IEC 62439-5

Edition 1.0 2010-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Industrial communication networks – High availability automation networks – Part 5: Beacon Redundancy Protocol (BRP)

Réseaux industriels de communication – Réseaux d'automatisme à haute disponibilité – Partie 5: Protocole de redondance à balise (BRP)

IEC 62439-5:2010

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

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International Standard IEC 62439-5 has been prepared by subcommittee 65C: Industrial Networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This standard cancels and replaces IEC 62439 published in 2008. This first edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC 62439 (2008):

– adding a calculation method for RSTP (rapid spanning tree protocol, IEEE 802.1Q),

– adding two new redundancy protocols: HSR (High-availability Seamless Redundancy) and DRP (Distributed Redundancy Protocol),

– moving former Clauses 1 to 4 (introduction, definitions, general aspects) and the Annexes (taxonomy, availability calculation) to IEC 62439-1, which serves now as a base for the other documents,

– moving Clause 5 (MRP) to IEC 62439-2 with minor editorial changes,

– moving Clause 6 (PRP) was to IEC 62439-3 with minor editorial changes,
– moving Clause 7 (CRP) was to IEC 62439-4 with minor editorial changes, and
– moving Clause 8 (BRP) was to IEC 62439-5 with minor editorial changes,
– adding a method to calculate the maximum recovery time of RSTP in a restricted configuration (ring) to IEC 62439-1 as Clause 8,
– adding specifications of the HSR (High-availability Seamless Redundancy) protocol, which shares the principles of PRP to IEC 62439-3 as Clause 5, and
– introducing the DRP protocol as IEC 62439-6.

This bilingual version (2012-04) corresponds to the English version, published in 2010-02.

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

FDIS	Report on voting
65C/583/FDIS	65C/589/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.

The French version of this standard has not been voted upon.

This International Standard is to be read in conjunction with IEC 62439-1:2010, *Industrial communication networks – High availability automation networks – Part 1: General concepts and calculation methods.*

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 amendment and the base 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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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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 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 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 a patent 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 for single faults in a two-way redundant system. This is given in Clauses 5 and 6.

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

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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 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 single attached end nodes to be connected on either of the two networks.

2 Normative references

The following referenced documents are indispensable for the application of this document. 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 62439-1:2010, *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* (IEEE 802.1)

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, *IEEE standards for local and metropolitan area networks: Media Access Control (MAC) Bridges*

IEEE 802.1Q, *IEEE standards for local and metropolitan area networks: 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.

3.2 Abbreviations and acronyms

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

BRP Beacon Redundancy Protocol

DANB double 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 clause 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 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.

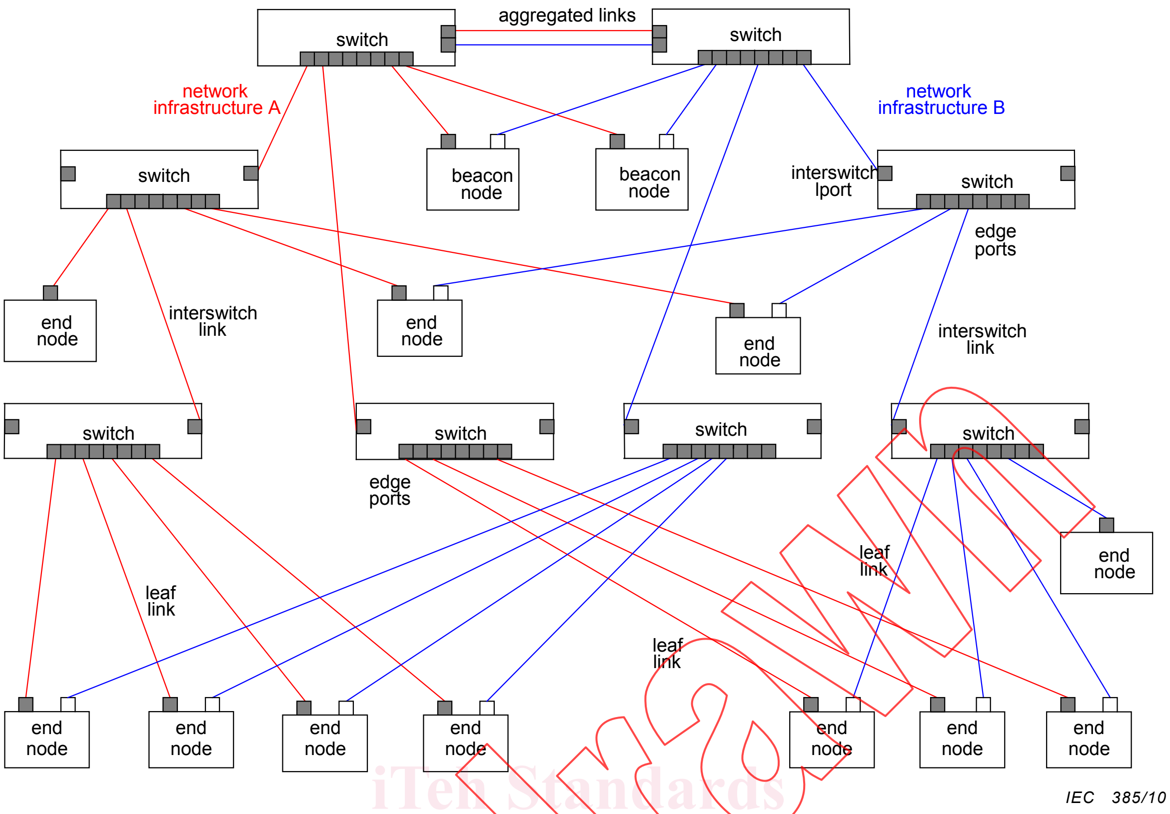

Figure 1 – BRP star network example

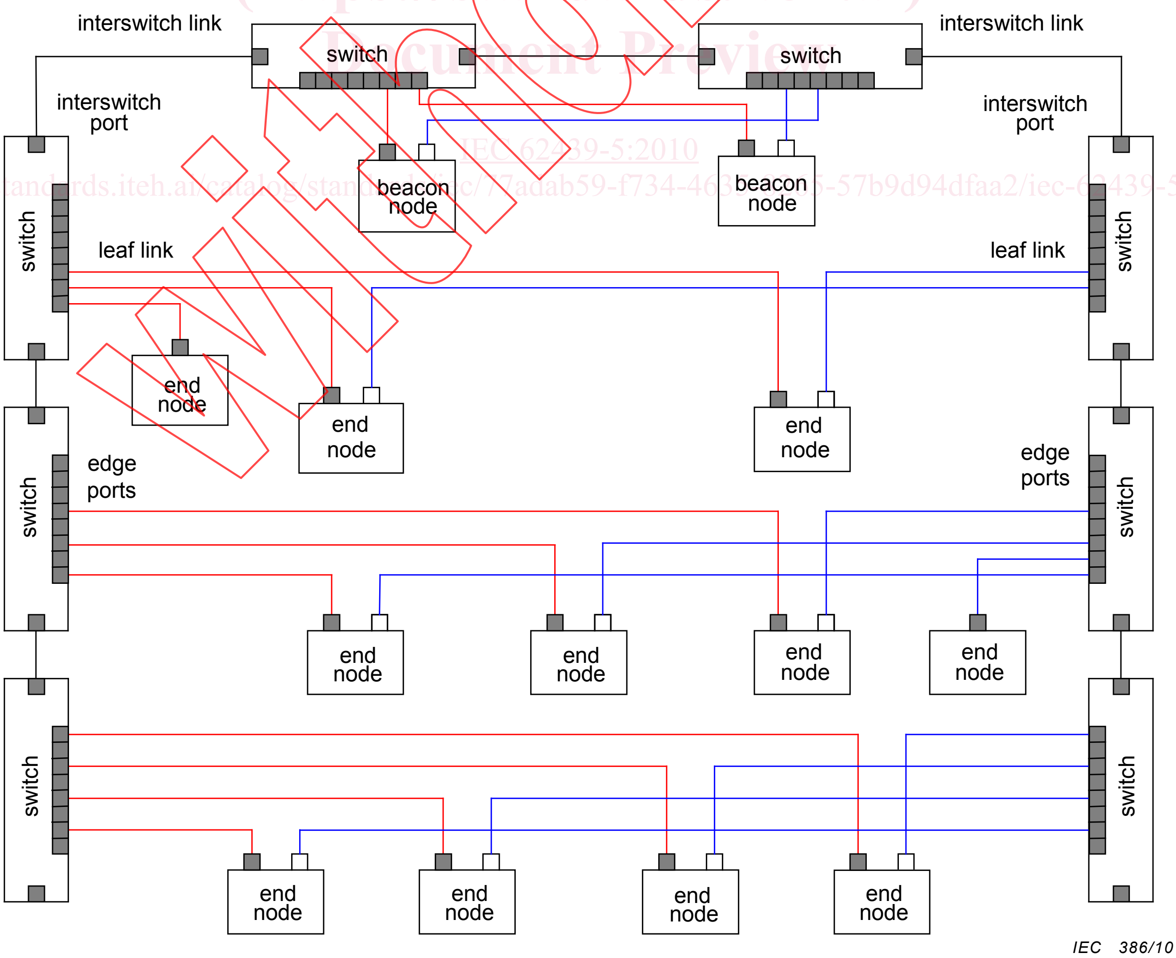

Figure 2 – BRP linear network example

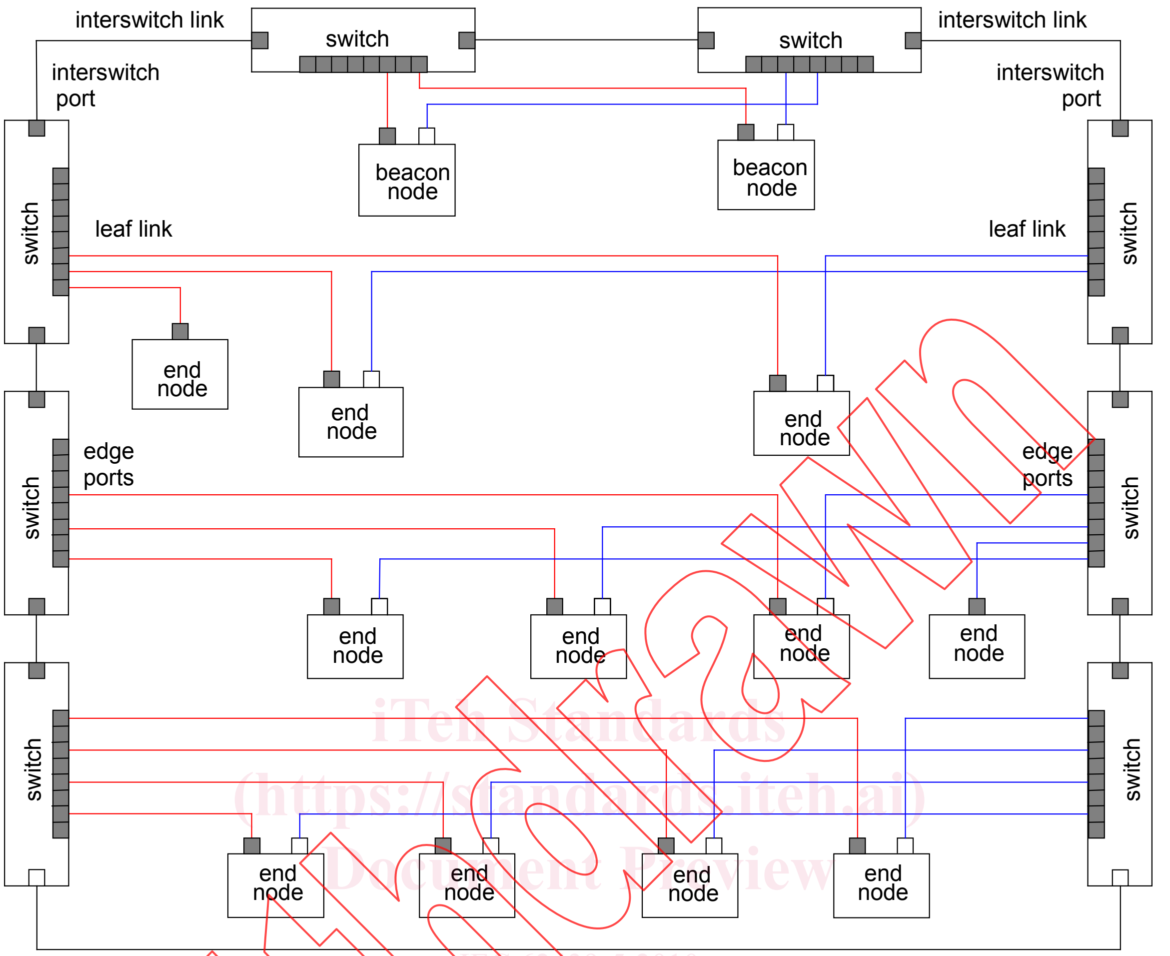

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Figure 3 – BRP ring network example

5.3 Network components

The BRP network is built from layer 2 switches compliant with IEEE 802.1D and ISO/IEC 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.

At any given point in time a BRP end node actively communicates through only one of its ports, while blocking all transmit and receive traffic on its other port, with the exception of received beacon messages and Failure_Notify messages. Fault tolerance is achieved in a distributed fashion by BRP end nodes switching between their ports from inactive to active mode and vice versa.

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. Similarly to BRP end nodes, 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, with the exception of received Failure_Notify messages. 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.

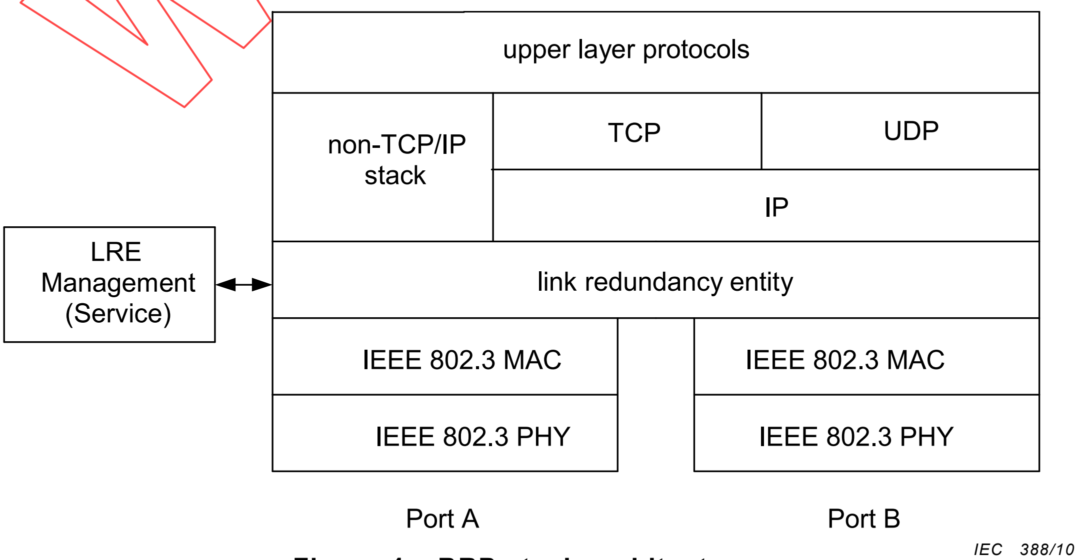

Figure 4 – BRP stack architecture

The BRP stack contains two identical ISO/IEC 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 8802-3 (IEEE 802.3). Though there are two physical ports, a BRP end node uses only a single MAC address.

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 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 they reconfigure themselves at expiry of the beacon timeout.

In a case when such failures are not detectable in the physical layer, the following mechanism is employed by the BRP link redundancy entity to detect them. The fault detection method for identifying all transmission failures shall be implemented using lists of communication nodes including a receive timeout value for each transmitting end node of interest to the node. This list may be communicated to the link redundancy entity manually or dynamically configured utilizing LRE management entity.

When a frame from a transmitting end node of interest fails to arrive before expiry of the associated Node_Receive timer, the receiving end node shall send a Failure_Notify message to the transmitting end node and send a Path_Check_Request message to beacon end nodes. Upon reception of a Failure_Notify message, the transmitting end node shall attempt to verify the transmit path by sending the Path_Check_Request message to beacon end nodes. When beacon end nodes receive these messages, they shall respond with Path_Check_Response messages. When Path_Check_Request fails to elicit response, an end node shall place its active port in faulted state and activate its inactive port, provided it is not in fault mode as well.

BRP beacon end nodes also behave in a similar way. When a frame from a transmitting end node of interest fails to arrive before expiry of the associated Node_Receive timer, the receiving beacon end node shall send a Failure_Notify message to the transmitting end node and send a Path_Check_Request message to a designated set of end nodes. When beacon end nodes receive Failure_Notify messages themselves, they shall verify their transmit path by sending a Path_Check_Request message to a designated set of end nodes. Upon receiving Path_Check_Request message, the designated end nodes shall respond with