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ETHERNET COMMUNICATION PROTOCOL PROPOSED FOR THE TMA 55 5 AXIS FLEXIBLE MANUFACTURING SYSTEM

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Abstract: In this paper we discuss the differences between the industrial communication protocols and one is selected for our flexible manufacturing cell composed from a five axis milling machine, two robots, one T shaped conveyor, storage system and one quality control system.

1. Introduction

Flexible manufacturing systems are made from different elements like quality assurance, computer hardware, support equipments and processing machines. These elements are all visible.

The software which controls the system is invisible and contains all the FMS specific programs and routines. These FMS softwares are complex and highly proprietary, built from several modules.

Each module is made up from a series of programs and routines relating to functions performed by various elements of the system. These modules includes tool management, work piece scheduling, traffic and material handling management, NC and robot program, downloading from the server, work order generation and simulation.

The FMS software must be tested rigorously, function predictably, reliably and in real time. The modules are individually developed and have to interact together in any conditions.

Building the FMS software from modules permits “phased installation”, allowing the user to begin using the system while some portions are still in development, testing or implementing. This modular build offers a quicker and easier tracing and finding of problems. (1)

2. Fieldbus

The software module communication with the hardware (PLC, CNC, robots, storage) is made using a fieldbus. The term fieldbus is the name of the computer network protocols used for real-time distributed control, standardized as IEC 61158.

A flexible manufacturing system needs an organized hierarchy controller system to function. In most cases in this hierarchy we find a human-machine interface where a human operator can monitor or operate the system. This is linked with multiple programmable logic controllers via ethernet. At the bottom of the control chain is the fieldbus which links the controllerrs to the components like electric motors, switches, valves, sensors and actuators.

In the past computers were connected through serial connections (RS-232) by which only two devices could communicate. This communication requires that each device have its own communication point at the controller level, while the fieldbus is the equivalent of the current LAN-type connections, which require only one communication point at the controller level to communicate with hundreds of points.

3. Industrial Ethernet

The name Industrial Ethernet was given to the use of ethernet networking in industrial environments to connect different systems (PLCs, sensors) for automation and process control. The large marketplace of computers using ethernet helps to reduce implementation costs and to improve the communication between industrial systems; however the industrial ethernet components used in manufacturing must be designed to work in harsh environments like extreme temperatures, humidity, vibrations that exceed the ranges for equipments intended for installation in controlled environments.

In these days the interest is increasing for the use of Ethernet as the link-layer protocol, with one of the industry standard protocols (Modbus, Sinec H1, Profibus, CANopen, DeviceNet or Foundation Fieldbus) as the application-layer.

Some of the advantages are:

- Increased speed, up from 9.6 kbit/s with RS-232 to 1 Gbit/s with IEEE 802 over Cat5e/Cat6 cables or optical fiber
- Increased overall performance
- Increased distance
- Ability to use standard access points, routers, switches, hubs, cables and optical fiber, which are immensely cheaper than the equivalent serial-port devices
- Ability to have more than two nodes on link, which was possible with RS-485 but not with RS-232
- Peer-to-peer architectures may replace master-slave ones
- Better interoperability

The difficulties of using Industrial Ethernet are:

- Migrating existing systems to a new protocol (however, many adapters are available)
- Real-time uses may suffer for protocols using TCP (but some use UDP and layer 2 protocols for this reason)
- Managing a whole TCP/IP stack is more complex than just receiving serial data
- The minimum Fast Ethernet frame size including inter-frame spacing is about 80 bytes, while typical industrial communication data sizes can be closer to 1-8 bytes. This often results in a data transmission efficiency of less than 5%, negating any advantages of the higher bitrate.
- On Gigabit Ethernet the minimum frame size is 512Bytes, reducing the typical efficiency to less than 1%.
- Some of the Industrial Ethernet protocols introduce modifications to the Ethernet protocol to improve efficiency. (2)

4. Main protocols.

Modbus is a serial communications protocol, has become one of the standard communications protocols in the industry, and now used to connect industrial electronic devices most commonly.

Profibus (Process Field Bus) is a standard for field bus communication in automation technology. It should not be confused with the PROFINET standard for Industrial Ethernet.

Profinet is the open industrial Ethernet standard of Profibus & Profinet for automation and uses TCP/IP standards. The Profinet concept features a modular structure the main goal to achieve the very high requirements of speed.

DeviceNet is a network system used in the automation industry to interconnect control devices for data exchange. It uses Controller Area Network as the backbone technology and defines an application layer to cover a range of device profiles. Typical applications include information exchange, safety devices, and large I/O control networks. (3)

CANopen is a communication protocol and device profile specification for embedded systems used in automation. The communication protocols have support for network management, device monitoring and communication between nodes, including a simple transport layer for message segmentation/desegmentation. (4)

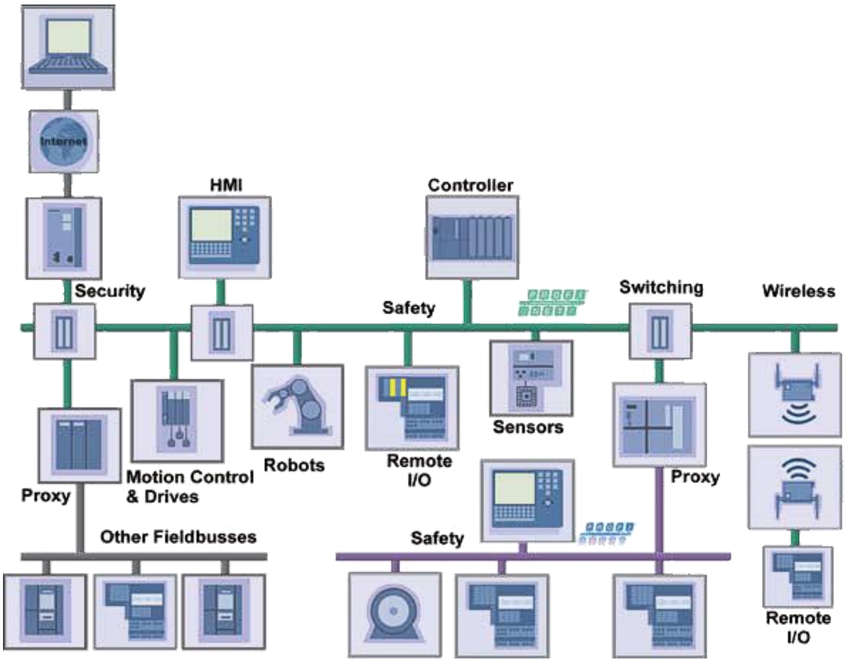

Fig. 1 Profinet overview

5. Conclusions

Our flexible manufacturing system is composed of:

- IRC5 ABB industrial robot controller with two IRB 1600 robots
    - RAPID programming language
    - Fieldbuses: Profinet, Profibus DP, DeviceNet, Ethernet/IP
    - Multi processor system (Pentium CPU)
    - FTP server
- Siemens S7-300 PLC to control a T shaped conveyor
    - Compact CPU with integrated digital inputs and outputs
    - Integrated memory
    - Profibus DP interface
- GE Fanuc 310i CNC equipment for 5 axis manufacturing centre
    - FTP server
    - Fieldbuses: Profinet, Profibus DP, DeviceNet, Ethernet/IP
    - 5 axis manufacturing
- storage system for raw materials and tools
- RFID control

To control the FMS we will use an ethernet network. On the top of this network is the server which runs the main control application. This is connected with the FMS and the design PCs by ethernet cables and switches. The S7-300 PLC will be modified for ethernet communication (now can only communicate through serial communication). The communication between the FMS modules and server will use the Profinet protocol. This provides a high-performance, reliable network with minimum bandwidth impact. Later in the control application we can add modules to send commands using other protocols like Modbus or CANopen.

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