IEC 62439-6

Edition 1.0 2010-02

INTERNATIONAL STANDRAD

Industrial communication networks–High availability networks–

Part6:Distributed Redundancy Protocol (DRP)

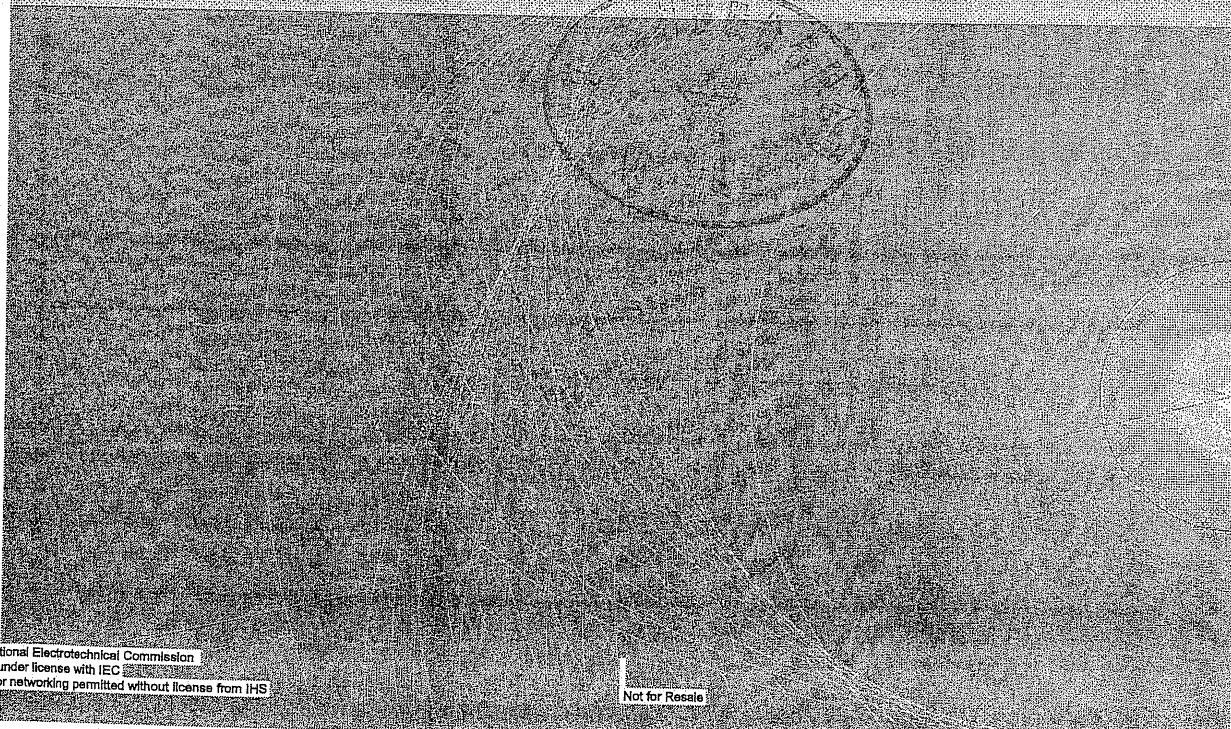
IEC 62439-6

Edition 1.0 2010-02

INTERNATIONAL STANDARD

colour inside

Industrial communication networks – High availability automation networks – Part 6: Distributed Redundancy Protocol (DRP)



IEC 62439-6:2010(E)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub
The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub
Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv
If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

IEC 62439-6

Edition 1.0 2010-02

INTERNATIONAL STANDARD

colour inside

Industrial communication networks – High availability automation networks – Part 6: Distributed Redundancy Protocol (DRP)

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE XB

ICS 25.040, 35.040

ISBN 2-8318-1081-6

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

INDUSTRIAL COMMUNICATION NETWORKS – HIGH AVAILABILITY AUTOMATION NETWORKS –

Part 6: Distributed Redundancy Protocol (DRP)

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.

International Standard 62439-6 has been prepared by subcommittee 65C: Industrial Networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

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

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

- adding a calculation method for RSTP (rapid spanning tree protocol, IEEE 802.1Q),
- adding two new redundancy protocols: HSR (High-availability Seamless Redundancy) and DRP (Distributed Redundancy Protocol),
- moving former Clauses 1 to 4 (introduction, definitions, general aspects) and the Annexes (taxonomy, availability calculation) to IEC 62439-1, which serves now as a base for the other documents,
- moving Clause 5 (MRP) to IEC 62439-2 with minor editorial changes,
- moving Clause 6 (PRP) was to IEC 62439-3 with minor editorial changes,

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

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

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

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

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

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

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

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

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

A bilingual version of this standard may be issued at a later date.

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 publication 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 8802-3 (IEEE 802.3) compatible, reliable data communication, and preserve determinism of real-time data communication. In cases of fault, removal, and insertion of a component, they provide deterministic recovery times.

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

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

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

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning about the communication procedure and fault detection and recovery for DRP given in 5.2 and 5.3.

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

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

SUPCON Group Co., Ltd & Zhejiang University
Hangzhou
China

Beijing Kyland Technology Co. LTD
No 95 Building
Southeast Corner of Xisanqi Bridge
Haidian
Beijing
China

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

ISO (www.iso.org/patents) and IEC (http://www.iec.ch/tctools/patent_decl.htm) maintain on-line data bases of patents relevant to their standards. Users are encouraged to consult the data bases for the most up to date information concerning patents.

INDUSTRIAL COMMUNICATION NETWORKS – HIGH AVAILABILITY AUTOMATION NETWORKS –

Part 6: Distributed Redundancy Protocol (DRP)

1 Scope

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

This part of the IEC 62439 series specifies a 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. Each switch has equal management role in the network. Double rings are supported.

2 Normative references

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

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

IEC 61158 (all parts), *Industrial communication networks – Fieldbus specifications*

IEC 61588:2009, *Precision clock synchronization protocol for networked measurement and control systems* (IEEE 1588)

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

ISO/IEC/TR 8802-1, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 1: Overview of Local Area Network Standards Technologies de* (IEEE 802.1)

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

IEEE 802.1D:2004, *IEEE standard for local Local and metropolitan area networks Media Access Control (MAC) Bridges*

IEEE 802.1Q, *IEEE standards for local and metropolitan area network. Virtual bridged local area networks*

3 Terms, definitions, abbreviations, acronyms, and conventions

3.1 Terms and definitions

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

3.1.1
active ring port
ring port which is connected in the ring network and works in Blocking or Forwarding state

3.1.2
cycle
shortest time interval after which the communication traffic pattern repeats itself

3.1.3
standby ring port
ring port which is connected in the ring network and works in the Disabled state

3.1.4
time offset
time difference from a specially designated time

3.2 Abbreviations and acronyms

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

3.3 Conventions

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

4 Overview

4.1 Principles

The Distributed Redundancy Protocol (DRP) defines a high availability network solution based on ISO/IEC 8802-3 (IEEE 802.3) and the functions of ISO/IEC/TR 8802-1 (IEEE 802.1) for communication link redundancy.

DRP provides a framework for describing the operational behaviour of the switches in a ring topology to detect a single network failure (such as an inter-switch link failure or a ring switch failure) and recover from it within a deterministic recovery time.

A DRP network has a ring topology with multiple switch nodes, each of which may be a switch or a switching end node. Each node requires an integrated switch with at least two ports (ring ports) connected to the ring, and which is able to detect and recover from failures in accordance with the DRP protocol.

Each node has equal management role in a DRP ring network. It means that each node observes and controls the ring topology by multicasting a ring test frame RingCheck and an inter-switch link test frame LinkCheck cyclically, and reacts on network faults. The LinkCheck test frame provides the mechanism to detect the failure of a switch node.

In a DRP network, each switch node is synchronized using IEC 61588 (IEEE 1588) with either boundary clock or transparent clock according to the application.

NOTE Typically, boundary clock is used according to IEC 61588 (IEEE 1588). In larger-scale application, the transparent clock should be used for better time synchronization.

Optionally, DRP supports double ring topology redundancy. In this case, each switch node shall have at least two pairs of ring ports: one pair of active ring ports and one pair of standby ring ports.

The DRP defines a service entity and a protocol entity, as well as a set of management frames. The service entity specifies the externally visible services for application layer and systems management. The communication model for DRP is shown in Figure 1.

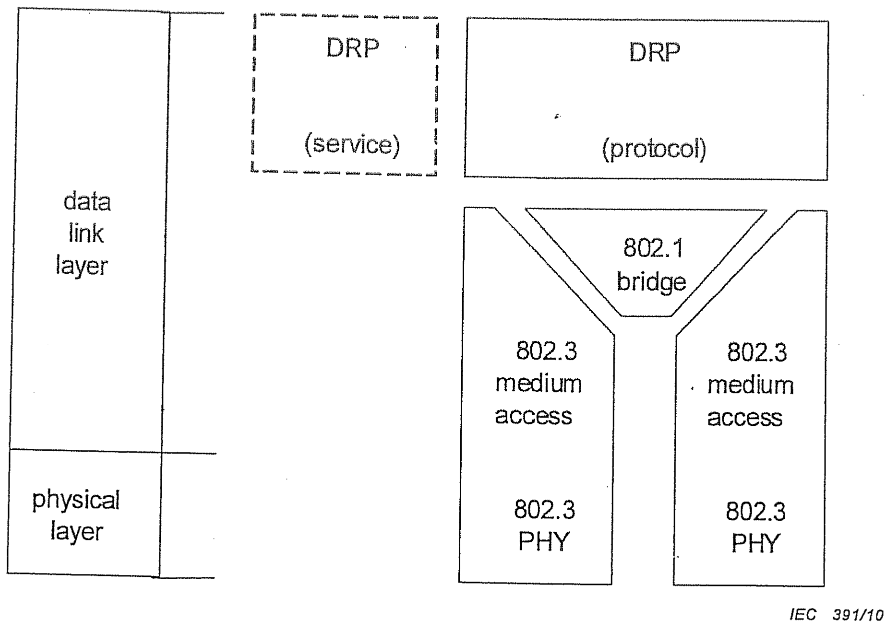


Figure 1 – DRP communication model

4.2 Ring ports

Each switch node shall have at least two ring ports connected to the ring network.

Some switch nodes in addition to the ring ports can have one or more non ring ports including leaf link ports. In such cases, the DRP frames (for example RingCheck, LinkCheck, LinkAlarm, LinkChange, DeviceAnnunciation and RingChange) shall not be forwarded to non-ring ports.

The ring ports which support DRP protocol shall have three states as follows:

a) Disabled
   - All frames shall be dropped.

b) Blocking

   All frames shall be dropped except the following:
   - DRP frames, such as RingCheck frame, LinkCheck frame, LinkAlarm frame, LinkChange frame, DeviceAnnunciation frame, RingChange frame.
   - Frames specified in IEEE 802.1D (2004) Table 7-10 to pass ports in "Discarding" state (e.g. LLDP, IEC 61588 (IEEE 1588) PTP).
   - Frames only produced or consumed by the higher layer entities of this node and never forwarded.

c) Forwarding:

All frames shall be passed through according to the forwarding behaviour of IEEE 802.1D.

4.3 DRP switch node

The communication roles of all switch nodes are equal in the DRP ring. Each switch node may be a switch or a switching end node.

Each switch node has the equal right to periodically multicast ring fault detection frame RingCheck and inter-switch link fault detection frame LinkCheck in both directions of the ring at the scheduled time.

4.4 Single ring topology redundancy

Each switch node shall have two ring ports connected to the ring network, which are called active ports (as shown in Figure 2).

In a DRP single ring network, only one active ring port operates in the Blocking state while all other ring ports operate in the Forwarding state. That is, only one switch node sets one of its active ring ports into the Blocking state, the other active ring port of this node is set into the Forwarding state. All other switch nodes set the two active ring ports into the Forwarding state.

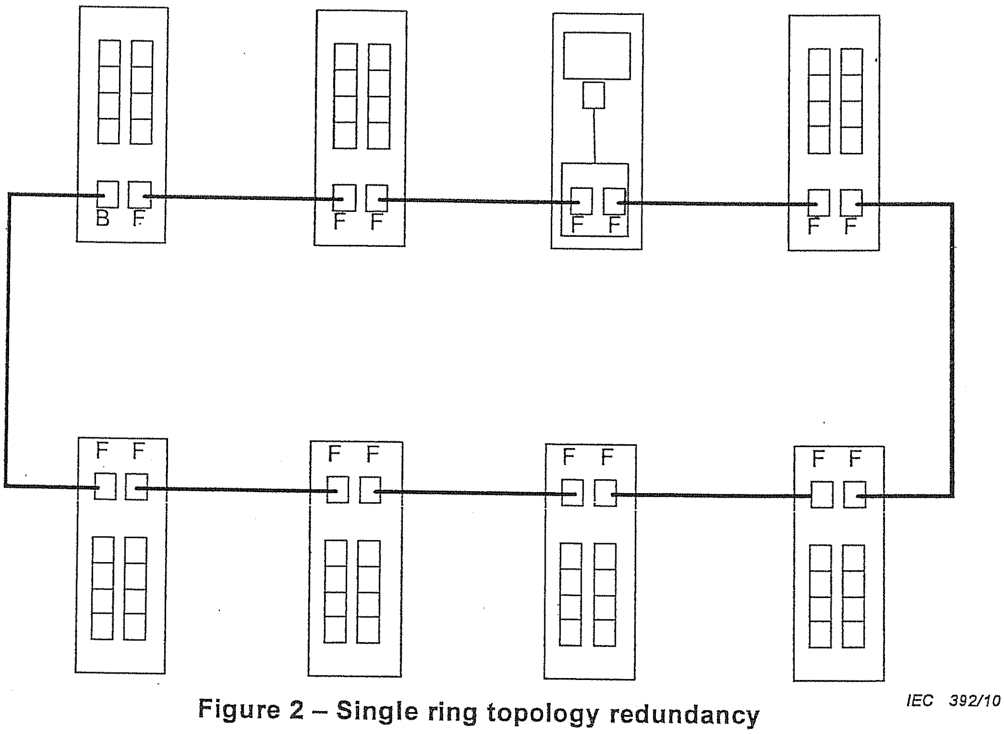


Figure 2 – Single ring topology redundancy

4.5 Double ring topology redundancy

As shown in Figure 3, each switch node shall have at least two pairs of ring ports connected to the ring network. One pair of ring ports is active (for example the ports in Ring1) while the other pair of ring ports is standby (for example the ports in Ring2).

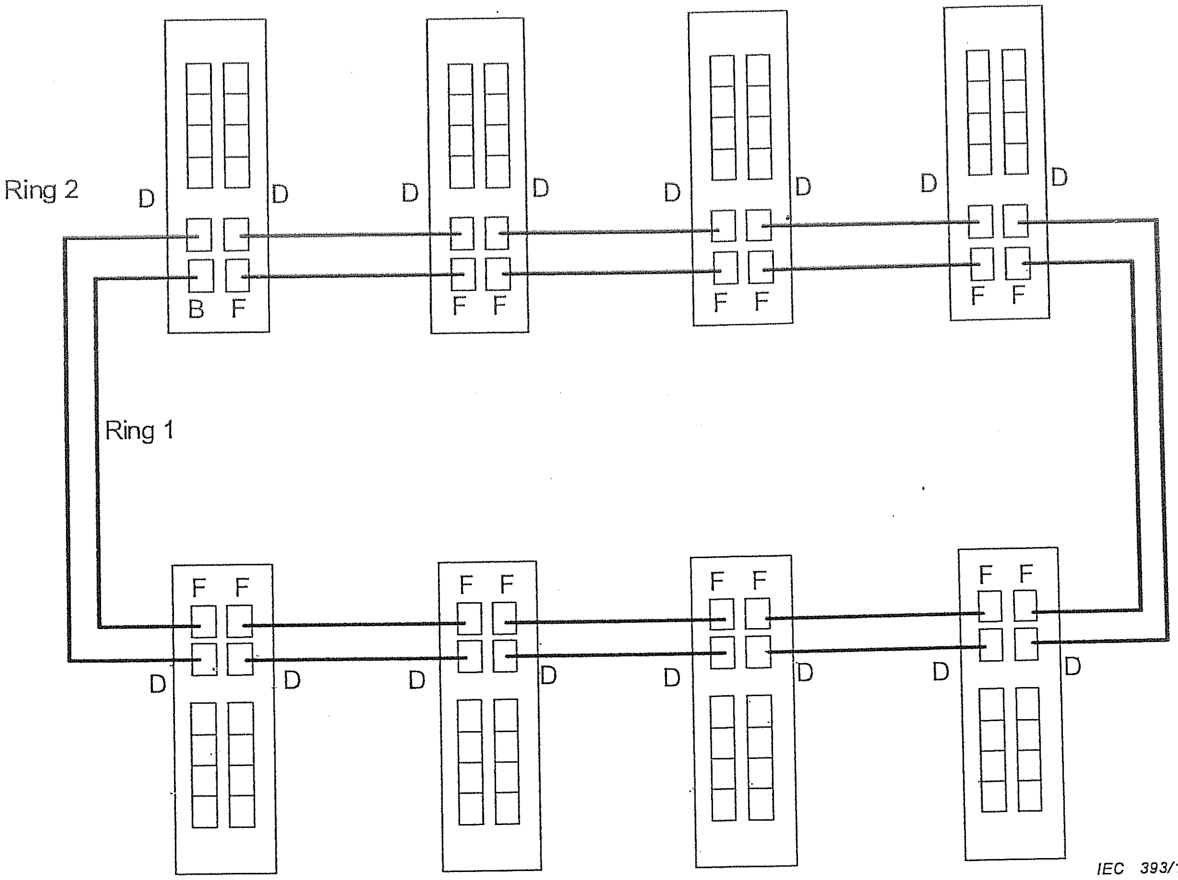


Figure 3 – Double ring topology redundancy

In a DRP double ring network, only one switch node sets one of its active ring ports into Blocking state, the other active ring port into the Forwarding state and the two standby ring ports into the Disabled state.

4.6 Configuration

4.6.1 Overview

Before the switch node is connected in a DRP network, it shall be configured using configuration software using the DRP Write service. The configuration shall include manufacturer configuration, communication configuration, and application configuration.

4.6.2 Manufacturer configuration

Manufacturer configuration includes the preset of DeviceID, ManufacturerName, DRPVersion, SoftwareVersion, HardwareVersion, Device MAC Address.

Manufacturer configuration information shall be downloaded in a DRP device only when it is manufactured, and it may be uploaded using the Read service.

4.6.3 Communication configuration

Communication configuration includes the preset of states of standby ring ports, Cycle, Ring Check SendTimeOffset, Ring Check Time Limit, Link Check SendTimeOffset, Link Check Time Limit, SynchronizationClockType, DRPSequenceID, DRPDeviceNumber.

For a single ring network, each switch node shall initialize one active ring port in the Blocking state, and the other ring port in the Forwarding state as described in 4.7.

For a double ring network, the two standby ring ports shall be set to the Disabled state.

Communication configuration information shall be written into a switch node using a Write service. It can be read from a switch node using the Read service.

4.6.4 Application configuration

Application configuration includes the preset of DRP Domain ID, PD-Tag, VLAN ID, Ring1 Port1 ID, Ring1 Port2 ID, Ring2 Port1 ID, Ring2 Port2 ID, SynchronizationClockType.

Application configuration information shall be downloaded into the switch node using Write service. It can be uploaded using Read service.

4.7 Start up

When powered on, each switch node shall initialize one active ring port in the Blocking state and the other ring port in the Forwarding state. Each switch node shall be synchronized using IEC 61588 (IEEE 1588) protocol (see 6.6 and 9.3 in IEC 61588 (IEEE 1588)).

If a switch node has not received any RingCheck frame in Ring Check Time Limit, and this switch node is directly connected to the grandmaster clock outside of the ring as defined in IEC 61588 (IEEE 1588), the switch node shall set the value of DRPDeviceNumber and the value of DRPSequenceID to 0x01, and send the RingCheck frame immediately.

When the value of Cycle is 0xFFFF FFFF FFFF FFFF, the switch node shall not transmit any DRP frames. Otherwise, it shall send the DeviceAnnunciation and the LinkCheck frames according to the communication configuration.

When the DRP system reaches steady state, only the switch node with the smallest DRPSequenceID will keep one ring port in the Blocking state.

5 DRP communications

5.1 Overview

In a DRP redundant network, the communication time is divided into several Cycles, marked as Cycle as shown in Figure 4. Where $t_{RingCheck}$ is the time offset for sending the RingCheck frame while $t_{LinkCheck}$ is the time offset for sending the LinkCheck frame.

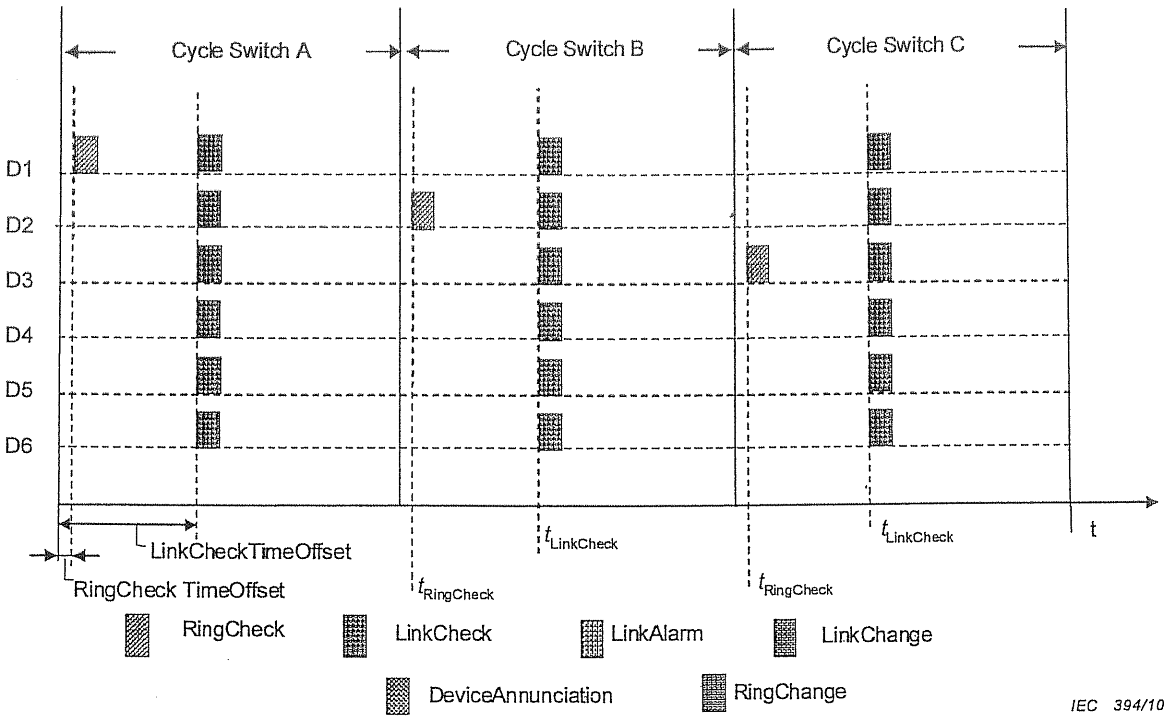


Figure 4 – DRP communication procedure

Within one Cycle, only one switch node multicasts the RingCheck frame to test the ring state at time $t_{RingCheck}$, while each switch node multicasts the LinkCheck frame to its two neighbour switch nodes at time $t_{LinkCheck}$ to test the operation state of all inter-switch links and switch nodes (see 5.3).

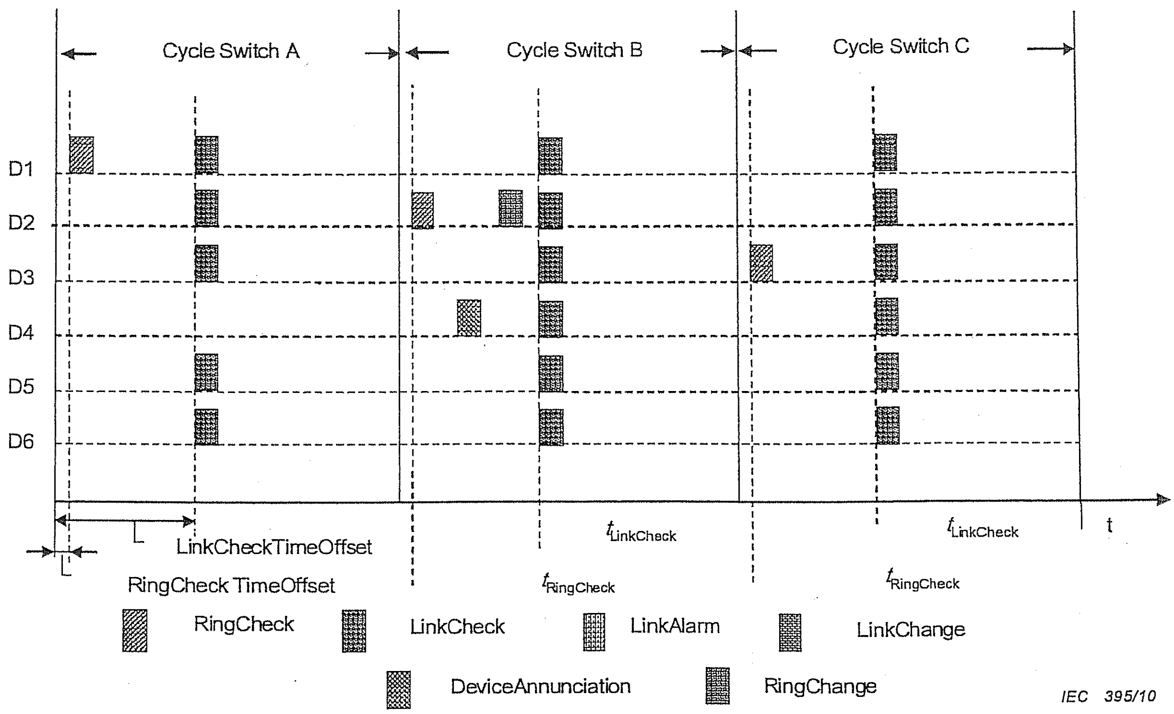


Figure 5 – Inserting a new switch node into the DRP system

As shown in Figure 5, a new switch node (D4) is inserted into the DRP system. The DeviceAnnunciation frame is sent by this new switch node as a multicast out of the two active ring ports. And the switch node multicasts the RingChange frame in its Cycle to all the switch nodes in the DRP system (see 5.7).

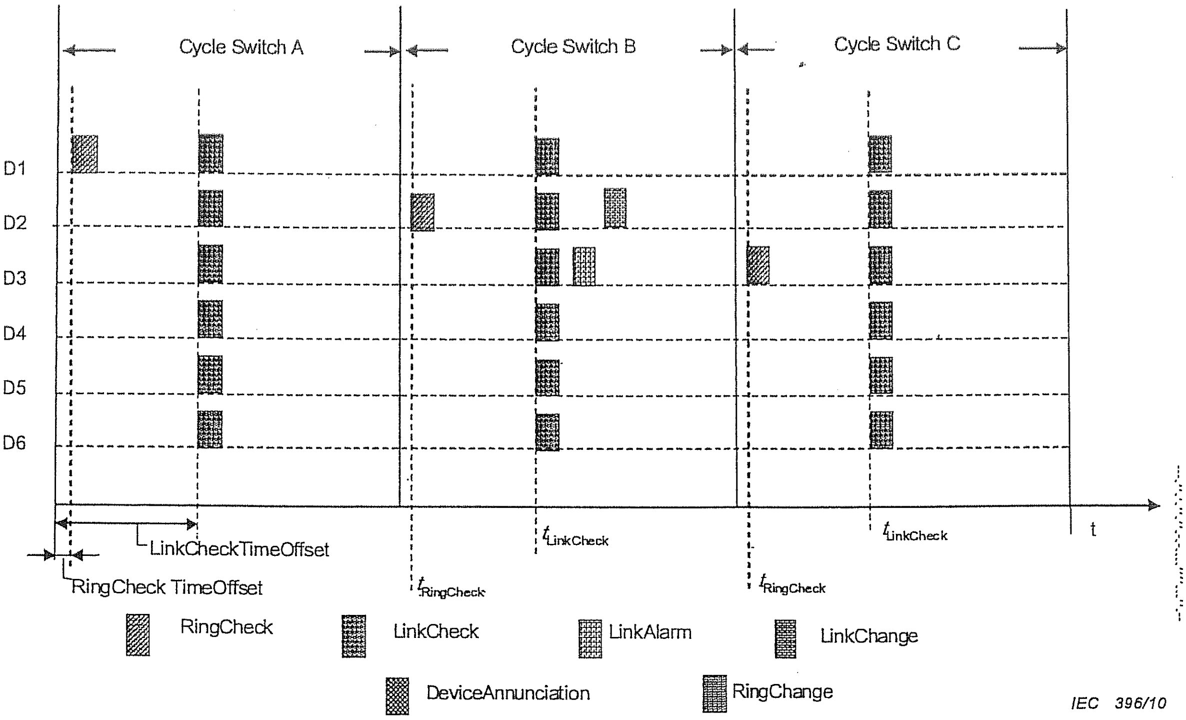


Figure 6 – Fault detection and recovery

As shown in Figure 6, fault is detected by a switch node (D3) in the DRP system. The LinkAlarm frame is sent by this switch node as a multicast out of the two active ring ports. And the switch node multicasts the LinkChange frame in its Cycle to all the switch nodes in the DRP system (see 5.3).

5.2 Communication procedure

In a DRP network system, each switch node shall operate as follows (see also Figure 7, Figure 8 and Figure 9):

a) When a switch node powers on, it shall initialize the states of its two active ring ports: the state of Ring1Port1 shall be Blocking while Ring1Port2 shall be Forwarding. If this switch node has standby ring ports, it shall set them into the Disabled state. After initialization, it shall wait to synchronize its local current time using IEC 61588 (IEEE 1588) protocol. No DRP frames shall be sent by this switch node before its local time is synchronized.

b) After time synchronization, the switch node shall check the configuration information.

  1) The parameters DRPDeviceNumber, DRPSequenceID, Ring Check SendTimeOffset, Link Check SendTimeOffset are defined in Clause 6. These parameters are configured by the end user or set by the RingChange frame. If any value of DRPDeviceNumber, DRPSequenceID or Cycle is the default value, that means, the local switch node is unconfigured, the switch node shall set all of them to the default value. And then do the following within the time Required Recovery Time from time synchronized.

     i) if a RingCheck frame has been received, the switch node shall send the DeviceAnnunciation frame immediately.

     ii) otherwise, the switch node shall send the LinkAlarm frame to request a new configuration.

  2) otherwise, it shall take no further actions.

c) After the configuration check, the switch node shall calculate when to send the RingCheck frames using the following algorithm:

If the following condition is met:

MOD (Local current time, (DRPDeviceNumber*Cycle)) ==

(DRPSequenceID-1)* *Cycle*+ Ring Check SendTimeOffset (1)

then it is time $t_{RingCheck}$ to send the RingCheck frame as a multicast out of the two active ring ports.

The switch which send the RingCheck frame shall do the following within the time Ring Check Time Limit from the RingCheck sending time $t_{RingCheck}$,

1) if the sent RingCheck frame itself has been received, it shall stop forwarding this RingCheck frame and take no further actions;
2) otherwise, it shall send the LinkAlarm frame to record the ring fault.

d) if the following condition is met:

MOD (Local current time, Cycle) == Ring Check SendTimeOffset (2)

then it is time that one switch node shall send the LinkCheck frame. The local switch node shall do the following within the time Ring Check Time Limit from this time if it's not its Cycle.

1) if a RingCheck frame has been received from one active ring port (for example Ring1Port1), set the corresponding bit in DRPDeviceState, and check if the communication configuration information in the RingCheck frame is equal to the local switch node.
   i) if the DRPDeviceNumber in the RingCheck frame is not equal to the local switch node, or the DRPSequenceID in the RingCheck frame is equal to the DRPSequenceID in the local switch node, the local switch node shall return the communication configuration to the default values and send the DeviceAnnunciation frame immediately.
   ii) otherwise, check if the RingCheck frame was sent by a switch node with one Blocking ring port:
      - if none of the ring port states in the RingCheck frame is Blocking, it shall take no further actions;
      - otherwise, the switch node shall check the local DRPSequenceID.
         – if local DRPSequenceID is smaller than that in the RingCheck frame, the switch node shall take no further actions;
         – otherwise, the switch node shall change the local Blocking ring port state to the Forwarding state.
2) if no RingCheck frame has been received, clear the corresponding bit in DRPDeviceState.

e) After the DeviceAnnunciation frame is received, the switch node shall check if this frame was sent by the node itself, that is:

1) if the DeviceAnnunciation frame was sent by the node itself, the switch node shall stop forwarding the DeviceAnnunciation frame;
2) otherwise, the switch node shall check if the DeviceAnnunciation frame is received during its Cycle:
   i) if the DeviceAnnunciation frame is not received during its Cycle, the switch node shall take no further actions;

ii) otherwise, the switch node shall assign an unused DRPSequenceID to the new switch node. Check if the new assigned DRPsequenceID is larger than current DRPDeviceNumber.

- if the DRPsequenceID assigned is larger than current DRPDeviceNumber, the switch node shall increment the DRPDeviceNumber by 1, and send the RingChange frame as a multicast out of the two active ring ports.
- otherwise, send the RingChange frame as a multicast out of the two active ring ports.

f) After the RingChange frame is received, the switch node shall check if this frame was sent by the node itself, that is:

1) if the RingChange frame was sent by the node itself, the switch node shall stop forwarding the RingChange frame;

2) otherwise, the switch node shall set the local DRPDeviceNumber to the value of DRPDeviceNumber in the received frame. And check if the local DRPSequenceID is 0x00 and the local MAC address is equal to the RingChange frame.

i) if the local switch is the one to be configured, set the local DRPSequenceID to the values in the received frame.

ii) otherwise, it shall take no further actions.

g) if the following condition is met:

$$\text{MOD (Local current time, Cycle)} == \text{Link Check SendTimeOffset} \quad (3)$$

Then it is time $t_{\text{LinkCheck}}$ to send the LinkCheck frame as a multicast out of the two active ring ports.

The switch which sent the LinkCheck frame shall do the following within the time Link Check Time Limit from the LinkCheck sending time $t_{\text{LinkCheck}}$,

1) if the switch node has received the LinkCheck frames from both its active ring ports, it shall take no further actions;

2) if the switch node has not received the LinkCheck frame from one ring port (for example Ring1Port1), it means that either the inter-switch link is faulty or the neighbour switch connected on this ring port is faulty, then

i) if the switch node is operating in a single ring network, it shall clear its FDB, and set this ring port (Ring1Port1) to the Blocking state. If another ring port (Ring1Port2) of this switch node operates in the Blocking state, it shall switch the states of both active ring ports immediately;

ii) if the switch node is operating in a double ring network, it shall clear its FDB and then check the corresponding standby ring port (for example Ring2Port1),

- if its corresponding standby ring port (Ring2Port1) link is up, the switch shall set this standby ring port (Ring2Port1) state from the Disabled to the original state of the broken active ring port (Ring1Port1), and put the broken active ring port (Ring1Port1) into the Disabled state;
- if its corresponding standby ring port (Ring2Port1) link is down, the switch shall set the broken ring port (Ring1Port1) to the Blocking. Then it shall send the LinkAlarm frame as a multicast out of the two active ring ports.

3) if the switch node has not received LinkCheck frames from either of the ring ports, it means that the switch is not connected to the ring anymore,

i) if the switch node is operating in a single ring network, it shall clear its own FDB, and set both its ring ports (Ring1Port1) to the Blocking state;

ii) if the switch node is operating in a double ring network, it shall clear its FDB and then check the corresponding standby ring port (for example Ring2Port1),

- if its corresponding standby ring port (Ring2Port1) link is up, the switch shall set this standby ring port (Ring2Port1) state from the Disabled to the original state of the broken active ring port (Ring1Port1), and put the broken active ring port (Ring1Port1) into the Disabled state;

- if its corresponding standby ring port (Ring2Port1) link is down, the switch shall set the broken ring port (Ring1Port1) to the Blocking. Then it shall send the LinkAlarm frame as a multicast out of the two active ring ports.

NOTE When the local switch detects an inter-switch link fault, the neighbour switch takes the corresponding actions to recover the fault.

h) After the LinkAlarm frame is received, the switch node shall check if the LinkAlarm frame was sent by the node itself: if yes, the switch node shall not forward this LinkAlarm frame; otherwise the switch node shall clear its own FDB and forward this LinkAlarm to another ring port, and

   1) if local switch node has not detected any inter-switch link or neighbour switch fault, it shall set both ring ports to the Forwarding state;

   2) if local switch node has not detected any inter-switch link or neighbour switch fault, and has a Blocking ring port, it shall change this ring port from the Blocking state into the Forwarding state;

   3) if local switch node has detected an inter-switch link fault or a neighbour switch fault, and has a Blocking ring port, then

      i) if its DRPSequenceID is smaller than the one in the LinkAlarm frame, it shall take no action;

      ii) otherwise, the local switch node shall set the Blocking ring port to the Forwarding state.

i) During its Cycle, the switch node shall check the number of the LinkAlarm frames received,

   1) if local switch node received two LinkAlarm frames during its Cycle, it shall put the smaller DRPSequenceID from the two LinkAlarm frames into the LinkChange frame and shall send this LinkChange frame as a multicast out of the two active ring ports;

   2) if local switch node received only one LinkAlarm frame during its Cycle, it shall put the DRPSequenceID from the LinkAlarm frame into the LinkChange frame and shall send this LinkChange frame as a multicast out of the two active ring ports;

j) After the LinkChange frame is received, the switch node shall check if this LinkChange frame was sent by the node itself, that is:

   1) if the LinkChange frame was sent by the node itself, the switch node shall stop forwarding the LinkChange frame;

   2) otherwise, the switch node shall forward the LinkChange frame, and then check,

      does it have a Blocking ring port,

      i) if the switch node does not have a Blocking ring port, the switch node shall take no further action;

      ii) otherwise, the switch node shall check the local DRPSequenceID,

         - if the local DRPSequenceID is equal to the BLOCKINGPORT_DRPSequenceID in this LinkChange frame, the switch node shall take no further action;

         - otherwise, the switch node shall change the local ring port from Blocking into the Forwarding state.

5.3 Fault detection and recovery

5.3.1 General

There can be two types of network faults in the ring network: inter-switch link fault and switch node fault.

Within a Cycle (T), only one switch node shall multicast a RingCheck frame on its two active ring ports to test ring fault at the time Ring Check SendTimeOffset from the beginning of the Cycle. Then this switch node shall wait to receive these two RingCheck frames from the opposite active ring ports respectively (as shown in Figure 4). That is, if the RingCheck frame is sent out from one active ring port (for example Ring1Port1), it shall be taken back from the other active port (for example Ring1Port2) in the ring network, and vice versa in the other direction. If the RingCheck frames are received back from both active ring ports, it means that no ring fault occurred. Otherwise, it shall record this fault.

In a DRP network, the LinkCheck frame is defined to detect both the inter-switch link fault and the switch node fault. At the time LinkCheckSendOffset from the beginning of every Cycle, each switch node shall multicast the LinkCheck frame to its two neighbor switch nodes through its two active ring ports.

Each switch node shall receive the LinkCheck frames from its two neighbour switch nodes. If the switch node receives one LinkCheck frame from one of its active ring ports, it means the neighbour switch node connected to this ring port is OK. Otherwise, if any switch node does not receive the LinkCheck frame from one active ring port (for example Ring1Port2) within Link Check Time Limit from the LinkCheck sending time $t_{\text{LinkCheck}}$ (see Figure 4), it means that either the inter-switch link is faulty or its neighbour node is faulty

5.3.2 Handling in a single ring network

For a single ring network (as shown in Figure 7), both switch A and B shall clear their FDBs, set the corresponding ring port state to the Blocking state, and then multicast the LinkAlarm frame reporting a fault, which could be an inter-switch link fault or a switch fault. The switch node (for example switch C) with one Blocking ring port shall set this Blocking ring port to the Forwarding state when receiving the LinkAlarm frame.

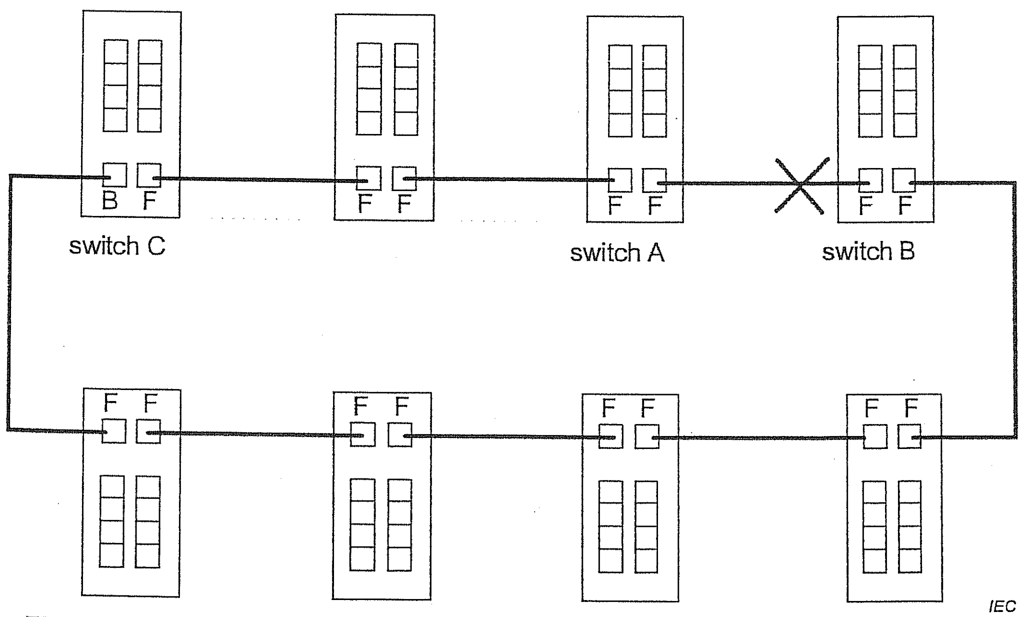


Figure 7 – Fault detection and recovery of single ring topology redundancy

The two switch nodes (switch A and B), which detected the fault, compare the DRPSequenceID in the LinkAlarm frame with the local DRPSequenceID. The switch node with the smaller local DRPSequenceID shall take no actions, and the other switch node shall set its Blocking ring port to the Forwarding state.

The switch node (for example, switch D), which sent the RingCheck frame within the same Cycle, shall multicast the LinkChange frame to notify topology change.

After the LinkChange frame is received, each switch node shall check its local DRPSequenceID with the BLOCKINGPort_DRPSequenceID in LinkChange frame. If they are different, the switch node shall set its Blocking ring port to Forwarding state.

Thus, the ring network recovers with only one Blocking ring port.

5.3.3 Handling in a double ring network

For a double ring network (as shown in Figure 8):

Switch A shall check the link state of the corresponding standby ring port (for example Ring2Port2), which shall be connected to switch B:

If Ring2Port2 ring port link is up and its state is in the Disabled state, switch A shall set it to the current state of ring port Ring1Port2. That means, if the state of Ring1Port2 was in the Forwarding state, the Ring2Port2 ring port shall be set to the Forwarding state, and vice versa, as shown in Figure 8.

Meanwhile, switch A shall clear its FDBs and set ring port Ring1Port2 in the Disabled state.

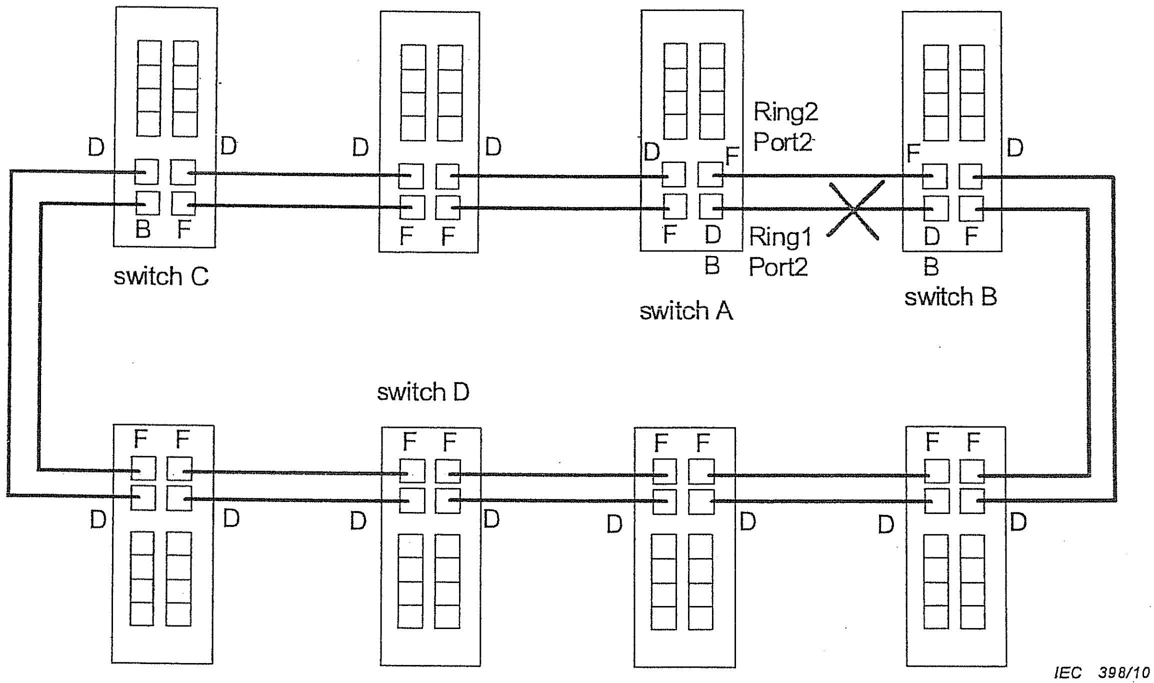


Figure 8 – Single inter-switch link fault detection and recovery of double ring topology redundancy

If Ring2Port2 ring port link is down (as shown in Figure 9), Switch A shall clear its FDB, set the ring port (Ring1Port2) to the Blocking state and then multicast the LinkAlarm frame out of the two active ring ports to report an inter-switch link fault or a switch fault.

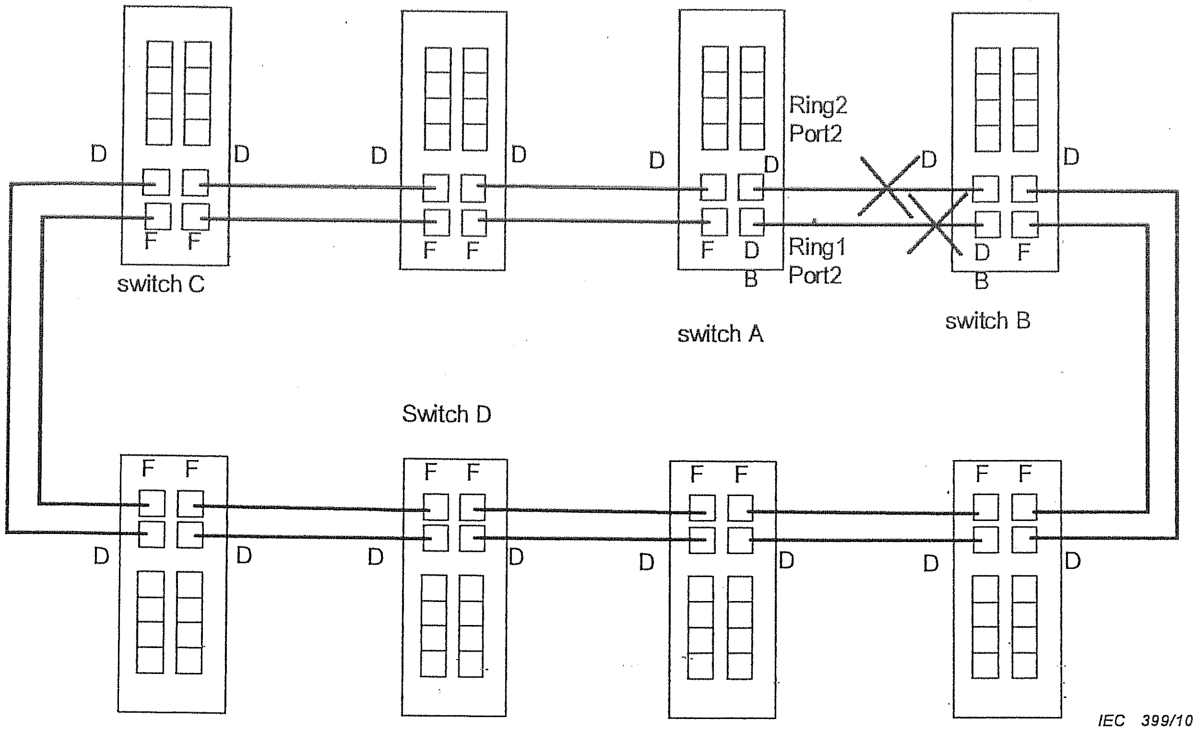


Figure 9 – Double inter-switch link fault detection and recovery of double ring topology redundancy

The switch node (for example switch C), which operated in the Blocking ring port, shall set this Blocking ring port to Forwarding state when receiving a LinkAlarm frame.

The two switch nodes (switch A and B), which detected the inter-switch link fault or neighbour switch node fault, shall compare their DRPSequenceIDs. The switch node with smaller DRPSequenceID shall take no actions. And the other switch node shall set its Blocking ring port to Forwarding state.

The switch node (for example switch D), which sent the RingCheck frame within the same Cycle, shall multicast the LinkChange frame to notify topology change.

After the LinkChange frame is received, each switch node shall check its DRPSequenceID with BLOCKINGPort_DRPSequenceID parameter in LinkChange frame. If they are different, the switch node shall set its Blocking ring port to Forwarding state.

Thus, the ring network recovers with only one Blocking ring port (as shown in Figure 9).

5.4 Repairing the inter-switch link fault

When a faulty inter-switch link is repaired and linked up, no action shall be taken by any switch node in the ring.

5.5 Repairing time synchronization fault

The grandmaster clock recovery shall be handled according to IEC 61588 (IEEE 1588).

When the time synchronization precision is worse than its specified TargetTimeSyncClass in DRP Class, the switch node shall multicast the LinkAlarm frame to report a synchronization fault.

The TargetTimeSyncClass in DRP class is set depending on the recovery time required. It is recommended that the TargetTimeSyncClass should be set according to Table 1.

Table 1 – Relationship between required recovery time and the TargetTimeSyncClass

Required Recovery time (ms)	TargetTimeSyncClass
100 000	1
10 000	2
1 000	3
100	4
10	5
1	6
0,1	7
0,01	8
0,001	9
0,000 1	10

5.6 Inserting a repaired switch node

When a switch node (for example switch B) powers on into a ring network after it is repaired, it shall initialize the states of its two active ring ports: the state of Ring1Port1 shall be Blocking while Ring1Port2 shall be Forwarding. Then this switch node shall synchronize its local clock with the grandmaster clock using the IEC 61588 (IEEE 1588) protocol.

Before the clock is synchronized, the inserted switch node shall receive the DRP frames from its two active ring ports but shall not send any DRP frames. When receiving a RingCheck frame which contains a Blocking ring port state, it shall compare its DRPSequenceID with that in the RingCheck frame. If its DRPSequenceID is smaller, the switch node shall take no action. Otherwise the switch node shall set its Blocking ring port to Forwarding state.

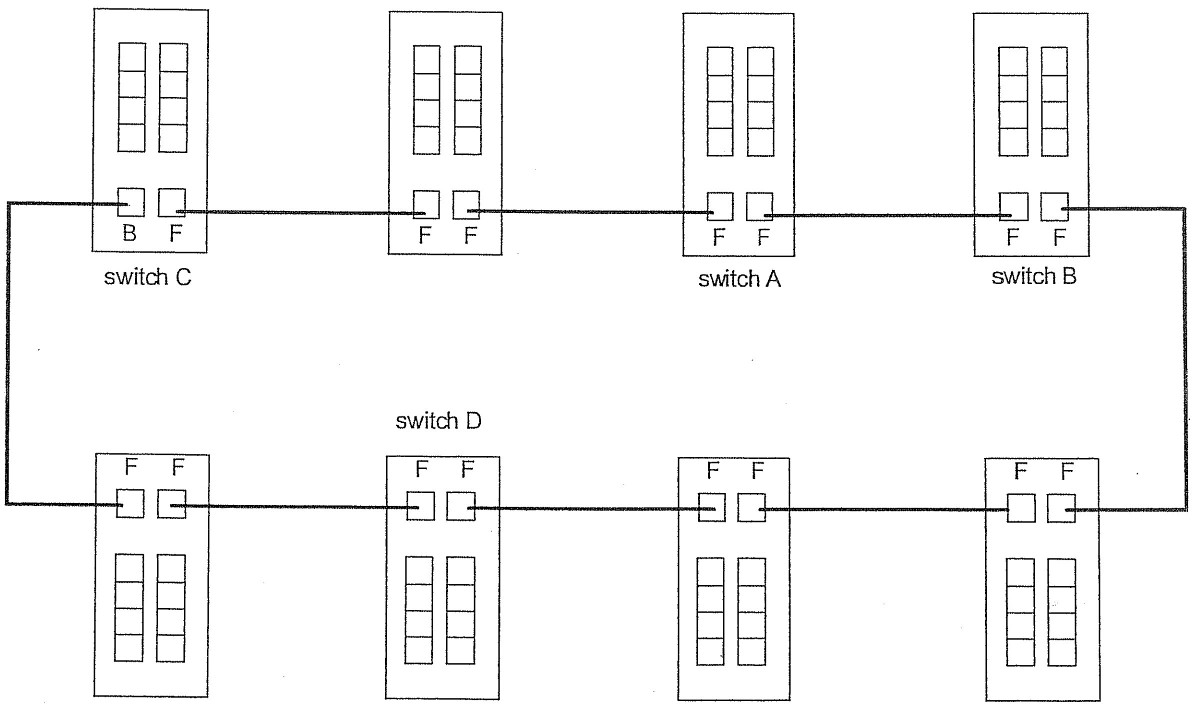


Figure 10 – Inserting a repaired switch node

Meanwhile, both of the neighbour switch nodes regard the repaired one (switch B) as a fault, and they shall act as described in 5.3.

After the inserted switch node (switch B) is synchronized, it can operate and send DRP frames as described in 5.2. Hereafter, each switch node shall compare its DRPSequenceID with that in the RingCheck frame whether this RingCheck frame contains a Blocking ring port. If its DRPSequenceID is smaller, the switch node shall take no action. Otherwise the switch node shall set the Blocking ring port to the Forwarding state (as shown in Figure 10).

5.7 Inserting a new switch node

When a switch node without configuration powers on into a ring network, it shall initialize the states of both its active ring ports: the state of Ring1Port1 shall be Blocking state while Ring1Port2 be Forwarding state. Then this switch node shall synchronize its clock with the grandmaster clock using the IEC 61588 (IEEE 1588) protocol.

Before the clock is synchronized, the inserted switch node shall not send any DRP frames. After the RingCheck frame is received from other switch node, the new switch node shall send the DeviceAnnunciation frame immediately.

After the DeviceAnnunciation frame is received during its Cycle, the switch node shall assign an unused DRPSequenceID to the new switch node. The switch node shall maintain the DRPDeviceNumber according the DRPSequenceID assigned, and send the RingChange frame immediately.

After receiving this RingChange frame, all switch nodes in the ring shall set its DRPDeviceNumber to the value of DRPDeviceNumber in the received frame.

In addition, the new switch node shall also set local DRPSequenceID to the value of DRPSequenceID in the received frame.

6 DRP class specification

The DRP ASE defines one object type as shown in table below.

The DRP class is described by the following template. The object of this class shall be resident in the DRP switch node.

ASE: Distributed redundancy ASE
CLASS: Distributed redundancy
CLASS ID: not used
PARENT CLASS: IEEE 802.3 and ISO/IEC/TR 8802-1 (IEEE 802.1) Distributed Redundancy Protocol

ATTRIBUTES:

1.	(m)	Key Attribute:	DeviceID
2.	(m)	Attribute:	ManufacturerName
3.	(m)	Attribute:	DRPSequenceID
4	(m)	Attribute:	PD-Tag
5.	(m)	Attribute:	Device MAC Address
6.	(m)	Attribute:	DRPVersion
7.	(m)	Attribute:	SoftwareVersion
8.	(m)	Attribute:	HardwareVersion
9.	(o)	Attribute:	VLAN ID
10.	(m)	Attribute:	DRP Domain ID
11.	(m)	Attribute:	Ring1 Port1 ID
12.	(m)	Attribute:	Ring1 Port2 ID
13.	(m)	Attribute:	Ring2 Port1 ID
14.	(m)	Attribute:	Ring2 Port2 ID
15.	(m)	Attribute:	Ring1 Port1 State
16.	(m)	Attribute:	Ring1 Port2 State
17.	(m)	Attribute:	Ring2 Port1 State
18.	(m)	Attribute:	Ring2 Port2 State

19.	(m)	Attribute:	Leaf Link State
20.	(m)	Attribute:	Cycle
21.	(m)	Attribute:	Ring Check SendTimeOffset
22.	(m)	Attribute:	Ring Check Time Limit
23.	(m)	Attribute:	DRPDeviceNumber
24.	(m)	Attribute:	Link Check SendTimeOffset
25.	(m)	Attribute:	Link Check Time Limit
26.	(m)	Attribute:	Ring State
27.	(m)	Attribute:	SynchronizationClockType
28.	(m)	Attribute:	TargetTimeSyncClass
29.	(m)	Attribute:	DRPDeviceState
30.	(m)	Attribute:	TransmissionDelay

SERVICES:

1	(m)	OpsService:	Read
2	(m)	OpsService:	Write

7 DRP attributes

DeviceID
This attribute defines a unique identifier for a switch node.
This attribute shall be preset only by the manufacturer when it is produced.
Data type: VisibleString[32]

ManufacturerName
This attribute defines the name of the manufacturer.
This attribute shall be preset only by the manufacturer when it is produced.
Data type: VisibleString[32]

DRPSequenceID
This key attribute defines a unique sequence number in a DRP redundancy domain for a switch node to transmit the RingCheck frame.
This attribute can be configured using application software by the end user or the RingChange frame. This value shall start at 0, and be increased by 1 from switch to switch. The default value of 0x00, which shall be preset when the switch node is produced, indicates that local switch node has no right to send the RingCheck frame.
Data type: Unsigned16

PD-Tag
This attribute is defined by the end user to describe the switch node in the system.
This attribute can be configured using the application software by the end user.
Data type: VisibleString[32]

Device MAC Address
This attribute defines the MAC address of a switch node. The Device MAC address shall be different from any port MAC address.
This attribute shall be preset by the manufacturer when it is produced.
Data type: OctetString[6]

DRPVersion
This attribute is defined for the DRP protocol version applied in local switch node.
This attribute shall be preset by the manufacturer when it is produced.
Data type: Unsigned16

SoftwareVersion
This attribute is defined by the manufacturer to designate the software version.
This attribute shall be preset by the manufacturer when it is produced.
Data type: Unsigned16

HardwareVersion

This attribute is defined by the manufacturer to designate the hardware version.
This attribute shall be preset by the manufacturer when it is produced.
Data type: Unsigned16

VLAN ID
This attribute contains the value for the VLAN identifier.
This attribute can be configured using the application software by the end user.
Data type: Unsigned16

DRP Domain ID
This attribute contains the value for the DRP redundancy domain identifier.
This attribute can be configured using the application software by the end user.
Data type: Unsigned16

Ring1 Port1 ID
This attribute specifies the port ID of ring port for Ring1 Port1 of the switch node.
Data type: Unsigned16

Ring1 Port2 ID
This attribute specifies the port ID of ring port for Ring1 Port2 of the switch node.
Data type: Unsigned16

Ring2 Port1 ID
This attribute specifies the port ID of ring port for Ring2 Port1 of the switch node.
Data type: Unsigned16

Ring2 Port2 ID
This attribute specifies the port ID of ring port for Ring2 Port2 of the switch node.
Data type: Unsigned16

Ring1 Port1 State
This attribute specifies the port state of Ring 1 Port 1:
0 = Disabled
1 = Blocking
2 = Forwarding
Data type: Unsigned8
Ring1Port1 shall be the active ring port and its value shall not be changed by the user.

Ring1 Port2 State
This attribute specifies the port state of Ring 1 Port 2:
0 = Disabled
1 = Blocking
2 = Forwarding
Data type: Unsigned8
Ring1Port2 shall be the active ring port and its value shall not be changed by the user.

Ring2 Port1 State
This attribute specifies the port state of Ring 2 Port 1:
0 = Disabled
1 = Blocking
2 = Forwarding
0xff = NON-EXISTENT
Others = reserved
Data type: Unsigned8
The initial value of Ring2Port1 shall be NON-EXISTENT. This attribute shall have no function in single ring topology.

Ring2 Port2 State
This attribute specifies the port state of Ring 2 Port 2:
0 = Disabled
1 = Blocking
2 = Forwarding

0xff = NON-EXISTENT
Others = reserved
Data type: Unsigned8
The initial value of Ring2Port2 shall be NON-EXISTENT. This attribute shall have no function in single ring topology.

Leaf Link State
This attribute describes the state of all leaf links of a switch node. One bit in this attribute maps to one leaf link of the switch node. This attribute is defined to report the link-up or link-down state for the leaf links of a switch node. The meaning for each bit is:
0 = LINKUP
1 = LINKDOWN
Data type: OctetString[8]
This attribute is changed by the switch node and shall not be written by the user.

Cycle
This attribute defines the communication period of each node.
This attribute shall be configured using application software by the end user. The initial value of 0xFFFFFFFFFFFFFFFF indicates that this attribute has not been configured.
Data type: TimeDifference

Ring Check SendTimeOffset
This attribute defines the time offset for a switch node to transmit the RingCheck frame from the beginning of a Cycle.
This attribute shall be configured using the application software by the end user. The initial value of 0xFFFFFFFFFFFFFFFF indicates that this attribute has not been configured.
Data type: Time Difference

Ring Check Time Limit
This attribute defines the time limit to assert network ring fault.
This attribute shall be configured using the application software by the end user. The initial value of 0xFFFFFFFFFFFFFFFF indicates that this attribute has not been configured.
Data type: Time Difference

DRPDeviceNumber
This attribute specifies the total number of DRP switch nodes connected in a redundancy domain.
This attribute shall be configured using the application software by the end user.
Data type: Unsigned16

Link Check SendTimeOffset
This attribute defines the time interval from the beginning of a Cycle for local switch node to send the LinkCheck frame.
This attribute shall be configured using the application software by the end user. The default value of 0xFFFFFFFFFFFFFFFF indicates that this attribute has not been configured.
Data type: Time Difference

Link Check Time Limit
This attribute defines the time limit for a switch node to assert an inter-switch link fault or a neighbour switch fault.
This attribute shall be configured using the application software by the end user. The default value of 0xFFFFFFFFFFFFFFFF indicates that this attribute has not been configured.
Data type: Time Difference

Ring State
This attribute specifies the ring state:
0 = CLOSED, if the switch node can receive its RingCheck frame;
1 = OPEN, if the switch cannot receive its RingCheck frame;
Data type: Unsigned8
This attribute is changed by the switch node and shall not be written by the end user.

SynchronizationClockType

This attribute specifies the type of clock synchronization:
0 = BOUNDARY
1 = TRANSPARENT
Others = reserved
Data type: Unsigned8
This attribute shall be configured using the application software by the end user. The default value of 0x00 indicates that this switch node uses BOUNDARY clock synchronization.

TargetTimeSyncClass
This attribute indicates the desired time synchronization precision supported by time client.
0 = no precision requirement;
1 = Time Synchronization precision <1 s;
2 = Time Synchronization precision <100 ms;
3 = Time Synchronization precision <10 ms;
4 = Time Synchronization precision <1 ms;
5 = Time Synchronization precision <100 µs;
6 = Time Synchronization precision <10 µs;
7 = Time Synchronization precision <1 µs;
8 = Time Synchronization precision <100 ns;
9 = Time Synchronization precision <10 ns;
10 = Time Synchronization precision <1 ns.
Data type: Unsigned32
This attribute shall be configured using the application software by the end user. This attribute is set depending on the system recovery time required. All DRP switches in a ring network must have the same TargetTimeSyncClass.

DRPDeviceState
This attribute defines the states of DRP switch nodes connected in a redundancy domain. One bit in this attribute maps to one switch node in the redundancy domain. This attribute is defined to record the work or fault state for the switch node. The meaning for each bit is:
0 = fault state
1 = work state
Data type: VisibleString[128]
This attribute is changed by the switch node and shall not be written by the end user.

TransmissionDelay
This attribute defines the transmission delay for the DRP frame in DRP switch node.
This attribute shall be configured using the application software by the end user. The default value of 0xFFFFFFFFFFFFFFFF indicates that this attribute has not been configured.
Data type: Time Difference

8 DRP services

8.1 Read

This service is used to read the attributes of a DRP switch node.

The parameters of the Read service are specified in Table 2.

Table 2 – Parameters of Read service

Parameter name	Req	Ind	Rsp	Cnf
Argument	M			
MessageID	M	M(=)		
DeviceID	M	M(=)		
Result(+)				S
MessageID			M	M(=)

Parameter name	Req	Ind	Rsp	Cnf
ManufacturerName			M	M(=)
DRPSequenceID			M	M(=)
PD-Tag			M	M(=)
Device MAC Address			M	M(=)
DRPVersion			M	M(=)
SoftwareVersion			M	M(=)
HardwareVersion			M	M(=)
VLAN ID			M	M(=)
DRP Domain ID			M	M(=)
DRPSequenceID			M	M(=)
Ring1 Port1 ID			M	M(=)
Ring1 Port2 ID			M	M(=)
Ring2 Port1 ID			M	M(=)
Ring2 Port2 ID			M	M(=)
Ring1 Port 1 State			M	M(=)
Ring1 Port 2 State			M	M(=)
Ring2 Port 1 State			M	M(=)
Ring2 Port 2 State			M	M(=)
Leaf Link State			M	M(=)
Cycle			M	M(=)
Ring Check SendTimeOffset			M	M(=)
Ring Check Time Limit			M	M(=)
DRPDeviceNumber			M	M(=)
Link Check Send TimeOffset			M	M(=)
Link Check Time Limit			M	M(=)
Ring State			M	M(=)
SynchronizationClockType			M	M(=)
TargetTimeSyncClass			M	M(=)
DRPDeviceState			M	M(=)
TransmissionDelay			M	M(=)
Result(-)				S
MessageID			M	M(=)
DeviceID			M	M(=)
Fault Code			M	M(=)
NOTE For the meaning of Req, Ind, Rsp, Cnf, M, U and S, refer to ISO/IEC 10164-1.				

Argument

The argument contains the parameters of the service request.

MessageID

This parameter contains the number of times this service has been invoked since power on. Each time this service is invoked, the value of this parameter is incremented by 1.

DeviceID

This parameter contains the DeviceID of the switch node.

ManufacturerName
This parameter contains the name of the manufacturer of the switch node.

DRPSequenceID
This parameter contains the DRPSequenceID of the switch node.

PD-Tag
This parameter contains the PD-Tag of the switch node.

Device MAC Address
This parameter contains the MAC address of the switch node.

DRPVersion
This parameter contains the DRPVersion of the switch node.

SoftwareVersion
This parameter contains the Software Version of the switch node.

HardwareVersion
This parameter contains the Hardware Version of the switch node.

VLAN ID
This parameter contains VLAN identifier of the switch node.

DRP Domain ID
This parameter contains the value for the DRP redundancy domain identifier.

Ring1 Port1 ID
This parameter contains the preset port ID of ring port for Ring1 Port1 of the switch node.

Ring1 Port2 ID
This parameter contains the preset port ID of ring port for Ring1 Port2 of the switch node.

Ring2 Port1 ID
This parameter contains the preset port ID of ring port for Ring2 Port1 of the switch node.

Ring2 Port2 ID
This parameter contains the preset port ID of ring port for Ring2 Port2 of the switch node.

Ring1 Port 1 State
This parameter contains the ring port state of Ring 1 Port 1.

Ring1 Port 2 State
This parameter contains the ring port state of Ring 1 Port 2.

Ring2 Port 1 State
This parameter contains the ring port state of Ring 2 Port 1.

Ring2 Port 2 State
This parameter contains the ring port state of Ring 2 Port 2.

Leaf Link State
This parameter contains the link up or link down state of each leaf link of the switch node.

Cycle
This parameter contains the value of Cycle of the node.

Ring Check SendTimeOffset
This parameter contains the value of Ring Check SendTimeOffset attribute of the switch node.

Ring Check Time Limit
This parameter contains the value of Ring Check Time Limit attribute of the switch node.

DRPDeviceNumber

This parameter contains the value of DRPDeviceNumber attribute of the switch node.

Link Check SendTimeOffset
This parameter contains the value of Link Check SendTimeOffset attribute of the switch node.

Link Check Time Limit
This parameter contains the value of Link Check Time Limit attribute of the switch node.

Ring State
This parameter contains the value of Ring State attribute of the switch node.

SynchronizationClockType
This parameter contains the value of SynchronizationClockType attribute of the switch node.

TargetTimeSyncClass
This parameter contains the value of time synchronization precision supported by time client.

DRPDeviceState
This parameter specifies the states of DRP switch nodes connected in a redundancy domain.

TransmissionDelay
This parameter specifies the transmission delay for the DRP frame in DRP switch node.

Fault Code
This parameter specifies the type of fault.

8.2 Write

This service is used to configure the attributes of a DRP switch node.

The parameters of the service are specified in Table 3.

Table 3 – Parameters of Write service

Parameter name	Req	Ind	Rsp	Cnf
Argument	M			
MessageID	M	M(=)		
DeviceID	M	M(=)		
DRPSequenceID	M	M(=)		
PD-Tag	M	M(=)		
DRP Domain ID	M	M(=)		
VLAN ID	M	M(=)		
Ring1 Port1 ID	M	M(=)		
Ring1 Port2 ID	M	M(=)		
Ring2 Port1 ID	M	M(=)		
Ring2 Port2 ID	M	M(=)		
Ring2 Port 1 State	M	M(=)		
Ring2 Port 2 State	M	M(=)		
Cycle	M	M(=)		
Ring Check Send TimeOffset	M	M(=)		
Ring Check Time Limit	M	M(=)		
DRPDeviceNumber	M	M(=)		
Link Check Send TimeOffset	M	M(=)		
Link Check Time Limit	M	M(=)		
SynchronizationClockType	M	M(=)		

Parameter name	Req	Ind	Rsp	Cnf
TargetTimeSyncClass	M	M(=)		
TransmissionDelay	M	M(=)		
Result(+)				S
MessageID			M	M(=)
DeviceID			M	M(=)
Result(-)				S
MessageID			M	M(=)
DeviceID			M	M(=)
Fault Code			M	M(=)
NOTE For the meaning of Req, Ind, Rsp, Cnf, M, U and S, refer to ISO/IEC 10164-1.				

Argument

The argument contains the parameters of the service request.

MessageID
This parameter contains the number of times this service has been invoked since power on. Each time this service is invoked, the value of this parameter is incremented by 1.

DeviceID
This parameter contains the DeviceID of the switch node.

DRPSequenceID
This parameter contains the DRPSequenceID of the switch node.

PD-Tag
This parameter contains the preset value of PD-Tag for the switch node.

DRP Domain ID
This parameter contains the preset value of DRP Domain ID for the switch node.

VLAN ID
This parameter contains the preset value of VLAN ID for the switch node.

Ring1 Port1 ID
This parameter contains the preset port ID of ring port for Ring1 Port1 of the switch node.

Ring1 Port2 ID
This parameter contains the preset port ID of ring port for Ring1 Port2 of the switch node.

Ring2 Port1 ID
This parameter contains the preset port ID of ring port for Ring2 Port1 of the switch node.

Ring2 Port2 ID
This parameter contains the preset port ID of ring port for Ring2 Port2 of the switch node.

Ring2 Port 1 State
This parameter contains the preset value of ring port state for Ring2 Port 1 of the switch node.

Ring2 Port 2 State
This parameter contains the preset value of ring port state for Ring2 Port 2 of the switch node.

Cycle
This parameter contains the value of Cycle of the switch.

Ring Check SendTimeOffset
This parameter contains the preset value of Ring Check SendTimeOffset for the switch node.

Ring Check Time Limit
This parameter contains the preset value of Ring Check Time Limit for the switch node.

DRPDeviceNumber
This parameter contains the preset value of DRP Device Number for the switch node.

Link Check SendTimeOffset
This parameter contains the preset value of Link Check SendTimeOffset for the switch node.

Link Check Time Limit
This parameter contains the preset value of Link Check Time Limit for the switch node.

SynchronizationClockType
This parameter contains the preset value of SynchronizationClockType for the switch node.

TargetTimeSyncClass
This parameter contains the value of time synchronization precision supported by time client.

TransmissionDelay
This parameter specifies the transmission delay for the DRP frame in DRP switch node.

Fault Code
This parameter specifies the type of fault.

9 DRP protocol specification

9.1 Basic types encoding

The data types shall be encoded as in IEC 61158 series.

9.2 ErrorDescription encoding

The type ErrorDescription consists of an Error Type and an Error Code field.

```
{
Unsigned8  Error Type;
Unsigned8  Error Code;
}
```

The Error Type field is encoded as an Unsigned8, its value represents the error class. The value of this field is specified in Table 4.

Table 4 – Error Type definition

Value (hexadecimal)	Meaning	Usage
0x00	Read/Write Service Error	mandatory
0x01	Link Fault in Ring	mandatory
0x02	No synchronization	mandatory
0x03 – 0xFF	Reserved	

The Error Code field is encoded as an Unsigned8, it gives a more concrete error description. This field shall be encoded with the values according to Table 5.

Table 5 – Error Code definition

Value (hexadecimal)	Meaning	Usage
0x00	memory-unavailable	mandatory
0x01	object-state-conflict	mandatory
0x02	object-constraint-conflict	mandatory
0x03	parameter-inconsistent	mandatory
0x04	illegal-parameter	mandatory
0x05	Size Error	mandatory
0x06	LinkDown	mandatory
0x07	LinkCheck timeout	mandatory
0x08 – 0xFF	Reserved	

9.3 Encoding of DRP Class

The Encoding of DRP Class is specified in Table 6.

Table 6 – Definition of DRP Class

No.	Parameter name	Data type	Octet offset	Octet length	Description
1	DeviceID	OctetString	0	32	unique identifier for the switch node
2	ManufacturerName	OctetString	32	32	name of the manufacturer
3	DRPSequenceID	Unsigned16	64	2	unique sequence number in a DRP redundancy domain for a switch node to transmit RingCheck frame
4	PD-Tag	OctetString	66	32	description for switch node
5	Device MAC Address	OctetString	98	6	MAC address of the switch node
6	DRPVersion	Unsigned16	104	2	DRP protocol version applied in local switch node
7	SoftwareVersion	Unsigned16	106	2	software version of local switch node
8	HardwareVersion	Unsigned16	108	2	hardware version of the switch node
9	VLAN ID	Unsigned16	110	2	value for the VLAN identifier
10	DRP Domain ID	Unsigned16	112	2	DRP redundancy domain identifier
11	Ring1 Port1 ID	Unsigned16	114	2	port ID of Ring 1 Port 1
12	Ring1 Port2 ID	Unsigned16	116	2	port ID of Ring 1 Port 2
13	Ring2 Port1 ID	Unsigned16	118	2	port ID of Ring 2 Port 1
14	Ring2 Port2 ID	Unsigned16	120	2	port ID of Ring 2 Port 2
15	Ring1 Port1 State	Unsigned8	122	1	state of Ring 1 Port 1
16	Ring1 Port2 State	Unsigned8	123	1	state of Ring 1 Port 2
17	Ring2 Port1 State	Unsigned8	124	1	state of Ring 2 Port 1
18	Ring2 Port2 State	Unsigned8	125	1	state of Ring 2 Port 2
19	Leaf Link State	OctetString	126	8	all leaf links state of the switch node
20	Cycle	Time Difference	134	8	communication period of the redundancy domain

No.	Parameter name	Data type	Octet offset	Octet length	Description
21	Ring Check SendTimeOffset	Time Difference	142	8	time offset for a switch node to transmit the RingCheck frame from the beginning of a Cycle
22	Ring Check Time Limit	Time Difference	150	8	time limit to assert network ring fault
23	DRPDeviceNumber	Unsigned16	158	2	total number of DRP switch nodes in a redundancy domain
24	Link Check SendTimeOffset	Time Difference	160	8	time interval from the beginning of a Cycle for local switch node to send the LinkCheck frame
25	Link Check Time Limit	Time Difference	168	8	time limit for a switch node to assert an inter-switch link fault or a neighbour switch fault
26	Ring State	Unsigned8	176	1	ring state
27	SynchronizationClockType	Unsigned8	177	1	type of clock synchronization
28	TargetTimeSyncClass	Unsigned32	178	4	required synchronization precision as to the time client
29	DRPDeviceState	VisibleString128	182	128	the states of DRP switch nodes connected in a redundancy domain
30	TransmissionDelay	Time Difference	310	8	transmission delay for the DRP frame in DRP switch node

9.4 PDU description

9.4.1 Encoding of DRP DLPDU

The encoding and decoding of the fields in DLPDU shall be according to ISO/IEC 8802-3 (IEEE 802.3). OUI definition

The IEEE Organizationally Unique Identifier for DRP is 01-15-4E. It shall be set according to Table 7.

Table 7 – DRP OUI

Value for OUI (hexadecimal)	Meaning
00-15-4E	global administered individual unicast
01-15-4E	global administered group (multicast) address
02-15-4E	local administered individual unicast
03-15-4E	local administered group (multicast) address

For DRP-PDUs, the destination address value shall be set according to Table 8.

Table 8 – DRP MulticastMACAddress

Value OUI (Multicast) (hexadecimal)	Value ExtensionIdentifier (hexadecimal)	Meaning
01-15-4E	00-03-00	Reserved
01-15-4E	00-03-01	Multicast MAC address used for DRP RingCheck LinkCheck, LinkAlarm, LinkChange, DeviceAnnunciation, RingChange frames
01-15-4E	00-03-02 to 00-03-FF	Reserved

9.4.2 Encoding of DLSDU

The encoding and decoding of the fields in DLSDU shall be according to IEEE 802.1Q. The DRP DLSDU is encoded as specified in Table 9.

Table 9 – Encoding of DLSDU

VLAN	LT	DRP PDU

The VLAN field can be omitted in case of optimized transfer. The field VLAN may be set by the encoder but it may be discarded by intermediate bridges. The decoder shall accept DLPDUs with or without VLAN fields.

9.4.3 Encoding of VLAN

The encoding and decoding of the fields in VLAN shall be according to IEEE 802.1Q.The VLAN field is optional for DRP. The priority of VLAN shall be set to 7 for DRP frames.

9.4.4 Ethertype

The LT field shall be encoded as data type of Unsigned16 with the value set to 0x8907.

9.4.5 Encoding of DRP PDU

The DRP PDU shall be encoded as specified in Table 10.

Table 10 – Encoding of DRP PDU

Version	DRP_Type	Length	MessageID	DRP_DATA

The Version field shall be the DRP protocol version applied in this switch node as data type of Unsigned8.

The DRP_Type field shall be encoded as data type of Unsigned8. It is defined to identify the DRP frames. This field shall be encoded with the values according to Table 11.

Table 11 – DRP_Type definition

Value (hexadecimal)	Meaning	Usage
0x00	RingCheck	mandatory
0x01	LinkCheck	mandatory
0x02	LinkAlarm	mandatory

0x03	LinkChange	mandatory
0x04	Read.req frame	mandatory
0x05	Read.rsp(+) frame	mandatory
0x06	Read.rsp(-) frame	mandatory
0x07	Write.req frame	mandatory
0x08	Write.rsp(+) frame	mandatory
0x09	Write.rsp(-) frame	mandatory
0x0A	DeviceAnnunciation frame	mandatory
0x0B	RingChange frame	mandatory
0x0C – 0xFF	Reserved	

The Length contains the size of DRP_DATA in octets as data type of Unsigned16.

The MessageID shall be encoded as data type of Unsigned16. It is used to identify the duplication of DRP frames in the ring. For each switch node, the value of MessageID shall start at 1, and shall be incremented by 1.

DRP_DATA contains the data of DRP frames, specified in 9.4.6.

9.4.6 Encoding of DRP_DATA

9.4.6.1 Encoding of RingCheck

The RingCheck frame is encoded as specified in Table 12.

Table 12 – Encoding of RingCheck frame

No.	Parameter name	Data type	Octet offset	Octet length	Description
1	DeviceID	OctetString	0	32	unique identifier for the switch node
2	ManufacturerName	OctetString	32	32	name of the manufacturer
3	DRPSequenceID	Unsigned16	64	2	unique sequence number in a DRP redundancy domain for a switch node to transmit the RingCheck frame
4	PD-Tag	OctetString	66	32	description for switch node
5	Device MAC Address	OctetString	98	6	MAC address of the switch node
6	SoftwareVersion	Unsigned16	104	2	software version of the switch node
7	HardwareVersion	Unsigned16	106	2	hardware version of the switch node
8	VLAN ID	Unsigned16	108	2	value for the VLAN identifier
9	DRP Domain ID	Unsigned16	110	2	DRP redundancy domain identifier
10	Ring1 Port1 State	Unsigned8	112	1	state of Ring 1 Port 1
11	Ring1 Port2 State	Unsigned8	113	1	state of Ring 1 Port 2
12	Ring2 Port1 State	Unsigned8	114	1	state of Ring 2 Port 1

No.	Parameter name	Data type	Octet offset	Octet length	Description
13	Ring2 Port2 State	Unsigned8	115	1	state of Ring 2 Port 2
14	Leaf Link State	OctetString	116	8	all leaf links state of the switch node
15	Cycle	Time Difference	124	8	communication period of the redundancy domain
16	Ring Check SendTimeOffset	Time Difference	132	8	time offset for a switch node to transmit the RingCheck frame from the beginning of a Cycle
17	Ring Check Time Limit	Time Difference	140	8	time limit to assert network ring fault
18	DRPDeviceNumber	Unsigned16	148	2	total number of DRP switch nodes in a redundancy domain
19	Link Check SendTimeOffset	Time Difference	150	8	time interval from the beginning of a Cycle for local switch node to send the LinkCheck frame
20	Link Check Time Limit	Time Difference	158	8	time limit for a switch node to assert an inter-switch link fault or a neighbour switch fault
21	Ring State	Unsigned8	166	1	ring state
22	SynchronizationClockType	Unsigned8	167	1	type of clock synchronization
23	TargetTimeSyncClass	Unsigned32	168	4	required synchronization precision as to the time client
24	TransmissionDelay	Time Difference	172	8	transmission delay for the DRP frame in DRP switch node

9.4.6.2 Encoding of DeviceAnnunciation

The DeviceAnnunciation frame is encoded as specified in Table 13.

Table 13 – Encoding of DeviceAnnunciation frame

No.	Parameter name	Data type	Octet offset	Octet length	Description
1	DeviceID	OctetString	0	32	unique identifier for the switch node
2	ManufacturerName	OctetString	32	32	name of the manufacturer
3	PD-Tag	OctetString	64	32	description for switch node
4	Device MAC Address	OctetString	96	6	MAC address of the switch node
5	SoftwareVersion	Unsigned16	102	2	software version of the switch node
6	HardwareVersion	Unsigned16	104	2	hardware version of the switch node
7	VLAN ID	Unsigned16	106	2	value for the VLAN identifier
8	DRP Domain ID	Unsigned16	108	2	DRP redundancy domain identifier

No.	Parameter name	Data type	Octet offset	Octet length	Description
9	Ring1 Port1 State	Unsigned8	110	1	state of Ring 1 Port 1
10	Ring1 Port2 State	Unsigned8	111	1	state of Ring 1 Port 2
11	Ring2 Port1 State	Unsigned8	112	1	state of Ring 2 Port 1
12	Ring2 Port2 State	Unsigned8	113	1	state of Ring 2 Port 2
13	Leaf Link State	OctetString	114	8	all leaf links state of the switch node
14	Cycle	Time Difference	122	8	communication period of the redundancy domain
15	Ring Check SendTimeOffset	Time Difference	130	8	time offset for a switch node to transmit the RingCheck frame from the beginning of a Cycle
16	Ring Check Time Limit	Time Difference	138	8	time limit to assert network ring fault
17	Link Check SendTimeOffset	Time Difference	146	8	time interval from the beginning of a Cycle for local switch node to send the LinkCheck frame
18	Link Check Time Limit	Time Difference	154	8	time limit for a switch node to assert an inter-switch link fault or a neighbour switch fault
19	Ring State	Unsigned8	162	1	ring state
20	SynchronizationClockType	Unsigned8	163	1	type of clock synchronization
21	TargetTimeSyncClass	Unsigned32	164	4	required synchronization precision as to the time client
22	TransmissionDelay	Time Difference	168	8	transmission delay for the DRP frame in DRP switch node

9.4.6.3 Encoding of RingChange

The RingChange frame is coded as shown in Table 14.

Table 14 – Encoding of RingChange frame

No.	Parameter name	Data type	Octet offset	Octet length	Description
1	DeviceID	OctetString	0	32	unique identifier for the switch node
2	DRP Domain ID	Unsigned16	32	2	DRP redundancy domain identifier for local switch node
3	DRPDeviceNumber	Unsigned16	34	2	total number of DRP switch nodes in a redundancy domain
4	New Device MAC Address	OctetString	36	6	MAC address of new insert switch node
5	New Device DRPSequenceID	Unsigned16	42	2	DRPSequenceID of new insert switch node
6	Cycle	Time Difference	44	8	communication period of the redundancy domain

9.4.6.4 Encoding of LinkCheck

The LinkCheck frame is coded as shown in Table 15.

Table 15 – Encoding of LinkCheck frame

No.	Parameter name	Data type	Octet offset	Octet length	Description
1	DeviceID	OctetString	0	32	unique identifier for the switch node
2	DRP Domain ID	Unsigned16	32	2	DRP redundancy domain identifier for local switch node
3	Ring1 Port1 State	Unsigned8	34	1	state of Ring 1 Port 1 of local switch node
4	Ring1 Port2 State	Unsigned8	35	1	state of Ring 1 Port 2 of local switch node
5	Ring2 Port1 State	Unsigned8	36	1	state of Ring 2 Port 1 of local switch node
6	Ring2 Port2 State	Unsigned8	37	1	state of Ring 2 Port 2 of local switch node

9.4.6.5 Encoding of LinkAlarm

The LinkAlarm frame is encoded as specified in Table 16.

Table 16 – Encoding of LinkAlarm frame

No.	Parameter name	Data type	Octet offset	Octet length	Description
1	DeviceID	OctetString	0	32	unique identifier for the switch node
2	DRP Domain ID	Unsigned16	32	2	DRP redundancy domain identifier for local switch node
3	Ring1 Port1 State	Unsigned8	34	1	state of Ring 1 Port 1 of local switch node
4	Ring1 Port2 State	Unsigned8	35	1	state of Ring 1 Port 2 of local switch node
5	Ring2 Port1 State	Unsigned8	36	1	state of Ring 2 Port 1 of local switch node
6	Ring2 Port2 State	Unsigned8	37	1	state of Ring 2 Port 2 of local switch node
7	Fault Code	ErrorDescription	38	2	identifier of fault , see 9.2

9.4.6.6 Encoding of LinkChange

The LinkCheck frame is encoded as specified in Table 17.

Table 17 – Encoding of LinkChange frame

No.	Parameter name	Data type	Octet offset	Octet length	Description
1	DRP Domain ID	Unsigned16	0	2	DRP redundancy domain identifier for local switch node
2	DeviceID	OctetString	2	32	unique identifier for the switch node
3	BLOCKINGPORT_ DRPSequenceID	Unsigned16	34	2	DRPSequenceID of switch node which shall keep a ring port in Blocking state
4	Fault Code	ErrorDescription	36	2	identifier of fault, see 9.2
5	Ring Check SendTimeOffset	Time Difference	38	8	time offset for a switch node to transmit the RingCheck frame from the beginning of a Cycle
6	Link Check SendTimeOffset	Time Difference	46	8	time interval from the beginning of a Cycle for local switch node to send the LinkCheck frame

9.4.7 Encoding of Read Service

9.4.7.1 Read request primitive

Read request parameters are encoded as specified in Table 18.

Table 18 – Encoding of Read Request

No.	Parameter name	Data type	Octet offset	Octet length	Description
1	DeviceID	OctetString	0	32	unique identifier for the switch node

9.4.7.2 Read positive response primitive

Read positive response parameters are encoded as specified in Table 19.

Table 19 – Encoding of Read Service Positive Response

No.	Parameter name	Data type	Octet offset	Octet length	Description
1	ManufacturerName	OctetString	0	32	name of the manufacturer
2	DRPSequenceID	Unsigned16	32	2	unique sequence number in a DRP redundancy domain for a switch node to transmit the RingCheck frame
3	PD-Tag	OctetString	34	32	description for the switch node
4	Device MAC Address	OctetString	66	6	MAC address of local switch node
5	DRPVersion	Unsigned16	72	2	DRP protocol version applied in local switch node
6	SoftwareVersion	Unsigned16	74	2	software version applied in local switch node
7	HardwareVersion	Unsigned16	76	2	hardware version applied in local switch node
8	VLAN ID	Unsigned16	78	2	value for the VLAN identifier
9	DRP Domain ID	Unsigned16	80	2	DRP redundancy domain identifier
10	DRPSequenceID	Unsigned16	82	2	unique sequence number in a DRP redundancy domain for a switch node to transmit the RingCheck frame
11	Ring1 Port1 ID	Unsigned16	84	2	port ID of Ring 1 port 1 of local switch node
12	Ring1 Port2 ID	Unsigned16	86	2	port ID of Ring 1 port 2 of local switch node
13	Ring2 Port1 ID	Unsigned16	88	2	port ID of Ring 2 port 1 of local switch node
14	Ring2 Port2 ID	Unsigned16	90	2	port ID of Ring 2 port 2 of local switch node
15	Ring1 Port1 State	Unsigned8	92	1	port state of Ring 1 port 1 of local switch node
16	Ring1 Port2 State	Unsigned8	93	1	port state of Ring 1 port 2 of local switch node
17	Ring2 Port1 State	Unsigned8	94	1	port state of Ring 2 port 1 of local switch node
18	Ring2 Port2 State	Unsigned8	95	1	port state of Ring 2 port 2 of local switch node
19	Leaf Link State	OctetString	96	8	all leaf links states of local switch node
20	Cycle	Time Difference	94	8	communication macro period of redundancy domain

No.	Parameter name	Data type	Octet offset	Octet length	Description
21	Ring Check SendTimeOffset	Time Difference	102	8	time offset for a switch node to transmit the RingCheck frame from the beginning of a Cycle
22	Ring Check Time Limit	Time Difference	110	8	time limit to assert network ring fault
23	DRPDeviceNumber	Unsigned16	118	2	total number of DRP switch nodes in a redundancy domain
24	Link Check SendTimeOffset	Time Difference	120	8	time interval from the beginning of a Cycle for local switch node to send the LinkCheck frame
25	Link Check Time Limit	Time Difference	128	8	time limit for a switch node to assert an inter-switch link fault or a neighbour switch fault
26	Ring State	Unsigned8	136	1	ring state
27	SynchronizationClockType	Unsigned8	137	1	type of time synchronization
28	TargetTimeSyncClass	Unsigned32	138	4	required synchronization precision as to the time client
29	DRPDeviceState	VisibleString128	142	128	the states of DRP switch nodes connected in a redundancy domain
30	TransmissionDelay	Time Difference	270	8	transmission delay for the DRP frame in DRP switch node

9.4.7.3 Read negative response primitive

Negative positive response parameters are encoded as specified in Table 20.

Table 20 – Encoding of Read Service Negative Response

No.	Parameter name	Data type	Octet offset	Octet length	Description
1	DeviceID	OctetString	0	32	unique identifier for the switch node
2	Fault Code	ErrorDescription	32	2	identifier of fault, see 9.2

9.4.8 Encoding of Write Service primitives

9.4.8.1 Write request primitive

Write request parameters are encoded as specified in Table 21.

Table 21 – Encoding of Write Request

No.	Parameter name	Data type	Octet offset	Octet length	Description
1	DeviceID	OctetString	0	32	unique identifier for the switch node
2	PD-Tag	Unsigned16	32	2	description for switch node
4	VLAN ID	Unsigned16	34	2	value for the VLAN identifier
6	Ring1 Port1 ID	Unsigned16	36	2	port ID of Ring 1 port 1
7	Ring1 Port2 ID	Unsigned16	38	2	port ID of Ring 1 port 2
8	Ring2 Port1 ID	Unsigned16	40	2	port ID of Ring 2 port 1
9	Ring2 Port2 ID	Unsigned8	42	2	state of Ring 2 port 2
10	Ring2 Port1 State	Unsigned8	44	1	state of Ring 2 port 1
11	Cycle	Unsigned8	45	1	state of Ring 2 port 2
12	Cycle	Time Difference	46	8	communication period of the redundancy domain
13	Ring Check Time Limit	Time Difference	54	8	time limit to assert network ring fault
14	DRPDeviceNumber	Unsigned16	62	8	time limit to assert network ring fault
15	Link Check Time Limit	Time Difference	70	8	time limit for a switch node to assert an inter-switch link fault or a neighbor switch fault
16	TargetTimeSyncClass	Unsigned8	78	1	required synchronization
17	TransmissionDelay	Time Difference	79	8	transmission delay for the DRP frame in DRP switch node

9.4.8.2 Write positive response primitive

Write positive response parameters are encoded as specified in Table 22.

Table 22 – Encoding of Write Service Positive Response

No.	Parameter name	Data type	Octet offset	Octet length	Description
1	DeviceID	OctetString	0	32	unique identifier for the switch node

9.4.8.3 Write negative response primitive

Write negative response parameters are encoded as specified in Table 23.

Table 23 – Encoding of Write Service Negative Response

No.	Parameter name	Data type	Octet offset	Octet length	Description
1	DeviceID	OctetString	0	32	unique identifier for the switch node
2	Fault Code	ErrorDescription	32	2	identifier of fault, see 9.2

9.5 Protocol machine

9.5.1 Switch node states description

Each DRP switch node has seven states: Power_On, Unsynchronized, Ready, S_State1, S_State2, D_State1, D_State2:

- Power_On

  In this state, Ring1Port1 shall be put in the Blocking state and Ring1Port2 shall be Forwarding state. The DRP object is not yet configured.

- Unsynchronized

  The DRP object has been configured. The switch node is under clock synchronization.

  In this state, the switch node shall not transmit any DRP frames.

- Ready

  Local clock is synchronized. The switch node is waiting to join a DRP network.

  In this state, the switch node shall only transmit the DeviceAnnunciation frame.

- S_State1

  The switch node is operating in single ring. Both standby ring ports (Ring2Port1 and Ring2Port2) do not exist. That is, the states of these two standby ring ports are NON-EXISTENT.

  In this state, both active ring ports are operating in the Forwarding states.

- S_State2

  The switch node is operating in single ring. Both standby ring ports (Ring2Port1 and Ring2Port2) do not exist. That is, the states of these two standby ring ports are NON-EXISTENT.

  In this state, one ring port is operating in the Forwarding state; the other ring port is operating in Blocking state.

- D_State1

  The switch node is operating in double ring. Two ring ports are operating in the Disabled state. And the other two ring ports are operating in the Forwarding states.

- D_State2

  The switch node is operating in double ring. Two ring ports are operating in the Disabled state. And the other two ring ports of switch node are working in the Forwarding and the Blocking states respectively.

9.5.2 Protocol State Machine description

The DRP protocol machine is shown in Figure 11.

The formal specification is described in Table 24.

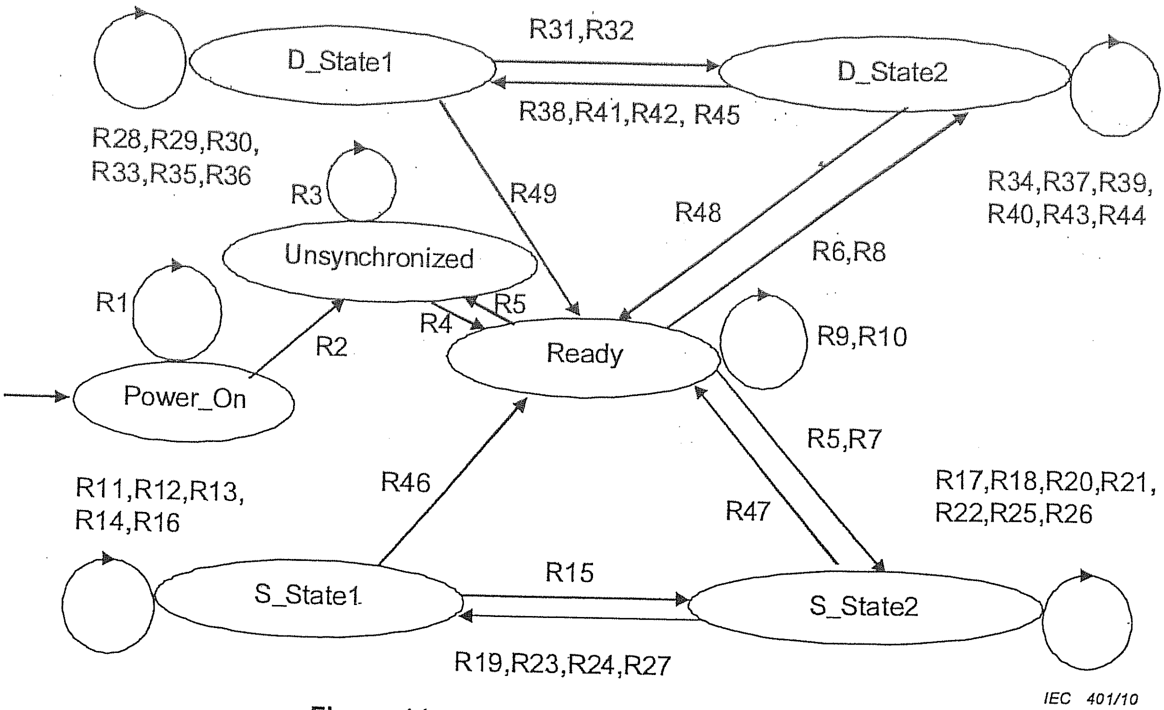


Figure 11 – DRP protocol state machine

9.5.3 State transitions

The state transitions of the DRP protocol state machine are specified in Table 24.

Table 24 – DRP state transitions

Nb	Current State	Event =>Action	Next State

R1	Power_On	Write.ind
		&& WriteSucceed() == FALSE
		=>
		Write.err{
		}
			Power_On

R2	Power_On	Write.ind
		&&WriteSucceed() == TRUE
		=>
		Write.rsp(+){
		}
		LoadRingPortState()
			Unsynchronized

R3	Unsynchronized	SynchronizationFinished()==FALSE => (no actions taken)	Unsynchronized
R4	Unsynchronized	SynchronizationFinished()==TRUE => (no actions taken)	Ready
R5	Ready	ConfigureInfo() == "SINGLE_RING" && DRPKeyParaConfigure() == TRUE => DRPSendTimer(RingCheck) DRPSendTimer(LinkCheck)	S_State2
R6	Ready	ConfigureInfo() == "DOUBLE_RING" && DRPKeyParaConfigure() == TRUE => DRPSendTimer(RingCheck) DRPSendTimer(LinkCheck)	D_State2
R7	Ready	DrpRecvMsg() == "RingChange" && ConfigureInfo() == "SINGLE_RING" && DRPKeyParaConfigure() == FALSE && CheckMACAddress() == TRUE => SetDRPKeyPara()	S_State2
R8	Ready	DrpRecvMsg() == "RingChange" && ConfigureInfo() == "DOUBLE_RING" && DRPKeyParaConfigure() == FALSE && CheckMACAddress() == TRUE => SetDRPKeyPara()	D_State2
R9	Ready	DrpRecvMsg() == "RingCheck" => SendDeviceAnnunciation()	Ready

Nb	Current State	Event =>Action	Next State
R10	Ready	ConfigureInfo() == "UNCONFIGURE" => SendLinkAlarm()	Ready
R11	S_State1	DrpRecvMsg()=="DeviceAnnunciation" && LocalSendRingCheck() == TRUE => SetDRPKeyPara() Assigned_SequenceID := SearchDeviceState() SendRingChange(Assigned_SequenceID)	S_State1
R12	S_State1	DrpRecvMsg()==" RingCheck" => ForwardingRingCheck()	S_State1
R13	S_State1	LocalSendRingCheck() == FALSE && RecvAnnunciationWithinTimeLimit() == FALSE => RecordDeviceState(FALSE)	S_State1
R14	S_State1	LocalSendRingCheck() == TRUE && RecvAnnunciationWithinTimeLimit() == FALSE => ChangeRingState(OPEN)	S_State1
R15	S_State1	FaultPort := RecvLinkCheckWithinTimeLimit(); FaultPort != All_RingPort_OK => Clear_FDB(0) ChangePortState (FaultPort) SendLinkAlarm()	S_State2
R16	S_State1	DrpRecvMsg()=="LinkAlarm" => Clear_FDB(0)	S_State1
R17	S_State2	DrpRecvMsg()==" RingCheck" && AnnunciationBlockingPort() == FALSE => ForwardingRingCheck()	S_State2
R18	S_State2	DrpRecvMsg()=="DeviceAnnunciation" && LocalSendRingCheck() == TRUE => SetDRPKeyPara() Assigned_SequenceID := SearchDeviceState() SendRingChange(Assigned_SequenceID)	S_State2

Nb	Current State	Event =>Action	Next State
R19	S_State2	DrpRecvMsg()==" RingCheck" && AnnunciationBlockingPort() == TRUE && LocalDRPSequenceIDSmaller() == FLASE => ForwardingRingCheck() SetRingPortState(Forwarding,Forwarding,None,None)	S_State1
R20	S_State2	LocalSendRingCheck() == TRUE && RecvAnnunciationWithinTimeLimit() == TRUE => ChangeRingState(CLOSE)	S_State2
R21	S_State2	LocalSendRingCheck() == TRUE && RecvAnnunciationWithinTimeLimit() == FALSE => ChangeRingState(OPEN)	S_State2
R22	S_State2	FaultPort := RecvLinkCheckWithinTimeLimit() FaultPort != All_RingPort_OK => Clear_FDB(0) ChangePortState(FaultPort) SendLinkAlarm()	S_State2
R23	S_State2	DrpRecvMsg()=="LinkAlarm" && NoLocalLinkFault() == TRUE => Clear_FDB(0) SetRingPortState(Forwarding,Forwarding,None,None)	S_State1
R24	S_State2	DrpRecvMsg()=="LinkAlarm" && NoLocalLinkFault() == FALSE && LocalDRPSequenceIDSmaller() == FALSE => Clear_FDB(0) SetRingPortState(Forwarding,Forwarding,None,None)	S_State1
R25	S_State2	DrpRecvMsg()=="LinkAlarm" && NoLocalLinkFault() == FALSE && LocalDRPSequenceIDSmaller() == TRUE => Clear_FDB(0)	S_State2
R26	S_State2	LocalSendRingCheck() == TRUE && RecvLinkAlarm() == TRUE => SmallerDRPSequenceID := BlockingPortSelect() SendLinkChange(SmallerDRPSequenceID)	S_State2

Nb	Current State	Event =>Action	Next State
R27	S_State2	DrpRecvMsg()=="LinkChange" && DRPSequenceIDCompare() == FALSE => Clear_FDB(0) SetRingPortState(Forwarding,Forwarding,None,None)	S_State1
R28	D_State1	DrpRecvMsg()=="DeviceAnnunciation" && LocalSendRingCheck() == TRUE => SetDRPKeyPara() Assigned_SequenceID := SearchDeviceState() SendRingChange(Assigned_SequenceID)	D_State1
R29	D_State1	LocalSendRingCheck() == TRUE && RecvAnnunciationWithinTimeLimit() == TRUE => ChangeRingState(CLOSE)	D_State1
R30	D_State1	LocalSendRingCheck() == TRUE && RecvAnnunciationWithinTimeLimit() == FALSE => ChangeRingState(OPEN)	D_State1
R31	D_State1	FaultPort := RecvLinkCheckWithinTimeLimit(); FaultPort != All_RingPort_OK && StandbyPortLinkState(FaultPort) == LINKDOWN && ActivePortLinkState(FaultPort) == LINKDOWN => Clear_FDB(0) ChangePortState(FaultPort) SendLinkAlarm()	D_State2
R32	D_State1	FaultPort := RecvLinkCheckWithinTimeLimit(); FaultPort != All_RingPort_OK && ActivePortLinkState(FaultPort) == LINKUP => Clear_FDB(0) ChangeDoublePortState(FaultPort)	D_State2
R33	D_State1	FaultPort := RecvLinkCheckWithinTimeLimit(); FaultPort != All_RingPort_OK && StandbyPortLinkState(FaultPort) == LINKUP && ActivePortLinkState(FaultPort) == LINKDOWN => Clear_FDB(0) ChangeDoublePortState(FaultPort)	D_State1

Nb	Current State	Event =>Action	Next State
R34	D_State2	FaultPort := RecvLinkCheckWithinTimeLimit(); FaultPort != All_RingPort_OK && ActivePortLinkState(FaultPort) == LINKUP => Clear_FDB(0) ChangeDoublePortState(FaultPort)	D_State2
R35	D_State1	DrpRecvMsg()=="LinkAlarm" => Clear_FDB(0)	D_State1
R36	D_State1	DrpRecvMsg()=="LinkChange" => (no actions taken)	D_State1
R37	D_State2	DrpRecvMsg()=="DeviceAnnunciation" && LocalSendRingCheck() == TRUE => SetDRPKeyPara() Assigned_SequenceID := SearchDeviceState() SendRingChange(Assigned_SequenceID)	D_State2
R38	D_State2	DrpRecvMsg()==" RingCheck" && AnnunciationBlockingPort() == TRUE && LocalDRPSequenceIDSmaller() == FLASE => ForwardingRingCheck() SetRingPortState(Forwarding,Forwarding,Disabled,Disable d)	D_State1
R39	D_State2	FaultPort := RecvLinkCheckWithinTimeLimit(); FaultPort != All_RingPort_OK && StandbyPortLinkState(FaultPort) == LINKDOWN => Clear_FDB(0) ChangePortState(FaultPort) SendLinkAlarm()	D_State2
R40	D_State2	RecvLinkCheckWithinTimeLimit() != All_RingPort_OK && StandbyPortLinkState(FaultPort) == LINKUP => Clear_FDB(0) ChangeDoublePortState(FaultPort)	D_State2
R41	D_State2	DrpRecvMsg()=="LinkAlarm" && NoLocalLinkFault() == TRUE => Clear_FDB(0) SetRingPortState(Forwarding,Forwarding,Disabled, Disabled)	D_State1

Nb	Current State	Event =>Action	Next State
R42	D_State2	DrpRecvMsg()=="LinkAlarm" && NoLocalLinkFault() == FALSE && LocalDRPSequenceIDSmaller() == FLASE => Clear_FDB(0) SetRingPortState(Forwarding,Forwarding, Disabled,Disabled)	D_State1
R43	D_State2	DrpRecvMsg()=="LinkAlarm" && NoLocalLinkFault() == FALSE && LocalDRPSequenceIDSmaller() == TRUE => Clear_FDB(0)	D_State2
R44	D_State2	LocalSendRingCheck() == TRUE && RecvLinkAlarm() == TRUE => SmallerDRPSequenceID := BlockingPortSelect() SendLinkChange(SmallerDRPSequenceID)	D_State2
R45	D_State2	DrpRecvMsg()=="LinkChange" && DRPSequenceIDCompare() == FALSE => SetRingPortState(Forwarding,Forwarding, Disabled,Disabled)	D_State1
R46	S_State1	TimeUnsynchronization()== TRUE || DrpRecvMsg()==" RingCheck" && DuplicateDRPSequenceID() == TRUE => ClearDRPKeyPara()	Ready
R47	S_State2	TimeUnsynchronization()== TRUE || DrpRecvMsg()==" RingCheck" && DuplicateDRPSequenceID() == TRUE => ClearDRPKeyPara()	Ready
R48	D_State1	TimeUnsynchronization()== TRUE || DrpRecvMsg()==" RingCheck" && DuplicateDRPSequenceID() == TRUE => ClearDRPKeyPara()	Ready
R49	D_State2	TimeUnsynchronization()== TRUE || DrpRecvMsg()==" RingCheck" && DuplicateDRPSequenceID() == TRUE => ClearDRPKeyPara()	Ready
R50	Ready	TimeUnsynchronization()== TRUE => PassiveMasterState()	Unsynchronized

9.5.4 Function descriptions

9.5.4.1 General

The functions used in DRP state transitions are listed in Table 25 through Table 59.

NOTE The drp_svc represents the message that comes from user configuration programs.

9.5.4.2 SetRingPortState()

SetRingPortState() is specified in Table 25.

Table 25 – SetRingPortState() descriptions

Name	SetRingPortState	**Using**	DRP
Input		**Output**	
Ring1Port1 State, Ring1Port2 State, Ring2Port1 State, Ring2Port2 State		None	
Function			
Set the state of ring ports.			

9.5.4.3 LoadRingPortState()

LoadRingPortState() is specified in Table 26.

Table 26 – LoadRingPortState() descriptions

Name	LoadRingPortState	**Using**	DRP
Input		**Output**	
None		None	
Function			
Load port ID and state of ring ports.			

9.5.4.4 WriteSucceed()

WriteSucceed() is specified in Table 27.

Table 27 – WriteSucceed() descriptions

Name	WriteSucceed	**Using**	DRP
Input		**Output**	
None		TRUE or FALSE	
Function			
Evaluate the write state. If failed, then return FALSE; if succeed, then return TRUE.			

9.5.4.5 SynchronizationFinished()

SynchronizationFinished() is specified in Table 28.

Table 28 – SynchronizationFinished() descriptions

Name	SynchronizationFinished	Using	DRP
Input		**Output**	
None		TRUE or FALSE	
Function			
Return TRUE if switch has been synchronized according to IEC 61588 (IEEE 1588).			

9.5.4.6 ActivePortLinkState()

ActivePortLinkState() is specified in Table 29.

Table 29 – ActivePortLinkState() descriptions

Name	ActivePortLinkState	Using	DRP
Input		**Output**	
RingPort		LINKUP or LINKDOWN	
Function			
Judge the link state of RingPort.			

9.5.4.7 StandbyPortLinkState()

StandbyPortLinkState() is specified in Table 30.

Table 30 – StandbyPortLinkState() descriptions

Name	StandbyPortLinkState	Using	DRP
Input		**Output**	
RingPort		LINKUP or LINKDOWN	
Function			
If the RingPort is Ring1 Port1, then return the link state of Ring2 Port1. If the RingPort is Ring1 Port2, then return the link state of Ring2 Port2. If the RingPort is Ring2 Port1, then return the link state of Ring1 Port1. If the RingPort is Ring2 Port2, then return the link state of Ring1 Port2.			

9.5.4.8 ConfigureInfo()

ConfigureInfo() is specified in Table 31.

Table 31 – ConfigureInfo() descriptions

Name	ConfigureInfo	Using	DRP
Input		**Output**	
None		SINGLE_RING, DOUBLE_RING, UNCONFIGURE	
Function			
Evaluate the ring network state. Return SINGLE_RING if the switch node is operating in single ring network. Return DOUBLE_RING if the switch node is operating in double ring network. Return UNCONFIGURE if the switch node is no configuration.			

9.5.4.9 DRPSendTimer()

DRPSendTimer() is specified in Table 32.

Table 32 – DRPSendTimer() descriptions

Name	RingCheckSendTimer	Using	DRP
Input		Output	
drp_svc		None	
Function			
If the drp_svc is RingCheck, set the timer for local switch node to send the RingCheck frame and set the timer of RingCheck Time Limit. If the drp_svc is LinkCheck, set the timer for local switch node to send the LinkCheck frame and set the timer of RingCheck Time Limit.			

9.5.4.10 SendRingChange()

SendRingChange() is specified in Table 33.

Table 33 – SendRingChange() descriptions

Name	SendRingChange	Using	DRP
Input		Output	
Assigned_SequenceID		TRUE or FALSE	
Function			
The Assigned_SequenceID should send in RingCheck frame to assigned the SequenceID for the unconfigured switch node. If the RingChange frame is sent successful, then return TRUE, otherwise return FALSE.			

9.5.4.11 ForwardingRingCheck()

ForwardingRingCheck() is specified in Table 34.

Table 34 – ForwardingRingCheck() descriptions

Name	ForwardingRingCheck	Using	DRP
Input		Output	
None		TRUE or FALSE	
Function			
If the received the RingCheck frame is not sent by local switch node, then forward this RingCheck frame from one ring port to the other ring port, otherwise drop the RingCheck frame.			

9.5.4.12 AnnunciationBlockingPort()

AnnunciationBlockingPort() is specified in Table 35.

Table 35 – AnnunciationBlockingPort() descriptions

Name	AnnunciationBlockingPort	Using	DRP
Input		Output	
None		TRUE or FALSE	
Function			
Evaluate the received the RingCheck frame. If one of ring port state in the RingCheck frame is Blocking, then return TRUE; otherwise return FALSE.			

9.5.4.13 LocalDRPSequenceIDSmaller()

LocalDRPSequenceIDSmaller() is specified in Table 36.

Table 36 – LocalDRPSequenceIDSmaller() descriptions

Name	**LocalDRPSequenceIDSmaller**	**Using**	**DRP**
Input		**Output**	
None		TRUE or FALSE	
Function			
Evaluate the DRPSequenceID in received frame. If the DRPSequenceID in the frame is smaller than the local DRPSequenceID, then return FALSE; otherwise return TRUE.			

9.5.4.14 RecvAnnunciationWithinTimeLimit()

RecvAnnunciationWithinTimeLimit() is specified in Table 37.

Table 37 – RecvAnnunciationWithinTimeLimit() descriptions

Name	**RecvAnnunciationWithinTimeLimit**	**Using**	**DRP**
Input		**Output**	
None		TRUE or FALSE	
Function			
When Ring Check Time Limit timer expires, if the switch node hasn't received either of its RingCheck frames, then return FALSE. Otherwise return TRUE.			

9.5.4.15 RecvLinkCheckWithinTimeLimit()

RecvLinkCheckWithinTimeLimit() is specified in Table 38.

Table 38 – RecvLinkCheckWithinTimeLimit() descriptions

Name	**RecvLinkCheckWithinTimeLimit**	**Using**	**DRP**
Input		**Output**	
None		0 = All_RingPort_OK, or 1 = Ring1Port1, or 2 = Ring1Port2, or 3 = Ring2Port1, or 4 = Ring2Port2	
Function			
Evaluate if the LinkCheck frame is received. In this Cycle, if all active ring ports received the LinkCheck frame, then return AllRingPortOK; if one ring port did not receive the LinkCheck frame, then return this ring port. If more than two ring ports did not receive the LinkCheck frame, just return the smaller ring port.			

9.5.4.16 NoLocalLinkFault()

NoLocalLinkFault() is specified in Table 39.

Table 39 – NoLocalLinkFault() descriptions

Name	**NoLocalLinkFault**	**Using**	**DRP**
Input		**Output**	
None		TRUE or FALSE	
Function			
Returns TRUE if no local link fault detected, otherwise return FALSE.			

9.5.4.17 RecvLinkAlarm()

RecvLinkAlarm() is specified in Table 40.

Table 40 – RecvLinkAlarm() descriptions

Name	RecvLinkAlarm	**Using**	DRP
Input		**Output**	
None		TRUE or FALSE	
Function			
Returns TRUE if one or two LinkAlarm frame have been received in one Cycle. Return FALSE if no LinkAlarm frame has been received.			

9.5.4.18 Clear_FDB(time)

Clear_FDB() is specified in Table 41.

Table 41 – Clear_FDB() descriptions

Name	Clear_FDB	**Using**	DRP
Input	time	**Output**	
None		TRUE or FALSE	
Function			
Clear FDB of the local switch after node time delay. If time is 0, this function shall clear FDB without any delay.			

9.5.4.19 ChangeRingState()

ChangeRingState() is specified in Table 42.

Table 42 – ChangeRingState() descriptions

Name	ChangeRingState	**Using**	DRP
Input		**Output**	
OPEN or CLOSE		TRUE or FALSE	
Function			
Change ring state recorded in state machine.			

9.5.4.20 BlockingPortSelect()

BlockingPortSelect() is specified in Table 43.

Table 43 – BlockingPortSelect() descriptions

Name	BlockingPortSelect	**Using**	DRP
Input		**Output**	
None		None	
Function			
In one Cycle, Evaluate which DRPSequenceID in the two LinkAlarm frame is smaller, return the small DRPSequenceID. When only one LinkAlarm frame is received, just return the DRPSequenceID in this LinkAlarm frame.			

9.5.4.21 SendLinkChange()

SendLinkChange() is specified in Table 44.

Table 44 – SendLinkChange() descriptions

Name	SendLinkChange	Using	DRP
Input		Output	
DRPSequenceID		TRUE or FALSE	
Function			
If the LinkChange frame is sent successful, then return TRUE, otherwise return FALSE			

9.5.4.22 DRPSequenceIDCompare()

DRPSequenceIDCompare() is specified in Table 45.

Table 45 – DRPSequenceIDCompare() descriptions

Name	DRPSequenceIDCompare	Using	DRP
Input		Output	
None		TRUE or FALSE	
Function			
Compare the BLOCKINGPORT_DRPSequenceID in the LinkChange frame with the value of DRPSequenceID of local switch node, return TRUE if the local switch node's DRPSequenceID is same as the BLOCKINGPORT_DRPSequenceID in received LinkChange frame.			

9.5.4.23 ChangePortState()

ChangePortState() is specified in Table 46.

Table 46 – ChangePortState() descriptions

Name	ChangePortState	Using	DRP
Input		Output	
RingPort		None	
Function			
If the RingPort is Ring1 Port1, then set the state of Ring1Port1 in Blocking, and Ring1Port2 in Forwarding, If the RingPort is Ring1 Port2, then set the state of Ring1Port2 in Blocking, and Ring1Port1 in Forwarding, If the RingPort is Ring2 Port1, then set the state of Ring2Port1 in Blocking, and Ring2Port2 in Forwarding, If the RingPort is Ring2 Port2, then set the state of Ring2Port2 in Blocking, and Ring2Port1 in Forwarding.			

9.5.4.24 ChangeDoublePortState()

ChangeDoublePortState() is specified in Table 47.

Table 47 – ChangeDoublePortState() descriptions

Name	ChangeDoublePortState	Using	DRP
Input		Output	
RingPort		TRUE or FALSE	
Function			
If the RingPort is Ring1 Port1 or Ring2 Port1, then exchange the link state of Ring1 Port1 and Ring2 Port1, If the RingPort is Ring1 Port2 or Ring2 Port2, then exchange the link state of Ring1 Port2 and Ring2 Port2.			

9.5.4.25 LocalSendRingCheck()

LocalSendRingCheck() is specified in Table 48.

Table 48 – LocalSendRingCheck() descriptions

Name	LocalSendRingCheck	**Using**	DRP
Input		**Output**	
None		TRUE or FALSE	
Function			
Evaluate if the RingCheck frame is sent by the node itself. Return TRUE if the Source MAC address in the RingCheck frame is equal to the MAC address of the switch node. otherwise return FALSE.			

9.5.4.26 DRPKeyParaConfigure()

DRPKeyParaConfigure() is specified in Table 49.

Table 49 – DRPKeyParaConfigure() descriptions

Name	DRPKeyParaConfigure	**Using**	DRP
Input		**Output**	
None		TRUE or FALSE	
Function			
Evaluate if both DRPDeviceNumber and DRPSequenceID are configured. Return TRUE if these parameters are configured, otherwise return FALSE.			

9.5.4.27 CheckMACAddress()

CheckMACAddress() is specified in Table 50.

Table 50 – CheckMACAddress() descriptions

Name	CheckMACAddress	**Using**	DRP
Input		**Output**	
None		TRUE or FALSE	
Function			
Evaluate if MAC Address in the RingChange frame is equal to local MAC Address. Return TRUE if MAC Address in the RingChange frame is equal to local MAC Address, otherwise return FALSE.			

9.5.4.28 SetDRPKeyPara()

SetDRPKeyPara() is specified in Table 51.

Table 51 – SetDRPKeyPara() descriptions

Name	SetDRPKeyPara	**Using**	DRP
Input		**Output**	
None		None	
Function			
Set the value of DRPDeviceNumber, DRPSequenceID and Cycle.			

9.5.4.29 SendDeviceAnnunciation()

SendDeviceAnnunciation() is specified in Table 52.

Table 52 – SendDeviceAnnunciation() descriptions

Name	SendDeviceAnnunciation	Using	DRP
Input		Output	
None		None	
Function			
Send NewDeviceAnnciation frame.			

9.5.4.30 FaultRecvRingCheck()

FaultRecvRingCheck() is specified in Table 53.

Table 53 – FaultRecvRingCheck() descriptions

Name	FaultRecvRingCheck	Using	DRP
Input		Output	
None		TRUE or FALSE	
Function			
Evaluate if the RingCheck frame is received in Ring Check Time Limit. Return TRUE if any RingCheck is received in Ring Check Time Limit, otherwise return FALSE.			

9.5.4.31 RecordDeviceState()

RecordDeviceState() is specified in Table 54.

Table 54 – RecordDeviceState() descriptions

Name	RecordDeviceState	Using	DRP
Input		Output	
TRUE or FALSE		None	
Function			
Set the corresponding bit in DRPDeviceState to 0, if the input parameter is FALSE.			

9.5.4.32 DrpRecvMsg()

DrpRecvMsg() is specified in Table 55.

Table 55 – DrpRecvMsg() descriptions

Name	DRPRecvMsg	Using	DRP
Input		Output	
drp_svc		drp_svc message type	
Function			
This function is invoked when a message is received. It decodes the em_svc and returns the type of the DRP frame.			

9.5.4.33 SendLinkAlarm()

SendLinkAlarm() is specified in Table 56.

Table 56 – SendLinkAlarm() descriptions

Name	SendLinkAlarm	Using	DRP
Input		Output	
None		TRUE or FALSE	
Function			
If the Link Alarm frame is sent successful, then return TRUE, otherwise return FALSE			

9.5.4.34 TimeUnsynchronization()

TimeUnsynchronization() is specified in Table 57.

Table 57 – TimeUnsynchronization() descriptions

Name	TimeUnsynchronization	Using	DRP
Input		Output	
None		TRUE or FALSE	
Function			
If the time synchronization precision is out of TargetTimeSyncClass, then return TRUE, otherwise return FALSE.			

9.5.4.35 PassiveMasterState()

PassiveMasterState() is specified in Table 58.

Table 58 – PassiveMasterState() descriptions

Name	PassiveMasterState	Using	DRP
Input		Output	
None		None	
Function			
Set the master port in switch node to passive state, and stop sending sync frame to its slave clock.			

9.5.4.36 SearchDeviceState()

SearchDeviceState() is specified in Table 59.

Table 59 – SearchDeviceState() descriptions

Name	SearchDeviceState	Using	DRP
Input		Output	
None		Assigned_SequenceID	
Function			
Searches from Lest Significant Bit to Most Significant Bit in DRPDeviceState, and will return the address number once it finds the first zero bit.			

Annex A
(informative)

DRP recovery time

A.1 Recovery time calculation

The maximum recovery time from a fault is:

$$T_r = T_{ti} + T_{to} + T_{pf} + T_{tt} \times DRPDeviceNumber + T_{ph} \times L_{ph}$$

where

T_r	is the recovery time;
T_{ti}	is the time interval between two LinkCheck frames, its value is equal to a Cycle;
T_{to}	is the receiving timeout delay of a LinkCheck frame, its value is equal to that of Link Check Time Limit;
T_{pf}	is the total processing delay of related DRP frames in a switch node;
T_{tt}	is the transmission delay of a DRP frame in a switch node in network;
T_{ph}	is the propagation delay of a DRP frame in 1 km cable;
L_{ph}	is the cable length (its unit is km) in the DRP redundancy domain;
DRPDeviceNumber	is the number of DRP switch nodes in a DRP redundancy domain.

and

$$T_{pf} = T_{sLA} + T_{rLA} + T_{sLC} + T_{rLC} + T_{cFDB}$$

T_{sLA}	is the transmission delay for a LinkAlarm frame in sending switch node;
T_{rLA}	is the processing delay for a LinkAlarm frame in receiving switch node;
T_{sLC}	Is the transmission delay for a LinkChange frame in sending switch node;
T_{rLC}	is the processing delay for a LinkChange frame in receiving switch node;
T_{cFDB}	is the time delay to clear FDBs.

and

$$T_{tt} = T_{tLA} + T_{dLA} + T_{tLC} + T_{dLC}$$

T_{tLA} is the forwarding delay of the LinkAlarm frame through two ring ports of a switch node;

T_{dLA} is the time delay to wait for a regular Ethernet frame with maximum size of 1 518 bytes transmission before transferring a LinkAlarm frame;

T_{tLC} is the forwarding delay of LinkChange frame through two ring ports of a switch node;

T_{dLC} is the time delay to wait for a regular Ethernet frame with maximum size of 1 518 bytes transmission before transferring a LinkChange frame.

and

$$T_{ph} = T_{phLA} + T_{phLC}$$

T_{phLA} is the transferring time delay of the LinkAlarm frame through physical media;

T_{phLC} is the transferring time delay of LinkChange frame through physical media.

A.2 Example of recovery time calculation

The following is an example of maximum recovery time for a DRP network with 50 switch nodes whose communication speed is 100 Mb/s for ring ports and the cable length between all switch nodes in the ring is 2 km.

For the following calculation example, some parameters of DRP Class defined in Clause 6 can be set as shown in Table A.1.

Table A.1 – An example of parameters setting for DRP Class

No	Parameter	Value	Descriptions
1	Cycle	50 ms	the communication period of the redundancy domain
2	Ring Check SendTimeOffset	0 ms	the time offset for a switch node to transmit the RingCheck frame from the beginning of a Cycle
3	RingCheckTimeLimit	1 ms	the time limit to assert network ring fault
4	Link CheckSendTimeOffset	20 ms	the time interval from the beginning of a Cycle for local switch node to send the LinkCheck frame
5	LinkCheckTimeLimit	1 ms	the time limit for a switch node to assert an inter-switch link fault or a neighbour switch fault
6	SynchronizationClockType	1	the type of clock synchronization
7	TargetTimeSyncClass	10 µs	the desired time synchronization precision supported by time client

The parameters for calculation of recovery time are given in Table A.2.

Table A.2 – Parameters for calculation of recovery time

Parameter	Max. Time (ms)	Descriptions
Tti	50	the time interval between two LinkCheck frames
Tto	5	the receiving timeout delay of a LinkCheck frame
Tpf	1	T_{sLA}, the transmission delay for a LinkAlarm frame in sending switch node
	1	T_{rLA}, the processing delay for a LinkAlarm frame in receiving switch node
	1	T_{sLC}, the transmission delay for a LinkChange frame in sending switch node
	1	T_{rLC}, the processing delay for a LinkChange frame in receiving switch node
	5	T_{cFDB}, the time delay to clear FDBs
Ttt	0,005	T_{tLA}, the transferring delay of the LinkAlarm frame through two ring ports of a switch node
	0,125	T_{dLA}, the time delay to wait for a regular Ethernet frame with maximum size of 1,518 bytes transmission before transferring a LinkAlarm frame
	0,005	T_{tLC}, the transferring delay of LinkChange frame through two ring ports of a switch node
	0,125	T_{dLC}, the time delay to wait for a regular Ethernet frame with maximum size of 1,518 bytes transmission before transferring a LinkChange frame
T_{ph}	0,03	T_{phLC}, the transferring time delay of the LinkChange frame on physical media
	0,03	T_{phLA}, the transferring time delay of the LinkAlarm frame on physical media

Thus, the maximum recovery time is calculated as follows:

$$T_r = T_{ti} + T_{to} + T_{pf} + T_{tt} \times \text{DRPDeviceNumber} + T_{ph} \times L_{ph}$$

$$= T_{ti} + T_{to} + (T_{sLA} + T_{rLA} + T_{sLC} + T_{rLC} + T_{cFDB})$$

$$+ (T_{tLA} + T_{dLA} + T_{tLC} + T_{dLC}) \times \text{DRPDeviceNumber} + (T_{phLA} + T_{phLC}) \times L_{ph}$$

$$= 50 + 5 + (1 + 1 + 1 + 1 + 5) + (0{,}005 + 0{,}125 + 0{,}005 + 0{,}125) \times 50 + (0{,}03 + 0{,}03)$$

$$\times 2 \times 50$$

$$= 50 + 5 + 9 + 17.5 + 3$$

$$= 84{,}5 \text{ ms}$$