SEMI E54-0704
SENSOR/ACTUATOR NETWORK STANDARD

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NOTICE: The designation of SEMI E54 was updated during the 0303 publishing cycle to reflect revisions to SEMI E54.9 and the creation of SEMI E54.13.

NOTICE: The document that was previously designated as SEMI E54 (Standard for Sensor/Actuator Network Common Device Model) has been redesignated as SEMI E54.1. Because the Sensor/Actuator Network Standard is the parent document, it has been designated as SEMI E54.

1 Purpose

1.1 This specification provides the structure of SEMI's Sensor/Actuator Network (SAN) standard. It provides the definition for interoperability with respect to SEMI SAN standard-compliant Sensor/Actuator devices.

2 Scope

2.1 This standard specifies how devices interoperate on a network as part of the control system for equipment.

2.2 This specification, which is the root of the SAN standard, defines the relationships of each of the other specifications that are components of the SEMI SAN standard.

NOTICE: This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicability of regulatory or other limitations prior to use.

3 Referenced Standards

3.1 *SEMI Standards*

SEMI E30 — Generic Model for Communications and Control of SEMI Equipment (GEM)

SEMI E39 — Object Services Standard: Concepts, Behavior, and Services

SEMI E54.1 — Standard for Sensor/Actuator Network Common Device Model

3.2 *Other Documents*

ISO 7498[1] — Basic Reference Model for Open Systems Interconnection (OSI)

James Rumbaugh, Michael Blaha, William Premerlani, Frederic Eddy, William Lorensen, *Object-Oriented Modeling and Design*, Englewood Cliffs, New Jersey: Prentice-Hall, 1991.

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

4 Terminology

4.1 *Abbreviations & Acronyms*

4.1.1 *API* — Applications Programming Interface

4.1.2 *CDM — Common Device Model*. The root object application model for devices on the sensor bus.

4.1.3 *DM* — DeviceManager. An object specified in SEMI E54.1 (Standard for Sensor/Actuator Network Common Device Model).

4.1.4 *IDL* — Interface Definition Language. A programming language-independent notation for specifying interfaces.

4.1.5 *ISO* — International Organization for Standardization.

4.1.6 *NCS* — Network Communication Standard. Provides the specification for mapping the CDM and SDM to specific network technologies. These standards will be incorporated as parts of the SEMI SAN standard.

4.1.7 *OEM* — Original Equipment Manufacturer. They are usually the control system developer, but in any case they are almost always responsible for the control system.

4.1.8 *OMT* — Object Modeling Technique. A methodology developed by James Rumbaugh, et al. for using objects to model systems.

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4.1.9 *OSI* — Open System Interconnection. A seven-layer model for communications developed by ISO.

4.1.10 *OSS* — Object Services Standard. SEMI E39.

4.1.11 *SAN* — Sensor/Actuator Network. It is frequently used to reference this standard.

4.1.12 *SDM* — Specific Device Model. This is an application model for a specific type of sensor, actuator, or entity.

4.2 *Definitions*

4.2.1 *application* — for software, this is a working series of computer instructions that provide end user services.

4.2.2 *applications model* — a formal description of the software elements and interactions that perform an end user task.

4.2.3 *entity* — in software engineering, this is something that is recognizable as distinct and particular from the other things that make up a software system or program.

4.2.4 *interface* — in information modeling, it is the boundary between two entities from which information will flow.

4.2.5 *user layer* — in communications, this is a set software function connected to the communication protocol's top layer, usually called the applications layer, from the user's application environment. It typically allows the user application to be protocol-independent.

5 Overview

5.1 Referring to Figure 1, the SAN standards specify a complete communications solution covering all the layers of the OSI reference model. The CDM and SDM together specify a protocol-independent set of application services, attributes, and behavior for a device that must be supported by the user layer as shown in Figure 1. An NCS completes the specification of the user layer by specifying a mapping to a network technology's interface. The NCS must specify its capabilities referenced against the ISO OSI Reference Model. An NCS may utilize an open or commercial solution. In any case, the NCS will provide references to those solution's specifications.

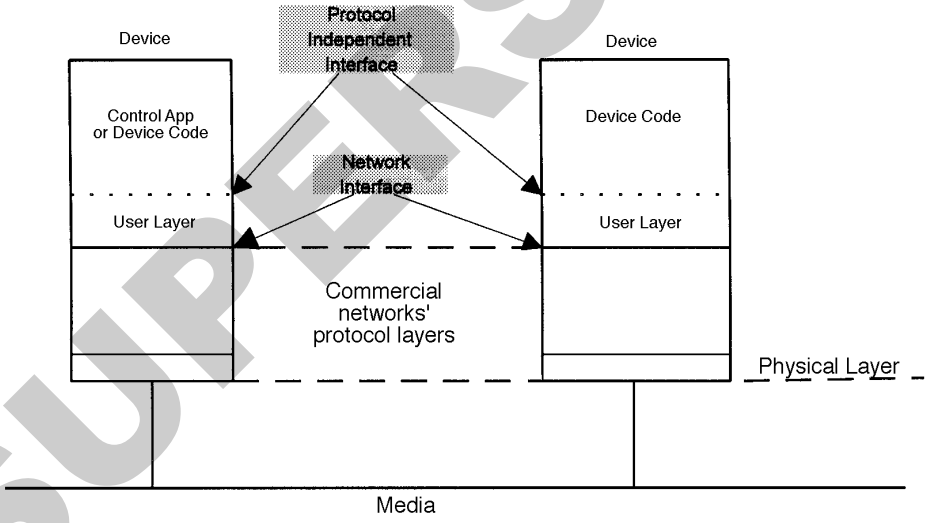

Figure 1
SEMI SAN Protocol Layers

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5.2 Generally, the functionality of a software layer is embodied by the definition of the services it provides. Its services are the set of messages it generates and to which it responds, and its subsequent behavior upon receipt of any particular message. The CDM and an SDM provide a complete user layer specification in a platform and language-neutral form (dotted line in Figure 1). The goal being to provide device interoperability at the applications level. The NCS will guarantee interoperability at the network level (i.e., across a single type of network). The SAN standard does not require implementation of the top interface to the user layer, as specified by the CDM and an SDM. The CDM and an SDM provide the information needed to develop an NCS, which defines the interface requirement between the user layer and a specific network technologies communication layer (the solid line labeled as Network Interface). This means that the SAN standard allows user applications, whether from the device or the controller side implementation viewpoint, to interact directly with a network technologies interface.

5.3 *Network Technology Supplier View* of *the SAN Standard*

5.3.1 The CDM and an SDM together specify the messages, behavior, and attributes of a device type that will be visible over the network. In Figure 1, this is the area above the line that indicates the protocol-independent interface. Network suppliers will map this information to the top layer of their protocol. They do this by helping to develop and extend their NCS.

5.3.2 Most network suppliers have an application layer already defined for their protocol. In that case, the user layer as specified in a SEMI SAN NCS is quite thin. In fact, it is just a simple mapping of SDM interface to messages and data (attributes) provided by the network. Thus, an NCS (one for each supported network) specifies a user layer that sits on top of the network supplier's protocol.

5.4 *Device Supplier View of the SAN Standard*

5.4.1 Device suppliers are not required to implement designs illustrated in the specific device model (SDM) specifications. The designs are presented using an object-modeling notation as a means to clearly specify the devices interface. An SDM provides a model of a device, it is not a design for the device. Device suppliers are not expected to provide an object-oriented implementation. However, in order to ensure that a device interface responds as expected, it is necessary for the device supplier to not only provide the support for the services and attributes specified, but to ensure that the code that is implemented on the device behaves as specified by the applications model for a specific device type.

5.5 *Equipment Supplier View of the SAN Standard*

5.5.1 The OEM's have the largest task in adopting the SAN standard. They have to implement applications that use the interfaces defined for the many devices that make up the typical equipment control system. They have to be familiar with the interfaces of a large number of the SDMs. On the other hand, they will become insulated from the inner workings of many devices, and from the code that they used to write to support those inner workings. In many cases, they may have to implement more than one Network Communication Standard.

5.5.2 During early adoption, OEM's may look to the SAN to act as a replacement for memory mapped discrete wired IO. With this type of adoption, the OEM will not lessen his burden of control code.

5.5.3 As Sensor Bus becomes more broadly adopted, OEM's may take advantage of the distributed processing capability offered by intelligent devices to reduce the complexity of their control software.

5.6 *The SAN Standard Structure*

5.6.1 A SAN employs devices from numerous suppliers. The SEMI SAN standard provides a framework to ensure interoperability of these devices within a network. The standard enables device suppliers and equipment control system developers to achieve that end. The SAN standard comprises five specifications.

5.6.2 The first specification is this document, which is the root document and specifies the connection between the other documents of the standard. It also specifies the construction for each of the other documents.

5.6.3 The next specification is the Common Device Model Specification. Each device on the SAN must comply with this specification.

5.6.4 The third specification defines the templates for creating ballots for specific device models and additions to the NCS.

5.6.5 The fourth specification is Specific Device Models standard. These standards contain models for various types of sensors, actuators, and entities. For instance, a model of a mass flow controller, a manometer, and a thermocouple will be specified.

5.6.6 The fifth type of specification is the Network Communication Standards. Each network technology has its own standard as an ancillary specification to the SAN standard.

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