Use of the Fieldbus Systems in Academic Setting

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Abstract

Computers are increasingly used to problems that require software solutions that must satisfy real-time constraints and are distributed in nature. The communication standards are developed and administrated by user organizations in which universities play an important role. In this paper, most of existing user organizations working in the field are listed and our experience with industry is shown. Advantages of fieldbus systems and the role of our laboratory in co-operation with industry are explained.

Controller Area Network (CAN) is a well-known bus technology in industrial communication systems. This paper shows an implementation of CANopen protocol used by one of our industrial partners in trains and mining machines.

1. Introduction

Fieldbus is the lowest level industrial network in computer communication hierarchy of factory automation and process control systems.

The fieldbuses are used today primarily as the communication system for exchange of information between automation systems and distributed field devices. In the past, incompatible vendor-specific fieldbuses were frequently used. Many fieldbus systems today are open standard systems. The user is no longer tied to individual vendors and is able to select the best and most economical product from a wide variety of products. Today, all leading manufacturers of automation technology offer fieldbus interfaces for their devices. That is why the fieldbus systems present very dynamically growing branch of science and development directly applied in industry. These technologies are developed and administrated by user organizations (i.e., AS-Interface [1], CAN in Automation [2], Open DeviceNet Vendor Association [3], Fieldbus Foundation [4], HART Communication Foundation [5], Interbus-S Club [6], LonMark Interoperability Association [7], International P-net User Organization [8], Profibus International [9], WorldFIP Headquarters [10]). Members of such non profit organizations include manufacturers of automation devices, software integrators, universities and research institutions. Regional user groups offer native language support around the world.

The work in the area of real-time and fault tolerant systems was done by several researches with the aim to satisfy real time requirements [16],[19] and to model these protocols using formal methods [14],[18].

2. Advantages of fieldbus systems

A distributed control system based on fieldbus technology has in comparison with the conventional centralized system various advantages:

- As there is one fieldbus going through all automation components there is considerable saving of cables connecting computer to the technology. In accordance to this installation is easier and faster.
- As there is usually one configuration tool for all devices it is easier to configure and parameterize the distributed system. Also other engineering work like preventive maintenance and system start-up are much faster.
- Resulting distributed control system is more flexible than the centralized one. This leads to improved functionality and reduced down time. In addition the fieldbus systems are designed in such a way that they offer accurate and reliable diagnostics.

3. University-industry co-operation

Participation in the project TRAFICC funded by EU, aimed in the creation of the laboratory for fieldbus-based automation systems helped us to equip our laboratory [15] with up to date hardware and software. We got in contact with several companies working in the field of fieldbus systems and we detected the following needs of our industrial partners:

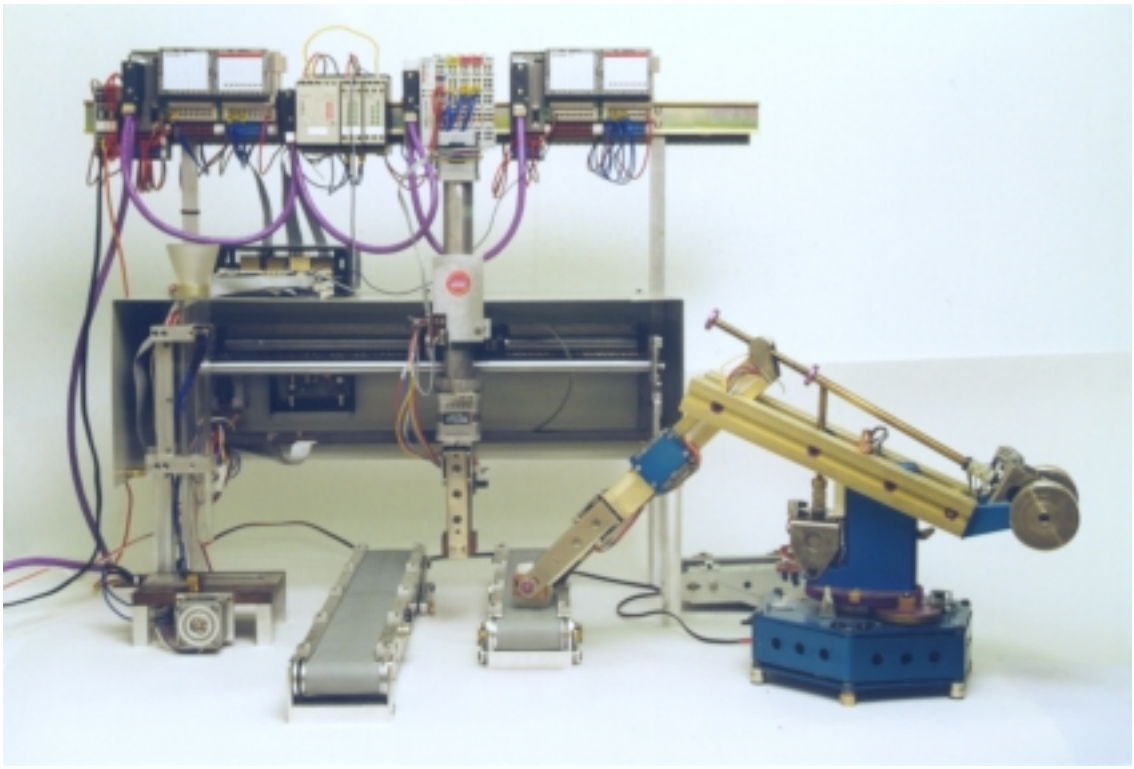

Figure 1: Multi-vendor control system based on Profibus

- big manufacturers of field devices want to promote their products and they are interested in courses for their industrial partners; they are also interested in the students education and join participation in the engineering fairs
- vendors and small companies that are beginners in the field are interested to take part in short introductory courses
- software integrators are usually specialist in the field and they are looking for good students from the last year familiar with this technology
- small companies developing their own hardware are interested to join their development effort with our laboratory

In the response to these demands the laboratory of distributed systems was created in the Department of control engineering carrying out the following sort of activities:

- Construction of the demonstration environment - based on the model of flexible manufacture and the hardware given/lend by industrial partners.
- Industrial courses – attended by our industrial partners. The first course was organized in a form of lecture (some 97 participants from industry), the second one consisted of short job-opportunity presentations by companies and laboratory exercises on five demonstrators with various fieldbuses (some 30 participants from industry).
- Academic education – the acquired knowledge and constructed demonstration environment are incorporated into the courses taught in the Department of control engineering (namely the subjects Distributed control systems and Programmable logical controllers). This team work also offers various themes for the student project work. Construction of one part of the Profibus demonstrator, laboratory set for configuration of the LonWorks demonstrator and visualization program for the Profibus demonstrator have been realized as bachelor/master project work.
- Technical support – development of the specific hardware and software fieldbus components. Many companies producing specific filed devices (i.e., industrial weights, special sensors and actuators) are interested to connect them to fieldbus systems (see the next chapter).

It is quite difficult to make a choice among various fieldbus systems and to make a definite decision which should be supported. One should take into account not only the technological awareness of the communication system but also marketing arguments, like market share of given fieldbus or standardization procedures. It is a little

hard for us to recognize that important decisions are not taken by managers and not by technicians and scientists. The effort in our laboratory was concentrated on the fieldbuses listed below. The amount of activities associated to them corresponds more or less to the specific interest of our industrial partners.

Profibus

- realization of demonstrator for multi-vendor control system for flexible manufacture (Siemens, Wago, SAIA, Weidmueller, ZAT, PMA, PEP, Entrelec Schiele) – see Figure 1
- hardware development of SPC3 and LSPM2 based Profibus DP cards [17]
- foundation of Profibus CZ association (Regional Profibus Organization for Czech Republic) situated in our department – for a list of members see our domain http://www.profibus.cz
- Profibus competence center (seminars, consulting,) – see http://novell.felk.cvut.cz/traficc/
- participation in engineering fairs – Amper 98, Brno Trade Fairs and Exhibitions 98
- excursions for students (Unicontrols a.s., WAGO Germany)

CAN

- demonstrator of distributed system consisting of conveyors and turn grippes controlled via CAN remote i/o modules and PC based master for demonstration of CAN nets
- implementation of CANopen protocol (minimum device configuration) for CAN remote i/o (digital i/o, analogue i/o , counter devices) modules.

ControlNet

- hydraulic control system implementation

LONWorks

- model of intelligent building (Weidmueller, Echelon)
- development of neuron chip based card
- participation in engineering fair – Amper 98

P-Net

- demonstrator of distributed control system

ASI

- part of the Profibus demonstrator

Most of these activities are carried out by PhD. students that are usually in closed contacts with industry. More theoretical work falling into domain of distributed control systems comprises the following subjects:

- Petri Nets algorithm modeling
- PN models of fieldbus protocols
- problem decomposition leading to applications implemented in multitasking operating systems
- parallel algorithms for control engineering

4. Implementation of CANopen protocol

The laboratory of distributed systems cooperates with Unicontrols at implementation of CANopen [11],[12],[13] protocol for intelligent IO remote modules based mainly on 8bits microcontrollers. Till now the protocol was implemented for Intel 51 and Motorola HC08 processors core. The modules cover wide range of sensors an actuators as digital inputs, outputs, analog inputs and counter inputs etc. These modules are useful for wide area of industrial applications and are used in many industrial projects.

CANopen protocol, that covers the application layer, is based on the CAN[12] and supports direct access to device parameters and time-critical process data communication. CANopen communication can be both cyclic and event-driven. CAN (Controller Area Network) is a serial bus system with real-time capabilities. The main area of applications are especially remote intelligent devices, sensors and actuators. The CAN protocol corresponds to the data link layer in the ISO/OSI.

Figure 2 shows a basic structure of the modules using the Intel51 processor core. The module is based on Dallas 320 microcontroller with external FLASH and BOOTROM memory and two CAN controllers. The BOOTROM memory, which is accessible after power on or HW reset, contains an initialization program and utilities for loading user code to the FLASH memory via RS232 interface and writing to the FLASH memory from a user program. The RS232 interface can be used either for loading code or for communication from user program as debugging process and for service and configuration utilities.

The firmware developed in our laboratory fully implements the CANopen protocol in minimum configurations that contains following features (Figure 3):

object directory, which contains information and configuration data structure such as communication parameters or standard device profiles with possibility to save current configuration to nonvolatile memory.

the node guarding protocol, which gets a device to the predefined state in case of a communication failure

emergency error handling

synchronous or asynchronous communication model

Because of the modules wide variability, especially easy to reload user code and debugging features, the modules are suitable for wide range of learning and practicing activities. The modules are used for the following activities:

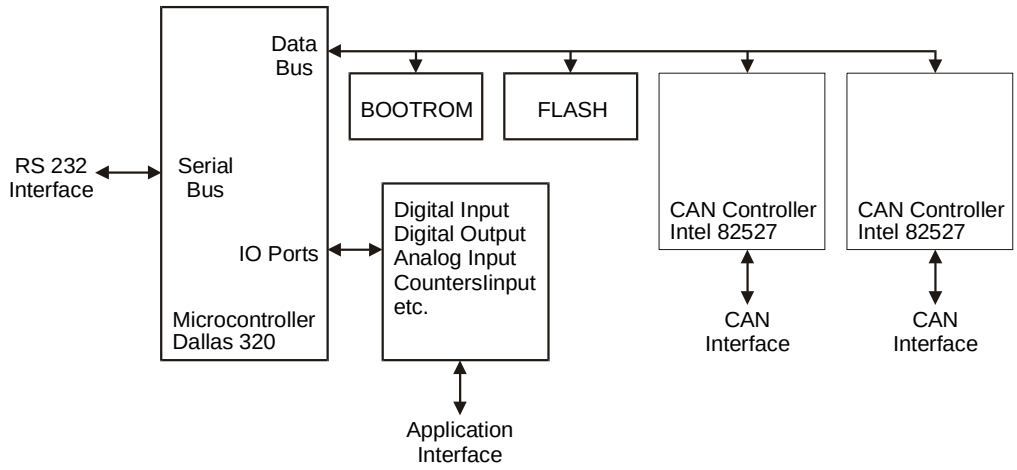

Figure 2: Structure of remote IO modules

microcontrollers programming - ASSEMBLER, C programming, simulations, debugging, system programming

real-time process programming - interrupt driven events, controlling time critical events, implementation of controlling loops

implementing of network communication protocols - from the low level such a sending and transmitting basic CAN messages to higher levels, networking devices, communication models

CANopen network - configuration of CANopen based modules, configuration tools for PC

programming PC based master software for controlling of manufacture model

These modules are also used in CANopen demonstrator (Figure 4) consisting of the controlled models based on two conveyors (DC motor, 5 position sensors) and two turn grippers (two stepper motors and 4 position sensors

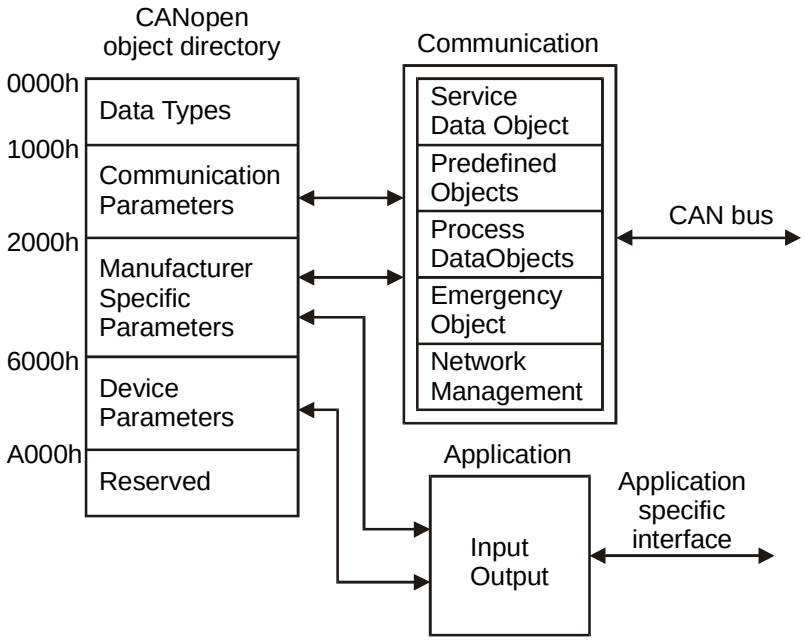

Figure 3: CANopen protocol and object directory

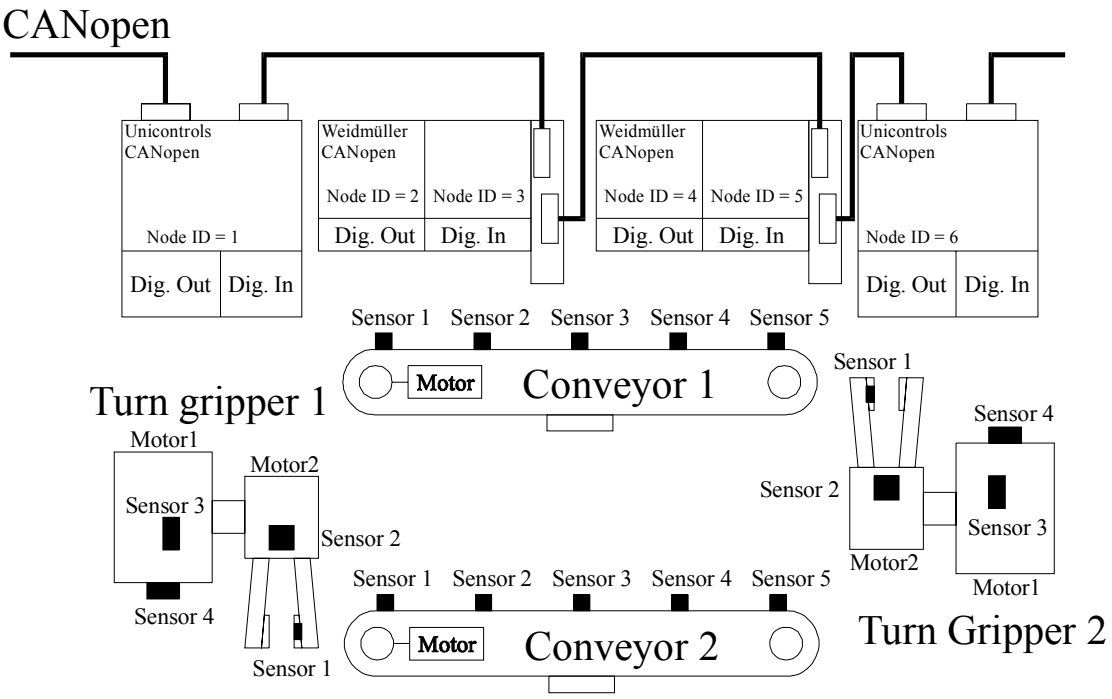

Figure 4: CANopen demonstrator

5. Conclusion

Large and complex systems such as flexible manufactures and process automation systems in the steel, chemical and power plants comprise several and distributed field devices. Interconnection of these field devices through networking increases reliability, flexibility and user comfort in design, operation, service and diagnostics of complex systems.

Close co-operation of educators with industry is the crucial point of meaningful work in this rapidly developing field. This co-operation ranges from introductory courses to long term development work. Implementation of CANopen protocol to the Unicontrols is one example of such work, which demands high professional level on both sides.

Acknowledgments

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