ISSN 1846-6168
UDK 67:316.776

KORIŠTENJE I PREDNOSTI PROFINET KOMUNIKACIJSKOG PROTOKOLA U INDUSTRIJI

USAGE AND ADVANTAGES OF PROFINET COMMUNICATION PROTOCOL FOR INDUSTRY

Igor Petrović, Mario Vinković

Stručni članak

Sažetak: *U složenim industrijskim procesima proizvodnje potrebno je ugraditi sustav automatizacije sa posebnim naglaskom na nadzor procesa. Veliki broj uređaja u automatizacijskom sustavu traži velike resurse u količini i brzini protoka podataka unutar sustava. Ukoliko se radi o velikom broju uređaja protokoli kao što su Profibus i slični očito ne mogu zadovoljiti sve potrebe takvog pogona. Uvođenje uređaja za nadzor i eventualno upravljanje pogonom u prostore koji nisu nužno vezani za samu proizvodnju, kao što su uredi inženjera, voditelja pogona, i slično, otvara se mogućnost kombinacije standardnih metoda komunikacije sa industrijskim protokolima. Jedan od najprihvaćenijih je Profinet koji koristi Ethernet standard u industrijske svrhe, i opisan je u ovom radu.*

Ključne riječi: *komunikacijski protokol, Profinet mreža, automatzacija, industrija*

Professional paper

Abstract: *In complex industrial production processes it is necessary to introduce automation system with special consideration to process supervision. High number of automation devices in system will require great resources in quantity and speed of data transfer. The protocols such as Profibus or similar obviously will not satisfy all demands of these production processes since the high number of devices are used. The possibilities of combining standard methods of communication with industrial protocols are available by introducing the devices for supervision and eventually process management placed outside the industrial plant, such as engineers or plant manager offices, etc. One of the most popular such protocols are Profinet which uses Ethernet standard for industrial purposes, and is described in this paper.*

Key words: *communication protocol, Profinet, automation, industry*

1. INTRODUCTION

The modern industry solutions are commonly equipped with high complexity automation system. In order to get clear insight in system status, automation system is often developed in modular structure (example for module of complex system is described in [1]). If such organization is applied it can primarily be divided in high, medium and low process levels. In order to provide synchronous operation of such modular automation system it is necessary to establish connection and active data interaction between these modules. Each process level is provided with unique set of demands on communication, as different requirement on applications are demanded.

In low process level the direct contact of electrical energy transfer and signal acquisition with mechanical equipment used for technology or manufacturing process is demanded, with less regard to data transfer speed. This level is described in [2]. These solutions are often provided in high EM noise and mounting problematical environments. In medium process level good quality of signal on receiving end of communication pair of modular automation devices is required. Multiple devices are often mounted inside hazardous environment so communication must be robust, but good for interchange a big sets of data. The high process level is providing data exchange for devices in automation system inside and outside the industry plant. Such demands require stabile, reliable and fast data exchange, often not affected with EM noise. The most common high process level interface is Profinet.

2. DEVICES AND MACINES IN INDUSTRY PLANT

The high process level in complex industry solutions is mainly provided for production process synchronization between devices. They all imply CPU's (Central Process Unit) devices responsible for each part of big automation system, PC's, hydraulic or pneumatic devices, switches, routers, etc. The idea of connecting HMI (Human-Machine Interface) devices, described in detail in [3], and SCADA (Supervisory Control And Data Acquisition) device, described in detail in [4], is easiest solution since the CPU's are connected to one single

network. The devices available in such networks are automation master and slave devices (CPU's, IO devices, etc.), SCADA devices, HMI panels and programming stations. Each automation device can be accessed from programming station regardless of connection place in network. In such way single programming station can access all devices in phase of developing and testing of process programs. The HMI panels are also available for accessed from programming station in order to configure user application. Various software are necessary for configuration of such devices since there is wide spread of HMI panel models. The most common place for HMI panels mounting is in near surroundings of the specified machine. Often HMI panels use only data from local PLC (Programmable Logical Controller) of the machine, but sometimes it is necessary to provide data from other PLC's in network. The SCADA device is usually only one and is placed in main control room which is not necessary placed inside the plant building. The main task of SCADA system is to supervise processes, enable control throughout the automation system, and finally gather all relevant information about industry process. In such way it is able to analyze historical data of production process and eventually conclude on some features important for work and improvement of such process. The configuration of industry plant automation system with Profinet network implemented in all process levels is presented in Figure 1. The example of implementation of programming station in a small automation system with SCADA is presented in Figure 2.

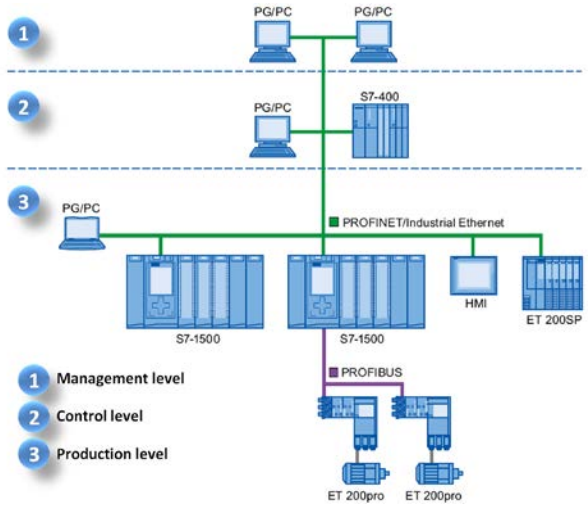

Figure 1. Process levels with Profinet in industry [5]

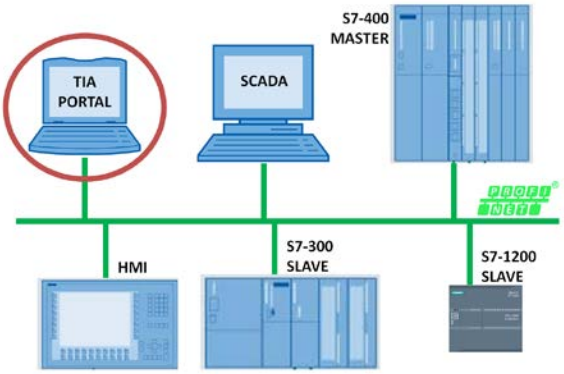

Figure 2. Programming station in Profinet network

3. PROFINET NETWORK FOR AUTOMATION SYSTEM

The Profinet IO was developed from knowledge provided form Profibus DP and Industrial Ethernet. Profinet IO is an Ethernet-based automation standard of Profibus International for universal communication between various vendors and models. The process data view is similar to Profibus DP and consists of I/O data, data records (storage) and connection to diagnostic system. All stations can simultaneously use the network, and simultaneously send and receive data, since the full-duplex operation of Switched Ethernet is used with speed of 100 Mbit/s via Profinet cable Type A, as presented in Figure 3. The Profinet IO is also used for communication of field devices between themselves. For Simatic, the controllers between themselves communicate trough Profinet CBA (Component Based Automation). The Profibus CBA was inspired by IEC61499 standard. The Profinet IO and Profinet CBA are mutually supported.

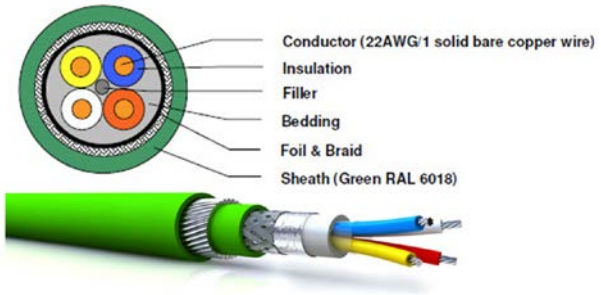

Figure 3. Mechanical Data Profinet Type A

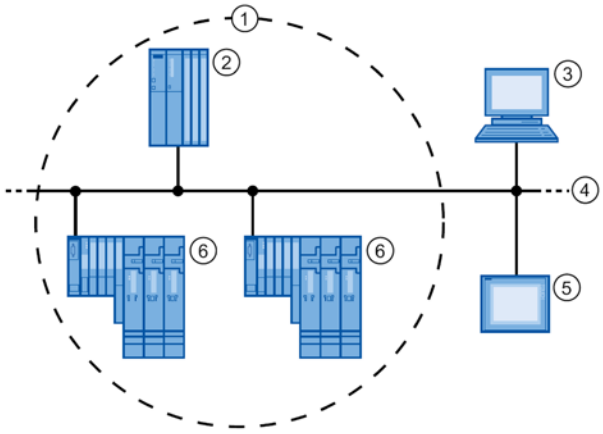

Figure 4. Parts of Profinet network [6]

When considering block (part) description presented in [6] and Figure 4., it can be divided that Profinet IO system (1) consists of IO controller (2) and multiple IO devices (6), all connected to single network (4). The Profinet IO supervisor (3) is a device for commissioning and diagnostics for network. The HMI (5) is used for operating and monitoring functions. This block structure is inherited from Profibus DP network. The similarity in network structure is evident, as it can be seen that for example Profinet IO supervisor is equivalent to Profibus DP Class 2 DP Master, Profinet IO controller is equivalent to Profibus DP Master, and Profinet IO device

is equivalent to Profibus DP slave. The example of configuration for Simatic is with Simatic NET. The application relation (AR) is established between controller and device. The AR's are used to define Communication Relationships (CR) for Profinet network. The usage of TCP/IP and IT standards are implemented in real-time applications for automation. The IT standard is available in Profinet from the Office environment for diagnostics and maintenance.

Three protocol levels are available:

- TCP/IP for Profinet CBA with reaction time of maximum 100 ms
- RT (Real-Time) protocol for Profinet CBA and Profinet IO with applications cycle time up to 10 ms
- IRT (Isoncronus Real-Time) for IO drive systems with cycle time less than 1 ms

The Real-Time level protocol is used for process data and alarms and is based on definitions of IEEE and IEC. It allows limited time for executing real-time services and within a bus cycle. The RT has always higher priority than TCP/IP. The Isoncronus Real-Time level protocol includes switch ports integrated inside field devices. This level has high degree of determinism and the start of a bus cycle is maintained with high precision. It is most often used for motion control and similar applications.

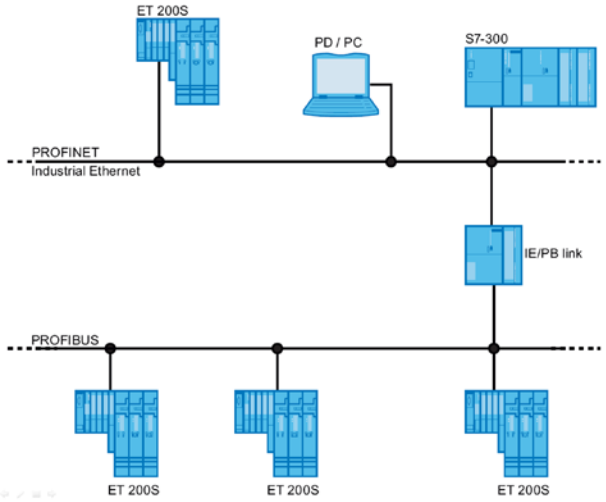

Figure 5. Multiple protocol network [6]

In the Profinet environment *device* is the generic term for Automation systems, Distributed I/O devices, Field devices, Active network components, Gateways to other types of networks and all Profibus or Profinet devices, as presented in [6] and Figure 5. In order for device to be Profinet device, it is necessary to have at least one Profinet port, regardless of all other characteristics. If device for example has 1 Profinet port and 4 Profibus ports, it is still Profinet device as well as it is Profibus device at the same time.

The Profinet devices can be provided with two ports for Linear topology, or with three or more ports for Star or Tree topology. The switch can be integrated in Profinet device, but it is not necessary. The examples of these topologies are presented in Figure 6. and Figure 7.

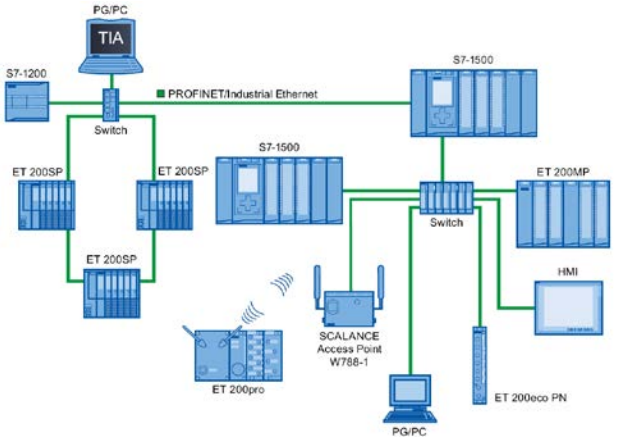

Figure 6. Combined topology network, sample 1 [3]

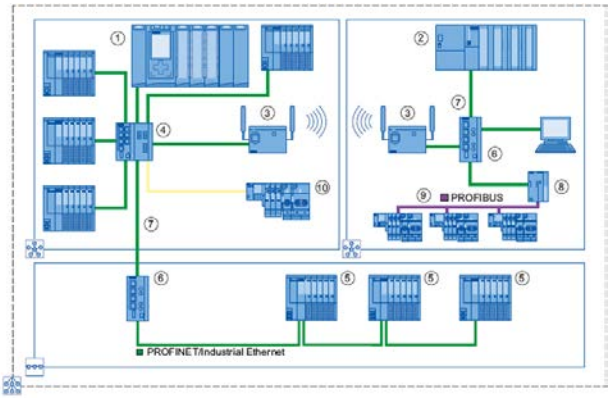

Figure 7. Combined topology network, sample 2 [3]

Each device on Profinet network has its own unique identity via its Profinet interface. The Profinet interface has a MAC address, IP address and device name. MAC address is unique for each device and is set as factory default value. Any change of devices will cause the MAC address to change since the new device is mounted. Since the IP address is dynamically assigned, the device name is used for a device identity. Symbols for interfaces and ports of all modules and devices are: X for interface (1, 2, etc.), and P for port (1, 2, etc.) for each interface. For example port address can be X2.P3. For allocation of IP addresses, subnet mask and gateway DCP (Discovery and Configuration Protocol) or DHCP (Dynamic Host Configuration Protocol) is used. The connection of CPU as a Profinet device in a Profinet network is presented in [7] and Figure 8.

Figure 8. The CPU module S7-1200 with connection on Profinet network [7]

4. IMPLEMENTATION OF PROFINET NETWORK FOR FIELD DEVICES

Profinet network can be used for total insight in process automation. It can be platform for HMI and SCADA applications with predefined visualization parameters. When used in this way, it can provide easy and good process status analysis in normal operating state. In other cases it can be good diagnostic tool since it allows direct access to each Profinet device. The same network can be used even for program download to any CPU connected to this network.

The usage in SCADA application can allow the SCADA to be placed in any location, which does not necessary have to be in direct contact to process plant. The Profinet network is very flexible for use in combination with any other network protocol. If standard field bus solutions, such as AS-I or Profibus, are neglected since they are almost always present, the most interesting additional solutions are wireless and internet network solutions. The Profinet network can easily be upgraded using WLAN, internet and GSM/GPRS, which are most popular additions to automation systems, as presented in Figure 9.

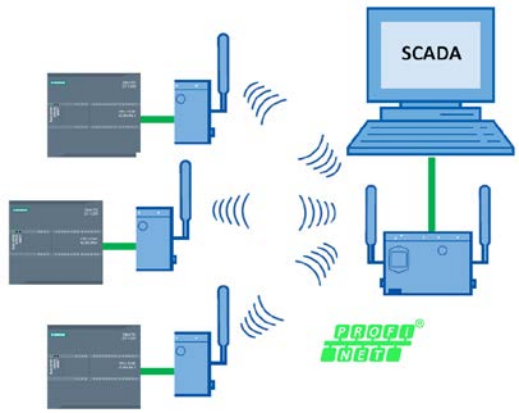

Figure 9. GSM/GPRS internetwork inside Profinet network

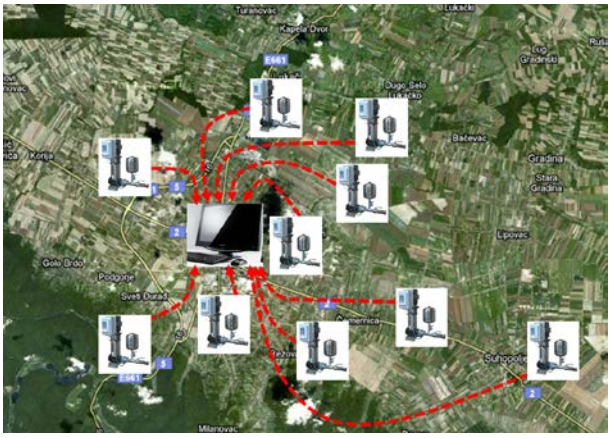

Figure 10. SCADA for water system

The PC used for SCADA is often, in some cases always, placed rather far from devices. The best example for SCADA very far from field devices is water or sewage system. In case of water system the pipeline is equipped with control shafts where water pressure and water flow is measured and used for system diagnostics. In case of sewage system a pumping station is placed whenever the ground configuration requires media rise, as described in [1]. One of such SCADA system is presented in Figure 10. These pumping stations and shafts are regularly so far from SCADA that wire connection is not economically solution. In such cases the wireless networks are used as an inter-connection inside a Profinet network. Therefore, all Profinet devices *see* Profinet network at their interface ports, although for example GSM/GPRS network is used to transfer Profinet protocol packages from one point to another.

The Profinet network can be used for accessing and programming any CPU in the network. By simple IP scan on network single CPU can be selected. Once selected and accessed, all properties of device can be altered on-line and changes will take effect immediately. The state of Profinet network with on-line CPU's which connections can be established is presented in Figure 11.

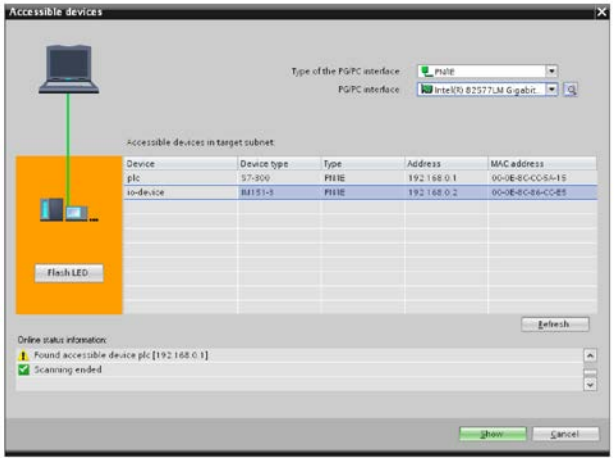

Figure 11. Accessible devices for configuration on network

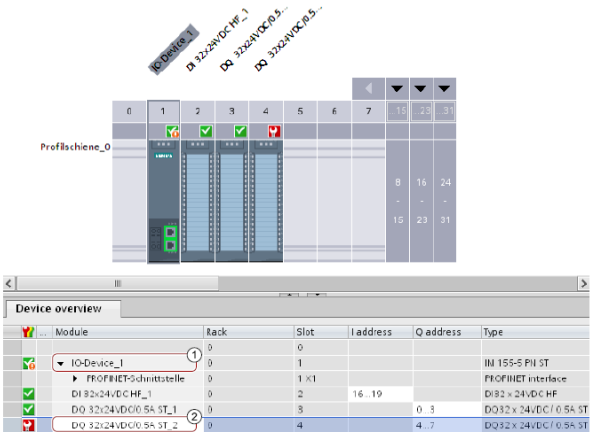

Figure 12. On-line device system diagnostic

If any additional information about device status is necessary it is easy to access required device and make diagnostics without stopping the device. The diagnostics are available in terms of device components status (on-line, error, etc.), parameter status (memory bits, bytes, etc., data blocks, I/O, etc.) and program status. The example of device components status is presented in Figure 12.

5. CONCLUSION

In complex automation systems with multiple CPU, HMI and SCADA the modules are usually not installed in same part of plant. If some modules are mounted in different buildings, but communicate between themselves, it is expensive to provide new lines of communication. Therefore, it is recommended to use standard networking solutions, such as Ethernet network, for necessary industry automation network. The most common standard computer network is Ethernet. The best way to use available network infrastructure is to provide Profinet protocol in automation system. It is possible to provide any alternative internetwork inside automation network, such as WLAN, GSM/GPRS, radio, etc., with no influence on data interchange quality for distributed automation modules. Various protocols are compatible, with response times of 100 ms, 10 ms, 1 ms or less. Therefore, the Profinet network is currently the best solution for complex automation network solutions.

6. REFERENCES

[1] Jurčević, D.; Petrović, I.: Automation of sewage pumping station shaft, *Tehnical journal, Vol. 7, Nr. 1, 2013*, pages 8-12

[2] Petrović, I.; Vinković, M.: Usage and advantages of ASI communication protocol for industry, *Tehnical journal, Vol. 7, Nr. 4, 2013*, pages 355-358

[3] Siemens Simatic HMI: HMI devices Basic Panels – Operating Manual, *Issue A5E02421799-03, Edition 04/2012*

[4] Siemens Simatic NET: Profinet with Step 7 V12 – Function Manual, *Issue A5E03444486-03, Edition 01/2013*

[5] Siemens Simatic HMI: WinCC flexible 2008 Compact/Standard/Advanced User's Manual, *Issue A5E01024750-02, Edition 07/2008*

[6] Siemens Simatic NET: Profinet System Description – System Manual, *Issue A5E00298288-04, Edition 06/2008*

[7] Siemens Simatic: S7-1200 Programmable controller system manual, *Issue A5E02486680-06, Edition 04/2012*

Kontakt autora:

Technical college in Bjelovar
Trg Eugena Kvaternika 4
43 000 Bjelovar
043/241–201

Igor Petrović, PhD
ipetrovic@vtsbj.hr

Mario Vinković, student
mariovinkovic@gmail.com