSRs (Block Offset 0x58, 78, ... , 238)

These registers indicate the capabilities of a device to reduce latency through optional protocol enhancements, and control whether these capabilities are enabled. All bits and bit fields in this register shall be as defined in Table 1-6.

Unless otherwise specified, the bits and bit fields of this register shall be read/write.

Table 1-6. Bit Settings for Port *n* Error and Status CSRs

Bit	Name	Reset Value	Description
0	Multiple Acknowledges Supported	See Footnote[1]	Indicates whether the port supports reception of Packet Accepted and Retry control symbols which acknowledge multiple outstanding ackIDs. 0b0 - A control symbol shall always acknowledge one ackID 0b1 - A control symbol shall acknowledge multiple outstanding ackIDs. This bit shall be read-only.
1	Error Recovery with ackID in PNA Supported	Impl. Spec.	Indicates whether the port is capable of transmitting Packet Not Accepted control symbols with a valid ackID_status value, indicating the ackID of the next expected packet , and transmits Status and VC_Status control symbols when a Packet Not Accepted control symbol is sent. Also indicates whether the port can use the ackID_status value found in received Packet Not Accepted control symbol to start transmitting packets before receipt of a link-response control symbol. 0b0 - The port cannot transmit or use the ackID_status value in a Packet Not Accepted control symbol 0b1 - The port can transmit and use the ackID_status value in a Packet Not Accepted control symbol This bit shall be read-only. It is recommended that the reset value of this bit be 1 when a device supports any of VC1-8.
2-7	—		Reserved
8	Multiple Acknowledges Enabled	See Footnote[1]	Controls whether the port shall accept and optionally transmit Packet Accepted and Retry control symbols which acknowledge multiple ackIDs. 0b0 - A Packet Accepted control symbol shall always acknowledge one ackID 0b1 - A Packet Accepted control symbol shall acknowledge all ackIDs up to and including the ackID found in the Packet Accepted control symbol. Retry control symbols shall acknowledge all ackIDs up to but not including the ackID_status found in the Retry control symbol. If the Multiple Acknowledges Supported field is clear, this field shall be reserved. When this bit is set, the port may transmit Packet Accepted and Retry control symbols which acknowledge multiple ackIDs.
9	Error Recovery with ackID in PNA Enabled	0b0	Controls when the port shall transmit and use Packet Not Accepted control symbo with a valid ackID_status value. 0b0 - The port shall not use the ackID_status value in received Packet Not Accepted control symbol. The “arbitrary, or ackID_status” field in transmitted Packet Not Accepted control symbols shall be an arbitrary value. 0b1 - The port may use the ackID_status value in received Packet Not Accepted control symbols. The “arbitrary, or ackID_status” field in transmitted Packet Not Accepted control symbols shall be a the ackID of the next expected packet. If the Error Recovery with ackID in PNA Supported field is clear, this field shall be reserved.
10-31	—		Reserved

[1] The reset value of this field shall be 0 for devices operating at Baud Rate Class 1 and 2. The reset value of this field shall be 1 for devices operating at Baud Rate Class 3.

“

Change Part 6 Annex C as indicated by underlined text below:

“

Annex A Interface Management (Informative)

A.1 Introduction

This appendix contains state machine descriptions that illustrate a number of behaviors that are described in the *RapidIO Part 6: LP-Serial Physical Layer Specification*. They are included as examples and are believed to be correct, however, actual implementations should not use the examples directly.

A.2 Packet Retry Mechanism

This section contains the example packet retry mechanism state machine referred to in Section 6.8, “Packet Transmission Protocol".

Packet retry recovery actually requires two inter-dependent state machines in order to operate, one associated with the input port and the other with the output port on the two connected devices. The two state machines work together to attempt recovery from a retry condition.

A.2.1 Input port retry recovery state machine

If a packet cannot be accepted by a receiver for reasons other than error conditions, such as a full input buffer, the receiver follows the state sequence shown in Figure A-1.

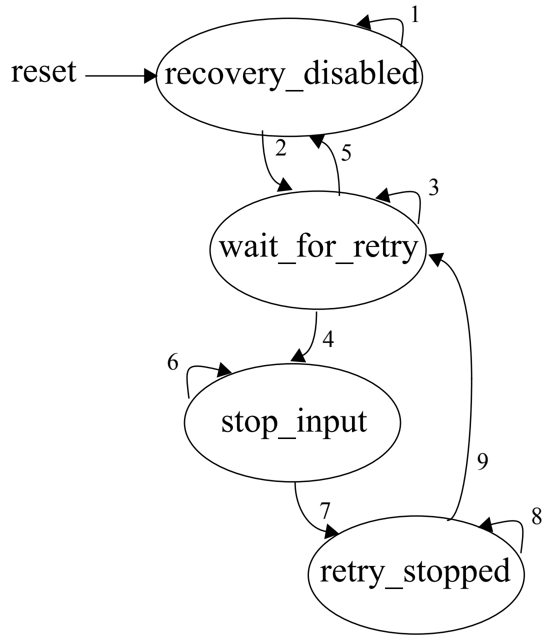

Figure A-1. Input Port Retry Recovery State Machine

Table A-1 describes the state transition arcs for Figure A-1. The states referenced in the comments in quotes are the RapidIO LP-Serial defined status states, not states in this state machine.

Table A-1. Input Port Retry Recovery State Machine Transition Table

Arc	Current State	Next state	Cause	Comments
1	recovery_disabled	recovery_disabled	Remain in this state until the input port is enabled to receive packets.	This is the initial state after reset. The input port can't be enabled before the initialization sequence has been completed, and may be controlled through other mechanisms as well, such as a software enable bit.
2	recovery_disabled	wait_for_retry	Input port is enabled.	
3	wait_for_retry	wait_for_retry	Remain in this state until a packet retry situation has been detected.	
4	wait_for_retry	stop_input	A packet retry situation has been detected.	Usually this is due to an internal resource problem such as not having packet buffers available for low priority packets.
5	wait_for_retry	recovery_disabled	Input port is disabled.	
6	stop_input	stop_input	Remain in this state until described input port stop activity is completed.	Send a packet-retry control symbol with the expected ackID, discard the packet, and don't change the expected ackID. This will force the attached device to initiate recovery starting at the expected ackID. Clear the "Port Normal" state and set the "Input Retry-stopped" state.

Table A-1. Input Port Retry Recovery State Machine Transition Table (Continued)

Arc	Current State	Next state	Cause	Comments
7	stop_input	retry_stopped	Input port stop activity is complete.	
8	retry_stopped	retry_stopped	Remain in this state until a restart-from-retry or link request (restart-from-error) control symbol is received or an input port error is encountered.	The "Input Retry-stopped" state causes the input port to silently discard all incoming packets and not change the expected ackID value.
9	retry_stopped	wait_for_retry	Received a restart-from-retry or a link request (restart-from-error) control symbol or an input port error is encountered.	Clear the "Input Retry-stopped" state and set the "Port Normal" state. An input port error shall cause a clean transition between the retry recovery state machine and the error recovery state machine.

A.2.2 Output port retry recovery state machine

On receipt of an error-free packet-retry control symbol, the attached output port follows the behavior shown in Figure A-2. The states referenced in the comments in quotes are the RapidIO 8/16 LP-LVDS defined status states, not states in this state machine.

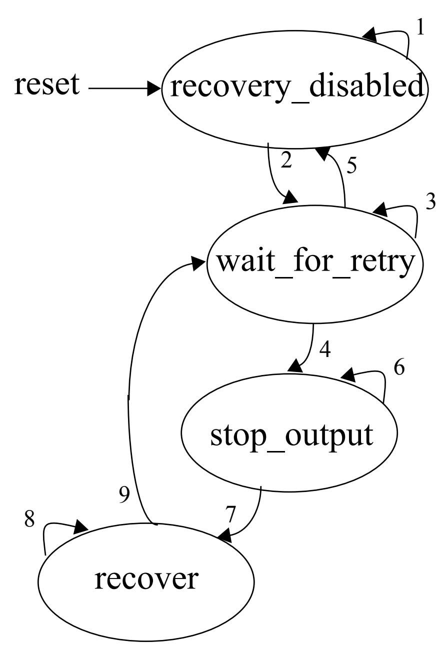

Figure A-2. Output Port Retry Recovery State Machine

Table A-2 describes the state transition arcs for Figure A-2.

Table A-2. Output Port Retry Recovery State Machine Transition Table

Arc	Current State	Next state	Cause	Comments
1	recovery_disabled	recovery_disabled	Remain in this state until the output port is enabled to receive packets.	This is the initial state after reset. The output port can't be enabled before the initialization sequence has been completed, and may be controlled through other mechanisms as well, such as a software enable bit.
2	recovery_disabled	wait_for_retry	Output port is enabled.	
3	wait_for_retry	wait_for_retry	Remain in this state until a packet-retry control symbol is received.	The packet-retry control symbol shall be error free.
4	wait_for_retry	stop_output	A packet-retry control symbol has been received.	Start the output port stop procedure.
5	wait_for_retry	recovery_disabled	Output port is disabled.	
6	stop_output	stop_output	Remain in this state until the output port stop procedure is completed.	Clear the "Port Normal" state, set the "Output Retry-stopped" state, and stop transmitting new packets.
7	stop_output	recover	Output port stop procedure is complete.	
8	recover	recover	Remain in this state until the internal recovery procedure is completed.	The packet sent with the ackID value returned in the packet-retry control symbol and all subsequent packets shall be retransmitted. Output port state machines and the outstanding ackID scoreboard shall be updated with this information, then clear the "Output Retry-stopped" state and set the "Port Normal" state to restart the output port. Receipt of a packet-not-accepted control symbol or other output port error during this procedure shall cause a clean transition between the retry recovery state machine and the error recovery state machine.
9	recover	wait_for_retry	Internal recovery procedure is complete.	Retransmission has started, so return to the wait_for_retry state to wait for the next packet-retry control symbol.

A.3 Error Recovery

This section contains the error recovery state machine referred to in Section 6.13.2, “Link Behavior Under Error."

Error recovery actually requires two inter-dependent state machines in order to operate, one associated with the input port and the other with the output port on the two connected devices. The two state machines work together to attempt recovery.

A.3.1 Input port error recovery state machine

There are a variety of recoverable error types described in detail in Section 6.13.2, “Link Behavior Under Error". The first group of errors are associated with the input port, and consists mostly of corrupt packet and control symbols. An example of a corrupt packet is a packet with an incorrect CRC. An example of a corrupt control symbol is a control symbol with error on the 5-bit CRC control symbol. The recovery state machine for the input port of a RapidIO link is shown in Figure A-3.

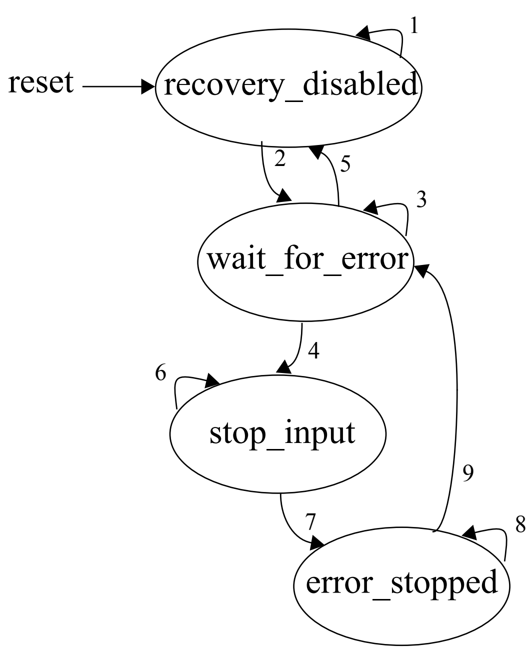

Figure A-3. Input Port Error Recovery State Machine

Table A-3 describes the state transition arcs for Figure A-3. The states referenced in the comments in quotes are the RapidIO LP-Serial defined status states, not states in this state machine.

Table A-3. Input Port Error Recovery State Machine Transition Table

Arc	Current State	Next state	Cause	Comments
1	recovery_disabled	recovery_disabled	Remain in this state until error recovery is enabled.	This is the initial state after reset. Error recovery can’t be enabled before the initialization sequence has been completed, and may be controlled through other mechanisms as well, such as a software enable bit.
2	recovery_disabled	wait_for_error	Error recovery is enabled.	
3	wait_for_error	wait_for_error	Remain in this state until a recoverable error is detected.	Detected errors and the level of coverage is implementation dependent.
4	wait_for_error	stop_input	A recoverable error has been detected.	An output port associated error will not cause this transition, only an input port associated error.
5	wait_for_error	recovery_disabled	Error recovery is disabled.	
6	stop_input	stop_input	Remain in this state until described input port stop activity is completed.	Send a packet-not-accepted control symbol and, if the error was on a packet, discard the packet and don’t change the expected ackID value. This will force the attached device to initiate recovery. Clear the "Port Normal" state and set the "Input Error-stopped" state.
7	stop_input	error_stopped	Input port stop activity is complete.	
8	error_stopped	error_stopped	Remain in this state until a link request (restart-from-error) control symbol is received.	The "Input Error-stopped" state causes the input port to silently discard all subsequent incoming packets and ignore all subsequent input port errors.
9	error_stopped	wait_for_error	Received a link request (restart-from-error) control symbol.	Clear the "Input Error-stopped" state and set the "Port Normal" state, which will put the input port back in normal operation.

A.3.2 Output port error recovery state machine

The second recoverable group of errors described in Section 6.13.2, “Link Behavior Under Error" is associated with the output port, and is comprised of control symbols that are error-free and indicate that the attached input port has detected a transmission error or some other unusual situation has occurred. An example of this situation is indicated by the receipt of a packet-not-accepted control symbol. The state machine for the output port is shown in Figure A-4.

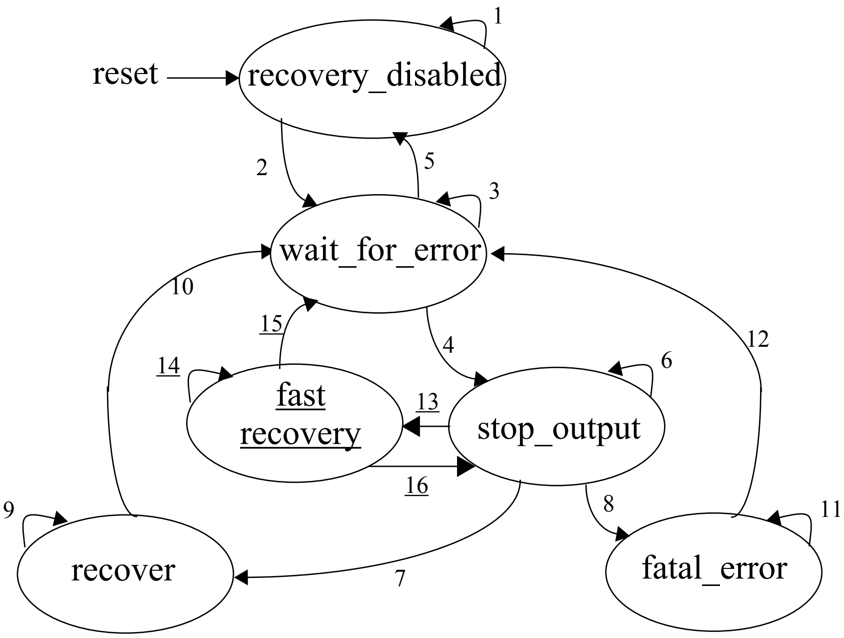

Figure A-4. Output Port Error Recovery State Machine

Table A-4 describes the state transition arcs for Figure A-4. The states referenced in the comments in quotes are the RapidIO 8/16 LP-LVDS defined status states, not states in this state machine.

Table A-4. Output Port Error Recovery State Machine Transition Table

Arc	Current State	Next state	Cause	Comments
1	recovery_disabled	recovery_disabled	Remain in this state until error recovery is enabled.	This is the initial state after reset. Error recovery can't be enabled before the initialization sequence has been completed, and may be controlled through other mechanisms as well, such as a software enable bit.
2	recovery_disabled	wait_for_error	Error recovery is enabled.	
3	wait_for_error	wait_for_error	Remain in this state until a recoverable error is detected.	Detected errors and the level of coverage is implementation dependent.
4	wait_for_error	stop_output	A recoverable error has been detected.	An input port associated error will not cause this transition, only an output port associated error.
5	wait_for_error	recovery_disabled	Error recovery is disabled.	

Table A-4. Output Port Error Recovery State Machine Transition Table (Continued)

Arc	Current State	Next state	Cause	Comments
6	stop_output	stop_output	Remain in this state until an exit condition occurs.	Clear the "Port Normal" state, set the "Output Error-stopped" state, stop transmitting new packets, and send a link-request/input-status control symbol. Ignore all subsequent output port errors. The input on the attached device is in the "Input Error-stopped" state and is waiting for a link-request/input-status in order to be re-enabled to receive packets. An implementation may wish to timeout several times before regarding a timeout as fatal using a threshold counter or some other mechanism.
7	stop_output	recover	The link-response is received and returned an outstanding ackID value	An outstanding ackID is a value sent out on a packet that has not been acknowledged yet. In the case where no ackID is outstanding the returned ackID value shall match the next expected/next assigned ackID value, indicating that the devices are synchronized. Recovery is possible, so follow recovery procedure.
8	stop_output	fatal_error	The link-response is received and returned an ackID value that is not outstanding, or timed out waiting for the link-response.	Recovery is not possible, so start error shutdown procedure.
9	recover	recover	Remain in this state until the internal recovery procedure is completed.	The packet sent with the ackID value returned in the link-response and all subsequent packets shall be retransmitted. All packets transmitted with ackID values preceding the returned value were received by the attached device, so they are treated as if packet-accepted control symbols have been received for them. Output port state machines and the outstanding ackID scoreboard shall be updated with this information, then clear the "Output Error-stopped" state and set the ‘Port Normal" state to restart the output port.
10	recover	wait_for_error	The internal recovery procedure is complete.	retransmission (if any was necessary) has started, so return to the wait_for_error state to wait for the next error.
11	fatal_error	fatal_error	Remain in this state until error shutdown procedure is completed.	Clear the "Output Error-stopped" state, set the "Port Error" state, and signal a system error.

Table A-4. Output Port Error Recovery State Machine Transition Table (Continued)

Arc	Current State	Next state	Cause	Comments
12	fatal_error	wait_for_error	Error shutdown procedure is complete.	Return to the wait_for_error state.
13	stop_output	fast_recovery	Port has stopped transmitting new packets, link-request/input-status has been transmitted, cause of error was receipt of a packet-not-accepted with valid ackID status field, and Error Recovery with PNA Ackid Enabled is set.	This transition cannot be taken after transition 16 has been taken and before returning to wait_for_error.
14	fast_recovery	fast_recovery	Remain in this state until error recovery has completed.	The packet sent with the ackID value received in the Packet Not Accepted and all subsequent packets shall be retransmitted. All packets transmitted with ackID values preceding the returned value were received by the attached device, so they are treated as if packet-accepted control symbols have been received for them. Output port state machines and the outstanding ackID scoreboard shall be updated with this information, then clear the "Output Error-stopped" state and set the 'Port Normal" state to restart the output port.
15	fast_recovery	wait_for_error	Link-response is received	retransmission (if any was necessary) has started, so return to the wait_for_error state to wait for the next error.
16	fast_recovery	stop_output	Link-response has not been received.	A link response has not been received after transmission restarted.

A.3.3 Changes in Error Recovery Behavior for CT

The basic states, as previously described, apply to the overall port. Each VC must carry some independent state:

Packets in a transmitter's VC queue are: pending transmission, sent-pending acknowledgement, or acknowledged (and subsequently removed from the queue). RT and CT VCs keep this same information, but behave slightly differently on error recovery. In RT queues, packets sent-pending acknowledgment, are returned to the pending transmission state. Packets pending acknowledgment in CT queues are moved to the acknowledged state. In this way, the sent packets in the CT queue are not resent.

(Note that it may not be necessary to keep the actual packet in a CT VC, only track the needed acknowledges to keep the credit balance for transmitter flow control accurate.)

“

1.6.3 VoQ Backpressure Optimization Proposal

Virtual Output Queue Backpressure optimization requires changes to Part 12 Virtual Output Queuing Extensions Specifications.

Change section 4.2 of Part 12 as indicated by the underlined text:

“

1.7 Rules for Generating Backpressure Control Symbols

a) The VoQ backpressure symbol shall only be transmitted to an upstream device if generation is enabled for a given port. If a congested port requests a symbol be sent to all upstream devices, only ports enabled for this feature shall actually transmit the symbol.

b) The backpressure symbol may be included with any other valid combination of stype 0 and stype 1 symbols if VC linking is not enabled when the control symbol format supports it.

c) The backpressure symbol shall only be included with a VC_status or Status control symbol to have the message linked to queues specific to VCs 0 through 8 (VC linking enabled) when the control symbol format supports it.

d) Ports shall be grouped in order. The ports numbered 0 through N-1 shall occupy port group 0 in the backpressure message, ports numbered N to 2N-1 shall occupy port group 1, and so on, where N is controlled by the Port n VoQ Backpressure CSR TX Port Group Size and the total number of port status bits available.~~., with the first 6 ports of the device occupying the first port group in the backpressure message (port group 0 encompasses ports 0 - 5, port group 1 covers ports 6 - 11, etc.).~~

e) The backpressure symbol shall be generated anytime the status of at least one of the ports in the group changes. It is up to the implementer to define what constitutes a status change.

f) The backpressure symbol may be generated at arbitrary intervals, based on a timer. The timer may be the same timer used for VC_status, or it may be a separate timer. Use of a timer is implementation specific.

g) The backpressure symbol may be generated after link recovery to avoid orphaned congestion states.

“

Change the format of the Port n VoQ Control Status Register as indicated by the underlined text:

“

1.7.0.1 Port *n* VoQ Control Status Register (Block Offset - Variable, see -Section 5.1.1)

This register is used by each port to configure VoQ backpressure operation.

Table 1-7. Port n VoQ Backpressure CSR

Bit	Name	Reset Value	Description
0	VoQ Backpressure Symbol Generation Supported	see footnote[1]	0b0 = generation of VoQ backpressure is not supported by this port 0b1 = generation of VoQ backpressure supported (read-only)
1	VoQ Backpressure Symbol Reception Supported	see footnote[1]	0b0 = reception of VoQ backpressure is not supported by this port 0b1 = reception of VoQ backpressure supported (read-only)
2	Linking with VCs supported	see footnote[1]	0b0 = linking of VoQ backpressure with virtual channels is not supported by this port 0b1 = linking of VoQ backpressure with virtual channels is supported (read-only)
3-7	reserved	0b0	
8	Enable VoQ Symbol Generation	0b0	0b0 = No VoQ symbols will be transmitted 0b1 = VoQ symbol generation is enabled
9	Enable VoQ Participation	0b0	0b0 = this port’s status will not be included in any VoQ symbols transmitted, nor cause symbols to be generated. (the port’s status will always be reflected as enabled). 0b1 = this port’s status will be reflected in VoQ backpressure symbols and will cause symbols to be generated
10	Port XOFF	0b0	0b0 = Port status will reflect current state of the port. 0b1 = Port status will always reflect congested (= 0b1)
11	Enable VC linking	0b0	0b0 = Linking VoQ backpressure with VC Status is disabled 0b1 = Linking VoQ backpressure with VC Status is enabled
12	Port Group Size 0 Supported	0b1	0b0 = A port group size of zero bits is not supported 0b1 = A port group size of zero bits is supported for both transmission and reception
13	Port Group Size 1 Supported	see footnote[1]	0b0 = A port group size of one bit is not supported 0b1 = A port group size of one bit is supported for both transmission and reception
14	Port Group Size 2 Supported	see footnote[1]	0b0 = A port group size of two bits is not supported 0b1 = A port group size of two bits is supported for both transmission and reception

Table 1-7. Port n VoQ Backpressure CSR

Bit	Name	Reset Value	Description
15	Port Group Size 3 Supported	see footnote[1]	0b0 = A port group size of three bits is not supported 0b1 = A port group size of three bits is supported for both transmission and reception
16	Port Group Size 4 Supported	0b1	0b0 = A port group size of four bits is not supported 0b1 = A port group size of four bits is supported for both transmission and reception
17	Port Group Size 5 Supported	see footnote[1]	0b0 = A port group size of five bits is not supported 0b1 = A port group size of five bits is supported for both transmission and reception
18	Port Group Size 6 Supported	see footnote[1]	0b0 = A port group size of six bits is not supported 0b1 = A port group size of six bits is supported for both transmission and reception
19-25	reserved	0x00	
26-28	TX Port Group Size	0x4	Current number of bits devoted to port group for transmitted VoQ Status control symbols, encoded as follows: 0x0 - No bits for port_group, all bits are port status 0x1 - One bit for port_group, remaining bits are port status 0x2 - Two bits for port_group, remaining bits are port_status ... 0x6 - Six bits for port_group, remaining bits are port_status 0x7 - Reserved This field should only be changed when Enable VoQ Symbol Generation is cleared.
29-31	RX Port Group Size	0x4	Current number of bits devoted to port group for received VoQ Status control symbols, encoded as follows: 0x0 - No bits for port_group, all bits are port status 0x1 - One bit for port_group, remaining bits are port status 0x2 - Two bits for port_group, remaining bits are port_status ... 0x6 - Six bits for port_group, remaining bits are port_status 0x7 - Reserved This field should only be changed when the link partners Enable VoQ Symbol Generation field is cleared.

[1]The reset value is implementation dependent

Symbol Generation by a port must be enabled only when the device at the other end of the link supports reception.

VC linking should only be enabled if both connected devices support it. Support is defined as being able to both generate and receive VC linked messages. Either requires an underlying queueing structure that can segregate traffic by both VC and port.

Bits 9 and 10 combine as shown in Table 1-8.

Table 1-8. Port Status Control

Bit 9	Bit 10	Status Reflected in VoQ Backpressure Messages
0	0	Port Status is always 0b0 (will not cause symbol to be generated)
0	1	Port Status is always 0b1 (will not cause symbol to be generated)
1	0	Normal operation, state transitions cause symbols to be generated and the status is reflected in the symbol
1	1	Port Status is always 0b1 (will cause a symbol to be generated if changing from normal operation causes a state change).

With bit 9 = 0b0, toggling bit 10 will change the ports reported state, but will not trigger any new symbols. With bit 9 = 0b1, changing from normal operation to congested or congested to normal operation will cause a symbol to be transmitted only if the state of the port changed.

Note that changing the status of the port does not necessarily imply traffic will change. That depends on the configuration of the upstream device.

“