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Foundation Field Bus and Implementation of Network Communication Stack

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***Abstract*: This paper focuses on the foundation field bus and implementation of the network communication stack. Field bus network is a distributed controlling system where the controlling algorithms are running in the fieldbus devices itself thus helping in the decentralized controlling of the devices avoiding the overhead on the communication channel. To achieve this purpose the field bus device has to be first identified by the field bus network. For this reason, every field bus device has to be occupied with the communication stack. This paper presents a brief introduction about the foundation field bus. After introduction we will present the implementation aspects of the communication stack, where we are going to discuss about the different building blocks of the communication stack.**

***Keywords*: Communication stack, Field bus, Foundation field bus.**

1. Introduction

Foundation Fieldbus is an all-digital, two-way, multi-drop communication system that brings the control algorithms into instrumentation. Foundation Fieldbus is a Local Area Network (LAN) for Foundation Fieldbus devices including process control sensors, actuators, and control devices. Using the Foundation Fieldbus device, you can incorporate traditional 4–20 mA devices into your Fieldbus network. Foundation Fieldbus supports digital encoding of data and many types of messages. Unlike many traditional systems which require a set of wires for each device, multiple Foundation Fieldbus devices can be connected to the same set of wires. Foundation Fieldbus overcomes some of the disadvantages of proprietary networks by offering a standardized network to connect systems and devices.

The Fieldbus Foundation is the organization that defines the Foundation Fieldbus specification and certifies products to be compliant with the standard. The Foundation Fieldbus standard defines the way you can bring new devices into the network, set them up, and configure them. Any company with the proper resources can make a Foundation Fieldbus device (if it passes the Conformance Test) that will work with all other foundation Fieldbus-certified devices and software. The goal of the Fieldbus Foundation is to help create products that use a robust industrial network based on existing standards and other proven technologies and to standardize using those sources. Foundation Fieldbus is an open standard, which allows you to use Foundation Fieldbus products from different vendors interchangeably.

2. The Fieldbus Network

Foundation Fieldbus is an all-digital, two-way, multi-drop communication system that brings the control algorithms into instrumentation. Foundation Fieldbus is a Local Area Network (LAN) for Foundation Fieldbus devices including process control sensors, actuators, and control devices. Using the National Instruments FP-3000 Foundation Fieldbus device, you can incorporate traditional 4–20 mA devices into your Fieldbus network. Foundation Fieldbus supports digital encoding of data and many types of messages. Unlike many traditional systems which require a set of wires for each device, multiple Foundation Fieldbus devices can be connected to the same set of wires. Foundation Fieldbus overcomes some of the disadvantages of proprietary networks by offering a standardized network to connect systems and devices. A simple Fieldbus network setup is shown in the following figure.

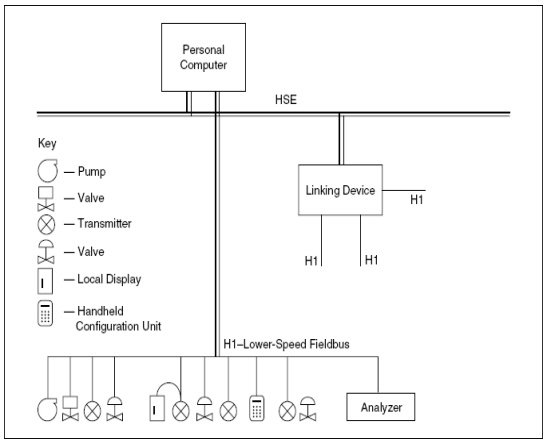

Fig. 1. Fieldbus network setup

3. Foundation Fieldbus Communication Protocols

Foundation Fieldbus has two communication protocols: H1 and HSE. The first, H1, transmits at 31.25 Kb/s and is used to connect the field devices. The second protocol, High Speed Ethernet (HSE), uses 10 or 100 Mbps Ethernet as the physical layer and provides a high-speed backbone for the network. H1 is an all digital, serial, two-way communication system running

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at 31.25 kbit/s which interconnects field equipment such as sensors, actuator, and controllers. H1 is a Local Area Network (LAN) for instruments used in both process and manufacturing automation with built-in capability to distribute the control application across the network.

HSE is based on 10/100 Mbps standard Ethernet/IP/TCP /UDP protocols and supports the same functions as H1, but at a much higher bandwidth (10/100 Mbps). Its large capacity to move data, along with the inherent Foundation Fieldbus functionality, and publish/subscribe access, fits in with plant-wide integration in the process industries.

Foundation Fieldbus networks may be composed of one or more of these interconnected segments. HSE sub networks can use a variety of commercially available interconnection devices such as hubs, switches, bridges, routers, and firewalls. H1 links are interconnected physically only by Foundation Fieldbus H1 Data Link bridges. HSE to H1 interconnections are performed by Foundation Fieldbus Linking Devices. A typical network topology has HSE connections between computers, and runs slower H1 links (31.25 Kbps) between the devices themselves. Devices designed for HSE can be connected to HSE directly. Most devices are designed to use one protocol or the other.

H1 and HSE were specifically designed as complementary networks. H1 is optimized for traditional process control applications, while HSE, which employs low-cost, commercial Off-the-shelf (COTS) Ethernet equipment, is designed for high-performance control applications and plant information integration. The combined H1/HSE Fieldbus solution allows for full integration of basic and advanced process control, and hybrid/batch/discrete control subsystems, with higher level, supervisory applications. H1/HSE provides the key to optimum enterprise performance by removing unneeded I/O conversion equipment and controllers, sensor networks, and gateways. This flat, integrated architecture provides increased plant uptime (through improved diagnostics and operator information), increased performance (COTS Ethernet), and reduced costs (COTS and less overall equipment).

4. FieldBus Communication Layers and Communication Stack

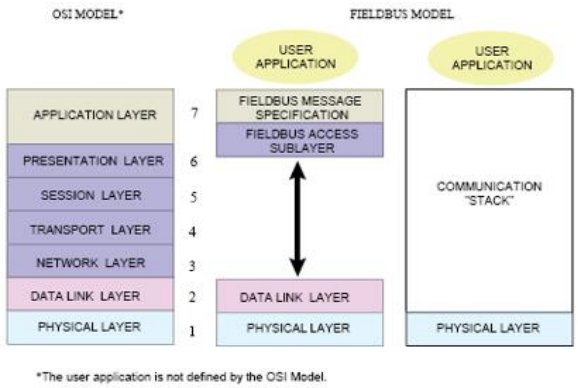

Fig. 2. The Open Systems Interconnect (OSI) targeted communications model

A. Physical Layer

The physical layer converts digital Fieldbus messages from the communication stack to physical signals on the Fieldbus transmission medium and vice versa. Refer to the *Foundation Specification: 31.25 kbit/s Physical Layer Profile* for the Foundation Fieldbus H1 physical layer specifications. The physical layer implements IEC Standard 1158-2 and ISA Standard ISA S50.02. Refer to the *Foundation Specification: HSE Presence* for the Foundation Fieldbus HSE physical layer specifications.

B. Communication Stack

The communication stack performs the services required to interface the user layer to the physical layer. The communication stack consists of three layers: the Fieldbus Message Specification, the Fieldbus Access Sublayer, and the Data Link Layer. The communication stack encodes and decodes user layer messages and ensures efficient and accurate message transfer.

The Data Link Layer manages access to the Fieldbus through the Link Active Scheduler by splitting data into frames to send on the physical layer, receiving acknowledgment frames, and re-transmitting frames if they are not received correctly. It also performs error checking to maintain a sound virtual channel to the next layer.

The Fieldbus Access Sublayer provides an interface between the Data Link Layer and the Fieldbus Message Specification layer. The Fieldbus Access Sublayer provides communication services such as client/server, publisher/subscriber, and event distribution.

The Fieldbus Messaging Specification layer defines a model for applications to interact over the Fieldbus. The object dictionary and the virtual field device are important in this model. The object dictionary is a structure in a Fieldbus device that describes data that can be communicated on the Fieldbus. You can think of the object dictionary as a lookup table that gives information about a value (such as data type) that can be read from or written to a device. The virtual field device is a model for remotely viewing data described in the object dictionary. The services provided by the Fieldbus Messaging Specification allow you to read and write information about the object dictionary, read and write the data variables described in the object dictionary, and perform other activities such as uploading/downloading data and invoking programs inside a device.

Within the Fieldbus Messaging Specification layer are two management layers called System Management and Network Management. System Management assigns addresses and physical device tags, maintains the function block schedule for the function blocks in that device, and distributes application time. You can also locate a device or a function block tag through System Management.

Network Management contains objects that other layers of the communication stack use, such as data link, Fieldbus Access Sublayer and Fieldbus Messaging Specification. You can read and write System Management and Network Management objects over the Fieldbus using the FMS Read and FMS Write services.

C. Virtual Field Devices

The virtual field device (VFD) is a model for remotely viewing data described in the object dictionary. The services provided by the Fieldbus Messaging Specification allow you to read and write information about the object dictionary, read and write the data variables described in the object dictionary, and perform other activities such as uploading/downloading data and invoking programs inside a device. Each physical device on the Fieldbus can have one or more virtual field devices. A network configuration application can assign each virtual field device a tag that is unique within the device. Most devices have only one virtual field device. Each virtual field device has one resource block and one or more function blocks and transducer blocks. Each block should be assigned a tag that is unique within the Fieldbus system.

D. User Layer

The user layer provides the interface for user interaction with the system. The user layer uses the device description to tell the host system about device capabilities. The user layer defines blocks and objects that represent the functions and data available in a device. Rather than interfacing to a device through a set of commands, like most communication protocols, Foundation Fieldbus lets you interact with devices through a set of blocks and objects that define device capabilities in a standardized way. The user layer for one device consists of the resource block, and one or more transducer blocks and function blocks, as illustrated in figure.

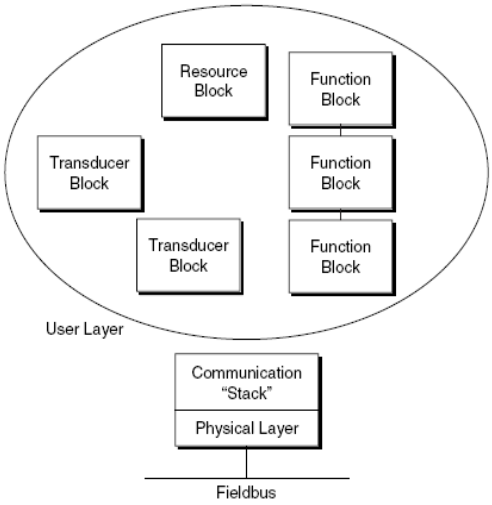

Fig. 3. User layer

5. Architectural Design

A. Logical Design

This section describes the abstract logical design of the software architecture. For the most part, the logical design of a fieldbus communication stack is specified in the Foundation™ Fieldbus specifications. Selected information is repeated or clarified here in order to aid comprehension of the physical design.

The FB-Shell provides services and functions that are common to all function blocks:

- Trend processing and notification.
- Alert processing - notification and reception of acknowledgement.
- Establishment and maintenance of function block links.
- Publishing of outputs and subscription of inputs.

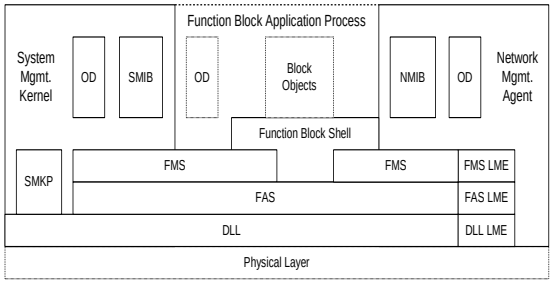

Fig. 4. Architectural design

B. Detailed Physical Design

This section partitions the solution into logical components to provide a top-level overview of the design of the system. Since this is a single program C-Language design, the components are module categories rather than subsystems. The following diagram shows the top-level module categories, and their gross relationships.

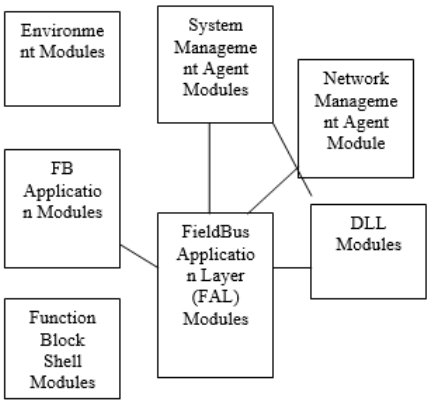

Fig. 5. Detailed physical design

6. Conclusion

Fieldbus Network is a Distributed Controlling System which brings the Controlling algorithms into Instrumentation. To achieve this goal, we have to incorporate the Field device into the network. For this reason, we tried to design and implement Network Communication stack. We used the configuration tools to configure. Only with configuration software can you do things like set device addresses, clear devices, download (necessary if you are setting up a system for the first time).

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