DRAFT FOR DEVELOPMENT

DD 238-7.1: 1996

Fieldbus —

Part 7: Fieldbus management —

Section 7.1: Specification for System management

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Foreword

This Part of DD 238 has been prepared by Technical Committee, AMT/7.

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This publication contains the following parts:

— *Part 1: Guide to system architecture;*
(Equivalent to FF-800 Revision 1.0[1)])

— *Part 2: Specification for 31.25 kbit/s — Physical layer profile;*
(Equivalent to FF-816 Revision 1.0[1)])

— *Part 3: Specification for Data link layer services subset;*
(Equivalent to FF-821 Revision 1.0[1)])

— *Part 4: Specification for Data link protocol;*
(Equivalent to FF-822 Revision 1.0[1)])

— *Part 5: Specification for Fieldbus access sublayer (Services and protocol);*
(Equivalent to FF-875 Revision 1.0[1)])

— *Part 6: Fieldbus Message Specification;*
(Equivalent to FF-870 Revision 1.0[1)])

— *Part 7: Fieldbus management*;

— *Section 7.1: Specification for System management;*
(Equivalent to FF-880 Revision 1.0[1)])

— *Section 7.2: Specification for Network management.*
(Equivalent to FF-801 Revision 1.0[1)])

This Draft for Development is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature because the subject matter is still under development requiring wider exposure. It should be applied on this provisional basis, so that information and experience of its practical application may be obtained.

A review of this Draft for Development will be carried out not later than 2 years after its publication. Notification of the start of the review period, with a request for the submission of comments from users of this Draft for Development, will be made in an announcement in the appropriate issue of *BSI Update*.

According to the replies received, the responsible BSI Committee will judge whether the Draft for Development can be converted into a British Standard or what other action should be taken.

Observations which it is felt should receive attention before the official call for comments will be welcomed.

These should be sent to the Secretary of BSI Technical Committee AMT/7 at BSI, 389 Chiswick High Road, London, W4 4AL, giving the document reference and clause number and proposing, where possible, an appropriate revision of the text.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to vi, pages 1 to 59 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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1 Scope

The purpose of this specification is to define the system management model and services in DD 238 systems. System management is used to coordinate the operation of the various devices in a distributed DD 238 system.

System management functions include node address assignment for devices, application clock synchronization, distributed application scheduling across the segment, and support for locating application tags. It provides the facilities which are needed to bring new devices on the segment to an operational state, and to control the overall system operation.

2 Overview

This document first describes the system management architecture. It then describes the interaction of system management with other components of the system architecture. The system management model and functions are described next, followed by a detailed specification of the services supported. The document concludes with the abstract syntax for the protocol data units and a formal definition of the System Management Information Base.

3 System Management Architecture

Figure 1 shows the relationship between system management and the other communication and application components of the architecture. System management uses FMS to remotely access management information within a device. System management also directly accesses the data link layer to carry out its other functions. These capabilities are provided at specific data link layer service access points (DLSAPs) bound to DLSAP addresses reserved in the data link layer specification for system management.

A single system management entity exists in each device for each data link segment connected to it. This entity consists of user applications and a System Management Kernel (SMK). The System Management Kernel provides a network-coordinated and synchronized set of functions. To enforce the coordination and synchronization of these functions across the network, a manager/agent model is used. In this model, the System Management Kernel in each device assumes the role of the agent and responds to instructions received from a system manager entity. The SMK protocol (SMKP), defined in this specification, is used for communications between managers and agents.

Information which is used to control system management operation is organized as objects stored in the System Management Information Base (SMIB). The SMIB is viewed from the network as belonging to the Management Virtual Field Device (VFD). This allows SMIB objects to be accessed using FMS application layer services such as read, write, etc. The Management VFD is shared with the Network Management Agent of the device, and thereby also provides access to NMA objects.

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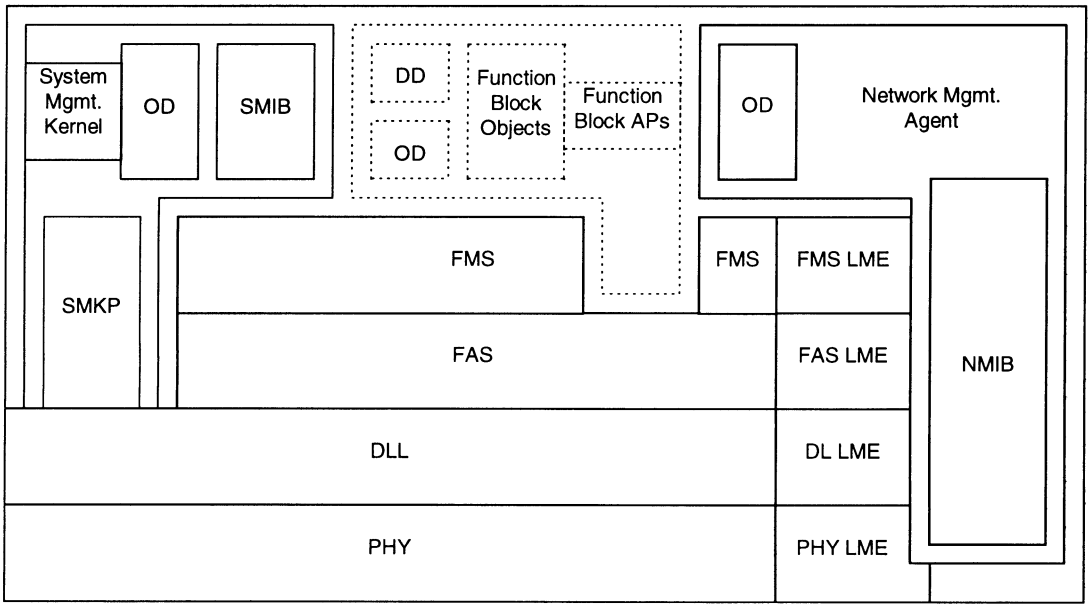


Figure 1 — General DD 238 Architecture

3.1 System Management Information Base

The System Management Kernel contains a System Management Information Base (SMIB) that contains critical configuration and operational parameters for a DD 238 system. Examples of objects included in the SMIB are:

— Device ID: This number is a unique identifier for each device. It is set by the manufacturer.

— Physical Device Tag: This tag is assigned by the user to designate a field device's role in the system.

— List of VFDs: A list which provides a reference and a name for each virtual field device supported.

— Time Object: An object containing the current application clock time and the parameters for its distribution.

— Schedule Object: It contains the scheduling information for coordination of distributed tasks (for example function blocks) which a user may include within this device.

— Configuration Mode/Status: This object contains status and control flags governing system management states.

3.2 System Management Interactions

To perform its functions, the System Management Kernel (SMK) interacts with both the communications system and the applications within a device. Figure 2 illustrates the architectural relationship that the SMK maintains to support these interactions.

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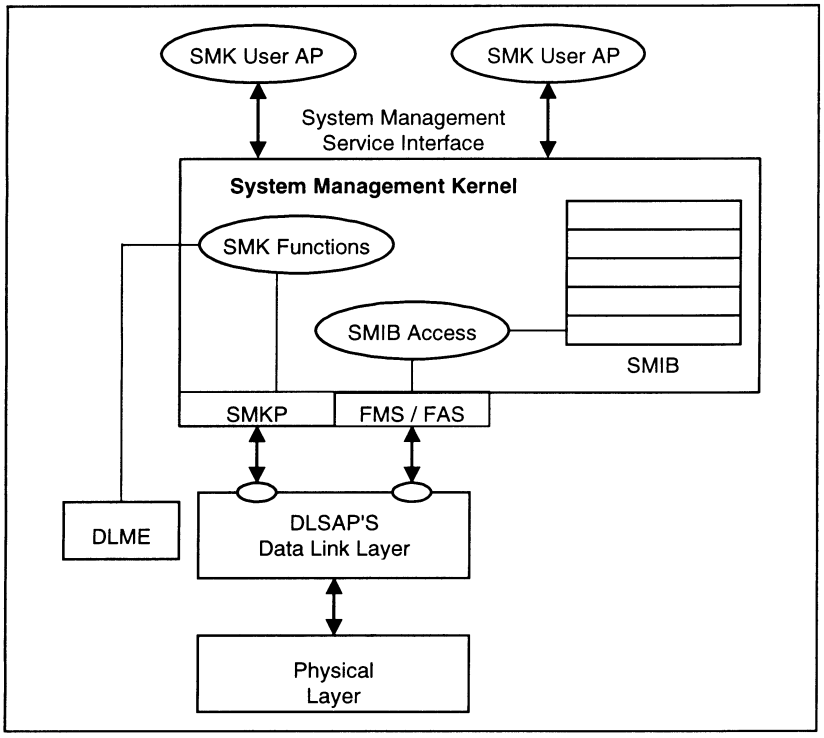


Figure 2 — Detail of System Management Architecture

3.2.1 *System Management Kernel/User Application Interactions*

System management supports node address assignment, scheduling of application services, application clock synchronization, and the resolution of addresses for application tags. SMK makes these functions available to user applications through the services listed below.

SET_PD_TAG

This service allows a local user application to interact with a remote SMK to set or clear the physical device tag of the remote device.

SET_ADDRESS

This service allows a local user application to interact with a remote SMK to assign the node address to the specified field device with the specified physical device tag, and ensures that basic SMIB information is initialized.

CLEAR_ADDRESS

This service allows a local user application to interact with a remote SMK to clear the assigned node address of the remote device.

SM_IDENTIFY

This service allows a local user application to interact with a remote SMK to request the device ID and physical device tag of the device at a specified address.

FIND_TAG_QUERY/FIND_TAG_REPLY

This service allows a local user application to interact with remote user applications to determine the addresses of application tags. The term “application tag” is used in this document to refer to function block tags, physical device tags, and VFD tags.

FB_START

This is an indication generated by the local System Management Kernel to tell a user application to start a function block. The indication contains the VFD reference and object index of the function block that needs to be executed.

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3.2.2 *System Management Kernel/FMS Interactions*

The SMK uses the capabilities of FMS to provide access to the SMIB in addition to using certain data link layer services. The SMK within a device is modeled as a VFD that is shared with the Network Management Agent of the device. SMIB objects are accessed using application layer services over the Management Virtual Communication Relationship (VCR). Details of the applicable service interface are given in the FMS specification. The standard Management VCR used for FMS access to system management (and the Network Management Agent) is defined in section 6 of this document.

3.2.3 *System Management Kernel/LME Interactions*

System management must interact with the data link management entity (DLME) during address assignment. The interface between SM and DLME is a local issue.

3.2.4 *System Management Kernel/Data Link Layer Interactions*

The System Management Kernel encodes communications to remote SMKs using the system management protocol (SMKP). These communications use two standard data link addresses at each device. One is an individual address that uniquely addresses the SMK in a particular device, and the other is a link local group address to communicate with the SMKs of all the devices on a link. The SMKP uses the connectionless-mode data link service, DL-Unitdata. The SMK uses the DL-time service to support application clock synchronization and function block scheduling.

4 System Management Model

In order to perform its functions, a system management entity in one device must cooperate with one or more system management entities in other devices on the DD 238 network.

The system management model provides a framework to accomplish this. It describes the operation of each of the system management functions, and the interaction between user applications and the System Management Kernel, between system management managers and agents, and between the System Management Kernel and the communication stack.

Most of the functions that system management provides are optional. A function does not have to be implemented if the application does not require it. In most cases, requester and responder roles are specified by the model. A particular device may support one or both of these roles for each of its functions.

Rules govern the execution of the models with respect to the order in which the services used by it may be invoked. These rules define system management states. In addition, there are restrictions on the simultaneous use of some of these services by agents. These restrictions are enforced by well-defined state behavior by system management agents.

System management objects are stored in a System Management Information Base (SMIB), which is modeled as an FMS Virtual Field Device (VFD). The definition of the objects are fixed, and are described in the FMS Object Dictionary (OD) for the VFD. FMS provides services to allow remote applications access to information stored in the SMIB for diagnostics and configuration.

FMS access for the SMIB supports the remote diagnosis of the device's system management behavior. A Virtual Communication Relationship (VCR) entry in the device's Virtual Communication Relationship List is exclusively reserved for the purpose of controlling the System Management Kernel. Only one device may use this VCR at a given time, and it can only be used in the SM_OPERATIONAL system management state described later. This avoids consistency problems between devices writing to the SMIB (other VCRs may be used for monitoring purposes only). Some of the objects in the SMIB are write protected, and may only be changed by the local SMK. They may also change as the result of local time events and requests received from remote SMKs via the SMKP, particularly when the local SMK is not in the SM_OPERATIONAL state.

The organization of the VFD is defined in Section 8. The object types and attributes of the system management objects are fixed. Special data types or data type structures have been reserved for some of the variables. The location of the objects in the SMIB are listed in a directory object, found at the beginning of the static entries in the VFD object dictionary. Additional objects may be included for configuration and diagnostic purposes. These objects must not conflict with the objects defined in this specification.

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4.1 System Management Functions

This section shows the grouping of system management functions within a device and describes them briefly.

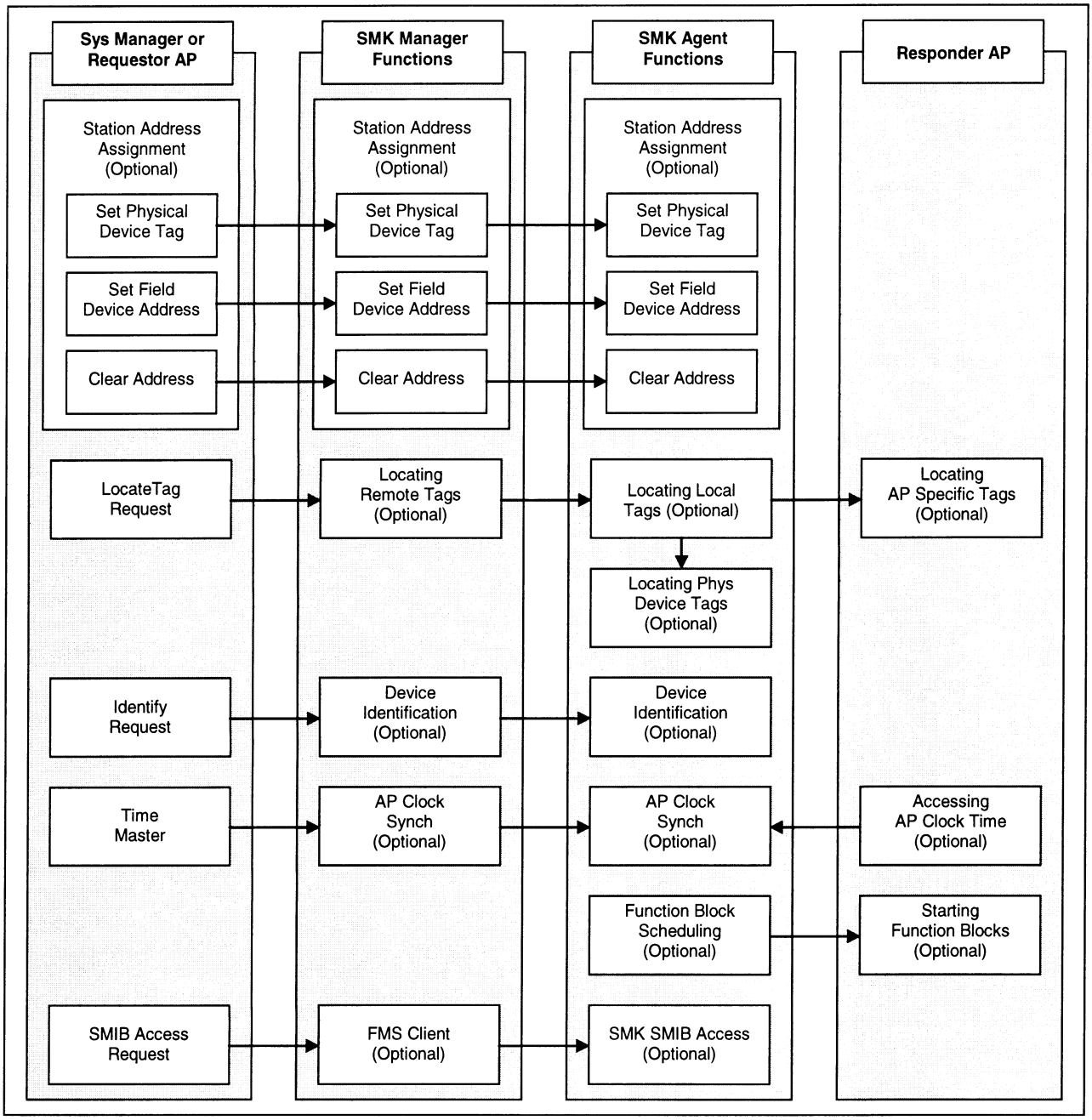


Figure 3 — Organization of System Management Functions

Field Device Address Assignment

The field device address assignment function ensures that field devices on a DD 238 network receive a unique node address. This process takes a field device through several states. The uninitialized device is first given a physical device tag off-line, which takes it to the initialized state. When a device is in this state it does not have an assigned node address, but may be attached to the network. Once on the network, a configuration device will detect the new device and assign a node address based on its physical device tag.

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Field device address assignment consists of a sequence of steps that are monitored by a timer to allow system management agents time to carry out their actions and respond to the manager. In the case of errors, an agent must return to the state in effect when the operation was started. It must also reject requests which are incompatible with its current state.

Locating Application Tags

DD 238 system management provides a function that allows a user application to query the devices on the network to locate an object identified by a tag. The device that contains the object returns a response that includes the object dictionary index and a list of Virtual Communication Relationships (VCR) for the object. Objects that can be identified by tags are physical devices (PD), Virtual Field Devices (VFD), function blocks (FB), and function block parameters. In addition, user applications are permitted to associate tags with other application specific objects as necessary. This function permits requesting user applications to determine if duplicate tags exist within a DD 238 system. When function blocks are supported without this function, VCRs between input and output parameters are pre-configured.

Application Clock Synchronization

The SMK provides a mechanism for the synchronization of application clocks in the network. This function is accomplished by using a time publisher SMK to distribute the correlation between the application clock time and the link scheduling time (LS-time) maintained by the data link layer. The distribution is made on a regular and configurable basis to the SMKs on the link. Redundant time publishers are supported, with protocol rules to resolve conflicts in determining which should be the active time publisher.

Application clock time is not used by the SMK to support any of its functions. Each device may support the application clock as a separate clock running independently of the DD 238 data link clock, or the application clock time can be calculated as needed from the data link clock.

Function Block Scheduling

The optional Function Block Scheduling function of an agent SMK uses a function block schedule stored in its SMIB to indicate to its external user applications that they are to execute their function blocks (or other schedulable application tasks).

This schedule is based on the repetitive execution of function blocks, referred to as a macrocycle. The start of the macrocycle, relative to LS-time maintained by the data link layer, is specified as the LS-time whose modulus, with respect to the macrocycle duration, is zero. The schedule specifies the start time of function blocks as the offset from the beginning of each macrocycle. With this information and the current LS-time, SMKs can determine when to issue an indication to a user application that it is time to execute a function block.

The function block schedule is coordinated with the schedule used by the Link Active Scheduler. This allows synchronization between the execution of function blocks with the transfer of their inputs and outputs. The coordination of these is beyond the scope of this specification.

Device Identification

This function allows devices attached to a DD 238 network to be identified by their physical device tag and device ID.

SMIB Access

FMS services can be used to access the SMIB for diagnostic and configuration purposes.

4.2 System Management Process

The system management process used to bring a device to an operational state on a DD 238 network is composed of a series of ordered steps. Each step involves the use of one or more system management functions. Not all of the steps that will be described are mandatory, since devices may achieve the same results through pre-configuration.

The process involves communication initialization, communication configuration, application configuration and operation. In addition, diagnostics and statistics functions can be initiated at various steps in the process. Crucial to this process is the assignment of a node address to the device.

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4.2.1 *Device Classes and Address Assignment*

Three classes of devices exist relative to address assignment. These are the field device, temporary device, and the master configuration device. The states through which a device passes when powered-up and the actions that it performs depend on its class and its system management functions, and on the system management functions in use on the network. The following descriptions assume that all functions are used, including address assignment and function block scheduling.

A *field device* joins the network passively by selecting a Data Link Layer defined default address and waiting for the Link Active Scheduler to bring it into the network. This procedure is done to avoid conflicts with operational devices, and is described later in more detail. It then waits for a Data Link Layer node address to be assigned to its SMK by either a master configuration device or a temporary device (for off-line configuration).

After receiving its assigned address, the SMK provides it to its Data Link Layer Management Entity (DLME) through an implementation dependent interface. The DLME applies the assigned node address, and this becomes the node address used by the Data Link Entity.

A *temporary device* can be used either on an operational network or off-line to configure a field device. It must first listen to the network to determine which situation exists. It then selects a visitor address defined by the Data Link Layer and either assumes control of the network or waits for the Link Active Scheduler to bring it into the network. The temporary device remains at this visitor address while it is connected to the network, and is not moved to an assigned address.

A *master configuration device* knows the node address for all devices on a given link. When joining the network it uses its own pre-configured node address, and becomes responsible for assigning addresses to field devices. If more than one master configuration device exists, each must have the same network configuration information. This condition is not checked by system management.

4.2.2 *SMK States*

A specific field device has no knowledge of the series of steps that is being executed to configure a network. However the SMK in a field device does maintain knowledge of the degree of completeness of its configuration so that it may determine what services it can provide. This is represented by the state of the SMK. In the most general case, the SMK in a field device goes through three major states before it can fully function on the network.

These states, and the system management services for the manager and agent roles that are enabled during the states are summarized in Table 1.

Table 1 — SMK Services Provided by State and Role

SMK Role	SMK States		
	UNINITIALIZED	INITIALIZED	SM_OPERATIONAL
Agent	SM_IDENTIFY SET_PD_TAG(Clear=False)	SM_IDENTIFY SET_ADDRESS SET_PD_TAG(Clear=True)	SM_IDENTIFY CLEAR_ADDRESS FIND_TAG_QUERY FIND_TAG_REPLY FB_START SMIB Access
Manager	None	None	All

UNINITIALIZED

In this state a device has neither a physical device tag nor a node address assigned by a master configuration device. During this state the only access to the device is through system management. The only system management functions permissible are those for identifying the device and for configuring the device with a physical device tag.

INITIALIZED

In this state a device has a valid physical device tag, but it has not been assigned a node address. It is ready to be attached to the network at the default system management node address. No services other than system management services are available during this state. The only system management services available are those for assigning a node address, clearing the physical device tag, and identifying the device.

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SM_OPERATIONAL

In this state a device has both a physical device tag and an assigned node address. Upon entering this state, the network management agent of the device starts the application layer protocols, allowing applications to communicate across the network. Further network management configuration and application configuration may be necessary in order for the device to become fully operational.

SMK performs its application clock synchronization function only in the SM_OPERATIONAL state. Also, FMS access to the SMIB is allowed only in this state.

NOTE All normal communication functions can be accessed on the bench by creating a minimal network consisting of, for example, a hand-held terminal and a field device.

4.3 System Management Information Base

Only one System Management Information Base (SMIB) exists per System Management Kernel. It is modeled as a virtual field device (VFD) containing all system management objects. This VFD is shared with the Network Management Agent of the device. The SMIB objects contained in it are defined in Section 8. The VFD definition shows which objects are accessible through which services.

The SMIB objects in the Management VFD are organized into four groups. In addition to the objects in these groups, profiles and manufacturers may define additional objects. The four groups are:

Physical Device Objects

Examples of these are the device identification and the physical device tag.

Virtual Field Device List

This list contains a VFD reference and name (VFD tag) for each virtual field device contained within the physical device. The reference to the Management VFD is included in this list.

Application Clock Synchronization

This holds parameters associated with the distribution and maintenance of application clock time, including the current time.

Scheduling Objects

Scheduling objects are used by the Function Block Scheduling function. Their parameters are necessary to synchronize distributed applications with the network traffic schedule enforced by the Link Active Scheduler.

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4.4 System Management Constraints

4.4.1 *Scope of Names and Tags*

The DD 238 supports a naming hierarchy for applications and their components. Application names are called tags. Tags and applications have corresponding representations in the communications stack. The relationship between application names and communication names, and the scoping rules applied to them are described in the next paragraphs. These various relationships are summarized below in Figure 4.

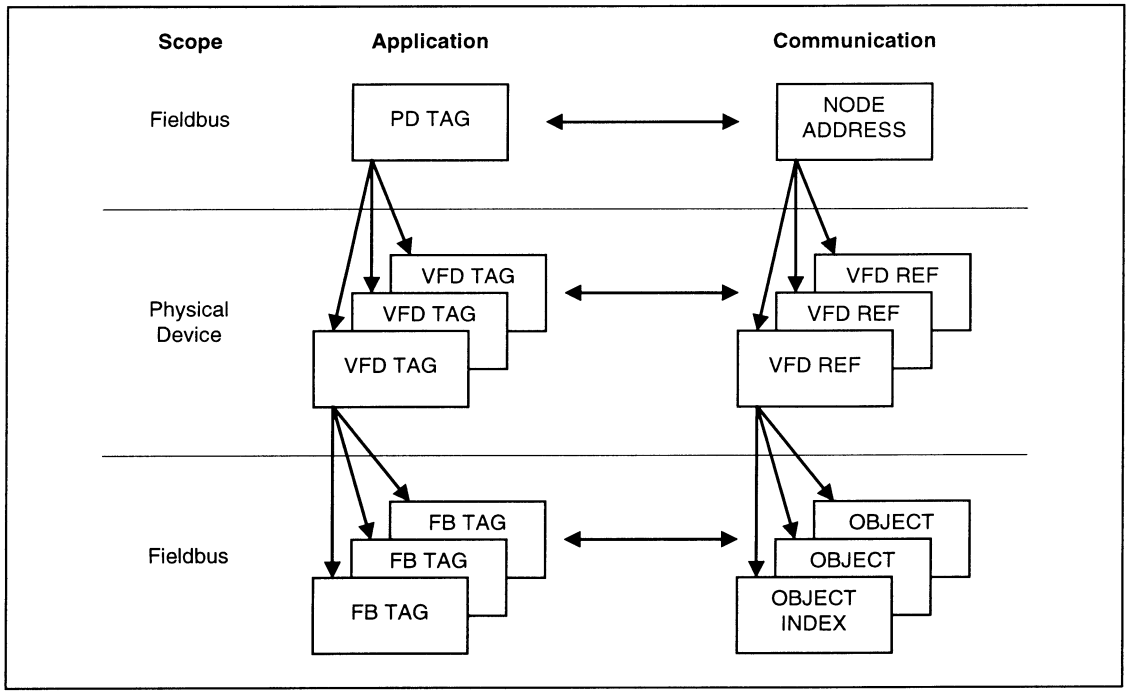


Figure 4 — Tag Definitions and Scope

Physical Device Tag

A physical device tag is a user assigned name that identifies a physical device. System management procedures allow a relationship to be established between a physical device tag and the node address, e.g. “TIC-101” is at node address 23.

A physical device tag must be unique across the DD 238 network. System management provides a mechanism to guarantee this only on each link.

Virtual Field Device Tag

Each physical device may contain one or more virtual field devices. For example, a multiplexor can be treated as a collection of virtual field devices, each handling one channel of information. Each such entity is named by a virtual field device tag.

Each virtual field device tag is unique within a physical device. Its scope is that of the physical device.

Function Block Tags

A function block tag is a user assigned name for an object or a collection of objects within a virtual field device. Its value may be the same as the physical device and virtual field device tags.

A function block tag must be unique across the DD 238 network. System management does not provide a mechanism to guarantee this.

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4.4.2 *Address Ranges*

Addresses used by system management are DLSAP-addresses as defined by the Data Link Layer Specification. They are used by the Data Link Layer Protocol to unambiguously locate the senders and receivers of Data Link Layer protocol data units. The following addresses are used by system management:

— Visitor Addresses

— Default Addresses

— Assigned Addresses

— Individual SM Entity Addresses

— Group SM Entity Addresses

Refer to the data link layer specification for the range and format of these addresses. The following paragraphs describe how these addresses are used by system management.

Visitor Addresses

Visitor addresses are node addresses reserved for use by devices that are not normally continuously present on the network. They are used in DD 238 networks by temporary devices such as hand-held terminals, configuration tools or diagnostic equipment. The values for the range of visitor addresses are defined and reserved by the Data Link Layer Specification.

Default Addresses

Default addresses are non-visitor node addresses reserved for DLEs waiting for node address assignment. They are used by field devices that are in the uninitialized or initialized state and thus have not been assigned an address by the master configuration device. The default address range is defined and reserved by the Data Link Layer Specification.

Assigned Addresses

Except for temporary devices, each device on a network must have an assigned node address before its communication stack can become operational. The node address is a Data Link Layer address that uniquely identifies the device on the network for the purpose of sending messages to it.

SMK Individual Addresses

The SMK individual address is a combination of the node address assigned to the device containing the SMK, and the DLSAP-selector specified in the Data Link Layer Specification as “the DLSAP-address for the node’s SMAE”. This DLSAP-address is the unique Data Link Layer address of an SMK, which is referred to in the Data Link Layer Specification as a Systems-management-application-entity (SMAE).

Group SMK Addresses

Group SMK addresses are used to multicast messages to a set of SMKs on the network. In particular, the application clock synchronization protocol requires the addressing of all system management entities on the local data link segment. The Data Link Layer Specification reserves an address for this purpose, specified as “the SMAEs of all DLEs on the link”. In addition, other group SMK addresses, reserved by communications profile, can be configured to support the function of locating application tags.

5 System Management Services and Procedures

This section describes the services and protocol sequences of system management in detail. The service model, service primitives, and time-sequence diagrams of this section are abstract descriptions of SM functions; they do not represent a specification for implementation.

5.1 General Features

This section describes some general functions and features used by all components of the system management protocol.

5.1.1 *Local Reset*

System management protocols require the SMK of a device to assume a valid state when the device is powered up or manually reset. The state that the device assumes depends on the pre-configuration that the device supports. Other factors, such as the cause of the reset or the amount of time that power was lost, may influence this state. This section in particular will address the situation when power is restored to a device that was previously operational on a DD 238 network.

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One possibility is for the SMK of the device to come up in the INITIALIZED state, in which the physical device tag is preserved, but not the assigned node address. This ensures that a device will not interfere with other operational devices when it is moved to another link, or if the link is reconfigured while the device is down. A master configuration device can detect the presence of the device and assign it a node address. During node address assignment, certain system management parameters are also downloaded.

If node address assignment is not being supported on the link, or if it is desired to avoid the time required to perform this procedure following a power outage, the SMK of the device may assume the SM_OPERATIONAL state when power is restored. However, it must retain, in addition to its node address, the other parameters that are normally set during node address assignment. In other words, it must come up with the same configuration that it would have if the node address assignment procedure were performed.

If a device has reached the SM_OPERATIONAL state, a boolean variable in the SMIB, OPERATIONAL_POWERUP controls which state the System Management Kernel will enter after power-up. If OPERATIONAL_POWERUP is true, the SMK will enter the SM_OPERATIONAL state on power-up. If the variable is false, SMK will enter the INITIALIZED state. Whether this variable is configurable or not is implementation dependent.

No system management services are defined to remotely reset a device. If address assignment is supported, then the services SET_PD_TAG and CLEAR_ADDRESS can be used to reset the SMK state.

5.1.2 *System Management Timers*

System management services use several timers during their execution. The first, called T1, is an intersequence timer. Its purpose is to ensure that devices responding to system management requests have sufficient time to carry out necessary actions and transmit a response. Other timers are described in the sections dealing with the services that use them.

5.1.3 *System Management Function Execution*

Agent SMKs execute their functions one at a time, completing the first before beginning the next, except for the application clock synchronization, function block scheduling, and application tag location functions. These functions can be executed in parallel with each other and other system management functions. Failure to complete a function, or errors in function execution always results in the agent SMK returning to where it was when it began the execution of the function. Responses received to a request after it's completion should be ignored.

A request is matched by the manager to its responses by the use of a unique identifier (ID) that is sent in the request. For the requests generated when performing the SET_ADDRESS, SET_PD_TAG, SM_IDENTIFY and CLEAR_ADDRESS services, the Invoke ID is generated by the System Management Kernel. For the FIND_TAG_QUERY and FIND_TAG_REPLY services, the Query ID is supplied by the user application.

5.1.4 *Conventions for Sequence Diagrams*

The following abbreviations and notation are used in the sequence charts and specifications:

cnf(+)	positive response, Result(+)
cnf(–)	negative response, Result(–)
[...]	PDU (Protocol Data Unit)
→	Direction of service primitives and PDUs
←	
:	Elapse of an interval of time
:	
“	Action
{...}	Parameters/parameter values of a service primitive.
Link. Node Address	Hierarchical Data Link Layer address identifying the data link segment and the device(node) on the segment.
Link.Node.DLSAP	Full DL-Address.
Active_Time_Publisher_SMK Node.DLSAP	Node Address and DLSAP Selector of the SMK for the currently active Time Publisher. The Active Time Publisher may be the Primary or one of the Secondary Time Publishers.

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Secondary_Time_Publisher_SMK Node.DLSAP	Node Address and DLSAP Selector of the SMK for an inactive Time Publisher.
Secondary_Time_Publisher_1 Node.DLSAP	Node Address and DLSAP Selector of the SMK for an inactive Time Publisher designated Time Publisher 1.
Secondary_Time_Publisher_2 Node.DLSAP	Node Address and DLSAP Selector of the SMK for an inactive Time Publisher designated Time Publisher 2.
SMK Link Local Group DLSAP	Group DLSAP for all SMKs on a single data link segment.

In the sequence charts, the System Management Kernel and SMK protocol are shown as one entity entitled “SM”.

5.2 Address Assignment

Node address assignment procedures enable field devices to be added to a network in a manner that safeguards the operation of the devices already running. Node addresses are assigned to field devices by a master configuration device when attached to the operational network, rather than setting the address of the field device before attaching it to the network. To be effective, the address assignment option needs to be specified by communication profile to ensure that all field devices on a link support it.

Node address assignment uses the physical device tag assigned to the device while its SMK is in the UNINITIALIZED state. The value of this tag is assigned by the user. Physical device tag assignment may be done off-line, on a network consisting only of the field device and a configuration device. This ensures that the physical device tag is being assigned to the correct device. However, this assignment can be done on-line, provided the device ID is either known in advance or allows differentiation of the uninitialized devices on the link. Once the physical device tag has been assigned, the SMK moves to the INITIALIZED state. After it has been assigned an address by a master configuration device, it transitions to the SM_OPERATIONAL state. Figure 5 shows the state diagram for address assignment.

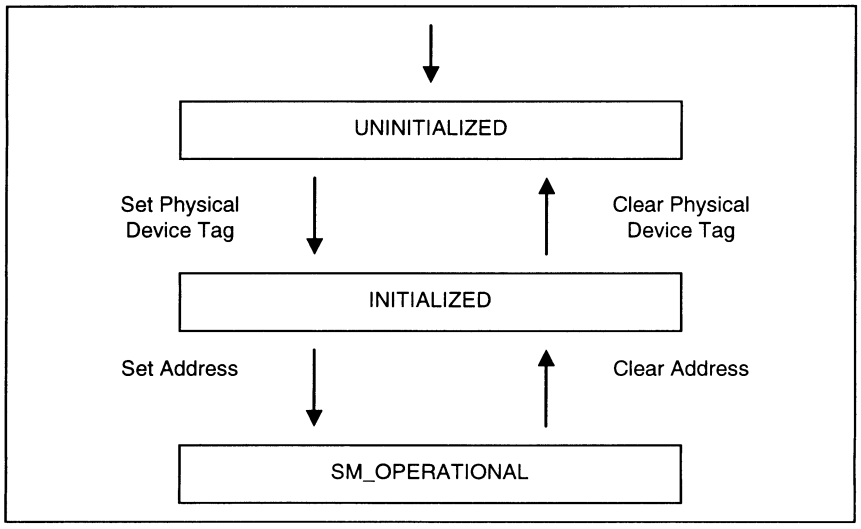


Figure 5 — State Diagram for Address Assignment

The following is a brief description of the data link layer activity, and data link layer management behavior, that takes place when a field device is added to a link, either on-line or off-line (in the off-line case, the configuration device acts as the Link Active Scheduler). When attached, a field device in either the INITIALIZED or UNINITIALIZED state selects one of the default addresses. It waits for a PN-DLPDU from the Link Active Scheduler (LAS) to this address, and responds with a PR-DLPDU containing a unique identifier. The LAS will echo this identifier back to the device in a DT-DLPDU to inform the device that it is adding it to the LAS Live List. The PN-DLPDU mentioned above contains the network parameters needed to communicate properly.

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The device is then ready to either have its physical device tag configured or to be assigned a node address. In either case, the device on the link which is acting as the address assignment manager can detect the presence of the new device in the Live List maintained by the LAS. If necessary, the current physical device tag and unique device identification of the new device can be obtained using the SM_IDENTIFY service. This information allows the manager to use the other system management services — SET_PD_TAG, SET_ADDRESS, and CLEAR_ADDRESS.

The system management address assignment procedure is only used for field devices, not for devices such as hand-held terminals which are randomly connected to the network for short periods of time. These temporary devices must also be capable of selecting an address when the network is not functioning by using the following procedure. A temporary device first listens to determine if there is any network traffic. If there is no traffic, it selects a visitor address and joins the network as the LAS. Otherwise, the device selects a visitor address and awaits a PN-DLPDU in the same fashion as a field device. However, the temporary device remains at this address while it is connected to the network, and is not moved to an assigned address.

Master configuration devices and field devices in the SM_OPERATIONAL state know their address, and when attached to a network they listen for a PN DLPDU from the LAS directed to this address. Additionally, if the device is a Link Master, it first listens to determine if there is any network traffic. If not, it assumes the role of the LAS.

If the address assignment option is selected for the devices on a link, at least one device must support the address assignment manager role. This can be any device supporting this role for off-line operation, and must be a master configuration device for on-line operation. If address assignment is not selected, a field device must have both a unique node address and physical device tag. If there are other system management options supported, additional basic parameters may need to be pre-configured before these features can be used. For example, Application Clock Synchronization needs the difference between the update intervals. The configuration of a device to be added must be consistent with those already on-line to avoid disruption of the network. The objects used for address assignment are described below.

5.2.1 *Address Assignment for Field Devices*

5.2.1.1 *Physical Device Tag Assignment*

Physical device tag assignment is carried out with a hand-held terminal or some other temporary configuration device connected directly to the field device to be configured. The configuration device can determine the address of the field device by monitoring the Live List maintained by the LAS. The device identification can then be obtained using the SM_IDENTIFY service.

5.2.1.1.1 *Objects*

PD_TAG

The user must ensure that each field device on the network has a unique physical device tag. It identifies the device for the purposes of system configuration and node address assignment. If one device is replaced by another, the replacement should be assigned the physical device tag of the original device. This is done using the SET_PD_TAG service. The physical device tag is stored in the object PD_TAG, and its value can be determined remotely by using the SM_IDENTIFY service.

If the device is in the UNINITIALIZED state, PD_TAG contains a blank tag. This is a tag with all characters being spaces.

If the node address is pre-configured, PD_TAG must also be assigned a unique value.

DEV_ID

This object holds the device identification for this device. A unique value is assigned to each individual device by the manufacturer, and is never changed. It is a hierarchical value which designates the manufacturer, model, revision, and a serial number. Since it is unique, it is used to guarantee during physical device tag and node address assignment that only one device will take action upon receiving the set message. The SM_IDENTIFY service can be used to determine the value remotely.

5.2.1.1.2 *SET_PD_TAG Service*

This confirmed system management service is used by a user application to install or clear the physical device tag maintained in the SMIB of the remote device located at the specified node address. To ensure that the physical device tag is being set in the right field device, this may be done on a network consisting only of the field device and a configuration device. This is referred to as off-line. For additional security, the service uses the device identification to avoid assigning the tag to another device which happens to be on the network (the service will fail).

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