HSE:
AN OPEN, HIGH-SPEED SOLUTION FOR PLANTWIDE AUTOMATION

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Introduction

The Fieldbus Foundation's High Speed Ethernet (HSE) technology provides a cost-effective, high-speed, plantwide backbone for process and discrete automation. HSE enables users to solve a wide range of hybrid, batch and time-critical discrete control applications.

HSE supports the entire scope of the FOUNDATION fieldbus technology, including standard function blocks and device descriptions, and takes full advantage of the low cost and ready availability of Commercial Off The Shelf (COTS) Ethernet components.

HSE complements, rather than replaces, the Fieldbus Foundation's H1 (31.25 kbit/s) fieldbus, and thus meets the worldwide market demand for a unified control network solution. It integrates H1 for distributed process control applications with a high-speed (100 Mbit/s) technology for advanced hybrid, batch and manufacturing applications, and provides for information integration with plant management systems.

Although HSE was developed for control networks running at 100 Mbit/s, it will support network speeds of 1 Gbit/s or higher as they become standardized by IEEE and ISO/IOC. This level of performance enables HSE to serve as effective backbone for integration of control applications with optimized data servers such as OLE for Process Control (OPC), and systems such as Microsoft's Distributed interNet Application for Manufacturing Network Architecture (DNA).

Unlike other fieldbus protocols, FOUNDATION fieldbus has the complete specifications necessary to achieve device interoperability. The FOUNDATION specifications, including H1 and HSE, cover the communications system and user layer above the communications layers. Whereas the communications system moves data from one point to another, the user layer supports distribution of control functionality to field devices.

FOUNDATION fieldbus is also a true open technology, allowing automation and MIS devices to be interconnected on a common plantwide network. Furthermore, this open network architecture enables control devices from different manufacturers to interoperate on the same control network without the need for custom programming.

Background

The HSE development project was approved by the Fieldbus Foundation’s board of directors in March 1998. A multi-vendor development team consisting of 35 volunteer architects, design engineers and managers from 15 Fieldbus Foundation member companies completed the HSE system architecture in June 1998.

A Draft Preliminary Specification (DPS) for HSE was distributed to foundation members for review in October 1998, and laboratory prototype devices were soon delivered by a number of major automation equipment suppliers. These included: Measurement Technology Limited (MTL), Luton, England; National Instruments Corporation, Austin, Texas; Smar Research Corporation, Holbrook, N.Y., and Smar Equipamentos Industriais Ltda., Sertaozinho, Brazil; Softing GmbH, Harr, Germany; Schneider Automation, North Andover, MA; and Richard Hirschmann of America, Pinebrook, NJ.

Following the completion of laboratory testing of prototype HSE devices in September 1999, the Fieldbus Foundation released the HSE Preliminary Specification (PS) for review by its members. This successful review was followed by release of the HSE Final Specification (FS) in March 2000. The HSE specification is fully compliant with the international IEC 61158 fieldbus standard.

Many of the industry's leading controls and instrumentation suppliers are now developing HSE-compliant fieldbus products. Much like H1 devices, these products will be tested and registered by the Fieldbus Foundation as they become available from manufacturers. The first HSE devices are expected to be registered in early 2001.

Technology Overview

The HSE physical layer signaling and data link protocols are specified in the IEEE 802.3 and ISO/IEC 8802-3 standards. However, HSE includes 11 new specifications above the IEEE 802 physical layer and communication "stack" to meet the requirements of Ethernet in industrial applications. The HSE system and network management agents, function blocks, HSE management agents and field device access agents all reside at the user layer, above the transport layers of the OSI model (Fig. 1).

In addition to the standard IEEE 802 Ethernet model, HSE employs standard Internet protocols, including TCP/IP, UDP and SNTP. The use of standard Ethernet/Internet protocols, coupled with COTS Ethernet cable, switches and routers, allows HSE networks of any size or topology to be built. HSE also provides large bandwidth in the field, and supports efficient, high-speed communication of H1 fieldbus message services across the backbone.

HSE's use of standard FOUNDATION fieldbus function blocks, such as AI, AO and PID, ensures a uniform presentation of data at all levels of the control network. The HSE specification assigns a primary time publisher responsible for posting time, and a secondary time publisher that serves a back-up in the event of failure by the primary time publisher. HSE's protocol for redundant time publishers, which is similar to the H1 FOUNDATION fieldbus time acquisition protocol, is handled by system management.

HSE supports both single and dual fault-tolerant Local Area Networks (LANs), and provides redundant communications paths which are transparent to the applications. Should either path be broken, the secondary path will immediately be used for communication. This redundancy is based on the Type N-2A and N-2B network classifications of redundancy (Fig. 2).

The status of the HSE network is shared among all devices. All devices periodically transmit network diagnostic messages on all ports, which are used to create a network status table (NST) in each device. The NST allows devices to independently pick ports for communication, thus avoiding all defective communication paths on the Ethernet.

HSE supports mission-critical monitoring and control applications through the use of fault-tolerant networks and linking devices. The HSE linking devices are used to interconnect H1 fieldbus segments and provide access to the HSE backbone (Fig. 3), and also can incorporate H1-H1 bridge and gateway functions to other networks.

As a bridge, the HSE linking devices enable peer-to-peer communication between H1 devices without the need for host system intervention. It also allows H1 devices on one linking device to communicate with H1 devices on another linking device via the HSE backbone. The HSE host can communicate with all linking devices and connected devices. In this manner, important data can be supplied to remote field devices for use in monitoring and reporting functions.

As a gateway, the HSE linking device connects the HSE network to other plant control and information networks. It aggregates messages from H1 fieldbus segments and converts H1 addresses into Internet IP or IP6 addresses.

H1 segment information supplied by HSE linking devices can be transmitted via the Internet to a plant's main control room and viewed from operators' web browsers. Control data retrieved from the network can also be supplied to Enterprise Resource Planning (ERP) and management systems. This Internet-based control integration solution enables a company to interconnect manufacturing operations at different locations around the world.

Developed specifically for the HSE program, but also usable with H1 fieldbus systems, new Flexible Function Blocks (FFBs) are configured for advanced process and discrete control, as well as integration of remote I/O and other sub-systems. They include eight-channel Multiple Input/Output (MIO) analog and discrete FFBs, and application-specific FFBs. These specialized FFBs, which serve as a "wrapper" for specific control algorithms, are created in the IEC 61131 standard programming language (Fig. 4).

FFBs support functions ranging from supervisory data acquisition to I/O interfaces, while also allowing multiplexers, PLCs and gateways to other protocols to use the HSE backbone. The addition of the FFB provides users with a standardized enterprise integration protocol.

The ability to move control functionality to the field-level is enhanced through the use of FFBs. The HSE linking device and field device form a single physical device supporting batch and logic control. With this approach, the need for proprietary unit controllers can often be eliminated. Users benefit from decreased equipment costs and space requirements.

In addition, a more unified, plantwide control structure can be achieved by distributing control to HSE linking devices. The linking devices can be located in key process elements, such as valves and final actuators, where points of communications converge. As a result, problems due to a loss or failure of supervisory control are minimized.

In addition, HSE’s optional use of fiber optic media supports Intrinsic Safety (IS) requirements through hazardous environments. The Ethernet network can be connected via a fiber optic line with HSE linking devices protectively-housed near hazardous areas of the process. In this manner, the linking devices are able to handle unit and batch control functions in the field, and users are able to reduce cost and space requirements for rack-mounted I/O equipment and controllers.

Summary

Users with continuous and time-critical plant automation applications will realize numerous benefits through the implementation of the Fieldbus Foundation’s HSE technology.

HSE enhances the performance and versatility of the FOUNDATION fieldbus H1 technology in continuous control environments, while expanding FOUNDATION fieldbus’ capabilities in the high-speed process automation and discrete manufacturing arenas. HSE's use of COTS Ethernet components and standard Ethernet wire and fiber optic media allows users to create Ethernet networks of virtually any size or topology.

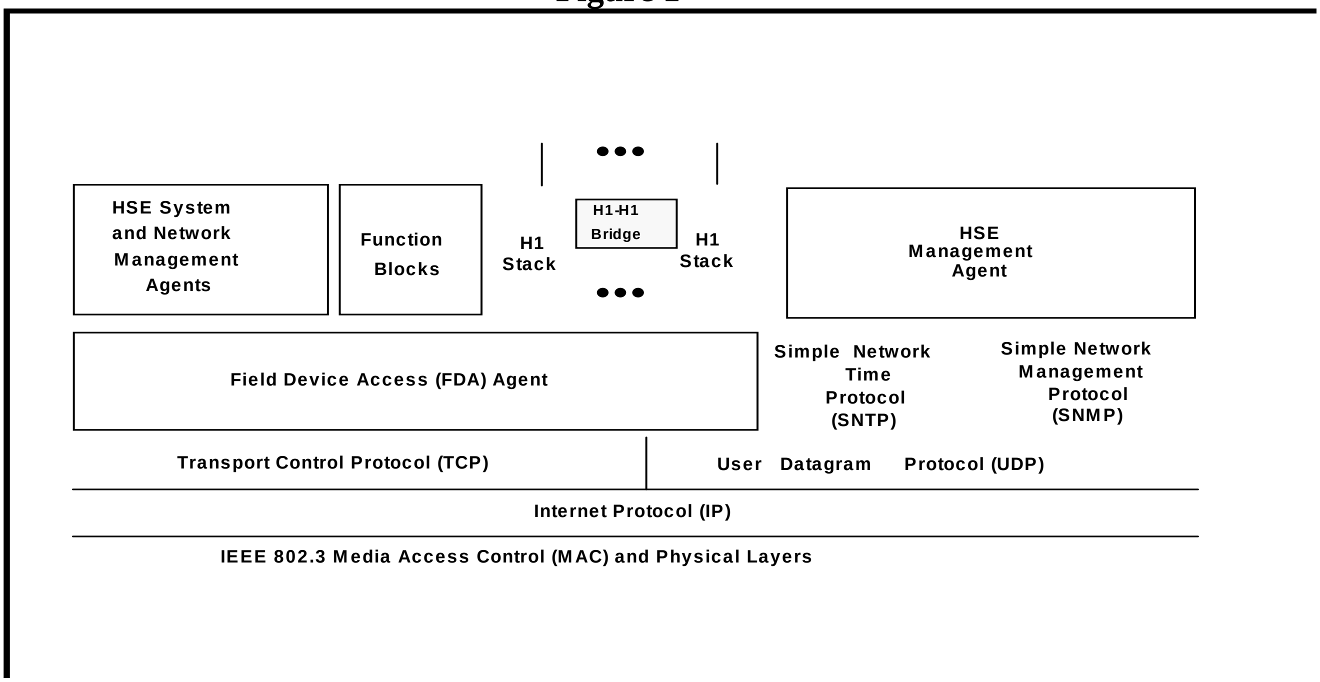
HSE's fault-tolerant network and linking device capability enables multiple H1 fieldbus segments to be interconnected. Running at speeds of up to 1Gbit/s, an HSE system can supply H1 messaging to a high-speed Ethernet backbone, and achieve the levels of redundancy and fault tolerance required for demanding control applications.

Finally, HSE enables users to realize even greater benefits from distributing control to the field-level — a unique capability of FOUNDATION fieldbus. Batch and logic control functions can be performed in the field by HSE linking devices employing standard function flocks as well as the new Flexible Function Block. This distributed architecture reduces the risks associated with supervisory control failure, and minimizes the need for large numbers of unit controllers and rack-mounted I/O in process areas.

ABOUT THE AUTHOR

David A. Glanzer is director of technology development for the Fieldbus Foundation. He plans and directs technology-based activities for the foundation worldwide, including specification and product development. Glanzer received a BS degree in electrical engineering from the South Dakota School of Mines and Technology. He is a member of the American Society for Quality (ASC), and is a senior member of The International Society for Measurement and Control (ISA).

Figure 1



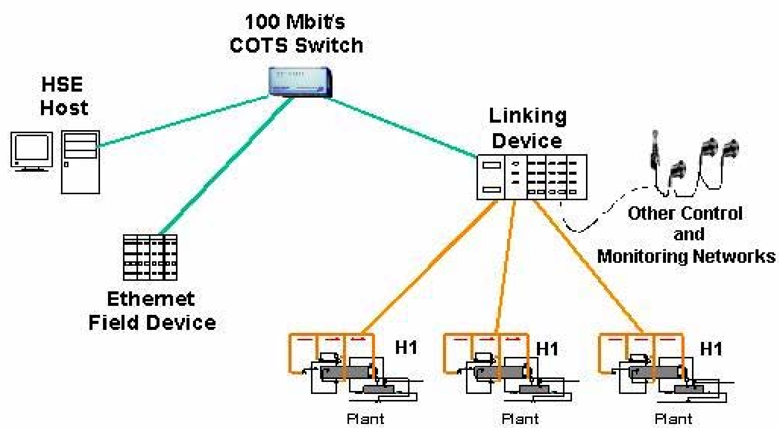
HSE System Architecture

Figure 2

HSE HSE Redundancy Type N-2B Single Fault Tolerant Network

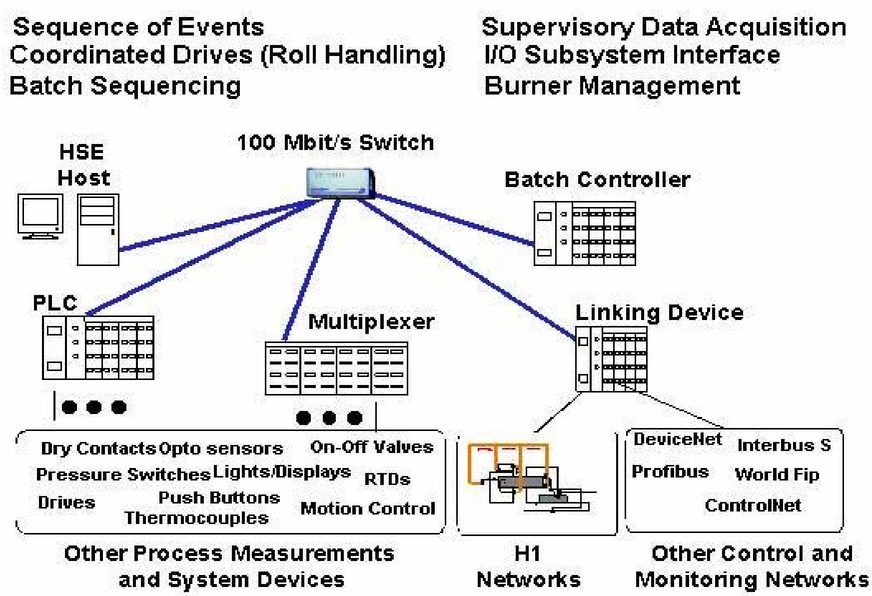
SHSE Redundancy Type N-2A Dual Network

Figure 3



HSE Linking Device

Figure 4



Flexible Function Blocks (FFBs)