


**Co-operative Network Training**



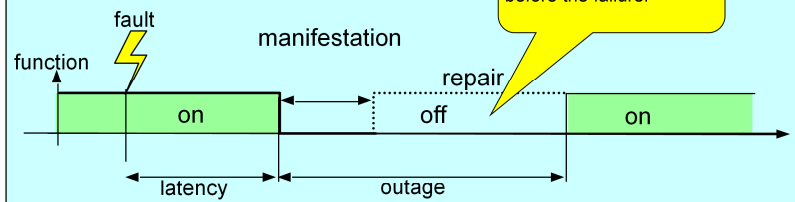
Education and Culture DG  
Lifelong Learning Programme

### Definitions: Fault, Error, Failure

- ❑ **Fault:** missing or wrong functionality of a control system device
  - ❑ **permanent:** due to irreversible change, consistent wrong functionality (e.g. short circuit between 2 lines)
  - ❑ **intermittent:** sometimes wrong functionality, recurring (e.g. loose contact)
  - ❑ **transient:** due to environment, reversible if environment changes (e.g. electromagnetic interference)
- ❑ **Error:** logical manifestation of a fault in an application (e.g. short circuit leads to computation error if 2 lines carry different signals)
- ❑ **Failure:** to perform a prescribed function (e.g. if different signals on both lines lead to wrong output of chip)

**fault**  $\xrightarrow{\text{may cause}}$  **error**  $\xrightarrow{\text{may cause}}$  **failure**

A **fault** is the cause of a **failure**, it may occur long before the failure.



These terms can be applied to the whole system, or to elements thereof.

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PROFINET IO Diagnostics

PROFINET IO is a very cost effective and reliable technology. However, extensive installations can have thousands of PROFINET IO devices operating on many networks. The reliable operation of these networks is essential to maintaining plant productivity. Further, the rapid diagnosis of faults on networks, devices, actuators and sensors is critical for minimizing plant downtime.

For a proper understanding of the problem is necessary to define basic terms like fault, error and failure and to classify the problems arising from the operation of distributed control systems.

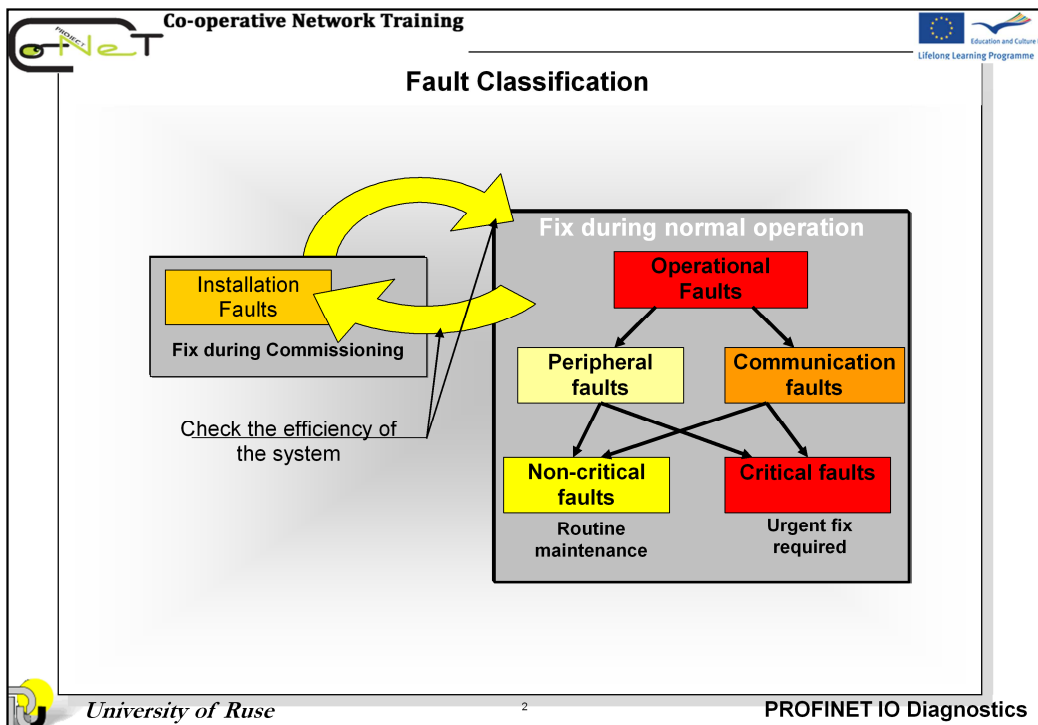
In the design stage of each device is intended specific system function - *mission*.

A **failure** is the non-fulfilment of this mission, e.g. termination of the ability of an item to perform its required function. Failures may be:

- momentary => outage;
- temporary => breakdown => need repair ( for repairable systems only);
- definitive;

A **fault** is the cause of a failure, it may occur long before the failure.

These terms can be applied to the whole system, or to elements thereof.



The most common problems in any fieldbus or high speed digital communications system are:

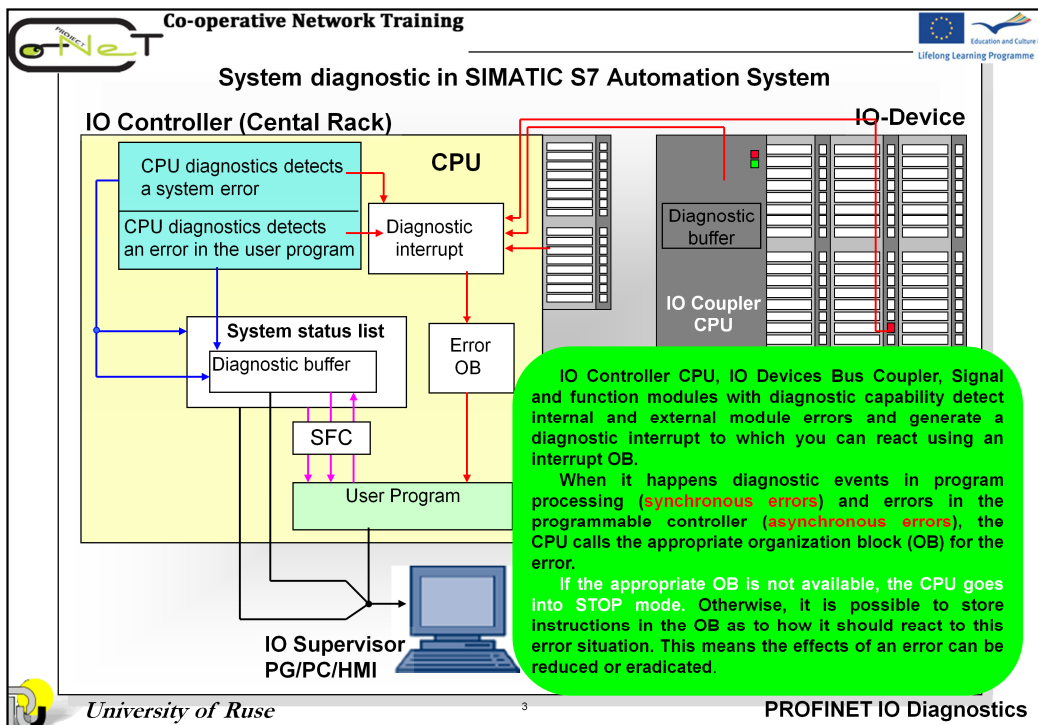
- Cabling and wiring faults:** Reflections, interference, cable routing and earthing faults etc.
- Poor design and installation:** Lack of awareness of avoidable issues at design stage, poor routing, layout, untrained installers, inaccurate or insufficient system documentation.
- Device and wiring failures:** Surprisingly rare but can lead to communications faults or peripheral faults.

Faults that occur during the operation of the plant can be broadly categorized as follows:

- **Peripheral faults:** Concerned with the sensor or actuator, e.g. sensor wire break, loss of output power, sticking valve etc. **The devices are still communicating.**
- **Communication faults:** Prevent signals reaching their destination, e.g. network wiring errors, interference pickup, reflections etc. **Communications are disrupted.**

Because the communication remains operational, peripheral faults can often be located and diagnosed using the communications system itself.

Communication errors do not always produce loss of control. This is because modern fieldbus technologies are very robust to errors that can corrupt data. Quite often users are unaware that their system has communication errors because the robustness of bus (PROFINET IO) can hide these faults. Only when the rate of data corruption reaches a critical threshold will the fault become visible.



IO Controller CPU, IO Devices Bus Coupler, Signal and function modules with diagnostic capability detect internal and external module errors and generate a diagnostic interrupt to which you can react using an interrupt OB.

When it happens diagnostic events in program processing (synchronous errors) and errors in the programmable controller (asynchronous errors), the CPU calls the appropriate organization block (OB) for the error. If the appropriate OB is not available, the CPU goes into STOP mode (exceptions: OB70, OB72, OB81, OB87). Otherwise, it is possible to store instructions in the OB as to how it should react to this error situation. This means the effects of an error can be reduced or eradicated.

System diagnostics detect, evaluate and report errors that occur within a S7 PLC. For this purpose, every S7 CPU and every module with system diagnostics capability (for example, Proxy module and IO Bus Couplers) has a diagnostic buffer in which detailed information on all diagnostic events is entered in the order they occurred.

The CPU recognizes system errors and errors in the user program and enters diagnostic messages in the system status list and the diagnostic buffer.

Co-operative Network Training		
Acquiring Diagnostic Data		
Diagnosics option	Use	Associated topics
LEDs on a PROFINET interface	The LEDs allow you to see whether problem-free communication is possible and whether data are being sent or received	<b>Diagnostics with LEDs</b>
System status lists (SSLs) read out	This allows you to evaluate the current status of your automation system.	<b>Online diagnostic with PG/PC</b>
Diagnostic data records read out		<input type="checkbox"/> Diagnostic Alarm – HW Config <input type="checkbox"/> Diagnostic Buffer – Module information
System status lists (SSLs) read out	Read out SSLs via the system function <b>SFC 51</b> in the user program	Evaluation of diagnostics in the user program Потребителят програмира реакцията на системата
Diagnostic data records read out	Read diagnostic records with <b>SFB 52</b> and evaluate in user program	
Diagnostic interrupt	Read diagnostic data for error ( <b>SFB54</b> )/ interrupt in the error OB	
Reporting system errors	STEP 7 automatically generate the necessary blocks and message texts. The user only needs to download the generated blocks to the CPU and the texts to connected HMI devices	<b>Diagnostic information is displayed in the form of messages on the HMI device.</b>
SNMP	With this protocol, you can run diagnostic checks on the network infrastructure	<b>Diagnostic screen with HMI (WinCC flexible RT)</b> <b>Topology Editor with PG/PC</b>

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PROFINET IO Diagnostics

You do not need to program the acquisition of diagnostic data by system diagnostics. This is a standard feature that runs automatically. SIMATIC S7 provides various diagnostic functions. Some of these functions are integrated on the CPU, others are provided by the modules (SMs, CPs, and FMs).

**Displaying Faults:** Internal and external module faults are displayed on the front panels of the module. The LED displays and their evaluation are described in the S7 hardware manuals. With the S7-300, internal and external faults are displayed together as a group error.

**System status List:** The system status list (SSL) describes the current status of the programmable logic controller. It provides an overview of the configuration, the current parameter assignment, the current statuses and sequences on the CPU, and the modules belonging to it. You can only read the data in the system status list but not modify them. It is a virtual list that is only created on request. The information that you can display using the system status list can be divided into four areas:

- System data
- Diagnostic status data in the CPU
- Diagnostic data on Modules
- Diagnostic buffer

There are two ways of reading out the information in system status lists, as follows:

- *Implicitly*, via **STEP 7 menu commands** from the programming device (memory configuration, static CPU data, diagnostic buffer, status displays).
- *Explicitly*, via the **system function SFC 51 in the user program**, by entering the number of the required partial system status list



Co-operative Network Training		
Acquiring Diagnostic Data		
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System status lists (SSLs) read out	This allows you to evaluate the current status of your automation system.	<b>Online diagnostic with PG/PC</b>
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Diagnostic interrupt	Read diagnostic data for error ( <b>SFB54</b> )/ interrupt in the error OB	
Reporting system errors	STEP 7 automatically generate the necessary blocks and message texts. The user only needs to download the generated blocks to the CPU and the texts to connected HMI devices	<b>Diagnostic information is displayed in the form of messages on the HMI device.</b>
SNMP	With this protocol, you can run diagnostic checks on the network infrastructure	<b>Diagnostic screen with HMI (WinCC flexible RT)</b> <b>Topology Editor with PG/PC</b>

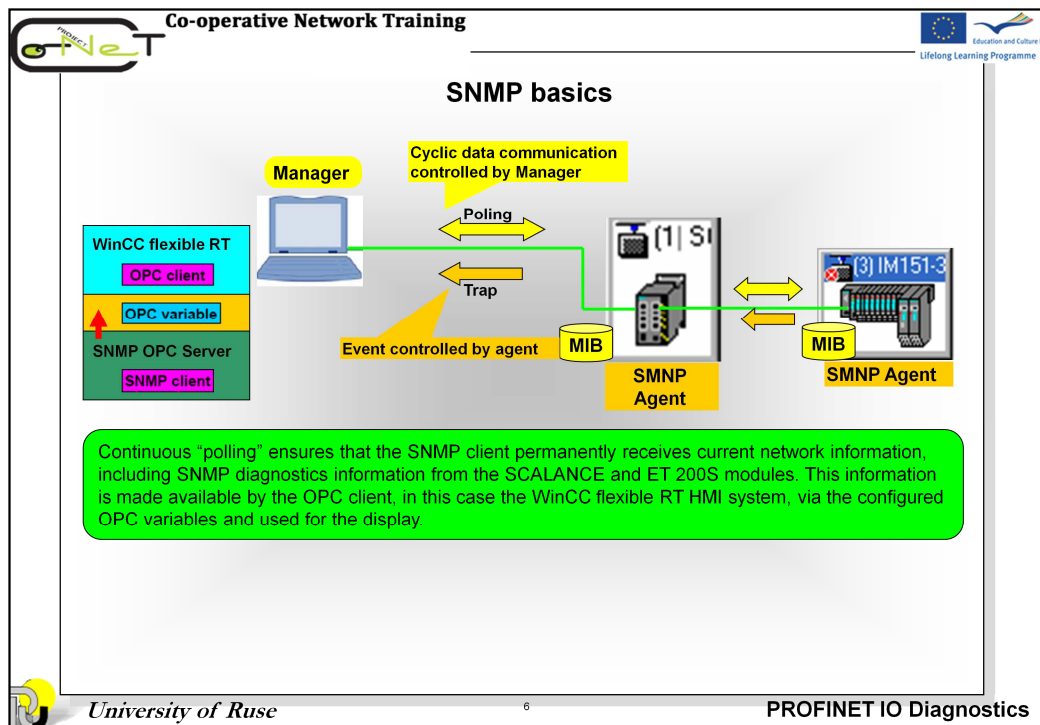
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**Diagnostic data records:** The diagnostic data of a module cannot be addressed individually but are always transferred in the form of complete data records. If the modules are capable of diagnostics, you obtain the diagnostic data of the module by reading data records 0 and 1.

**Diagnostic interrupt:** Signal and function modules with diagnostic capability detect internal and external module errors and generate a diagnostic interrupt to which you can react using an interrupt OB.

**Report system error (RSE) :** You can configure the generation of blocks with “Report system error”, so that the generated data blocks can be supplied with the current status PROFINET IO systems. The PROFINET IO DB (DB126) supports the status of IO device on IO systems (100), ..., (115) and the status of DP slaves on DP master systems (2980ff) downstream from an IE/PB Link.

The generated data block depicts the current status of all configured devices. If desired, it can describe the status of a device more exactly in response to a query from an HMI device. The data block is dynamically created and depends on the HW configuration. The DB uses the RSE diagnostics FB (by default, FB49) to access the diagnostics data. This FB enters the current status of the devices directly in the DB..

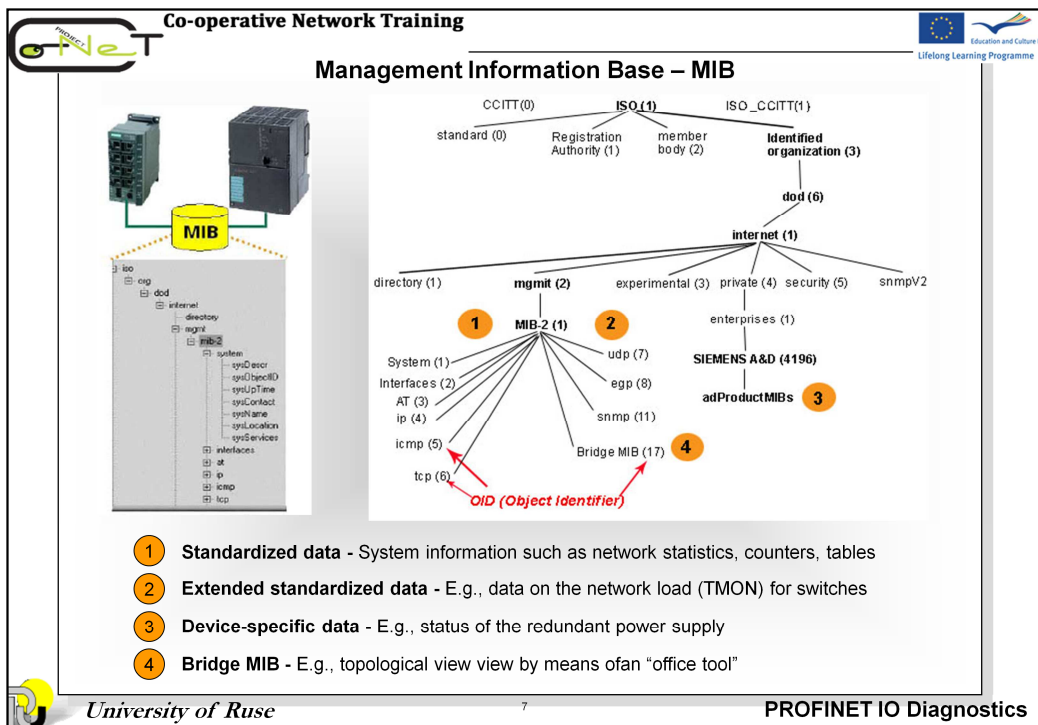


SNMP – **S**imple **N**etwork **M**anagement **P**rotocol – is a UDP-based protocol that was specified specifically for the administration of data networks and has established itself also as a de facto standard for TCP/IP devices in the meantime. The individual nodes in the network – network components or terminals – feature an SNMP agent that provides information in a structured form. This structure is referred to as MIB – **M**anagement **I**nformation **B**ase. In the network node, the agent is usually realized as a firmware functionality.

A network management solution based on SNMP operates according to the client-server model. The management station (SNMP client) can poll information from the agents to be controlled that act as servers.

The MIB information is cyclically called from the management station and visualized if required. In addition, the nodes are also capable of reporting specific statuses to the network management station via traps without explicit requests. SNMP enables not only the monitoring of the nodes but also instructions for controlling the devices. These instructions include activating or deactivating a port on a network component.

The communication between agents and network management station is performed in the background and loads the network only insignificantly.



An MIB (Management Information Base) is a standardized data structure consisting of different SNMP variables that are described by a language independent of the target system.

The cross-vendor standardization of the MIBs and the access mechanisms enable the user to monitor and control also a heterogeneous network with components of different manufacturers.

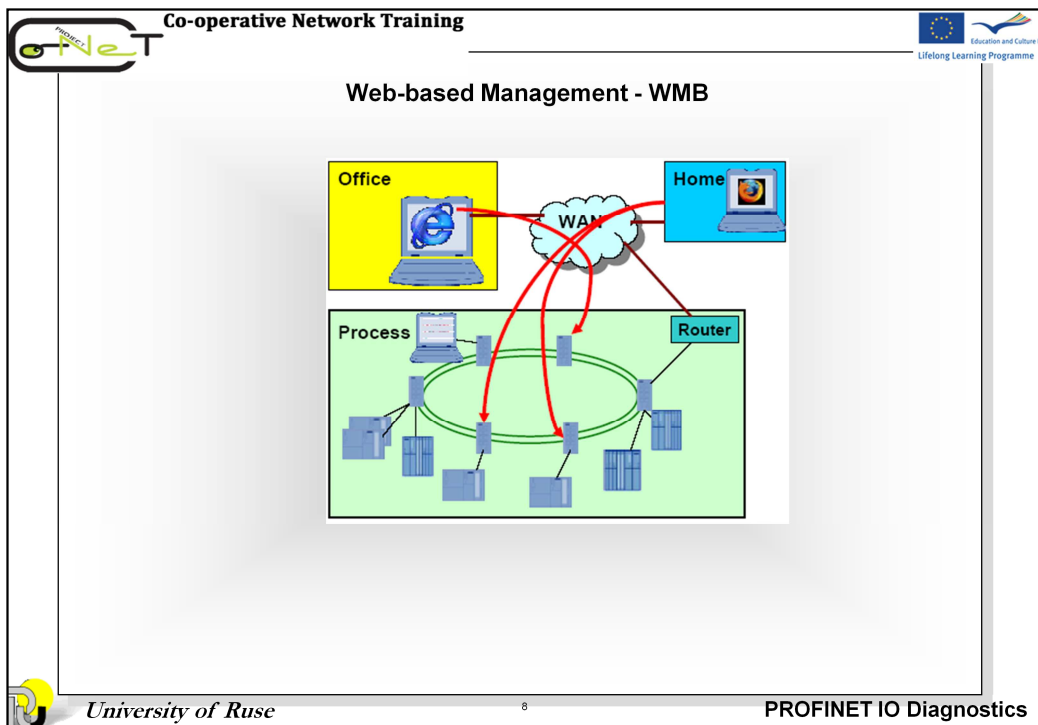
If component-specific, non-standardized data are required for network monitoring, these data can be described by the manufacturers in "private MIBs".

An MIB describes the entity of all SNMP objects (SNMP variables) that are located in the network. The MIB information structure is similar to the Windows registry structure.

The OID (Object Identifier) describes the address of the MIB object. The address of standardized MIB objects is preset. Private MIB objects are always stored in the "Enterprise" directory. The manufacturer is responsible for the addresses in this structure. It is only required that the manufacturer number is registered.

A device profile describes the scope of the variables of a device, e.g. the SCALANCE X208 switch, that are displayed on the OPC server. Only variables included in the device profile can be integrated into an application.

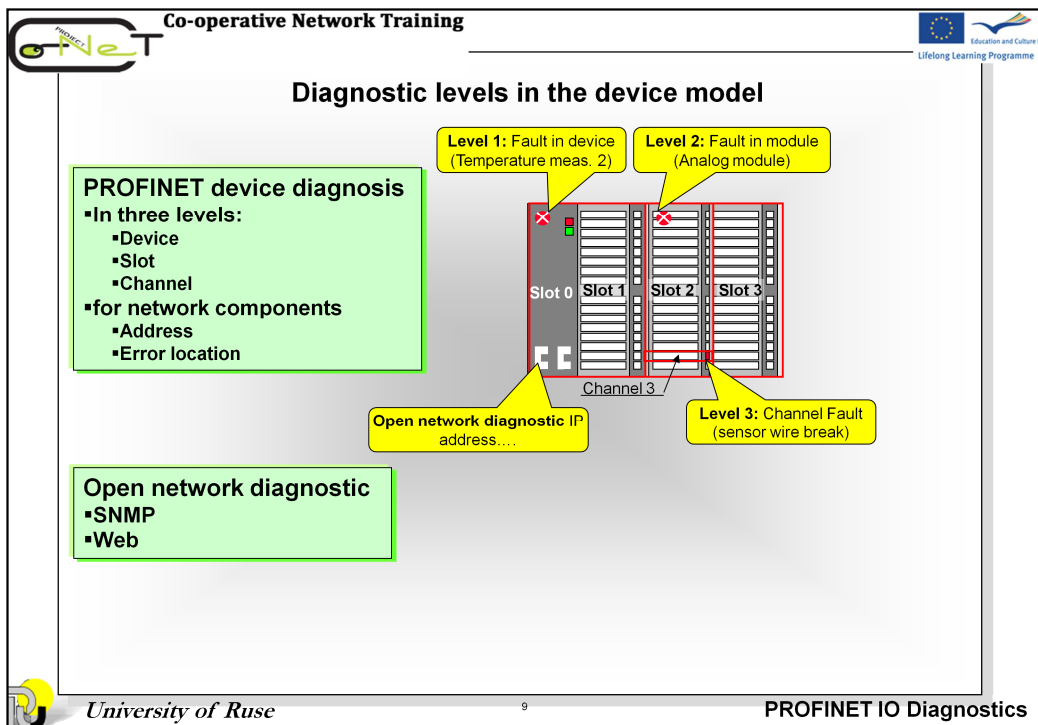
The SNMP OPC server additionally includes an MIB compiler that is used to adapt existing device profiles or to create new device profiles. This is done by entering the required SNMP variables from the public and, if necessary, private MIBs in the profile.



Web-based Management enables the parameterization and monitoring of network nodes – network components such as the SCALANCE modules or terminals – via standard internet browsers such as Firefox or Internet Explorer.

Via a browser, HTML pages containing the desired information are called in the nodes. The corresponding module dynamically supplies these HTML pages with information.

This requires only the IP address of the SCALANCE module and a password to be able to perform a read and/or write access to the information as a user or administrator.



PROFINET offers a powerful integrated diagnostic concept that comprises all devices configured in PROFINET (including the network components that are PROFINET devices, for example SCALANCE X208).

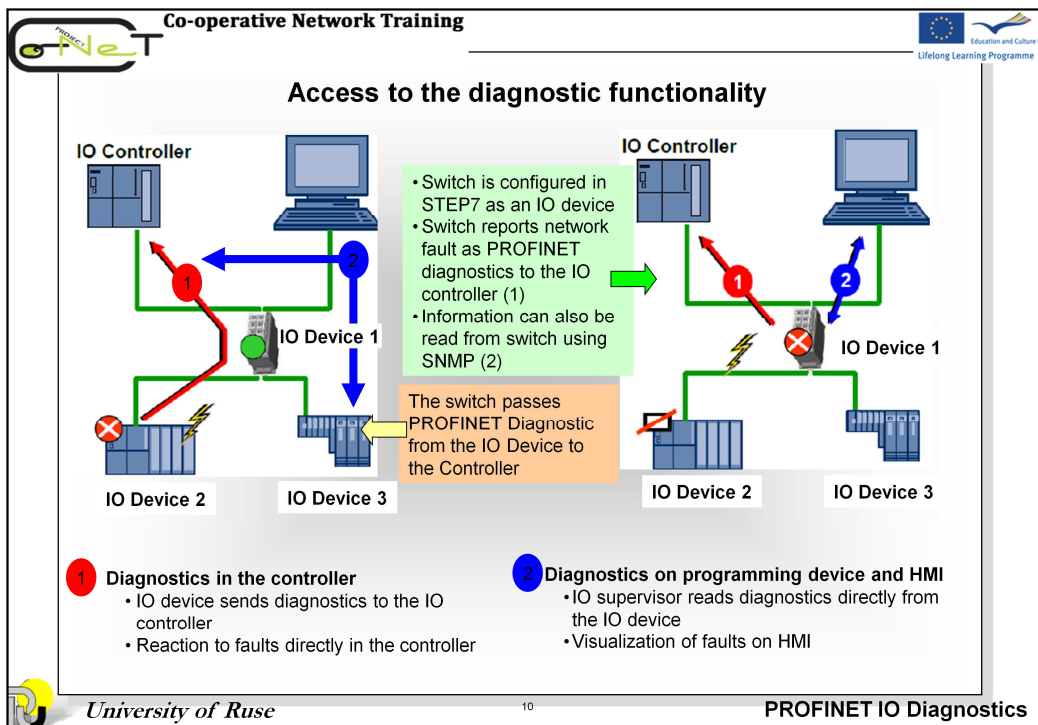
Device diagnostics are divided into three levels:

- Error on the device: Failure of a station
- Error on the slot: Defect of an individual module
- Channel error: For example, wire break

If an error occurs, the relevant IO device generates a diagnostic interrupt that is reported to the controller. The user is responsible for its evaluation.

This diagnostic information can be read out and evaluated by a programming unit in the following diagnostics views:

- STEP 7 Basis diagnostics
- Diagnostics with the Topology Editor
- Diagnostics using the Web server of the PROFINET IO controller



### Diagnostics in the controller

In the event of a fault on the IO device, an interrupt is sent to the CPU of the PLC. The user program here is searched for an error OB that is assigned to the interrupt. If the assigned error OB does not exist in the user program, the CPU switches to the Stop state. If, on the other hand, the error OB does exist in the user program, it is processed once.

### Diagnostics on programming device and HMI

With the programming device, the service personnel can use the appropriate menus in STEP 7 to read the diagnostics buffer in which the diagnostic events have been entered.

With appropriate configuration, some events can be directly displayed on the HMI device.

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**Diagnostic via LED**

Please see the manufacturer documentation for the detailed functions of the PROFINET node displays.

<p><b>CPU</b></p> <ul style="list-style-type: none"> <li>BF1</li> <li>BF2</li> <li>SF</li> <li>5 V DC</li> <li>FRCE</li> <li>RUN</li> <li>STOP</li> </ul>	<p><b>SF</b> System error present</p> <p><b>5V DC</b> The 5V supply for CPU and S7-300 bus OK</p> <p><b>FRCE</b> Force job Active</p> <p><b>BF1</b> Bus fault at the PROFINET interface</p> <p><b>BF2</b> Bus fault at the ETHERNET interface</p> <p><b>LINK</b> A connection to PROFINET has not been established</p> <p><b>RX/TX</b> The port sends or receives data</p>	<p><b>IM 151-3</b></p> <ul style="list-style-type: none"> <li>SF</li> <li>BF</li> <li>ON</li> <li>LINK</li> <li>RX/TX</li> </ul>	<p><b>IE/PB LINK</b></p> <ul style="list-style-type: none"> <li>SF</li> <li>BF PN</li> <li>BF DP</li> <li>RX/TX</li> <li>RX/TX</li> <li>STOP</li> </ul>
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<b>BF/ BF1, BF2</b>	<p><b>Lights up red:</b></p> <ul style="list-style-type: none"> <li>• Bus fault (no cable connection to a subnet/switch)</li> <li>• Wrong transmission speed</li> <li>• Full duplex transmission not activated</li> </ul>	<p><b>Flashing (PN IO Controller):</b></p> <ul style="list-style-type: none"> <li>• Failure of a connected I/O device</li> <li>• At least one of the assigned IO devices cannot be addressed</li> <li>• Incorrect configuration</li> </ul>	<p><b>Flashing (PN IO Device):</b></p> <ul style="list-style-type: none"> <li>• Response monitoring timeout.</li> <li>• Communication on the PROFINET bus is down.</li> <li>• Incorrect IP address</li> <li>• Incorrect configuration</li> <li>• Incorrect parameter assignment</li> <li>• Incorrect or missing device name</li> <li>• IO controller not found / switched off, but there is an Ethernet connection.</li> </ul>
<b>RX</b>	<p><b>Lights up yellow:</b> Receiving data at the interface.</p>		<p>The LED flickers when small data volumes are transferred.</p>
<b>TX</b>	<p><b>Lights up yellow:</b> Sending data at the interface.</p>		
<b>LINK</b>	<p><b>Lights up green:</b> Another device (usually a switch) is connected and the physical connection is up.</p>		

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**LED displays** characterize the status of IO controllers and devices. The figure shows the LEDs for included in the project of SIEMENS devices.

If the red BF 2 LED (Bus Fault 2) flashes on a CPU 31x-2 PN IO, a device is faulty somewhere in the PROFINET IO system.

The LINK and RX/TX LEDs are located under the cover. A continuous **green light on the LINK LED** indicates a functional connection to the next network node. If the LED is not lit, a connection is interrupted. The **yellow RX/TX LED** indicates data communication via the interface.

Faulty devices are indicated by the SF LED lit in red.

During start-up, the red BF LED flashes, faulty connections to the next network node are indicated by continuous red light.

If the IO controller is in **RUN** mode, the PROFINET nodes should no longer indicate any communication problems.

In case any stations are indicating communication problems at this stage, additional checks should be undertaken, e.g.:

- Device type correctly configured?
- Device configuration OK / Device name correctly configured?

For geographic location of the devices in the field, flashing of the Link LEDs can be activated in the same manner as for the controllers. The Link LED is located under the covers of ET 200S PN and IE/PB LINK PN IO.

The meaning of the individual LEDs or their combination differs from module to module. For information on the meaning of the LED display, please refer to the module manual.



**Hardware diagnostics with PG/PC**

**Hardware Diagnostics - Quick View**

Module	Addr.	DP	PN	R	S
CP 343-1	E 2030	-	1002	0	2
DP-Slave	202	-	-	-	-

**Hardware Diagnostics - ONLINE**

**Hardware Diagnostics - Quick View**

- The **Quick View** only displays components that are faulty or that have reported an error. The following information is displayed:
  - Data on the online connection to the CPU
  - Diagnostics symbol for the CPU and modules for which the CPU has detected a fault.
  - Module type and module address (rack, slot, PN IO system with station number)

**Hardware Diagnostics - ONLINE**

The **Diagnostics View** displays the entire station configuration that can be accessed online. The following information is displayed:

- Configuration of the racks
- Diagnostics symbols for all configured modules. They indicate the status of the corresponding module and – for CPU modules – additionally the mode.
- Module type, order number and address, comments on the configuration

**Hardware Diagnostics - Quick View**

- CPU in Stop mode
- Device with Error
- Module is not connected

**Hardware Diagnostics - ONLINE**

- CPU in Stop mode
- Device with Error
- Module is not connected

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PROFINET IO Diagnostics

Aside from the visual diagnostics via LED, you can see whether diagnostic information is available for a module by the presence of diagnostics symbols. Diagnostics symbols facilitate troubleshooting in the event of a fault. If there is no module fault, only the module type symbol is displayed. If, however, a fault has occurred, the module type symbol is displayed with an additional diagnostics symbol.

Diagnostics symbols are displayed in the project window in the online view as well as in the "**Quick view**" (default setting) or the diagnostic view when you call the function "**Hardware Diagnostics.**"

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**Hardware diagnostics in HW Config – Diagnostic Symbols**

- Target/actual deviation from the configuration:** The configured module does not exist or another module type has been inserted.
- Error:** Module faulted. Possible causes: Detection of a diagnostic alarm, an I/O access error or an error LED.
- Diagnostics are not possible** since there is no online connection or since the CPU does not provide diagnostics information.

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PROFINET IO Diagnostics

Detailed diagnostic information is displayed in the "Module Information" application, which you can start by doubleclicking a diagnostics symbol in the quick view or the diagnostic view.

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Hardware diagnostics - Detailed Diagnostic information

SIMAIC Manager ONLINE

Accessible Nodes

"Hardware Diagnostics" command or online view

Quick View

Diagnostic View

Module Information

Module Information - IM151-3PN

Path: |PN IO Condig|SIMATIC 300(1)|CPU 315F-2 | operating mode of the CPU: RUN

Status: Error

Network Connection | Statistics | Identification

General | IO Device Diagnostics | Communication Diagnostics | Interface

Description: IM151-3PN System Identification: PROFINET IO

Name: siemens-io-device

Version:

Order No. / Description	Component	Version
6ES7 151-3BA23-0AB0	Hardware	6
...	Firmware	V 7.0.0

IO system: 100 Address: I 2030

Device Number: 2

Plant designation:

Location designation:

Status: Faulty module (diagnostic interrupt detected)  
External error

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PROFINET IO Diagnostics

Depending on the diagnostics capability of the module, a varying number of tabs are displayed in the "Module Information" dialog box. When displayed in an active situation, only those tabs relevant to the selected module are displayed. The most important information appears in the following tables:

- **General:** Identification data of the selected module (type, order number, revision level, status, slot in the rack)
- **Diagnostic buffer:** Overview of the events in the diagnostic buffer and detailed information on the selected event.
- **Diagnostic alarm:** Diagnostics data of the selected module
- **Memory:** Memory configuration, current main memory utilization, load memory and retentive memory, data of the selected CPU or M7 FM.

For each tab, the following information is displayed:

- Online path to the selected module
- Operating mode of the corresponding CPU (for example, RUN, STOP)
- Status of the selected module (for example, error, OK)
- Operating mode of the selected module (for example, RUN, STOP) if it has its own operating mode (for example, PROXY module)

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**Displaying Ethernet Nodes in the "Accessible Nodes" Window**

**Requirements**

You have set up the programming device (PG)/PC interface to work with a TCP/IP interface card, which means that the Ethernet interface of your programming device (PG)/PC can be accessed from STEP 7.

For an online connection via the "Accessible Nodes" window, the programming device (PG)/PC and "Accessible Nodes" must be connected to the same physical Ethernet subnet.

If nodes are only accessible via intermediate switches or routers (with the use of a protocol), they will not be displayed in the list of "Accessible Nodes".

Object name	Rack/Slot	Status	Module type	Station name
pr-io-controller	0/2	RUN	CPU 315F-2PN/DP	SIMATIC 300(1)
PRDXY	-/-	RUN	IE/PB Link	
DK9103	-/-	not obtainable	BK Device	
industrial-switch	-/-	DK	SCALANCE X200	
Phoenix-IO-Device	-/-	DK		
siemens-io-device	-/-	DK		
		DK		

Object name	Rack/Slot	Status	Module type	Station name
MAC = 00-0E-8C-CC-6E-8D	-/-	no IP address	S7-300	
PRDXY	-/-	no IP address	IE/PB Link	
MAC = 00-30-DE-02-15-22	-/-	no IP address	WAGO 4-IO-SYSTE...	
Phoenix-Coupler	-/-	no IP address	Inline	
scalanco-x200	-/-	no IP address	SCALANCE X200	
siemens-coupler	-/-	no IP address	ET 200S	

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This type of access enables you to access a programmable logic controller quickly, for test purposes, for example. You can access all the accessible programmable modules in the network.

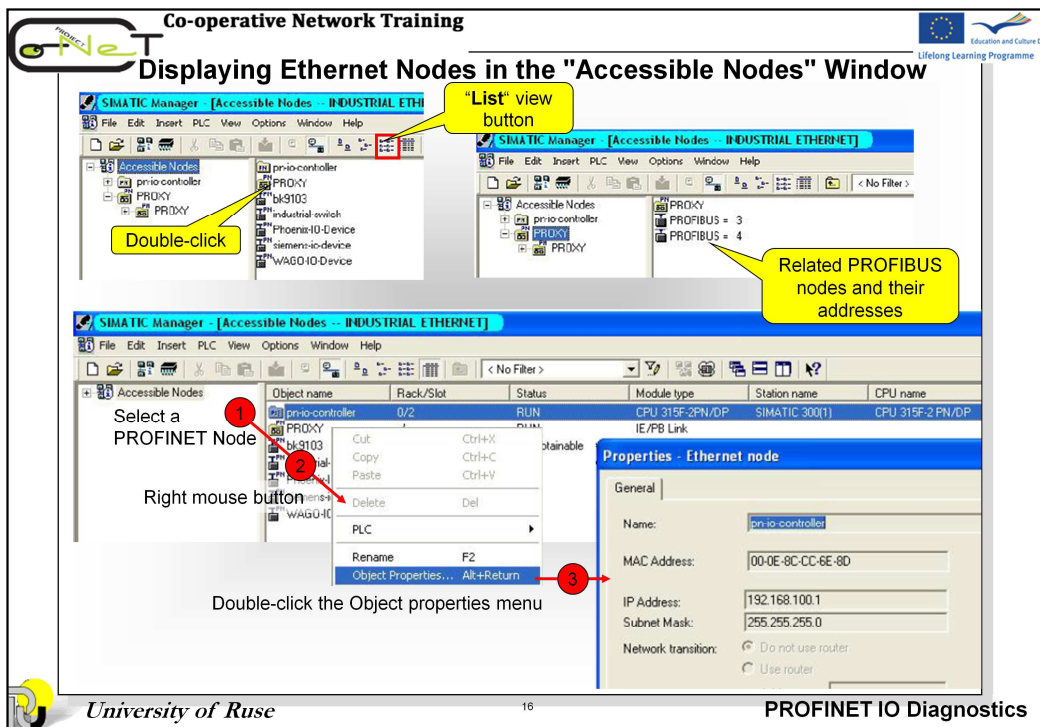
*The method is selected when you do not have data for system configuration in your PG, or if you want to determine which devices are connected to the network.*

The window is selected in the menu **PLC -> Display Accessible nodes** or by the same name button on the toolbar.

If PROFINET device name is assigned, the column "Object Name" indicates the device name. If PROFINET IO device is without assigned device name, the column "Object Name" indicates the IP address. As a substitute (for an unassigned IP address) the MAC address is displayed.

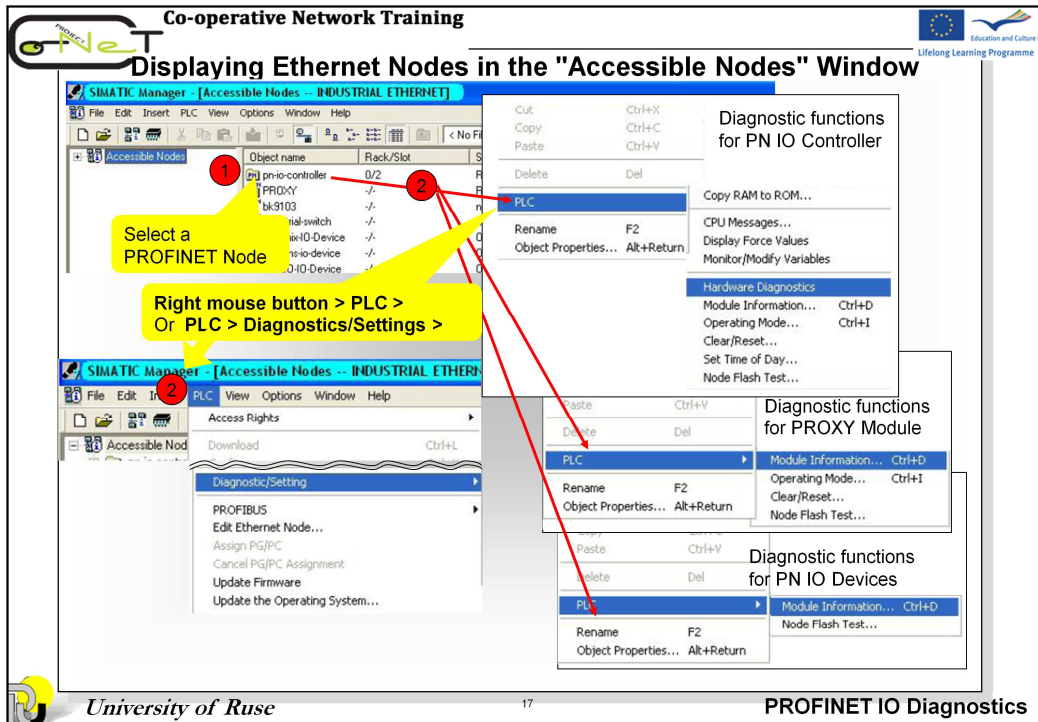
The "Details" view shows the device type as well as status information: e.g. operating mode (RUN/STOP/OK Error), IP addresses inadvertently assigned twice ("doubled-up"), etc. For the S7 CPU, "Details" view also shows the information (if available) from the associated STEP 7 project: station name, CPU name, plant designation.

For some devices (no S7 nodes or devices with DCP protocol) information can not be displayed.



The IE/PB link module is special issue: if you select the IE/PB link in the "Accessible Nodes" list, the detailed list then displays the connected DP slaves along with their PROFIBUS addresses as well as other information.

For PROFINET IO devices with assigned device name, IP address and MAC address can be determined in a properties dialog.



You can perform system diagnostics from the "Accessible Nodes" window. To do so, proceed as follows:

1. Select the component to be diagnosed.
2. Select the appropriate menu command (menu: **PLC > Diagnostics/Settings > ...**, or **Right mouse button > PLC** ).

As of STEP 7 V5.3 Service Pack 2, the "Module Information" diagnostic function can also be used for DP slaves "behind" the IE/PB link; that is, for those devices that are not directly connected to the Ethernet.

The operating mode of the CPU itself and the status of the selected module cannot be displayed if the module information for a non-CPU module is opened from the "Accessible Nodes" window.



**Co-operative Network Training**  
**Displaying Ethernet Nodes in the "Accessible Nodes" Window**

The screenshot shows the SIMATIC Manager interface with the 'Accessible Nodes' window. A table lists various nodes with columns for Object name, Rack/Slot, Status, Module type, and Station name. A context menu is open over a selected node, and the 'Node Flash Test...' option is highlighted. A 'Node Flash Test' dialog box is also open, showing a path, a flashing duration of 12 seconds, and 'Flashing On' and 'Flashing Off' buttons.

Annotations in the image:

1. Select a PROFINET Node
2. Right mouse button
3. Double-click the Node Flash Test menu
4. Select Duration
5. Start Function

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For establishing the location of the selected device, use the command **Node Flashing Test**.

To still be able to find directly connected nodes, select the **PLC > Diagnostics/Settings > Node Flashing Test** menu command.

In the dialog box that is displayed, you can set the flashing duration and then start the flashing test. The directly connected node will be identified by a flashing LED. For example, for CPU type S7 300 flashing FORCE LED and the flashing test cannot be carried out if the FORCE function is active.