

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Industrial communication networks – High availability automation networks –
Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless
Redundancy (HSR)**

**Réseaux industriels de communication – Réseaux d'automatisme à haute
disponibilité –
Partie 3: Protocole de redondance parallèle (PRP) et redondance transparente de
haute disponibilité (HSR)**



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CONTENTS

FOREWORD.....	5
0 INTRODUCTION	7
0.1 General.....	7
0.2 Changes with respect to the previous edition.....	7
0.3 Patent declaration	8
1 Scope.....	9
2 Normative references	9
3 Terms, definitions, abbreviations, acronyms, and conventions.....	10
3.1 Terms and definitions	10
3.2 Abbreviations and acronyms.....	10
3.3 Conventions	10
4 Parallel Redundancy Protocol (PRP)	10
4.1 PRP principle of operation.....	10
4.1.1 PRP network topology	10
4.1.2 PRP LANs with linear or bus topology	11
4.1.3 PRP LANs with ring topology	12
4.1.4 DANP node structure.....	12
4.1.5 PRP attachment of singly attached nodes.....	13
4.1.6 Compatibility between singly and doubly attached nodes.....	14
4.1.7 Network management.....	14
4.1.8 Implication on configuration.....	14
4.1.9 Transition to non-redundant networks.....	14
4.1.10 Duplicate handling.....	15
4.1.11 Network supervision.....	19
4.1.12 Redundancy management interface.....	19
4.2 PRP protocol specifications.....	19
4.2.1 Installation, configuration and repair guidelines	19
4.2.2 MAC addresses	20
4.2.3 Multicast MAC addresses	20
4.2.4 IP addresses	20
4.2.5 Nodes.....	20
4.2.6 Duplicate Accept mode (testing only).....	21
4.2.7 Duplicate Discard mode.....	21
4.3 PRP_Supervision frame	24
4.3.1 Supervision frame for DANP	24
4.3.2 PRP_Supervision frame contents	27
4.3.3 PRP_Supervision frame for RedBox	27
4.3.4 Reception of a PRP_Supervision frame and NodesTable.....	27
4.4 Bridging node.....	28
4.5 Constants.....	28
4.6 PRP service specification	28
5 High-availability Seamless Redundancy (HSR).....	28
5.1 HSR objectives.....	28
5.2 HSR principle of operation.....	29
5.2.1 Basic operation with a ring topology	29
5.2.2 DANH node structure.....	30

5.2.3	Topology	31
5.2.4	RedBox structure.....	39
5.3	HSR node specifications	41
5.3.1	HSR operation.....	41
5.3.2	DANH receiving from its link layer interface	41
5.3.3	DANH receiving from an HSR port.....	42
5.3.4	DANH forwarding rules	43
5.3.5	CoS	43
5.3.6	Clock synchronization.....	43
5.3.7	Deterministic medium access	44
5.4	HSR RedBox specifications	44
5.4.1	RedBox properties.....	44
5.4.2	RedBox receiving from interlink	44
5.4.3	RedBox forwarding on the ring.....	46
5.4.4	RedBox receiving from an HSR port	46
5.4.5	RedBox receiving from its link layer interface.....	47
5.4.6	Redbox ProxyNodeTable handling.....	47
5.4.7	RedBox CoS.....	48
5.4.8	RedBox clock synchronization	48
5.4.9	RedBox medium access	48
5.5	QuadBox specification.....	48
5.6	Duplicate Discard method.....	48
5.7	Frame format for HSR	48
5.7.1	Frame format for all frames	48
5.7.2	HSR_Supervision frame	50
5.8	Constants.....	52
5.9	HSR service specification.....	53
6	Protocol Implementation Conformance Statement (PICS)	54
7	PRP/HSR Management Information Base (MIB)	55
	Annex A (normative) Use of IEC 61588 and IEEE C37.238 for IEC 62439-3.....	69
	Annex B (informative) Deterministic medium access in HSR	83
	Bibliography.....	84
	Figure 1 – PRP example of general redundant network.....	11
	Figure 2 – PRP example of redundant network as two LANs (bus topology).....	12
	Figure 3 – PRP example of redundant ring with SANs and DANPs.....	12
	Figure 4 – PRP with two DANPs communicating	13
	Figure 5 – PRP RedBox, transition from single to double LAN	15
	Figure 6 – PRP frame extended by an RCT.....	16
	Figure 7 – PRP VLAN-tagged frame extended by an RCT.....	17
	Figure 8 – PRP padded frame closed by an RCT	17
	Figure 9 – Duplicate Discard algorithm boundaries	18
	Figure 10 – HSR example of ring configuration for multicast traffic	29
	Figure 11 – HSR example of ring configuration for unicast traffic	30
	Figure 12 – HSR structure of a DANH	31
	Figure 13 – HSR example of topology using two independent networks	32

Figure 14 – HSR example of peer coupling of two rings	33
Figure 15 – HSR example of connected rings	34
Figure 16 – HSR example of coupling two redundant PRP LANs to a ring	35
Figure 17 – HSR example of coupling from a ring node to redundant PRP LANs.....	36
Figure 18 – HSR example of coupling from a ring to two PRP LANs.....	37
Figure 19 – HSR example of coupling three rings to one PRP LAN	38
Figure 20 – HSR example of meshed topology.....	39
Figure 21 – HSR structure of a RedBox	40
Figure 22 – HSR frame without a VLAN tag	49
Figure 23 – HSR frame with VLAN tag	49
Figure 24 – HSR node with management counters.....	53
Figure 25 – HSR RedBox with management counters	54
Figure A.1 – PTP one-step clock synchronization and delay measurement.....	71
Figure A.2 – PTP two-step clock synchronization and delay measurement.....	72
Figure A.3 – Two-step and one-step transparent clocks translator	73
Figure A.4 – Two-step to one-step translation	73
Figure A.5 – Connection of a Grandmaster Clock to an Ordinary Clock over PRP	74
Figure A.6 – HSR with one GMC	76
Figure A.7 – PTP messages sent and received by an HSR node (one-step).....	77
Figure A.8 – PTP messages sent and received by an HSR node (two-step).....	78
Figure A.9 – Attachment of a GMC to an HSR ring through a RedBox.....	80
Figure A.10 – PRP to HSR coupling by Transparent Clocks	81
Figure A.11 – PRP to HSR coupling by BCs.....	82
62439-3-2012	
Table 1 – NodesTable attributes	22
Table 2 – PRP_Supervision frame with no VLAN tag.....	25
Table 3 – PRP_Supervision frame with (optional) VLAN tag.....	26
Table 4 – PRP constants	28
Table 5 – HSR_Supervision frame with no VLAN tag	50
Table 6 – HSR_Supervision frame with optional VLAN tag	51
Table 7 – HSR Constants	52

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INDUSTRIAL COMMUNICATION NETWORKS –
HIGH AVAILABILITY AUTOMATION NETWORKS –****Part 3: Parallel Redundancy Protocol (PRP) and
High-availability Seamless Redundancy (HSR)**

FOREWORD

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International Standard IEC 62439-3 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This second edition cancels and replaces the first edition published in 2010. This edition constitutes a technical revision. The main changes with respect to the previous edition are listed below:

- specification of the interconnection of PRP and HSR networks;
- introduction of a suffix for PRP frames;
- clarification and modification of specifications to ensure interoperability;
- slackening of the specifications to allow different implementations;
- consideration of clock synchronization according to IEC 61588;
- introduction of test modes to simplify testing and maintenance.

The text of this standard is based on the following documents:

FDIS	Report on voting
65C/687/FDIS	65C/705/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This International Standard is to be read in conjunction with IEC 62439-1:2011.

A list of the IEC 62439 series can be found, under the general title *Industrial communication networks – High availability automation networks*, on the IEC website.

This publication has been drafted in accordance with ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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0 INTRODUCTION

0.1 General

IEC 62439-3 standard belongs to IEC 62439 series, *Industrial communication networks – High availability automation networks*, specifying the HSR and PRP redundancy protocols, and was adopted by TC57 WG10 as the redundancy method for demanding substation automation networks based on IEC 61850 series, introducing new requirements.

0.2 Changes with respect to the previous edition

The major changes with respect to IEC 62439-3:2010 are listed below.

Aligning the sequence number between PRP and HSR, to enable coupling of HSR and PRP networks and simplify the implementation of dual-mode nodes in hardware. At the same time, introduce a suffix in the PRP Redundancy Control Trailer to allow better identification, future extensions and coexistence with other protocols that also happen to use a trailer. This change is not backwards-compatible, so means are provided to identify the version and ensure that the networks are homogeneous.

Removing all implementation restrictions on the Duplicate Discard algorithm (especially references to the drop window algorithm and references to connection orientation) since other methods such as hash tables can be used.

Removing the purging of the duplicate table. Replace this specific method by requiring that any Duplicate Discard algorithm provides a mechanism to remove old entries, thus ensuring that a node can properly reboot.

Making node tables optional for simple nodes to simplify hardware implementation.

Suppression of explicit mention of the HSR-PRP mode (PRP with HSR Tags), but allow it through the Mode N (no forwarding).

Introducing Mode T (forward through) to allow maintenance laptops to configure an open ring when attached to one end and Mode M (mixed) to allow forwarding of non-HSR-tagged frames in a closed ring.

Recommending the position of connectors, rather than impose it.

Defining the behaviour of an HSR node when non-HSR frames are encountered without requiring the recording of the source addresses and specify how IEEE 802.1D:2004, Table 7-10 frames are treated.

Prefixing the supervision frames on HSR by an HSR tag to simplify the hardware implementation and introduce a unique EtherType for HSR to simplify processing.

Changing the rule for the RedBox to allow more than one PRP network to be connected to an HSR ring, and introduce an identifier per RedBox pair.

Specifying tagging of IEC 61588 frames to follow IEEE C37.238 recommendations (informal).

Suppressing MAC address substitution.

Adapting the MIB to above changes.

0.3 Patent declaration

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning Filtering of redundant frames in a network node given in 5.2.3.3.

IEC takes no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has assured the IEC that he/she is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with IEC. Information may be obtained from:

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The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning Reception of redundant and non-redundant frames (ABB Schweiz AG – WO 2006/053459 A1, EP 1825657, US 20070223533, CN 101057483) given in 4.2.7, concerning Identifying improper cabling of devices (ABB Schweiz AG – EP 2 015 501 A1) given in 4.3, concerning Critical device with increased availability (ABB Schweiz AG – EP 2 090 950 A1) given in 4.4, concerning Ring coupling nodes for high availability networks (ABB Schweiz AG – WO 2010/010120 A1) given in 5.2.3.

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INDUSTRIAL COMMUNICATION NETWORKS – HIGH AVAILABILITY AUTOMATION NETWORKS –

Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR)

1 Scope

The IEC 62439 series is applicable to high-availability automation networks based on the ISO/IEC 8802-3 (Ethernet) technology.

This part of the IEC 62439 series specifies two redundancy protocols designed to provide seamless recovery in case of single failure of an inter-bridge link or bridge in the network, which are based on the same scheme: duplication of the LAN, resp. duplication of the transmitted information.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-191, *International Electrotechnical Vocabulary – Chapter 191 : Dependability and quality of service*

IEC 61588, *Precision clock synchronization protocol for networked measurement and control systems*

IEC 62439-1, *Industrial communication networks – High availability automation networks – Part 1: General concepts and calculation methods*

IEC 62439-2, *Industrial communication networks – High availability automation networks – Part 2: Media Redundancy Protocol (MRP)*

IEC 62439-6, *Industrial communication networks – High availability automation networks – Part 6: Distributed Redundancy Protocol (DRP)*

IEC 62439-7, *Industrial communication networks – High availability automation networks – Part 7: Ring-based Redundancy Protocol (RRP)*

ISO/IEC 8802-3:2000, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

IEEE 802.1D:2004, *IEEE Standard for Local and Metropolitan Area Networks – Media Access Control (MAC) Bridges*

IEEE 802.1Q:2011, *IEEE Standard for Local and Metropolitan Area Networks – Media Access Control (MAC) Bridges and Virtual Bridge Local Area Network*

3 Terms, definitions, abbreviations, acronyms, and conventions

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-191, as well as in IEC 62439-1, as well as the following, apply.

3.1.1 interlink

link that connects two network hierarchies

3.1.2 RedBox

device attaching single attached nodes to a redundant network

3.1.3 QuadBox

quadruple port device connecting two peer HSR rings, which behaves as an HSR node in each ring and is able to filter the traffic and forward it from ring to ring

3.1.4 HSR frame

frame that carries as EtherType the HSR_ethertype

3.1.5 switching logic

hardware that transmits a frame from one port to another port, possibly providing cut-through

Note 1 to entry: In this document, the words “bridge” respectively “bridging” are synonymous to the words “switch”, respectively “switching” when they apply to layer 2 connectivity.

3.2 Abbreviations and acronyms

For the purposes of this document, the abbreviations and acronyms given in IEC 62439-1, as well as the acronyms below, apply.

CoS	Class of Service (layer 2 quality of service)
DANH	Double attached node implementing HSR
DANP	Double attached node implementing PRP
RCT	Redundancy Check Trailer
VDAN	Virtual Doubly Attached Node (SAN as visible through a RedBox)

3.3 Conventions

This part of the IEC 62439 series follows the conventions defined in IEC 62439-1.

4 Parallel Redundancy Protocol (PRP)

4.1 PRP principle of operation

4.1.1 PRP network topology

This redundancy protocol implements redundancy in the nodes rather than in the network, using doubly attached nodes obeying to PRP (DANPs).

A DANP is attached to two independent Local Area Networks (LANs) of similar topology, named LAN_A and LAN_B, which operate in parallel. A source DANP sends the same frame over both LANs and a destination DANP receives it from both LANs within a certain time, consumes the first frame and discards the duplicate.

Figure 1 shows a redundant network consisting of two LANs, each of which can have any topology, e.g. tree, ring or meshed.

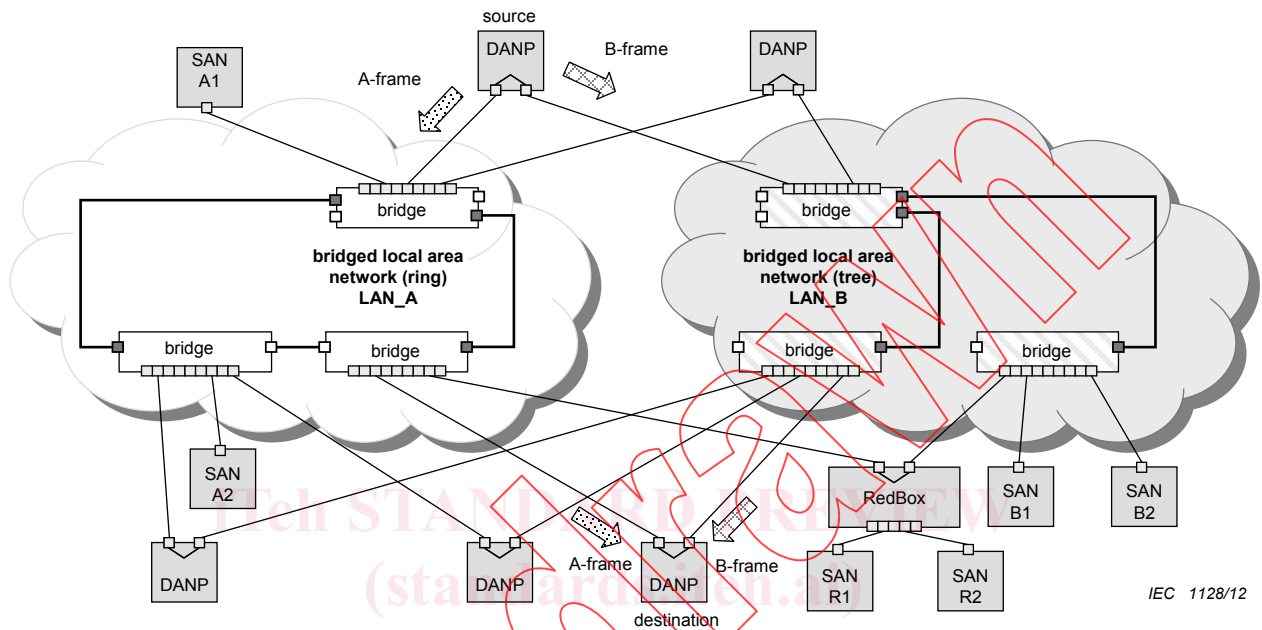


Figure 1 – PRP example of general redundant network

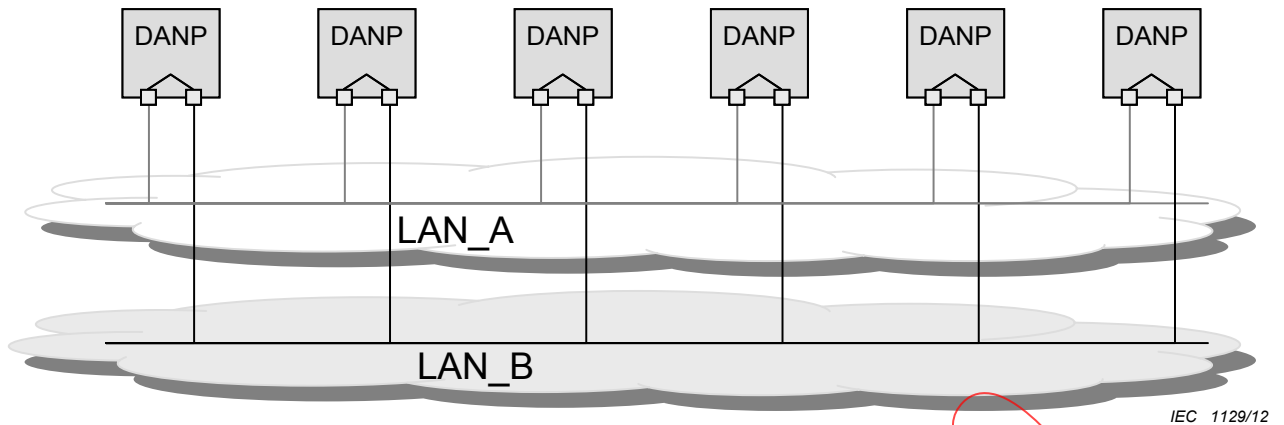
The two LANs are identical in protocol at the MAC-LLC level, but they can differ in performance and topology. Transmission delays may also be different, especially if one of the networks reconfigures itself, e.g. using RSTP, to overcome an internal failure.

The two LANs follow configuration rules that allow the network management protocols such as Address Resolution Protocol (ARP) and Simple Network Management Protocol (SNMP) to operate correctly.

The two LANs have no connection between them and are assumed to be fail-independent. Redundancy can be defeated by single points of failure, such as a common power supply or a direct connection whose failure brings both networks down. Installation guidelines in this document provide guidance to the installer to achieve fail-independence.

4.1.2 PRP LANs with linear or bus topology

As an example of a simpler topology, Figure 2 draws a PRP network as two LANs in linear topology, which may also be a bus topology.

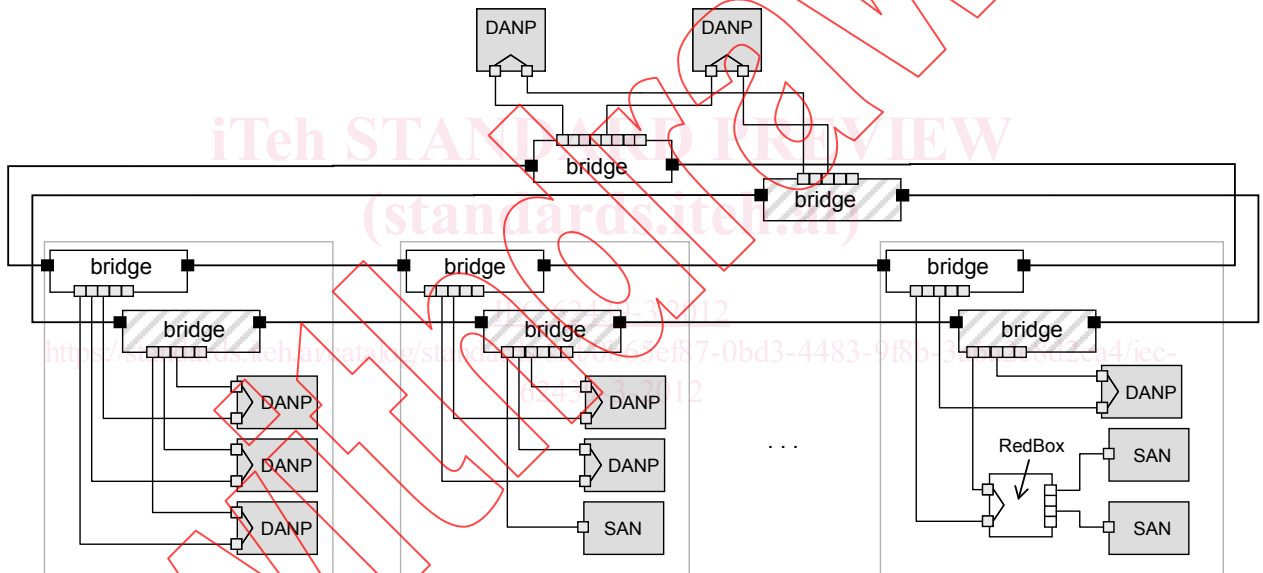


IEC 1129/12

Figure 2 – PRP example of redundant network as two LANs (bus topology)

4.1.3 PRP LANs with ring topology

The two LANs can have a ring topology, as Figure 3 shows.



IEC 1130/12

Figure 3 – PRP example of redundant ring with SANs and DANPs

NOTE In this case ring redundancy is provided by a different mechanism, for instance as defined in IEEE 802.1D or in other IEC 62439 protocols, i.e. MRP.

4.1.4 DANP node structure

Each node has two ports that operate in parallel and that are attached to the same upper layers of the communication stack through the Link Redundancy Entity (LRE), as Figure 4 shows.

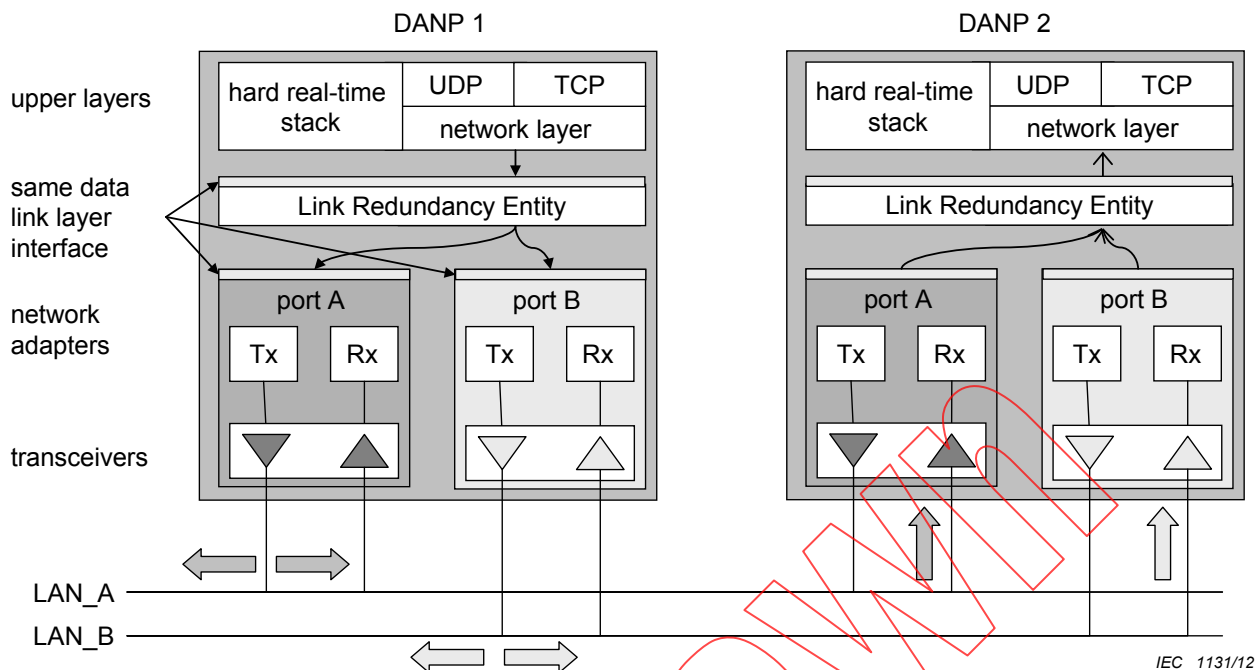


Figure 4 – PRP with two DANPs communicating

For the basic communication, the LRE presents toward its upper layers the same interface as a non-redundant network adapter, so the upper layers are unaware of redundancy.

The LRE has two tasks: handling of duplicates and management of redundancy.

When receiving a frame from the node's upper layers, the LRE appends to the frame a Redundancy Check Trailer (RCT) containing a sequence number and sends the frame through both its ports at nearly the same time. The two frames are nearly identical except for the LAN identifier (and the checksum).

The two frames transit through the two LANs with different delays, ideally they arrive at nearly the same time at the destination node.

When receiving frames from the network, the LRE forwards the first received frame of a pair to its node's upper layers and discards the duplicate frame (if it arrives). It removes the RCT if required.

For management of redundancy and checking of the presence of other DANPs, an LRE periodically sends PRP_Supervision frames and can evaluate the PRP_Supervision frames sent by other DANPs.

4.1.5 PRP attachment of singly attached nodes

Singly attached nodes (SANs) can be attached in two ways:

SANs can be attached directly to one LAN only. Such SANs can only communicate with other SANs on the same LAN. For instance, in Figure 1, SAN A1 can communicate with SAN A2, but not with SAN B1 or SAN B2. SANs can communicate (not redundantly) with all DANPs.

SANs can be attached over a RedBox (redundancy box) to both LANs, as Figure 1 shows for SAN R1 and SAN R2 (see also 4.1.9). Such SANs can communicate with all DANP and SANs, for instance SAN A1 and SAN R1 can communicate.

NOTE SANs are not aware of PRP; they can be off-the-shelf computers or printers.