

ACR-NEMA STANDARDS PUBLICATION/ NO. 300-1985

NEC

Digital Imaging and Communications



NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION



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FOREWORD

With the introduction of computed tomography (CT) followed by other digital diagnostic imaging modalities in the 1970's, and the increasing use of computers in clinical applications, the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) recognized the emerging need for a standard method for transferring images and associated information between devices manufactured by various vendors. These devices produce a variety of digital image formats. With a standard for data exchange, it becomes possible to connect a system of such devices to other sources of hospital information, which might include clinical labs, medical records, and various financial and management systems. Such a system could facilitate efficient management and operation of a diagnostic imaging department.

In the preparation of this Standards Publication, input of users and other interested parties has been sought and evaluated. Inquiries, comments and proposed or recommended revisions should be submitted to the Diagnostic Imaging and Therapy Systems Division by contacting:

Manager, Engineering Department
National Electrical Manufacturers Association
2101 L Street, N.W.
Washington, D.C. 20037

SCOPE

This Standards Publication specifies a minimum set of necessary attributes for an imaging device interface to communicate successfully with other devices that also meet the specifications of this Standards Publication. The Standards Publication is not intended to be an overall picture archiving and communications system (PACS) or workstation specification, nor an archive or magnetic tape transfer standard, nor a network standard. Imaging devices include CT scanners, MR imaging systems, nuclear cameras, ultrasound systems, and x-ray film digitizers.

HISTORY

PURPOSE

The American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) formed a joint committee to develop a standard that should:

- 1) promote communication of digital image information, regardless of source format or device manufacturer;
- 2) facilitate the development and expansion of picture archiving and communication systems (PACS) that can also interface with other systems of hospital information; and
- 3) allow the creation of diagnostic information data bases that can be interrogated by a wide variety of devices distributed geographically.

This Standards Publication (hereinafter called the ACR-NEMA Standard) specifies the hardware interface, a minimum set of software commands, and a consistent set of data formats for communication across an interface between an imaging device and a network interface unit or another imaging device. Figure 1-1 depicts a typical PACS network configuration and the location of the ACR-NEMA Standard interface. Figure 1-2 depicts the use of the ACR-NEMA Standard interface without a network to connect an imaging device with a supporting device, such as a workstation or printer.

The ACR-NEMA Standard should help to assure that a hospital or imaging center can add new equipment that may communicate with existing equipment or systems meeting this standard.

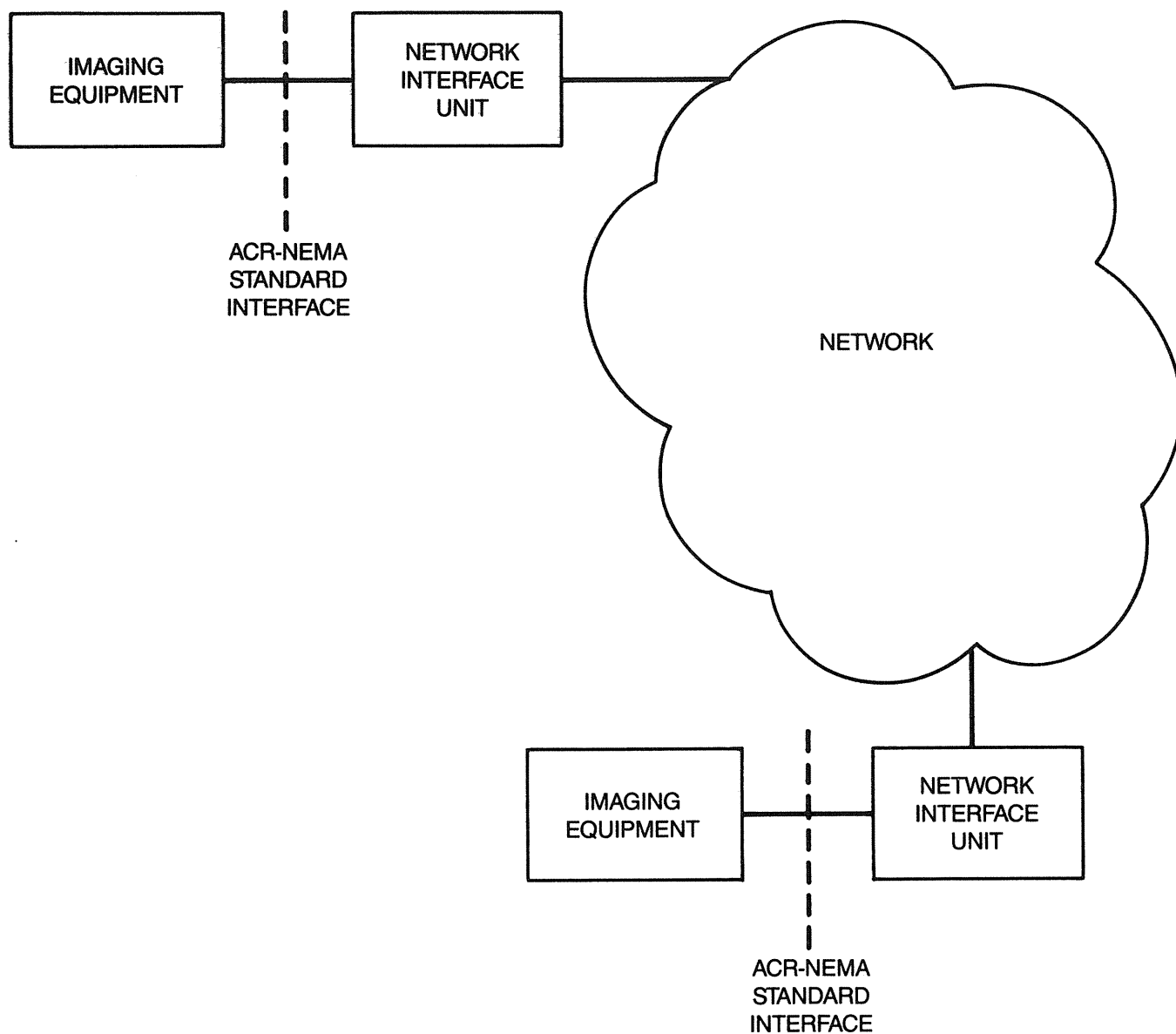


Figure 1-1
LOCATION OF ACR-NEMA STANDARD INTERFACE
WITH A NETWORK

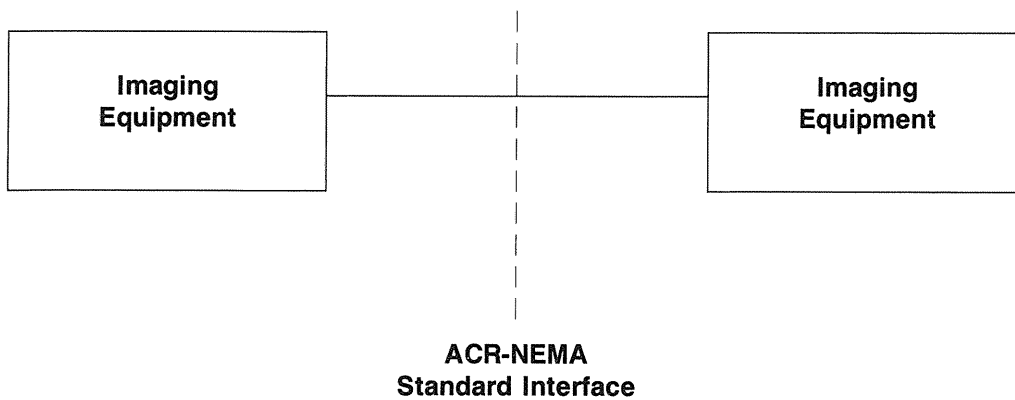


Figure 1-2
LOCATION OF ACR-NEMA STANDARD INTERFACE
WITHOUT A NETWORK

RATIONALE

The medical imaging community has expressed several needs. First, newly acquired data, whether from imaging modalities or other clinical sources, should be brought to central or distributed viewing or interpretation locations. Second, all clinically relevant information for a patient, such as historical images or laboratory data, should be accessible from these viewing locations. Third, image and data transfer should be accomplished without corruption. Fourth, information should be available at more than one location simultaneously. Fifth, addition of another piece of equipment to a communicating group of devices should be easily possible.

The ACR-NEMA Standard is created so that a group of devices, each of which meets this standard, may be organized into a system to meet the above user needs, a potential especially important in a multivendor environment.

VALIDATION

The ACR-NEMA Standard does not contain a validation procedure. A working group of the ACR-NEMA Standards Committee has been established to address this issue. It is recognized that a validation procedure would be very useful in demonstrating interoperability.

EVOLUTION OF THE ACR-NEMA STANDARD

It is anticipated that the ACR-NEMA Standard would be an evolving standard and that periodic enhancements should be forthcoming from the member organizations and input from users of the standard. A continuing requirement for these updates should be compatibility with the previous versions of the ACR-NEMA Standard. ACR and NEMA will continue to support the activities of the joint committee to clarify and update the ACR-NEMA Standard.

OVERVIEW OF THIS DOCUMENT

This document is organized in several sections. Section 1 provides referenced standards and definitions. Section 2 provides a technical review of the ACR-NEMA Standard, including a description of the relationship of the ACR-NEMA Standard to the ISO-OSI reference model. Section 3 describes the performance specifications around which the ACR-NEMA Standard was designed. Section 4 contains the design philosophy and explanatory details of the structure of a message. A detailed description of the specific data elements is in Section 10. Section 5 details the representation of images, text and other data. Section 6 provides definitions and explanatory details of the commands defined to permit transfer of images from one device to another. Section 7 describes design philosophy and details of the electrical signals and the physical layer protocol. Section 8 defines the data transfer protocols for establishing end-to-end connections and for exchanging messages. Section 9 gives examples of formats and protocols for sending and receiving messages. Section 10 contains the format data dictionary specifying the required and optional data elements for the messages.

The appendices provide examples of message exchange, further descriptions of the hierarchical grouping of images, and the coordinate system designation.

Each section provides explanatory information (Authorized Engineering Information) in addition to the requirements.

Section 1

REFERENCED STANDARDS AND DEFINITIONS

1.1 REFERENCED STANDARDS

The following publications are adopted, in whole or in part as indicated, by reference in this standards publication. Mailing address of each referenced organization is also provided.

American National Standards Institute
1430 Broadway
New York, New York 10018

ANSI X3.4-1977 *Codes for Information Interchange*
ANSI X3.9-1978 *FORTRAN*

Electronic Industries Association
2001 Eye Street, N.W.
Washington, D.C. 20026

EIA 485 *Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems*

Institute for Electrical and Electronic Engineers
345 East 47th Street
New York, New York 10017

IEEE 488 *Standard Digital Interface for Programmable Instrumentation*

International Organization for Standardization
1 Rue de Varembe
Geneva, Switzerland

ISO 7498-1983 *Information Processing Systems—Open Systems Interconnection—Basic Reference Model*

Prentice-Hall, Inc.
Englewood Cliffs, New Jersey

Andrew S. Tanenbaum, *Computer Networks*, 1981, p. 16.

1.2 DEFINITIONS

ASCII. American National Standard Code for Information Interchange.

Bit. A unit of information represented by either a zero or a one.

Byte. A group of eight (8) adjacent bits operated on as a unit.

Command Group. The group containing instructions

concerning the intended use of the data set.

Data Element. Individual segments of information.

Data Set. The collection of all groups in a message except the command group.

Double Word. Two adjacent words operated on as a unit.

Group. A collection of data elements which contain information of a similar nature.

Imaging Equipment (IE). A device which assembles and sends, or receives and disassembles ACR-NEMA messages.

Message. The entity of information transmitted across the interface consisting of one command group and one data set.

Network Interface Units (NIUs). Devices which operate in pairs to relay ACR-NEMA messages across an intervening data communications network.

Sink. A piece of imaging equipment which receives an

image across the interface.

Source. A piece of imaging equipment which transmits an image across the interface.

TTL. Transistor-transistor logic.

Twos Complement (2's complement). A true complement with a base of two.

Word. A sixteen (16) bit entity.

NEMA Standard 10-16-1985.

Section 2

TECHNICAL OVERVIEW OF THE STANDARD

2.1 INTRODUCTION

This section provides a brief introduction to the technical aspects of the ACR-NEMA Standard. The hardware and software specifications and protocols are summarized, and correspondences between the ACR-NEMA Standard with the International Standards Organization Open Systems Interconnection (ISO-OSI) reference model for networks is illustrated. There are differences in terminology as well as scope between the ACR-NEMA Standard and the ISO-OSI model.

Authorized Engineering Information 10-16-1985.

2.2 FUNCTIONAL DESCRIPTION

The ACR-NEMA Standard interface is intended to provide manufacturers of medical imaging equipment (including image sources, archive devices, and viewing systems) with a means by which data may be interchanged between these devices. For the benefit of the institutions using these devices, the ACR-NEMA Standard interface can support mixed-vendor system interconnections. The specification of the ACR-NEMA Standard interface includes both hardware definitions and software protocols and formats.

Authorized Engineering Information 10-16-1985.

2.2.1 Hardware

A complete description of the hardware and lower layer software protocols can be found in Sections 7 and 8 of this document. Hardware specifications include a connector and pinout assignment, cabling, timing and the electronic devices to support the interface signals. A 50 pin microtype connector should be specified. It can support 16 data circuits, one parity circuit, and six control circuits, which are all differential pair circuits. Circuit ground lines are also included.

In order to allow any device connected via the ACR-NEMA Standard interface to operate within its data rate capability and to function as a peer, the data exchange should be asynchronous and the cabling provide crossed control lines as illustrated in Section 7.

No minimum operating speed is specified, although an effective lower limit of two bytes/second exists because of interface timeout limits. The target rate should be 8 Megabytes per second. Any cable length is allowed. However, use of longer cable lengths may result in lower data rates. Data should be transferred in parallel as

sixteen-bit words with parity.

Authorized Engineering Information 10-16-1985.

2.2.2 Protocol Elements

The physical protocol, which handles control signal handshakes and interrupts, supports the transfer of data using the electrical lines of the interface. It is defined by a description, a state diagram, and a timing diagram in Section 7.

Data flow should be supported by the use of a frame protocol at the Data Link Layer. A packet protocol at the Transport/Network Layer supports virtual channels and conveys segments of a message across the interface. End-to-end message delivery should be supported by the Session Layer protocol. These protocols are defined in Section 8.

Messages should contain data and commands directing use of the data. The structure of messages is detailed in Section 4. The content of messages is discussed in Sections 5 and 10. The use of commands is detailed in Section 6. Figures 2-1 and 2-2 summarize the data transfer protocols.

The specifics of a protocol implementation in an IE are not detailed in the ACR-NEMA Standard. While the internal design details may differ from manufacturer to manufacturer, the protocol formats and sequences conveyed across an interface should be standardized to allow different implementations to communicate.

Authorized Engineering Information 10-16-1985.

2.2.3 Interface Location

The interface plane across which the data moves should be located between the imaging equipment (IE) and a second device, as shown in Figure 1-2. In more complex systems, the second device could be a network interface unit (NIU) to provide access to an interconnecting network, as shown in Figure 1-1. The ACR-NEMA Standard imposes no specifications on such external networks except those implied by the Session Layer connection service.

Authorized Engineering Information 10-16-1985.

2.3 COMPARISON WITH THE ISO-OSI MODEL

In the design of the ACR-NEMA Standard interface, an effort was made to adhere to the ISO-OSI reference model. This Open Systems Interconnect (OSI) model

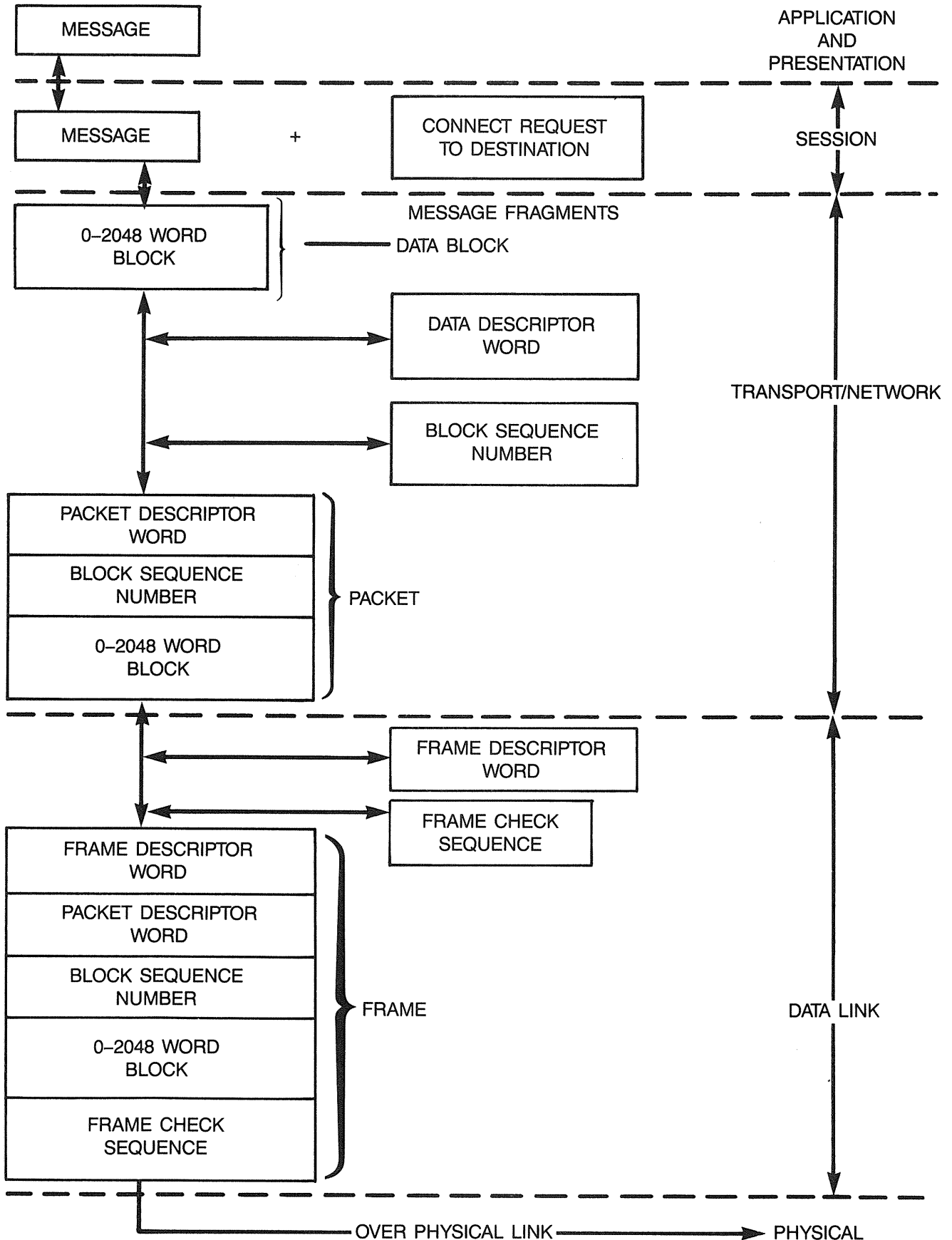


Figure 2-1
MESSAGE FRAGMENTATION

separates the functions of device-to-device communication into well-defined layers. Much as in other structured systems, each layer is self-contained, and the data which move into and out of these layers are defined. This allows software and/or hardware in any layer to be modified without necessarily altering other layers. Also, compatibility of different systems should be enhanced since the data requirements are known for each layer.

The idea of a layered structure should be particularly applicable to the ACR-NEMA Standard because the func-

tions of the layers are defined without specifying a particular implementation.

For reference, the ISO-OSI model is illustrated in Figure 2-3. The hierarchy starts at the Physical Layer and extends upward to the Application Layer. Data move both up and down through the layers, depending on whether the device supporting the layers is receiving or sending a message. For full explanations of the ISO-OSI model, refer to ISO 7498-1983.

Authorized Engineering Information 10-16-1985.

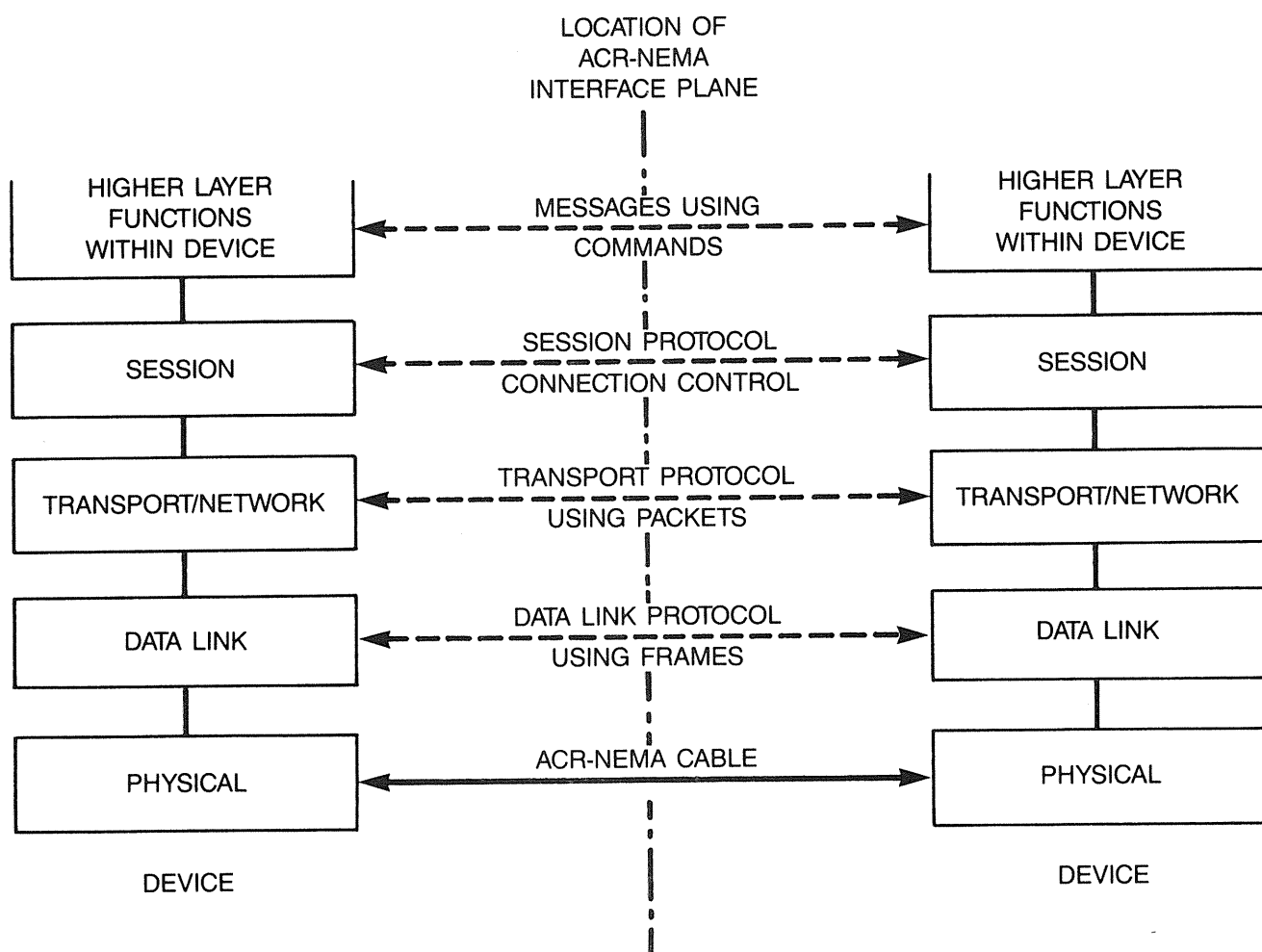


Figure 2-2
PROTOCOL LAYERS SUMMARY

2.3.1 Corresponding Layers

A correspondence between the ISO-OSI layers and those of the ACR-NEMA Standard is illustrated in Figure 2-4.

Authorized Engineering Information 10-16-1985.

2.3.1.1 PHYSICAL LAYER

This layer should be completely described by the hardware specifications and by interface access and word exchange protocols. It should define interlocked signal sequences to provide high speed data transmission across the interface and be used by the Data Link Layer to send data and to provide flow control and error detection.

Authorized Engineering Information 10-16-1985.

2.3.1.2 DATA LINK LAYER

The ACR-NEMA Data Link Layer corresponds to the ISO-OSI Data Link Layer. This layer should frame data from the Transport/Network Layer with control words and send it out via the Physical Layer. This should be accomplished through the protocol detailed in Section 8.2. During the receipt of data from the Physical Layer it should remove the framing words, check for transmission errors, and deliver the data to the Transport/Network Layer.

Authorized Engineering Information 10-16-1985.

2.3.1.3 TRANSPORT/NETWORK LAYER

In the ACR-NEMA Standard, functions similar to those found in the ISO-OSI Network Layer and Transport Layer are combined in a Transport/Network Layer. Because the ACR-NEMA Standard defines a point to point interface across a plane, a Network Layer, with all of its routing-control parts, should not be necessary. In the ACR-NEMA Standard, the fragmenting of the message into blocks (up to 2048 words), and the subsequent packetization (with added packet sequencing and description headers), should be performed at this Transport/Network Layer. Section 8.3 describes the protocol in further detail.

Authorized Engineering Information 10-16-1985.

2.3.1.4 SESSION LAYER

The Session Layer in the ISO-OSI model is an interface layer between application programs and the communication protocols. The ACR-NEMA Session Layer defines the protocol for establishing and breaking end to end connections to applications in another device.

Authorized Engineering Information 10-16-1985.

2.3.1.5 PRESENTATION AND APPLICATION LAYERS

The uppermost two layers, presentation and application, are addressed by the ACR-NEMA Standard at the level of the message format. Building the message (completing the groups and organizing them) should be a Presentation Layer function. Given the data entered at the equipment via Application Layer programs, the Presentation Layer should serve to reorganize the data into the groups and elements defined by the ACR-NEMA Standard. The ACR-NEMA Standard provides commands (see Section 6) to invoke certain operations which should require connection with a second device.

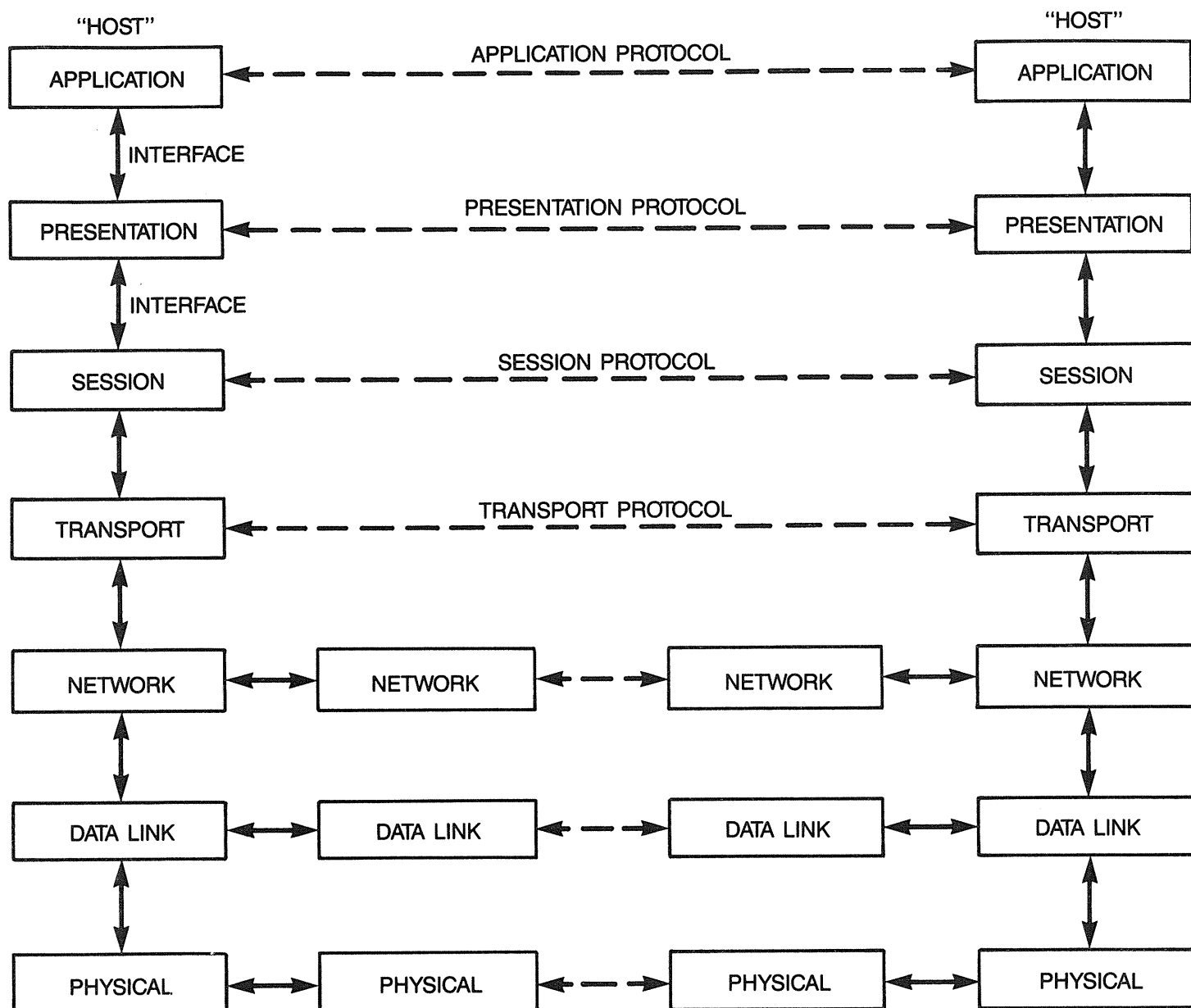
Authorized Engineering Information 10-16-1985.

2.4 SUMMARY OF PROTOCOL AND DATA STRUCTURES

Figure 2-1 illustrates the fragmenting of a message into data blocks and combining channel control words to make packets. The packets should be passed to the Data Link Layer where they should be combined with control words to make frames. The frames should be passed to the Physical Layer for transmission across the interface.

Figure 2-2 summarizes the protocol layers specified in this ACR-NEMA Standard and the peer to peer communications supported. The figure again emphasizes that the protocols define data exchange across a plane between two pieces of equipment which comply with this standard.

Authorized Engineering Information 10-16-1985.



Adapted from Andrew S. Tanenbaum, *Computer Networks*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1981, p. 16.

Figure 2-3
ISO-OSI MODEL

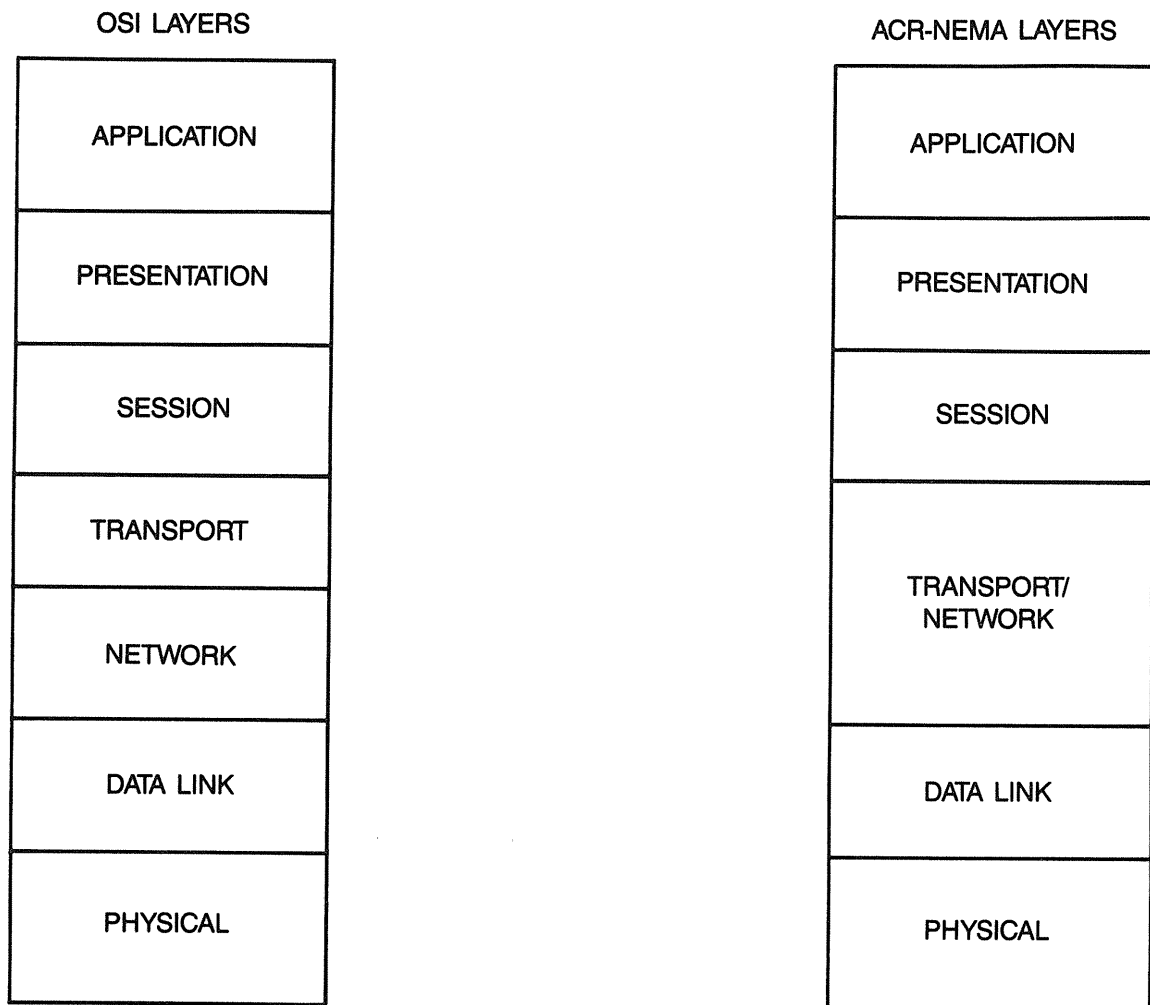


Figure 2-4
COMPARISON OF OSI LAYERS AND ACR-NEMA LAYERS

Section 3

PERFORMANCE SPECIFICATIONS

3.1 INTRODUCTION

This section discusses the performance requirements for compatibility with the ACR-NEMA Standard interface. The specific functions to be implemented in hardware and software are described in Sections 4 to 8 of this document.

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3.2 ERROR RATES

The sum of the individual error rates on the 17 parallel lines in the interface shall be no greater than 17×10^{-9} , prior to any correction. Error correction algorithms are not specified in the ACR-NEMA Standard.

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3.3 RATE OF DATA TRANSFER

The target data rate should be 8 Megabytes/second. The hardware interface may be capable of successfully operating at rates faster than the target rate. Asynchronous handshake protocols should be used, thereby permitting devices to successfully connect to this interface and operate at slower data rates.

A standard test for measuring actual data rate for a cable length of zero meters is defined in Appendix A.

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3.4 ENVIRONMENTAL SPECIFICATIONS

Environmental considerations should be left to the individual manufacturers.

Authorized Engineering Information 10-16-1985.

3.5 MINIMUM NECESSARY FUNCTIONS FOR COMPATIBILITY

To be ACR-NEMA compatible, a piece of imaging equipment has certain minimum functions which it utilizes the ACR-NEMA interface to perform. In the simplest cases, the imaging device may be either an image source or image sink; some devices may be both source and sink devices or neither (see Table 3-1 for examples).

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For every command, a response is defined. Any ACR-NEMA compatible device must recognize all commands, and must send a response. An acceptable command response has a status code indicating "refused." This negative response is required to inform the requestor that the target device is not equipped or is otherwise unable to respond to that command.

NEMA Standard 10-16-1985.

An ACR-NEMA device must support at least one channel which is then called channel 0. (See Section 8)

NEMA Standard 10-16-1985.

The physical interface presented on an ACR-NEMA compatible device must use the specified 50 pin microtype connector and associated signal levels and timing. Messages must include all required information as defined in Section 4.

NEMA Standard 10-16-1985.

Table 3-1
EXAMPLES OF SOURCE, SINK, AND SOURCE/SINK DEVICES *

DEVICE	IMAGE SOURCE	IMAGE SINK	IMAGE SOURCE/SINK	NEITHER
Film Digitizer	X			
Digital Radiography Unit	X			
Ultrasound System	X			
Densitometer	X			
Thermographic System	X			
Electrocardiograph	X			
Gamma Camera	X			
Multiformat Camera		X		
Printer		X		
Workstation		X	X	
Archive			X	
Management Terminal				X
CT Systems	X		X	
MR Systems	X		X	
PET Systems	X		X	
Digital Subtraction Angiographic System	X		X	

* The devices listed are felt to be representative of equipment found in many imaging departments; the list is not meant to be exhaustive. The designation as source or sink or both is based on the most common modes of operation, not on specialized ones. Management terminals are listed as an example of a non-image data device likely to be found in an imaging department.

Section 4

MESSAGE FORMAT

4.1 INTRODUCTION

In order for images to be interpreted, a minimum amount of information should be available with the images. This information can be divided into general categories of: identifying, patient, acquisition, relationship, image presentation, overlay and image pixel data.

The image or other data, its associated information, and its associated instructions should be contained within a message. This message should be organized into groups representing the general categories of information. Each group may be further subdivided into related data elements.

Within each group there may be data elements which are mandatory and optional. The mandatory items should provide data necessary to display an image and to interpret it. Optional data elements may be included to provide supplemental information.

Twenty-four (24) groups which have been defined are listed in Table 4-1 and they should adhere to the specifications in 4.3. Group 0000H, which gives information necessary for commands, is described in Section 6 and detailed in Section 10. Other groups, which may be associated with images or other information, are described in this and the following section, and detailed in Section 10. Some groups have been reserved for manufacturer or user specific information. All other groups are reserved for future expansion of the ACR-NEMA Standard.

Authorized Engineering Information 10-16-1985.

4.2 MESSAGE

Except for the DIALOG command, all information to be transmitted across the interface between two pieces of equipment shall be contained within an entity called a message. Messages shall be exchanged between devices to provide user or system functions or services. All messages shall consist of two parts: a command group and a data set (see 4.4).

NEMA Standard 10-16-1985.

4.3 GROUPS

Each message shall be organized in groups.

NEMA Standard 10-16-1985.

All groups shall be formatted in the same way.

NEMA Standard 10-16-1985.

Each group shall appear at most once within a message.
NEMA Standard 10-16-1985.

Groups shall appear in the resulting message in numeric order, with group 0000H first.
NEMA Standard 10-16-1985.

A group number is a word interpreted as an unsigned integer.
NEMA Standard 10-16-1985.

Every even numbered group shall be reserved for use in the ACR-NEMA Standard. Certain of these groups, standard groups, are defined and listed in Table 4-1.
NEMA Standard 10-16-1985.

All odd numbered groups shall be available for use by manufacturers or users, with the requirement only that group structure conventions as described in 4.5 must be followed.
NEMA Standard 10-16-1985.

The ACR-NEMA Standard does not contain a method to resolve any conflicts arising from such use.
Authorized Engineering Information 10-16-1985.

Odd numbered groups with a group number which is one greater than a standard group number are called shadow groups. These shadow groups shall be reserved for users and manufacturers to place data elements with information of the same category as that in the standard group. The use of certain data element numbers in these groups is restricted as described in 4.5. If a data element is defined as mandatory in a standard group, putting it in some form in a shadow group shall not eliminate the requirement for it to be present in the standard group.
NEMA Standard 10-16-1985.

It is expected that shadow groups should be used to transmit information omitted by the standard or to supplement data that is specified by the standard. The meanings of these elements may be made public. A continuing ACR-NEMA Committee may also choose to recommend elements to be included in these groups between revisions of the ACR-NEMA Standard.

Authorized Engineering Information 10-16-1985.

Group 0000H is defined as the command group, and contains information relating to the intended use of the data contained in the message.

NEMA Standard 10-16-1985.

Group 0001H is the shadow group of group 0000H.
Authorized Engineering Information 10-16-1985.

All other groups are defined as data groups and the data groups collectively are defined as the data set.

NEMA Standard 10-16-1985.

4.4 DATA SET TYPES

Various data set types should be defined by the groups they contain. For a given data set type, groups should be classified as either required, optional or not allowed. The classification of each group within the defined data set types is given by Table 4-2. See 4.8 for further description of groups in optional data sets.

Authorized Engineering Information 10-16-1985.

In addition to the data sets shown in Table 4-2, three additional data set types shall be defined by the standard. The shadow data sets of IMAGE, TEXT, and GRAPHICS shall be PRIVATE IMAGE, PRIVATE TEXT, and PRIVATE GRAPHICS. Classification of groups in these shadow data sets must be the same as for the standard data sets except that one or more of the required groups is a shadow (manufacturer or user specific) group and not present as the required group.

NEMA Standard 10-16-1985.

Any data set containing group 7FE0H is by definition a data set of type IMAGE; thus, group 7FE0H shall not be used in any other data set type.

NEMA Standard 10-16-1985.

Data sets of type TEXT shall always contain group 4000H.

NEMA Standard 10-16-1985.

Data sets of type GRAPHICS shall always contain at least one of the groups 6000H-601EH (even).

NEMA Standard 10-16-1985.

Data sets of type OTHER shall be used for data sets which cannot be classified as IMAGE, TEXT, or GRAPHICS.

NEMA Standard 10-16-1985.

IDENTIFIER is a special case of data sets of type

OTHER. If this data set type is used, then it shall be used as the type for the data groups associated with FIND_REQUEST, FIND_RESPONSE, GET_REQUEST, and MOVE_REQUEST.

NEMA Standard 10-16-1985.

A data set of type NULL is a special case of data set type OTHER which contains no groups. It shall be used when the command group (group 0000H) is the only group in the message.

NEMA Standard 10-16-1985.

4.5 DATA ELEMENTS

Each group is subdivided into data elements which contain individual segments of information. The components of the data element are contained in four fields: a group number; a data element number; a length; and a value. These components shall be present in the order stated. In the ACR-NEMA Standard, a specific data element within a specific group is referred to as element name (group number, data element number).

A data element number is a word interpreted as an unsigned integer.

A particular combination of group number and data element number shall appear at most once within a message.

Data element number 0000H of all groups shall be the first data element. Its value shall be the number of bytes expressed in binary from the end of its own value field to the beginning of the next group. All groups, whether standard, shadow, user, or manufacturer-specific, must have this element.

All data elements with the same group number must be grouped together and shall be ordered sequentially according to data element number.

Data element numbers within defined groups which are not identified in Section 10 shall be reserved for future use.

In a shadow group, element numbers 0001H through 7FFFH shall be reserved for manufacturers. Element numbers 8000H through FFFFH shall be reserved for users.

NEMA Standard 10-16-1985.

4.6 LENGTH

The length field is a double word (32 bits) interpreted as an unsigned integer representing the number of bytes from the end of the length field to the beginning of the next data element, or to the next potential element if the element is the last element. This binary number must be even.

NEMA Standard 10-16-1985.

4.7 VALUE

The value of the data element shall be an even number of bytes. The value shall be an ASCII string unless otherwise specified in Section 10.

The combination of group number and data element number shall determine the unique representation of the associated value. Section 10 contains this representation for all defined elements. The multiplicity of values permitted for a particular data element is specified in Section 10. There are certain data elements for which only specific entries within the value field (enumerated values) are allowed. These are specified in Section 10.

NEMA Standard 10-16-1985.

4.7.1 ASCII Values

Values represented in ASCII shall use the character set as defined in ANSI X3.4-1977.

If an element is represented with an ASCII value, character defined as part of the graphic character set (20H to 7EH) of the ANSI standard shall be used. The control characters carriage return (0DH) and line feed (0AH) shall be permitted also. The characters * (2AH) and @ (40H) shall have special meanings when present in the value fields associated with the FIND__REQUEST (See 6.2.2). The character \ (5CH) is the delimiter (see 4.7.3).

An integer number, represented by ASCII numeric, shall contain only the characters 0 through 9, +, and -.

A fixed point number, represented by ASCII numeric, shall contain only the characters 0 through 9, +, -, and an explicit decimal point marker (.). Implied decimal points shall not be permitted.

A floating point number, represented by ASCII numeric, shall be as defined in ANSI X3.9-1978. Character E shall be the valid character to indicate the start of the exponent.

Where a word consists of two ASCII characters, the first character shall appear in the least significant byte.

All ASCII fields shall be padded if necessary to produce an even number of bytes. ASCII alphanumeric text shall be left justified. ASCII numeric text shall be right justified. The padding character for ASCII strings shall be the space (20H).

NEMA Standard 10-16-1985.

4.7.2 Binary Values

Binary values shall be represented in 2's complement form, except for pixel values which shall be represented in a form specified by Pixel Representation (0028H,0103H).

In a double precision 32-bit binary integer, the least significant word shall be transmitted first across the interface. Such an integer must be used in the value field of a data element which represents a length to the end of a group or a message.

NEMA Standard 10-16-1985.

4.7.3 Multiple Values

Multiple values shall be allowed in designated value fields. For ASCII values, only the backslash (\) shall be used as a delimiter. Multiple binary values shall be a sequence of 16 bit 2's complement words unless otherwise specified (i.e., for pixels or overlays).

NEMA Standard 10-16-1985.

4.8 DATA ELEMENT TYPES

Data elements are classified into three types:

Type 1—necessary for storage or display of the data

Type 2—primary items used for interpretation

Type 3—secondary items used for interpretation

Types 1 and 2 are subdivided into default and nondefault types.

NEMA Standard 10-16-1985.

4.8.1 Type 1 Data Elements

Type 1 data elements shall contain meaningful values and shall be sent with every message. The value field shall contain valid data.

NEMA Standard 10-16-1985.

4.8.2 Type 1D (Default) Data Elements

If type 1D data elements are not sent with a message, the receiver shall assume the default value(s) as defined in the standard. If the default value is not to be used, then these elements shall be sent with the message and the value field shall contain valid data.

NEMA Standard 10-16-1985.

4.8.3 Type 2 Data Elements

Type 2 data elements shall be sent with every message (except as noted in 4.8.6). If the value for a data element is not known, that data element must be sent with the length set to zero and with no value (i.e., value field does not exist).

NEMA Standard 10-16-1985.

4.8.4 Type 2D (Default) Data Elements

If type 2D data elements are not sent with a message, the receiver shall assume the default values as defined in the standard (except as noted in 4.8.6). If the default value is not to be used, then these elements must be sent with the message. If the value for a data element is not known, that data element shall be sent with the length set to zero and with no value (i.e., value field does not exist).

NEMA Standard 10-16-1985.

4.8.5 Type 3 Data Elements

Senders shall not be required to send type 3 data elements. If they are sent, they must be sent with a value field. Receivers shall not be required to interpret type 3 data elements.

NEMA Standard 10-16-1985.

The difference between type 1 and type 2 elements is that all type 1 elements must be known before a valid message can be sent, while type 2 elements may be unknown but must still be sent as zero length elements.

Type 3 elements are meant for additional useful information and are optional.

NEMA Standard 10-16-1985.

4.8.6 Data Elements in Optional Groups

Depending on the data set type, groups are classified as required, optional, or not allowed as defined in Table 4-2.

If a group is required by its particular data set type, then the definitions of type 1 and type 2 data elements require that these elements must be present in this group. The definitions of type 1D and type 2D data elements require that their defaults be assumed if these elements are not present in a required group.

If an optional group is sent, all type 1 data elements must be sent and all type 1D defaults shall be assumed if the element is not sent. If type 2 data elements are contained in optional groups, senders are not required to send them. In optional groups defaults shall not be assumed for type 2D data elements.

NEMA Standard 10-16-1985.

4.9 EXAMPLES

Examples of typical messages can be found in Appendix B.

Authorized Engineering Information 10-16-1985.

Table 4-1
IDENTIFICATION AND DESCRIPTION OF STANDARD GROUPS

Group Number (Hex)	Type of Information	Description of Group Content
0000	Command	Information which provides for end to end communication capability between two pieces of imaging equipment
0008	Identifying	Information which provides unique image identification parameters to the user
0010	Patient	Information related to the patient
0018	Acquisition	Information related to the image acquisition device and imaging procedure
0020	Relationship	Information relating the image to the location within the patient and to other associated images
0028	Image Presentation	Information related to the manner in which the image can be presented or displayed in a consistent and reproducible manner
4000	Text	ASCII text
Even 6000- 601E	Overlay	Information related to overlay pixel data associated with the image
7FE0	Pixel Data	Image pixel data

Table 4-2
CLASSIFICATION OF GROUPS FOR EACH DATA SET TYPE

DATA SET	GROUPS				
	0008H, 0010H, 0018H, 0020H, 0028H	4000H	EVEN 6000H- 601EH	7FE0H	PRIVATE
IMAGE	R	O	O	R	O
TEXT	O	R	N	N	O
GRAPHICS	O	O	R	N	O
OTHER	O	N	N	N	O
IDENTIFIER	O	N	N	N	N
NULL	N	N	N	N	N

R = required
O = optional
N = not allowed

Section 5

MESSAGE CONTENT

5.1 INTRODUCTION AND OVERVIEW

A message should contain a single data set. Four types of data sets which are contained in messages are discussed in this section: images, overlays, text, and other.

Authorized Engineering Information 10-16-1985.

In addition to the medical content of a particular image, information may contain the temporal sequencing of images (e.g., the growth of a lung tumor on two chest films 3 months apart; the distinction of arterial and venous supply to a tumor on images taken every second for 30 seconds).

Authorized Engineering Information 10-16-1985.

The relationship between the data contained in an image and the location of that image in the patient may also be important. On occasion, an additional relationship should also be specified; e.g., that between the patient (or image) and the geometrical configuration of the imaging device.

Authorized Engineering Information 10-16-1985.

Images shall be arranged and identified in a hierarchical grouping containing four levels: study (most inclusive); series; acquisition; and image (least inclusive).

NEMA Standard 10-16-1985.

The orientation of the image relative to the patient shall be specified and a means of specifying the relation of an image to an equipment coordinate frame is provided.

NEMA Standard 10-16-1985.

The bit fields containing pixel data shall be explicitly specified. If overlays are associated with an image they shall be stored one bit with each pixel or in a separate data element as indicated in (X,2000H).

NEMA Standard 10-16-1985.

If special display characteristics are necessary for images or overlays, then these characteristics shall be defined in lookup tables or parameters defining linear transformations.

NEMA Standard 10-16-1985.

5.2 IMAGES

5.2.1 Hierarchical Relationships of Sets of Images

No more than one image is contained in a message. Relationships to other images shall be described in four levels: image, acquisition, series, study. The image is the lowest level. One or more images may be derived from a single acquisition which is a single continuous gathering of raw data. Related acquisitions form a series and related series form a study. Data elements representing these four levels shall be included with an image. If any of these data elements for a given modality is not used, its value shall be set equal to one.

NEMA Standard 10-16-1985.

When associating one image with another, the data elements: study(0020H,0010H)\series(0020H,0011H)\acquisition(0020H,0012H)\image(0020H,0013H) shall be used.

NEMA Standard 10-16-1985.

Some hospitals and departments may have their own study number, computed, for example, by an information management system. In any given case, the meaning of these terms should depend upon the particular modality and implementation. Some possible implementations and examples are shown in Appendix C. Depending on the implementation it may be necessary to use additional data elements to guarantee unique identification of an image.

Authorized Engineering Information 10-16-1985.

5.2.2 Image Identification

For the purpose of image identification, three types of images are defined:

1. Original image—pixel values represent original, non-transformed data.
2. Modified image—pixel values have been modified.
3. Composite image—two or more images (from the same study) have been combined into one image for display or storage.

NEMA Standard 10-16-1985.

Composite images composed of images from different studies are not supported by this version of the standard. They may be handled using private groups.

Authorized Engineering Information 10-16-1985.

5.2.2.1 ORIGINAL IMAGE IDENTIFICATION

There are many ways to uniquely identify images. For the examples given in this document it is assumed that devices generating images assign a study number which does not repeat during a single day. Thus an original image may be uniquely identified by:

Station ID	Element	(0008H,1010H)
Study Date		(0008H,0020H)
Study		(0020H,0010H)
Series		(0020H,0011H)
Acquisition		(0020H,0012H)
Image		(0020H,0013H)

Authorized Engineering Information 10-16-1985.

5.2.2.2 MODIFIED IMAGE IDENTIFICATION

Modified images must contain the following three data elements which shall be supplied by the modifying device:

Modifying Device ID	(0020H,3401H)
Modified Image ID	(0020H,3402H)
Modified Image Date	(0020H,3403H)

The data elements used to identify the original image shall not be changed in the modified image. For subtraction images the series, acquisition, and image numbers of the mask image must be given in Masking Image (0020H,0080H).

NEMA Standard 10-16-1985.

An example of a modified image is one which has been changed by picture processing or subtraction.

Authorized Engineering Information 10-16-1985.

5.2.2.3 COMPOSITE IMAGE IDENTIFICATION

For composite images, the Station ID, Study Date, and Study Number data elements must refer to the original images. The original Series, Acquisition and Image data element values have no meaning for the composite image and they must be set to 1. In addition, composite images must contain the following elements:

Modifying Device ID	(0020H,3401H)
Modified Image ID	(0020H,3402H)
Modified Image Date	(0020H,3403H)

NEMA Standard 10-16-1985.

References to the images used to generate the composite image shall be contained in Source Image IDs (0020H,3100H) to (0020H,31FFH) with one data element

per reference image. The value field of each of these elements shall contain: "Series \ Acquisition \ Image \ Modifying Device ID \ Modified Image ID \ Modified Image Date." If the reference image is an original image, only the first three identifiers shall be required. In that case, the last three identifiers are sent as null (i.e., "Series \ Acquisition \ Image \ \ "). If the reference image is a modified image, only the last three identifiers shall be required (i.e., " \ \ \ Modifying Device ID \ Modified Image ID \ Modified Image Date").

NEMA Standard 10-16-1985.

Examples of composite images include: sagittal and coronal reconstructions, perspective views of three dimensional images, and collages.

Authorized Engineering Information 10-16-1985.

5.2.3 Image Coordinate System

The image coordinate system shall be implicitly defined by the order of pixel transmission. Image pixel data is transmitted in rows. The positive row axis (R) is in the direction from the first to last pixel of any row containing two or more pixels. The positive column axis (C) is perpendicular to the row axis in the direction of successively transmitted rows. The origin is located at the first pixel transmitted.

NEMA Standard 10-16-1985.

5.2.4 Patient Orientation

The patient orientation relative to the image shall be specified by a two valued data element Patient Orientation (0020H,0020H) that designates the anatomical direction of the positive row axis and positive column axis (see Figure 5-1).

NEMA Standard 10-16-1985.

Anatomical directions shall be designated by the capital characters: A (anterior), P (posterior), R (right), L (left), H (head), F (foot). Each value of the orientation element shall contain at least one of these characters. If refinements in the orientation descriptions are to be specified, then they shall be designated by additional letters in each value. Within each value the letters will be ordered with the principal orientation designated in the first character. See Appendix D for examples.

NEMA Standard 10-16-1985.

Some combinations of characters are clearly nonsensical (e.g., HF \ AP or H \ F). The orientation is expected to be meaningfully constructed.

Authorized Engineering Information 10-16-1985.

5.2.5 Coordinate Systems

5.2.5.1 INTRODUCTION

Image locations and orientations are specified with respect to equipment based coordinate systems. If two images from the same image source have the same study and series identifier number (see 5.2.2.1) then they shall be referred to by the same coordinate system.

NEMA Standard 10-16-1985.

The definitions of coordinate frames should be based on CT and MR modalities.

Authorized Engineering Information 10-16-1985.

5.2.5.2 AXIS DEFINITION

An imaging device shall have a manufacturer-defined front and back identified for its gantry. When facing the front of the gantry, and with the gantry in a neutral (untitled) position, the x-axis shall be increasing to the right; the y-axis shall be increasing down (defined by gravitational attraction); and the z-axis shall be defined as the line orthogonal to x and y, with increasing values from the front to the back of the gantry.

NEMA Standard 10-16-1985.

5.2.5.3 ORIGIN DEFINITION

An origin is defined as a point fixed with respect to the pallet.

NEMA Standard 10-16-1985.

The purpose of a fixed origin is to allow images with the same series and study number to be spatially related. The result of this is an equipment based coordinate frame fixed to the patient during a series.

Authorized Engineering Information 10-16-1985.

5.2.5.4 IMAGE LOCATION AND ORIENTATION

If required for a modality, an image shall include Image Position (0020H,0030H) specifying the x, y and z coordinates of the first pixel in the image relative to the equipment related axes. Similarly, an image shall also include Image Orientation (0020H,0035H) specifying the direction cosines of the first row and column of the image with respect to the equipment related axes.

NEMA Standard 10-16-1985.

5.2.5.5 LOCALIZER IMAGES

A projection image, such as a localizer scan in CT and MR, shall be treated as a plane described in the same co-

ordinate system as any cross sectional images associated with it in the same study.

NEMA Standard 10-16-1985.

The coordinates of the first pixel in Image Position (0020H,0030H) and the orientation of this localizer image plane in Image Orientation (0020H,0035H), compared to the values of the same elements for cross sectional images, give sufficient information to show the location of the cross sectional images on the localizer.

Authorized Engineering Information 10-16-1985.

5.2.5.6 OTHER LOCATION INFORMATION

If the Slice Location (0020H,1041H) is specified, then it shall be the distance of the slice image plane from the anatomical reference marker in Position Reference Indicator (0020H,1040H). If both the Slice Location (0020H,1041H) and the Image Location (0020H,0050H) and Image Orientation (0020H,0035H) are present then the combination of Image Location and Image Orientation shall have precedence over Slice Location in determining relative location of slices.

NEMA Standard 10-16-1985.

5.2.6 Pixel Bit Fields

Pixels of various bit depths shall be accommodated. The data elements for Bits Allocated (0028H,0100H), Bits Stored (0028H,0101H), and High Bit (0028H,0102H) shall define the pixel structure. Designation of bits allocated shall determine packing of the data.

NEMA Standard 10-16-1985.

For example, in pixel data with 12 bits allocated, 12 bits stored and bit 11 designated as the high bit, four pixels should be transmitted in three words. For additional examples of various packing schemes, see Appendix E.

Authorized Engineering Information 10-16-1985.

The field of bits representing the value of a pixel shall be a binary 2's complement integer or unsigned integer as specified by the Pixel Representation (0028H,0103H). These values shall be directly usable for physically meaningful quantitative calculation.

NEMA Standard 10-16-1985.

If the pixel value range is limited, then Smallest Pixel Value (0028H,0104H) and Largest Pixel Value (0028H,0105H) shall be used to specify these elements.

NEMA Standard 10-16-1985.

Some CT scanners incorporate text, annotation and region of interest into the pixel value field with, for example, all numbers greater than 1000 or less than -1000 annotation values. ACR-NEMA compatibility requires that all such information should be placed in an overlay plane; no way of specifying overlay like information in this way is included.

Authorized Engineering Information 10-16-1985.

5.2.7 Image Geometry

The image geometry specified in the Image Format data element (0028H,0040H) shall be rectangular.

NEMA Standard 10-16-1985.

The spacing of pixel centers along rows and columns shall be specified by the values of Pixel Size (0028H,0030H).

NEMA Standard 10-16-1985.

The image aspect ratio can be calculated from the number of Rows (0028H,0010H), number of Columns (0028H,0011H), and Pixel Size (0028H,0030H).

Authorized Engineering Information 10-16-1985.

5.2.8 Image Display

If a transformation of pixel values to a gray scale display is specified, it shall be contained in Lookup Table Descriptors—Gray (0028H,1100H) and Lookup Data—Gray (0028H,1200H) and Window Center (0028H,1050H) and Window Width (0028H,1051H), or a Rescale Intercept (0028H,1052H) and Rescale Slope (0028H,1053H). The window transformation shall be applied to the result of the rescale or lookup table transformations. If both the rescale and lookup table transformations are present the lookup table transformation shall be applied to the result of the rescale transformation.

If there are multiple window or rescale transformations, then these shall be stored as multiple values of the elements.

If a transform of pixel values to a red, green or blue display is specified, it shall be contained in the corresponding lookup table elements.

An example of a lookup table is contained in Appendix F. In the table data, all 0's correspond to black; all 1's correspond to white. Pixel values smaller than the smallest number transformed by the table are transformed by the first entry of the table. Pixel values larger than the largest number transformed by the table are transformed by the

last entry of the table.

NEMA Standard 10-16-1985.

5.3 OVERLAYS AND GRAPHICS

5.3.1 Definitions

An overlay plane shall contain graphics or text which is coincident with the image and is used to indicate such items as regions of interest, reference marks, and annotation. Sufficient information shall be available to allow an overlay to be presented at a display station superimposed on a particular image with which it is associated.

NEMA Standard 10-16-1985.

5.3.2 Overlay Representations

Each overlay plane shall be assigned one bit. When there are one or more overlay planes they shall be described by using groups 6000H to 601EH (even). Each group contains a pointer, Overlay Location (X,0200H), which shall point to the location of the overlay data. Its default is the current group.

NEMA Standard 10-16-1985.

Origin (X,0050H) shall be the row and column coordinates of the first overlaid image point; its default shall map the overlay origin into the image origin.

NEMA Standard 10-16-1985.

The display levels of an overlay plane are defined by a set of elements specifying two entry lookup tables, (X,1100-1103H) and (X,1200-1203H). The first and second entries of each overlay display table shall correspond to overlay bit values 0 and 1 respectively.

NEMA Standard 10-16-1985.

The values contained in these elements are similar to the values found in the lookup tables for image pixel values.

Authorized Engineering Information 10-16-1985.

Overlays may be stored: with the image in group 7FE0H and still be interpreted, using Overlay Location (X,0200H); with different numbers of rows and columns than those comprising the image; or without image pixel data, thus allowing a representation of pure graphics.

Authorized Engineering Information 10-16-1985.

5.3.3 Regions of Interest

A region of interest (ROI) is a specific use of an overlay. The overlay bits corresponding to the pixels included in the region of interest shall be set to 1. All other bits are set to 0.

NEMA Standard 10-16-1985.

If statistical parameters of the ROI are to be transmitted with it, then the ROI Area (X,1301H), the ROI Mean (X,1302H), and the ROI Standard Deviation (X,1303H) shall be used.

NEMA Standard 10-16-1985.

Boundaries of the regions may also be shown as overlays. However, ROI Area (X,1301H), ROI Mean (X,1302H), and ROI Standard Deviation (X,1303H), if used, should then only refer to the pixels under the boundaries, not those in the included regions.

Authorized Engineering Information 10-16-1985.

5.4 TEXT

If narrative text information is to be included in a message, then this type of data is carried in group 4000H.
NEMA Standard 10-16-1985.

A short report, explanatory information, or other text messages may be included in this group. A comment data element which exists in most groups provides a location for brief explanatory text.

Authorized Engineering Information 10-16-1985.

5.5 OTHER

Any medical data which is not image, graphics, or text, shall be data type Other.

NEMA Standard 10-16-1985.

Raw data or spectroscopic data carried in a private group is an example of the data type Other.

Authorized Engineering Information 10-16-1985.

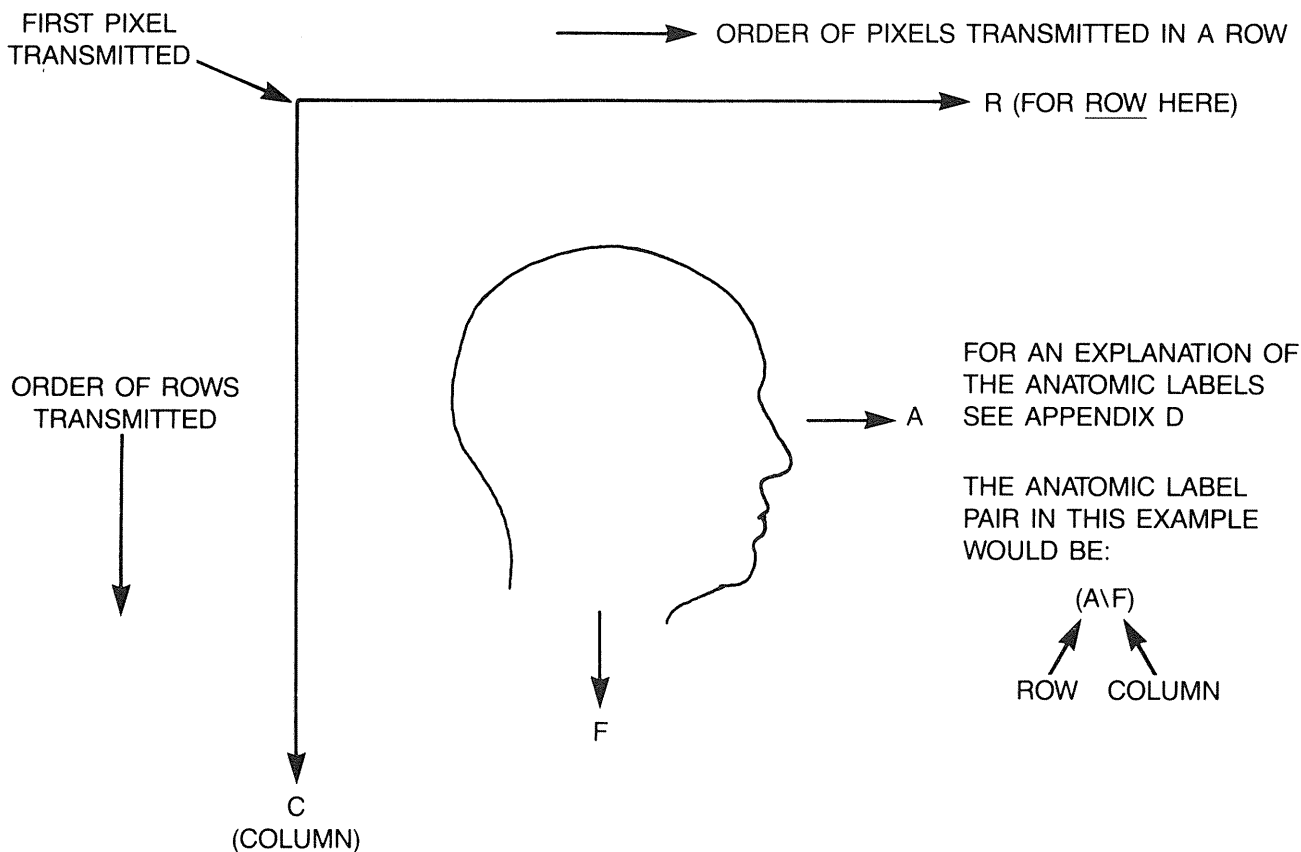


Figure 5-1
IMAGE COORDINATES

Section 6

COMMAND STRUCTURE

6.1 INTRODUCTION

A minimum set of commands is defined in this section. The commands, parameters and data elements defined in Section 10 are imbedded in the data structure defined in Section 4.

Three types of commands are defined: one type for normal processing (SEND, GET, MOVE, FIND, and DIALOG); one for exceptions (CANCEL); one for verification (ECHO).

Commands shall be initiated by imaging equipment. The initiator, receiver, FIND Location and MOVE Destination fields in the command shall always describe imaging equipment defined by its logical address. The command response shall always be initiated by the receiver whose logical address was specified in the original command request. The command response must be sent back to the initiator of the command request.

Imaging equipment that is a source of data must be able to initiate a SEND__REQUEST and must be able to receive SEND__RESPONSE. Imaging equipment that is a sink must be able to receive a SEND__REQUEST and must be able to initiate a SEND__RESPONSE. All imaging equipment must be able to recognize an ECHO__REQUEST and respond with an ECHO__RESPONSE. The ability to initiate all other commands shall be optional. The minimum command handling required for compatibility is discussed in Section 3.

Associated with commands are parameters which are defined in Section 10, Tables 10-1 and 10-2. Group 0000H contains all command information.

Examples of commands are found in Appendix G.

NEMA Standard 10-16-1985.

6.1.1 Status

The status referred to in the remainder of this section is always indicated in data element (0000H,0900H). Message status codes shall be one word. The most significant byte of the word shall be generated and interpreted according to the meanings listed in Tables 10-3 and 10-4. All other codes are reserved for future use by the ACR-NEMA Standard. The least significant byte of the word shall contain either 1) a zero value indicating no specific additional status information, or 2) a non-zero value containing more detailed status information.

NEMA Standard 10-16-1985.

An implementation may always put zeros in the least significant byte of the status. When enumerated codes are

available it may use one of them. When the code in the high order byte implies that the specific status is not specified (e.g., AFxxH or CFxxH), the implementation specific codes may be placed in the least significant byte.

Authorized Engineering Information 10-16-1985.

6.2 COMMANDS FOR NORMAL PROCESSING

6.2.1 SEND Commands

The SEND__REQUEST command is used to transfer data to a receiver. The SEND__RESPONSE command acknowledges the receipt of the data.

NEMA Standard 10-16-1985.

The data source (the device that has the data) shall initiate the SEND__REQUEST and must receive an indication of the successful data transfer (Status = Success) or an error message (Status = Failed) via the SEND__RESPONSE. The SEND__RESPONSE is a distinct command issued by the SEND__REQUEST receiver. A successful response shall indicate that the message was successfully received by an imaging device. The interpretation of a successful response is implementation specific.

NEMA Standard 10-16-1985.

A successful response should be interpreted by the original data source as an indication that the data transfer was successful. Depending on the pieces of equipment involved, this may have different meanings. For instance, an imaging device sending an image to an archive may have a protocol that a successful response is the indication that the archive is assuming responsibility for the integrity of the image and that the imaging equipment can purge its disk of the image data. On the other hand, an archive sending an image to a printer may have a protocol that would not purge the image data from the archive. In this case the successful response may indicate that the image was successfully printed or may indicate only that the image was received by the printer.

Authorized Engineering Information 10-16-1985.

6.2.2 FIND Commands

The FIND__REQUEST is used to query a device to determine if the requested data exists. This command shall contain elements describing the data sought. The device receiving the FIND__REQUEST replies with FIND__RESPONSEs which shall contain any matches found.

NEMA Standard 10-16-1985.



Documents

Document Sharing Hub

In order to describe the data which is desired from the FIND__REQUEST receiver, group 0000H shall be followed by data groups containing data elements whose value fields indicate the known and sought data. All data groups are optional.

NEMA Standard 10-16-1985.

A datum on the receiver shall be matched to the FIND__REQUEST when every element (other than element numbers 0000H and 0001H) of the FIND__REQUEST matches its corresponding element in that datum. When its corresponding element is multivalued, that element must be matched if any of its values match.

NEMA Standard 10-16-1985.

The characters * and @ shall be used as special characters representing the sought data, and shall be allowed to be used in any element whose value is ASCII. The * shall mean that some number of characters are unknown and shall allow no (0) characters to be present. The * used alone in a value field shall mean all possible values for that data element are desired. The @ shall mean that the single character represented by @ in the FIND__REQUEST is unknown. The FIND__RESPONSE shall replace the @ with the single character that is part of the match, and shall replace the * with the characters that are part of the match.

NEMA Standard 10-16-1985.

As examples, the patient name SMITH would be returned for values in element (0010H,0010H) of *, S*, *I*, *IT@, and S@@@@, but not S@@@@ or S*T. A value of A*B would return matches of AB,ABB, and ACBDB.

Authorized Engineering Information 10-16-1985.

If a FIND__REQUEST contains type 3 elements with known values or partial sought values (an * with another character or at least one @) then only data sets which contain that element with the sought values shall cause a match.

NEMA Standard 10-16-1985.

If a FIND__REQUEST contains a type 3 element with only an * as its value, then a match shall be caused by data sets which match the other elements specified whether the type 3 element is present or not in that data set. A set with the type 3 element present and one with it not present shall give separate matches.

NEMA Standard 10-16-1985.

In many cases the same information may be stored in different formats; for example, patient name. The same

name may be stored as:

- (1) Smith, James C. Jr.;
- (2) Smith Jr., J.C.;
- (3) Smith, J.;
- (4) James C. Smith.

It is not the intent of this standard to require any given name format; the implementation should carry the responsibility for standardization. Initiators of FIND__REQUESTs should anticipate various formats. For example:

SMITH*J*C will return the first two names above;

SMITH*J* will return the first three names; and

SMITH will return all four names.

Whether the receiver treats upper and lower case characters as equivalent is also implementation specific.

Authorized Engineering Information 10-16-1985.

If an element with binary values is sent in a FIND__REQUEST, then, if the length of the value field is zero, all values of this element shall be returned in the responses. If the length of the value field is not zero, then only values that match shall be returned. This shall allow binary fields to be searched in a manner similar to ASCII fields. Matches shall not be made against elements describing group length or message length.

NEMA Standard 10-16-1985.

Multiple responses to a FIND__REQUEST shall be permitted. Each FIND__RESPONSE shall contain group 0000H followed by the same groups and data elements contained in the FIND__REQUEST, with the * and @ replaced by the value or values found. In the response, only the element numbers provided with known values or values sought (or both) in the request shall be returned. Each unique matched value set shall provide a separate response. In the FIND__RESPONSE, data element (000H,0850H) shall contain the number of data sets which give an identical FIND__RESPONSE. If the length of (000H,0850H) is set to zero, there can be other identical FIND__RESPONSEs. Status shall be set to Pending in all responses except the last, in which it shall be set to Success. In order to allow these responses to arrive in a different order than they are generated, data element (0000H,0860H), Sequence Number, shall be set to 1 for the first response, which can indicate multiple images, and shall be incremented by 1 for each succeeding response. Indication that no matching data was found shall be receipt of a response with the Status=Success and Sequence Number=0.

NEMA Standard 10-16-1985.

The location of the matched data set is indicated through the FIND Location (0000H,0400H).

NEMA Standard 10-16-1985.

6.2.3 GET COMMANDS

The GET__REQUEST asks the request receiver to SEND a data set back to the request initiator. A GET__RESPONSE indicates that the request has been received.

NEMA Standard 10-16-1985.

In order to describe the data which is desired from the GET__REQUEST receiver, group 0000H shall be followed by data groups containing data elements whose value fields indicate the known data. All data groups are optional.

NEMA Standard 10-16-1985.

This set of data elements shall be a specification which defines a data set to be transmitted in response to the GET__REQUEST. Each value shall be treated as an exact match requirement. The symbols used as special characters in the FIND command shall not be treated as such in the GET command; instead they shall represent themselves.

NEMA Standard 10-16-1985.

The receiver of a GET command shall search for images that have group element values that exactly match the elements in the GET__REQUEST message. However, matches shall not be made against elements describing group length or message length. The GET__REQUEST receiver shall respond with two GET__RESPONSE messages. The first shall indicate the status of the received GET__REQUEST message. The second shall indicate the number of matches found in element (0000H,0850H) if the device is capable of determining this information; otherwise (0000H,0850H) shall be set to zero. Even if there is more than one match, only one match shall be returned by the subsequent SEND command, which is implementation specific.

NEMA Standard 10-16-1985.

If the data set is available, then the receiver of the GET__REQUEST command shall use the SEND__REQUEST command to send the data set to the initiator of the GET__REQUEST command. This SEND__REQUEST (and the subsequent SEND__RESPONSE) shall be identical to normal SEND command, except that this SEND command shall include Message ID Being Responded To (0000H,0120H) field which shall contain the message ID of the original GET__REQUEST command.

NEMA Standard 10-16-1985.

The GET command initiator should be expected to know enough to uniquely specify data sets. The GET command should not be intended for use as a network or system search command. It should be used to fetch a specific, known and existing data set.

Authorized Engineering Information 10-16-1985.

6.2.4 MOVE Commands

The MOVE__REQUEST initiator sends to the MOVE__REQUEST receiver a message which directs that receiver to SEND the specified data set to a third party; i.e., that receiver becomes the initiator of a SEND__REQUEST.

NEMA Standard 10-16-1985.

The MOVE__REQUEST receiver shall respond with two MOVE__RESPONSE messages. The first MOVE__RESPONSE shall indicate successful receipt of the MOVE__REQUEST message by having Status=Pending. The Status contained in the second MOVE__RESPONSE shall indicate the result of the MOVE__REQUEST.

NEMA Standard 10-16-1985.

In the case that the SEND__REQUEST initiated by the MOVE__REQUEST failed, the status code returned in the SEND__RESPONSE shall be transmitted to the MOVE__REQUEST initiator in the second MOVE__RESPONSE.

NEMA Standard 10-16-1985.

A data set is described in a MOVE__REQUEST in a manner identical to the GET__REQUEST. Any of the reasons why a GET can fail shall be a reason for a MOVE to fail. Unlike GET, the MOVE__REQUEST shall fail if there is more than one data set found by its receiver.

NEMA Standard 10-16-1985.

If any status other than pending is returned in the first MOVE__RESPONSE message, then it must be a failure response, and no second MOVE__RESPONSE shall be transmitted or expected.

NEMA Standard 10-16-1985.

Although MOVE is similar to GET, success for a MOVE command is more restrictive than success for a GET command (GET succeeds if there are multiple matches; MOVE does not) due to the effect on a third party. The MOVE command may be allowed to specify the data destination to be the same as the initiator, in which case the MOVE command has the effect of a GET command, except that only a single match is allowed for the MOVE command.

Authorized Engineering Information 10-16-1985.

6.2.5 DIALOG Commands

The DIALOG command shall provide the means for exchanging unformatted and interactive information between entities (operators or programs) in imaging equipment.

NEMA Standard 10-16-1985.

The request initiator shall send a DIALOG__REQUEST message requesting that an interactive connection be established with the DIALOG__REQUEST receiver's program or service identified in data element (0000H,4000H) (see Section 10) which must be operating in the equipment specified as receiver in data element (0000H,0300H). The request receiver must respond with a DIALOG__RESPONSE command which contains Status (0000H,0900H) indicating Success or Failed for the specified reason code (see Section 10).

NEMA Standard 10-16-1985.

If the response indicates Success, then the program or service requested shall be available to the initiator via further message segments sent across the interface in Command packets (see 9.5 for details).

NEMA Standard 10-16-1985.

Since the DIALOG__REQUEST receiver is an unspecified program, the details of the exchange cannot be specified, but two examples are shown in Appendix H.

Authorized Engineering Information 10-16-1985.

The connection shall be considered to be established when the DIALOG__RESPONSE with Status=Success has been received from the DIALOG__REQUEST receiver by the DIALOG__REQUEST initiator. The connection shall remain until the DIALOG__REQUEST initiator or the DIALOG__REQUEST receiver terminates it.

NEMA Standard 10-16-1985.

Group 0000H has a data element in which a description of the Terminal Type (0000H,4010H) may be included. The value of this data element is expected to be understood by the receiver.

Authorized Engineering Information 10-16-1985.

The default type shall be a standard console device which accepts ASCII text in 80 character lines with no screen control except carriage return and line feed.

NEMA Standard 10-16-1985.

All equipment which supports DIALOG shall include a default DIALOG receiver which shall be called "SYSTEM." It shall accept DIALOG messages and route them for presentation on the equipment console device. No return stream need be generated and sent. The initiator shall be responsible for disconnection, but the receiver can initiate a disconnect after an implementation-specific timeout.

NEMA Standard 10-16-1985.

The terminating equipment should be responsible for performing the Session Layer Disconnect and closing the channel. The protocols of the connection are those of a user at a terminal running a program in an attached computer. The DIALOG__REQUEST receiver may require log in and a password before allowing access. The receiver may send prompts for service choices. The initiator responds with information. If the initiator is an operator at the equipment console, the DIALOG service software may send a message segment after each carriage return. The receiver software delivers these segments to the DIALOG receiver. The DIALOG receiver responds with prompts or data which its service software sends to the initiator using the protocols defined in Section 9.

Authorized Engineering Information 10-16-1985.

Among the uses of this command should be to make connection to a database of patient studies kept by other equipment, to run a statistics program, to send patient or schedule data to an information system, to exchange data in a different format, etc. The DIALOG receiver still has full access control, and an initiator should provide any passwords, etc.

Authorized Engineering Information 10-16-1985.

6.3 COMMAND FOR EXCEPTION PROCESSING—CANCEL

6.3.1. CANCEL as Applicable to Commands in General

The ability to generate a CANCEL__REQUEST shall be optional for all devices except as noted in this section. The ability to react to a CANCEL__REQUEST shall be mandatory for devices which implement the ability to generate FIND__RESPONSES. If a device implements the ability to perform a MOVE__REQUEST and implements the ability to respond to a CANCEL, it must be able to generate a CANCEL__REQUEST. The ability to react to a CANCEL__REQUEST shall be optional for all other devices.

A CANCEL__REQUEST shall have meaning only when initiated by a device which has previously transmitted a command request. The CANCEL__REQUEST shall reference the message ID number of that command request in Message ID Being Responded To (0000H,0120H).

If a command request has been completely transmitted then a CANCEL__REQUEST message shall be sent in order to cancel the command request.

If a command request has been partially transmitted, then the channel on which the message is being transmitted shall be closed or reset to cancel the command request.

If a CANCEL__REQUEST is successful, all devices must return to the state they would have been in if the original command request had not been transmitted.

If a CANCEL__REQUEST is not successful, all devices must be in the state they would have been in if no CANCEL__REQUEST had been invoked.

A receiving device shall return a CANCEL__RESPONSE only to indicate to the initiating device that it does not support the CANCEL__REQUEST.

A receiving device shall indicate to the transmitting device that a CANCEL__REQUEST has been successful by returning the appropriate command response with Status=Cancelled.

A receiving device shall indicate that a CANCEL__REQUEST was not successful by returning a command response with the status equal to the value it would have been if no CANCEL__REQUEST had been invoked.

If a device does not support CANCEL, it shall return a CANCEL__RESPONSE indicating it does not support CANCEL and it shall ignore the CANCEL__REQUEST and continue processing the command request as if no CANCEL__REQUEST had been transmitted. This shall be the only use of the CANCEL__RESPONSE.

NEMA Standard 10-16-1985.

6.3.2 CANCEL as Applicable to Specific Commands

6.3.2.1 INTRODUCTION

Each command follows the general rules described in the previous section. Special actions for specific commands are described in the following sections. Device A transmits the command request and implements the CANCEL__REQUEST. Device B responds to the CANCEL__REQUEST and transmits the command response. In all cases it is assumed that device A has completed transmitting the command request across the interface.

NEMA Standard 10-16-1985.

6.3.2.2 SEND

There are no special considerations for a CANCEL of a SEND command.

NEMA Standard 10-16-1985.

6.3.2.3 GET

If device A has received a SEND__REQUEST from device B, a SEND__RESPONSE shall be returned with Status=Cancelled.

If device A has not received a SEND__REQUEST from device B, device A shall send a CANCEL__REQUEST to device B.

If device B has not sent the SEND__REQUEST when it receives a CANCEL__REQUEST from device A, device B shall send a second GET__RESPONSE with Status=Cancelled and does not send a SEND__REQUEST.

NEMA Standard 10-16-1985.

6.3.2.4 FIND

If device B has not yet transmitted the first FIND__RESPONSE when it recognizes the CANCEL__REQUEST, it shall then transmit a single FIND__RESPONSE with Status=Cancelled.

If device B has begun transmitting responses when it recognizes the CANCEL__REQUEST, it shall terminate transmission of the normal FIND__RESPONSEs and it shall transmit a single additional FIND__RESPONSE with Status=Cancelled.

If device B has begun transmitting the final FIND__RESPONSE when it recognizes the CANCEL__REQUEST, it shall continue the final response with Status = Success indicating to device B that the CANCEL__REQUEST was not successful.

NEMA Standard 10-16-1985.

6.3.2.5 MOVE

Device A requests Device B to send image to Device C. If device B has not yet transmitted the first MOVE__RESPONSE to device A when it recognizes the CANCEL__REQUEST, it shall transmit a MOVE__RESPONSE to device A with Status=Cancelled and shall not transmit the SEND__REQUEST to device C.

If device B has transmitted the first MOVE__RESPONSE to device A, but not yet transmitted the SEND__REQUEST to device C when it recognizes the CANCEL__REQUEST, it shall transmit the second MOVE__RESPONSE to device A with Status=Cancelled and shall not transmit the SEND__REQUEST to device C.