Application Example • 02/2017

Setup of a Ring Topology based on “MRPD”

SIMATIC S7-1500 / ET 200SP

Warranty and Liability

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1 Task and Solution

1.1 Task Description

Description
Automated plants often need to be in operation 24/7. Therefore, failure safety and high availability are important, the basic requirements of many automation systems. Special media redundancy protocols that ensure a loop-free network topology and a detection of communication interruptions address these issues. Redundant systems require a switching time to detect interruptions and to switch over to redundant structures. However, these switching times do not always entirely meet the requirements of the plant’s application. For high-dynamic applications or for process engineering, for example, short interruptions are unacceptable.

This configuration description shows the concept of a bumpless redundancy. In this process, the switchover takes place without reconfiguration time in the event of an error.

Requirements
The following requirements have to be considered:
- High availability of the communication between the participants of the ring
- Short update times of the of the PROFINET Devices.
- The concepts must be applicable for an IRT network.
- During line interruptions or during a device exchange, no data loss must occur in the rest of the plant.

1.2 Possible solutions

Description
The requirements are met on the basis of a ring topology of the MRP (“Media Redundancy Protocol”) extension “Media Redundancy with Planned Duplication of frames” (“MRPD”). During a device or line failure in the ring, all other devices continue to be supplied with IO data without interruption.

MRPD is based on IRT and MRP. To avoid interruptions in the event of an error, the PROFINET devices that participate in the ring send their data in both directions. Since the devices receive these data at both ring ports, there is no reconfiguration time for the ring.
Diagrammatic representation

The figure below shows a schematic illustration of the “MRPD” function:

Figure 1-1

Advantages

The MRP extension MRPD offers you the following advantages:

- short update times due to IRT.
- During a device or line failure in the ring, all other devices continue to be supplied with IO data without interruption and reconfiguration time.
- Manufacturer-independent, as MRPD is specified by the PROFINET standard.
- Comprehensive diagnostics via PROFINET.
- Realizable without the use of additional external Ethernet Switches.

Prerequisite

The following prerequisites must be met for the use of the media redundancy with MRPD:

- All participating devices must support MRPD, including the terminals at the switch, which through a ring component cyclically exchange IRT data.
- MRP is configured for all participants in the ring. The MRP role “Not device in the ring” is assigned to all devices that are not in the ring.
- IRT is configured for all participating components.

Note

Additionally, the same prerequisites apply for MRPD as for the MRP.

For ring topologies that have “MRP” activated, the “MRPD” function is automatically activated for IRT-capable devices, if it is supported by the devices.
# Basics on MRPD

## Definition and function of MRPD

The “Media Redundancy for Planned Duplication” (MRPD) is specified by the IEC 61158 standard and specially developed for PROFINET IRT (Isochronous Real Time). It ensures a bumpless switching of the ring topology in the event of an error. The MRPD mechanism is based on IRT and MRP. A reconfiguration time of 0 ms is made possible by sending the cyclic IRT data packages via the two communication paths in the ring. The recipient receives the same IRT frame twice, if there is no error in the network.

### Task of the redundancy manager

The redundancy manager monitors and controls the ring with regard to network errors. For this, it sends test frames both from ring port 1 and ring port 2. These test frames pass the ring in both directions until they arrive at the redundancy manager’s other ring port.

In the error-free state, the redundancy manager blocks the network traffic on one of its ring ports (except for the test frames). Thus, the physical ring structure at the logical level for normal network traffic is converted back to a linear structure and loops are avoided.

However, if there is no test frame, a network error has occurred. The ring might be interrupted e.g. due to a failure of a connection between two devices or of a device in the ring.

In this case, the redundancy manager connects through the previously blocked ring port. Via this substitute path, a functioning connection between all remaining devices is restored in form of a linear network topology.

## Technical data

The following table shows the technical data of MRPD.
2 Basics on MRPD

Table 2-1

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network topology</td>
<td>Ring topology</td>
</tr>
<tr>
<td>Transmission medium</td>
<td>Fiber optic cable and Twisted Pair</td>
</tr>
<tr>
<td>Connection parameters</td>
<td>• Full duplex</td>
</tr>
<tr>
<td></td>
<td>• 100Mbit/s</td>
</tr>
<tr>
<td>Maximum number of devices</td>
<td>32</td>
</tr>
<tr>
<td>Reconfiguration time</td>
<td>0ms (for IRT communication)</td>
</tr>
</tbody>
</table>

Media redundancy role

Depending on the device in use, the following roles are available; “Manager”, “Manager (Auto)”, “Client” and “Not device in the ring”.

There are the following rules for the configuration of the media redundancy roles of the PROFINET participants:

- The “Manager” role must be assigned to one device only in the ring. No additional devices with the “Manager” or “Manager (Auto)” role are allowed. All other devices in the ring must be assigned with the “Client” role.
- If there is no device in the ring with the “Manager” role, the ring must have at least one device with the “Manager (Auto)” role.
- Any number of devices with the “Client” role is allowed, as long as the maximum number of devices and the available bandwidth is observed.

Redundancy levels of IO Devices with MRPD

With MRPD, there are several redundancy levels of an IO Device. This redundancy level indicates, how severely real-time communication is affected in the event of a network interruption between the IO Device and its IO Controller.

The following redundancy levels are available:

- Full media redundancy: The real-time communication is not affected, since IO Controller and IO Device are in the same ring.
- Partial media redundancy:
  - Real-time communication cannot be maintained, if there is an interruption in a non-redundant part (line) between IO Controller and IO Device.
  - The real-time communication is not affected, if there is an interruption in the redundant part (ring).
- No media redundancy: The real-time communication is always affected, since there are no redundant paths between IO Controller and IO Device.

The following figure shows the redundancy levels by means of a configuration example with MRPD. The three IO Devices in the ring (2) and the switch (3) have the redundancy level “Full redundancy”. The IO Device at the switch (4) has the redundancy level “Partial redundancy”, as the connection to the switch is not redundant.
Modules supporting MRPD

The most important prerequisite for MRPD is that every module used supports MRPD.

Not every module supports the MRPD function. The following entries of the Siemens Industry Online Support show, which modules used as IO Controller or IO Device support MRPD.

https://support.industry.siemens.com/cs/ww/de/view/102325771

Note

A redundant linking of MRPD rings is not possible.
3 Configuration

3.1 Infrastructure information

Required components

The use of the “MRPD” function with the components shown here requires the following components:

- A CPU 1516-3 PN/DP (or other S7-1500 with FW V2.0 or higher)
- A SIMATIC MEMORY CARD
- Two ET 200SP stations as IO device with “MRPD” function, including the interface module IM 155-6PN HS (FW V4.0 or higher).
- One 24V power supply with cable connector and terminal block plug (the modules can also be operated with a shared power supply)
- One PG/PC with the configuration tool “STEP 7 V14” installed

Software package

Install STEP 7 V14 on your PC/PG.

Setting up the infrastructure

Connect all the components involved in this solution via the integrated PROFINET interface.

Figure 3-1

Note

It is recommended not to create any PROFINET loops/rings during commissioning.

Do not close the ring until the MRP or MRPD configuration is configured and loaded.
3.2 Configuring an MRPD ring

In the following, it is described how to configure the PROFINET IO system with MRPD in STEP 7 as of version V14 or higher. The description is limited to an IO Controller of the S7-1500 FW V2.0 family and two IO Devices with the IM 155-6 PN HS FW V4.0 interface module.

Configuring the MRPD ring

Note: MRPD itself must not be configured, however, an MRP redundancy must be configured. Use the corresponding application example for the MRP configuration (6). The function is available as soon as all participants of the ring support MRPD.

Preparation

Open the TIA Portal configuration software and create a new project.

Implementing the devices

Add the following devices:

1. Add an S7-1500 CPU with FW V2.0 (in this case CPU 1516-3 PN/DP) using the project navigation. This CPU gets the name “PLC_1”.
2. In the “Devices & networks” overview, insert two ET 200SP stations with a PROFINET interface module (in this case 155-6 PN HS) and equip it with the desired modules (in this case one DI module and one DO module) as well as with a server module.

Networking the devices

To set up an automation system, the individual hardware components must be configured, parameterized and connected to each other. Proceed as follows:

1. Open the device view of the CPU by double clicking “Device configuration”.
2. In the graphical view, select the “X1” interface of the CPU to be networked. The properties of the selected interface are displayed in the inspector window.
3. Select the parameter group “Ethernet addresses” and, under “Interface networked with”, click “Add new subnet”.

Result
The interface is now connected to a new subnet of the suitable subnet type. When this is done, the address parameters of the interface are set consistently automatically.

Finally, add the interface modules (in this case IM 155-6 PN HS) to the newly created network.

For both interface modules, proceed as follows:
1. Access the “Devices & Networks” overview in the project navigation.
2. At the interface module, click “Not assigned” and select the IO controller (“PLC_1”) to which this IO device is assigned.

Result
The interface and the selected subnet are now connected. When this is done, the address parameters of the interface are set consistently automatically.
Configuring the topology

To configure the ring in STEP7, you need to set the topology of the participants.

1. You are currently in the topology view.
2. Generate a ring via the port interconnections. First, interconnect the devices to a line topology. Connect the non-occupied port of the last device in the line with the non-occupied port of the first device.

![Figure 4-5](image)

**Note**
The configured topology must be identical with the actual interconnection.

Configuring the media redundancy

Configure the ring’s media redundancy.

1. Go to “Network View”.
2. Select the PROFINET IO System by clicking on the network connection.
3. In the inspector window, navigate to “Properties” > “General” > “Domain management” > “MRP domains” to the field “Ring interconnection”.

![Figure 6-7](image)

This field displays all topological rings of the IO System with the corresponding MRP domain.

4. In the field “Ring interconnection”, select the ring generated above. The table below displays all PROFINET devices of the selected ring.
5. In the “MRP role” column, set the media redundancy role for the PROFINET devices.

![Figure 8-9](image)

**Note**
Alternatively, you can also use the automatic MRP configuration. The media redundancy role is then automatically assigned to the PROFINET participants.
To do this, click the “Configure MRP automatically” button.
After the automatic MRP configuration, you can make modifications manually, as usual.

**Configuring IRT**
For media redundancy with MRPD, IRT must be activated in the configuration. For this, please follow the instructions below:
1. In the network view, select an IO device.
2. In the inspector window, navigate to “Properties” > “General” > “PROFINET interface” > “Advanced options” > “Real time settings” > “Synchronization”.
3. Change the “RT class” to “IRT”.

![Figure 10-11](image)

**Note**
Activate IRT for all the participants in the ring and for the communication partners.

**Loading and closing the ring**
The configuration is now finished. Load the program into the controller and close the ring by connecting the remaining network cable.
Receiving diagnostic interrupts from the MRPD clients

To receive diagnostic interrupts from the MRPD clients, proceed as follows:

1. In the network view, select a client of the MRP ring from which you want to receive diagnostic interrupts in the MRP Manager.
2. In the inspector window, navigate to “Properties” > “General” > “PROFINET interface” > “Advanced options” > “Media redundancy”.
3. Check the “Diagnostic interrupts” check box.

Figure 12-13

Note
The diagnostic interrupts can be evaluated in the Manager of the controller that is superordinate to the MRPD ring.
4 Links & Literature

Table 02/2017-1

<table>
<thead>
<tr>
<th>Topic</th>
<th>Topic</th>
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</table>
| 1 | Siemens Industry Online Support  
http://support.industry.siemens.com |
| 2 | Download page of the entry  
| 3 | PROFINET with STEP 7 V13  
https://support.industry.siemens.com/cs/de/de/view/49948856 |
| 4 | STEP 7 Professional V14  
https://support.industry.siemens.com/cs/de/de/view/109011420 |
| 5 | ET 200SP Manual Collection  
https://support.industry.siemens.com/cs/ww/de/view/84133942 |
| 6 | Application Example MRP  
https://support.industry.siemens.com/cs/ww/de/view/109739614 |

5 History

Table 5-1

<table>
<thead>
<tr>
<th>Version</th>
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<th>Modifications</th>
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</thead>
<tbody>
<tr>
<td>V1.0</td>
<td>02/2017</td>
<td>First version</td>
</tr>
</tbody>
</table>