



BSI Standards Publication

Industrial communication networks — High availability automation networks

Part 2: Media Redundancy Protocol (MRP)

National foreword

This British Standard is the UK implementation of EN IEC 62439-2:2022. It is identical to IEC 62439-2:2021, incorporating corrigendum May 2023. It supersedes BS EN 62439-2:2017, which will be withdrawn on 19 January 2025.

The start and finish of text introduced or altered by corrigendum is indicated in the text by tags. Text altered by IEC corrigendum May 2023 is indicated in the text by AC1 AC1.

The UK participation in its preparation was entrusted to Technical Committee GEL/65, Measurement and control.

A list of organizations represented on this committee can be obtained on request to its committee manager.

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

© The British Standards Institution 2024
Published by BSI Standards Limited 2024

ISBN 978 0 539 29846 8

ICS 25.040.40; 25.040.40; 35.100.05; 35.100.05

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2022.

Amendments/corrigenda issued since publication

Date	Text affected
30 September 2024	Implementation of IEC corrigendum May 2023

English Version

Industrial communication networks - High availability automation
networks - Part 2: Media Redundancy Protocol (MRP)
(IEC 62439-2:2021)

Réseaux de communication industriels - Réseaux de haute
disponibilité pour l'automatisation - Partie 2: Protocole de
redondance du support (MRP)
(IEC 62439-2:2021)

Industrielle Kommunikationsnetze: Hochverfügbare
Automatisierungsnetze - Teil 2: Medienredundanz-Protokoll
(MRP)
(IEC 62439-2:2021)

This European Standard was approved by CENELEC on 2022-01-19. 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.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document 65C/1118/FDIS, future edition 3 of IEC 62439-2, prepared by SC 65C "Industrial networks" of IEC/TC 65 "Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 62439-2:2022.

The following dates are fixed:

- latest date by which the document has to be implemented at national (dop) 2022-10-19 level by publication of an identical national standard or by endorsement
- latest date by which the national standards conflicting with the (dow) 2025-01-19 document have to be withdrawn

This document supersedes EN 62439-2:2017 and all of its amendments and corrigenda (if any).

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.

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

Endorsement notice

The text of the International Standard IEC 62439-2:2021 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 61158-1 NOTE Harmonized as EN IEC 61158-1

IEC 61784-1 NOTE Harmonized as EN IEC 61784-1

IEC 61784-2 NOTE Harmonized as EN IEC 61784-2

Endorsement notice to Corrigendum May 2023

The text of the corrigendum IEC 62439-2:2021/COR1:2023 was approved by CENELEC as EN IEC 62439-2:2022/AC:2023-05 without any modification.

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60050-192	-	International Electrotechnical Vocabulary (IEV) - Part 192: Dependability	-	-
IEC 61158-6-10	2019	Industrial communication networks - Fieldbus specifications - Part 6-10: Application layer protocol specification - Type 10 elements	EN IEC 61158-6-10	2019
IEC 62439-1	2010	Industrial communication networks - High availability automation networks - Part 1: General concepts and calculation methods	EN 62439-1	2010
AMD1	2012		A1	2012
AMD2	2016		A2	2017
ISO/IEC 10164-1		Information technology - Open Systems Interconnection - Systems Management: Object Management Function	-	-
ISO/IEC/IEEE 8802-3		Telecommunications and exchange between information technology systems - Requirements for local and metropolitan area networks - Part 3: Standard for Ethernet	-	-
IEEE Std 802.1Q	2018	IEEE Standard for Local and Metropolitan Area Network - Bridges and Bridged Networks	-	-
IEEE Std 802.3	2018	IEEE Standard for Ethernet	-	-

CONTENTS

FOREWORD.....	7
INTRODUCTION.....	9
1 Scope.....	10
1.1 General.....	10
1.2 Code component distribution.....	10
2 Normative references	11
3 Terms, definitions, abbreviated terms and conventions	11
3.1 Terms and definitions.....	11
3.2 Abbreviated terms.....	12
3.3 Conventions.....	12
4 MRP Overview.....	12
5 MRP Media redundancy behavior	16
5.1 General.....	16
5.2 Ring ports	16
5.3 Media Redundancy Manager (MRM)	17
5.4 Media Redundancy Client (MRC)	19
5.5 Redundancy domain	19
5.6 Media Link Check	19
5.7 Application of the Continuity Check protocol	20
5.7.1 General	20
5.7.2 Continuity Check Message Interval.....	20
5.7.3 Maintenance Domain Level.....	20
5.7.4 Maintenance Association ID (MAID).....	20
5.7.5 Maintenance Association End Point ID (MEPID)	21
5.7.6 Sender ID TLV.....	21
5.7.7 Port Status TLV	21
5.7.8 Interface Status TLV.....	21
5.8 Usage with diagnosis and alarms	21
5.9 Ring diagnosis	22
5.10 Multiple MRM in a single ring: Manager voting option.....	22
5.10.1 General	22
5.10.2 Basic principle of the manager voting process	23
5.10.3 The manager voting process.....	24
5.11 BLOCKED not supported (Option).....	26
5.12 Interconnection port.....	26
5.13 Media redundancy Interconnection Manager (MIM)	28
5.14 Media redundancy Interconnection Client (MIC).....	30
5.15 Interconnection domain.....	31
5.16 Interconnection diagnosis	31
6 MRP Class specification	31
6.1 General.....	31
6.2 Template.....	32
6.2.1 Media redundancy template.....	32
6.2.2 Media redundancy Interconnection template	33
6.3 Attributes	34
7 MRP Service specification	38

7.1	Start MRM	38
7.2	Stop MRM.....	39
7.3	State Change.....	40
7.4	Start MRC.....	41
7.5	Stop MRC	42
7.6	Read MRM.....	43
7.7	Read MRC	45
7.8	Start MIM	46
7.9	Stop MIM	48
7.10	Interconnection State Change	49
7.11	Start MIC	49
7.12	Stop MIC.....	51
7.13	Read MIM	52
7.14	Read MIC	53
8	MRP protocol specification	55
8.1	PDU description.....	55
8.1.1	Basic data types	55
8.1.2	DLPDU abstract syntax reference	55
8.1.3	Coding of the DLPDU field SourceAddress	56
8.1.4	Coding of the DLPDU field DestinationAddress.....	56
8.1.5	Coding of the field TagControlInformation.....	56
8.1.6	Coding of the field LT	57
8.1.7	MRP APDU abstract syntax	57
8.1.8	Coding of the field MRP_TLVHeader	59
8.1.9	Coding of the field MRP_SubTLVHeader	59
8.1.10	Coding of the field MRP_Ed1Type and MRP_Ed1ManufacturerData	60
8.1.11	Coding of the field MRP_Version	60
8.1.12	Coding of the field MRP_SequenceID	60
8.1.13	Coding of the field MRP_SA	60
8.1.14	Coding of the field MRP_OtherMRMSA.....	61
8.1.15	Coding of the field MRP_Prio.....	61
8.1.16	Coding of the field MRP_OtherMRMPrio	61
8.1.17	Coding of the field MRP_PortRole	61
8.1.18	Coding of the field MRP_RingState.....	62
8.1.19	Coding of the field MRP_Interval	62
8.1.20	Coding of the field MRP_Transition.....	62
8.1.21	Coding of the field MRP_TimeStamp	62
8.1.22	Coding of the field MRP_Blocked.....	63
8.1.23	Coding of the field MRP_ManufacturerOUI	63
8.1.24	Coding of the field MRP_IECOUI	63
8.1.25	Coding of the field MRP_ManufacturerData	63
8.1.26	Coding of the field MRP_DomainUUID	63
8.1.27	Coding of the field MRP_InState	64
8.1.28	Coding of the field MRP_InID.....	64
8.1.29	Coding of the field MRP_LinkInfo.....	64
8.2	Protocol machines	64
8.2.1	MRM protocol machine	64
8.2.2	MRC protocol machine	75
8.2.3	MRA protocol machine.....	

8.2.4	MRA, MRM and MRC functions.....	102
8.2.5	FDB clear timer	106
8.2.6	Topology change timer	106
8.2.7	MIM protocol machine.....	107
8.2.8	MIC protocol machine	115
8.2.9	MIM and MIC functions	122
8.2.10	Interconnection Topology Change timer	127
8.2.11	Interconnection Link Status Poll timer	127
9	MRP installation, configuration and repair.....	128
9.1	Ring port and Interconnection port parameters.....	128
9.2	Ring topology parameters	128
9.3	MRM parameters	129
9.4	MRC parameters and constraints	129
9.5	MRA compatibility to earlier Automanager protocol version	130
9.6	Interconnection topology parameters	130
9.7	MIM parameters	130
9.8	MIC parameters and constraints	131
9.9	Calculation of MRP ring recovery time	132
9.9.1	Overview	132
9.9.2	Deduction of formula	132
9.9.3	Worst-case calculation for recovery time of 10 ms	134
9.9.4	Worst-case calculation for 50 devices	135
9.10	Calculation of MRP Automanager voting time.....	135
9.11	Calculation of MRP Interconnection recovery time	135
10	MRP Management Information Base (MIB)	137
10.1	General.....	137
10.2	MRP MIB with a monitoring view	137
10.3	MRP MIB with a management and monitoring view	151
Annex A (normative)	Optional earlier version of the Automanager protocol	166
Annex B (informative)	Timing considerations for 10 Mbit/s link speed	167
Annex C (informative)	Using MRP together with scheduling and shaping mechanisms as defined in IEEE Std 802.1Q and interspersing express traffic as defined in IEEE Std 802.3	169
C.1	General.....	169
C.2	Avoiding negative impact on the recovery time of an MRP ring	169
C.2.1	General	169
C.2.2	Interspersing express traffic.....	169
C.2.3	Enhancements for scheduled traffic	170
C.3	Configuration guidelines for increased performance of MRP	170
C.3.1	General	170
C.3.2	Interspersing express traffic.....	170
C.3.3	Enhancements for scheduled traffic	171
C.4	Calculation of MRP ring recovery time	171
C.4.1	Worst-case calculation for recovery time of 10 ms, using frame preemption	171
C.4.2	Worst-case calculation for 50 devices, using frame preemption	172
Annex D (informative)	Advanced MRP and MRP Interconnection topologies	173
D.1	General.....	173
D.2	MRP Single Switch Multiple Rings (MRP-SSMR).....	173

D.3 Multiple MRP Interconnection	173
D.4 MRP Interconnection Dual Switch Multiple Couplings (MRP-I DSMC).....	174
Bibliography.....	175
Figure 1 – Two MRP rings redundantly connected via MRP Interconnection	14
Figure 2 – MRP stack	16
Figure 3 – MRP ring topology with one manager and clients	17
Figure 4 – MRP open ring with MRM.....	18
Figure 5 – MRP ring with MRA at network startup	23
Figure 6 – MRP ring after the manager voting process.....	23
Figure 7 – Manager voting process	25
Figure 8 – MRA located outside the MRP ring.....	26
Figure 9 – MRP Interconnection topology.....	28
Figure 10 – MRP ring interconnection open	29
Figure 11 – MRP protocol machine for MRM.....	65
Figure 12 – MRP protocol machine for MRC	76
Figure 13 – MRP protocol machine for MRA.....	82
Figure 14 – MRP protocol machine for MIM in RC-mode and LC-mode	107
Figure 15 – MRP protocol machine for MIC in RC-mode and LC-mode.....	115
Figure D.1 – MRP Topologies	173
Figure D.2 – MRP Interconnection Topologies	174
Figure D.3 – MRP Interconnection Dual Switch Multiple Couplings Topology	174
Table 1 – Coding of the Maintenance Association ID (MAID).....	21
Table 2 – MRP Start MRM	38
Table 3 – MRP Stop MRM.....	40
Table 4 – MRP Change State.....	40
Table 5 – MRP Start MRC.....	41
Table 6 – MRP Stop MRC	42
Table 7 – MRP Read MRM.....	43
Table 8 – MRP Read MRC	45
Table 9 – MRP Start MIM.....	47
Table 10 – MRP Stop MIM	48
Table 11 – MRP Interconnection Change State	49
Table 12 – MRP Start MIC	50
Table 13 – MRP Stop MIC	51
Table 14 – MRP Read MIM	52
Table 15 – MRP Read MIC	54
Table 16 – MRP DLPDU syntax for ISO/IEC/IEEE 8802-3 (IEEE Std 802.3).....	55
Table 17 – MRP OUI.....	56
Table 18 – MRP MulticastMACAddress	56
Table 19 – MRP TagControlInformation.Priority field.....	57
Table 20 – MRP LT field	57
Table 21 – MRP APDU syntax	

Table 22 – MRP Substitutions	58
Table 23 – MRP_TLVHeader.Type	59
Table 24 – MRP_SubTLVHeader.Type	59
Table 25 – MRP_Ed1Type and MRP_Ed1ManufacturerData	60
Table 26 – MRP_Ed1Type and MRP_Ed1ManufacturerData	60
Table 27 – MRP_Version	60
Table 28 – Coding of the field MRP_OtherMRMSA	61
Table 29 – MRP_Prio	61
Table 30 – Coding of the field MRP_OtherMRMPrio	61
Table 31 – MRP_PortRole	62
Table 32 – MRP_RingState	62
Table 33 – MRP_Interval	62
Table 34 – MRP_Transition	62
Table 35 – MRP_TimeStamp	63
Table 36 – MRP_Blocked	63
Table 37 – MRP_DomainUUID	63
Table 38 – MRP_InState	64
Table 39 – MRP_LinkInfo	64
Table 40 – MRP Local variables of MRM protocol machine	66
Table 41 – MRM State machine	67
Table 42 – MRP Local variables of MRC protocol machine	77
Table 43 – MRC state machine	77
Table 44 – MRP local variables of MRA protocol machine	83
Table 45 – MRA state machine	84
Table 46 – MRP functions and macros	102
Table 47 – MRP FDB clear timer	106
Table 48 – MRP topology change timer	107
Table 49 – MRP Local variables of MIM protocol machine	108
Table 50 – MIM State machine for LC-mode	109
Table 51 – MIM State machine for RC-mode	111
Table 52 – MRP Local variables of MIC protocol machine	116
Table 53 – MIC State machine for LC-mode	116
Table 54 – MIC State machine for RC-mode	120
Table 55 – MRP Interconnection functions	123
Table 56 – MRP Interconnection topology change timer	127
Table 57 – MRP Interconnection link status poll timer	128
Table 58 – MRP Network/Connection parameters	128
Table 59 – MRP MRM parameters	129
Table 60 – MRP MRC parameters	130
Table 61 – MRP MIM parameters	131
Table 62 – MRP MIC parameters	131
Table A.1 – Compatible mode MRP_Option for MRP_Test Substitutions	166
Table A.2 – Compatible mode MRP_Option frames MRP_TestMgrNAck and MRP_TestPropagate Substitutions	166

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INDUSTRIAL COMMUNICATION NETWORKS –
HIGH AVAILABILITY AUTOMATION NETWORKS –****Part 2: Media Redundancy Protocol (MRP)****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.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62439-2 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation. It is an International Standard.

This third edition cancels and replaces the second edition published in 2016. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) improvements for the Continuity Check Protocol,
- b) introduction of further specifiers for the rings, the interconnection links, and the device roles,
- c) extensions and information on the use of baudrates smaller than 100 Mbit/s,
- d) information on using MRP together with scheduling and shaping mechanisms,
- e) introduction of an MRP Interconnection profile for a 30 ms reconfiguration time.

The text of this International Standard is based on the following documents:

Draft	Report on voting
65C/1118/FDIS	65C/1137/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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

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

This IEC standard includes Code Components i.e. components that are intended to be directly processed by a computer. Such content is any text found between the markers <CODE BEGINS> and <CODE ENDS>, or otherwise is clearly labeled in this standard as a Code Component.

The purchase of this IEC standard carries a copyright license for the purchaser to sell software containing Code Components from this standard directly to end users and to end users via distributors, subject to IEC software licensing conditions, which can be found at: <http://www.iec.ch/CCv1>.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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

The holder of this patent right has assured IEC that s/he 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 the patent database available at <http://patents.iec.ch>.

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

AC1 This Corrigendum 1 corrects an oversight during the final editing process of IEC 62439-2:2021. The MIB specifications included in Subclauses 10.2 and 10.3 refer to the FDIS documents and need to be updated with references to the final publications (both standard and associated MIB file).

NOTE This Corrigendum 1 includes corrections for the MIBs in Subclauses 10.2 and 10.3. The MIB in 10.3 is provided as a code component in a companion document, see <https://www.iec.ch/sc65c/supportingdocuments>. The (minor) correction for Subclause 10.3 is provided for convenience, while the version in the companion document IEC_62439-2_2021A2.mib contains the corrected code and prevails in case of discrepancies. **AC1**

INDUSTRIAL COMMUNICATION NETWORKS – HIGH AVAILABILITY AUTOMATION NETWORKS –

Part 2: Media Redundancy Protocol (MRP)

1 Scope

1.1 General

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

This part of the IEC 62439 series specifies a recovery protocol based on a ring topology, designed to react deterministically on a single failure of an inter-switch link or switch in the network, under the control of a dedicated media redundancy manager node.

1.2 Code component distribution

Each Code Component is a ZIP package containing at least the electronic representation of the Code Component itself and a file describing the content of the package (IECManifest.xml).

The IECManifest contains different sections giving information on:

- the copyright notice;
- the identification of the code component;
- the publication related to the code component;
- the list of the electronic files which compose the code component;
- an optional list of history files to track changes during the evolution process of the code component.

The Code Components included in this IEC standard are a set of SNMP MIBs. The Code Component IEC-62439-2-MIB.mib is a file containing the MIB with the management and monitoring view. It will be available in a full version, which contains the MIB defined in this document with the documentation associated and access is restricted to purchaser of this document.

The Code Component (full version) is freely accessible on the IEC website for download at: https://www.iec.ch/sc65c/supportingdocuments/IEC_62439-2.MIB.{VersionStateInfo}.full.zip but the usage remains under the licensing conditions.

The life cycle of a code component is not restricted to the life cycle of the related publication. The publication life cycle goes through two stages, Version (corresponding to an edition) and Revision (corresponding to an amendment). Consequently, new release(s) of the Code Component(s) may be released, which supersede(s) the previous release, and will be distributed through the IEC website at: <https://www.iec.ch/sc65c/supportingdocuments>.

The latest version/release of the document will be found by selecting the file IEC_62439-2.MIB.{VersionStateInfo}.full.zip for the code component with the highest value for VersionStateInfo.

In case of any differences between the downloadable code and the IEC pdf published content, the downloadable code(s) is(are) the valid one; it may be subject to updates. See history files.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60050-192, *International Electrotechnical Vocabulary – Part 192: Dependability* (available at www.electropedia.org)

IEC 61158-6-10:2019, *Industrial communication networks – Fieldbus specifications – Part 6-10: Application layer protocol specification – Type 10 elements*

IEC 62439-1:2010, *Industrial communication networks – High availability automation networks – Part 1: General concepts and calculation methods*

IEC 62439-1:2010/AMD1:2012

IEC 62439-1:2010/AMD2:2016¹

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

ISO/IEC/IEEE 8802-3, *Telecommunications and exchange between information technology systems – Requirements for local and metropolitan area networks – Part 3: Standard for Ethernet*

IEEE Std 802.1Q-2018, *IEEE Standard for Local and Metropolitan Area Networks – Bridges and Bridged Networks*

IEEE Std 802.3-2018, *IEEE Standard for Ethernet*

3 Terms, definitions, abbreviated terms and conventions

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-192 and in IEC 62439-1, and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1.1

interconnection port

port of a switch that is used to interconnect two ring topologies

3.1.2

interconnection topology

topology in which two ring topologies are connected

¹ A consolidated version of this publication exists, comprising IEC 62439-1:2010, IEC 62439-1:2010/AMD1:2012 and IEC 62439-1:2010/AMD2:2016.

3.2 Abbreviated terms

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

ASE	Application Service Element
CCM	Continuity Check Messages
CFM	Connectivity Fault Management
CFM-MRP	Connectivity Fault Management for MRP
CPU	Central Processing Unit
FDB	Filtering Database
LC-mode	Link Check mode
LSB	Least Significant Bit
MAID	Maintenance Association ID
MD	Maintenance Domain
MD Level	Maintenance Domain Level
MEP	Maintenance End Point
MEPID	Maintenance Association End Point ID
MIB	Management Information Base
MRA	Media Redundancy Automanager
MRC	Media Redundancy Client
MRM	Media Redundancy Manager
MRP	Media Redundancy Protocol
MIC	Media Redundancy Interconnection Client
MIM	Media Redundancy Interconnection Manager
RC-mode	Ring Check mode

3.3 Conventions

This document follows the conventions defined in IEC 62439-1.

The expression "don't care" is used as a logical element for explaining that the value shall be ignored for further processing.

4 MRP Overview

This document specifies the Media Redundancy Protocol (MRP), a recovery protocol based on a ring topology, and the redundant interconnection of MRP rings via the Media Redundancy Interconnection Protocol as shown in Figure 1.

MRP is designed to react deterministically on a single failure of an inter-switch link or switch in the ring or interconnection topology.

MRP is based on functions of ISO/IEC/IEEE 8802-3 (IEEE Std 802.3) and IEEE Std 802.1Q™ including the Filtering Database (FDB) and is located between the Data Link Layer and Application Layer (see Figure 2).

NOTE Layering is assumed to be in accordance with IEC 61158-1.

An MRP compliant network shall have a ring topology with multiple nodes.

One of the nodes has the role of a Media Redundancy Manager (MRM). The function of the MRM is to observe and to control the ring topology in order to react on network faults. The MRM does this by sending frames on one ring port over the ring and receiving them from the ring over its other ring port, and vice-versa in the other direction. To ensure the best results, the test frames have to be prioritized in such a way that they are exclusively handled as the highest priority traffic in the ring. The calculations for guaranteed recovery times given in 9.9 work under this assumption. If this is not the case, the potential interference that test frames can experience from other traffic in the ring have to be taken into consideration when calculating the ring recovery time.

The other nodes in the ring have the role of Media Redundancy Clients (MRC). An MRC reacts on received reconfiguration frames from the MRM and can detect and signal link changes on its ring ports.

Certain nodes or all nodes in the ring may also start as a Media Redundancy Automanager (MRA). MRAs select one MRM among each other by using a voting protocol. The remaining MRAs transition to the role MRC.

Each node in the ring is able to detect the failure or recovery of an inter-switch link or the failure or recovery of a neighboring node.

To redundantly connect two MRP rings, two nodes of each ring are assigned additional roles.

One of the nodes has the role of a media redundancy interconnection manager (MIM), in addition to the role of a MRC or MRM. The function of the MIM is to observe and to control the redundant interconnection topology in order to react on interconnection faults. To cover a maximum of applications, two detection methods are provided by this document. The MIM can observe the interconnection topology by either reacting directly on interconnection port link change notification messages (LC-mode) or by sending test frames on the interconnection port over the connected rings and receiving them over its ring ports, and vice-versa in the other direction (RC-mode). The ring that contains the MIM of an interconnection is called the "primary ring" of this Interconnection.

The other three nodes in the interconnection topology have the role of media redundancy interconnection clients (MIC), in addition to the role of a MRC or MRM.

- The MIC located in the primary ring together with the MIM is called the "primary MIC".
- The MIC opposite the primary MIC, sharing the primary link with it, is called the "primary coupled MIC".
- The MIC opposite the MIM, sharing the secondary link with it, is called the "secondary coupled MIC".
- The ring coupled to the primary ring, containing primary coupled MIC and secondary coupled MIC, is called the "secondary ring".

The MICs react on received reconfiguration frames from the MIM, they can detect and signal link changes of their interconnection port, and they can issue link change notification messages.

LC-mode has the advantage of restricting the interconnection test frame load only to the interconnection links, whereas RC-mode has the advantage of deloading the MICs from interconnection test frame processing. The selection of the mode has to be made in accordance with the requirements of the application and is outside the scope of this document.

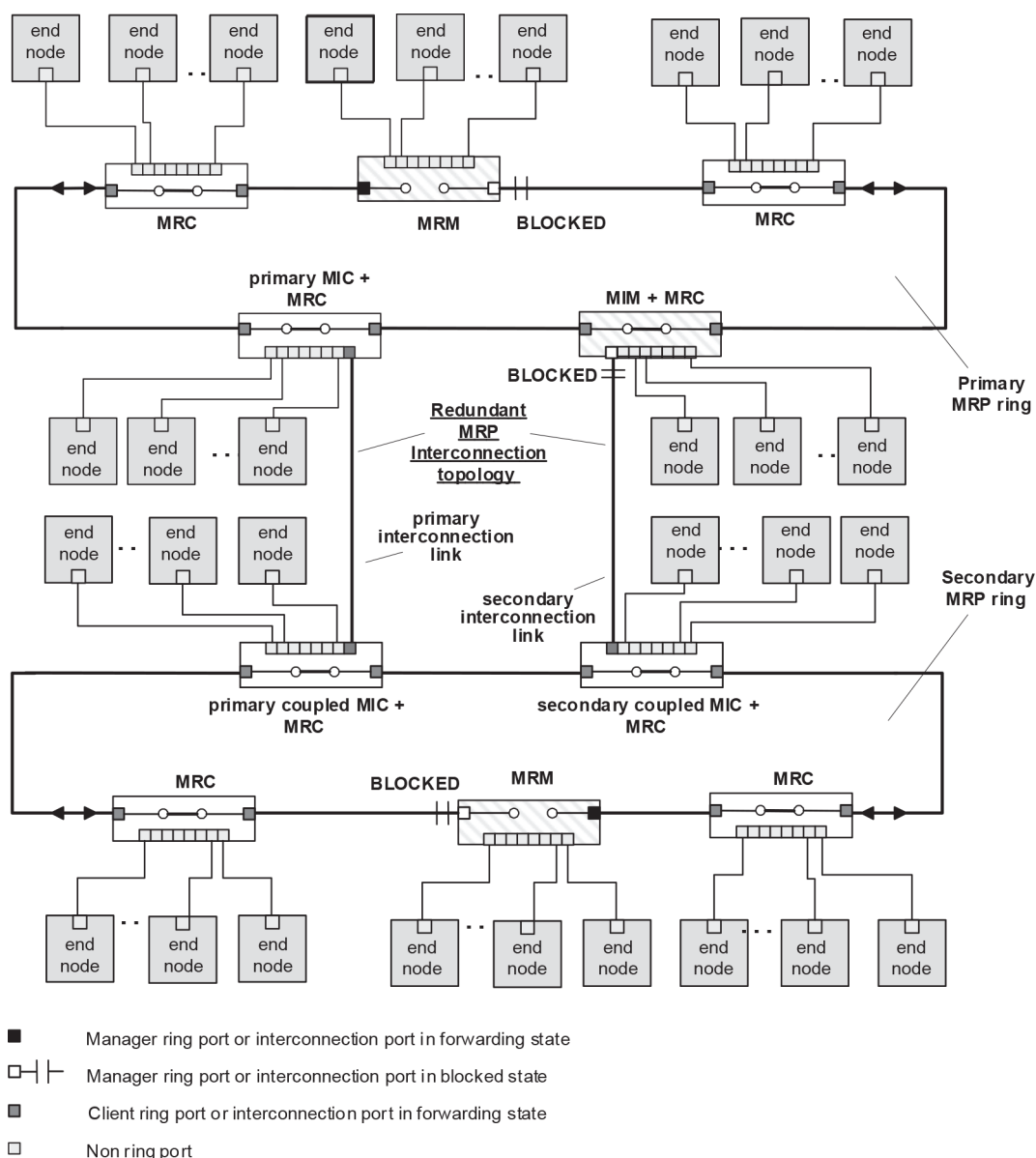


Figure 1 – Two MRP rings redundantly connected via MRP Interconnection

MRC, MRM and MRA that support being operated in rings where an RC-mode MRP Interconnection is applied, are “RC-mode aware”. MRC, MRM and MRA that support being operated in rings where an LC-mode MRP Interconnection is applied are “LC-mode aware”.

The vendor may implement only the LC-mode or only the RC-mode or both modes. The MIM and all MICs of one MRP Interconnection topology shall be configured to the same mode. A ring may contain multiple MRP Interconnections of only RC-mode MRP Interconnections or of only LC-mode MRP Interconnections. A ring may also contain multiple MRP Interconnections of both modes if all ring devices support this, i.e. all devices are at least RC-mode and LC-mode aware (see 5.3 and 5.4, LC-mode awareness and RC-mode awareness).

Each MRP compliant node requires an IEEE Std 802.1 compliant switch element with two ring ports connected to one ring and shall have the ability to perform at least as one of the following:

- media redundancy manager (MRM); or
- media redundancy client (MRC); or
- both MRM or MRC (but both roles shall not be active at the same time for the same ring).

Each Media Redundancy Interconnection compliant node requires an IEEE Std 802.1 compliant switch element with two ring ports connected to one ring, and with one interconnection port connected to another MRP ring and shall have the ability to perform at least as one of the following:

- both MRC and media redundancy interconnection manager (MIM) (both roles shall be active at the same time); or
- both MRM/MRA and MIM (both roles shall be active at the same time); or
- both MRC and media redundancy interconnection client (MIC) (both roles shall be active at the same time); or
- both MRM/MRA and MIC (both roles shall be active at the same time).

More than two MRP rings may be redundantly connected by applying the redundant interconnection topology multiple times from one ring to other rings. This leads to rings containing multiple nodes configured to MIM and multiple nodes configured to MIC. A redundant connection of more than two rings may also be achieved by two nodes of a ring containing multiple instances of MIMs or MICs. See Annex D for an overview of advanced MRP and MRP Interconnection topologies.

An MRP compliant node may implement multiple instances of the MRC, MRM, MRA, MIM or MIC functionality. In this case it shall obey the following configuration rules:

- if one or more MIM or MIC instances are active on one node, then there shall be only one MRC or one MRM or one MRA instance active on this node at the same time;
- if more than one MRC or MRM or MRA instances are active on one node, then no MIC or MIM shall be active on this node at the same time;
- if more than one MRC or MRM or MRA instances are active on one node, thereby connecting the related rings connected to the ring ports of this node, then there shall be no other node in the network connecting the same rings over its MRC or MRM or MRA instances.

Clauses 5 to 10 with MRP and MRP Interconnection definitions always apply to one MRP instance or one MRP Interconnection instance per compliant node. Multiple activation of MRP instances or MRP Interconnection instances, in accordance with the configuration rules stated above, can demand additional requirements to correct frame processing and frame forwarding, which are out of the scope of this document.

NOTE Additional interconnection ports can be used to connect to additional rings.

The MRP consists of a service and a protocol entity, see stack model in Figure 2.

The service entity specifies, in an abstract way, the externally visible service provided by the Data Link Layer in terms of:

- primitive actions and events of the service;
- parameters associated with each primitive action and event, and the form which they take, and;
- interrelationship between these actions and events, and their valid sequences.

MRP defines the services provided to:

- the Application Layer at the boundary between the Application Layer and the Data Link Layer; and
- the MRP Management at the boundary between the Data Link Layer and the MRP Management.

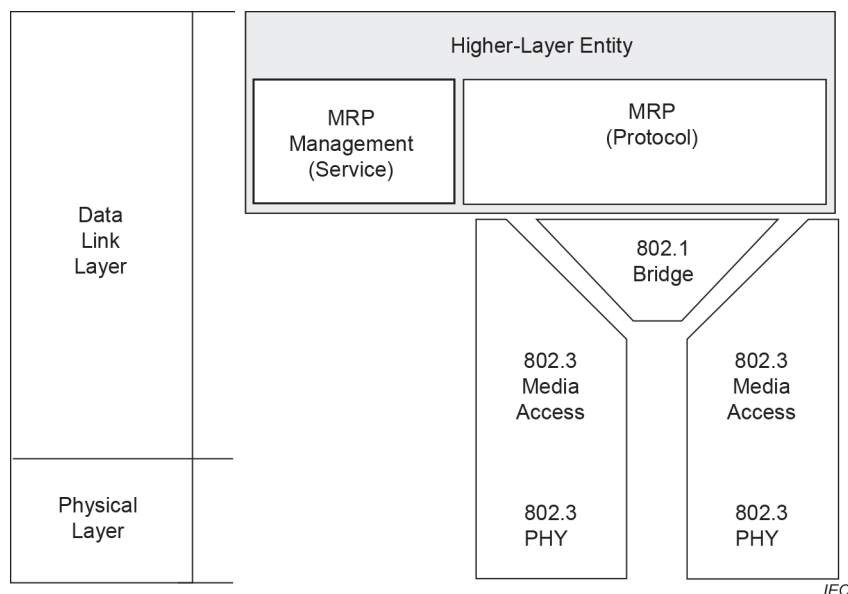


Figure 2 – MRP stack

5 MRP Media redundancy behavior

5.1 General

The following definitions for Media redundancy protocol roles always refer to one instance of the MRP role.

5.2 Ring ports

The MRM and the MRC shall have two ring ports.

The MRM and MRC shall be able to detect the failure or recovery of a link on a ring port with mechanisms based on ISO/IEC/IEEE 8802-3 (IEEE Std 802.3).

The MRM and MRC shall not forward MRP_Test frames, MRP_TopologyChange frames, and MRP_LinkChange frames to non-ring ports.

Ring ports shall behave as if either STP, or RSTP, or MSTP is disabled.

A ring port shall take one of the following port states:

- DISABLED

All frames shall be dropped.
- BLOCKED

All frames shall be dropped except the following:

 - MRP_TopologyChange frames, MRP_Test frames and MRP_TestMgrNAck frames;
 - MRP_LinkChange frames and MRP_TestPropagate from an MRC;
 - MRP_Option frames;
 - MRP_InTest, MRP_InTopologyChange and MRP_InLinkStatusPoll from an MIM;
 - MRP_InLinkChange frames from an MIC;
 - frames specified in IEEE Std 802.1Q-2018, Table 8-1 to pass ports in “Discarding” state (e.g. LLDP, IEEE 1588-2008 PTP peer to peer frames);

- frames only produced or consumed by the higher layer entities of this node and never forwarded.

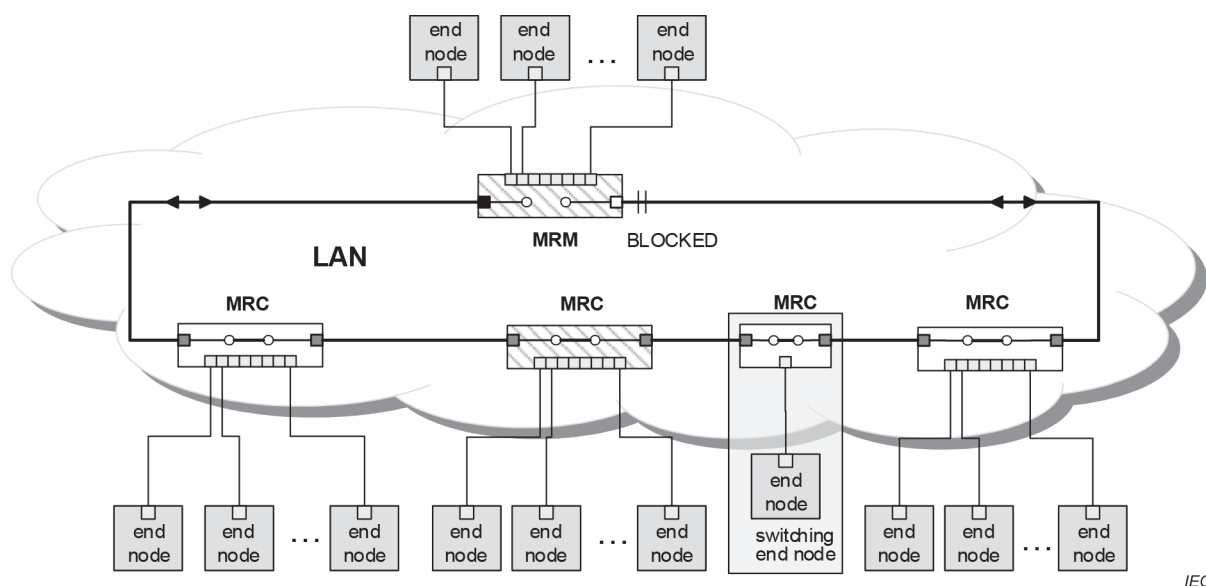
– FORWARDING

All frames shall be passed through in accordance with the forwarding behavior specified in IEEE Std 802.1Q.

NOTE IEEE Std 802.1Q refers to the port state corresponding to BLOCKED as “Discarding”.

5.3 Media Redundancy Manager (MRM)

One ring port of the MRM shall be connected to a ring port of an MRC. The other ring port of that MRC shall be connected to a ring port of another MRC or to the second ring port of the MRM, thereby forming a ring topology as shown in Figure 3.



IEC

Figure 3 – MRP ring topology with one manager and clients

The MRM shall control the ring state by:

- sending MRP_Test frames at a configured time period in both directions of the ring;
- setting one ring port to FORWARDING state and the other ring port to BLOCKED state if it receives its own MRP_Test frames (this means that the ring is closed, see Figure 3);
- setting both ring ports to FORWARDING state if it does not receive its own MRP_Test frames on both ring ports within a configured time according to MRP_TSTdefaultT, MRP_TSTshortT and MRP_TSTNRmax in Table 59 (this means that the ring is open, see Figure 4).

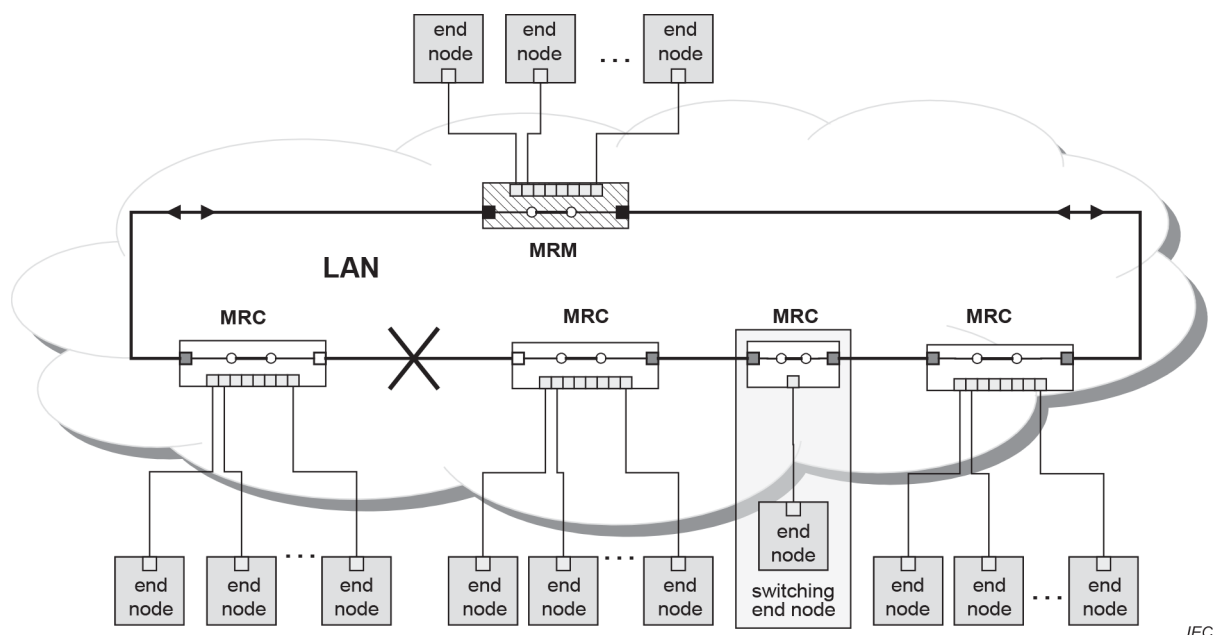


Figure 4 – MRP open ring with MRM

The following mechanism supports synchronization between MRM and MRC in ring topology changes.

The MRM shall indicate changes in the ring state to the MRCs by means of MRP_TopologyChange frames.

The MRM shall not forward MRP specific frames (MRP_Test frames, MRP_TopologyChange frames, MRP_LinkChange frames) between its ring ports.

If the MRM receives an MRP_LinkUp or MRP_LinkDown frame, then the MRM shall reduce its test monitoring time in accordance with Table 59 to accelerate the detection of the open ring. When the open ring is detected, then the MRM shall set one ring port to forwarding state and shall send the MRP_TopologyChange frames through both its ring ports.

If parameter MRP_REACT_ON_LINK_CHANGE is set, see Table 41, the MRM shall, on receiving an MRP_LinkDown frame, immediately set one ring port to forwarding state and shall then send the MRP_TopologyChange frames through its ring ports.

The MRM shall send to the MRCs an MRP_TopologyChange frame containing the delay, after which the ring topology change will be performed. The parameter carrying this delay is called MRP_Interval. When this time has expired, all MRCs shall clear their Filtering Database (FDB) information for their ring ports.

Each MRC shall send the configured delay in MRP_Interval to the MRM in the MRP_LinkUp and MRP_LinkDown frames to tell the MRM after which time the MRC will change its port state from BLOCKED to FORWARDING (MRP_LinkUp frame) or from FORWARDING to BLOCKED (MRP_LinkDown frame).

Measures shall be included to prevent the MRM from remaining stuck in the closed state in case of node failure.

The MRM shall forward MRP_InLinkChange frames, MRP_InLinkStatusPoll frames and MRP_InTopologyChange frames between its ring ports, if it supports being operated in rings where an LC-mode MRP Interconnection is applied (LC-mode awareness) and both of its ring ports are in the state FORWARDING.

The MRM shall forward MRP_InTest frames, MRP_InLinkChange frames, and MRP_InTopologyChange frames between its ring ports, if it supports being operated in rings where an RC-mode MRP Interconnection is applied (RC-mode awareness) and both of its ring ports are in the state FORWARDING.

The MRM may support LC-mode awareness or RC-mode awareness, or both.

The MRM shall not forward MRP_InTest frames, MRP_InLinkChange frames, MRP_InLinkStatusPoll frames and MRP_InTopologyChange frames between its ring ports, if one of its ring port is in the port state BLOCKED.

The MRM shall process MRP_InTopologyChange frames. It shall clear its FDB if requested by an MRP_InTopologyChange frame in a given time interval MRP_Interval. It shall send an MRP_TopologyChange frame if requested by the MRP_InTopologyChange frame, in order to ensure that all MRCs, MIMs and MICs in the ring domain clear their FDB at the same time.

5.4 Media Redundancy Client (MRC)

Each MRC shall forward MRP_Test frames received on one ring port to the other ring port and vice versa.

If the MRC detects a failure or recovery of a ring port link, the MRC may optionally notify the change by sending MRP_LinkChange frames through both of its ring ports. Each MRC shall forward MRP_LinkChange frames received on one ring port to the other ring port, and vice versa.

Each MRC shall forward MRP_TopologyChange frames received on one ring port to the other ring port and vice versa. Each MRC shall process these frames. It shall clear its FDB if requested by an MRP_TopologyChange frame in a given time interval MRP_Interval.

Each MRC shall forward MRP_InLinkChange frames, MRP_InTopologyChange frames and MRP_InLinkStatusPoll frames between its ring ports, if it supports being operated in rings where an LC-mode MRP Interconnection is applied (LC-mode awareness).

Each MRC shall forward MRP_InTest frames, MRP_InLinkChange frames, MRP_InTopologyChange frames between its ring ports, if it supports being operated in rings where an RC-mode MRP Interconnection is applied (RC-mode awareness).

The MRC may support LC-mode awareness or RC-mode awareness or both.

5.5 Redundancy domain

The redundancy domain represents a ring. By default, all MRMs and MRCs belong to the default domain. A unique domain ID can be allocated to all ring nodes of one ring as a key attribute. This is especially essential to distinguish frames if a device is member of multiple rings by implementing multiple instances of MRMs or MRCs. A node shall assign exactly two unique ring ports per redundancy domain.

NOTE A device can have other ports than the two assigned to the MRP. These other ports are not influenced by the MRP.

5.6 Media Link Check

To enhance the quality of the link detection of certain ring or interconnection ports, a media link check protocol may be used. It shall be used for LC-mode.

The Continuity Check protocol, defined in the Connectivity Fault Management (CFM) protocol suite within IEEE Std 802.1Q-2018 and further specified in this document under the name Connectivity Fault Management for MRP (CFM-MRP), shall be supported as a media link check protocol.

CFM-MRP shall be used at the interconnection ports of the MIM and MICs when operating the ring interconnection in LC-mode in combination with the 200 ms or slower timing profiles. CFM-MRP should also be used for profiles faster than 200 ms if possible. CFM-MRP may be used at the interconnection ports if operating the ring interconnection in RC-mode.

CFM-MRP may also be used at the ring ports of MRP devices.

5.7 Application of the Continuity Check protocol

5.7.1 General

When applying the CFM-MRP protocol in accordance with the specification of the Continuity Check protocol, as defined in IEEE Std 802.1Q-2018, to check the links between ring- or interconnection ports, then the ring- and interconnection ports represent Maintenance End Points (MEP) belonging to a Maintenance Domain (MD) and a Maintenance Association (MA) in the sense of IEEE Std 802.1Q-2018.

An MRP device, applying the CFM-MRP protocol on its interconnection ports or ring ports, shall internally produce a MAUTypeChangeInd event when the Continuity Check receiver instance on its MRP port has detected a remote Maintenance End Point (MEP) error by detecting a lifetime violation of the Continuity Check messages (CCM) from the linked remote MRP devices MEP CFM-MRP initiator.

5.7.2 Continuity Check Message Interval

The CCM Interval to be used shall be either 3,33 ms or 10 ms. It may be slower, in accordance with IEEE Std 802.1Q-2018, for the redundant passive link or a single active link.

5.7.3 Maintenance Domain Level

The Maintenance Domain Level (MD Level) to be used between two ring- or interconnection ports of two MRP devices shall be level 0 for lowest-level physical connections. Thereby the fixed CCM Multicast MAC Address 01-80-C2-00-00-30 is also assigned in accordance with IEEE Std 802.1Q-2018.

5.7.4 Maintenance Association ID (MAID)

The Maintenance Association ID (MAID) to be used, in accordance with IEEE Std 802.1Q-2018, may be as specified in Table 1.

Table 1 – Coding of the Maintenance Association ID (MAID)

Subfield	Value
Maintenance Domain Name Format (Character String)	4
Maintenance Domain Name Length	20
Maintenance Domain Name	Character string containing: “CFM CCM <MAC ADDRESS>” The substitution <MAC ADDRESS> shall represent the port MAC address converted to a string without any blanks or hyphens. E.g. the port MAC address 08-00-06-08-47-11 would result in the string “CFM CCM 080006084711”. Two ports exchanging CFM CCM frames shall negotiate the final common Maintenance Domain Name of that Maintenance connection to be the string of the port with the lower MAC address, i.e. the port with the higher MAC address value changes the Maintenance Domain Name to be the name of the port with the lower MAC address value.
Short MA Name Format (2-octet integer)	3
Short MA Name Length	2
Short MA Name	Two octets containing the value: 0x0001

5.7.5 Maintenance Association End Point ID (MEPID)

A Maintenance End Point (MEP) shall start sending CFM CCM frames with the MEPID value of “1”. If it receives CFM CCM frames from a remote MEP with a Maintenance Domain Name containing a lower port MAC Address than its own, it shall change its MEP ID to the value “2” together with changing its Maintenance Domain Name to the remote MEPs Maintenance Domain Name. If the remote MEPs Maintenance Domain Name contains a higher MAC Address than its own, it shall neither change its MEPID nor its Maintenance Domain Name.

5.7.6 Sender ID TLV

The use of the Sender ID TLV in accordance with IEEE Std 802.1Q is optional for MRP.

5.7.7 Port Status TLV

The use of the Port Status TLV in accordance with IEEE Std 802.1Q is optional for MRP.

5.7.8 Interface Status TLV

The use of the Interface Status TLV in accordance with IEEE Std 802.1Q is optional for MRP.

5.8 Usage with diagnosis and alarms

If the attribute Check Media Redundancy has the value TRUE, media redundancy events shall cause diagnosis events and alarm notifications.

5.9 Ring diagnosis

In a redundancy domain, the following diagnosis events handling shall be implemented by each MRM:

- If a device is configured as MRM, but not operating in the manager role, it shall signal a “MANAGER_ROLE_FAIL” diagnosis event and suspend reporting of all other media redundancy diagnosis events while not in the manager role.
- If a device is operating in manager role and this device detects another active MRM, it shall signal the “MULTIPLE MANAGERS” event. This event can occur concurrently with the ring state event “RING_OPEN”.
- If a device is operating in manager role and detects an open ring, it shall signal the “RING_OPEN” event.

These events shall be signaled by using the State Change service (see 7.3).

NOTE The presence of MRP_Test frames enables the checking of the existence of an MRM.

5.10 Multiple MRM in a single ring: Manager voting option

5.10.1 General

There shall be only one active MRM in the ring, even if several nodes have this ability.

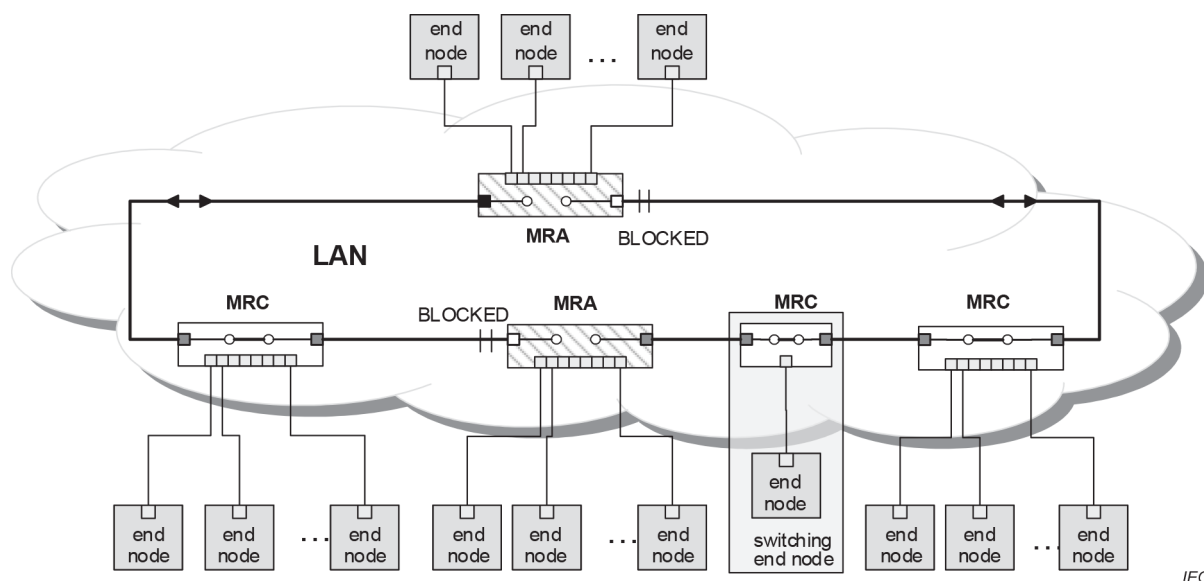
NOTE 1 Multiple active MRMs cause the ring to divide itself into several segments.

As an alternative to manual MRP-role configuration, if more than one node has the ability of becoming an MRM in the ring, an enhanced manager voting option, specified in this document, may be used to decide which of these nodes shall finally become the MRM, while the other nodes take over the MRC role as shown in Figure 5 and Figure 6. To this effect, the nodes with the MRM ability have different priorities that shall be conveyed in the MRP_Prio field of the MRP_Test frame.

If an option for multiple MRM in a single ring is used, then all MRM in the ring shall support the same manager voting option, as defined in this document.

MRM supporting the manager voting option are named Media Redundancy Automanager or MRA.

Figure 5 shows an MRP ring at network startup with two devices in the administrative MRA role.



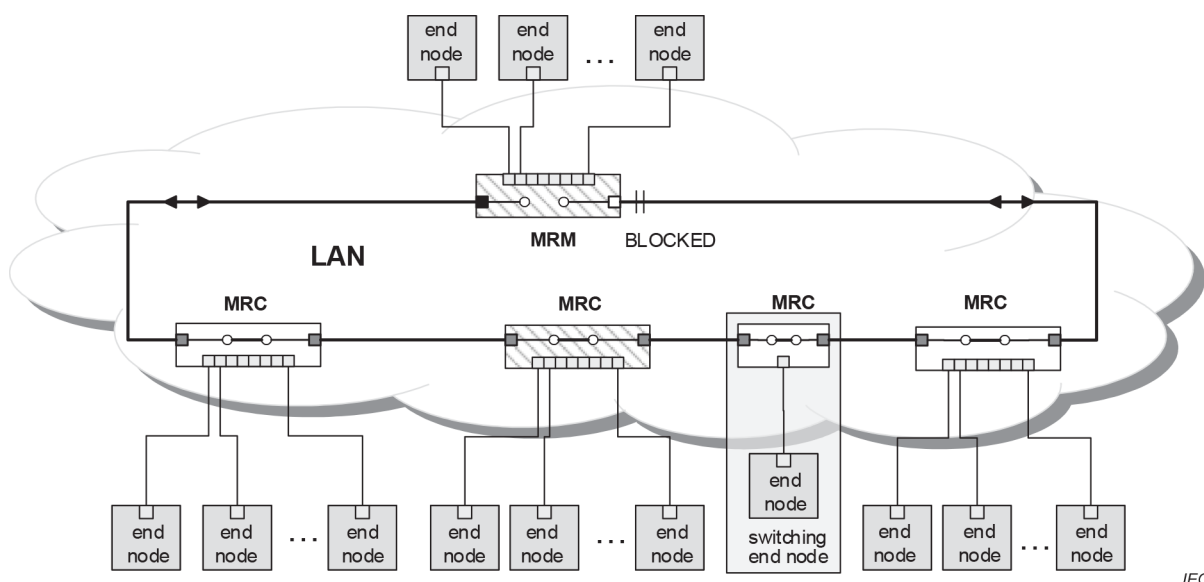
IEC

Figure 5 – MRP ring with MRA at network startup

The MRA role is an MRP role which comprises both the MRP roles MRM and MRC. Additionally, the MRA has the capability to transition at any point in time, by virtue of the voting protocol, from its initial operational role manager (MRA) to the operational role client (MRC), and back again, in coordination with possible other MRAs in the ring.

NOTE 2 To emphasize the principle, the following explanations in 5.10 and its subclauses use the expression "MRM" for the remaining MRA managing the ring, although the device continues to be MRA, and is always capable of voting again.

Figure 6 shows the same network ring after the manager voting process has taken place. The MRA transitioned to the MRP roles MRM and MRC.



IEC

Figure 6 – MRP ring after the manager voting process

5.10.2 Basic principle of the manager voting process

The manager voting is an optional process only for devices that are capable of taking over the MRM role within the MRP.

The manager voting phase of the MRP shall take place right after device startup, and before the device starts to take one of the possible MRP-roles (MRM or MRC).

The basic functionality of the manager voting process shall be as follows:

- Each network node of the ring with MRM-capability and manager voting option support, thereby being a so-called “Manager (Auto)” or short “MRA”, may be set to the MRP-role “Manager (Auto)” by factory-default.
- Each MRA shall have assigned a priority (MRP_Prio) value. This MRP_Prio-value, combined with the MAC address, results in a finally unique priority. A lower MRP_Prio-value means a higher priority. If devices have identical MRP_Prio values, then the value of the device MAC address decides. A lower MAC address means a higher priority.
- At startup, each MRA network node shall start up with the manager voting process and shall send MRP_Test frames.
- Other MRA shall receive the MRP_Test frames and shall compare their own priority with the priority of the next MRA. If they do have the higher priority, they shall cause the remote manager that is sending the MRP_Test frame to withdraw from the MRA-role into the MRC-role by sending a negative test manager acknowledgement.
- The MRA or MRM with the highest priority shall become the one and only MRM of the ring and shall now start to manage the ring in accordance with MRP.
- If the MRM elected via the manager voting option is taken out of the ring or fails to operate, the voting process shall start again and the next priority MRA shall become the managing MRM.
- If an additional MRA is inserted into a ring containing an already elected MRM, then the already elected MRM and the newly inserted MRA will exchange MRP_Test frames and will thereby vote the new remaining MRM among each other.
- For the manager voting option to work correctly, all devices in the ring supporting the manager role shall be set to MRP-role “Manager (Auto)” or shall remain in the MRP-role “Client”. At least one device of a ring shall be set to either the MRP-role “Manager (Auto)” or “Manager”, though.
- If an MRM without MRA capability is part of the network ring, regardless whether the ring is open or closed, all MRAs shall be configured to the MRC role.

NOTE Configuring MRA to the MRC role is not performed automatically by the automanager voting process, but is done by the user.

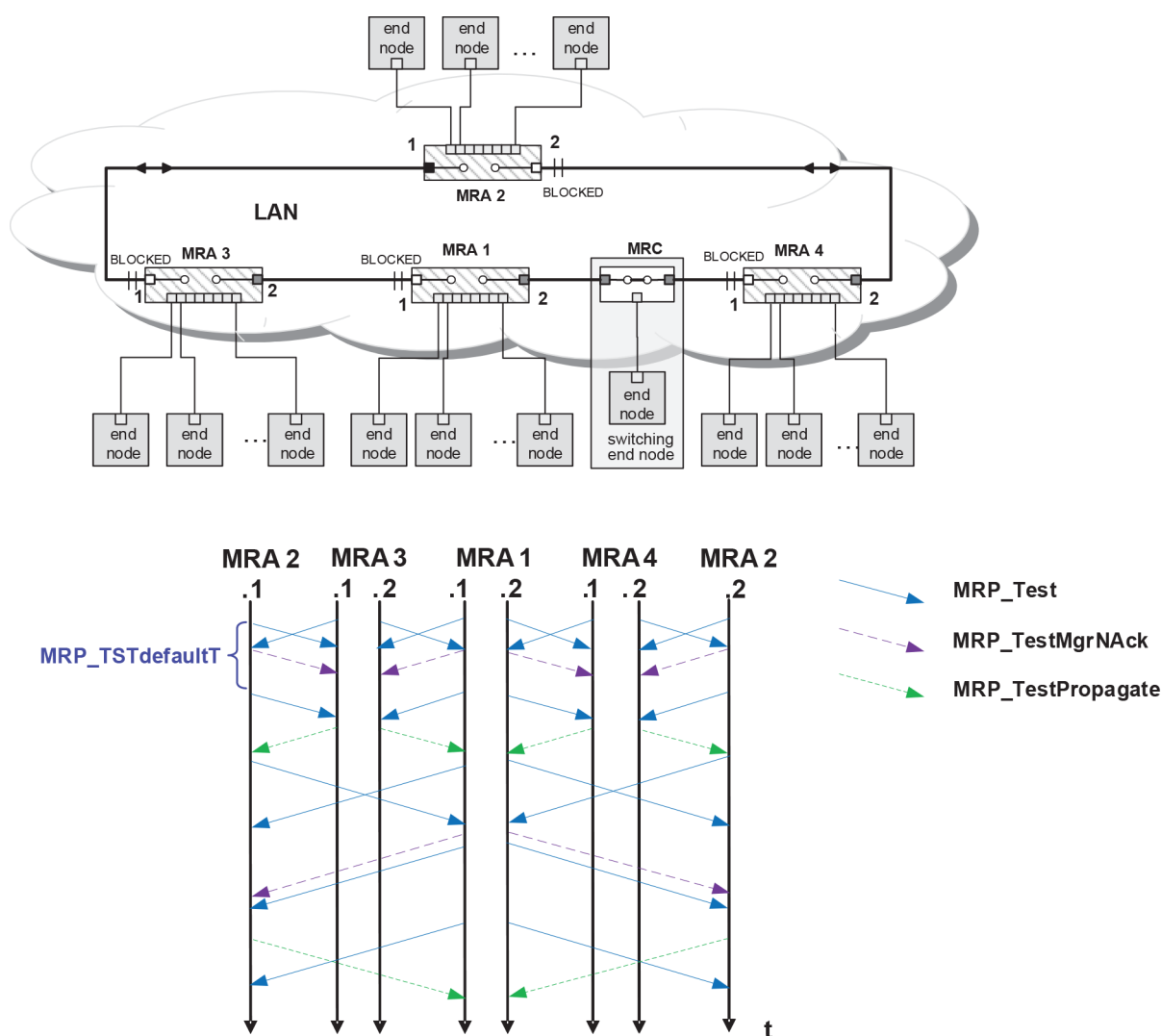
5.10.3 The manager voting process

The manager voting process shall be as follows:

- At power on, all MRA shall start with the manager voting process.
- Each MRA shall start to send MRP_Test frames on both ring-ports. The MRP_Test frame shall contain the MRAs priority value MRP_Prio.
- Received MRP_Test frames shall be forwarded to the local host only.
- The remote managers priority values contained in the received MRP_Test frames shall be compared with their own priority, as described in 5.10.2. If their own priority is higher than the received priority, a negative test manager acknowledgement (“MRP_TestMgrNack”) frame, with the remote managers MAC address as additional information, shall be sent.
- If a negative test manager acknowledgement (“MRP_TestMgrNack”) with their own MAC address is received, the receiving MRA shall initiate the transition into client (MRC) role by:
 - recording the MAC address and priority of the higher priority manager;
 - entering the client role and propagating the role change and the higher priority manager information via a “MRP_TestPropagate” frame sent on both ring-ports.
- On reaching the MRP client role, it shall forward MRP_Test frames between ring ports like a standard MRC. Additionally, it shall also forward MRP_Test frames to the host.

- From now on, the MRA in client role shall monitor whether the recorded higher priority manager is still alive, i. e. whether it still receives MRP_Test frames from that manager.
- The MRP_TestPropagate frame shall be used to inform other MRA devices in client role about the role change and the new higher priority manager. The clients receiving this frame shall update their higher priority manager information accordingly. This ensures that clients stay in client role in the event of a role change of the monitored higher priority manager.
- The frames MRP_TestMgrNAck and MRP_TestPropagate shall be sent using the destination multicast address MC_TEST.
- If the MRA in client role recognises (via MRP_Test frame reception monitoring timeout) that the higher priority manager has failed, it shall fall back into automanager role and shall thereby start a new manager voting process with the other MRAs, which have fallen back into automanager role in the same way and for the same reason.

Figure 7 shows the frame exchanges over the time during the manager voting phase.



IEC

Figure 7 – Manager voting process

A handshake (negative test acknowledgement) is required to ensure that the higher priority manager is located in the ring. This is necessary, because the switch frame forwarding rules allow MRP_Test frames from a manager device located outside the ring, which is connected via its ring-port to a non-ring port of an MRP device being part of the ring, to be also forwarded into the ring, if a switch without “inbound” filtering capability (“ingress filtering”) is used.

Figure 8 shows an MRP ring with one MRA (MRA2) located outside the ring. MRA2 is connected via one of its ring ports to a non-ring port of a device that is part of the ring. The frames follow the forwarding rules defined in 5.2.

While the lower priority manager MRA1 receives test frames from the higher priority manager MRA2, MRA2 does not receive test frames from the lower priority manager MRA1 as these are not forwarded to non-ring ports, which excludes it from the voting process. Therefore, MRA2 does not send negative test acknowledgements, and MRA1 will stay in the MRM role. If MRA1 had a higher priority than MRA2, MRA1 would send negative test acknowledgements, but these would not reach MRA2 because they are not forwarded to non-ring ports either.

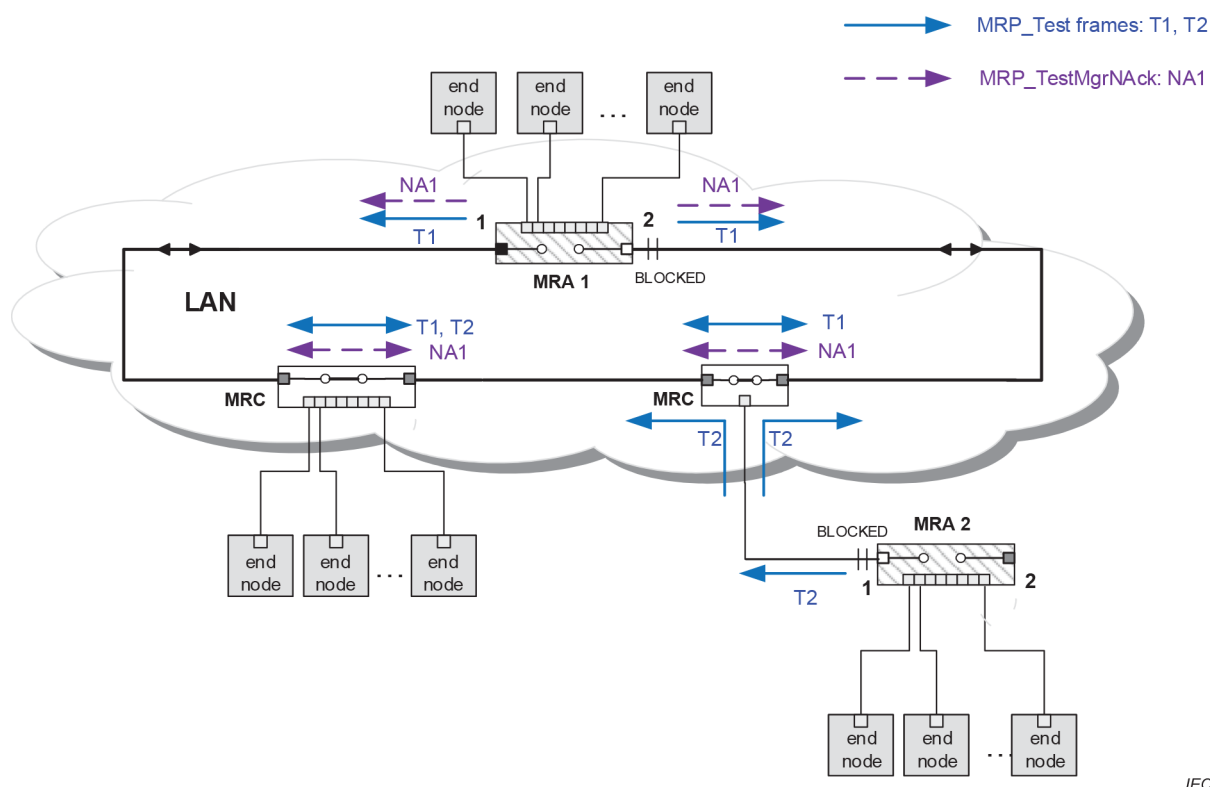


Figure 8 – MRA located outside the MRP ring

5.11 BLOCKED not supported (Option)

If an MRC is not able to support the BLOCKED port state at its ring ports, the MRC shall report it in the corresponding parameter of the MRP_LinkChange frames.

If an MRC does not support the BLOCKED state in a ring, then an MRM shall support additional functionalities (see Table 40 and Table 41, MRP_BLOCKED_SUPPORTED).

5.12 Interconnection port

The MIM and the MIC shall have one interconnection port.

The MIM and the MIC shall be able to detect the failure or recovery of a link on the interconnection port as follows:

- by using link detection mechanisms based on ISO/IEC/IEEE 8802-3 (IEEE Std 802.3).

In addition, by applying one or both of the following mechanisms:

- a media link check protocol between interconnection ports. The media link check protocol shall be used at the MIM's and MICs' interconnection port if the MIM is configured in link check mode (LC-mode), and may be used if the MIM is configured in ring check mode (RC-mode).
- a periodic MRP_InTest frame which shall be sent and received by the MIM on its ring ports and interconnection port and shall be forwarded by the MICs on their ring ports and interconnection port. This mechanism shall be used for RC-mode and shall not be used for LC-mode.

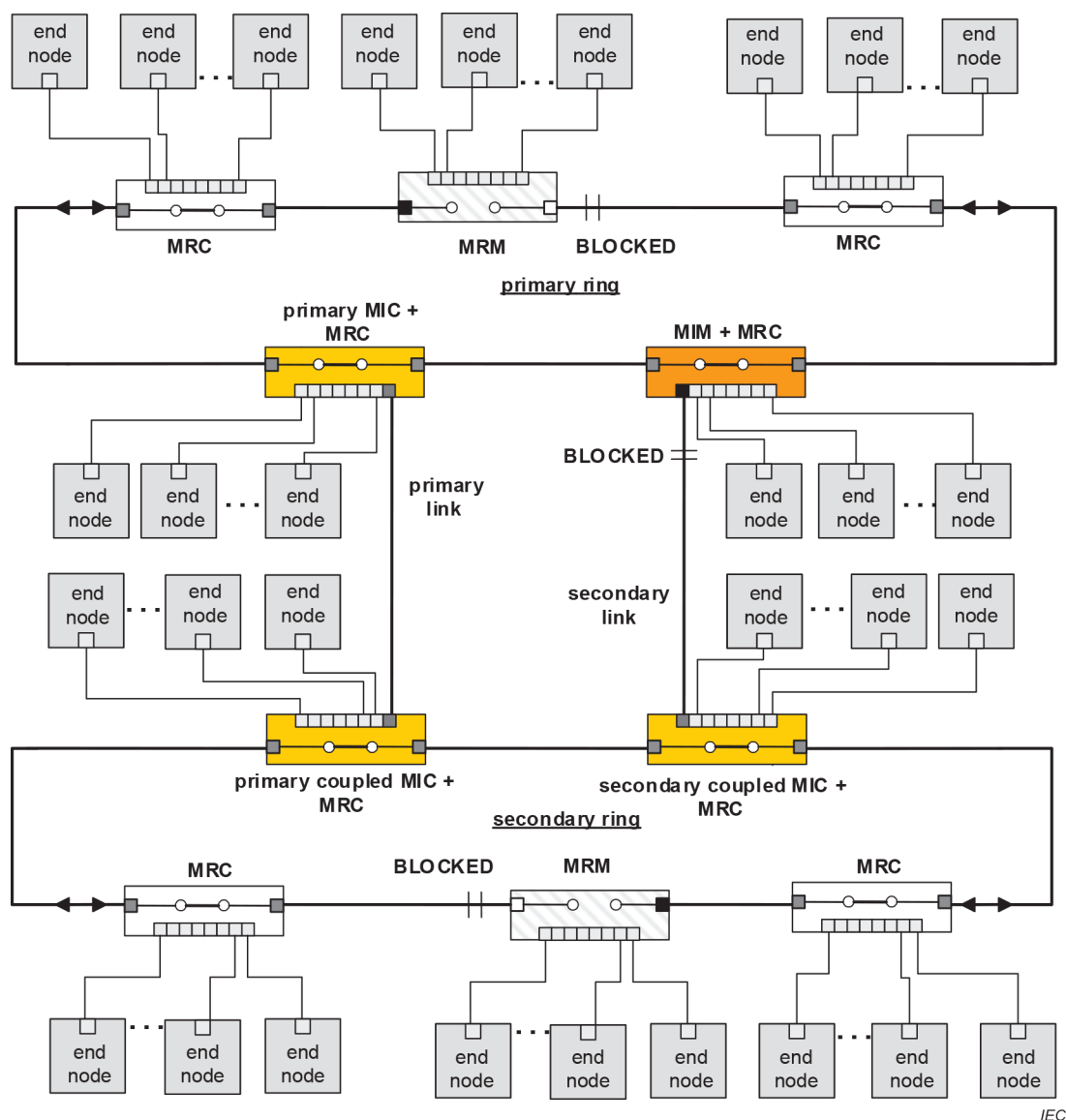
The MIM and the MIC shall not forward MRP_InTest frames, MRP_InTopologyChange frames, MRP_InLinkStatusPoll frames and MRP_InLinkChange frames to ports other than ring ports and other than the interconnection port.

The interconnection port shall take one of the following port states:

- DISABLED
All frames shall be dropped.
- BLOCKED
All frames shall be dropped, except for the following:
 - MRP_InTest frames;
 - MRP_InLinkChange frames and MRP_InTopologyChange frames;
 - MRP_InLinkStatusPoll frames;
 - media link check frames CFM-MRP (continuity check frames in accordance with IEEE Std 802.1Q-2018);
 - frames specified in IEEE Std 802.1Q-2018, Table 8-1 to pass ports in “Discarding” state (e.g. LLDP, IEEE 1588-2008 PTP peer to peer frames);
 - frames only produced or consumed by the higher layer entities of this node and never forwarded.
- FORWARDING
All frames shall be passed through in accordance with the forwarding behavior of IEEE Std 802.1Q.

NOTE IEEE Std 802.1Q refers to the port state corresponding to BLOCKED as “Discarding”.

5.13 Media redundancy Interconnection Manager (MIM)



IEC

Figure 9 – MRP Interconnection topology

The interconnection port of the MIM in the primary ring shall be connected to the interconnection port of the secondary coupled MIC in the secondary MRP ring, and the interconnection port of the primary MIC in the same primary ring shall be connected to the interconnection port of the primary coupled MIC in the secondary MRP ring, thereby forming an MRP Interconnection topology as shown in Figure 9.

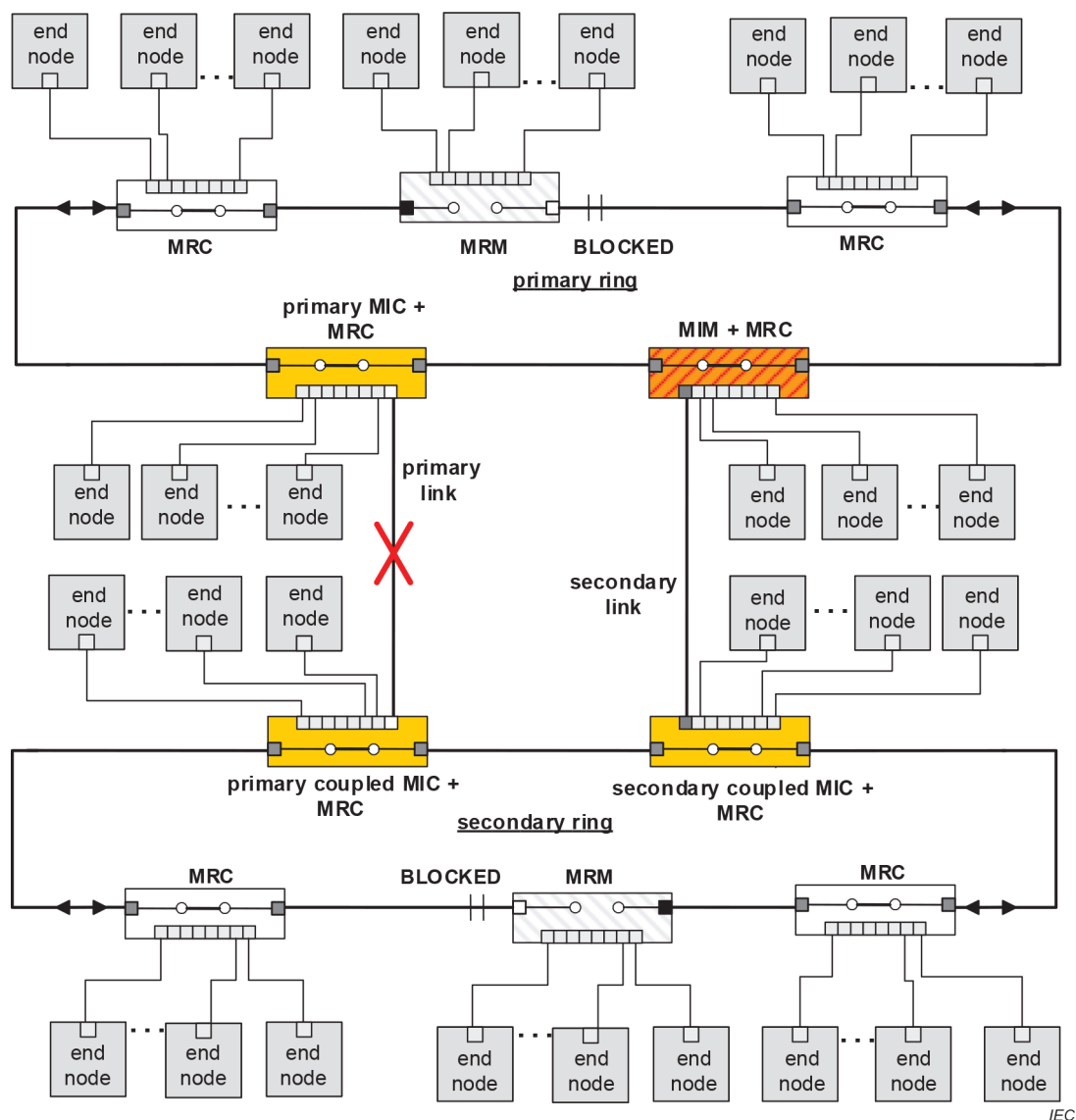


Figure 10 – MRP ring interconnection open

The MIM shall control its interconnection port state as follows:

- by directly reacting only on interconnection port link change notifications from the MICs and from its own interconnection port (link check mode: LC-mode);
- or optionally by reacting on MRP_InTest frames (ring check mode: RC-mode);
- setting its interconnection port in BLOCKED state if:
 - it is in LC-mode and receives interconnection port link up notifications from its own interconnection port and from the MICs of the primary interlink connection (this means that the interconnection topology is closed, see Figure 9);
 - it is in RC-mode and receives its own MRP_InTest frames (this means that the interconnection topology is closed, see Figure 9).
- setting the interconnection port in FORWARDING state if:
 - it is in LC-mode and receives an interconnection port link down notification from at least one of the MICs of the primary interlink connection (this means that the interconnection topology is open, see Figure 10);
 - it is in RC-mode and does not receive its own MRP_InTest frames within a configured time in accordance with MRP_IN_TSTdefaultT and MRP_IN_TSTNRmax in Table 59 (this means that the interconnection topology is open, see Figure 10);

The following mechanism supports synchronization between the MIM and the MIC at interconnection topology changes.

The MIM shall indicate changes in the interconnection topology state to the MICs, and to the MRMs in the connected MRP rings, by means of MRP_InTopologyChange frames.

When it is in LC-mode, the MIM shall, after startup and after recognition of a link up at its interconnection port, issue an MRP_InLinkStatusPoll frame at its ring ports, to poll the status of the redundant interlink connection from the MICs.

When it is in RC-mode, the MIM shall, after startup and after recognition of a link up at its interconnection port, cyclically send and receive MRP_InTest frames at its ring ports and at its interconnection port, to detect the status of the interconnection topology.

When a transition to open or closed interconnection topology is detected, then the MIM shall send the MRP_InTopologyChange frames through both ring ports and through its interconnection port to the MICs and to the MRMs, to initiate the interconnection topology change.

If the MIC receives an MRP_InTopologyChange frame, then the MIC shall, after recognition of a link up at its interconnection port, change the port state of its interconnection port to FORWARDING.

If the MRMs receive an MRP_InTopologyChange frame, then the MRMs shall send MRP_TopologyChange frames at both ring ports, containing a delay value, after which all MRCs and MICs in the connected MRP rings will clear their Filtering Database (FDB).

The MIM shall not forward its own MRP_InTest frames between the ring ports and its interconnection port.

The MIM shall forward MRP_InLinkChange frames, MRP_InLinkStatusPoll frames and MRP_InTopologyChange frames received on one ring port to the other ring port and vice versa. The MIM shall process MRP_InLinkChange frames and MRP_InTopologyChange frames. The MIM shall not forward MRP_InLinkChange frames, MRP_InLinkStatusPoll frames and MRP_InTopologyChange frames, if the MIM received these frames at its interconnection port.

Each MIC shall send the configured delay in MRP_Interval to the MIM in the MRP_InLinkUp and MRP_InLinkDown frames to tell the MIM after which time the MIC will change its interconnection port state from BLOCKED to FORWARDING (MRP_InLinkUp frame) or from FORWARDING to BLOCKED (MRP_InLinkDown frame).

Each MIM shall support BLOCKED port state at the interconnection port.

5.14 Media redundancy Interconnection Client (MIC)

The interconnection port of the secondary coupled MIC shall be connected to the interconnection port of a MIM in a primary MRP ring, and the interconnection port of the primary coupled MIC in the same secondary ring shall be connected to the interconnection port of the primary MIC in this other primary MRP ring, thereby forming an MRP Interconnection topology, as shown in Figure 9.

Each MIC in RC-mode or with RC-mode awareness shall forward MRP_InTest frames received on one ring port to the other ring port. Each MIC in RC-mode shall forward MRP_InTest frames to the interconnection port. Each MIC in RC-mode shall forward MRP_InTest frames received on the interconnection port to both ring ports. If the MIC detects a failure or recovery of the interconnection port link, the MIC shall notify the change by sending MRP_InLinkChange frames through both of its ring ports. Each MIC shall forward MRP_InLinkChange frames received on one ring port to the other ring port and vice versa. Each secondary coupled MIC shall forward MRP_InLinkChange frames received on one of the ring ports to the interconnection port.

Each MIC shall forward MRP_InTopologyChange frames received on one ring port to the other ring port and vice versa. Each MIC shall process MRP_InTopologyChange frames. It shall, after recognition of a link up at its interconnection port, change the port state of its interconnection port to FORWARDING.

After receiving an MRP_InLinkStatusPoll frame from the MIM, each MIC in LC-mode shall respond with an MRP_InLinkChange status frame informing about its current interconnection port link status.

Each MIC shall support BLOCKED port state at the interconnection port.

5.15 Interconnection domain

The interconnection domain represents an interconnection topology. The MIM and the MICs of one interconnection topology belong to the same interconnection domain. A unique interconnection ID shall be allocated as a key attribute, especially if MIM and MICs are member of rings with multiple interconnections. A node shall assign exactly one unique interconnection port per interconnection domain.

Each interconnection topology in the network shall have a unique interconnection ID.

There shall be only one active MIM in an interconnection domain.

Ring ports shall behave as if either STP, or RSTP, or MSTP is disabled.

5.16 Interconnection diagnosis

In an interconnection domain the following diagnosis events handling shall be implemented by each MIM.

- If a device is configured as MIM, but not operating in this role, it shall signal a “MRP_INTERCONNECTION_MANAGER_ROLE_FAIL” diagnosis event and suspend reporting of all other media redundancy interconnection protocol diagnosis events while not in the manager role.
- If a device is operating in MRP Interconnection manager role (MIM) and detects or is informed about an open interconnection topology, it shall signal the “INTERCONNECTION_OPEN” event.

These events shall be signaled by using the State Change service (see 7.10).

6 MRP Class specification

6.1 General

The MRP Application Service Element (ASE) defines two object types.

6.2 Template

6.2.1 Media redundancy template

An MRP object is described by the following template:

ASE: Media redundancy ASE

CLASS: Media redundancy

CLASS ID: not used

PARENT CLASS: IEEE Std 802.3, IEEE Std 802.1Q

ATTRIBUTES:

1.	(m)	Key Attribute:	Domain ID
2.	(m)	Attribute:	Domain Name
3.	(m)	Attribute:	Ring Port 1 ID
4.	(m)	Attribute:	Ring Port 2 ID
5.	(o)	Attribute:	VLAN ID
6.	(m)	Attribute:	Expected Role (MANAGER (AUTO), MANAGER, CLIENT)
7.	(c)	Constraint:	Expected Role = MANAGER
7.1	(m)	Attribute:	Manager Priority
7.2	(m)	Attribute:	Topology Change Interval
7.3	(m)	Attribute:	Topology Change Repeat Count
7.4	(m)	Attribute:	Short Test Interval
7.5	(m)	Attribute:	Default Test Interval
7.6	(m)	Attribute:	Test Monitoring Count
7.7	(m)	Attribute:	Non-blocking MRC supported (TRUE, FALSE)
7.8	(c)	Constraint:	Non-blocking MRC supported = TRUE
7.8.1	(m)	Attribute:	Test Monitoring Extended Count
7.9	(o)	Attribute:	React On Link Change (TRUE, FALSE)
7.10	(m)	Attribute:	Check Media Redundancy (TRUE, FALSE)
7.10.1	(c)	Constraint:	Check Media Redundancy = TRUE
7.10.1.1	(m)	Attribute:	Real Role State
7.10.1.2	(m)	Attribute:	Real Ring State
7.10.1.3	(o)	Attribute:	Ring Port 1 Port State
7.10.1.4	(o)	Attribute:	Ring Port 2 Port State
8.	(c)	Constraint:	Expected Role = CLIENT
8.1	(m)	Attribute:	Link Down Interval
8.2	(m)	Attribute:	Link Up Interval
8.3	(m)	Attribute:	Link Change Count
8.4	(o)	Attribute:	Ring Port 1 Port State
8.5	(o)	Attribute:	Ring Port 2 Port State
8.6	(m)	Attribute:	BLOCKED state supported (TRUE, FALSE)

SERVICES:

1	(m)	OpsService:	Start MRM
2	(m)	OpsService:	Stop MRM
3	(o)	OpsService:	State Change
4	(m)	OpsService:	Start MRC
5	(m)	OpsService:	Stop MRC
6	(o)	OpsService:	Read MRM
7	(o)	OpsService:	Read MRC

6.2.2 Media redundancy Interconnection template

An MRP Interconnection object is described by the following template:

ASE: **Media redundancy interconnection ASE**

CLASS: **Media redundancy interconnection**

CLASS ID: **not used**

PARENT CLASS: **IEEE Std 802.3, IEEE Std 802.1Q**

ATTRIBUTES:

1.	(m)	Key Attribute:	Interconnection ID
2.	(m)	Attribute:	Interconnection Name
3.	(m)	Attribute:	Interconnection Port ID
4.	(o)	Attribute:	Interconnection Port State
5.	(o)	Attribute:	Interconnection VLAN ID
6.	(o)	Attribute:	Interconnection Mode
7.	(m)	Attribute:	Interconnection Role (MANAGER, CLIENT)
8.	(c)	Constraint:	Interconnection Role = MANAGER
8.1	(m)	Attribute:	Interconnection Topology Change Interval
8.2	(m)	Attribute:	Interconnection Topology Change Repeat Count
8.3	(o)	Attribute:	Interconnection Default Test Interval
8.4	(o)	Attribute:	Interconnection Test Monitoring Count
8.5	(o)	Attribute:	Interconnection Link Status Poll Interval
8.6	(o)	Attribute:	Interconnection Link Status Poll Repeat Count
8.7	(m)	Attribute:	Interconnection Topology State
9.	(c)	Constraint:	Interconnection Role = CLIENT
9.1	(m)	Attribute:	Interconnection Link Down Interval
9.2	(m)	Attribute:	Interconnection Link Up Interval
9.3	(m)	Attribute:	Interconnection Link Change Count
9.4	(m)	Attribute:	Interconnection Link Information

SERVICES:

1	(m)	OpsService:	Start MIM
2	(m)	OpsService:	Stop MIM
3	(o)	OpsService:	Interconnection State Change
4	(m)	OpsService:	Start MIC
5	(m)	OpsService:	Stop MIC
5	(o)	OpsService:	Read MIM
6	(o)	OpsService:	Read MIC

6.3 Attributes

Domain ID

This key attribute defines the redundancy domain representing the ring the MRP object belongs to. It is set to default Domain ID or provided as a unique ID by the engineering team.

Attribute Type: UUID

Domain Name

This attribute defines the redundancy domain representing the ring the Media redundancy object belongs to. It is set to default Domain Name or provided as a unique ID by the engineering team.

Attribute Type: VisibleString[240]

Ring Port 1 ID

This attribute specifies one port of a switch which is assigned as ring port 1 in the redundancy domain referenced by the value of the attribute Domain ID.

Attribute Type: Unsigned16

Ring Port 2 ID

This attribute specifies another port of a switch different from Ring Port 1 ID which is assigned as ring port 2 in the redundancy domain referenced by the value of the attribute Domain ID.

Attribute Type: Unsigned16

VLAN ID

This optional attribute may be used by the MRP object and specifies its VLAN identifier in the redundancy domain.

Attribute Type: Unsigned16

Expected Role

This attribute specifies the role of the MRP object in the redundancy domain.

Attribute Type: Unsigned16

Allowed values: MANAGER (Auto), MANAGER, CLIENT

Manager Priority

This attribute shall contain the priority of the MRM. A lower value indicates a higher priority, 0x0000 (highest priority) to 0xFFFF (lowest priority) in increments of 0x0001.

Attribute Type: Unsigned16

Topology Change Interval

This attribute specifies the interval for sending MRP_TopologyChange frames.

Attribute Type: Unsigned16

Topology Change Repeat Count

This attribute specifies the interval count that controls repeated transmissions of MRP_TopologyChange frames.

Attribute Type: Unsigned16

Short Test Interval

This attribute specifies the short interval for sending MRP_Test frames on ring ports after link changes in the ring.

Attribute Type: Unsigned16

Default Test Interval

This attribute specifies the default interval for sending MRP_Test frames on ring ports.

Attribute Type: Unsigned16

Test Monitoring Count

This attribute specifies the interval count for monitoring the reception of MRP_Test frames.

Attribute Type: Unsigned16

Non-blocking MRC supported

This attribute specifies the ability of the MRM to support MRCs without BLOCKED port state support in the ring.

Attribute Type: Boolean

Test Monitoring Extended Count

This attribute specifies the extended interval count for monitoring the reception of MRP_Test frames.

Attribute Type: Unsigned16

React On Link Change

This optional attribute specifies whether the MRM reacts immediately on MRP_LinkChange frames or not.

Attribute Type: Boolean

Check Media Redundancy

This attribute specifies whether monitoring of MRM state is enabled (TRUE) or disabled (FALSE) in the redundancy domain.

Attribute Type: Boolean

Real Role State

This attribute specifies the current role of the MRP object in the redundancy domain.

Attribute Type: Unsigned16

Allowed values: MANAGER (Auto), MANAGER, CLIENT, UNDEFINED

Real Ring State

This attribute specifies the current ring state of the MRP object in the redundancy domain. The Ring State shall have one of the following values:

OPEN: Ring is open due to link or MRC failure in ring.

CLOSED: Ring is closed (normal operation, no error).

UNDEFINED: Shall be set if the attribute Real Role State contains the value CLIENT (i.e. MRP object was reconfigured to client role).

Attribute Type: Unsigned16

Allowed values: OPEN, CLOSED, UNDEFINED

Ring Port 1 Port State

This optional attribute specifies the current port state of Ring Port 1. The Ring Port 1 state shall be specified in accordance with the Ring port states in 5.2.

Attribute Type: Unsigned16

Allowed values: DISABLED, BLOCKED, FORWARDING

Ring Port 2 Port State

This optional attribute specifies the current port state of Ring Port 2. The Ring Port 2 state shall be specified in accordance with the Ring port states in 5.2.

Attribute Type: Unsigned16

Allowed values: DISABLED, BLOCKED, FORWARDING

Link Down Interval

This attribute specifies the interval for sending MRP_LinkDown frames on ring ports.

Attribute Type: Unsigned16

Link Up Interval

This attribute specifies the interval for sending MRP_LinkUp frames on ring ports.

Attribute Type: Unsigned16

Link Change Count

This attribute specifies the MRP_LinkChange frame count that controls repeated transmission of MRP_LinkChange frames.

Attribute Type: Unsigned16

BLOCKED state supported

This attribute specifies whether the MRC supports the BLOCKED state at its ring ports or not.

Attribute Type: Boolean

Interconnection ID

This key attribute defines the interconnection domain representing the interconnection topology the MRP Interconnection object belongs to. It is provided as a unique ID by the engineering team.

Attribute Type: Unsigned16

Interconnection Name

This attribute specifies the name of the interconnection domain referenced by the value of the attribute Interconnection ID. It is set to a default Interconnection Name or provided as an Interconnection Name by the engineering team.

Attribute Type: VisibleString[240]

Interconnection Port ID

This attribute specifies one port of a switch that is assigned as interconnection port in the interconnection domain referenced by the value of the attribute Interconnection ID.

Attribute Type: Unsigned16

Interconnection Port State

This optional attribute specifies the current port state of the interconnection port. The Interconnection Port state shall be specified in accordance with the Interconnection port states in 5.2.

Attribute Type: Unsigned16

Allowed values: DISABLED, BLOCKED, FORWARDING

Interconnection VLAN ID

This optional attribute may be used by the MRP Interconnection object and specifies its VLAN identifier in the interconnection domain.

Attribute Type: Unsigned16

Interconnection Mode

This attribute specifies the mode of the MRP Interconnection object in the interconnection domain.

LC_MODE: Link check mode. The MIM analyses the ring interconnection state by using the link change notifications of the MICs. MRP_InTest frames are disabled.

RC_MODE: Ring check mode. The MIM analyses the ring interconnection state by sending and receiving MRP_InTest frames. Link change notifications of the MICs may additionally be used to optimize the recovery time.

Attribute Type: Unsigned16

Allowed values: UNDEFINED, LC_MODE, RC_MODE

Interconnection Role

This attribute specifies the role of the MRP Interconnection object in the interconnection domain.

Attribute Type: Unsigned16

Allowed values: MANAGER, CLIENT

Interconnection Topology Change Interval

This attribute specifies the interval for sending MRP_InTopologyChange frames.

Attribute Type: Unsigned16

Interconnection Topology Change Repeat Count

This attribute specifies the interval count that controls repeated transmissions of MRP_InTopologyChange frames.

Attribute Type: Unsigned16

Interconnection Default Test Interval

This attribute specifies the default interval for sending MRP_InTest frames on ring ports and on the interconnection port.

Attribute Type: Unsigned16

Interconnection Test Monitoring Count

This attribute specifies the interval count for monitoring the reception of MRP_InTest frames.

Attribute Type: Unsigned16

Interconnection Link Status Poll Interval

This attribute specifies the interval for sending MRP_InLinkStatusPoll frames.

Attribute Type: Unsigned16

Interconnection Link Status Poll Repeat Count

This attribute specifies the interval count that controls repeated transmissions of MRP_InLinkStatusPoll frames.

Attribute Type: Unsigned16

Interconnection Topology State

This attribute specifies the current interconnection topology state of the MRP Interconnection object in the interconnection domain. The Interconnection Topology State shall have one of the following values:

UNDEFINED: Device has no information (yet) about the Interconnection topology;

OPEN: Interconnection topology is open due to link or MIC failure in the interconnection topology;

CLOSED: Interconnection topology is closed (normal operation, no error).

Attribute Type: Unsigned16

Allowed values: UNDEFINED, OPEN, CLOSED

Interconnection Link Down Interval

This attribute specifies the interval for sending MRP_InLinkDown frames on ring ports.

Attribute Type: Unsigned16

Interconnection Link Up Interval

This attribute specifies the interval for sending MRP_InLinkUp frames on ring ports.

Attribute Type: Unsigned16

Interconnection Link Change Count

This attribute specifies the MRP_InLinkChange frame count that controls repeated transmission of MRP_InLinkChange frames.

Attribute Type: Unsigned16

Interconnection Link Information

This attribute specifies the MRP_InLinkChange frame's additional information, such as whether issued by the primary or secondary link and the reason for the state change.

Attribute Type: Unsigned16

7 MRP Service specification

7.1 Start MRM

The Start MRM service creates a local instance of the MRM protocol machine.

Table 2 shows the parameters of the service.

Table 2 – MRP Start MRM

Parameter name	Req	Cnf
Argument	M	
Domain ID	M	
Ring Port 1 ID	M	
Ring Port 2 ID	M	
VLAN ID	U	
Manager Priority	U	
Topology Change Interval	U	
Topology Change Repeat Count	U	
Short Test Interval	U	
Default Test Interval	U	
Test Monitoring Count	U	
Non-blocking MRC supported	U	
Test Monitoring Extended Count	U	
React On Link Change	U	
Check Media Redundancy	U	
Result(+)		S
Domain ID		M
Result(-)		S
Domain ID		M
Error Code		M
The meaning of Req, Cnf, M, U and S is specified in ISO/IEC 10164-1.		

Argument

The argument shall convey the service-specific parameters of the service request.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Ring Port 1 ID

This parameter contains the ID of the port that serves as first ring port.

Ring Port 2 ID

This parameter contains the ID of the port that serves as second ring port.

VLAN ID

This optional parameter contains the value for the VLAN identifier.

Manager Priority

This parameter contains the value for the manager priority.

Topology Change Interval

This parameter contains the value of the interval for sending MRP_TopologyChange frames.

Topology Change Repeat Count

This parameter contains the value of the interval count that controls repeated transmissions of MRP_TopologyChange frames.

Short Test Interval

This parameter contains the value of the short interval for sending MRP_Test frames on ring ports after link changes in the ring.

Default Test Interval

This parameter contains the value of the default interval for sending MRP_Test frames on ring ports.

Test Monitoring Count

This parameter contains the value of the interval count for monitoring the reception of MRP_Test frames.

Non-blocking MRC supported

This parameter specifies the ability of the MRM to support MRCs without BLOCKED port state support in the ring.

Test Monitoring Extended Count

This optional parameter contains the value of the extended interval count for monitoring the reception of MRP_Test frames.

React On Link Change

This optional parameter specifies whether the MRM reacts on MRP_LinkChange frames or not.

Check Media Redundancy

This parameter selects whether monitoring of MRM state is enabled or disabled.

Result(+)

This parameter indicates that the service request succeeded.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Result(-)

This parameter indicates that the service request failed.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Error Code

The parameter Result contains the error code of the specific error.

Type: Unsigned16

Allowed values: DOMAIN_ID_MISMATCH, ROLE_NOT_SUPPORTED, INVALID_RINGPORT

7.2 Stop MRM

This service shall be used to stop the MRM protocol machine. Ring port states and switch functionality remain.

Table 3 shows the parameters of the service.

Table 3 – MRP Stop MRM

Parameter name	Req	Cnf
Argument	M	
Domain ID	M	
Result(+)		S
Domain ID		M
Result(-)		S
Domain ID		M
Error Code		M
The meaning of Req, Cnf, M and S is specified in ISO/IEC 10164-1.		

Argument

The argument shall convey the service specific parameters of the service request.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Result(+)

This parameter indicates that the service request succeeded.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Result(-)

This parameter indicates that the service request failed.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Error Code

The parameter Result contains the error code of the specific error.

Type: Unsigned16

Allowed values: DOMAIN_ID_MISMATCH

7.3 State Change

This service shall be used to indicate a change of the MRP domain state.

Table 4 shows the parameters of the service.

Table 4 – MRP Change State

Parameter name	Ind
Argument	M
Domain ID	M
Error Type List	M
The meaning of Ind and M is specified in ISO/IEC 10164-1.	

Argument

The argument shall convey the service-specific parameters of the service request.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Error Type List

This attribute consists of the following elements:

Error Type

This attribute identifies a media redundancy error.

Attribute Type: Unsigned16

Allowed values: MANAGER_ROLE_FAIL, RING_OPEN, MULTIPLE_MANAGERS

Appear

This attribute identifies whether the error appears or disappears.

Attribute Type: Boolean

Allowed values: TRUE, FALSE

7.4 Start MRC

The Start MRC service creates an instance of the MRC protocol machine.

Table 5 shows the parameters of the service.

Table 5 – MRP Start MRC

Parameter name	Req	Cnf
Argument	M	
Domain ID	M	
Ring Port 1 ID	M	
Ring Port 2 ID	M	
VLAN ID	U	
Link Down Interval	U	
Link Up Interval	U	
Link Change Count	U	
BLOCKED state supported	U	
Result(+)		S
Domain ID		M
Result(-)		S
Domain ID		M
Error Code		M
The meaning of Req, Cnf, M, U and S is specified in ISO/IEC 10164-1.		

Argument

The argument shall convey the service-specific parameters of the service request.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Ring Port 1 ID

This parameter contains the ID of the port that serves as first ring port.

Ring Port 2 ID

This parameter contains the ID of the port that serves as second ring port.

VLAN ID

This optional parameter contains the value for the VLAN identifier.

Link Down Interval

This parameter contains the value of the interval for sending MRP_LinkDown frames on ring ports.

Link Up Interval

This parameter contains the value of the interval for sending MRP_LinkUp frames on ring ports.

Link Change Count

This parameter contains the value of the MRP_LinkChange frame count that controls repeated transmissions of MRP_LinkUp or MRP_LinkDown frames.

BLOCKED state supported

This parameter specifies whether the MRC supports the BLOCKED state at its ring ports or not.

Result(+)

This parameter indicates that the service request succeeded.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Result(-)

This parameter indicates that the service request failed.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Error Code

The parameter Result contains the error code of the specific error.

Type: Unsigned16

Allowed values: DOMAIN_ID_MISMATCH, ROLE_NOT_SUPPORTED, INVALID_RINGPORT

7.5 Stop MRC

This service shall be used to stop the MRC protocol machine. Ring port states and switch functionality remain. Table 6 shows the parameters of the service.

Table 6 – MRP Stop MRC

Parameter name	Req	Cnf
Argument	M	
Domain ID	M	
Result(+)		S
Domain ID		M
Result(-)		S
Domain ID		M
Error Code		M
The meaning of Req, Cnf, M and S is specified in ISO/IEC 10164-1.		

Argument

The argument shall convey the service-specific parameters of the service request.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Result(+)

This parameter indicates that the service request succeeded.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Result(-)

This parameter indicates that the service request failed.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Error Code

The parameter Result contains the error code of the specific error.

Type: Unsigned16

Allowed values: DOMAIN_ID_MISMATCH

7.6 Read MRM

The optional Read MRM service reads the current state of the MRM protocol machine.

Table 7 shows the parameters of the service.

Table 7 – MRP Read MRM

Parameter name	Req	Rsp
Argument	M	
Domain ID	M	
Result(+)		S
Domain ID		M
Ring Port 1 ID		M
Ring Port 2 ID		M
VLAN ID		U
Manager Priority		M
Check Media Redundancy		M
Real Role State		M
Real Ring State		M
Ring Port 1 Port State		U
Ring Port 2 Port State		U
Topology Change Interval		U
Topology Change Repeat Count		U
Short Test Interval		U
Default Test Interval		U
Test Monitoring Count		U
Non-blocking MRC supported		U
Test Monitoring Extended Count		U
React On Link Change		U
Result(-)		S
Domain ID		M
Error Code		M
The meaning of Req, Rsp, M, U and S is specified in ISO/IEC 10164-1.		

Argument

The argument shall convey the service-specific parameters of the service request.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Result(+)

This parameter indicates that the service request succeeded.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Ring Port 1 ID

This parameter contains the ID of the port which serves as first ring port.

Ring Port 2 ID

This parameter contains the ID of the port which serves as second ring port.

VLAN ID

This optional parameter contains the value for the VLAN identifier.

Manager Priority

This parameter contains the value for the manager priority.

Check Media Redundancy

This parameter indicates whether monitoring of MRM is enabled or disabled

Topology Change Interval

This parameter contains the value of the interval for sending MRP_TopologyChange frames.

Topology Change Repeat Count

This parameter contains the value of the interval count that controls repeated transmission of MRP_TopologyChange frames.

Short Test Interval

This parameter contains the value of the short interval for sending MRP_Test frames on ring ports after link changes in the ring.

Default Test Interval

This parameter contains the value of the default interval for sending MRP_Test frames on ring ports.

Test Monitoring Count

This parameter contains the value of the interval count for monitoring the reception of MRP_Test frames.

Non-blocking MRC supported

This parameter contains the ability of the MRM to support the MRC without BLOCKED port state support in the ring.

Test Monitoring Extended Count

This optional parameter contains the value of the extended interval count for monitoring the reception of MRP_Test frames.

Real Role State

This attribute contains the current role of the MRP object in the redundancy domain.

Real Ring State

This attribute contains the current ring state of the MRP object in the redundancy domain.

Ring Port 1 Port State

This optional attribute contains the current port state of Ring Port 1.

Ring Port 2 Port State

This optional attribute contains the current port state of Ring Port 2.

React On Link Change

This optional parameter contains whether the MRM reacts on MRP_LinkChange frames or not.

Result(-)

This parameter indicates that the service request failed.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Error Code

The parameter Result contains the error code of the specific error.

Type: Unsigned16

Allowed values: DOMAIN_ID_MISMATCH, MANAGER_READ_FAIL

7.7 Read MRC

The optional Read MRC service reads the current state of the MRC protocol machine.

Table 8 shows the parameters of the service.

Table 8 – MRP Read MRC

Parameter name	Req	Rsp
Argument	M	
Domain ID	M	
Result(+)		S
Domain ID		M
Ring Port 1 ID		M
Ring Port 2 ID		M
VLAN ID		U
Ring Port 1 Port State		U
Ring Port 2 Port State		U
Link Down Interval		U
Link Up Interval		U
Link Change Count		U
BLOCKED state supported		U
Result(-)		S
Domain ID		M
Error Code		M
The meaning of Req, Rsp, M, U and S is specified in ISO/IEC 10164-1.		

Argument

The argument shall convey the service-specific parameters of the service request.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Result(+)

This parameter indicates that the service request succeeded.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Ring Port 1 ID

This parameter contains the ID of the port which serves as first ring port.

Ring Port 2 ID

This parameter contains the ID of the port which serves as second ring port.

VLAN ID

This optional parameter contains the value for the VLAN identifier.

Link Down Interval

This parameter contains the value of the interval for sending MRP_LinkDown frames on ring ports.

Link Up Interval

This parameter contains the value of the interval for sending MRP_LinkUp frames on ring ports.

Link Change Count

This parameter contains the value of the MRP_LinkChange frame count which controls repeated transmission of MRP_LinkUp or MRP_LinkDown frames.

Ring Port 1 Port State

This optional attribute contains the current port state of Ring Port 1.

Ring Port 2 Port State

This optional attribute contains the current port state of Ring Port 2.

BLOCKED state supported

This parameter specifies whether the MRC supports BLOCKED state at its ring ports or not.

Result(-)

This parameter indicates that the service request failed.

Domain ID

This is the key attribute to identify the instance of the protocol machine.

Error Code

The parameter Result contains the error code of the specific error.

Type: Unsigned16

Allowed values: DOMAIN_ID_MISMATCH, CLIENT_READ_FAIL

7.8 Start MIM

The Start MIM service creates a local instance of the MIM protocol machine.

Table 9 shows the parameters of the service.