Vertical Integration Model with Profinet

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Abstract

Mobility and reduction of industrial activity time is one of the major requirements raised to modern systems of automation. One of the most effective ways of achievement of this purpose is vertical integration with use of wireless technologies. The lab set – model of vertical integration - for data gathering from the intellectual Profibus PA sensor, Profibus DP data transmission, controllers configuration for Profinet IO direct interfacing of distributed field devices on the Ethernet is discussed in this topic.

Keyword

Vertical integration, data transmission, Profinet, Profibus, lab set

Introduction

Vertical integration exists for process network from uniform control centre and for providing of access to the system data from all levels. Industrial Wireless communication has become the component part of these networks. This, allows new potential for availability to be tapped within existing automation systems. Previously inaccessible isolated groups can also be integrated into the automation network.

In this work Integration can be divided into three basic levels (Fig.1):

1) Field level. At this level integration from Profibus networks in Profinet is carried out and communications at controllers level are provided.

2) Server Level. It is the level data collecting, doing their accessible in the corresponding form to other clients, and as for service and diagnostics of controllers.

3) Client Level. Here supervision over the processes occurring at the field level is carried out. If necessary, having access rights, it is possible to operate system.

Expansion of possibilities of already existing Profibus system is carried out by means of its integration into communications Profinet IO. It gives the chance to make vertical integration of all system as a whole.

1 Networks overview

1.1 Profinet

Profinet (PROcess Field NET) includes installation technology, real-time communication, network management and functions for Web integration [1]. Through its proxy concept, Profinet allows seamless integration of fieldbus systems for the plant expansions

Profinet is based on Industrial Ethernet and fulfills all demands for use of Ethernet in communication at the controller level with I/O systems.

Profinet IO permits direct interfacing of distributed field devices on the Ethernet. All devices used are connected in a uniform network structure, and therefore offer uniform communication throughout the complete production plant. Profinet is the only Ethernet solution which consistently covers all the requirements of real time communication without restricting the openness.

Profinet IO exclusively uses real-time communication (RT) for exchanging process data with the cycle times of 10 ms. Isochronous real-time communication (IRT) enables cycle times with an order of magnitude of 1 ms.

Profinet is based on Ethernet technology and uses standards such as TCP/IP [1]. Profinet Ethernet is basically a network of stations which are connected together through network components by means of cables with point-to-point connections. Network components such as hubs, switches and routers are required in order to switch the data between the end points. Twisted copper conductors with a maximum transmission rate of 100 Mb/s (Fast Ethernet) are mostly used for the wire connection. Profinet allows design wireless networks in line with industrial requirements (Industrial WLAN) [2].

Fig.1 Levels of vertical integration
1.2 Profibus

Profibus (PROcess Field BUS) has the cycle time, which can be less than 1 ms. This cycle time is extremely stable which makes it Real-Time.

The Profibus DP ( Distributed Peripherals) offers a standardized interface for the exchange of mainly process data over RS 485 between an “interface module” installed in the centralized programmable logic controller and the field devices. The interface module is referred to as DP master and the field devices as DP slaves. Profibus DP is a standard based on IEC 61158/EN 50170. The maximum line length of the Profibus segment depends on the baud rate. A DP master and DP slaves connected to it make up a DP master system.

The Profibus PA (Process Automation) is a communication network for the process industry and defines all functions and parameters for different classes of instruments. The PA profile defines cyclical data, status, diagnostic information and parameters.

Profibus PA devices are integrated in Profibus DP networks by using segment couplers. The network component for linking ProBus DP and Profibus PA, the DP/PA coupler, is operated at transmission rate of 45.45 kbit/s [3].

1.3 Fieldbus Integration

Profibus offers a simple and seamless transition strategy for interfacing existing Profibus systems to Profinet [1]. For this purpose, Profinet supports a proxy concept which makes it possible to integrate any installed field devices into Profinet without modifications.

A proxy largely consists of two main components, an Ethernet-based unit and a fieldbus unit, for example a Profibus DP master. This guarantees that all I/O and diagnostics data can be exchanged with the configured slaves. The result is then placed by the DP master in a common memory. If the consumer is present in the Profibus unit, the Profibus DP master transmits the arriving link data to the respective DP slave in the next Profibus cycle.

IO Controllers with DP master functionality support simultaneous operation of Profibus and Profinet IO systems. Alternatively, it is possible for Profibus DP slaves to integrate them as an IO Device via a Profinet IO device with proxy functionality.

2 Laboratory setup

The test bench of vertical integration model consists of the following equipment:

1. 2 PLC CPU 315F-2 PN/DP (masters)
2. PLC CPU 314-2DP (slave)
3. DP/PA Coupler FDC 157-0
4. Intelligent signal processing SITRANS LR250
5. Industrial Ethernet switch Scalance X208
6. Access point Scalance W788-1PRO
7. DP/DP Coupler
8. Antenna ANT795-4MR is shipped with the Access Points

2.1 Networks configuration

Two types of networks were configured on this setup: Profibus and Profinet.

Two CPU 315F-2PN/DP Master devices (with addresses 2 and 6) have been connected in network Profibus DP. CPU 315-2DP/PN plug-in interface modules are used as DP masters Class 1 for the data exchange in the online process mode, service and diagnostic tasks are carried out by a programming device Class 2 Master [3].

DP/DP Coupler makes communication and data exchange between controllers, i.e. DP/DP Coupler copies the output data of one network in the input data of other network and vice versa.

Components of field level are connected with help Profinet cable (a shielded double-core cable). The transmission speed determines the length of the cable within a segment. 4 segments are connected in series to the Profibus system (Fig. 2).

Fig.2. The laboratory setup with several masters

Intelligent signal processing SITRANS LR250 is a 2-wire, 25 GHz pulse radar level transmitter for continuous monitoring of liquids and slurries in storage vessels [4]. It is unit on a Profibus PA network with communications SIMATIC PDM [5]. SIMATIC PDM software package allows designing, parameterizing, commissioning, diagnosing and maintaining device.

Fig.3 SIMATIC PDM process monitors the process values, alarms and status signals of the device

Two controllers are connected in parallel to the switch by means of Profinet cable (Fig. 4).
A star-shaped network topology for Profinet Network was chosen because it automatically results by connecting the stations to a switch. If a single Profinet device fails, this structure does not automatically result in failure of the complete network, in contrast to other structures. Only the failure of a switch results in failure of part of the communication network. The cascading depth and the total expansion of the network are only limited by the signal propagation times of the communication links.

SCALANCE X208 offers the possibility of wirelessly transmitting Profinet IO data reliably and cyclically. SCALANCE X208 Web server allows to make installation, configuration, and parameters diagnostics by standard Web browser [6].

All system works by a principle that Profinet network is integrated into existing ProfinBUS network. The network scheme is shown in Fig 4. For controllers linking 8-port switch Scalance X208 is used. The signal from field level is transferred in controllers through ProfinBUS network. By means of function proxy the data flow is transferred to Profinet network. In parallel switch sends the data to access point Scalance W788-1 Pro. Through this access point all wireless devices are connected in a uniform network. PG processes the data accepted through «the radio channel» and displays them in SCADA system.

Profinet IO devices have been configured using the Simatic Step 7 engineering tool [7]. They are selected in HW-Config from the module catalog. Coupling to a Profinet IO System and parameterization with an IP address are carried out graphically in HW-Config or Netpro (fig. 5).

Step 7 automatically checks whether all quantity frameworks defined by the hardware have been observed in the project and that the configuration is consistent and free of errors. During operation online/offline comparison of the device configurations can be made for Profinet IO devices, the current device status can be displayed, and online data can be scanned for test and diagnostics.

### 2.2 Diagnostics

The Internet Control Message Protocol (ICMP) was used for transmitting status information and error messages between IP network nodes with two diagnostics tools: PING and TRACEROUTE [7].

These commands are used for fast diagnostics of the network devices. For this purpose it is necessary to execute a command cmd and to order (to instruct) command PING or TRACEROUTE. First of all for device diagnostics it is necessary to check up, whether it responds to PING command. In this work for CPU 300 with Ip-address 192.168.1.4 the DOS window has the following form (fig.6):

```
C:\Documents and Settings\User> Ping 192.168.1.4
```

```
Pinging 192.168.1.4 with 32 bytes of data:
```

```
Reply from 192.168.1.4: bytes=32 time=5ms TTL=30
```

```
Ping statistics for 192.168.1.4:
```

```
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip time in milli-seconds:
Minimum = 1ms, Maximum = 5ms, Average = 2ms
```

User program carries out the diagnostic functions of the controller (Fig.7). System functional block SFB 52 "RDREC" reads out diagnostic message directly from the refused module.

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User program with Step 7
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2.3 Site survey of WLAN network

To make an estimation of action radius, the account of the following factors is necessary:

- Transfer power
- Antenna gain
- Environment

The SINEMA E (SIMATIC Network Manager Engineering) software is used for the planning, configuration, simulation and measurement (site survey) of WLAN networks [7].

The program simulation and measurement of WLAN network simplifies a problem of installation and start of networks WLAN by means of modelling function.

Sinema E simulates the signal coverage, speed of data transmission, a signal-noise and access points of Wi-Fi taking into account ecological conditions and equipment parameters. The program possesses complex check in which real values are established at configuration. It allows to lower probability of errors still before the network has been established.

In the developed program the one-storeyed building having the form of a star (Fig. 8) has been simulated. Building parameters: a thickness of a brick wall of 0.25 meters, height of a ceiling of 3 meters. At a building there is a wooden door in height of 2 meters.

Fig. 8 Model of an one-storeyed building of the star-shaped form

When simulating an access point the program has given out the following picture (Fig. 9). On the orientation diagram, distribution of a signal from access point in a building and outside of it is represented. The access point is in the centre. Building contours are shown by brown color. The pink colour „petals“ show the signal power in dBmV at removal from an access point.

Other wireless devices address through the access point to PG and also can observe the parameters, transferred by the meter. Such participation of devices is called as passive because supervision is only allowed.

This problem can be solved opening of access for wireless devices. Knowing the password, it is possible to operate all system through the main computer PG SCADA.

Fig. 9 Signal distribution.

Conclusion

Vertical integration of automation components and systems in a uniform architecture have been carried out by IO controllers which support simultaneous work with systems Profibus and Profinet IO. New technology Profinet was applied to realise vertical integration of field devices to management top level through wireless technology. The configuration for communications Profinet has been programmed and the topology of a network operated has been created.

Questions on the organisation of vertical integration by means of Profinet have been solved by means of Wireless technology.

At vertical integration design with Profinet the minimum quantity of equipment, namely two controllers S7-300 CPU315F-2 PN/DP, switch Scalance x208 and access point Scalance W788-1Pro were used.

In the future work wireless and reliable data communication system will include more sensors.

References

3. www.profibus.com