Ethernet interface in application – case study

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The paper describes development of three industrial devices, which utilises Ethernet interface. The first two are designed to allow connection of already existing systems to the LAN. Both systems assume that the connected system is already equipped with serial port and implements some type of communication protocol. The first one crates virtual serial port, so already existing software can be utilised. The second system works as a specialised web server. It implements a universal script language, which allows to send ad receive data through serial intarface and dynamically create web content.

The third device is a datalogger equipped with number of universal analog and digital inputs. The collected data are recorded in the memory of the datalogger and accessible using embedded web and ftp server.

1. Ethernet in automation

Considering the advantages of modern computer communication technologies, especially Ethernet, it is in place to ask how to utilize them in an industrial system (by the industrial system we can understand a control system, PLC, smart controller or measurement instrument). When building a new system, the answer is evident, simply to buy one with already implemented Ethernet interface. However, in case of already installed system (or when the manufacturer doesn't offer an Ethernet variant) it is necessary to utilize some alternative solution.

When looking for such solution it is desirable at first to ask, what effect should the Ethernet bring to the user? Then according to the desired effect it is possible to choose a proper solution. Basically, the expected effect is to get a remote access to the system, either over local intranet or over Internet.

When examining existing industrial systems one can find that the common feature of majority of the systems is presence of some kind of serial interface (RS-232/422/485), regardless of the used communication protocol. Considering this, the obvious way of connecting any already installed industrial system to the local network is to use some kind of Serial/Ethernet converter/gateway. Functionality of such gateway can vary according to the user's needs; from simple bridge to sophisticated embedded web sever.

2. Serial/Ethernet gateway – virtual COM port

The application of the S/E gateway assumes that the connected system is already equipped with a serial communication port and there is some software utilizing the communication link. The S/E gateway guarantees the transfer of data between PC and the remote device over Ethernet.

The simplest way is to use only bridge, which tunnels the serial protocol of the industrial system over intranet or Internet, with dedicated gateways on both sides of the communication link. Such approach is suitable for interconnection of two non-PC devices. However, when connecting a system to PC, this solution has some substantial drawbacks. In fact, it is cumbersome to convert the data from Ethernet back to the serial line, since it is much more simple to equip the computer with a standard network card. The gateway on the PC side is replaced by software, which simulates operations of a standard COM port (see Figure 1.). There is no need to

change the user software; the user only selects the virtual COM port in the configuration of his software. There is no need for dedicated hardware also, so there is no limitation on the number of computers, which can be connected to the system. The only limitation is that there can be only one computer currently connected to the remote system.

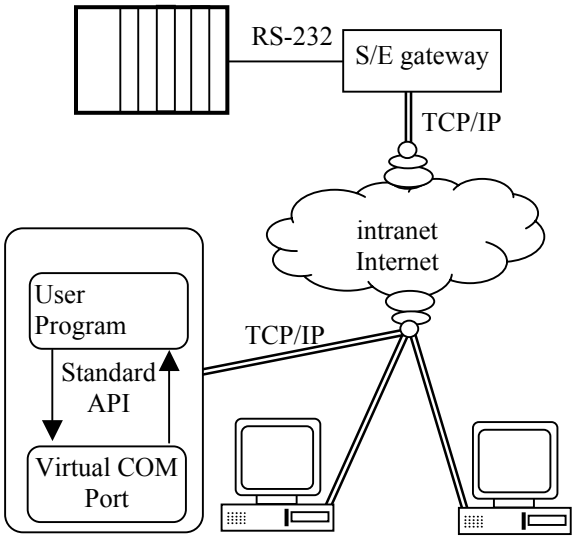

Figure 1. Virtual COM Port

The whole project was separated to two parts. The first part was the software on the PC side. The software is developed for Windows 2000/XP, although it can be easily ported to different version of Windows. It consists of three components – driver, port configurator and gateway configurator. The function of the driver is obvious. It simulates the COM port functions, collects requests from the Windows system and performs them and communicates using TCP/IP protocol with the gateway. The communication protocol, which transfers data between the driver and the gateway, uses both raw socket connection for data transmission (data written to the socket on the PC side are directly written to the serial port of the gateway a vice versa) and Modbus TCP protocol for configuration of the serial port (baud rate, parity, handshake, etc).

The second part, port configurator, allows the user to automatically detect present devices on the local network and install the virtual COM port. It is also possible to enter list of devices which are not on the local subnet, but are located in another network where can't be automatically detected (for the detection of the present gateways is used a broadcast UDP message, which can be received only on the given subnet).

The last part of the software is the gateway configurator. It is used to set IP address and other TCP/IP parameters of the interface. To be able to configure selected gateway, the device has to be on the same subnet as the computer running the configuration program. It can scan local network for the already configured devices (it means they have valid IP address) or configure a new device using it's MAC address only. There is utilised an UDP broadcast message for this purpose.

The hardware of the gateway is based on Ethernet module RCM2200, developed by Rabbit Semiconductor. This module integrates an advanced 8-bit microprocessor Rabbit2000, a standard Ethernet controller Realtek8019AS (10Mbit/s) and sufficient amount of memory. These modules are suitable compromise in price/performance ratio. Connected to the module is a daughter board with a 5V power source, small serial EEPROM to store the actual configuration and the drivers for RS-232 and RS-485, so the interface provides two independent serial ports.

3. Embedded web server

The previous solution is suitable in cases when there is available an already existing software managing the industrial device. The virtual COM port only makes a remote access link to the distant system, either over local network or Internet. However there are situation where this solution isn't suitable, e.g. when there is a need to share data from the industrial process over web.

The first solution, which is available, is to use the previous type of interface together with a PC to collect data, where the PC with installed web server is used to publish the data on the web. However much better idea is "why don't we include the web server already into the gateway?"

The embedded web server has to be flexible to be able to work with different types of industrial systems. The web server has to communicate with the system and dynamically generate html code, which will reflect the actual data. From this reason a simple scripting language is implemented in this device. The script enables the user to implement any serial communication protocol. It has similar syntax to the JavaScript used in the web browsers. The function set is sufficient to work with the serial port, send data to the serial port, receive information, process them and finally put the result in the generated html page. To define dynamic content the web server uses so called "server side includes". The server side include is a special command included directly in the source code of the html page. When a client (e.g. Internet Explorer) requests such page the web server processes the commands and replaces them by a result. The cgi script can be also used as the target url in forms defined in the html page, so the user can pass to the script any parameters.

```
Command in the html code:
Outside temperature is <!-- echo
var="temperature">°C.

Result after server processing:
Outside temperature is 25°C.

Command in the html code:
The valve is <!—exec cmd="Script01.cgi">

Script definition:
       function Script01() {
         if(valve)
           _Output_ = "open.";
         else
           _Output_ = "closed.";
       }

Result after server processing:
The valve is closed.
```

Figure 2. Example of the SSI

Such approach providesgives very efficient and flexible tool. Because the system uses standard http protocol for data transfer it is easy to interface it with any third party system. The used mechanism of data transfer even allows using of modern XML language for data representation and its automatic processing. The system can be easily combined with JavaScript or Java applets so the processing and graphical representation of the data from the connected system is done on the user's computer, thus reducing the load of the embedded web server.

The hardware of this embedded web server is again based on the above-mentioned Ethernet module. Both devices can share tools for configuration (IP address, etc.).

4. Standalone data logger

The third device, the datalogger, was developed as a platform that would enable to collect data from a technological process and allow access to all this information from Intranet or Internet without any additional hardware. It was required that no special software should be needed for access to this data. Only standard software such as a web browser or ftp-client was allowed.

In principle, there are two ways how to achieve this goal. One is to embed all the necessary hardware in a sensor and individually connect each sensor to Internet. Although one can fully utilize all features of the sensor (full configuration and parameter setting over Internet), drawbacks such as higher price and lack of suitable components for such task (size, power consumption, price) prevent realization.

The other way is to create a universal device with number of universal inputs and connect standard sensors to them. Such data concentrator offers higher flexibility, possibility to pre-process collected data directly in the data concentrator, lower price per sensor, etc.

Such data concentrator was realized in close cooperation between authors department and BD Sensors s.r.o. company. The device is equipped with 14 analog inputs (0/4 ... 20mA) and 8 universal digital I/O. There is also a serial port allowing to connect GSM modem. The inputs lines are periodically scanned and the measured values are stored in the memory (1MB flash, this capacity enables to store data from all channels for 1 week with 3 minutes period).

The embedded web server enables access to both actual and past data. The server in the datalogger provides dynamically generated html pages. The content of these pages is user defined and can reflect actual measurements provided by connected sensors (it uses the same technique of server side includes as the previous device). The stored data can be displayed aither as a table or using Java applet as a graph. The web server includes also a special configuration page, which allows easy configuration of analog and binary inputs and data storage. The datalogger implements also a ftp server. It allows the user to download stored data as a file.

The devices implements some additional functions. For example it can be configured to send email when some input crosses predefined limits (a SMS when a GSM module is connected). It can also work as a simple on-off controller.

The hardware of the datalogger utilizes Net+ARM microprocessor manufactured by NET+Silicon company. It is 32-bit microprocessor with well-known ARM core. The main advantage of this processor is integrated 10/100 Ethernet controller module, which serves as the Ethernet Medium Acces Control layer. This module, together with powerful ARM core, gives us enough performance for processing of the massive data flow from Ethernet interface and for processing of TCP/IP and application layer protocols. It allows to use both widespread Ethernet standards, 10BaseT and 100BaseT.

5. Conclusion

During development of the described systems it has been found that Ethernet with TCP/IP protocol suite is a

good choice as an automation networking technology that allows easy connection to Internet. The system shows several advantages of Internet technologies in the industrial segment. The TCP/IP protocol allows to use several communication protocol to exchange data, independently on each other.

All three systems were developed on authors department. The first two in cooperation with GMC s. r. o. company, the last one in cooperation with BD Sensors s. r. o. company. One of the effects of this effort was to collect practical experience with Ethernet and it's application in industrial communication. None of the presented device is designed to meet tight real time requirements. The main area of application is remote monitoring and data acquisition.

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