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Ersatz für
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Industrial communication networks –
High availability automation networks –
Part 5: Beacon Redundancy Protocol (BRP)
(IEC 62439-5:2016);
English version EN IEC 62439-5:2018

Réseaux de communication industrielle –
Réseaux d'automatisme à haute disponibilité –
Partie 5: Protocole de redondance à balise (BRP)
(IEC 62439-5:2016);
Version anglaise EN IEC 62439-5:2018

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Anwendungsbeginn

Anwendungsbeginn für die von CENELEC am 2016-05-04 angenommene Europäische Norm als DIN-Norm ist 2018-08-01.

Für DIN EN 62439-5:2010-09 besteht eine Übergangsfrist bis 2021-02-02.

Nationales Vorwort

Vorausgegangener Norm-Entwurf: E DIN EN 62439-100:2015-03.

Für dieses Dokument ist das nationale Arbeitsgremium K 956 „Industrielle Kommunikation“ der DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE (www.dke.de) zuständig.

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Da sich die Benutzer der vorliegenden Norm der englischen Sprache als Fachsprache bedienen, wird die Englische Fassung der EN IEC 62439-5:2018 veröffentlicht. Zu deren Abschnitt 1, der den Anwendungsbereich festlegt, und Unterabschnitt 3.1, der die Begriffe festlegt, wurde eine Übersetzung angefertigt und als Nationaler Anhang NA der vorliegenden Norm hinzugefügt. Für einige der verwendeten Begriffe existieren keine gebräuchlichen deutschen Benennungen, da sich die deutschen Anwender in der Regel ebenfalls der englischen Benennungen bedienen. Diese Norm steht nicht in unmittelbarem Zusammenhang mit Rechtsvorschriften und ist nicht als Sicherheitsnorm anzusehen.

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Änderungen

Gegenüber DIN EN 62439-5:2010-09 wurden folgende Änderungen vorgenommen:

a) Das Protokoll ist nun unabhängig von der Applikation (das Path_Check_Request wird periodisch gesendet);

b) die Fehlererkennungsnachricht wurde entfernt;

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c) das Frame-Format wurde geändert;

d) neue MAC-Adresse wurde hinzugefügt.

Frühere Ausgaben

DIN EN 62439: 2009-01
DIN EN 62439-5: 2010-09

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Nationaler Anhang NA
(informativ)

Auszugsweise Übersetzung[N1)]

1 Anwendungsbereich

Die Normenreihe IEC 62439 gilt für hochverfügbare Automatisierungsnetzwerke auf der Basis der Ethernet-Technologie nach ISO/IEC 8802-3 (IEEE 802.3).

Dieser Teil der Normenreihe IEC 62439 beschreibt ein Redundanzprotokoll, welches auf der Verdopplung des Netzwerks basiert, wobei das Redundanzprotokoll innerhalb der Endknoten ausgeführt wird, im Gegensatz zu einem Redundanzprotokoll, welches in Switchen eingebaut ist. Schnelle Fehlererkennung wird von zwei Lichtsignalknoten bereitgestellt, die Entscheidung zur Umschaltung wird in jedem Knoten individuell getroffen. Die Kreuz-Netzwerkverbindungsfähigkeit, erlaubt es einzelnen beigefügten Endknoten mit beiden der zwei Netzwerke verbunden zu werden.

3 Begriffe, Abkürzungen, Akronyme und Konventionen

3.1 Begriffe

Für die Anwendung dieses Dokuments gelten die Begriffe nach IEC 60050-191 und nach IEC 62439-1.

N1) Nationale Fußnote: Die Nummerierung aus IEC 62439-5:2016-03 wurde beibehalten.

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN IEC 62439-5

Feburary 2018

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Industrial communication networks - High availability automation networks - Part 5: Beacon Redundancy Protocol (BRP) (IEC 62439-5:2016)

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(IEC 62439-5:2016)

Industrielle Kommunikationsnetze - Hochverfügbare Automatisierungsnetze - Teil 5: Funkbaken-Redundanz-Protokoll (BRP)
(IEC 62439-5:2016)

This European Standard was approved by CENELEC on 2016-05-04. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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European foreword

The text of document 65C/834/FDIS, future edition 2 of IEC 62439-5:2016, prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 62439-5:2017.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2018-08-02
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2021-02-02

This document supersedes EN 62439-5:2010.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 62439-5:2016 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61158 (all parts)	NOTE	Harmonized as EN 61158 (all parts).
IEC 62439-2	NOTE	Harmonized as EN 62439-4 (not modified).
IEC 62439-3	NOTE	Harmonized as EN 62439-6 (not modified).
IEC 62439-4	NOTE	Harmonized as EN 62439-4 (not modified).
IEC 62439-6	NOTE	Harmonized as EN 62439-4 (not modified).

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INTRODUCTION

The IEC 62439 series specifies relevant principles for high availability networks that meet the requirements for industrial automation networks.

In the fault-free state of the network, the protocols of the IEC 62439 series provide ISO/IEC/IEEE 8802-3 (IEEE 802.3) compatible, reliable data communication, and preserve determinism of real-time data communication. In cases of fault, removal, and insertion of a component, they provide deterministic recovery times.

These protocols retain fully the typical Ethernet communication capabilities as used in the office world, so that the software involved remains applicable.

The market is in need of several network solutions, each with different performance characteristics and functional capabilities, matching diverse application requirements. These solutions support different redundancy topologies and mechanisms which are introduced in IEC 62439-1 and specified in the other parts of the IEC 62439 series. IEC 62439-1 also distinguishes between the different solutions, giving guidance to the user.

The IEC 62439 series follows the general structure and terms of the IEC 61158 series.

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of patents concerning fault-tolerant Ethernet provided through the use of special interfaces providing duplicate ports that may be alternatively enabled with the same network address. Switching between the ports corrects single faults in a two-way redundant system. This is given in Clauses 5 and 6.

These patents are listed in the table below, where the [xx] notation indicates the holder of the patent rights:

US 7,817,538 B2	[RA]	Fault-tolerant Ethernet network
US 8,493,840	[RA]	Fault-tolerant Ethernet network

IEC takes no position concerning the evidence, validity and scope of these patent rights.

The holder of this patent right has assured the IEC that he/she is willing to negotiate licences either free of charge or 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:

[RA] Rockwell Automation Technologies, Inc.
1 Allen-Bradley Drive
Mayfield Heights
Ohio 44124, USA

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INDUSTRIAL COMMUNICATION NETWORKS – HIGH AVAILABILITY AUTOMATION NETWORKS –

Part 5: Beacon Redundancy Protocol (BRP)

1 Scope

The IEC 62439 series is applicable to high-availability automation networks based on the ISO/IEC/IEEE 8802-3 (IEEE 802.3) Ethernet technology.

This part of the IEC 62439 series specifies a redundancy protocol that is based on the duplication of the network, the redundancy protocol being executed within the end nodes, as opposed to a redundancy protocol built in the switches. Fast error detection is provided by two beacon nodes, the switchover decision is taken in every node individually. The cross-network connection capability enables singly attached end nodes to be connected on either of the two networks.

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

ISO/IEC TR 8802-1, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 1: Overview of Local Area Network Standards*

ISO/IEC/IEEE 8802-3:2014, *Standard for Ethernet*

ISO/IEC 10164-1, *Information technology – Open Systems Interconnection – Systems Management: Object Management Function*

IEEE 802.1D, *IEEE Standard for Local and metropolitan area networks: Media Access Control (MAC) Bridges*

IEEE 802.1Q, *IEEE Standard for Local and metropolitan area networks: Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks*

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, apply.

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3.2 Abbreviations and acronyms

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

BRP Beacon Redundancy Protocol

DANB doubly attached node implementing BRP

3.3 Conventions

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

4 BRP overview

This part of the IEC 62439 series specifies a protocol for an Ethernet network tolerant to all single point failures. This protocol is called Beacon Redundancy Protocol or BRP. A network based on the BRP is called a BRP network. The BRP network is based on switched ISO/IEC/IEEE 8802-3 (IEEE 802.3) (Ethernet) and ISO/IEC/TR 8802-1 (IEEE 802.1) technologies and redundant infrastructure. In this network, the decision to switch between infrastructures is made individually in each end node.

5 BRP principle of operation

5.1 General

Subclauses 5.2 to 5.4 are an explanation of overall actions performed by the BRP state machine. If a difference in the interpretation occurs between these subclauses and the state machines in Clause 7, then the state machines take precedence.

5.2 Network topology

The BRP network topology can be described as two interconnected top switches, each heading an underlying topology of star, line, or ring. Beacon end nodes shall be connected to the top switches. Examples of star, linear and ring BRP networks are shown in Figure 1, Figure 2 and Figure 3 respectively.

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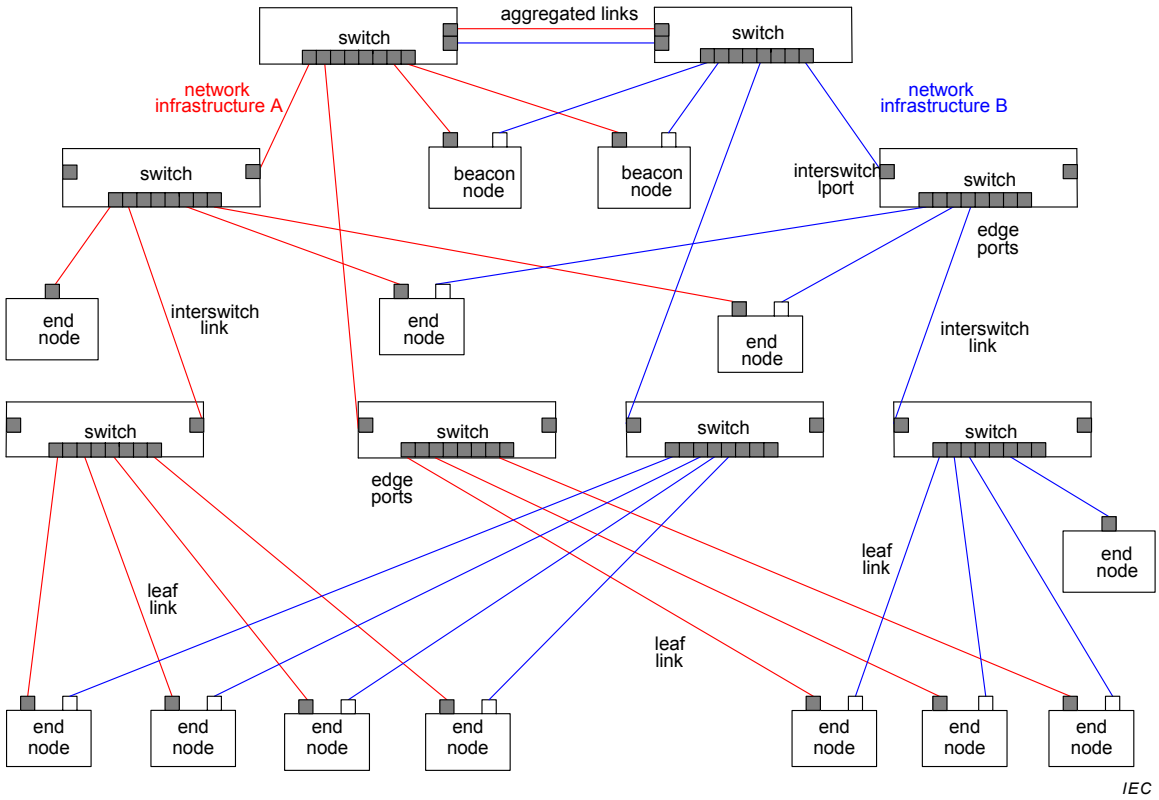

Figure 1 – BRP star network example

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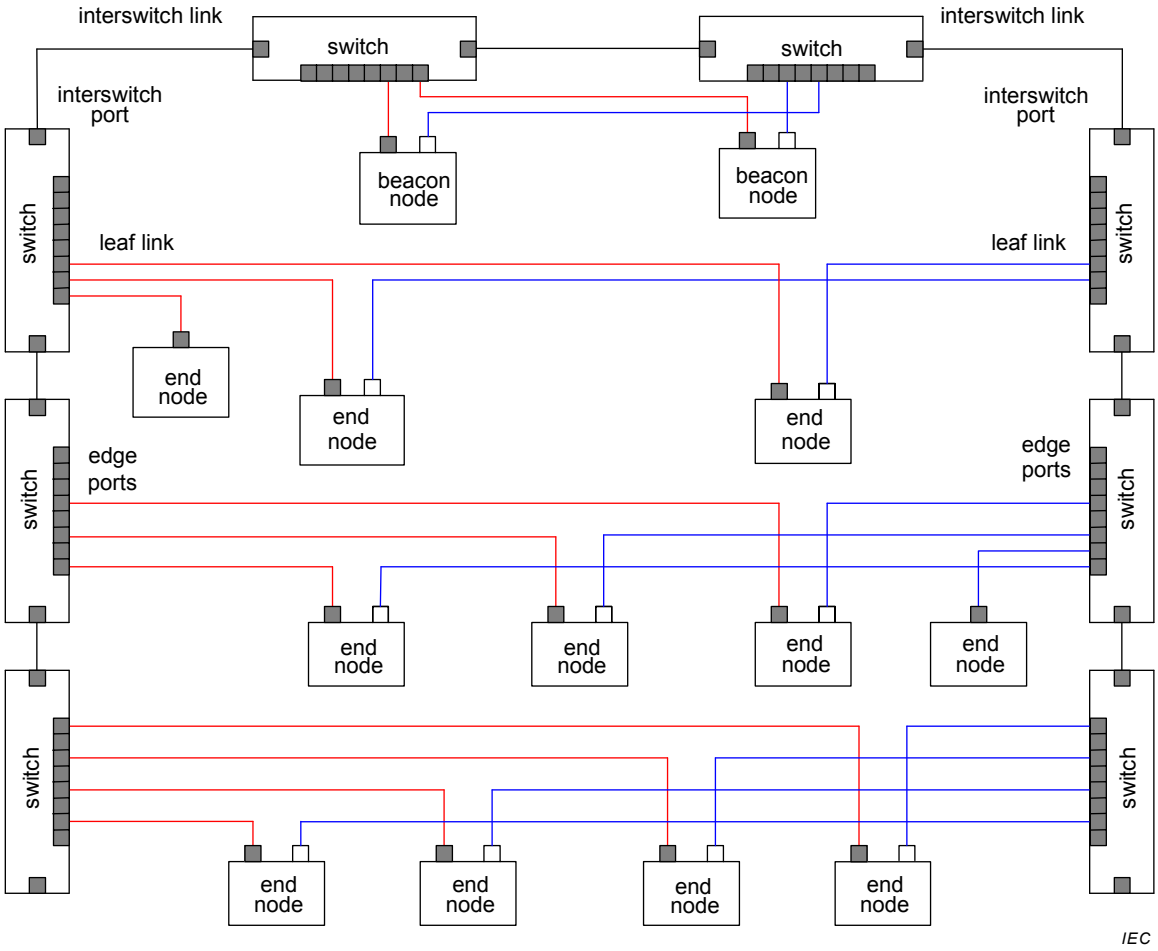

Figure 2 – BRP linear network example

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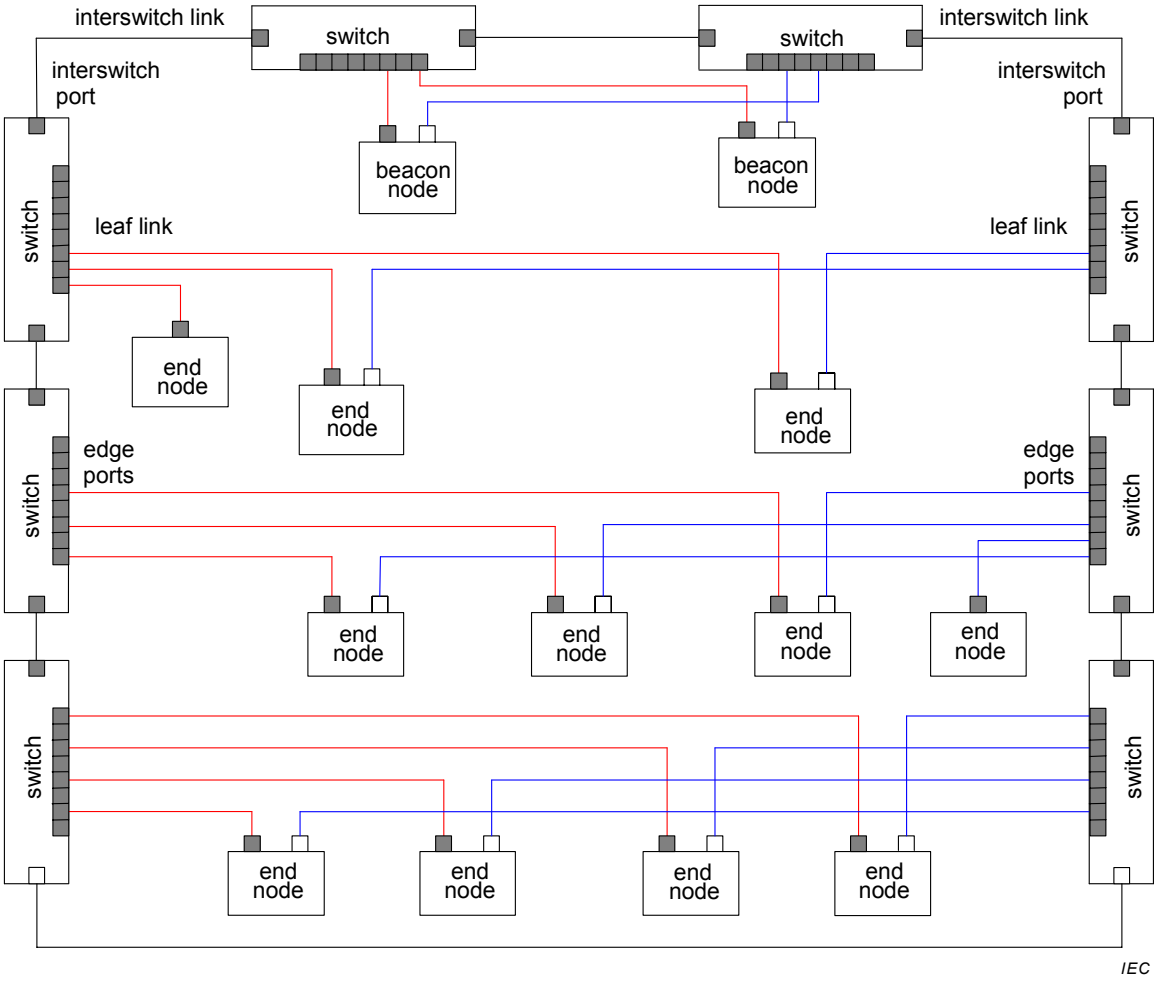

Figure 3 – BRP ring network example

5.3 Network components

The BRP network is built from layer 2 switches compliant with IEEE 802.1D and ISO/IEC/IEEE 8802-3 (IEEE 802.3). No support of the BRP protocol in switches is required.

Figure 1 shows an example of a BRP star network in the 2-way redundancy mode. It uses two sets of network infrastructure A and B (shown in two different colours). The number of levels of switches and number of switches on each level are dependent only on application requirements. Even with three levels of hierarchy it is possible to construct very large networks. For example, a BRP star network built from switches with eight regular ports and one uplink port can contain 500 nodes maximum. Two switches at the top level shall be connected to each other with one or more links providing sufficient bandwidth. With link aggregation capability, traffic is shared among bundle of links and failure of one link does not bring the network down. With such an arrangement infrastructures A and B form a single network.

Two types of end nodes can be connected to the BRP network: doubly attached and singly attached. A doubly attached end node can function as a BRP end node or a BRP beacon end node. A BRP beacon end node is a special case of a doubly attached end node that is connected directly to the top switches. Though doubly attached BRP end nodes have two network ports they use only one MAC address.

As shown in Figure 1, Figure 2 and Figure 3, two beacon end nodes shall be connected to top level switches. Beacon end nodes multi/broadcast a short beacon message on the network periodically.

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Similarly to BRP end nodes, a beacon end node at any given point in time actively communicates through only one of its ports, while blocking all traffic on its other port. Fault tolerance is achieved by beacon end nodes switching between their ports from inactive to active mode and vice versa.

Singly attached end nodes may also be connected to BRP network but they do not support the BRP protocol. A singly attached node can communicate with doubly attached nodes as well as other singly attached nodes on the network.

Since switches are IEEE 802.1D compliant, they support the RSTP protocol. This eliminates loop formation in BRP ring networks like in the one shown in Figure 3.

5.4 Rapid reconfiguration of network traffic

For fast reconfiguration, multicast control features in the switches shall be disabled. The multicast traffic is therefore treated as the broadcast traffic.

Unicast packets are affected by switches learning and filtering features. After end node port reconfiguration, switches have invalid knowledge. A switch implementing learning shall update its database when a packet with a learned MAC address in the source field is received on a different port from the learned port stored in the database.

When a BRP end node switches to the inactive port, its first action is to send a short multicast message, called Learning_Update message, through its newly enabled port. As this message propagates through the network, switches update their MAC address database resulting in rapid reconfiguration of the unicast traffic. This message is of no interest to other end nodes in the network and is dropped by them.

6 BRP stack and fault detection features

Figure 4 shows the BRP stack architecture. It is applicable to both BRP and beacon end nodes.

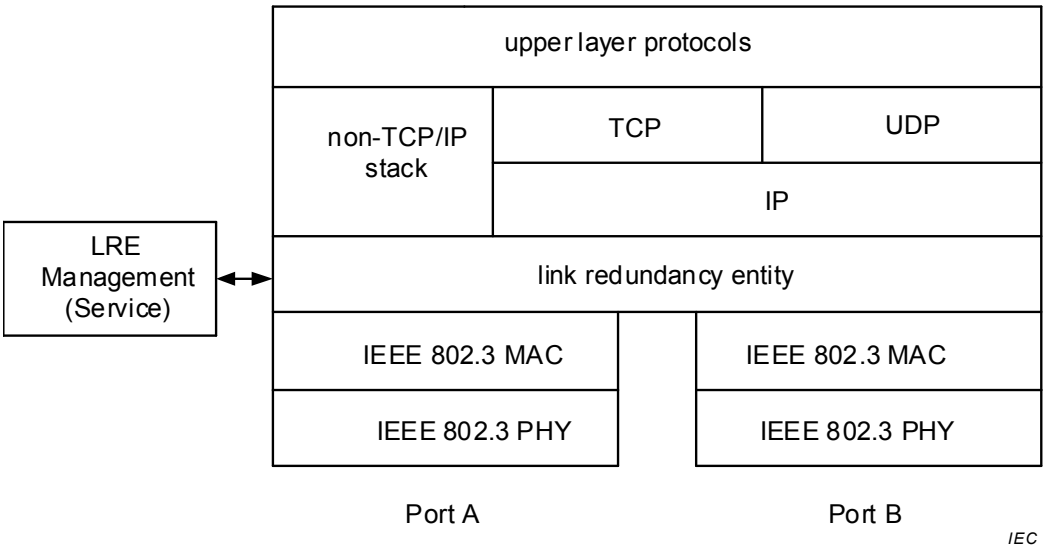

Figure 4 – BRP stack architecture

The BRP stack contains two identical ISO/IEC/IEEE 8802-3 (IEEE 802.3) ports, identified here as ports A and B, connected to the network. These ports interface with the MAC sub-layer compliant with ISO/IEC/IEEE 8802-3 (IEEE 802.3). Though there are two physical ports, a BRP end node uses only a single MAC address.

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The link redundancy entity continuously monitors the status of leaf links between both ports and corresponding ports on the switches. When a failure of the leaf link between the end node active port and the corresponding port on the switch is detected, the link redundancy entity shall reconfigure end node ports, provided the inactive port was not in the fault mode as well. After reconfiguration, all traffic flows through the newly activated port. Some messages may be lost during the failure detection and reconfiguration process, and their recovery is supported by upper layer protocols which also deal with messages lost due to other network errors.

The link redundancy entity also monitors arrival of beacon messages on both ports. When a beacon message fails to arrive at the active port for a configured timeout period, the port is declared to be in the fault mode, and the link redundancy entity shall reconfigure end node ports, provided the other port was not in the fault mode as well. After reconfiguration all traffic starts flowing through the newly activated port. Failure of beacon messages to arrive at inactive ports shall also be detected.

If one of the top switches fails, then all BRP nodes connected directly to it, or to network infrastructure below it, switch to the other network infrastructure. If, for example, the top switch of the LAN A fails, then all BRP nodes connected to LAN A switch over to LAN B.

If the fault occurred on a beacon end node, the network continues to operate without any problems, since the other beacon end node is active. The rate of beacon message arrival decreases from approximately two messages per beacon timer interval to one.

It is possible for transmit path failures to occur in the opposite direction to the flow of beacon messages. If such a fault manifests itself in the physical layer, it is detected by end nodes or switches adjacent to the faulty link. This results in a BRP end node reconfiguring its ports immediately or results in traffic being blocked on the affected link. The latter event leads to loss of beacon messages at the downstream end nodes, so that they reconfigure themselves at expiry of the beacon timeout.

When the faulted port is restored, it shall stay idle until a switchover is initiated or the currently active port fails. When both ports are operational, the BRP end node shall periodically switch its message activity from one port to the other. This switchover is controlled by the Active_Port_Swap timer.

The LRE management entity is used to select an end node type (normal or beacon), configure protocol parameters (for example, beacon timer) and obtain the end node port status (active, failed, idle).

All detected failures shall be reported to the LRE management entity to trigger further diagnosis and repair. Fault diagnostics services shall be provided by LRE management entity or other accessible entities in the network.

In a case when transmit path faults are not detectable in the physical layer, the following mechanism is employed by the BRP link redundancy entity to detect them. The BRP end devices shall send a Path_Check_Request message once every Path Check Request Interval to one of the currently active beacon devices on their active port in a round robin manner. For example, if three beacon devices are currently active, a BRP end device shall send a Path_Check_Request message to beacon device 1 in the first interval, to beacon device 2 in the second interval and so on. Upon receiving a Path_Check_Request message on its active port, a beacon device shall respond with a Path_Check_Response message to the requesting device on its active port.

A BRP end device shall detect transmit path faults in direction opposite to beacon flow through a timeout on non-reception of Path_Check_Response messages from BRP beacon devices for repeated Path_Check_Request messages. When a BRP end device detects such a loss on its active port, it shall immediately switch its active port.

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