

LINX Protocols

Abstract

*This document describes the Enea **LINX protocol version 1.0**. See the Revision History section (and document header line) for the version of this document.*

LINX is a distributed communication protocol stack for transparent inter node and inter process communication for a heterogeneous mix of systems.

Copyright © 2006-2007 Enea Software AB.

LINX, OSE, OSEck, OSE Epsilon, Optima, NASP, Element, Polyhedra are trademarks of Enea Software AB. Linux is a registered trademark of Linus Torvalds. All other copyrights, trade names and trademarks used herein are the property of their respective owners and are used for identification purposes only.

Disclaimer. The information in this document is subject to change without notice and should not be construed as a commitment by Enea Software AB.

Table of Contents

- [1. Introduction](#)
 - [1.1 Purpose](#)
 - [1.2 Revision History](#)
 - [1.3 References](#)
 - [1.4 Definitions and Acronyms](#)
- [2. Overview](#)
- [3. The RLNH Protocol](#)
 - [3.1 RLNH Link Creation and Initialization](#)
 - [3.2 Publication of Names](#)
 - [3.3 Remote Name Lookup](#)
 - [3.4 Link Supervision](#)
 - [3.5 Protocol Messages](#)
 - [3.5.1 RLNH_INIT](#)
 - [3.5.2 RLNH_INIT_REPLY](#)
 - [3.5.3 RLNH_PUBLISH](#)
 - [3.5.4 RLNH_QUERY_NAME](#)
 - [3.5.5 RLNH_UNPUBLISH](#)
 - [3.5.6 RLNH_UNPUBLISH_ACK](#)
- [4. Enea LINX Connection Manager Protocols](#)
 - [4.1 Connection Establishment](#)
 - [4.2 Reliable Message Passing](#)
 - [4.3 Connection Supervision](#)
- [5. Enea LINX Ethernet Connection Manager](#)
 - [5.1 Protocol Descriptions](#)
 - [5.1.1 Enea LINX Ethernet Connection Manager Headers](#)
 - [5.1.1.1 ETHCM_MAIN Header](#)
 - [5.1.2 Enea LINX Connect Protocol](#)
 - [5.1.2.1 Connect Protocol](#)
 - [5.1.2.2 Connect Protocol Description](#)
 - [5.1.2.3 ETHCM_CONN Header](#)
 - [5.1.3 Enea LINX User Data Protocol](#)
 - [5.1.3.1 User data and Fragmentation Protocol](#)
 - [5.1.3.2 ETHCM_UDATA Header](#)
 - [5.1.3.3 ETHCM_FRAG Header](#)
 - [5.1.4 Enea LINX Reliability Protocol](#)
 - [5.1.4.1 Reliability Protocol Description](#)
 - [5.1.4.2 ETHCM_ACK header](#)
 - [5.1.4.3 ETHCM_NACK header](#)
 - [5.1.5 Enea LINX Connection Supervision Protocol](#)
 - [5.1.5.1 Connection Supervision protocol description](#)
 - [5.2 LINX Discovery Daemon](#)
 - [5.2.1 Linxdisc protocol](#)
- [6. Enea LINX Point-To-Point \(PTP\) Connection Manager](#)
 - [6.1 Protocol Descriptions](#)
 - [6.1.1 Enea LINX Point-To-Point Connection Manager Headers](#)
 - [6.1.1.1 PTP_CM_Main Header](#)
 - [6.1.1.2 PTP_CM_UDATA Header](#)
 - [6.1.1.3 PTP_CM_FRAG Header](#)
 - [6.1.1.4 PTP Connection Manager Control Headers](#)
 - [6.1.1.5 PTP Connection Protocol Description](#)
 - [6.2 PTP CM Connection Supervision Protocol](#)
- [7. Enea LINX TCP Connection Manager](#)
 - [7.1 TCP CM Protocol Descriptions](#)
 - [7.1.1 TCP Connection Manager Headers](#)
 - [7.1.1.1 TCP CM Generic Header](#)
 - [7.1.1.2 TCP_UDATA Header](#)
 - [7.2 TCP CM Connection Supervision Protocol](#)

1. Introduction

1.1 Purpose

This document describes the Enea LINX protocol.

1.2 Revision History

Current version is also seen in document header when printed (HTML title line).

| Revision | Author | Date | Status and Description of purpose for new revision |
|-----------------|---------------|-------------|--|
| 11 | lejo,wivo | 2007-09-14 | Added TCP CM |
| 10 | zalpa,lejo | 2007-08-29 | Approved. Added PTP CM |
| 9 | lejo | 2006-10-25 | Added copyright on front page. Cleaned out prerelease entries of document history. |
| 8 | lejo | 2006-10-13 | Converted document from Word to XHTML. |
| 7 | jonj | 2006-09-13 | Added reserved field in UDATA Header, Fixed bug in MAIN header. |
| 6 | jonj | 2006-09-11 | Fixed a few bugs, improved RLNH protocol description. |
| 5 | jonj | 2006-08-05 | Approved. Updated after review (internal reference ida 010209). |

1.3 References

1.4 Definitions and Acronyms

Definitions

- A**
The active (initiating) side in a protocol exchange.
- B**
The passive (responding) side in a protocol exchange.
- CM**
Connection Manager, the entity implementing the transport layer of the Enea LINX protocol.
- Endpoint**
A (part of) an application that uses the Enea LINX messaging services.
- Connection**
An association between Connection Managers.
- Connection ID**
A key used by Ethernet Connection Managers to quickly lookup the destination of an incoming packet. Connection ID based lookup is much efficient than MAC-address based lookup.
- Connection Manager**
A Connection Manager provides reliable communication for message passing. The connection layer roughly corresponds to layer four, the transport layer, in the OSI model.
- Connection Supervision**
A function within the Connection Manager responsible for detection of connection failure.
- Header**
Protocol Data filled in by the Connection Manager. A PDU consists of several headers.
- Link**
An association between link handlers using the Enea LINX protocol.
- Link Handler**
A concept from the OSE world. A Link Handler makes the OSE messaging IPC mechanism available in a distributed context.
- MAC-address**
Link layer address on Ethernet.
- Message**
A unit of information transported over LINX. Messages are transformed by Connection Managers in order to fit the media.
- Packet**
Protocol Data Unit sent over a connection.
- RLNH**
Rapid Link Handler, the link handler of Enea LINX.

Abbreviation

- IPC**
Inter Process Communication.
- PDU**
Protocol Data Unit.

2. Overview

Enea LINX is an open technology for distributed system IPC which is platform and interconnect independent, scales well to large systems with any topology, but that still has the performance needed for high traffic bearing components of the system. It is based on a transparent message passing method.

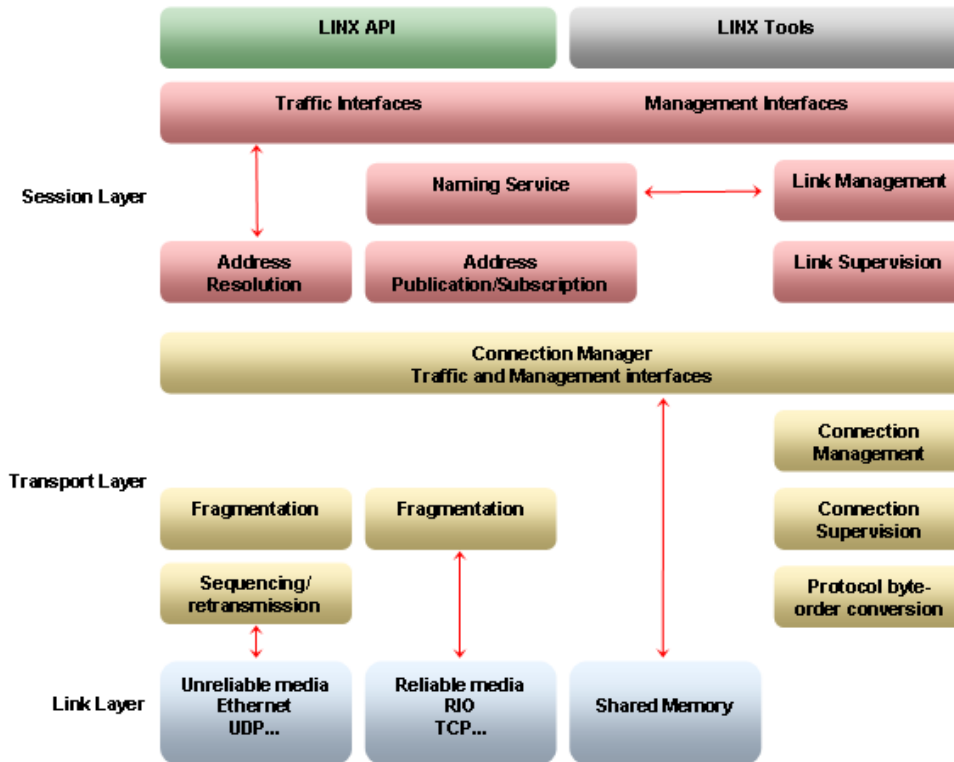


Figure 1 LINX Architecture

Enea LINX provides a solution for inter process communication for the growing class of heterogeneous systems using a mixture of operating systems, CPUs, microcontrollers DSPs and media interconnects such as shared memory, RapidIO, Gigabit Ethernet or network stacks. Architectures like this poses obvious problems, endpoints on one CPU typically uses the IPC mechanism native to that particular platform and they are seldom usable on platform running other OSes. For distributed IPC other methods, such as TCP/IP, must be used but that comes with rather high overhead and TCP/IP stacks may not be available on small systems like DSPs. Enea LINX solves the problem since it can be used as the sole IPC mechanism for local and remote communication in the entire heterogeneous distributed system.

The Enea LINX protocol stack has two layers - the RLNH and the Connection Manager, or CM, layers. RLNH corresponds to the session layer in the OSI model and implements IPC functions including methods to look up endpoints by name and to supervise to get asynchronous notifications if they die. The Connection Manager layer corresponds to the transport layer in the OSI model and implements reliable in order transmission of arbitrarily sized messages over any media.

3. The RLNH Protocol

The RLNH protocol is designed to be light-weight and efficient. The RLNH-to-RLNH control PDUs are described in detail below. The required overhead associated with user signal transmission is not carried in any dedicated RLNH PDU. Instead it is passed as arguments along with the signal data to the Connection Manager layer, where an optimized transmission scheme and message layout can be implemented based on knowledge of the underlying media and/or protocols. In particular the source and destination link addresses are sent this way, the addresses identifies the sending and receiving endpoints respectively. RLNH protocol messages are sent with source and destination link addresses set to zero (0).

3.1 RLNH Link Creation and Initialization

The Connection Manager is initialized by RLNH. It is responsible for providing reliable, in-order delivery of messages and for notifying RLNH when the connection to the peer becomes available / unavailable. An RLNH link is created maps a unique name to a Connection Manager object.

As soon as the Connection Manager has indicated that the connection is up, RLNH transmits an RLNH_INIT message to the peer carrying its protocol version number. Upon receiving this message, the peer responds with an RLNH_INIT_REPLY message indicating whether it supports the given protocol version or not. When this simple message exchange has been successfully completed, RLNH is ready to provide messaging services for the link name.

The RLNH protocol is stateless after this point.

3.2 Publication of Names

RLNH assigns each endpoint a link address identifier. The association between the name of an endpoint and the link address that shall be used to refer to it is published to the peer in an RLNH_PUBLISH message. RLNH_PUBLISH is always the first RLNH message transmitted when a new endpoint starts using the link.

Upon receiving an RLNH_PUBLISH message, RLNH creates a local representation of the remote name. Local applications can communicate transparently with such a representation, but the signals are in reality forwarded by RLNH to the peer system where the real destination endpoint resides (and the destination will receive the signals from a representation of the true sender).

The link addresses of source and destination for each signal are given to the Connection Manager for transmission along with the signal data and delivered to the peer RLNH. The link addressing scheme is designed to enable $O(1)$ translation between link addresses and their corresponding local OS IDs.

3.3 Remote Name Lookup

When a hunt call is performed for the name of a remote endpoint, the request is passed on by RLNH to the peer as a RLNH_QUERY_NAME message. If the hunter has not used the link before, an RLNH_PUBLISH message is sent first.

Upon receiving a RLNH_QUERY_NAME message, RLNH resolves the requested endpoint name locally and returns an RLNH_PUBLISH message when it has been found and assigned a link address. As described above, this triggers the creation of a representation at the remote node. This in turn resolves the hunt call - the hunter is provided with the OS ID of the representation.

3.4 Link Supervision

RLNH supervises all endpoints that use the link. When a published name is terminated, a RLNH_UNPUBLISH message with its link address is sent to the peer.

When a RLNH_UNPUBLISH message is received, RLNH removes its local representation of the endpoint referred to by the given link address. When RLNH no longer associates the link address with any resources, it returns a RLNH_UNPUBLISH_ACK message to the peer.

The link address can be reused after a RLNH_UNPUBLISH_ACK message.

3.5.5 RLNH_UNPUBLISH

The RLNH_UNPUBLISH message tells the remote RLNH that the endpoint previously assigned the given link-address has been closed.

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | | 1 | | | | | | | | | | 2 | | | | | | | | | | 3 | |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 |
| 0 | | | | | 1 | | | | | 2 | | | | | 3 | | | | | | | | | | | | | | | | |
| Sig_no | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Linkaddr | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Table 10. RLNH Unpublish Header

| Field | Definition |
|----------|---|
| Sig_no | Message type. The value of RLNH_UNPUBLISH is 3. |
| Linkaddr | The address of the closed endpoint. |

Table 11. RLNH Unpublish Header Description

3.5.6 RLNH_UNPUBLISH_ACK

The RLNH_UNPUBLISH_ACK message tells the remote RLNH that all associations regarding an unpublished link address have been terminated. This indicates to the peer that it is ok to reuse the link address.

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | | 1 | | | | | | | | | | 2 | | | | | | | | | | 3 | |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 |
| 0 | | | | | 1 | | | | | 2 | | | | | 3 | | | | | | | | | | | | | | | | |
| Sig_no | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Linkaddr | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Table 12. RLNH Unpublish Ack Header

| Field | Definition |
|----------|---|
| Sig_no | Message type. The value of RLNH_UNPUBLISH_ACK is 4. |
| Linkaddr | The link address of the unpublished endpoint. |

Table 13. RLNH Unpublish Ack Header Description

4. Enea LINX Connection Manager Protocols

This chapter describes in general terms the functionality a Connection Manager must provide.

A Connection Manager shall hide details of the underlying media, e.g. addressing, general media properties, how to go about to establish connections, media aggregation, media redundancy and so on. A Connection Manager shall support creation of associations, known as connections that are suitable for reliable message passing of arbitrarily sized messages. A Connection Manager must not rely on implicit connection supervision since this can cause long delay between peer failure and detection if the link is idle. A message accepted by a Connection Manager must be delivered to its destination.

If, for any reason, a Connection Manager is unable to deliver a message RLNH must be notified and the connection restarted since its state at this point is inconsistent.

Since Enea LINX runs on systems with very differing size, the Connection Manager protocol must be scalable. A particular implementation may ignore this requirement either because the underlying media doesn't support scalability or that a non-scalable implementation has been chosen. However, interfaces to the Connection Manager and protocol design when the media supports big configuration shall not make design decisions that prevents the system to grow to big configurations should the need arise.

Enea LINX must be able to coexist with other protocols when sharing media.

4.1 Connection Establishment

Creation of connections always requires some sort of hand shake protocol to ensure that the Connection Manager at the endpoints agrees on communication parameters and the properties of the media.

4.2 Reliable Message Passing

A channel suitable for reliable message passing must appear to have the following properties:

- Messages are delivered in the order they are sent.
- Messages can be of arbitrary size.
- Messages are never lost.
- The channel has infinite bandwidth.

Although no medium has all these properties some come rather close and others simulate them by implementing functions like fragmentation of messages larger than the media can handle, retransmission of lost messages, and flow control i.e. don't send more than the other side can consume. If a Connection Manager is unable to continue deliver messages according to these rules the connection must be reset and a notification sent to RLNH.

4.3 Connection Supervision

A distributed IPC mechanism should support means for applications to be informed when a remote endpoint fails. Connection Managers are responsible for detecting when the media fails to deliver messages and when the host where a remote endpoint runs has crashed. There are of course other reasons an endpoint might fail to respond but in those situations the communication link continues to function and higher layers in the LINX architecture manages supervision.

5. Enea LINX Ethernet Connection Manager

This chapter describes version 2 of the Enea LINX Ethernet Connection Manager Protocol.

5.1 Protocol Descriptions

Enea LINX PDUs are stacked in front of, possible, user data to form an Enea LINX Ethernet packet. All PDUs contain a field next header which contain the protocol number of following headers or the value -1 (1111b) if this is the last PDU. All headers except Enea LINX main header are optional. Everything from the transmit() down call, including possible control plane signaling, from the RLNH layer is sent reliably as user data. The first field in all headers is the next header field, having this field in the same place simplifies implementation and speeds up processing.

If a malformed packet is received the Ethernet Connection Manager resets the connection and informs RLNH.

When the Ethernet Connection Manager encounters problems which prevents delivery of a message or part of a message it must reset the connection. Notification of RLNH is implicit in the Ethernet CM, when the peer replies with RESET or, if the peer has crashed, the Connection Supervision timer fires.

5.1.1 Enea LINX Ethernet Connection Manager Headers

Version 2 of the Enea LINX Ethernet Connection Manager protocol defines these headers.

| Protocol number | Definition |
|-----------------|---|
| ETHCM_MAIN | Main header sent first in all Enea LINX messages. |
| ETHCM_CONN | Connect header. Used to establish and tear down connections. |
| ETHCM_UDATA | User data header. All messages generated outside the Connection Manager are sent as UDATA. |
| ETHCM_FRAG | Fragment header. Messages bigger than the MTU are sent fragmented and PDUs following the first carries the ETHCM_FRAG header instead of ETHCM_UDATA. |
| ETHCM_ACK | Reliability header. Carries seqno and ackno. ACK doubles as empty acknowledge PDU and ACK-request PDU, in sliding window management and connection supervision. |
| ETHCM_NACK | Request retransmission of one or more packets. |
| ETHCM_NONE | Indicates that the current header is the last in the PDU. |

Table 16. Ethernet Connection Manager Protocol Headers

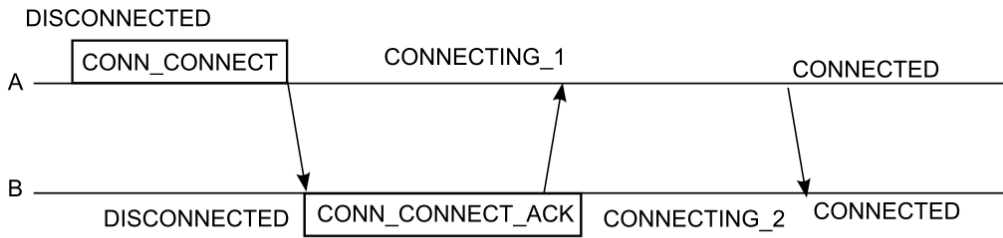
5.1.2 Enea LINX Connect Protocol

The Enea LINX Connect Protocol is used to establish a connection on the Connection Manager level between two peers A and B. A Connection Manager will only try to establish a connection or accept connection attempt from a peer if it has been explicitly configured to do. After configuration a CM will maintain connection with the peer until explicitly told to destroy the connection or an unrecoverable error occurs.

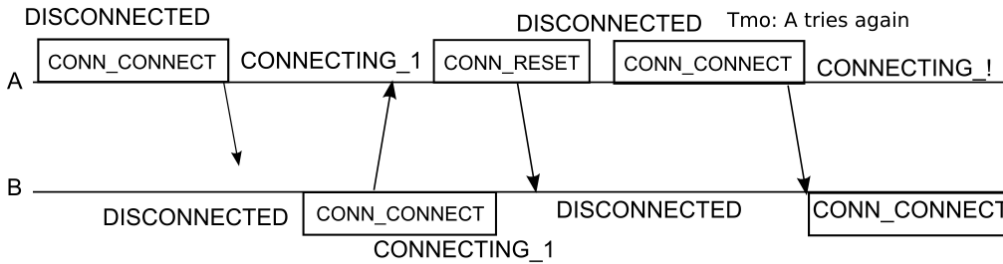
If a Connect-message is received, with a version number different from 2, the Ethernet CM refuses to connect.

The Connect Protocol determines Connection IDs to be used for this connection. Connection IDs are small keys used by receivers to quickly lookup a packets destination. Each side selects the Connection ID to be used by the peer when sending packets over the connection. The peer saves the ID and will use it for all future communication. If a node has a lot of connections it may run out of available Connection IDs. In this case the node sends Connection ID 0, which means no Connection ID and reverts to the slower MAC-addressing mode to determine destination for incoming packets.

A window size options may be sent in the CONNECT-header to indicate how the sender configuration deviates from the default. Deviations from default values are configured per connection in the create_conn()-call.



Below, A starts first and tries to connect. B is not active, so the PDU is lost. A tries again..



Above, when B tries to connect to A, A is in the wrong state and sends RESET to synchronize
 Figure 2 Successful Connect.

5.1.2.1 Connect Protocol

In the following protocol description the side initiating the connection is called A and the side responding to the request is called B. All protocol transitions are supervised by a timer, if the timer fires before the next step in the protocol have been completed the state machine reverts to state disconnected.

The Connect Protocol is symmetrical, there is no master and both sides try to initiate the connection. Collisions, i.e. when the initial CONNECT PDU is sent simultaneously from both sides, are handled by the protocol and the connection restarted after a randomized back of timeout.

5.1.2.2 Connect Protocol Description

Unless a Connection Manager has been configured to create a connection to a peer no messages are sent and the Connection Manager doesn't respond to connection attempts.

A-side

1. When a Connection Object is created at A by calling create_conn() A starts from DISCONNECTED state, sends a CONNECT PDU to B and enters state CONNECTING_1.
 - a. If tmo, go back to step 1 and try again after a grace period.
 - b. If B replies with a CONNECT_ACK PDU, move to CONNECTED state, send ACK PDU to B, notify RLNH that a connection have been established, and start the Connection Supervision function.
 - c. If any other PDU is received from B send RESET and go back to step 1 and try again after a short grace period.

B-side

1. After configuration, B waits in state DISCONNECTED for a CONNECT PDU from A.
 - a. If a CONNECT PDU arrives, send a CONNECT_ACK PDU and go to state CONNECTING_2
 - b. If some other PDU arrives, send RESET to A and go back to step 2.
2. In state CONNECTING_2, B waits for an ACK PDU from A.
 - a. When CONN_ACK arrives, the connect protocol is complete, the Connection Manager notifies higher layers that a connection have been established, and start the Connection Supervision function.
 - b. If some other PDU is received or the timer fires, send RESET and go to state DISCONNECTED

Allowed messages and state changes are summarized in this state diagram. The notation [xxx/yyy] means: event xxx causes action yyy.

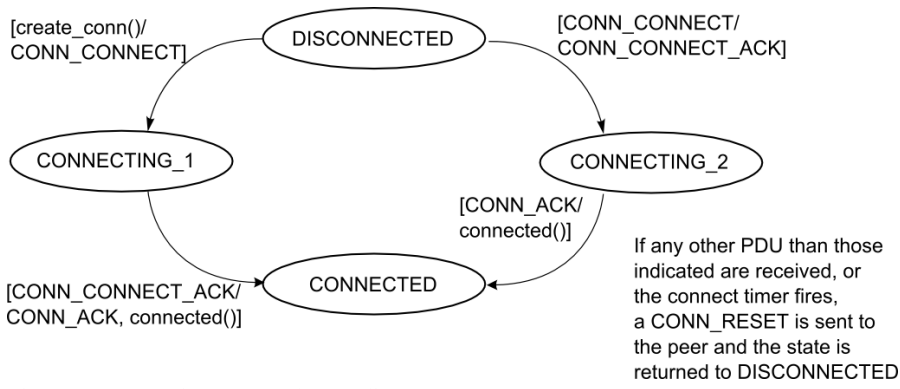


Figure 3 Connection protocol state diagram.

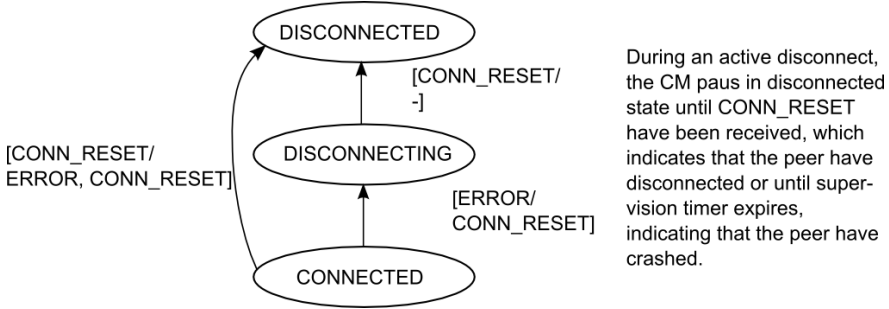


Figure 4 Disconnect state diagram.

5.1.4 Enea LINX Reliability Protocol

The Connection Manager uses a selective repeat sliding window protocol with modulo m sequence numbers. The ack header carries sequence and request numbers for all reliable messages sent over the connection. Sequence and Request numbers are 12 bits wide and m is thus 4096.

In the Selective Retransmit Sliding Window algorithm the B-side explicitly request retransmission of dropped packets and remembers packets received out of order. If the sliding window is full, the A-side queues outgoing packets in a deferred queue. When space becomes available in the window (as sent packets are acknowledged by B) packets are from the front of the deferred queue and sent as usual. A strict ordering is maintained, as long as there are packets waiting in the deferred queue new packets from RLNH are deferred, even if there is space available in the window.

5.1.4.1 Reliability Protocol Description

For sliding window operation the sender A have the variables SN_{min} and SN_{max} , SN_{min} points to the first unacknowledged packet in the sliding window and SN_{max} points at the next packet to be sent. In addition the sliding window size is denoted n and size of sequence numbers are modulo m . The receiver side B maintains a variable RN which denotes the next expected sequence number. In the protocol description, the sequence number and the request number of a packet is called sn and rn respectively. The module number m must be $\geq 2n$. In version two of the Enea LINX Ethernet protocol m is 4096 and n is a power of $2 \leq 128$. Drawing sequence number from a much larger space than the size of the window allows the reliability protocol to detect random packets with bad sequence numbers.

At A, the algorithm works as follows:

1. Set modulo variables SN_{min} and SN_{max} to 0.
2. In A if a message is sent from higher layer or there are packets in the defer queue, and $(SN_{max} - SN_{min}) \bmod m < n$, accept a packet into the sliding window set sn to SN_{max} and increment SN_{max} to $(SN_{max} + 1) \bmod m$. If $(SN_{max} - SN_{min}) \bmod m \geq n$ defer sending the packet, i.e. queue the packet until there is room in the sliding window.
3. If an error free frame is received from B containing rn , and $(RN - SN_{min}) \bmod m \leq (RN - SN_{max}) \bmod m$, set SN_{min} to RN and remove packets with $sn < SN_{min} \bmod m$ from send queue.
4. If a NACK frame is received, retransmit NACKed packets in-order with rn set to RN .
5. At arbitrary times but within bounded delay after receiving a reliable packet from B and if there are unacknowledged packets in the sliding window, send the first un-acked packet with rn RN and the request bit set.

The selective repeat algorithm at B:

1. Set the modulo m variable RN to 0.
2. When an error free frame is received from A containing sn equal to RN , release the packet as well as following queued packets with consecutive sn to higher layer and increment RN to $(last\ released\ sn + 1) \bmod m$.
3. When an error free frame is received from A containing sn in the interval $RN < sn < RN + n$, put the packet in sequence number order in the receive queue and send NACK requesting retransmission of sequentially dropped packets to A. The seqno field in the NACK frame shall contain RN and the count field shall contain the number of missing packets.
4. At arbitrary times but within a bounded delay after receiving an error free frame from A transmit a frame containing RN to A. If there are frames in the receive queue send a NACK indicating missing frames.

Note that only user data is sent reliable, i.e. consume sequence numbers. ACKR, NACK and empty ACK are unreliable messages sequence numbers are not incremented as they are sent.

6. Enea LINX Point-To-Point (PTP) Connection Manager

This chapter describes version 1 of the Enea LINX Point-To-Point Connection Manager Protocol.

The PTP Connection Manager is designed to meet the following requirements:

- **Generic design** - The design should allow several shared memory concepts. It should be easy to port the solution to other hardware. The generic parts should be separated for reuse with interfaces supporting as many different underlying layers as possible.
- **Performance** – The throughput should be as high as possible and the latency as low as possible. This includes minimizing the number of data copying and use of locks.
- **Robust** – The data exchange should be performed as simple as possible. Minimizing the complexity of the solution will minimize the possibility of making errors.

This CM is intended to communicate over reliable media, but in case of one side failure, the peer side is able to detect and react, as described in chapter [6.2 PTP Connection Supervision Protocol](#)

6.1 Protocol Descriptions

Enea LINX PDUs are stacked in front of, possible, user data to form an Enea LINX packet. All PDUs contain a "next header" field which indicates the type of the next PDU to be sent. Everything from the transmit() down call, including possible control plane signaling, from the RLNH layer is sent reliably as user data. The first field in all headers is the current type, followed by "next" field.

If a malformed packet is received the PTP Connection Manager resets the connection and informs RLNH.

When the PTP Connection Manager encounters problems which prevents delivery of a message or part of a message it must reset the connection. If the peer replies with RESET, or if the peer has crashed and the Connection Supervision timer fires, the PTP CM will notify the RLNH.

6.1.1 Enea LINX Point-To-Point Connection Manager Headers

The Enea LINX Point-To-Point Connection Manager protocol defines these headers.

| Protocol number | Value | Definition |
|-------------------------|-------|---|
| PTP_CM_MAIN | 0x01 | Main header. It is always sent first. |
| PTP_CM_CONN_RESET | 0x02 | Reset header. Used to notify the remote side that the connection will be torn down and reinitialized. |
| PTP_CM_CONN_CONNECT | 0x03 | Connect header. Used to establish connections. |
| PTP_CM_CONN_CONNECT_ACK | 0x04 | Notify remote side that connection was established. |
| PTP_CM_UDATA | 0x05 | All messages generated outside the Connection Manager are send as UDATA. |
| PTP_CM_FRAG | 0x06 | Fragment header. Messages larger than MTU are fragmented into several packages. The first fragmented package has a PTP_CM_UDATA header followed by PTP_CM_FRAG header, the following packages has only PDU PTP_CM_FRAG. |
| PTP_CM_HEARTBEAT | 0x07 | Header for heart beat control messages. These messages are used to discover a connection failure. |
| PTP_CM_HEARTBEAT_ACK | 0x08 | Acknowledgement header for heartbeat messages. Sent as a reply to PTP_CM_HEARTBEAT messages. |
| PTP_CM_NONE | 0xFF | Indicates that the current header is the last in the PDU. |

Table 31. PTP Connection Manager Protocol Headers

6.1.1.5 PTP Connection Protocol Description

Unless a Connection Manager has been configured to create a connection to a peer, no messages are sent and the Connection Manager does not respond to connection attempts. Below is described one case when a connection is created and B side initiates the connection later than A side.

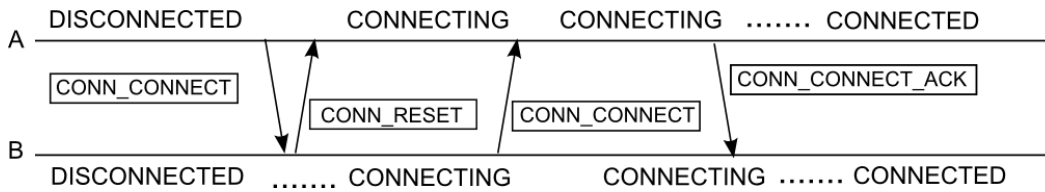


Figure 8 Connect Sequence diagram for PTP Connection Manager

A side

1. When a Connection Object is created, A moves from DISCONNECTED state to CONNECTING, then sends a PTP_CM_CONN_CONNECT to B.
 - a. If B replies with a PTP_CM_CONN_RESET PDU, A remains in CONNECTING state.
 - b. If B sends a PTP_CM_CONN_CONNECT PDU, A moves to CONNECTED state, sends PTP_CM_CONN_CONNECT_ACK PDU to B and notifies RLNH that a connection have been established.
 - c. If PTP_CM_CONN_RESET or PTP_CM_CONN_CONNECT PDUs are received, while in CONNECTED state, A side returns to disconnected state.

B side

1. In DISCONNECTED state, B does not evolve from this state unless a local attempt to create a connection is made.
2. When a Connection Object is created, B moves from DISCONNECTED state to CONNECTING and sends a PTP_CM_CONN_CONNECT to A.
 - a. When PTP_CM_CONN_CONNECT arrives, A is waiting already in CONNECTING state so it enters CONNECTED state and responds to B with PTP_CM_CONN_CONNECT_ACK.
 - b. When receiving PTP_CM_CONN_CONNECT_ACK, B side enters in CONNECTED state too.
 - c. If PTP_CM_CONN_RESET or PTP_CM_CONN_CONNECT PDUs are received while in CONNECTED state, B side returns to disconnected state

If either sides receive PTP_CM_CONN_CONNECT message while in CONNECTED state, it moves to DISCONNECTED and sends a PTP_CM_CONN_RESET message.

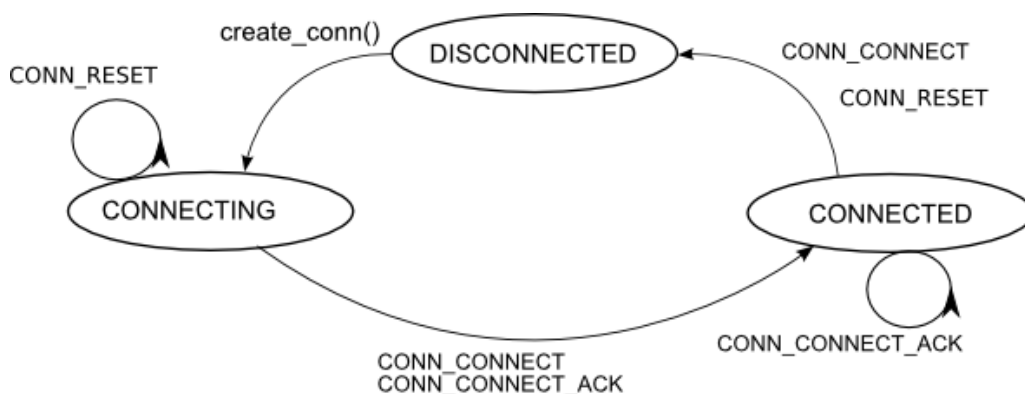


Figure 9 State diagram for PTP Connection Manager

6.2 PTP Connection Supervision Protocol

The purpose of Supervision function is to detect crashed on peer side. In order to do that, PTP_CM_HEARTBEAT PDU is sent periodically to the other side. When a PTP_CM_HEARTBEAT_ACK is received, an internal counter is re-set. If no acknowledgement is received within a certain time interval, the heartbeat counter is decremented. After a number of ACK missed, the connection is considered crashed and will be disconnected. The timeout and the number of acknowledgments are configurable.

The supervision activity is independent of user data flow over the connection. Each side is responsible to detect peer's activity, and each side will request acknowledgment to own heartbeat messages.

7. Enea LINX TCP Connection Manager

This chapter describes version 1 of the Enea LINX TCP Connection Manager Protocol.

The TCP Connection Manager uses a TCP socket (SOCK_STREAM) as a connection between two LINX endpoints. As the TCP protocol is reliable, the CM itself has no mechanism for reliability of its own. This CM is suitable to use across the internet.

7.1 TCP CM Protocol Descriptions

With the Enea LINX TCP Connection Manager Protocol, a connection is established in the following manner.

- The TCP CM listens on port 19790 by default. Node A wants to connect to node B. A creates a TCP socket and connects it to B, and then waits for a randomly amount of time for an acknowledgement. If an acknowledgment is not received, A will start the connect procedure again.
- B accepts the socket and when B wants to connect to A, it will lookup the previously accepted socket and send a TCP_CONN header to A.
- B considers the connection established if the send was successful and then notifies the upper layer of the established connection.
- A receives the TCP_CONN header and notifies the upper layer of the connection.

If both nodes try to connect to each other at the same time, neither of the nodes will receive an acknowledgment. This will lead to retries of the connection procedure. The timeouts for the retries are random.

7.1.1 TCP Connection Manager Headers

The Enea LINX TCP Connection Manager protocol defines the following header and package types.

| Protocol number | Value | Definition |
|-----------------|-------|---|
| TCP_CONN | 0x43 | Connect type. Used for connection acknowledgement . |
| TCP_UDATA | 0x55 | User data type. |
| TCP_PING | 0x50 | Keep-alive header type. |

Table 40. TCP Connection Manager Protocol Header Types

