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Part 1: Network Capable Application Processor (NCAP) information model

Technologies de l'information — Interface de transducteurs intelligente pour capteurs et actuateurs —

Partie 1: Modèle d'information de processeur d'application utilisable en réseau (NCAP)

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Foreword

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IEEE Std 1451.1-1999

IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Network Capable Application Processor (NCAP) Information Model

Sponsor

TC-9 Committee on Sensor Technology
of the
IEEE Instrumentation and Measurement Society

Approved 26 June 1999

IEEE-SA Standards Board

Abstract: This standard defines an object model with a network-neutral interface for connecting processors to communication networks, sensors, and actuators. The object model containing blocks, services, and components specifies interactions with sensors and actuators and forms the basis for implementing application code executing in the processor.
Keywords: actuators, communication network, object model, sensors

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Introduction

[This introduction is not part of IEEE Std 1451.1-1999, IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Network Capable Application Processor (NCAP) Information Model.]

The objective of the IEEE/NIST Working Group on transducer interface standards is to utilize existing control networking technology and develop standardized connection methods for Smart Transducers to control networks. Little or no changes would be required to use different methods of analog-to-digital (A/D) conversion, different microprocessors, or different network protocols and transceivers.

This objective is achieved through the definition of a common object model for the components of a Networked Smart Transducer, together with interface specifications to these components.

The Networked Smart Transducer model shows two key views of a smart transducer:

— Physical view
— Logical view

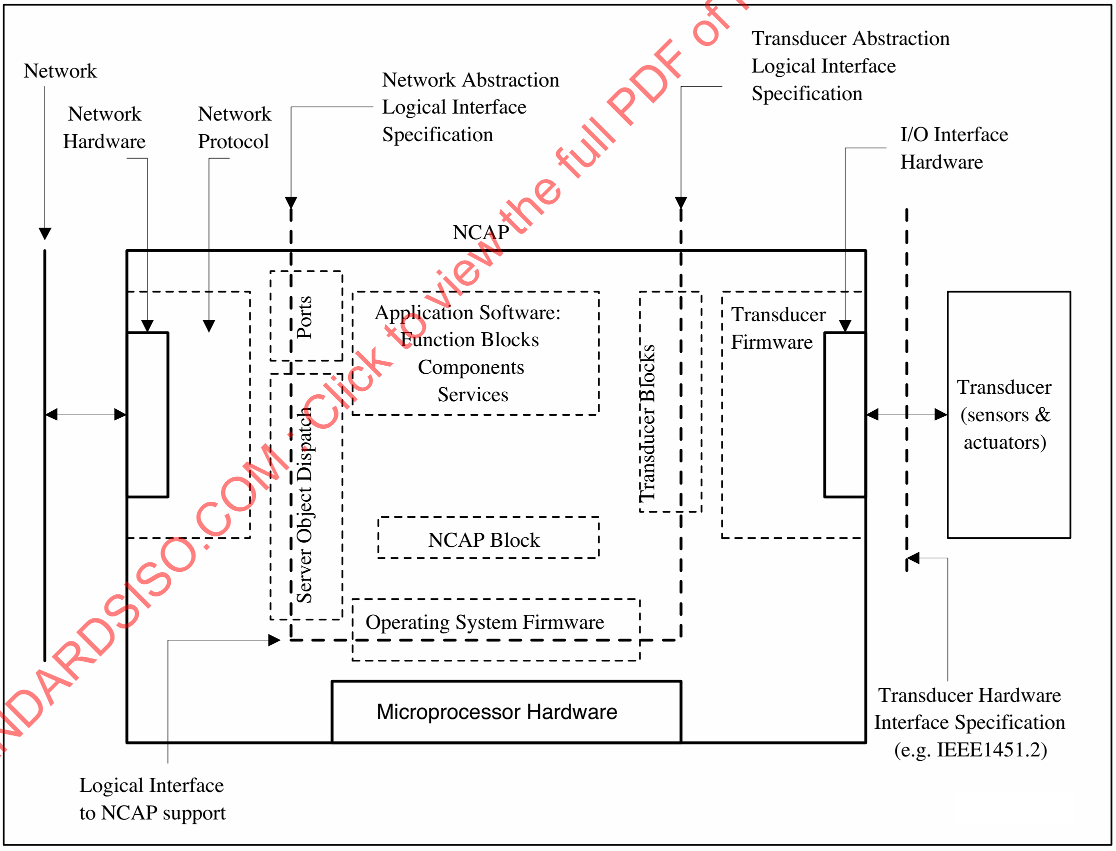

Network
Network Hardware
Network Protocol
Network Abstraction Logical Interface Specification
Transducer Abstraction Logical Interface Specification
I/O Interface Hardware
NCAP
Ports
Application Software: Function Blocks Components Services
Transducer Blocks
Transducer Firmware
Transducer (sensors & actuators)
Server Object Dispatch
NCAP Block
Operating System Firmware
Microprocessor Hardware
Transducer Hardware Interface Specification (e.g. IEEE1451.2)
Logical Interface to NCAP support

Figure 1—Networked Smart Transducer model

Physical view

The first view shows the physical components of the system. This view is indicated by components drawn in solid lines in Figure 1.

Figure 1 shows a model composed of sensors and actuators connected to form a transducer. The transducer is connected over an interface to a microprocessor or controller that is in turn interfaced to the network. The Hardware Interface Specification between the sensor/actuator and the rest of the device hardware, known as the network capable application processor (NCAP), is indicated by the rightmost thick, dashed line in the figure. A typical specification is described in the companion standard [IEEE Std 1451.2-1997].

The NCAP hardware consists of the microprocessor and its supporting circuitry as well as hardware implementing the physical layer of the attached network and the input/output (I/O) interface to the transducer, as shown in Figure 1.

Logical view

The second view is the logical view of the system and is indicated by components shown in dotted lines in Figure 1.

The logical components may be grouped into application and support components. The support components are the operating system, the network protocol, and transducer firmware components shown. The operating system provides an interface to applications, indicated by the dashed line labeled “Logical Interface to NCAP support.”

A second logical interface, labeled “Network Abstraction Logical Interface Specification,” consists of Port and Server Object Dispatch components defined in this standard. This interface provides an abstraction to hide communication details specific to a given network within a small set of communication methods. The details of this interface are defined by this standard.

The third logical interface, labeled “Transducer Abstraction Logical Interface Specification” performs the same abstraction function for the specifics of the transducer I/O hardware and firmware. In effect, this interface makes all such transducer interfaces look like I/O drivers. The details of this interface are defined by this standard.

Applications are modeled as Function Blocks in combination with Components and Services. The NCAP block provides application organization and support for the other blocks. All of these Blocks, Components, and Services are defined by this standard.

These interfaces are optional in the sense that not all must be exposed in an implementation.

NOTE—If support for interoperable transducers is not required, it is permissible to not use the IEEE1451.2 Interface Specification, or a similar transducer interface standard, but to still use the IEEE1451.1 object model. Similarly, if networking is not supported, or if the networking implementation is closed, it is not necessary to use IEEE1451.1 to still get the benefits of using IEEE1451.2 or a similar transducer interface standard.

Contents

IEEE Standard for a Smart Transducer Interface for Sensors and Actuators— Network Capable Application Processor (NCAP) Information Model

1. Overview

This standard is divided into 16 clauses:

Clause	Purpose
1.	Provides the scope, purpose, and benefits of this standard
2.	Lists references to other standards that are referenced by this standard
3.	Provides definitions that are either not found in other standards or have been modified for use with this standard
4.	Provides conventions for the notation used in this standard
5.	Provides an overview of the information model specified by the standard
6.	Defines the datatypes used in this standard
7.	Defines object properties common to all objects specified in this standard
8.	Defines the top-level objects of an IEEE 1451.1 system
9.	Defines the Block classes
10.	Defines the Component classes
11.	Defines the Service classes
12.	Defines the properties of publications
13.	Defines standard publications
14.	Defines the encoding and decoding rules
15.	Defines the rules for memory management
16.	Defines requirements for conformance

Annexes are provided as follows:

Annex	Purpose
A	Provides an overview of the use of the object model
B	Provides a detailed explanation of client-server interactions
C	Provides a detailed explanation of publish-subscribe interactions
D	Provides detailed examples of the configuration of systems
E	Provides detailed considerations of interoperability
F	Defines a string character set required for certain strings
G	Defines a string language enumeration
H	Defines a Transducer Block for IEEE 1451.2 transducers
I	Bibliography

1.1 Scope

This standard defines an interface for connecting network-capable processors to control networks through the development of a common control network information object model for smart sensors and actuators.

The object model includes definitions of

— Transducer Blocks

— Function Blocks

— NCAP Blocks

This standard will not define individual device algorithms or specifics on what is implemented by using the model.

1.2 Purpose

Many control network implementations are currently available that allow transducers to be accessed over a network. The purpose of this standard is to provide a network-neutral application model that will reduce the effort in interfacing smart sensors and actuators to a network.

1.3 Benefits

A system designed and built in conformance to this standard is expected to provide the following benefits:

— A uniform design model for system implementation

— A uniform and network-independent set of operations for system configuration

— Defined network-independent models for communication

— Interoperability of all communications

— Defined network-independent models for implementing application functionality

— Portable application models

— A network-independent abstraction layer and encode-decode rules that isolate applications from the details of network communications

— A uniform information model for representing physical parametric data

— Uniform models for managing and representing event data, parametric data, and bulk data

— Uniform models for managing and representing time

— Uniform models for intranode concurrency management and components to manage internode concurrency

— Uniform models for memory management

2. References

This standard shall be used in conjunction with the publications and standards listed in this clause. The notation [document-designator] in this standard is a reference to the document in this clause denoted [document-designator].

2.1 General references

[IEEE 754]: IEEE Std 754-1985 (Reaff 1990), IEEE Standard for Binary Floating-Point Arithmetic.[1]

[IEEE 1451.2]: IEEE Std 1451.2-1997, IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats.

2.2 References pertaining to String representation

The following standards shall be used in conjunction with the `StringCharacterSet` and `StringLanguage` enumerations (see 6.1.2).

ANSI X3.4 1986, Coded Character Set—7-bit American National Standard Code for Information Interchange.[2]

CNS 11643-1992, (Taiwan) Standard Interchange Code for Generally Used Chinese Characters.[3]

FSS-UTF, File System Safe Universal Transformation Format (FSS_UTF). X/Open CAE Specification C501 ISBN 1-85912-082.[4]

GB 2312-80 (PRC), China State Bureau of Standards. Coded Chinese Graphic Character Set for Information Interchange.[5]

[ISO 639]: ISO 639:1988-04-01 (E/F), Code for the Representation of Names of languages. Later editions of this standard shall not be used.[6]

[1]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (http://www.standards.ieee.org/).

[2]ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (http://www.ansi.org/).

[3]This document is available on the World Wide Web at the following site: http://www.imc.org/rfc1922.

[4]This document is available by contacting X/Open company, Ltd.—USA, 3141 Fairview Park Drive., Suite 670, Falls Church, VA 22042-4501, USA.

[5]CSBS documents are available from the China State Bureau of Standards, P.O. Box 8010, 42 Hi Chun Road, Haidian District, Beijing 100088, China.

ISO/IEC 646:1991, Information technology—ISO 7-bit coded character set for information interchange.

ISO/IEC 2022: 1994, Information technology—Character code structure and extension techniques.

ISO/IEC 6429: 1992, Information technology—Control functions for coded character sets.

ISO/IEC 8859-1: 1998, Information technology—8-bit single-byte coded graphic character sets—Part 1: Latin alphabet No. 1.

ISO/IEC 8859-2: 1999, Information technology—8-bit single-byte coded graphic character sets—Part 2: Latin alphabet No. 2.

ISO/IEC 8859-3: 1999, Information technology—8-bit single-byte coded graphic character sets—Part 3: Latin alphabet No. 3.

ISO/IEC 8859-4: 1998, Information technology—8-bit single-byte coded graphic character sets—Part 4: Latin alphabet No. 4.

ISO/IEC 8859-5: 1999, Information technology—8-bit single-byte coded graphic character sets—Part 5: Latin/Cyrillic alphabet.

ISO/IEC 8859-6: 1999, Information technology—8-bit single-byte coded graphic character sets—Part 6: Latin/Arabic alphabet.

ISO/IEC 8859-7: 1987, Information processing—8-bit single-byte coded graphic character sets—Part 7: Latin/Greek alphabet.

ISO/IEC 8859-8: 1999, Information technology—8-bit single-byte coded graphic character sets—Part 8: Latin/Hebrew alphabet.

ISO/IEC 8859-9: 1999, Information technology—8-bit single-byte coded graphic character sets—Part 9: Latin alphabet No. 5.

ISO/IEC 8859-10: 1998, Information technology—8-bit single-byte coded graphic character sets—Part 10: Latine alphabet No. 6.

ISO/IEC 10646-1: 1993, Information technology—Universal multiple-octet coded character set (UCS)—Part 1: Architecture and basic multilingual plane.

ISO/IEC DIS 10646-2, Information technology—Universal multiple-octet coded character set (UCS)—Part 2: Ideographic character sets.

JIS X 0208:1997, Japanese Standards Association. Code of the Japanese Graphic Character Set for Information Interchange.[7]

JIS X 0212-1990, Japanese Standards Association. Code of Supplementary Japanese Graphic Character Set for Information Interchange.

KS X 1001:1992, Korea Bureau of Standards. Korean Graphic Character Set for Information Interchange.[8]

[6]ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iso.ch/). ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (http://www.ansi.org/).

[7]JIS documents are available from the Japanese Standards Association, 1-24, Akasaka 4-chome, Minato-Ka, Tokyo, Japan 107.

KS X 1002:1991, Korea Bureau of Standards. Korean Graphic Character Set for Information Interchange. (supplemental character set).

TIS 620-2533 1990, Character Codes for Computers.[9]

2.3 References pertaining to uncertainty

[ISA uncertainty]: Measurement Uncertainty: Methods and Applications, Ronald H. Dieck (This document refers to and is compatible with [ISO uncertainty].) Instrument Society of America, ISBN 1-55617-628-7.[10]

[ISO uncertainty]: Guide to the expression of uncertainty in measurement, International Organization for Standardization, first edition 1995. ISBN 92-67-10188-9.

[NIST]: NIST Technical Note 1297, 1994 edition: Guidelines for evaluating and expressing the uncertainty of NIST measurement results, Barry N. Taylor and Chris E. Kuyatt. Produced by the Physics Laboratory, National Institute of Standards and Technology, United States Department of Commerce, Gaithersburg, MD 20899-0001, USA. (This NIST publication refers to and is compatible with [ISO uncertainty].)[11]

3. Definitions

Most terms in the text of this standard appearing with the first letter of each word capitalized will be found in the subclauses identified; see 4.2.4. Such terms shall have the IEEE 1451.1-specific interpretations given in this clause. Exceptions are some terms in examples or informative material that are defined where they are used or are obvious from the context. Terms in this clause in uncapitalized form represent common parlance terms with a specific interpretation to be used in this standard.

3.1 Abstract Class: A class that can not be instantiated but only subclassed as specified in 7.1.1.

3.2 Action: An instance of the class `IEEE1451_Action` or of a subclass thereof; see 10.10.

3.3 Active Concurrency: Concurrent Execution that appears to be independent as specified in 7.2.4.2.2.

3.4 actuator: A component that provides a physical output in response to a stimulating variable or signal.

3.5 Application System: The collection of components in a system built according to this standard as specified in 5.1.

3.6 argument: The usual mathematical meaning.

3.7 Argument: A value of type `Argument`; see 6.2.14.

3.8 Argument Array: A value of type `ArgumentArray`; see 6.2.14.

3.9 Array: Denotes the IEEE 1451.1 array datatype; see 6.2.1.

[8]KS documents are available from the Korean Bureau of Standards, 2 Chung-ang-dong Kwach'on-city, Kyonggi-do 171-11, Korea.

[9]TIS documents are available from the Thai Industrial Standards Institute, Rama 6 Street, Bangkok 10400, Thailand, (tel. 202-3348; fax 247-8739).

[10]ISA documents are available from the Instrument Society of America, 67 Alexander Drive, P.O. Box 12277, Research Triangle Park, NC 27709.

[11]This document is available from the Superintendent of Documents, United States Government Printing Office, Washington, DC 20402, USA.

3.10 Associated Block Cookie: A particular Block Cookie associated with an Object as specified in 7.3.1.

3.11 Asynchronous Client Port: An instance of the class `IEEE1451_AsynchronousClientPort` or of a subclass thereof; see 11.5.

3.12 asynchronous communication: In the IEEE 1451.1 client-server model, refers to a communication in which the client does not block. State is maintained to allow the client to determine whether the return has been received from the server and to permit the client to retrieve the return.

3.13 Base Client Port: An instance of a subclass of `IEEE1451_BaseClientPort`; see 11.3.

3.14 Base Port: An instance of a subclass of `IEEE1451_BasePort`; see 11.2.

3.15 Base Publisher Port: An instance of a subclass of `IEEE1451_BasePublisherPort`; see 11.6.

3.16 Base Transducer Block: An instance of a subclass of the class `IEEE1451_BaseTransducerBlock`; see 9.4.

3.17 behavior: A statement of the externally visible response and internal change of state of an object to invoked operations or internal events, given its current internal state.

3.18 Block: An instance of a subclass of `IEEE1451_Block`; see 9.1.

3.19 Block Cookie: The value of the cookie of a specific Block; see 9.1.3.3.

3.20 Block Major State: One of the states specified for a Block class in 9.1.3.2.

3.21 Block State Machine: The state machine specified for the referenced Block. The general Block State Machine for all Blocks is specified in 9.1.3.2.

3.22 boot-up: The process an NCAP and its operating system perform, usually on application of power, in preparation for executing operations related to the application and application visible components of the system. System level network visible actions may be accomplished as well, for example, the publication of `PSK_NCAPBLOCK_ANNOUNCEMENT`.

3.23 channel: A physical or logical communication link to a single transducer or to a group of transducers considered as a single transducer.

3.24 class: A collection of objects that share common characteristics and features.

3.25 Class ID: All classes have a descriptive header entry “Class ID,” the value of which is the Class ID (note capitalization); see 7.1.1. For any object of class `IEEE1451_Root`, the operation `GetClassID` returns a value, `class_id`, that has the same value as Class ID; see 8.1.1.2.

3.26 Class Name: All classes have a descriptive header entry “Class,” the value of which is the Class Name (note capitalization), see 7.1.1. For any Object, the operation `GetClassName` returns a value, `class_name`, that has the same value as Class Name; see 8.1.1.1.

3.27 Client Cached Block Cookie: A particular Block Cookie associated with a Base Client Port as specified in 11.3.2.3.

3.28 Client object: Any object that invokes operations on other objects. Also, the client in a client-server communication as modeled in this standard, in which case the Server operation is invoked via an `IEEE1451_BaseClientPort` Object.

3.29 Client Port: An instance of the class `IEEE1451_ClientPort` or of a subclass thereof; see 11.4.

3.30 client-server communication: A communication pattern, where a specific object, the client, communicates in a one-to-one fashion with a specific server object, the server.

3.31 commissioning: The process of providing to the appropriate components, the information necessary for the designed communication between components.

3.32 Component: An instance of a subclass of `IEEE1451_Component`; see 10.1. The term component, uncapitalized, has its usual common parlance meaning.

3.33 Component Group: An instance of the class `IEEE1451_ComponentGroup` or of a subclass thereof; see 10.13.

3.34 Concurrent Execution: A form of simultaneous execution of operations as specified in 7.2.4.2.

3.35 Condition Variable Service: An instance of the class `IEEE1451_ConditionVariableService` or of a subclass thereof; see 11.12.

3.36 Configurable Startup Set: A Component Group Object owned by an NCAP Block Object for use in bringing the system to a known state as specified in 9.2.5.8.

3.37 configuration: A process often synonymous with commissioning. Often includes the selection of attributes of an object that change its appearance or performance characteristics as opposed to its communication properties.

3.38 configuration, collection: In a collection of objects, the configuration is the enumeration of the members of the collection, and the specification of the allowed communications between the members. To configure a collection means to make the necessary changes to the collection and its members to make real the defined enumeration of members and the specification of allowed communication between members**.**

3.39 configuration, object: In an object, the configuration is the specification of its allowed communications and of the internal state or organization of the object. To configure an object means to make the necessary changes to the object to make real these specifications.

3.40 cookie: A quantity used to indicate or signal to a recipient of data, significant changes in the state of the entity supplying the data.

3.41 data, analog: Data that represents a variable that is mathematically continuous in the domain of the application. For example, the measurements of time, velocity, pressure, are all continuous variables, excluding quantum effects**.**

3.42 data, digital: Data that does not admit to representations obeying the laws of arithmetic. Examples of digital data are digital state vectors, image bit maps, and proximity switch outputs.

3.43 data, discrete: Data that represents a variable that can be mathematically represented in integer form. For example, a count of whole items processed is a discrete variable.

3.44 dimension: The number of degrees of freedom of a physical quantity. For example, an electric field, which is a spatial vector quantity, has dimension 3.

3.45 Direct Ownership: A relationship between a Block and an object as specified in 5.1.3.

3.46 domain: When used in this standard in contexts other than publish-subscribe communications, the term domain, uncapitalized, has its usual mathematical interpretation.

3.47 Domain: In IEEE 1451.1 publish-subscribe communications, the Domain is a publication-specific scoping mechanism that defines the set of entities that can potentially communicate via the publish-subscribe model; see 12.3.5. Specifically, the term Domain shall denote a value having type `PubSubDomain`.

3.48 Dot2 Transducer Block: Denotes an instance of the class `IEEE1451_Dot2TransducerBlock` or of a subclass thereof; see 9.6.

3.49 Dot3 Transducer Block: An instance of the class `IEEE1451_Dot3TransducerBlock` or of a subclass thereof; see 9.7.

3.50 Dot4 Transducer Block: An instance of the class `IEEE1451_Dot4TransducerBlock` or of a subclass thereof; see 9.8.

3.51 DotX Transducer Block: A Transducer Block implementing one of the IEEE 1451.X family of standards, see 16.3.6.

3.52 encode/decode: Encoding is the mapping of typed information from its internal datatype format into the types allowed by the signatures of the `Perform-`, `Execute-`, and `Publish-`like operations. Decoding is the mapping from the types allowed by the signatures of the `Perform-`, `Execute-`, and subscription callback-like operations into the datatypes used internally.

3.53 entity: Signifies the hardware/software embodiment of an object.

3.54 Entity: An instance of a subclass of `IEEE1451_Entity`; see 8.2.

3.55 epoch: The reference time defining the origin of the time scale used in a particular measurement.

3.56 event: An abstraction of the mechanism by which asynchronously generated signals or conditions are generated and represented.

3.57 Event Generator Publisher Port: An instance of the class `IEEE1451_EventGeneratorPublisherPort` or of a subclass thereof; see 11.9.

3.58 file: An abstraction of the mechanism for the allocation, deallocation, initialization, and use of memory resources in a device.

3.59 File: An instance of the class `IEEE1451_File` or of a subclass thereof; see 10.11.

3.60 Full Implementation: Refers to the implementation of an operation on an Object. A Full Implementation means that all the referenced visible functionality of the operation is implemented as specified for the operation; see 7.2.1.2.2.

3.61 Function Block: An instance of a subclass of `IEEE1451_FunctionBlock`, see 9.3.

3.62 Get Semantics: Denotes retrieval semantics as specified in 7.2.4.1.1.

3.63 Human-Machine Interface (HMI): Includes keyboards, displays, keypads, touch screens, and similar devices to allow human interaction with a system.

3.64 hot swap: A disconnection of a subcomponent and a reconnection of the same or a replacement component without first turning off the power at the connection interface.

3.65 IEEE 1451.1 language: Consists of the `StringLanguage`, `StringCharacterCode`, and `StringCharacterSet` values defined in Annex F. This language is used in certain Strings specified in this standard.

3.66 Indirect Ownership: A relationship between a Block and an object as specified in 5.1.3.

3.67 initialization: A process of setting initial values of variables, constants, state, and other artifacts to establish the startup conditions for an object.

3.68 instance: The specific object that results from allocating resources to implement a single consistent set of internal variables required for the operations and behavior defined for a class definition.

3.69 Interface Definition Language (IDL): A programming language-independent method of specifying operation syntax.

3.70 Interface Only Implementation: Refers to the implementation of an operation on an Object. This means that only the interface properties of the operation are implemented. The operation will return an appropriate error code but otherwise have no other effect on the Object; see 7.2.1.2.1.

3.71 Local: As an adjective shall indicate that the modified term's extent is a single process space. Thus, a Local operation may be invoked only from within the process space of the object; see 5.1.2.3.

3.72 Local NCAP Block: The unique network capable application processor (NCAP) Block within a process as specified in 5.1.2.2.

3.73 Major Field: A field of a return code as specified in 7.2.3.1.1.

3.74 mapping onto network protocol: The embodiment of hardware and software as it relates to supporting IEEE 1451.1 communications on a specific bus standard.

3.75 marshaling/demarshaling: The mapping of information typed as given in the signatures of `Perform-`, `Execute-`, and `Publish`-like operations into the network-specific, on-the-wire formats, including any required endian issues. Demarshaling is the reverse process.

3.76 Minor Field: A field of a return code as specified in 7.2.3.1.1.

3.77 mutex: A mechanism for implementing mutual exclusion.

3.78 Mutex Service: An instance of the class `IEEE1451_MutexService` or of a subclass thereof; see 11.11.

3.79 NCAP Block: An instance of the class `IEEE1451_NCAPBlock` or of a subclass thereof; see 9.2.

3.80 Network Capable Application Processor (NCAP or IEEE1451_NCAP): A device that supports a network interface, application functionality, and generally access to the physical world via one or more transducers. An IEEE1451_NCAP is an NCAP conformant to this standard**.**

3.81 network: A communication mechanism for interconnecting multiple Smart Transducers.

3.82 network infrastructure: The network and associated software used to communicate between network capable application processors (NCAPs) as specified in 5.3.

3.83 Network Visible: Refers to objects or operations that can be accessed or invoked from a different process than the process in which the object or operation executes, in particular if the processes are in different network capable application processors (NCAPs) communicating over a network. In IEEE 1451.1, Network Visible objects or operations are also locally visible; see 5.1.2.3.

3.84 object: A collection of data and operations.

3.85 Object: An instance of the class `IEEE1451_Entity` or of a subclass thereof; see 8.2.

3.86 Object Dispatch Address: A network-specific identifier for an endpoint of a client-server communication. Specifically, a value having datatype `ObjectDispatchAddress`; see 6.1.3.

3.87 Object ID: A unique identifier for an instance of an Object as specified in 8.2.3.5.

3.88 object model: A definition of data structures and operations organized in a formal specification. An object model provides applications with a common view and a common way of interfacing to an element of functionality.

3.89 Object Name: A nonconfigurable name for an instance of an Object used to convey the purpose or function of the Object instance. For any Object, the operation `GetObjectName` returns a value, `object_name`, that has the same value as Object Name; see 8.2.1.4.

3.90 Object Tag: A configurable identifier for the endpoints of client-server communications. Specifically a value having datatype `ObjectTag`; see 6.2.3. For any Object, the operation `GetObjectTag` returns a value, `object_tag`, that has the same value as Object Tag; see 8.2.1.1.

3.91 Octet Array: A value of type `OctetArray`; see 6.2.1.

3.92 operation: At the specification level, an operation is a service that a class knows how to carry out. In an implementation of the IEEE 1451.1 standard, an operation on a specified class is mapped to a public method on the corresponding realized class.

3.93 Operation ID: A reference to an operation as specified in 7.2.2.4.

3.94 Operation Name: A name given to an operation defined for an IEEE 1451.1 class; see 7.2.2.3.

3.95 orientation: The positioning of the dimensions of a spatial vector. For example, spatial vectors may be represented by a cartesian coordinate system oriented in space in some application-specific manner.

3.96 Own: A relationship between objects as specified in 5.1.3.

3.97 Owning Block: A relationship between Block and other objects as specified in 5.1.3.1.

3.98 parameter: An attribute usually representing some property subject to change, for example, a configuration parameter.

3.99 Parameter: An instance of the class `IEEE1451_Parameter` or of a subclass thereof; see 10.2. A Parameter is a representation of a variable. Parameters may selectively be manipulated across a network, and can be an externally visible representation for data.

3.100 Parameter With Update: An instance of the class `IEEE1451_ParameterWithUpdate` or of a subclass thereof; see 10.3.

3.101 parametric data: Data representing an internal state variable of an object that is represented by a Parameter. More specifically, physical parametric data generally represents some aspect of the physical world.

3.102 partition: A subdivision of a file.

3.103 Partition: An addressable portion of a Partitioned File; see 10.12.

3.104 Partitioned File: An instance of the class `IEEE1451_PartitionedFile` or of a subclass thereof; see 10.12.

3.105 Permanent Startup Set: A Component Group Object owned by an NCAP Block Object for use in bringing the system to a known state as specified in 9.2.5.8.

3.106 Physical Parameter: An instance of a subclass of `IEEE1451_PhysicalParameter`; see 10.4.

3.107 Physical Parameter Type: The syntax and interpretation of the Physical Parameter's data and metadata. The value of Physical Parameter Type for a given Physical Parameter is determined as specified in 10.4.1.1.

3.108 Physical Units: The designator of the units of a variable of datatype `Units` using the conventions of [IEEE 1451.2] as specified in H.4.2.4.

3.109 port: An abstraction of an access point to network communications.

3.110 Port: A Port Object. Context may indicate that the Port Object is of a specific class.

3.111 Port Object: Any Object whose class is `IEEE1451_SubscriberPort` or a subclass thereof or a subclass of `IEEE1451_BasePort`.

3.112 Precedence Concurrency: Concurrent Execution that may appear to preempt other activity as specified in 7.2.4.2.2.

3.113 process: Consists of all execution within a single distinct address space supported by the operating system of a computer.

3.114 Public Transducer: A Parameter or other class instance, that is the public interface or abstraction of one or more physical transducers supported by an NCAP; see 9.5.

3.115 Publication Change ID: A publisher-defined identifier of the semantics of the publication as specified in 11.8.3.4.2.

3.116 Publication Contents: The publisher-defined contents of a publication. The syntax and other properties of Publication Contents shall be as specified in 11.7 and 11.8 for Publisher Ports and for individual publications where they are defined. Publication Contents is always of type `ArgumentArray`.

3.117 Publication Domain: A Domain for a specific publication. See also: Domain.

3.118 Publication Key: A publisher-defined identifier specifying the form and contents of a publication in a publish-subscribe communication. Specifically, a value having the datatype and properties specified in 12.3.2. For a Publisher Port, the operation `GetPublicationKey` returns a value, `publication_key,` that has the same value as Publication Key; see 11.6.1.3.

3.119 Publication Topic: A configurable identifier for the name of a publication in a publish-subscribe communication. Specifically a value having datatype `PublicationTopic`; see 6.2.8. For a Publisher port, the operation `GetPublicationTopic` returns a value, `publication_topic`, that has the same value as Publication Topic; see 11.6.1.1.

3.120 Publisher object: Any object that posts publications onto the network via an Object of class `IEEE1451_BasePublisherPort` or a subclass thereof.

3.121 Publisher Port: An instance of the class `IEEE1451_PublisherPort` or of a subclass thereof; see 11.7.

3.122 publish-subscribe communication: A communication pattern where one or more objects, publishers, communicate information on a specific topic to one or more subscriber objects interested in that topic without the necessity of any of these objects knowing the identity of any other object. In an IEEE 1451.1 system, the pattern is established via the Publication Topic, Publication Key, and Publication Domain of the publication.

3.123 return code: A value, returned to the caller of an operation, providing information about the completion status of the operation. This standard defines two forms of return codes; see 7.2.3.1.

3.124 Root: An instance of a subclass of `IEEE1451_Root`; see 8.1.

3.125 Scalar Parameter: An instance of the class `IEEE1451_ScalarParameter` or of a subclass thereof; see 10.5.

3.126 Scalar Series Parameter: An instance of the class `IEEE1451_ScalarSeriesParameter` or of a subclass thereof; see 10.6.

3.127 Self Identifying Publisher Port: An instance of the class `IEEE1451_SelfIdentifyingPublisherPort` or of a subclass thereof; see 11.8.

3.128 sensor: A component providing a useful output in response to a physical, chemical, or biological phenomenon. This component may already have some signal conditioning associated with it. Examples: platinum resistance temperature detector, humidity sensor with voltage output, light sensor with frequency output, pH probe, and piezoresistive bridge.

3.129 Series Parameter: A Scalar Series Parameter or a Vector Series Parameter.

3.130 Server Object: Any Object that executes one or more of its operations in response to a request from a Client object. A Server Object is the server in a client-server communication as modeled in this standard.

3.131 Server Object Tag: An attribute of a Client Port that identifies the Object Tag of the Server Object with which the Port communicates in client-server communications; see 11.3.1.1.1.

3.132 Service: An instance of a subclass of `IEEE1451_Service`; see 11.1.

3.133 Set Semantics: Update semantics as specified in 7.2.4.1.2.

3.134 Smart Transducer: A transducer that provides functions over and above that necessary for generating a correct representation of a sensed or controlled physical quantity. This functionality typically simplifies the integration of the transducer into applications in a networked environment.

3.135 Smart Transducer object model: An object model for a Smart Transducer. The model includes an interface to a transducer object and a transducer bus.

3.136 state transition diagram: A graphical means of expressing the allowed states of an object and the allowed transitions from one state to another; see 4.6.

3.137 Smart Transducer Interface Module (STIM): The supporting electronics on the transducer side of the hardware interface to the NCAP. In IEEE 1451.1, an STIM and an NCAP combined form a Networked Smart Transducer. In the various IEEE 1451.X standards, for example IEEE 1451.2, the term STIM may have a more precise meaning within the scope of the particular standard.

3.138 String: The IEEE 1451.1 representation of a sequence of human readable characters; see 6.1.2.

3.139 Subscriber object: Any object that receives publications from the network via an Object of class `IEEE1451_SubscriberPort`.

3.140 Subscriber Port: An instance of the class `IEEE1451_SubscriberPort` or of a subclass thereof; see 11.10.

3.141 Subscription Domain: A Domain identified by a subscriber for a specific publication. See also: Domain.

3.142 Subscription Key: The Subscriber defined analog of the Publication Key used to help define the selection of received publications in a publish-subscribe communication. Specifically, a value having the datatype and properties specified in 12.3.2. For a Subscriber Port, the operation `GetSubscriptionKey` returns a value, `subscription_key,` that has the same value as the Port's Subscription Key; see 11.10.1.3.

3.143 Subscription Qualifier: A configurable identifier used to help define the selection of received publications on the basis of publication's Publication Topic in a publish-subscribe communication. Specifically, a value having datatype `SubscriptionQualifier`; see 6.2.8. For a Subscriber Port, the operation `GetSubscriptionQualifier` returns a value, `subscription_qualifier`, that has the same value as Port's Subscription Qualifier; see 11.10.1.1.

3.144 synchronous communication: In the IEEE 1451.1 client-server model, refers to a stateless communication in which the client blocks until the return is received from the server. That is, the client can perform no activities until unblocked by the return of the result.

3.145 Transducer Electronic Data Sheet (TEDS): Several of the IEEE 1451.X standards use TEDS to provide a machine-readable specification of the characteristics of the transducer interface.

3.146 Time Parameter: An instance of the class `IEEE1451_TimeParameter` or of a subclass thereof; see 10.9.

3.147 timeout: A mechanism for terminating requested activity that, at least from the requester's perspective, does not complete within the time specified by the timeout's "value."

3.148 transducer: A device converting energy from one domain into another, calibrated to minimize the errors in the conversion process. A sensor or an actuator.

3.149 Transducer Block: An instance of a subclass of `IEEE1451_TransducerBlock`; see 9.5

3.150 units: The units of a measured value of a physical variable define the standard quantity of the measure of that variable used to express the value. The representation of the units of an Object is the datatype `Units`; see 6.2.9.

3.151 unrepresented channel: A channel that is not represented by a Public Transducer.

3.152 Vector Parameter: An instance of the class `IEEE1451_VectorParameter` or of a subclass thereof; see 10.7.

3.153 Vector Series Parameter: An instance of the class `IEEE1451_VectorSeriesParameter` or of a subclass thereof; see 10.8.

3.154 visibility, Local: Operations or objects are locally visible if they can not be accessed or invoked except from within the process in which the object or operation executes. In IEEE 1451.1, objects not specifically designated as Network Visible are only Locally visible.

4. Conventions

The specifications of this clause shall apply to all objects defined in this standard, and where appropriate, to any Objects defined by subclassing class definitions found in this standard.

4.1 Class naming

The names of all classes specific to this standard shall have a prefix "`IEEE1451_`". The purpose is to allow specifications or source code implementing this standard to be easily searched for Class Names associated with this standard.

4.2 Descriptive syntax

The syntax conventions specified in 4.2.1, 4.2.2, 4.2.3, and 4.2.4 are used in this standard.

4.2.1 Lexical form syntax

A lexical form refers to

a) An operation signature

b) Element of a signature

c) A datatype

When a lexical form appears in the text of the standard, it will be in the special computer font and will obey the conventions stated below. The computer font is Courier whereas normal font is Times. In particular, when an IEEE 1451.1-defined datatype is referred to in text, it will always appear in computer font. Likewise, the formal name or the formal name standing for the value of an argument of an IEEE 1451.1-defined operation will always appear in computer font.

In addition, the conventions illustrated in the following list regarding lexical forms shall be used:

— Type names: e.g., `TemperatureSensor` (no word separation, initial letter of each word capitalized, computer font).

— Class Names: e.g., `IEEE1451_FunctionBlock` (no word separation, initial letter of each word capitalized, prefixed by `IEEE1451_` if specified by this standard, computer font).

— Class operations: e.g., `OpenValve` (no word separation, initial letter of each word capitalized, computer font).

— Enumeration members and global constants: e.g., `HIGH, TEMPERATURE_SETPOINT` (underscore word separation, all letters capitalized, computer font).

— Fields of structures: e.g., `setPoint, element, specialElement` (no word separation, initial word not capitalized, initial letter capitalization on subsequent words, computer font).

— All other variables: `read, read_status` (underscore word separation, no letters capitalized, computer font).

— `<local name for something>:` text enclosed in angle brackets, < >, is used where the standard needs to refer to something whose syntax or lexical form is dependent on the local implementation and language. In text, these will appear in computer font.

Example: "The value returned by the operation `GetClassID` for this class shall be 1.2." "The datatype of `member_properties` is `ObjectProperties`."

When a lexical form appears in text, as opposed to in a signature, a type, or a format definition, the form is to be interpreted as singular, plural, or possessive as appropriate to the context of the text. This is to avoid computer font terms with plural or possessive endings in normal font.

4.2.2 Reference to a collection of specific IEEE 1451 Objects

When a lexical form in the standard refers to one or a collection of specific IEEE 1451.1-specified Objects or their values, the form will be in normal font with the first letter capitalization on each word. A definition and clause reference for all such lexical forms appears in Clause 3.

Example: "All Function Blocks will have a state machine," where Function Blocks refers to instances of the class `IEEE1451_FunctionBlock`.

4.2.3 General concepts

A general concept, that is the common parlance or mathematical meaning of a term, will not be capitalized, and will appear in normal font.

Example: "Applications are constructed using objects."

4.2.4 Terms

Terms for concepts that have been given a specific meaning in this standard will appear in normal font with the first letter capitalized on each word. A definition and clause reference for all such lexical forms appears in Clause 3.

Example: "All Network Visible Objects are registered."

4.3 Word usage

4.3.1 Shall

The word shall, equivalent to "is required to," is used to indicate mandatory requirements, strictly to be followed in order to conform to the standard and from which no deviation is permitted.

4.3.2 Recommended

The word recommended is used to indicate flexibility of choice with a strong preference alternative.

4.3.3 Must

The word must is NOT used. The use of the word must is deprecated and shall not be used when stating mandatory requirements. The word must is used only to describe unavoidable situations.

4.3.4 Should

The word should, equivalent to “is recommended that,” is used to indicate

— Among several possibilities one is recommended as particularly suitable, without mentioning or excluding others.

— That a certain course of action is preferred but not necessarily required.

— That (in the negative form) a certain course of action is deprecated but not prohibited.

4.3.5 May

The word may, equivalent to “is permitted,” is used to indicate a course of action permissible within the limits of the standard.

4.3.6 Can

The word can, equivalent to “is able to,” is used to indicate possibility and capability, whether material or physical.

4.4 Class definitions

Class definitions are described by using schema. Each schema consists of one or more of the following elements as needed:

— The name of the class

— The name of the class’s parent

— The class’s ID

— A description of the class

— A list of the class’s Network Visible operations

— A list of non-Network Visible, that is Local only, operations of the class

— A list of publications and subscriptions for the class

— State machine diagrams and other material defining the class’s behavior

An operation is the term standardized in the Unified Modeling Language (UML) [B5], and is used for all IEEE 1451.1 class descriptions. It refers to what some programming languages call a method or a member function.

An implementation of an IEEE 1451.1 class may have other, unlisted operations that are not visible over the network. However, unless otherwise noted, these operations are not in the scope of this standard and are not included in the class definitions.

Non-Network Visible operations that are specified in the class definition are indicated in the schema by preceding the operation designation by the word “Local.”

Operation signatures, enumerations, structures, and other IEEE 1451.1-specified data types are presented in a form of IDL [B3].

All IDL specifications in this document are preceded by the characters “IDL:” in bold type. If an electronic copy of this document is parsed with an appropriate script, the IDL may be extracted for use in code development.

4.5 Operation signature datatypes

The datatypes appearing in the signatures of operations shall define the datatype used to represent the actual values of the referenced information. These datatypes shall not be construed as limiting implementations to “pass by value” or any other technique. It is recommended that vendors provide documentation defining the mapping of the signatures of all IEEE 1451.1 operations to the vendor’s chosen language and implementation.

The only data types that shall occur in the IDL signature of an IEEE 1451.1-specified operation are those data types that are defined in the IEEE 1451.1 specification. IDL has no concept of a pointer or a reference to a datum. This does not imply that all Network Visible operation arguments and return values are “pass by value.” Rather, the actual types of these arguments are IEEE 1451.1 implementation and implementation language dependent.

For example:

IF: The IDL specification of the signature of the operation is:

```
IDL: OpReturnCode Write(
           in UInteger16 transaction_id,
           in UInteger32 requested_number_of_octets,
           in OctetArray data,
           out UInteger32
                      actual_number_of_octets_written);
```

THEN

For a C implementation: The header for the `Write` operation might be:

```
OpReturnCode Write(
           /*in*/ UInteger16 transaction_id,
           /*in*/ UInteger32
                      requested_number_of_octets,
           /*in*/ OctetArray *data,
           /*out*/ UInteger32
                      *actual_number_of_octets_written);
```

OR

For a C++ implementation: The header for the `Write` operation might be:

```
OpReturnCode Write(
           /*in*/ UInteger16 transaction_id,
           /*in*/ UInteger32
                      requested_number_of_octets,
           /*in*/ OctetArray &data,
           /*out*/ UInteger32 &actual_number_of_octets_written);
```

OR

For a Java implementation: The signature of the `Write` operation might be:

```
OpReturnCode Write(
           /*in*/ UInteger16 transaction_id,
           /*in*/ UInteger32 requested_number_of_octets,
           /*in*/ OctetArray data,
           /*out*/ Long actual_number_of_octets_written);
```

where `actual_number_of_octets_written` and `data` are declared as object references, for example:

```
           Long actual_number_of_octets_written = new Long (0);
           OctetArray data = new OctetArray( );
```

4.6 Behavioral specification notation

State transition diagrams are used to specify the behavioral characteristics of the object model as illustrated in Figure 2. Each state transition diagram is composed of the following components:

— Named boxes, representing states

— Directed arrows, indicating transitions from one state to the next

Each transition is labeled with

— The enabling event or predicate label for a transition

— The transition action label for a transition

The notation describes state transition diagrams using the Mealy style, where actions are associated with the transition from one state to another.

Events, e.g., event_1, event_2, and event_3, identify the inputs to the state machine. They can be operation requests and responses; or internal occurrences such as timer expirations.

Predicates, e.g., event_1 OR event_2, identify enabling conditions for transitions. The first predicate encountered that is `TRUE` selects the transition to execute and therefore the next state.

Transition actions, e.g., result_1, are the actions that are executed before transitioning to the next state.

The next state identifies the state for the state machine after the selected transition action completes. As the transition to the next state occurs, the value of the current state changes.

A bold line for a state box indicates that the box represents multiple states. Any transition shown that begins and terminates in such a state box indicates that there has been no change in state.

Transitions, e.g., the transition resulting in result_3, that have no indicated enabling conditions, occur via unspecified mechanisms. Unless otherwise stated, in IEEE 1451.1 these mechanisms are implementation-specific and outside the scope of the standard.

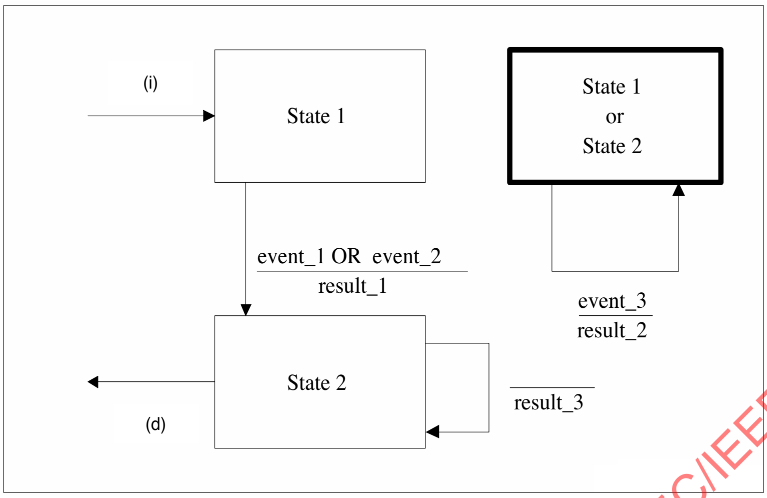


Figure 2—Mealy state transition diagram

A transition into a state machine, for example, (i), is indicated by a transition arrow that has no source state. A transition out of a state machine, for example, (d), is indicated by a transition arrow with no destination state.

Example: As a result of either event_1 or event_2 becoming TRUE, State 1 is replaced with the value of the next state. In this example, the next state is State 2, which is specified as the name of the state box that is the target of the transition arrow. Before this transition, result_1 occurs. event_3 can occur in either State 1 or State 2. The state is unchanged but an action, result_2, occurs as the result of event_3.

5. Information model

The IEEE 1451.1 standard specifies a software architecture. This architecture is applicable to distributed systems consisting of one or more Network Capable Application Processors (NCAPs), communicating over a network. The NCAPs may interact with the physical world via attached transducers.

The standard provides

— A network abstraction layer

— A transducer abstraction layer

The standard specifies

— The software interfaces between application functions on an NCAP and a communication network in a manner independent of any specific network.

— The software interfaces between application functions on an NCAP and transducers attached to that NCAP in a manner independent of any specific transducer driver interface.

Systems implemented according to IEEE 1451.1 standard will achieve a high degree of interoperability regardless of the underlying network or transducer technologies.

The IEEE 1451.1 software architecture is defined via three types of models

— An object model (for the software components of IEEE 1451.1 systems)

— A data model (for the information communicated across the specified object interfaces)
— Two network communications models

NOTES

1—The IEEE 1451.1 software architecture specification is presented in this document from an object-oriented perspective. However, there is no requirement that actual implementations use object-oriented implementation techniques. For example, a C language implementation is not required to have run time dispatch to handle calls to inherited operations. It may instead directly implement all operations, including inherited operations for an "object" as specific function calls in a code module representing that object's functionality.

2—The standard does not specify any application functions. Application functions are to be constructed by using the standard's models rather than be specified by the models.

3—More detailed descriptions of the use of the software architecture specified by this standard are given in Annex A, Annex B, Annex C, and Annex D.

5.1 Object model specifications

The IEEE 1451.1 object model specifies the software component types used to design and implement Application Systems. The object model provides the software "building blocks" for Application Systems. The standard specifies each object class in the model by defining

— The object class interface (expressed as the set of signatures of the object's operations)
— The object class behavior (described via text and, where appropriate, state machine diagrams)

The IEEE 1451.1 object class hierarchy is shown in Figure 3. The figure gives the abbreviated Class Name (the name with the IEEE 1451 prefix dropped) and the Class ID for each class. The subclass relation is denoted by the indentation levels.

An object shall be termed an Object if, and only if, its class is a subclass of `IEEE1451_Entity`.

The class of any Object occurring in an IEEE 1451.1 system shall be either

— One of the classes in Figure 3 listed in bold type
— A specialization (subclass) of one of those classes

The IEEE 1451.1 classes in Figure 3 listed in italic type are abstract classes, and they shall not be instantiated. An instantiated Object of class A is also an instance of all classes that are parents of A recursively up to and including `IEEE1451_Root`.

The software in an Application System consists of a collection of Objects of class `IEEE1451_Block` and their associated objects.

The IEEE 1451-defined Object types associated with the Block types are Service Objects and Component Objects. The association shall be that of Block Ownership, which is a special form of containment; see 5.1.3.

5.1.1 Object classes

There are four object classes found in an Application System

— Block classes
— Component classes
— Service classes
— Non-IEEE 1451.1 object classes

Root	1
Entity	1.1
Block	1.1.1
NCAP Block	1.1.1.1
Function Block	1.1.1.2
Base Transducer Block	1.1.1.3
Transducer Block	1.1.1.3.1
Dot2 Transducer Block	1.1.1.3.1.1
Dot3 Transducer Block	1.1.1.3.1.2
Dot4 Transducer Block	1.1.1.3.1.3
Component	1.1.2
Parameter	1.1.2.1
Parameter With Update	1.1.2.1.1
Physical Parameter	1.1.2.1.1.1
Scalar Parameter	1.1.2.1.1.1.1
Scalar Series Parameter	1.1.2.1.1.1.1.1
Vector Parameter	1.1.2.1.1.1.2
Vector Series Parameter	1.1.2.1.1.1.2.1
Time Parameter	1.1.2.1.2
Action	1.1.2.2
File	1.1.2.3
Partitioned File	1.1.2.3.1
Component Group	1.1.2.4
Service	1.1.3
Base Port	1.1.3.1
Base Client Port	1.1.3.1.1
Client Port	1.1.3.1.1.1
Asynchronous Client Port	1.1.3.1.1.2
Base Publisher Port	1.1.3.1.2
Publisher Port	1.1.3.1.2.1
Self Identifying Publisher Port	1.1.3.1.2.2
Event Generator Publisher Port	1.1.3.1.2.2.1
Subscriber Port	1.1.3.2
Mutex Service	1.1.3.3
Condition Variable Service	1.1.3.4

Figure 3—IEEE 1451.1 class hierarchy

5.1.1.1 Block classes

Three base Block classes are specified by the standard

— `IEEE1451_NCAPBlock` class (provides standard software interfaces for supporting network communications and system configuration)

— `IEEE1451_BaseTransducerBlock` classes (provide standard software interfaces between transducers and application functions)

— `IEEE1451_FunctionBlock` classes (encapsulate application-specific functionality)

5.1.1.2 Component classes

Objects of class Component provide common application constructs

— Structured information, for example, measurements and files

— Collections of related application-specific objects

— Actions with state where the action takes place over a relatively long period of time

5.1.1.3 Service classes

Service class Objects support

— Communication between objects on distinct NCAPs

— Systemwide synchronization

5.1.1.4 Non-IEEE 1451.1 objects

Nothing in this standard precludes an Application System from making use of objects that are not Objects, that is, of a subclass of `IEEE1451_Entity`. The conformance requirements, see Clause 16, place some restrictions on the areas of applicability of non-IEEE 1451.1 objects. Unless otherwise stated, the specification and behavior of such objects are outside the scope of this standard.

5.1.2 Object relations

There are several binary and unary relations specified on the various types of objects in an IEEE 1451.1 system.

5.1.2.1 The relationship between NCAPs, processes, and Block Objects

The top-level relations between Block Objects, software processes, and an NCAP shall be as illustrated in Figure 4.

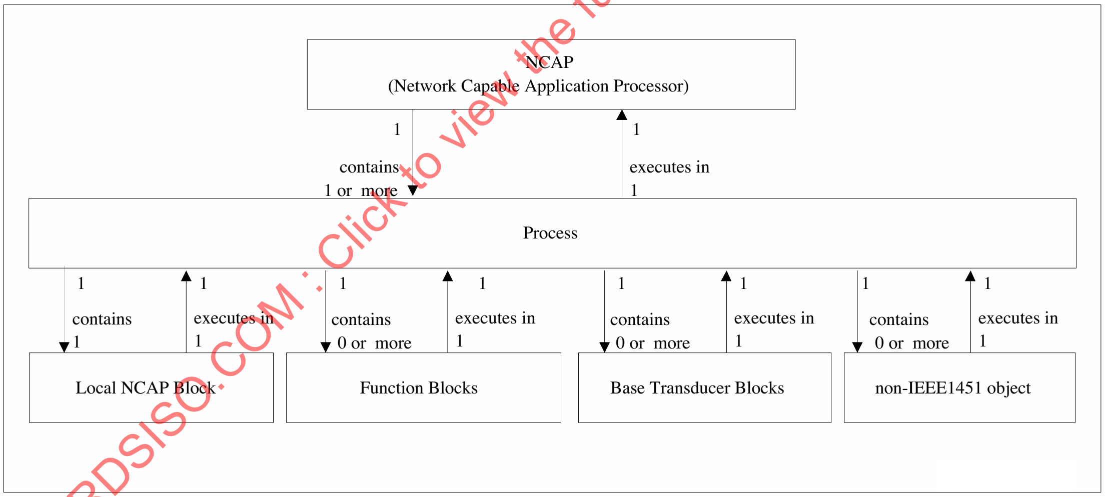


Figure 4—Top-level object relationships

Each NCAP in an Application System is modeled to contain at least one software process. The term *software process* in this standard is used only as a convenient term for defining an address space in which objects in an NCAP reside. The term *process* or any equivalent term shall not appear in the signatures of any Object's operations.

Within a given NCAP, there may be several active software processes. Within each process, there shall be exactly one Object of class `IEEE1451_NCAPBlock` along with zero or more Objects of class `IEEE1451_FunctionBlock`, zero or more Objects of class `IEEE1451_BaseTransducerBlock`, and zero or more non-IEEE 1451 objects. Each object in an Application System shall always be associated with exactly one NCAP process.

5.1.2.2 Local NCAP Block definition

Each Object, O, in an Application System exists only within the scope of a unique NCAP process, and within each NCAP process there shall be a unique NCAP Block Object. That NCAP Block Object is called O's Local NCAP Block.

5.1.2.3 Network Visible Object definition

An object shall be Network Visible if, and only if, all of the following apply:

— Its class is a subclass of `IEEE1451_Entity`, **AND**

— It is registered with its Local NCAP Block, (see 9.2), **AND**

— It is Owned by its Local NCAP Block (see 5.1.3).

An NCAP Block Object shall always be made Network Visible. The selection of which additional Block, Component and Service Objects to make Network Visible is application-specific, except where otherwise specified in the standard.

Any Object whose class is defined by this standard that participates in network communications shall be Network Visible. An object is defined as "participating in network communications" if, and only if

— The object directly requests the network infrastructure to transmit a message, **OR**

— The network infrastructure directly invokes an operation on the object.

For each Network Visible Object, whose class is defined by this standard, only those operations specifically designated in the Object's class definition as being Network Visible operations shall be capable of being invoked by the network infrastructure.

Those operations specified in the standard that are not Network Visible operations are denoted as Local operations. Local operations on an object O, shall be invoked only by other objects in O's process space even if O is itself Network Visible. Network Visible operations on a Network Visible Object may be invoked either locally or remotely.

NOTE—The requirement that Objects participating in network communication be Network Visible requires that any Port Object used for network communication be Network Visible. For an instance Object of one of the Port classes defined in this standard (see Clause 11) the Object's Object Tag or Publication Topic is modifiable over the network. If, in a given IEEE 1451.1 system, it is desired that these Port attributes be fixed when a Port Object is created, the appropriate Port class can be subclassed such that the subclass allows the Object Tag or the Publication Topic to be read but not
written.

5.1.3 Object Ownership definition

For each NCAP process space in the system, the Owns relation has as its domain all Block Objects in the process space, and as its range, all objects in the space.

The Owns relation is defined as follows:

— The Local NCAP Block in the space Owns itself, and it shall be the only Block Object in the space to do so, **AND**

— For a Block Object B in the space and an object O in the space, B Owns O (equivalently, O is Owned by B) if and only if O being operational implies that B is operational. Here, an object T is operational if and only if T is capable of accepting and processing operation requests from other objects in the space.

The Block Objects in an IEEE 1451.1 system shall satisfy the following Owns relation constraint:

Let $\mathcal{B}$ be the set of all Blocks in an NCAP process space that Own at least one object in the space. Then, for an Owned object O in the space, if B_1 and B_2 are distinct Block Objects in $\mathcal{B}$ that both Own O, then either B_1 Owns B_2 or B_2 Owns B_1.

From this definition of Owns and the above constraint, the properties of the Owns relation in an IEEE 1451.1 system are as follows:

— Only Block Objects may Own objects.

— The Owns relation does not cross process space boundaries.

— The Owns relation is transitive.

— An NCAP Block Object is the only object type that Owns itself.

— An NCAP Block Object is not Owned by any other object.

— The Owns/Owned-by relation defines a tree structure for all the objects in an NCAP process space owned by an NCAP Block where the root of the tree is the Local NCAP Block Object.

— For each Owned object, O, there shall be precisely one Block Object which Owns O and does not Own any other Block Object that also Owns O. This Block Object is said to Directly Own O.

An Owned object O is usually Owned by multiple Block Objects via the transitive nature of the Owns relation. However, there is only one Block Object that Directly Owns O. The other Block Objects that Own O are said to Indirectly Own O.

Specifications in this standard that restrict the behavior of objects Owned by a Block Object on the basis of the state of that Block Object shall use the definition of Owned given in this clause. Restrictions shall apply to the Owned objects irrespective of whether the object is an Object or not, and if an Object is Network Visible or not, unless otherwise stated in the object's class definition. The mechanisms for enforcing ownership responsibilities are implementation-specific and outside the scope of this standard.

NOTE—The Owning relation is used during IEEE 1451.1 system design, boot-up, initialization, and configuration.

5.1.3.1 Owning Block definition

Among the Blocks Owning a Network Visible Object, there shall be a unique Block denoted as the Object's Owning Block. The definition of a Network Visible Object's Owning Block shall be as follows:

Given a process space within an NCAP and O, a Network Visible Object in the space, the Owning Block of O shall be the Block Object B in the space satisfying the following conditions:

— B is Network Visible, **AND**

— If a Network Visible Block B_1 Owns O, then $B_1 = B$ or B_1 Owns B.

From this definition, the properties of Owning Blocks are as follows:

— Every Network Visible Object in the space has an Owning Block. This follows from the definition because the Object's Local NCAP Block is always Network Visible and the Owns relation is transitive.

— The Owning Block of a Network Visible Object in the space is unique.

If a Network Visible Block Object B in a process space has as its Owning Block the space's Local NCAP Block Object, then B is said to be a top-level Block.

NOTES

1—The Owning Block relation is used for two primary purposes

— As the basis for mechanisms to cleanly start and shut down an Application System

— To help track and recognize dynamic system modifications, for example, a transducer "hot swap"

2—If a Block B is the Owning Block of an object O, then, by definition, B Owns O. The converse, however, need not be true, as a Block can Own O but not be Network Visible. In this case, that Block is not O's Owning Block.

5.1.3.2 The relationship of Block Objects to Component, Service, and other objects

The relationship of the Block Objects to the Component Objects, Service Objects, and other objects in a process space of an IEEE 1451.1 system shall be as shown in Figure 5.

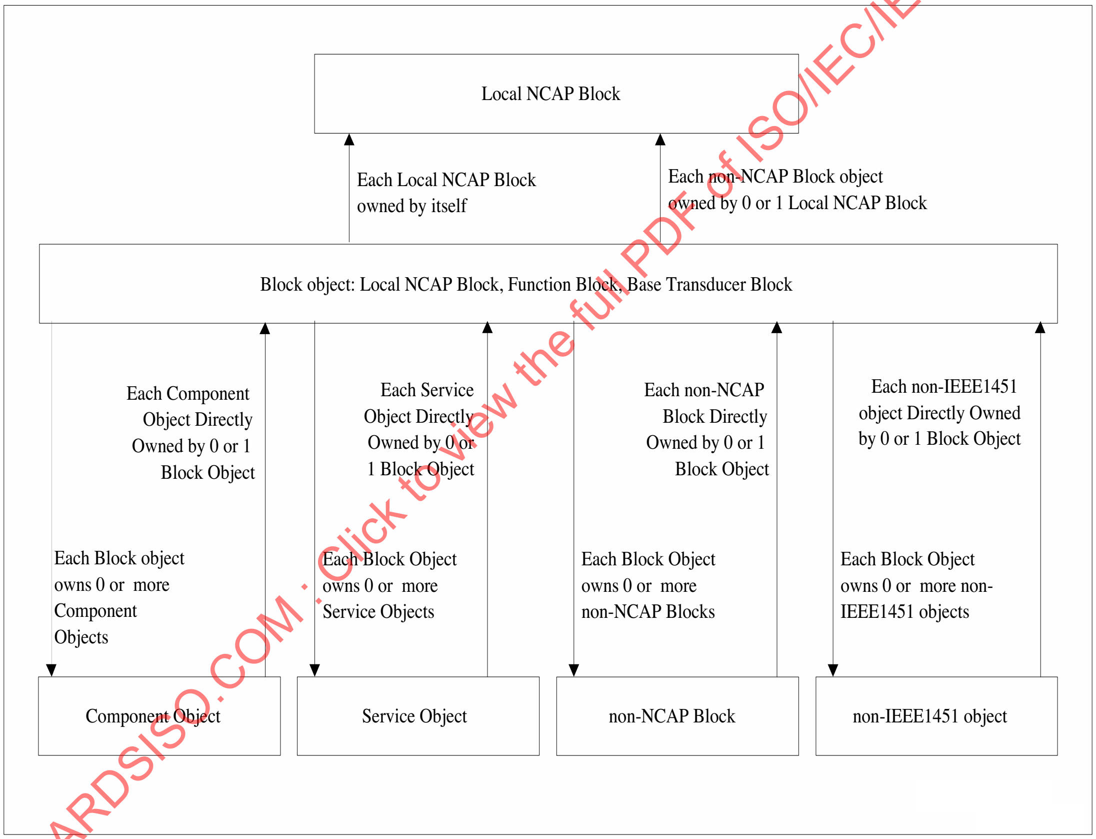

Local NCAP Block
Each Local NCAP Block owned by itself
Each non-NCAP Block object owned by 0 or 1 Local NCAP Block
Block object: Local NCAP Block, Function Block, Base Transducer Block
Each Component Object Directly Owned by 0 or 1 Block Object
Each Service Object Directly Owned by 0 or 1 Block Object
Each non-NCAP Block Directly Owned by 0 or 1 Block Object
Each non-IEEE1451 object Directly Owned by 0 or 1 Block Object
Each Block object owns 0 or more Component Objects
Each Block Object owns 0 or more Service Objects
Each Block Object owns 0 or more non-NCAP Blocks
Each Block Object owns 0 or more non-IEEE1451 objects
Component Object
Service Object
non-NCAP Block
non-IEEE1451 object

Figure 5—Relationships between Block, Component, Service, and non-IEEE objects

5.1.4 Object identifying properties

An Object's identifying properties are the Object's

— Class ID

— Class Name

— Object ID

— Object Tag

— Object Name

— Object Dispatch Address

NOTES

1—With the exception of Object Dispatch Address, the representations of the listed items are defined by this standard. The representation of an Object Dispatch Address is specific to each underlying communication network and IEEE 1451.1 implementation.

2—With the exception of Object Tag, the properties are "read only" from a remote NCAP.

5.1.4.1 Properties of Class ID

An Object's Class ID

— Identifies the Object's class

— Identifies the position in the class hierarchy of the Object's class

— Helps identify the Object's semantics

— Is established by the creator of the class

— Cannot be modified

— Is unique for the classes defined in this standard

5.1.4.2 Properties of Class Name

An Object's Class Name

— Provides a human-readable description of the semantics of the class

— Is established by the creator of the class

— Cannot be modified

— Is unique for the classes specified in this standard

NOTE—For those classes specified by this standard, Class Names are represented using the IEEE 1451.1 character set; see Annex F.

5.1.4.3 Properties of Object ID

An Object's Object ID

— Is unique within a system. This standard specifies several algorithms for generating values for Object ID that are unique for all systems; see 8.2.3.5.

— Unambiguously distinguishes the Object from any other Object.

— Unless fixed, that is "read only," is generated by the Object's Local NCAP Block.

5.1.4.4 Properties of Object Tag

An Object's Object Tag

— Defines a logical endpoint for the server side of client-server communications

— Is usually assigned by the end user as a part of the system configuration process

— Is preferably unique within a given system

5.1.4.5 Properties of Object Name

An Object's Object Name

— Provides a human-readable semantic description of an instance of a class
— Is usually established by an IEEE 1451.1 component developer or system developer
— Is bound when the Object is created

5.1.4.6 Properties of Object Dispatch Address

An Object's Object Dispatch Address

— Provides an unambiguous network communication reference for the Object
— Shall be unique within an executing system
— Is communication network and IEEE 1451.1 implementation-specific

5.2 Data model specifications

The IEEE 1451.1 data model specifies the type and form of the information communicated across the IEEE 1451.1-specified Object interfaces in both local and remote communications. The model is realized in an implementation of IEEE 1451.1 as a collection of primitive datatypes and a collection of structure datatypes. Listed here are examples of the datatypes.

A complete description of all of the IEEE 1451.1 datatypes is given in Clause 6.

5.2.1 Primitive types

The data model includes the usual variety of primitive datatypes and arrays of these types, including

— A Boolean type
— An octet type
— Integer types
— Floating point types
— String types

5.2.2 Structure types

5.2.2.1 Physical quantity types

The data model has a number of data structures designed for use in measurement and control systems. These datatypes include
— Datatypes for representing time
— Datatypes for representing the value of a physical quantity
— Datatypes for representing the metadata of a physical quantity (e.g., the units of a measurement)

5.2.2.2 Object property types

There are several structure datatypes used to carry information about Objects. These types include

— `ObjectProperties`
— `ClientPortProperties`
— `PublisherInformation`

5.2.2.3 Network communication related types

There are several IEEE 1451.1 datatypes used in network communications.

The following datatypes are used to direct and filter publications:

— `PublicationTopic`

— `SubscriptionQualifier`

— `PubSubDomain`

A special IEEE 1451.1-specified datatype shall be used to represent application data in all IEEE 1451.1 network communications. This datatype, `Argument`, is a container, which can hold any of the other IEEE 1451.1 types. All application data in a network communication shall be carried in arrays of `Argument`, the `ArgumentArray` datatype.

5.3 Network communication models

The IEEE 1451.1 standard provides two models of network communication between objects in an IEEE 1451.1 system

— A tightly coupled, point-to-point client-server model for one-to-one communications

— A loosely coupled, publish-subscribe model, for one-to-many and many-to-many communications

The communication models define the syntax and the semantics of the software interfaces between application objects and a communications network. The IEEE 1451.1 standard does this by specifying Client, Publisher, and Subscriber Port Objects and the `Perform` operation on Server Objects. These interfaces are independent of the specific network being used.

The IEEE 1451.1 standard does not specify any network transfer syntax or protocol. For each specific network, it is expected that network software suppliers will provide code libraries that contain routines for the calls between the IEEE 1451.1 communication operations and the network. These libraries will include marshaling and demarshaling routines for transforming IEEE 1451.1 datums to and from their on-the-wire format. In this standard, the services provided by such a library are collectively referred to as the network infrastructure.

Although the IEEE 1451.1 communication models are presented only as network communication models, these presentations shall not preclude implementations of IEEE 1451.1 that bypass the network for communications within the same NCAP process.

NOTE—It is expected that many of the details of both client-server and publish-subscribe operations will be hidden from application developers by the network-specific libraries and generic Function Blocks, Components, and Services provided by manufacturers. In particular, Operation IDs and the details of `Execute`, `ExecuteAsynchronous`, and `Perform` may be hidden from application writers dealing primarily with Blocks.

5.3.1 Client-server communication

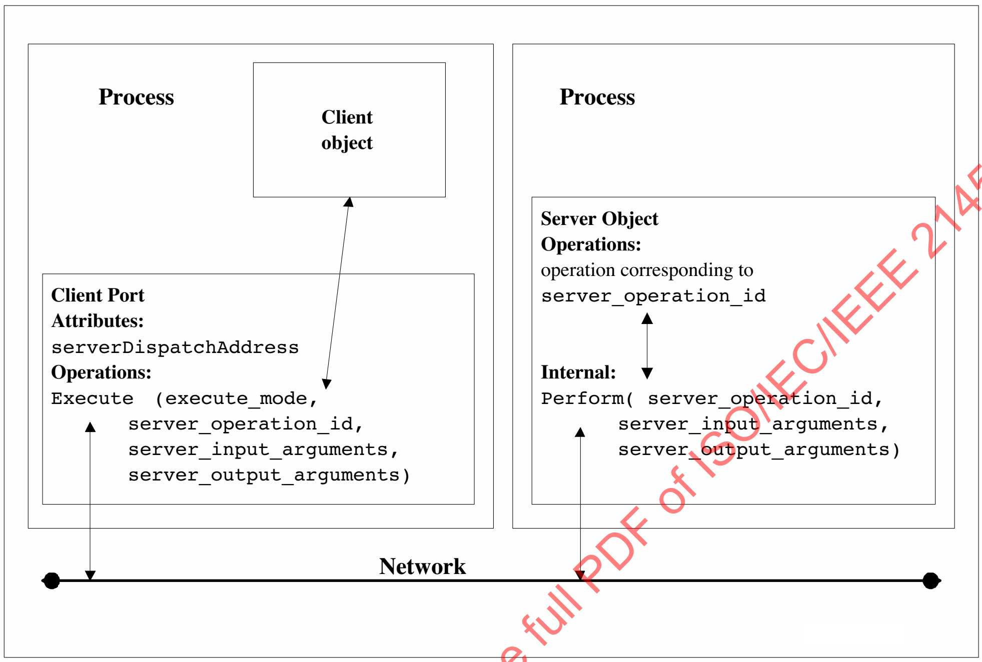
The client-server communication model is supported by two complementary application-level operations

— `Execute` on client-side Client Port Objects

— `Perform` on all Network Visible, server-side Objects

The `Execute` and the `Perform` operations work together to provide a remote-object-operation-invocation style messaging service.

The object organization providing client-server communications is illustrated in Figure 6.



Process
Client object
Client Port
Attributes:
serverDispatchAddress
Operations:
Execute (execute_mode, server_operation_id, server_input_arguments, server_output_arguments)
Process
Server Object
Operations:
operation corresponding to server_operation_id
Internal:
Perform(server_operation_id, server_input_arguments, server_output_arguments)
Network

Figure 6—Client-server communication components

The steps required for a Client object to remotely invoke an operation on a Server Object are as follows:

Step 1: During system commissioning, the `serverDispatchAddress` attribute of a Client Port Object in the Client object's process space is bound to the Server Object's Object Dispatch Address value.

Step 2: During system initialization, the Client object is provided with a reference to the Client Port Object.

Step 3: The Client object invokes the `Execute` operation on the Client Port Object, indicating which operation of the remote Server Object is to be executed. It provides that operation's input arguments and references to its output arguments, each encoded into an Argument Array; see 11.4.1.1.

Step 4: Using the network infrastructure, the invocation of the Client Port Object's `Execute` operation results in the invocation of the `Perform` operation on the target Server Object.

Step 5: The `Perform` operation then invokes the desired Server Object operation.

Step 6: When the Server Object's operation completes, it returns to `Perform` with its output arguments bound.

Step 7: The `Perform` operation uses the network infrastructure to return the operation's results to the Client Port Object.

Step 8: The `Execute` operation returns to the invoking Client object with the output Argument Array's Arguments bound.

NOTES

1—The `Execute` operation on a Client Port Object also supports a "send and forget" messaging mode. In this mode, the operation returns to the invoking Client object as soon as the message is transmitted. Any returns from the remote server operation are ignored.

2—There is a second type of Client Port, the `IEEE1451_AsynchronousClientPort.` This Port type provides an `ExecuteAsynchronous` operation, which returns to the invoking Client object as soon as the message is transmitted. Later, the client can query the Port as to whether the remote server operation has completed and, if so, request from the Port any returned data.

3—For more details on Client-server interactions see Clause 11 and Annex B.

5.3.2 Publish-subscribe communication

The publish-subscribe communication model provides a loosely coupled mechanism for network communications between objects where the sending object, the Publisher object, does not need to be aware of the receiving objects, the Subscriber objects.

The IEEE 1451.1 publish-subscribe communication model is supported by two operations

— `Publish` on Publisher Port Objects
— `AddSubscriber` and an associated callback operation on Subscriber Port Objects

The object organization providing publish-subscribe communications is illustrated in Figure 7.

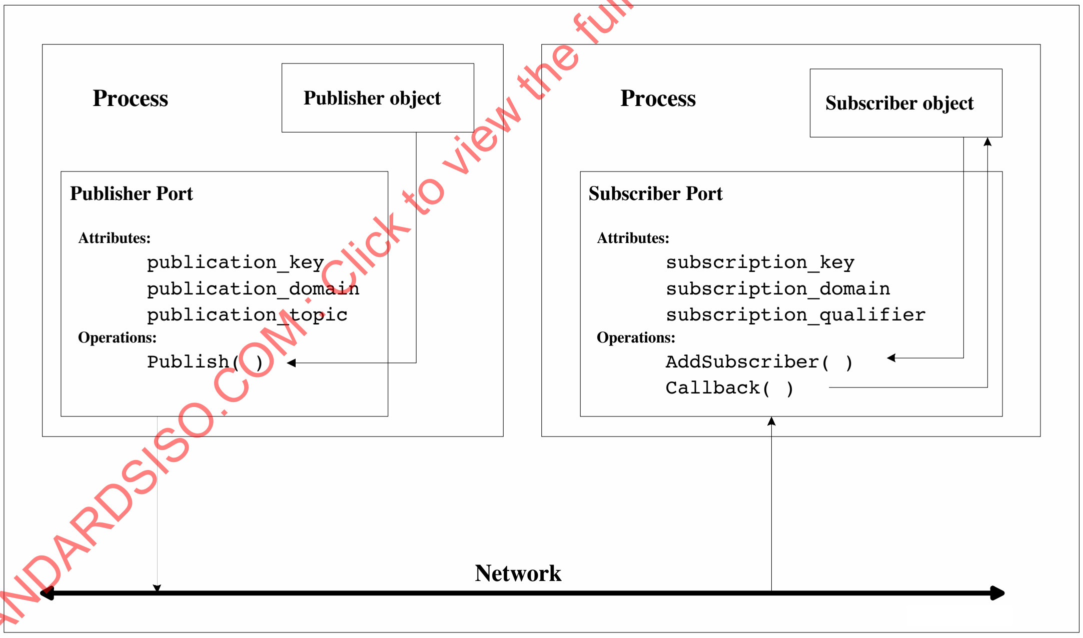


Figure 7—Publish-subscribe communication components

Each IEEE 1451.1 publication carries with it

— A Publication Domain that defines a distribution scope for the publication
— A Publication Key that identifies the application-independent syntax and semantics of the publication from the Publisher's point of view
— A Publication Topic that can be used to identify the application-specific syntax and semantics for the publication's contents

A Subscriber Port Object has the attributes

— Subscription Domain

— Subscription Key

— Subscription Qualifier

The combination of Domains, keys, and topics/qualifiers allows only those publications of interest to a Subscriber object to be selected from publications received by a Subscriber Port.

The IEEE 1451.1 publish-subscribe process is as follows:

Step 1: During IEEE 1451.1 system initialization

— The Publication Key attribute of a Publisher Port Object in the Publisher object's process space is bound.

— The Subscription Key attribute of a Subscriber Port Object in the Subscriber object's process space is bound to a value matching the Publication Key of publications of interest.

— The Publisher object is provided with a local reference to the Publisher Port Object.

— The Subscriber object is provided with a local reference to the Subscriber Port object.

Step 2: During system commissioning

— The Publication Domain and Publication Topic attributes of the Publisher Port Object are bound

— The Subscription Domain and Subscription Qualifier attributes of the Subscriber Port Object are bound to values that "match" the values of the Publisher Port Object's Publication Domain and Publication Topic attributes, respectively, so that precisely the desired publications are selected

— The Subscriber object uses the Subscriber Port Object's `AddSubscriber` operation to register with the Port its interest in receiving the publications selected by the Port. The `AddSubscriber` operation requires as an input argument a reference to an operation on the Subscriber object that is invoked by the Port whenever a selected publication is received. This operation is called a subscriber callback operation and is shown in Figure 7.

Step 3: Any time after the system is commissioned

— The Publisher object invokes the `Publish` operation on its associated local Publisher Port passing in as an input argument the publication's contents.

— Using the network infrastructure, the invocation of the `Publish` operation results in the delivery of the publication to all Subscriber Ports in the publication's Domain.

— The receiving Subscriber Ports each use the values of their Subscription Key, Subscription Domain, and Subscription Qualifier attributes to filter the incoming publication.

— If the publication passes a Subscriber Port's filter, the Port invokes all of its registered Subscribers' callback operations, see Figure 7, providing as an input argument the publication's contents. Subscribers register using the `AddSubscriber` operation, 11.10.2.1.

NOTES

1—IEEE 1451.1 provides other types of publisher ports

— The `IEEE1451_SelfIdentifyingPublisherPort` class (publications contain information about the Publisher)

— The `IEEE1451_EventGeneratorPublisherPort` class (publications have special contents that include a description of when the event occurred)

2—For more details on publish-subscribe interactions, see Clause 11 and Annex C.

5.4 IEEE 1451.1 users

There are three primary categories of users of the IEEE 1451.1 standard. These user categories are referred to throughout the remaining clauses of the standard.

The primary categories of users of the IEEE 1451.1 standard are

— System developers

— Component developers

— End users

5.4.1 System developers

These are primarily manufacturers of

— NCAPs

— NCAP Block classes

— Transducer Block classes

— Other Object classes

— Network-specific infrastructure libraries

5.4.2 Component developers

These are primarily manufacturers of reusable Function Block classes to be used as components in IEEE 1451.1 systems.

5.4.3 End users

These are primarily builders or installers of specific end-use Application Systems.

NOTES

1—It is expected that system developers manufacturing NCAPs will also provide software implementing the IEEE 1451.1 standard on those NCAPs. It is expected that these system developers will deliver an `IEEE1451_NCAPBlock` class and one or more variations of the class `IEEE1451_TransducerBlock` all integrated with their hardware. This software will allow application functionality to be realized by application-specific `IEEE1451_FunctionBlock` classes, including the possibility of downloading these Block classes over the network. Likewise, it is expected that component developers will provide reusable `IEEE1451_FunctionBlock` classes implementing common application functions. The standard does specify mechanisms to aid in integrating “off-the-shelf” blocks into an Application System. These mechanisms include the File components and the various registration features of the NCAP Block. The details will be implementation-specific.

2—End users may use components obtained from the system developers and the component developers or, in some cases, develop their own specialization of components provided by developers.

6. Datatypes in an IEEE 1451.1 system

For every datatype defined in an IEEE 1451.1 system, there shall be a default value designated. Quantities declared as having a type shall be instantiated with the default value unless otherwise specified in the class specification. The normative definitions of Table 1 are used in this clause.

Table 1—Datatype conventions

Definition	Meaning
IDL: `typedef <datatype> <datatypeArray>[ ];`	An implementation of IEEE 1451.1 Array of the datatype: `<datatype>.`
IDL: `typedef <datatype1> <datatype2>;`	Where `<datatype1>` is a primitive or previously defined IEEE 1451.1 datatype, it shall mean that `<datatype2>` is a mnemonic synonym for `<datatype1>.`

If an IEEE 1451.1 datatype appears in the signature of one or more IEEE 1451.1-specified Network Visible operations, it has its own `TypeCode`. This is the case even when that the datatype is a mnemonic synonym for another datatype. The datatype synonyms are used for semantic clarity in both the IEEE 1451.1 standard and implementations of the standard.

6.1 Primitive datatypes

The datatypes defined in Table 2 shall be defined in all IEEE 1451.1 systems. All other datatypes shall be derived from these primitive types.

The definition of data of these types shall be correctly represented in the local system after such data has been communicated over the network.

6.1.1 Simple primitive types

In any IEEE 1451 implementation, these datatypes shall be mapped to implementation language-dependent primitives.

Table 2—Simple primitive types

Datatype	Default value	Definition
`Boolean`	`FALSE`	`TRUE` or `FALSE`
`Integer8`	0	8-bit signed integer
`UInteger8`	0	8-bit unsigned integer
`Integer16`	0	16-bit signed integer
`UInteger16`	0	16-bit unsigned integer
`Integer32`	0	32-bit signed integer
`UInteger32`	0	32-bit unsigned integer
`Integer64`	0	64-bit signed integer
`UInteger64`	0	64-bit unsigned integer
`Float32`	+0.0	IEEE Std 754-1985 single-precision floating point number [IEEE 754]
`Float64`	+0.0	IEEE Std 754-1985 double-precision floating point number [IEEE 754]
`Octet`	All bits set to 0	8-bit quantity not interpreted as a number

6.1.2 Type `String` specification

IDL: struct `String`

```
{
   UInteger8 characterSet;
   UInteger8 characterCode;
   UInteger8 language;
   OctetArray stringData;
  };
```

The default value for a variable of type `String` shall be the String with `stringData` of length 0, and the values of `characterSet`, `characterCode`, and `language` all 0.

IDL: `typedef String StringArray[];`

The default value for a `StringArray` shall be the 0-length Array of that type.

6.1.2.1 Member `characterSet` specification

The allowed values of `characterSet` shall be taken from the `StringCharacterSet` enumeration shown in Table 3. The informative column indicates the standard that defines the referenced character set and the common usage. The default value for `characterSet` shall be 0.

IDL: enumeration `StringCharacterSet;`

Table 3—`StringCharacterSet` enumeration

Value	Enumeration	Meaning (informative)
0	SCS_Latin1	ISO 8859-1:1988 Latin characters: set 1
1	SCS_Latin2	ISO 8859-2:1999 Latin characters: set 2
2	SCS_Latin3	ISO 8859-3:1999 Latin characters: set 3
3	SCS_Latin4	ISO/IEC 8859-4:1998 Latin characters: set 4
4	SCS_Cyrillic	ISO 8859-5:1999 Cyrillic characters
5	SCS_Arabic	ISO 8859-6:1999 Arabic characters
6	SCS_Greek	ISO 8859-7:1987 Greek characters
7	SCS_Hebrew	ISO 8859-8:1999 Hebrew characters
8	SCS_Latin5	ISO/IEC 8859-9:1999 Latin characters: set 5
9	SCS_Latin6	ISO/IEC 8859-10:1998 Latin characters: set 6
10	SCS_ASCII	ANSI X3.4:1986 (Reaff 1992) same characters as ASCII, and ISO 646 IRV
11	SCS_10646L1UCS2	ISO 10646-1, level 1:1993 UCS 2 characters
12	SCS_10646L2UCS2	ISO 10646-1, level 2:1993 UCS 2 characters
13	SCS_10646L1UCS4	ISO 10646-1, level 1:1993 UCS 4 characters
14	SCS_10646L2UCS4	ISO 10646-1, level 2:1993 UCS 4 characters
15	SCS_Japanese1978	JIS X0208:1997 Japanese characters circa 1978
16	SCS_Japanese1990	JIS X0212:1990 Japanese supplemental set
17	SCS_Korea	KS X 1001:1992 Korean basic set
18	SCS_PRC	GB 2312-80: 1980 characters of the People's Republic of China
19	SCS_Taiwan	CNS 11643-1992:1992 characters used in Taiwan
20	SCS_Thailand	TIS 620-2529:1990 characters used in Thailand
21	SCS_KOREA_SUP	KS X 1002:1991 Korean supplemental set
22–254		Reserved for future expansion
255	SCS_IEEE1451DOT1	Annex F: characters used for certain Strings in this standard

6.1.2.2 Member `characterCode` specification

The allowed values of `characterCode` shall be taken from the `StringCharacterCode` enumeration shown in Table 4. The informative column indicates the standard that defines the referenced character code width and the common usage. The default value for `characterCode` shall be 0.

IDL: enumeration `StringCharacterCode;`

Table 4—`StringCharacterCode` enumeration

Value	Enumeration	Meaning (informative)
0	`SCC_OCTET1`	1 Octet fixed-width
1	`SCC_OCTET2`	2 Octets fixed-width
2	`SCC_OCTET4`	4 Octets fixed-width
3	`SCC_2022`	ISO 2022:1994
4	`SCC_SJIS`	Shift-JIS (SJIS) Japan
5	`SCC_6429`	ISO/IEC 6429:1992
6	`SCC_UTF8`	FSS-UTF AT&T's "File System Safe Universal Transformation Format." See also ISO 10646-1
7	`SCC_EUC`	ISO 2022:1994 "Extended UNIX Code" (EUC).
8	`SCC_2022_JP`	ISO 2022:1994 locale specific
9	`SCC_2022_JP1`	ISO 2022:1994 locale specific
10	`SCC_2022_JP2`	ISO 2022:1994 locale specific
11	`SCC_2022_CN`	ISO 2022:1994 locale specific
12	`SCC_2022_CN_EXT`	ISO 2022:1994 locale specific
13	`SCC_2022_KR`	ISO 2022:1994 locale specific
14	`SCC_EUC_JP`	ISO 2022:1994 "Extended UNIX Code" (EUC) local variant Japan
15	`SCC_EUC_KR`	ISO 2022:1994 "Extended UNIX Code" (EUC) local variant Korea
16	`SCC_EUC_CN`	ISO 2022:1994 "Extended UNIX Code" (EUC) local variant PRC
17	`SCC_EUC_TW`	ISO 2022:1994 "Extended UNIX Code" (EUC) local variant Taiwan
18–255		Reserved for future expansion

Unless otherwise specified by the relevant standard, the octet order of a multi-octet character representation, shall be big endian.

NOTE—The term big endian commonly used in computer technology is defined as follows:

> Let C be a byte-addressable computer and d any addressable, multiple-byte integer datum in C's store. For example, d might be a 32-bit unsigned integer or a 16-bit signed integer. The address of d is always the numerically least byte address of the bytes comprising d.
>
> The computer C is said to have a little endian (or right-to-left) architecture if the address of d is the address of d's low-order byte. C is said to have a big endian (or left-to-right) architecture if the address of d is the address of d's high-order byte.

6.1.2.3 Member `language` specification

The allowed values of `language` shall be taken from the `StringLanguage` enumeration. The default value for `language` shall be 0.

IDL: enumeration `StringLanguage;`

The enumerated value corresponds to the languages of the [ISO 639] standard. Only edition 1988-04-01 of [ISO 639] shall be used. (For the assignment of values for this enumeration, see Annex G).

All languages listed in edition 1988-04-01 of the [ISO 639] standard have enumeration values assigned in Annex G. The enumerated value for languages not listed in Annex G shall not use the reserved enumeration values from 137 to 252.

6.1.2.3.1 Representing languages other than specified by 6.1.2.3

Two values of the enumeration, 253 and 254, are available to users who wish to use languages other than specified by 6.1.2.3. The print behavior of Strings using the values 253 and 254 is outside the scope of this standard.

The enumeration value 255 indicates that the language is the IEEE 1451.1 language defined in Annex F, for use in certain Strings specified by this standard.

6.1.2.4 Member `stringData` specification

The contents of the Octet Array `stringData` shall be the representation of the desired String using character representations defined for the language specified in the `language` field.

6.1.2.5 String semantics

The IEEE1451.1 `String` datatype appears in the signatures of operations for two different purposes

— To provide human-readable information only. Strings used for this purpose never need to be compared, parsed, or otherwise processed for any of the operations or behaviors mandated by this standard. Examples are the String returned by `GetBlockManufacturerID` or `GetBlockModelNumber` on the NCAP Block.

— To provide human-readable information and as an input to a computation such as a comparison. The String returned by the `GetObjectName` operation on any Object is an example. This String is used to convey human-readable information, for example, to a configuration tool. This String is also used as a “key” in the operation `LookupMembersByName` on the Component Group Class. This comparison is done according to the matching algorithm described later in this clause.

Annex F defines a character set, the IEEE 1451.1 character set, that is used to represent

— All Strings defined by this standard representing the name of an Object as returned by `GetObjectName`; see 8.2.1.4.

— All Strings representing the name of a class defined by this standard as returned by `GetClassName`; see 8.1.1.1.

Two Strings shall be identical if, and only if, all of the following are true:

— They have identical `characterSet` values

— They have identical `characterCode` values

— They have identical `language` values

— The lengths of their `stringData` members are identical

— An octet-by-octet comparison of their `stringData` members indicates that corresponding octets of the two `stringData` members are identical

where `characterSet`, `characterCode`, `language`, and `stringData` values are the member values of the String datums being compared.

NOTE—Configuration tools may present information about Object Tags, Publication Topics, and Subscription Qualifiers to users; see Annex D. All of these are of underlying type `OctetArray`. There is no print form specified. The only computations defined on these quantities are matching algorithms. The generation of print forms for use in configuration tools is outside the scope of this standard.

6.1.3 Type `ObjectDispatchAddress` specification

IDL: `ObjectDispatchAddress;`

This type is specific to the network used for communication.

6.2 Derived datatypes

The datatypes in this clause are based on the primitive datatypes. The definition of data of these types shall be correctly represented in the local system after the data has been communicated over the network.

Only the primitive or derived datatypes defined in this clause shall be allowed as part of the signature for any IEEE 1451 system operation. Purely local operations, except those specified in this standard, may use any user-defined datatypes, deemed appropriate by the implementer. Data based on such user-defined datatypes shall be encoded into the IEEE 1451.1 primitive or derived datatypes if they are to be made visible over the network.

Unless otherwise stated

— The default properties for a struct type shall be the struct with each member having the default value for the member type.

— The default value for an Array type shall be the 0 length Array of that type.

Unless otherwise stated, when required, the array element with index 0, that is the 0th element, shall be designated the most significant member of the array, the element with index 1 the next most significant member, and so forth.

6.2.1 Specification of Arrays of simple primitive types

Any implementation of this standard shall provide a mechanism by which the number of elements in an IEEE 1451.1 Array can be determined. This number shall be represented as a `UInteger32`. The implementation of the mechanism is outside the scope of this standard.

```
IDL: typedef Boolean     BooleanArray[];

IDL: typedef Integer8    Integer8Array[];

IDL: typedef UInteger8   UInteger8Array[];

IDL: typedef Integer16   Integer16Array[];

IDL: typedef UInteger16  UInteger16Array[];
```

```
IDL: typedef Integer32   Integer32Array[];

IDL: typedef UInteger32  UInteger32Array[];

IDL: typedef Integer64   Integer64Array[];

IDL: typedef UInteger64  UInteger64Array[];

IDL: typedef Float32     Float32Array[];

IDL: typedef Float64     Float64Array[];

IDL: typedef Octet       OctetArray[];
```

6.2.2 Class identifier type specification

```
IDL: typedef OctetArray ClassID;
```

6.2.3 Object identifier type specifications

```
IDL: typedef OctetArray ObjectTag;
IDL: typedef ObjectTag ObjectTagArray[];
IDL: typedef OctetArray ObjectID;
```

6.2.4 Time type specifications

The `TimeRepresentation` type may be used to specify both

— Timestamps (Time with respect to an epoch)

— Time increments

```
IDL: struct TimeRepresentation

    {
     UInteger32 seconds;
     Integer32 nanoseconds;
    };
```

The range of the absolute value of the `nanoseconds` member shall be restricted to

$$0 \le \left|\texttt{nanoseconds}\right| < 10^9$$

The sign of the `nanoseconds` member shall be interpreted as the sign of the entire representation.

A negative timestamp shall indicate time prior to the epoch.

A negative increment shall result, for example, from subtracting a timestamp A from a timestamp B, where A is an instant later in time than B.

Example: A timestamp whose `seconds` member value is 10 and whose `nanoseconds` member value is -5×10^8 represents an instant 10.5 seconds before the epoch.

The `TimeInterval` type may be used to specify time intervals with a specific origin.

```
IDL: struct TimeInterval
      {
      TimeRepresentation startTime;
      TimeRepresentation deltaTime;
      };
IDL: typedef TimeRepresentation TimeRepresentationArray[];
IDL: typedef TimeInterval TimeIntervalArray[];
```

6.2.5 Bit sequence type specifications

```
IDL: typedef OctetArray BitSequence;
```

The `OctetArray` shall be interpreted on a bit-by-bit basis to represent a sequence of bits. There is no requirement that all bits of each octet be meaningful.

```
IDL: typedef BitSequence BitSequenceArray[];
```

6.2.6 Object properties structure specifications

```
IDL: struct ObjectProperties
      {
      ObjectTag objectTag;
      ObjectTag owningBlockObjectTag;
      ObjectDispatchAddress objectDispatchAddress;
      String objectName;
      UInteger16 blockCookie;
      };
IDL: ObjectProperties ObjectPropertiesArray[];


IDL: struct ClientPortProperties
      {
      ObjectTag clientPortObjectTag;
      String clientPortName;
      ObjectDispatchAddress clientPortDispatchAddress;
      ObjectTag serverObjectTag;
      ObjectDispatchAddress serverDispatchAddress;
      };
IDL: typedef ClientPortProperties ClientPortPropertiesArray[];
```

6.2.7 Return code type specifications

```
IDL: typedef UInteger16 OpReturnCode;
IDL: typedef UInteger32 ClientServerReturnCode;
```

NOTE—The internal structures of the `OpReturnCode` and `ClientServerReturnCode` types are defined in 7.2.3.1.

6.2.8 Publication Topic, Subscription Qualifier and Domain specifications

```
IDL: typedef OctetArray PublicationTopic;
IDL: typedef OctetArray SubscriptionQualifier;
IDL: typedef Octet PubSubDomain[8];
```

The length of `PubSubDomain` shall be 8 octets. The default value of `PubSubDomain` shall be value 1 for all bits in the Array.

6.2.9 Units type specifications

IEEE 1451.1 units representations shall follow the specification for units in 3.3.8 of [IEEE 1451.2].

```
IDL: typedef Octet Units[10];
```

The length of `Units` shall be 10 octets. The default value for `Units` shall be the value 0 for all bits in the Array.

```
IDL: typedef Units UnitsArray[];
```

6.2.10 Uncertainty type specifications

```
IDL: typedef struct Uncertainty
      {
      UInteger8 interpretation;
      Float32     uncertaintyValue;
      Float32     coverageFactor,
      Float32     customFactor;
      };
IDL: typedef Uncertainty UncertaintyArray[ ];
```

6.2.11 Enumeration type specifications

An enumeration member of an IEEE 1451.1 enumeration type is represented as a `UInteger8`. Unless otherwise noted, the assignment of values to the enumeration members shall start at 0 (zero), for the first member listed of an enumeration, and shall increment by +1 (one), for each succeeding member. Unless otherwise stated, the default value of an `enumeration` member shall be 0.

Any enumeration used in an IEEE 1451.1 system shall have members of the form `<prefix>_<suffix>`. Here, `<prefix>` shall be enumeration-type-specific, shall be the same for all members of the enumeration, and shall be unique in the space of all enumeration prefixes occurring in the system. This requirement shall apply to all IEEE 1451.1-specified enumerations and user-specified enumerations with the exception of the IEEE 1451.1-specified `TypeCode` enumeration. The members of the `TypeCode` enumeration, because of the special role of `TypeCode` as the discriminant type of the `Argument` union data type, have the unique form `<data_type_designator>_TC`.

6.2.11.1 Enumeration semantics

Enumerations defined in this standard always appear in operation signatures or publication formats as `UInteger8` types. For each enumeration, the value of the `UInteger8` has been assigned for each member of the enumeration. Enumerations have no “print form” specified. Implementations shall not include any operational dependency on the particular textual description used in the definition of the enumeration. Any textual description of the semantics associated with the enumeration value shall not appear in the signature of any operation, or in the format of any publication, except for informational purposes.

6.2.11.2 Enumeration summary list

Most enumerations are defined in the clause where they are first used. Table 5 provides a list of all enumerations defined in this standard along with a reference to the defining clause.

Table 5—Enumeration summary

Enumeration Name	Reference clause
`ActionState`	10.10.1.3.1
`AsynchronousClientResultStatus`	11.5.1.4.2
`BlockMajorState`	9.1.1.3.1
`CalibrationKey`	Annex H.4.2.6
`ChannelDataModel`	Annex H.4.2.5
`ChannelGrouping`	Annex H.4.2.2
`ChannelTypeKey`	Annex H.4.2.1
`CoordinateSystem`	10.7.2.5.3
`CorrectionMode`	9.5.1.3.1
`EventGeneratorState`	11.9.1.1.1
`ExecuteMode`	11.4.1.1.1
`FileState`	10.11.1.7.1
`FunctionBlockState`	9.3.1.1.1
`MajorReturnCode`	7.2.3.2.2
`MessagePriority`	11.2.1.3.1
`MinorReturnCode`	7.2.3.2.1
`NCAPBlockState`	9.2.1.1.1
`ParameterBuffering`	10.4.1.4.2
`ParameterInterpretation`	10.4.1.4.1
`PartitionedFileSubstate`	10.12.1.4.1
`PartitionReturn`	10.12.1.1
`PhysicalParameterType`	10.4.1.1.1
`PhysicalUnitsInterpretation`	Annex H.4.2.4
`PublicationContentCode`	11.8.3.4.3
`PublicationContentsReturn`	11.6.2.1
`PublisherMetadataReturn`	11.8.1.1
`PubSubKey`	12.3.2
`SetClientPortServerObjectBindingsReturn`	9.2.1.7
`StringCharacterCode`	6.1.2.2
`StringCharacterSet`	6.1.2.1
`StringLanguage`	6.1.2.3
`TimeEpoch`	13.2.1.6
`TimeType`	10.9.1.2.1
`TypeCode`	6.2.14
`UncertaintyInterpretation`	7.4.1
`UUIDAlgorithmID`	8.2.3.5.1
`Wildcard`	12.3.4

6.2.12 Structure `PublisherInformation` specification

```
IDL: struct PublisherInformation
      {
      ObjectTag portObjectTag;
      UInteger16 publicationID;
      UInteger16 publicationChangeID;
      };
```

6.2.13 Union type specifications

Any union datatype that occurs either directly or indirectly in the signature of a Network Visible operation shall be a discriminated union with the discriminant being an enumeration. A union datatype U occurs indirectly in the signature of an operation if for some data type in the signature, say T, U occurs as a node in the datatype tree representing the recursive decomposition of T into primitive datatypes.

Any instance of a discriminated union datatype shall satisfy one of the following restrictions:

— The value of the instance shall always be well defined—that is, an attempt to access the union's value shall not fail.

— There shall be a mechanism for detecting that the value is not well defined that may be used prior to attempts to access the union's value.

Attempts by the network infrastructure to marshal a union whose value is not well defined shall result in an error signaled by the return code `MJ_FAILED_MARSHALING` to the client initiating the marshaling.

In the special case of unions with discriminate of datatype `TypeCode`, the `TypeCode` enumeration has a distinguished value, `EMPTY_TC`. If the value of an instance of such a discriminated union is undefined, the value of the discriminant shall be `EMPTY_TC`.

For a discussion of discriminated unions, see [B4].

6.2.14 Type `Argument` specification

The IEEE 1451.1 type `Argument` is declared in the IDL as a discriminated union where the discriminator is a `TypeCode`.

In this standard, the term "value of the Argument" shall be interpreted as follows:

— An `Argument` is modeled as a discriminated union with an associated `TypeCode` as the discriminant.

— The member of the union corresponding to this `TypeCode` has a value represented in the datatype corresponding to this `TypeCode.`

— The "value of the Argument" shall be this member value.

More generally, for any IEEE 1451.1-specified data structure, *S*, that is declared in the IDL as a discriminated union, the term "value of the union" shall be interpreted as follows:

— The member of the union corresponding to the value of the discriminant has a value represented in the datatype corresponding to this discriminant.

— The value of the union shall be this member value.

There is a `TypeCode` for every distinct IEEE 1451.1 declared nonobject type that can be communicated over the network.

```
IDL: enumeration TypeCode
       {
       EMPTY_TC,
       ARGUMENT_ARRAY_TC,
       BIT_SEQUENCE_TC,
       BIT_-SEQUENCE_ARRAY_TC,
       BOOLEAN_TC,
       BOOLEAN_ARRAY_TC,
       CLASS_ID_TC,
       CLIENT_PORT_PROPERTIES_TC,
       CLIENT_PORT_PROPERTIES_ARRAY_TC,
       CLIENT_SERVER_RETURN_CODE_TC,
       FLOAT32_TC,
       FLOAT32_ARRAY_TC,
       FLOAT64_TC,
       FLOAT64_ARRAY_TC,
       INTEGER16_TC,
       INTEGER16_ARRAY_TC,
       INTEGER32_TC,
       INTEGER32_ARRAY_TC,
       INTEGER64_TC,
       INTEGER64_ARRAY_TC,
       INTEGER8_TC,
       INTEGER8_ARRAY_TC,
       OBJECT_DISPATCH_ADDRESS_TC,
       OBJECT_ID_TC,
       OBJECT_PROPERTIES_TC,
       OBJECT_PROPERTIES_ARRAY_TC,
       OBJECT_TAG_TC,
       OBJECT_TAG_ARRAY_TC,
       OCTET_TC,
       OCTET_ARRAY_TC,
       OP_RETURN_CODE_TC,
       PHYSICAL-_PARAMETER_DATA_TC,
       PHYSICAL_PARAMETER_DATA_ARRAY_TC,
       PHYSICAL_PARAMETER_METADATA_TC,
       PHYSICAL_PARAMETER_METADATA_ARRAY_TC,
       PUBLICATION_TOPIC_TC,
       PUBLISHER_INFORMATION_TC,
       PUBSUB_DOMAIN_TC,
       STRING_TC,
       STRING_ARRAY_TC,
       SUBSCRIPTION_QUALIFIER_TC,
       TIME_INTERVAL_TC,
       TIME_INTERVAL_ARRAY_TC,
       TIME_REPRESENTATION_TC,
       TIME_REPRESENTATION_ARRAY_TC,
       UINTEGER16_TC,
       UINTEGER16_ARRAY_TC,
       UINTEGER32_TC,
       UINTEGER32_ARRAY_TC,
       UINTEGER64_TC,
       UINTEGER64_ARRAY_TC,
       UINTEGER8_TC,
       UINTEGER8_ARRAY_TC,
       UNCERTAINTY_TC,
       UNCERTAINTY_ARRAY_TC,
       UNITS_TC,
       UNITS_ARRAY_TC
       };
```

```
IDL: union Argument switch (TypeCode)
      {
      case ARGUMENT_ARRAY_TC:
            ArgumentArray argumentArrayVal;
      case BIT_SEQUENCE_TC:
            BitSequence bitSequenceVal;
      case BIT_SEQUENCE_ARRAY_TC:
            BitSequenceArray bitSequenceArrayVal;
      case BOOLEAN_TC:
            Boolean booleanVal;
      case BOOLEAN_ARRAY_TC:
            BooleanArray booleanArrayVal;
      case CLASS_ID_TC:
            ClassID classIDVal;
      case CLIENT_PORT_PROPERTIES_TC:
            ClientPortProperties clientPortPropertiesVal;
      Case CLIENT_PORT_PROPERTIES_ARRAY_TC:
            ClientPortPropertiesArray
                  clientPortPropertiesArrayVal;
      case CLIENT_SERVER_RETURN_CODE_TC:
            ClientServerReturnCode clientServerReturnCodeVal;
      case FLOAT32_TC:
            Float32 float32Val;
      case FLOAT32_ARRAY_TC:
            Float32Array float32ArrayVal;
      case FLOAT64_TC:
            Float64 float64Val;
      case FLOAT64_ARRAY_TC:
            Float64Array float64ArrayVal;
      case INTEGER16_TC:
            Integer16 integer16Val;
      case INTEGER16_ARRAY_TC:
            Integer16Array integer16ArrayVal;
      case INTEGER32_TC:
            Integer32 integer32Val;
      case INTEGER32_ARRAY_TC:
            Integer32Array integer32ArrayVal;
      case INTEGER64_TC:
            Integer64 integer64Val;
      case INTEGER64_ARRAY_TC:
            Integer64Array integer64ArrayVal;
      case INTEGER8_TC:
            Integer8 integer8Val;
      case INTEGER8_ARRAY_TC:
            Integer8Array integer8ArrayVal;
      case OBJECT_DISPATCH_ADDRESS_TC:
            ObjectDispatchAddress objectDispatchAddressVal;
      case OBJECT_ID_TC:
            ObjectID objectIDVal;
      case OBJECT_PROPERTIES_TC:
            ObjectProperties objectPropertiesVal;
      case OBJECT_PROPERTIES_ARRAY_TC:
            ObjectPropertiesArray objectPropertiesArrayVal;
```

```
case OBJECT_TAG_TC:
      ObjectTag objectTagVal;
case OBJECT_TAG_ARRAY_TC:
      ObjectTagArray objectTagArrayVal;
case OCTET_TC:
      Octet octetVal;
case OCTET_ARRAY_TC:
      OctetArray octetArrayVal;
case OP_RETURN_CODE_TC:
      OpReturnCode opReturnCodeVal;
case PHYSICAL_PARAMETER_DATA_TC:
      PhysicalParameterData physicalParameterDataVal;
case PHYSICAL_PARAMETER_DATA_ARRAY_TC:
      PhysicalParameterDataArray
            physicalParameterDataArrayVal;
case PHYSICAL_PARAMETER_METADATA_TC:
      PhysicalParameterMetadata
            physicalParameterMetadataVal;
case PHYSICAL_PARAMETER_METADATA_ARRAY_TC:
      PhysicalParameterMetadataArray
            physicalParameterMetadataArrayVal;
case PUBLICATION_TOPIC_TC:
      PublicationTopic publicationTopicVal;
case PUBLISHER_INFORMATION_TC:
      PublisherInformation publisherInformationVal;
case PUBSUB_DOMAIN_TC:
      PubSubDomain pubsubDomainVal;
case STRING_TC:
      String stringVal;
case STRING_ARRAY_TC:
      StringArray stringArrayVal;
case SUBSCRIPTION_QUALIFIER_TC:
      SubscriptionQualifier subscriptionQualifierVal;
case TIME_INTERVAL_TC:
      TimeInterval timeIntervalVal;
case TIME_INTERVAL_ARRAY_TC:
      TimeIntervalArray timeIntervalArrayVal;
case TIME_REPRESENTATION_TC:
      TimeRepresentation timeRepresentationVal;
case TIME_REPRESENTATION_ARRAY_TC:
            TimeRepresentationArray
            timeRepresentationArrayVal;
case UINTEGER16_TC:
      UInteger16 uInteger16Val;
case UINTEGER16_ARRAY_TC:
      UInteger16Array uInteger16ArrayVal;
case UINTEGER32_TC:
      UInteger32 uInteger32Val;
case UINTEGER32_ARRAY_TC:
      UInteger32Array uInteger32ArrayVal;
case UINTEGER64_TC:
      UInteger64 uInteger64Val;
case UINTEGER64_ARRAY_TC:
      UInteger64Array uInteger64ArrayVal;
```

```
        case UINTEGER8_TC:
              UInteger8 uInteger8Val;
        case UINTEGER8_ARRAY_TC:
              UInteger8Array uInteger8ArrayVal;
        case UNCERTAINTY_TC:
              Uncertainty uncertaintyVal;
        case UNCERTAINTY_ARRAY_TC:
              UncertaintyArray uncertaintyArrayVal;
        case UNITS_TC:
              Units unitsVal;
        case UNITS_ARRAY_TC:
              UnitsArray unitsArrayVal;
              };

IDL: typedef Argument ArgumentArray[];
```

6.2.15 Physical Parameter related structure specifications

```
IDL: struct PhysicalParameterSingletonData
        {
        ArgumentArray value;
        TimeRepresentation timestamp;
        };

IDL: struct PhysicalParameterSeriesData
        {
        ArgumentArray value;
        TimeRepresentation timestamp;
        Argument abscissaIncrement;
        Argument abscissaOrigin;
        };

IDL: union PhysicalParameterData switch (PhysicalParameterType)
        {
        case PP_SCALAR_ANALOG:
              PhysicalParameterSingletonData singletonData;
        case PP_SCALAR_DISCRETE:
              PhysicalParameterSingletonData singletonData;
        case PP_SCALAR_DIGITAL:
              PhysicalParameterSingletonData singletonData;
        case PP_SCALAR_ANALOG_SERIES:
              PhysicalParameterSeriesData seriesData;
        case PP_SCALAR_DISCRETE_SERIES:
              PhysicalParameterSeriesData seriesData;
        case PP_SCALAR_DIGITAL_SERIES:
              PhysicalParameterSeriesData seriesData;
        case PP_VECTOR_ANALOG:
              PhysicalParameterSingletonData singletonData;
        case PP_VECTOR_DISCRETE:
              PhysicalParameterSingletonData singletonData;
        case PP_VECTOR_DIGITAL:
              PhysicalParameterSingletonData singletonData;
        case PP_VECTOR_ANALOG_SERIES:
              PhysicalParameterSeriesData seriesData;
        case PP_VECTOR_DISCRETE_SERIES:
              PhysicalParameterSeriesData seriesData;
        case PP_VECTOR_DIGITAL_SERIES:
              PhysicalParameterSeriesData seriesData;
        };

IDL: typedef PhysicalParameterData PhysicalParameterDataArray[];

IDL: struct ScalarAnalogMetadata
        {
        String parameterName;
        UInteger8 parameterInterpretation;
        UInteger8 buffering;
        UInteger8 datatype;
        Units units;
        Argument upperLimit;
        Argument lowerLimit;
        Uncertainty uncertainty;
        };

IDL: struct ScalarDigitalMetadata
        {
        String parameterName;
        UInteger8 parameterInterpretation;
        UInteger8 buffering;
        UInteger8 datatype;
        Units units;
        UInteger16 numberOfOctets;
        UInteger16 numberOfSignificantBits;
        Boolean rightJustifiedFlag;
        };

IDL: struct ScalarDiscreteMetadata
        {
        String parameterName;
        UInteger8 parameterInterpretation;
        UInteger8 buffering;
        UInteger8 datatype;
        Units units;
        Argument upperLimit;
        Argument lowerLimit;
        };

IDL: struct ScalarAnalogSeriesMetadata
        {
        String parameterName;
        UInteger8 parameterInterpretation;
        UInteger8 buffering;
        UInteger8 datatype;
        Units units;
        Argument upperLimit;
        Argument lowerLimit;
        Units abscissaUnits;
        Argument abscissaIncrement;
```

```
      Argument abscissaOrigin;
      Uncertainty abscissaIncrementUncertainty;
      Uncertainty abscissaOriginUncertainty;
      Uncertainty uncertainty;
      };
```

IDL: `struct ScalarDigitalSeriesMetadata`

```
      {
      String parameterName;
      UInteger8 parameterInterpretation;
      UInteger8 buffering;
      UInteger8 datatype;
      Units units;
      Units abscissaUnits;
      Argument abscissaIncrement;
      Argument abscissaOrigin;
      Uncertainty abscissaIncrementUncertainty;
      Uncertainty abscissaOriginUncertainty;
      UInteger16 numberOfOctets;
      UInteger16 numberOfSignificantBits;
      Boolean rightJustifiedFlag;
      };
```

IDL: `struct ScalarDiscreteSeriesMetadata`

```
      {
      String parameterName;
      UInteger8 parameterInterpretation;
      UInteger8 buffering;
      UInteger8 datatype;
      Units units;
      Argument upperLimit;
      Argument lowerLimit;
      Units abscissaUnits;
      Argument abscissaIncrement;
      Argument abscissaOrigin;
      Uncertainty abscissaIncrementUncertainty;
      Uncertainty abscissaOriginUncertainty;
      };
```

IDL: `struct VectorAnalogMetadata`

```
      {
      String parameterName;
      UInteger8 parameterInterpretation;
      UInteger8 buffering;
      UInteger16 dimension;
      CoordinateSystem coordinateSystem;
      UInteger8Array datatype;
      UnitsArray units;
      ArgumentArray upperLimit;
      ArgumentArray lowerLimit;
      UncertaintyArray uncertainty;
      };
```

```
IDL: struct VectorDigitalMetadata
       {
       String parameterName;
       UInteger8 parameterInterpretation;
       UInteger8 buffering;
       UInteger16 dimension;
       CoordinateSystem coordinateSystem;
       UInteger8Array datatype;
       UnitsArray units;
       UInteger16 Array numberOfOctets;
       UInteger16 Array numberOfSignificantBits;
       Boolean Array rightJustifiedFlag;
       };

IDL: struct VectorDiscreteMetadata
       {
       String parameterName;
       UInteger8 parameterInterpretation;
       UInteger8 buffering;
       UInteger16 dimension;
       CoordinateSystem coordinateSystem;
       UInteger8Array datatype;
       UnitsArray units;
       ArgumentArray upperLimit;
       ArgumentArray lowerLimit;
       };

IDL: struct VectorAnalogSeriesMetadata
       {
       String parameterName;
       UInteger8 parameterInterpretation;
       UInteger8 buffering;
       UInteger16 dimension;
       CoordinateSystem coordinateSystem;
       Units abscissaUnits;
       Argument abscissaIncrement;
       Argument abscissaOrigin;
       Uncertainty abscissaIncrementUncertainty;
       Uncertainty abscissaOriginUncertainty;
       UInteger8Array datatype;
       UnitsArray units;
       ArgumentArray upperLimit;
       ArgumentArray lowerLimit;
       UncertaintyArray uncertainty;
       };

IDL: struct VectorDigitalSeriesMetadata
       {
       String parameterName;
       UInteger8 parameterInterpretation;
       UInteger8 buffering;
       UInteger16 dimension;
       CoordinateSystem coordinateSystem;
       Units abscissaUnits;
```

```
        Argument abscissaIncrement;
        Argument abscissaOrigin;
        Uncertainty abscissaIncrementUncertainty;
        Uncertainty abscissaOriginUncertainty;
        UInteger8Array datatype;
        UnitsArray units;
        UInteger16Array numberOfOctets;
        UInteger16Array numberOfSignificantBits;
        BooleanArray rightJustifiedFlag;
        };

IDL: struct VectorDiscreteSeriesMetadata
        {
        String parameterName;
        UInteger8 parameterInterpretation;
        UInteger8 buffering;
        UInteger16 dimension;
        CoordinateSystem coordinateSystem;
        Units abscissaUnits;
        Argument abscissaIncrement;
        Argument abscissaOrigin;
        Uncertainty abscissaIncrementUncertainty;
        Uncertainty abscissaOriginUncertainty;
        UInteger8Array datatype;
        UnitsArray units;
        ArgumentArray upperLimit;
        ArgumentArray lowerLimit;
        };

IDL: union PhysicalParameterMetadata switch
              (PhysicalParameterType)
        {
        case PP_SCALAR_ANALOG:
              ScalarAnalogMetadata scalarAnalogMetadata;
        case PP_SCALAR_DISCRETE:
              ScalarDiscreteMetadata scalarDiscreteMetadata;
        case PP_SCALAR_DIGITAL:
              ScalarDigitalMetadata scalarDigitalMetadata;
        case PP_SCALAR_ANALOG_SERIES:
              ScalarAnalogSeriesMetadata
                    scalarAnalogSeriesMetadata;
        case PP_SCALAR_DISCRETE_SERIES:
              ScalarDiscreteSeriesMetadata
                    scalarDiscreteSeriesMetadata;
        case PP_SCALAR_DIGITAL_SERIES:
              ScalarDigitalSeriesMetadata
                    scalarDigitalSeriesMetadata;
        case PP_VECTOR_ANALOG:
              VectorAnalogMetadata vectorAnalogMetadata;
        case PP_VECTOR_DISCRETE:
              VectorDiscreteMetadata vectorDiscreteMetadata;
        case PP_VECTOR_DIGITAL:
              VectorDigitalMetadata vectorDigitalMetadata;
        case PP_VECTOR_ANALOG_SERIES:
              VectorAnalogSeriesMetadata
                    VectorAnalogSeriesMetadata;
        case PP_VECTOR_DISCRETE_SERIES:
              VectorDiscreteSeriesMetadata
                    vectorDiscreteSeriesMetadata;
        case PP_VECTOR_DIGITAL_SERIES:
              VectorDigitalSeriesMetadata
                    vectorDigitalSeriesMetadata;
        };
```

```
IDL: typedef PhysicalParameterMetadata
              PhysicalParameterMetadataArray[];
```

7. Common properties

This clause specifies common properties for

- Class designators
- Object operation properties
- Expression of uncertainty in a value

7.1 Class designator properties

This clause defines the header format used in the specifications of class definitions in Clause 8 through Clause 11.

7.1.1 Class header format

Abstract Class (if required for the class definition)

Class: `IEEE1451_ClassDescriptor`

Parent Class: `IEEE1451_ParentClassDescriptor`

Class ID: `classID`

These terms are defined in Table 6.

7.1.2 Specification of Class IDs

The value of the Class ID

- Shall be of type `ClassID`, and therefore represented as Octet Arrays; see 6.2.2
- Shall encode the position of a class in the class hierarchy
- Shall consist of an ordered listing of identifiers, which constitute the path in the class tree to a particular class
- Shall be ordered such that the most significant, that is the 0th, identifier of the listing is the root of the class tree

Table 6—Class header terms

Format	Definition
Abstract Class	A class designated as an "Abstract Class" shall serve as a specification of commonality applicable to all subclasses. Abstract Classes shall not be instantiated. Only subclasses of Abstract Classes can be instantiated.
Class: `IEEE1451_ClassDescriptor`	The value of: `IEEE1451_ClassDescriptor` shall be the formal name for the class.
Parent Class: `IEEE1451_ParentClass Descriptor`	The value of: `IEEE1451_ParentClassDescriptor` shall be the `IEEE1451_ClassDescriptor` of the immediate parent class in the hierarchy from which this class is subclassed.
Class ID: `classID`	The value of `classID` shall identify the position in the IEEE 1451.1 class structure. The position in the class hierarchy implicitly defines the complete specification of an Object. Class IDs specified in this standard are unique.

7.1.2.1 Rules for Class ID identifiers

For the assignment of identifiers and for the definition of additional classes, over and above those defined in this standard, the following rules shall be followed:

— Each identifier shall be represented by a single octet, which shall be interpreted as an `UInteger8`.

— Assignment of values for the root identifier shall be restricted to specification by this standard and any subsequent balloted amendments, that is, by IEEE 1451.1 authority.

— For each subsequent identifier, (that is at any node in the class hierarchy tree), the values 0–127 shall be reserved for assignment by IEEE 1451.1 authority. (i.e., when any class is considered for refinement into subclasses, the first 128 subclasses of it shall be reserved for IEEE 1451.1 standards activity).

— All values of an identifier greater than 127 are not specified by IEEE 1451.1, but may be used by industry groups or other developers of subclasses of the classes defined by this standard.

— Manufacturers of subclasses shall assign Class ID values to their subclasses that are unique within the scope of the specific manufacturer.

— It is recommended that system integrators or developers of specific installations ensure that the Class IDs of objects in the system are unique.

Example: The Class ID with Octet Array {1,3,45} represents the identifier list 1.3.45. The list is of the form W.X.Y, where W, X, and Y are successive unsigned elements from the Octet Array interpreted as `UInteger8` numbers. The numbers denote the class, subclass, and sub-subclass identifier fields, respectively.

Two Class ID instances shall be the same if, and only if

— The number of fields is the same for both, **AND**

— All corresponding fields have the same value

7.1.2.2 Subclass determination algorithm

Given two classes, A and B, with Class IDs class_IDA and class_IDB, class A is a proper subclass of class B if, and only if

— The number of fields in class_IDB is less than the number of fields in class_IDA,

AND

— All fields of class_IDB have the same value as the corresponding fields of class_IDA

7.1.2.3 Purpose of Class IDs

The primary reasons for the hierarchically structured Class IDs are

— To provide a principled way of identifying the heritage of specializations of the IEEE 1451.1-specified classes.

— To provide a way for an object to identify its class to itself and to other objects.

For example, a server object operation may want to restrict client access to clients that are of a given class or a subclass of that class. By requiring a client's Class ID as an argument to that operation, the operation could check if a client was an acceptable client. Class names would not work for this.

7.1.3 Inherited class definition properties

For classes defined in this standard, the following shall all be inherited by the subclass definition from the parent class and grandparent class definitions up to and including the `IEEE1451_Root` class:

— All operations, both Network Visible and Local

— All publications and subscriptions

— All state machines and other material defining the class's behavior

— All required owned Objects

7.2 Object operation properties

All operation definitions include

— Implementation requirements

— Designators for the operation

— The signature of the operation

— The behavior of the operation

7.2.1 Specification of implementation requirements

All operations are indicated in the class summary for each class definition as being either

— Mandatory (m)

— Optional (o)

7.2.1.1 Mandatory (m): definition

The term Mandatory means that the referenced Network Visible functionality associated with the operation shall be implemented as specified. The major return code `MJ_NOP_OPERATION` shall not be returned for a mandatory operation. This option is designated as a Full Implementation.

7.2.1.2 Optional (o): definition

The term Optional shall designate one of two implementations of the operation

— Interface Only Implementation

— Full Implementation

7.2.1.2.1 Interface Only Implementation: definition

An implementation is defined to be an Interface Only Implementation if the designated operation has no meaning for the implementation of the class (i.e., a write on a read-only object). The invocation of the operation shall not cause any change of state of the object and shall return immediately with a major return code of: `MJ_NOP_OPERATION`. This option is designated as an Interface Only Implementation.

7.2.1.2.2 Full Implementation: definition

An implementation is defined to be a Full Implementation if the designated operation has meaning for the implementation of the class. The result of an invocation of the operation shall be exactly as required for a mandatory operation. Class specifications may include circumstances for which implementers shall fully implement the operations as defined by this clause. This option is designated as a Full Implementation.

7.2.2 Specification of designators for an operation

All operations defined in this standard are designated by an Operation Name and an Operation ID. These designators are listed in the class summary clause of each class definition.

All operations specified in this standard are invoked locally.

References to operations defined in this standard or otherwise defined can appear in the signatures of operations defined in this standard. These references appear only in the signatures of Local operations and appear only as a single "in" or "out" argument. If the specific NCAP implementation requires that references consist of more than a single piece of information, then the "in" or "out" argument of the signature shall be construed as having the appropriate structure to represent the several pieces of reference information.

Class definitions that refer to objects and operations in the Local environment as part of an operation signature denote these references as follows:

— `<local object reference>`

— `<local operation reference>`

The specification of these references shall have the indicated interpretation expressed in the local language and environment, and will be written as follows:

7.2.2.1 `<local object reference>`: definition

This shall be a local reference that allows unambiguous identification of an instance of an IEEE 1451.1 or a non-IEEE 1451.1 object. The notation `<local object reference>[]` shall be used to denote an Array of local object references.

7.2.2.2 `<local operation reference>`: definition

This reference shall provide sufficient information to allow the invocation of any local operation.

Depending on the language and implementation this reference may include a `<local object reference>` and an Operation ID or may be as simple as a local function pointer.

7.2.2.3 Operation Name: definition

The Operation Name shall be a lexical reference to the name of the operation that shall be unique within the class defining the operation. Within a class, the Operation Name and the Operation ID shall be in a one-to-one correspondence.

7.2.2.4 Operation ID: definition

The Operation ID shall provide a reference to the operation that shall be unique within the class defining the operation.

An Operation ID shall be of type `UInteger16`.

The underlying network implementations shall preserve this identifier across the network. An implementation may choose to represent these identifiers as an enumeration for clarity in code development. Enumerations of these identifiers are outside the scope of this standard.

The Operation ID allowed values shall be based on the position in the class hierarchy as defined in Table 7.

Table 7—Operation ID values restrictions

Level	Values reserved for IEEE 1451 standard	Values available to industry groups and application developers
0 (that is Root class)	0–2047	none
1	2048–3071	3072–4095
2	4096–5119	5120–6143
3	6144–7167	7168–8191
4	8192–9215	9216–10239
5	10240–11263	11264–12287
6	12288–13311	13312–14335
7	14336–15359	15360–16383
8	16384–17407	17408–18431
9	18432–19455	19456–20479
10	20480–21503	21504– 22527
11	22528–23551	23552–24575
12	24576–25599	25600–26623
$12 < N \leq 31$	2048N through 2048N + 1023	2048N +1024 through 2048N + 2047

The Operation ID assigned to operations in classes specified in this standards document are unique across all classes in addition to conforming to the values allowed by Table 7. There is no requirement that user or industry-defined subclasses assign values to the Operation ID for operations that are unique across classes.

7.2.3 Operation signature specification

All operations are specified by using IDL syntax. Operation signatures shall define the syntax of the operation by specifying

— Return codes

— Operation Name

— Arguments

— Argument order

— Formal names for arguments

Within a class definition, several operations may share the same formal name for operation arguments. If the argument specifications for these arguments with shared names are identical, they will be given at the first appearance of the formal name and not repeated throughout the class definition.

7.2.3.1 Types of return codes for operations

There are two types of return codes defined in this standard

— `OpReturnCode`

— `ClientServerReturnCode`

7.2.3.1.1 Specification of `OpReturnCode`

The `OpReturnCode` is used by most operations. The underlying type is `UInteger16`; see 6.2.7. An `OpReturnCode` shall be expressed as a sequence of two fields

— Minor Field

— Major Field

The Minor Field shall be the high-order 8 bits, interpreted as a `UInteger8`, of the `OpReturnCode` underlying type `UInteger16`.

The Major Field shall be the low-order 8 bits, interpreted as an `UInteger8`, of the `OpReturnCode` underlying type `UInteger16`.

Example: An `OpReturnCode` value of 259 would have

— A Major Field = 3

— A Minor Field = 1

The Major Field shall represent system-level return-status information while the Minor Field is operation-specific.

7.2.3.1.2 Specification of `ClientServerReturnCode`

A `ClientServerReturnCode` is used by the operations

— `Execute`

— `GetResult`

— `Perform`

The underlying type is `UInteger32`; see 6.2.7.

A `ClientServerReturnCode` shall be expressed as a sequence of fields defined in Table 8.

Table 8—`ClientServerReturnCode` fields

Field Name	Bits in Client-Server Return Code	Information
`portCode`	High-order 8 bits interpreted as an `UInteger8.`	The return code of the client-side Port Object `Execute` or `GetResult` operation. Values shall be selected from the `MajorReturnCode` enumeration.
`performCode`	Next 8 bits interpreted as an `UInteger8.`	The return code of the server-side Object `Perform` operation. Values shall be selected from the `MajorReturnCode` enumeration.
`operationMinorCode`	Next 8 bits interpreted as an `UInteger8.`	The Minor Field of the `OpReturnCode` of the operation invoked on the Server Object.
`operationMajorCode`	Lower-order 8 bits interpreted as an `UInteger8.`	The Major Field of the `OpReturnCode` of the operation invoked on the Server Object.

Example: A `ClientServerReturnCode` value of 67 240 195, that is

16 777 216 × 4 + 65 536 × 2 + 256 × 1 +1 × 3, would have the following field values:

— `portCode = 4`
— `performCode = 2`
— `operationMinorCode = 1`
— `operationMajorCode = 3`

7.2.3.2 Return Code enumeration specifications

Return code enumerations are specified for

— Minor Field
— Major Field

7.2.3.2.1 Minor Field enumeration specification

The Minor Field shall be the enumeration defined in Table 9.

IDL: enumeration `MinorReturnCode;`

— A Minor Field return other than `MI_NO_ADDITIONAL_INFORMATION,` shall be indicated by a Major Field return other than `MJ_COMPLETE.`

— A Major Field return other than `MJ_COMPLETE,` may be accompanied by a Minor Field return other than `MI_NO_ADDITIONAL_INFORMATION.`

— Classes may specify additional members of the Minor Field return code for specific operations. In those cases, the Minor Field is defined by a new enumeration. The meaning of the first six members of the new enumeration shall correspond to the first six members of the `MinorReturnCode` enumeration.

Table 9—`MinorReturnCode` values

Name	Value	Meaning
`MI_NO_ADDITIONAL_INFORMATION`	0	No additional information available.
`MI_MEMORY_ALLOCATION_ERROR`	1	Insufficient memory.
`MI_MISSING_INPUT`	2	An input argument was not provided.
`MI_INVALID_TYPE`	3	The argument type is not valid.
`MI_INVALID_VALUE`	4	The value is not valid. For example: out of range.
`MI_COMPUTATION_ERROR`	5	Math errors and exceptions.
Reserved	6–127	
User-defined	128–255	Operation-specific.

7.2.3.2.2 Major Field enumeration specification

The Major Field shall be an enumeration of the status of the operation invocation. Permitted values shall be selected from the `MajorReturnCode` enumeration defined in Table 10.

IDL: enumeration `MajorReturnCode;`

Table 10—`MajorReturnCode` values

Name	Value
`MJ_COMPLETE`	0
`MJ_NOP_OPERATION`	1
`MJ_NO_RETURN_CODE`	2
`MJ_FAILED_NON_SPECIFIC`	3
`MJ_COMMUNICATION_ERROR`	4
`MJ_BUSY`	5
`MJ_SERVICE_UNAVAILABLE`	6
`MJ_ILLEGAL_OPERATION`	7
`MJ_FAILED_INPUT_ARGUMENT`	8
`MJ_FAILED_OUTPUT_ARGUMENT`	9
`MJ_FAILED_MARSHALING`	10
`MJ_FAILED_DEMARSHALING`	11
`MJ_ILLEGAL_TRANSACTION`	12
`MJ_OPERATION_INTERRUPTED`	13
`MJ_OPERATION_TIMEOUT`	14
`MJ_INSUFFICIENT_RESOURCES`	15
`MJ_BLOCK_COOKIE_MISMATCH`	16
`MJ_TRANSDUCER_ERROR`	17
`MJ_SUSPECT_INVOCATION_RESULT`	18
`MJ_NOT_PROPERLY_CONFIGURED`	19
Reserved	20–127
User-defined	128–255

7.2.3.3 Restrictions on return codes

Unless otherwise stated, the allowed value and meaning of the Major Field of an `OpReturnCode` or the `portCode`, `performCode`, and `operationMajorCode` fields of a `ClientServerReturnCode` shall be in accordance with 7.2.3.3.1, 7.2.3.3.2, 7.2.3.3.3, and 7.2.3.3.4. Values marked N/A shall not be used in the indicated field.

7.2.3.3.1 Restrictions on allowed `portCode` field values

Errors may be detected in the following Base Client Port operations:

— `Execute`; see 11.4.2.3

— `GetResult`; see 11.5.2.7.1

These errors shall be indicated by an entry in the `portCode` field. The allowed values shall be selected from Table 11.

Table 11—Allowed `portCode` values

Name	Meaning
MJ_COMPLETE	No Base Client Port errors detected.
MJ_NOP_OPERATION	The Base Client Port operation was implemented with an Interface Only Implementation.
MJ_NO_RETURN_CODE	N/A
MJ_FAILED_NON_SPECIFIC	Nonspecific failure. Shall not be used if any of the subsequent enumerations apply.
MJ_COMMUNICATION_ERROR	No response from any Object at the Object Dispatch Address targeted by this Base Client Port.
MJ_BUSY	Requested operation is legal, but cannot be executed, since the Base Client Port is busy, and cannot support multiple requests.
MJ_SERVICE_UNAVAILABLE	The requested Base Client Port operation is not currently available because of some aspect of its internal state; for example, the Port is being configured.
MJ_ILLEGAL_OPERATION	Requested operation is illegal on the Base Client Port.
MJ_FAILED_INPUT_ARGUMENT	One or more operation input arguments are invalid or missing, for `Execute` or `GetResult`.
MJ_FAILED_OUTPUT_ARGUMENT	One or more operation output arguments are invalid or missing, for `Execute` or `GetResult.`
MJ_FAILED_MARSHALING	A failure to marshal to on-the-wire format.
MJ_FAILED_DEMARSHALING	A failure to demarshal from on-the-wire-format.
MJ_ILLEGAL_TRANSACTION	For `Execute`: N/A For `GetResult`: There is no such active Asynchronous Client Port transaction as indicated in the call.
MJ_OPERATION_INTERRUPTED	The operation did not complete because of errors other than a Client Port timeout expiration.
MJ_OPERATION_TIMEOUT	The indicated operation did not complete before a timeout period of the Base Client Port expired.
MJ_INSUFFICIENT_RESOURCES	Requested operation is legal but cannot be executed because of lack of resources available to the Base Client Port.
MJ_BLOCK_COOKIE_MISMATCH	N/A
MJ_TRANSDUCER_ERROR	N/A
MJ_SUSPECT_INVOCATION_RESULT	N/A
MJ_NOT_PROPERLY_CONFIGURED	The Base Client Port is not configured or is improperly configured.
Reserved	Reserved for future use by the IEEE 1451.1 standard committee.
User-defined	May be used by industry groups or implementers.

7.2.3.3.2 Restrictions on allowed `performCode` field values

Errors may be detected in the `Perform` operation on a server. These errors shall be indicated by an entry in the `performCode` field of the following operation's `ClientServerReturnCode`:

— `Perform`, see 8.2.2.1, on the Server Object, AND

— `Execute`, see 11.4.2.3, on a Client Port, OR

— `GetResult`, see 11.5.2.7.1, on an Asynchronous Client Port

The allowed values for the `performCode` field shall be selected from Table 12.

Table 12—Allowed `performCode` values

Name	Meaning
MJ_COMPLETE	`Perform` did not detect any error during execution.
MJ_NOP_OPERATION	N/A
MJ_NO_RETURN_CODE	No return code is available.
MJ_FAILED_NON_SPECIFIC	Nonspecific failure. Shall not be used if any of the subsequent enumerations apply.
MJ_COMMUNICATION_ERROR	N/A
MJ_BUSY	`Perform` cannot be executed since the server is busy and cannot support multiple requests.
MJ_SERVICE_UNAVAILABLE	`Perform` is currently not available because of some aspect of the server's internal state.
MJ_ILLEGAL_OPERATION	The requested Operation ID is not valid on the target Server Object.
MJ_FAILED_INPUT_ARGUMENT	One or more input arguments are invalid or missing for `Perform`.
MJ_FAILED_OUTPUT_ARGUMENT	One or more output arguments are invalid or missing for `Perform`.
MJ_FAILED_MARSHALING	A failure to marshal to on-the-wire format.
MJ_FAILED_DEMARSHALING	A failure to demarshal from on-the-wire-format.
MJ_ILLEGAL_TRANSACTION	N/A
MJ_OPERATION_INTERRUPTED	`Perform` did not complete.
MJ_OPERATION_TIMEOUT	N/A
MJ_INSUFFICIENT_RESOURCES	`Perform` cannot be executed because of lack of resources in the target Server Object.
MJ_BLOCK_COOKIE_MISMATCH	A Block Cookie mismatch has been detected.
MJ_TRANSDUCER_ERROR	N/A
MJ_SUSPECT_INVOCATION_RESULT	N/A
MJ_NOT_PROPERLY_CONFIGURED	N/A
Reserved	Reserved for future use by the IEEE 1451.1 standard committee.
User-defined	May be used by industry groups or implementers.

7.2.3.3.3 Restrictions on allowed Major Field and `operationMajorCode` field values

Errors may be detected in the execution of the invoked server operation. These errors shall be indicated by an entry in the Major Field of the `OpReturnCode` for the invoked operation. These entries are returned to the client via the `operationMajorCode` field of the following operation's `ClientServerReturnCode`:

— `Perform`, see 8.2.2.1, on the server, AND

— `Execute`, see 11.4.2.3, on a Client Port, OR

— `GetResult`, see 11.5.2.7.1, on an Asynchronous Client Port

The allowed values for these entries shall be selected from Table 13.

Table 13—Allowed `operationMajorCode` values

Name	Meaning
`MJ_COMPLETE`	The operation did not detect any error during execution.
`MJ_NOP_OPERATION`	The operation has an Interface Only Implementation.
`MJ_NO_RETURN_CODE`	No return code is available (not applicable to the `OpReturnCode` of the invoked operation itself).
`MJ_FAILED_NON_SPECIFIC`	Nonspecific failure. Shall not be used if any of the subsequent enumerations apply.
`MJ_COMMUNICATION_ERROR`	N/A
`MJ_BUSY`	Requested operation is legal but cannot be executed since the target Server Object is busy and cannot support multiple requests.
`MJ_SERVICE_UNAVAILABLE`	The requested service is not currently available because of the internal state of the Server Object, for example, when it is disabled.
`MJ_ILLEGAL_OPERATION`	N/A
`MJ_FAILED_INPUT_ARGUMENT`	One or more input arguments are invalid or missing.
`MJ_FAILED_OUTPUT_ARGUMENT`	One or more output arguments are invalid or missing.
`MJ_FAILED_MARSHALING`	N/A
`MJ_FAILED_DEMARSHALING`	N/A
`MJ_ILLEGAL_TRANSACTION`	There is no such server transaction as indicated in the call.
`MJ_OPERATION_INTERRUPTED`	The operation did not complete because of errors other than a server timeout.
`MJ_OPERATION_TIMEOUT`	The indicated operation did not complete before a server timeout expired.
`MJ_INSUFFICIENT_RESOURCES`	Requested operation is legal but cannot be executed because of lack of resources in the target Server Object.
`MJ_BLOCK_COOKIE_MISMATCH`	N/A
`MJ_TRANSDUCER_ERROR`	A transducer failed during operation.
`MJ_SUSPECT_INVOCATION_RESULT`	A value provided by the target may be in error (e.g., transducer overloaded, computation overflow).
`MJ_NOT_PROPERLY_CONFIGURED`	The Server Object has detected some state that is not configured or is improperly configured.
Reserved	Reserved for future use by the IEEE 1451.1 standard committee.
User-defined	May be used by industry groups or implementers.

7.2.3.3.4 Restrictions on allowed Major Field values for an `OpReturnCode`

Errors may be detected in the execution of operations having an `OpReturnCode` as part of the signature. The Major Field shall be selected from Table 14.

Table 14—Allowed OpReturnCode values

Name	Meaning
MJ_COMPLETE	The operation did not detect any error during execution.
MJ_NOP_OPERATION	The operation has an Interface Only Implementation.
MJ_NO_RETURN_CODE	N/A
MJ_FAILED_NON_SPECIFIC	Nonspecific failure. Shall not be used if any of the subsequent enumerations apply.
MJ_COMMUNICATION_ERROR	N/A (see exceptions).
MJ_BUSY	Requested operation is legal but cannot be executed since the target Object is busy and cannot support multiple requests.
MJ_SERVICE_UNAVAILABLE	The requested service is not currently available because of the internal state of the Object, for example, when it is disabled.
MJ_ILLEGAL_OPERATION	N/A
MJ_FAILED_INPUT_ARGUMENT	One or more input arguments are invalid or missing.
MJ_FAILED_OUTPUT_ARGUMENT	One or more output arguments are invalid or missing.
MJ_FAILED_MARSHALING	N/A (see exceptions).
MJ_FAILED_DEMARSHALING	N/A
MJ_ILLEGAL_TRANSACTION	There is no such transaction as indicated in the call.
MJ_OPERATION_INTERRUPTED	The operation did not complete because of errors other than a timeout defined on the target Object.
MJ_OPERATION_TIMEOUT	The indicated operation did not complete before a timeout defined on the target Object expired.
MJ_INSUFFICIENT_RESOURCES	Requested operation is legal but cannot be executed because of lack of resources in the target Object.
MJ_BLOCK_COOKIE_MISMATCH	N/A
MJ_TRANSDUCER_ERROR	A Transducer failed during operation.
MJ_SUSPECT_INVOCATION_RESULT	A value provided by the target may be in error (e.g., Transducer overloaded, computation overflow).
MJ_NOT_PROPERLY_CONFIGURED	The Object has detected some state that is not configured or is improperly configured.
Reserved	Reserved for future use by the IEEE 1451.1 standard committee.
User-defined	May be used by industry groups or implementers.

In the case of the ExecuteAsynchronous operation on an Asynchronous Client Port Object, a Publish operation on a Publisher Port, or a PublishWithIdentification operation on a Self Identifying Publisher Port, the following exceptions shall be observed:

— The Major Field value of MJ_COMMUNICATION_ERROR shall be allowed and shall indicate a general communication error.

— The Major Field value of MJ_FAILED_MARSHALING shall be allowed and shall indicate a failure to correctly marshal data.

7.2.4 The behavior of operations

7.2.4.1 Get and Set Semantics operation requirements

Get and Set Semantics operations shall obey the concurrency requirements of 7.2.4.2.

7.2.4.1.1 Get Semantics: definition

A Get Semantics operation is any operation, Network Visible or Local that allows any portion of the internal state of an object to be observed.

The returned values shall be determined by the internal behavior defined for the class.

Get Semantics operations include operations described as `Read` or with other Operation Names that potentially operate to view the internal state variables of an object.

7.2.4.1.2 Set Semantics: definition

A Set Semantics operation is any operation, Network Visible or Local, that allows any portion of the internal state of an object to be modified.

If a Set Semantics operation is provided for a class, the value that would be returned by a Get Semantics operation that precedes in time any Set Semantics operation on the same state variable shall return either

— The default value defined for the datatype of the variable

— An initial value for the variable specified as part of the class definition

— An application-specific initial value for the variable.

If a Network Visible Set Semantics operation is provided, a corresponding Network Visible Get Semantics operation shall be provided.

Set Semantics operations include operations described as `Write` or with other Operation Names that potentially operate to change the internal state variables of an object.

7.2.4.2 Concurrency requirements

The concurrency requirements of 7.2.4.2 shall apply to all IEEE 1451.1 classes or subclasses thereof. Subclass definitions shall include the specification of any additional concurrency requirements as part of each class's behavioral definition.

The term Concurrent Execution shall be interpreted to mean that subsequent to the invocation of an operation on an object, and prior to the completion of that operation, an operation is invoked on the same or a different object.

With respect to the concurrency specifications of this clause and its subclauses, the term operation shall include

— Both Network Visible and Local operations

— Any implementation-specific Local operations

— Any other object activity, including internal activity that potentially interacts with a concurrent operation

Unless otherwise stated, the resolution of concurrency violations is outside the scope of this standard.

In 7.2.4.2, serialization of two operations shall be interpreted as meaning that one operation completes before the second operation starts execution.

The management of the various forms of Concurrent Execution is specified in 7.2.4.2.1 and 7.2.4.2.2.

These and other related problems are inherent in distributed systems. Analogous difficulties arise in centralized systems. These problems are the subject of a rich literature [B1].

7.2.4.2.1 Inter-NCAP concurrency specifications

Any IEEE 1451.1 system that has more than one NCAP is a distributed multiprocessor system and, as such, must contend with inter-NCAP concurrent, asynchronous operation execution.

The management of inter-NCAP concurrency is outside the scope of this standard.

To help IEEE 1451.1 application developers deal with inter-NCAP concurrency, implementations may use the Mutex Service and Condition Variable Services; see 11.11 and 11.12. These Services provide the application interfaces to two underlying mechanisms for synchronizing the execution of two or more code segments residing in distinct NCAP process spaces.

7.2.4.2.2 Intra-NCAP concurrency specifications

An IEEE 1451.1 system must also contend with intra-NCAP Concurrent Execution if the operating system of any NCAP in the system supports multiple processes, threads, or interrupts.

Case 1: Multiple process concurrency

If an IEEE 1451.1 NCAP has multiple executing processes, each process has its own Local NCAP Block, and interprocess communication is logically the same as inter-NCAP communication. The management of this type of concurrency is outside the scope of this standard.

Case 2: Multiple operations on objects within a single process

An IEEE 1451.1 implementation may allow Concurrent Execution of operations on objects within an NCAP process.

Except as provided in cases 3 and 4 of this clause, if Concurrent Execution is implemented, two or more concurrently executing operations shall behave as if the operation execution is serialized.

Unless otherwise stated in a subclass definition, there shall be no dependence assumed on the order of any possible serial execution.

Unless otherwise stated in a class definition, there shall be no requirement to support the Concurrent Execution of operations.

NOTE—If an implementation is capable of detecting incipient concurrency violations, possible actions are to serialize, or to return an appropriate error code to one or more of the operations.

Case 3: Interfering operations: Precedence Concurrency

Classes may specify a special set of operations obeying Precedence Concurrency defined as follows:

— An operation A that is a member of the set, invoked on an instance of the class concurrently with another operation B not a member of the set on the same instance, shall execute to completion irrespective of the completion status of operation B

— The behavior of operation B in these circumstances is outside the scope of this standard unless otherwise stated in a class definition

— The invocation of two operations from this set shall obey the concurrency requirements Case 2 for multiple operations on objects within a single process.

NOTE—This form of concurrency is required of operations that may be required to interfere with ongoing activity to properly implement their behavior. A typical example is a Reset operation that is being used to "clear" a fault in an object that is preventing normal operation of the system.

Case 4: Operations and continuing object activity: Active Concurrency

Classes may specify a special set of operations obeying Active Concurrency, defined as follows:

— An operation A that is a member of the set, invoked on an instance of the class concurrently with some continuing activity initiated earlier by some other operation on the instance, shall execute to completion irrespective of any possible termination of the continuing activity.

— If operation A accesses any internal state variable, also accessed by the continuing activity, the accesses to this state variable shall behave as though serialized.

— The invocation of two operations from this set shall obey the concurrency requirements of Case 2 for multiple operations on objects within a single process.

NOTE—This form of concurrency is required of operations that may be required to cooperate with ongoing activity to properly implement their behavior. A typical example is a status operation that is being used to observe the progress of an ongoing activity. System and application developers should note that the failure of operations initiating concurrent ongoing activity may introduce significant problems in an operating system. A typical failure scenario is the failure of a client to receive a transaction ID before the expiration of a Client Port timeout, when initiating ongoing activity. Other clients will be prevented from initiating a transaction but the original client is unaware that the activity has actually started. Classes in this standard subject to this behavior include

— Actions
— Files
— Partitioned Files
— Mutex Services
— Condition Variable Services
— Asynchronous Client Ports

7.2.4.3 Operation failure behavior specifications

Unless otherwise stated in a class or subclass definition, operations that produce a change of state in the target Object shall behave as follows:

— The successful completion of an operation shall produce the specified behavior. Any return code shall so indicate the successful completion by a Major Field value of `MJ_COMPLETE`.

— An unsuccessful execution of an operation may produce unspecified behavior in the target Object. Any return code shall so indicate an unsuccessful execution by a Major Field value not equal to `MJ_COMPLETE`.

— The execution of an operation that creates a new Object instance of a class A may fail. Such failure shall leave the local process in a state such that attempts to invoke operations of class A on the new Object shall fail.

— The execution of an operation that creates a new transaction within an existing Object instance of a class A may fail. Such failure shall leave the Object instance in a state such that attempts to invoke operations on the Object instance that are specific to the new transaction shall fail. That is, it shall appear that the new transaction was not created.

— The execution of an operation that changes the state of a state machine specified in the state behavior of an Object instance of class A may fail. Such failure shall leave the state of the Object instance unchanged or shall result in a change to a class specific state defined as an error condition state.

7.3 Block Cookie properties

Block Cookies provide a principled way for a client to tell whether the context of the server has changed. The responsibility for declaring a change of context lies with the server. The management of cookie values is mediated by the Local NCAP Block.

7.3.1 Block Cookies associated with an Object

Only Objects of class `IEEE1451_Block` shall have a Block Cookie.

All Network Visible Objects of class `IEEE1451_Block` shall have a Block Cookie.

All Network Visible Objects of class `IEEE1451_Entity` have associated with them a Block Cookie. This Block Cookie shall be termed the Associated Block Cookie for purposes of this standard. This Associated Block Cookie shall be determined as follows:

— If the Object is an instance of an `IEEE1451_Block`, then the Associated Block Cookie shall be the Block Cookie of the Block itself.

— If the Object is not an instance of an `IEEE1451_Block`, then the Associated Block Cookie shall be the Block Cookie of the Owning Block of the instance, see 5.1.3.

7.3.2 Block Cookie implementation restrictions

The implementation of the Block Cookie mechanism for a Block is outside the scope of this standard.

Implementation of the Block Cookie is subject to the restrictions of 7.3.2.1 through 7.3.2.8.

7.3.2.1 Block Cookie Restriction 1

The Block Cookie of a Block shall be locally visible for the following purposes:

— For implementing the `GetObjectProperties` operation, see 8.2.1.7

— For implementing the `GetNetworkVisibleServerObjectProperties` operation; see 9.1.1.11

— For implementing the publishing of publications with a Publication Key `PSK_NETWORK_VISIBLE_SERVER_OBJECT_PROPERTIES`; see 9.2.3.2

— For implementing the server-side behavior of client-server communication; see 8.2.3.2

— For any purpose of any object Owned by the Block

7.3.2.2 Block Cookie Restriction 2

The underlying type for the Block Cookie shall be `UInteger16`; see `ObjectProperties` structure in 6.2.6.

A `UInteger16` variable with value 0 when interpreted as a Block Cookie has a Block Cookie value NOT_SET.

7.3.2.3 Block Cookie Restriction 3

A `UInteger16` variable that when interpreted as a Block Cookie has a value NOT_SET shall not represent the Block Cookie of any Block Object.

7.3.2.4 Block Cookie Restriction 4

The locally visible Block Cookie of a Block shall not have the value NOT_SET.

7.3.2.5 Block Cookie Restriction 5

The values of two Block Cookies shall match if and only if

— The values are identical, **AND**

— Neither value is NOT_SET

7.3.2.6 Block Cookie Restriction 6

The value of the Block Cookie of a Block shall change if any of the following conditions occur:

— The Network Visible interface of a Block or of an object Directly or Indirectly Owned by the Block has changed. For example, the datatype of an argument of an operation on the Block has changed.

— The clients view of the semantic definition of the Block or of an object Directly or Indirectly Owned by the Block has changed. For example, a Parameter no longer represents the same quantity even though the Parameter interface remains unchanged.

It is recommended that developers of servers carefully consider whether a change in server state warrants a change in the Block Cookie under this clause.

7.3.2.7 Block Cookie Restriction 7

The occurrence of repeating Block Cookie values resulting from changes in the Block's Block Cookie shall be minimized.

7.3.2.8 Block Cookie Restriction 8

A Block may cause its Block Cookie to be changed only by invoking the local `ChangeBlockCookie` operation on its Local NCAP Block; see 9.2.2.5.

7.4 Value uncertainty specification

The uncertainty in a scalar value shall be represented by the `Uncertainty` datatype structure; see 6.2.10. The members of this structure are

— `interpretation`

— `uncertaintyValue`

— `coverageFactor`

— `customFactor`

It is strongly recommended that the ISO uncertainty guidelines [ISO uncertainty] be followed wherever possible.

The computation of the `uncertaintyValue` shall be based on the same units as the value of the variable to which the uncertainty pertains unless otherwise stated in a class definition.

7.4.1 Member `interpretation` specification

The value of the `interpretation` member shall be taken from the `UncertaintyInterpretation` enumeration of Table 15.

IDL: enumeration `UncertaintyInterpretation;`

Table 15—`Uncertainty Interpretation` enumeration

Enumeration	Value
UI_ISO_GUIDELINES	0
UI_NO_ERROR	1
UI_CUSTOM	2
Reserved	3–255

7.4.2 Specification of the remaining members

The interpretation of the remaining members of the `Uncertainty` datatype structure is dependent on the value of the `interpretation` member.

Case 1: For an `interpretation` value of `UI_ISO_GUIDELINES`, the following restrictions shall apply:

— The `uncertaintyValue` member shall be the “uncertainty” computed by following the ISO guidelines.

— The `coverageFactor` member shall be the “coverage factor” computed by following the ISO guidelines. If an appropriate value is not available under these guidelines the value 2 shall be assigned following the recommendation of the NIST guidelines [NIST].

— The interpretation of the `uncertaintyValue` member shall be that the actual value of the variable for which this uncertainty is applicable shall be in the range

value – `uncertaintyValue` ≤ value ≤ value + `uncertaintyValue`

— The `customFactor` has no meaning for this value of interpretation and shall be set to the default value for its type.

Case 2: For an `interpretation` value of `UI_NO_ERROR` the following restrictions shall apply:

— The actual value of the variable for which this uncertainty is applicable shall be interpreted as having perfect accuracy; that is, the “uncertainty” is zero.

— The `uncertaintyValue`, `coverageFactor`, and `customFactor` members shall be set to the default values for their types.

Case 3: For the interpretation value of `UI_CUSTOM`, the interpretation of the `uncertaintyValue`, `coverageFactor`, `customFactor` members is application-specific and outside the scope of this standard.

NOTE—One possible use of this interpretation is to augment the definition of uncertainty used with `UI_ISO_GUIDELINES`, to represent uncertainty that is asymmetrical around the expected value. The `customFactor` member is provided for this purpose. This problem is studied in the ISA guidelines [ISA uncertainty].

8. Top-level class definitions

8.1 Root abstract class

Abstract Class

Class: `IEEE1451_Root`

Parent Class: `IEEE1451_Root`

Class ID: 1

Description: The Root abstract class shall be the root for the class hierarchy of all objects defined by this standard.

Class summary:

Network Visible operations (see Table 16).

Table 16—`IEEE_Root` Network Visible operations

Operation Name	Requirement	Operation ID
`GetClassName`	(m)	1
`GetClassID`	(m)	2

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

8.1.1 Operation specifications: Network Visible

8.1.1.1 Operation `GetClassName` specification

IDL: `OpReturnCode GetClassName(`**`out`**` String class_name);`

There are no operation-specific additions to the Minor Field of the return code enumeration.

8.1.1.1.1 argument `class_name` specification

The argument `class_name` shall have the value of the Class Name for the class of which the addressed object is an instance. The String form of the `IEEE1451_ClassDescriptor` appearing in the class specification header shall be the value of the Class Name for each instance of the class that is identified by the `class_id`. In this case, the descriptor is the `String` form of `IEEE1451_Root` and the identifier has the value 1.

The `class_name` argument for classes defined by this standard shall be represented in the IEEE 1451.1 character set defined in Annex F.

Example: The value of the output argument `class_name` returned by the operation `GetClassName` on an instance of the class `IEEE1451_Root`, is the `String` with member values

`characterSet`	= `255`	(i.e. SCS_IEEE1451DOT1)
`characterCode`	= `0`	(i.e. SCC_OCTET1)
`language`	= `255`	(i.e. SL_IEEE)
`stringData`	= an Octet Array of length 1 with the value of the octet being 10 (decimal)	

The choice of string, character set, and language representations for the `String` form of `class_name` values for classes not defined by this standard is outside the scope of the standard.

8.1.1.2 Operation `GetClassID` specification

IDL: `OpReturnCode GetClassID(`**`out`**` ClassID class_id);`

There are no operation-specific additions to the Minor Field of the return code enumeration.

8.1.1.2.1 argument `class_id` specification

The `class_id` argument shall be value of the Class ID of the class. The Class ID is the designator of the position in the class hierarchy of the class for which the target object is an instance. The Class ID appearing in object description header, for example, in this case 1 shall be the value for the `class_id` for each instance of the class.

8.1.2 Common behavior

There is no additional behavior defined at this level.

8.2 Entity abstract class

Abstract Class

Class: `IEEE1451_Entity`

Parent Class: `IEEE1451_Root`

Class ID: 1.1

Description: The Entity abstract class shall be the root for the class hierarchy of all Objects defined by this standard that may be made visible over the network.

Class summary:

Network Visible operations (see Table 17).

Table 17—**IEEE1451_Entity** Network Visible operations

Operation Name	Requirement	Operation ID
GetObjectTag	(m)	2048
SetObjectTag	(m)	2049
GetObjectID	(m)	2050
GetObjectName	(m)	2051
GetDispatchAddress	(m)	2052
GetOwningBlockObjectTag	(m)	2053
GetObjectProperties	(m)	2054

Local operations (see Table 18).

Table 18—**IEEE1451_Entity** Local operations

Operation Name	Requirement
Perform	(m)

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

8.2.1 Operations specifications: Network Visible

8.2.1.1 Operation **GetObjectTag** specification

IDL: `OpReturnCode GetObjectTag(out ObjectTag object_tag);`

There are no operation-specific additions to the Minor Field of the return code enumeration.

8.2.1.1.1 argument **object_tag** specification

The `object_tag` argument value shall be the current value of the Object Tag of the Object. Object Tags are logical names for the network address of a network-addressable Object. The properties and generation of Object Tags are defined in 8.2.3.4.

8.2.1.2 Operation SetObjectTag specification

IDL: `OpReturnCode SetObjectTag(in ObjectTag object_tag);`

There are no operation-specific additions to the Minor Field of the return code enumeration.

8.2.1.3 Operation **GetObjectID** specification

IDL: `OpReturnCode GetObjectID(out ObjectID object_id);`

There are no operation-specific additions to the Minor Field of the return code enumeration.

8.2.1.3.1 argument `object_id` specification

The `object_id` argument value shall be the current value of the Object ID of the Object. The properties and generation of Object IDs are defined in 8.2.3.5.

8.2.1.4 Operation `GetObjectName` specification

```
IDL: OpReturnCode GetObjectName(out String object_name);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

8.2.1.4.1 argument `object_name` specification

The `object_name` argument value shall be the value of the Object Name for the Object. The properties and generation of Object Names are defined in 8.2.3.6.

8.2.1.5 Operation `GetDispatchAddress` specification

```
IDL: OpReturnCode GetDispatchAddress(
             out ObjectDispatchAddress dispatch_address);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

8.2.1.5.1 argument `dispatch_address` specification

The `dispatch_address` argument value shall be the value of the Object Dispatch Address of the Object. The Object Dispatch Address shall be the network-specific address used by the underlying network infrastructure to address the Object. The properties and generation of Object Dispatch Addresses are defined in 8.2.3.7.

8.2.1.6 Operation `GetOwningBlockObjectTag` specification

```
IDL: OpReturnCode GetOwningBlockObjectTag(
             out ObjectTag owning_block_object_tag);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

8.2.1.6.1 argument `owning_block_object_tag` specification

The `owning_block_object_tag` argument value shall be the current value of the Object Tag of the Owning Block Object; see 5.1.3.1.

8.2.1.7 Operation `GetObjectProperties` specification

```
IDL: OpReturnCode GetObjectProperties(
             out ObjectProperties object_properties);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

8.2.1.7.1 argument `object_properties` specification

The `object_properties` argument shall be an instance of the `ObjectProperties` structure, holding the current values for the Object Tag, Object Dispatch Address, Object Name, and the Associated Block Cookie of this Object and the Object Tag of the Owning Block of this Object.

8.2.2 Operations specifications: Local

8.2.2.1 Local operation `Perform` specification

```
IDL: ClientServerReturnCode Perform(
         in UInteger16 server_operation_id,
         in ArgumentArray server_input_arguments,
         out ArgumentArray server_output_arguments);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

8.2.2.2 argument `server_operation_id` specification

The `server_operation_id` argument value shall be the value of the Operation ID of the operation, `<InvokedOperation>`, to be invoked on the target Object.

8.2.2.3 argument `server_input_arguments` specification

The `server_input_arguments` argument value shall be the "in" arguments specified for `<InvokedOperation>` on the target Object encoded into an Argument Array; see Clause 14.

8.2.2.3.1 argument `server_output_arguments` specification

The `server_output_arguments` argument value shall be a reference to an Argument Array that upon return from `<InvokedOperation>` shall contain the "out" arguments specified for `<InvokedOperation>` on the target Object encoded into an Argument Array; see Clause 14.

8.2.3 Entity abstract class behavior

8.2.3.1 Operation `Perform` behavior specification

The `Perform` operation is the server-side construct for providing network independence in the client-server communication model illustrated in Figure 8. The details of client-side behavior, Steps 1, 2, 3, 4, 11, 12, and 13 of the figure, may be found in 11.4.2.4 and 11.5.2.5.

8.2.3.2 Client-server communication: Server-side behavior

In the following the step numbers refer to the steps in Figure 8.

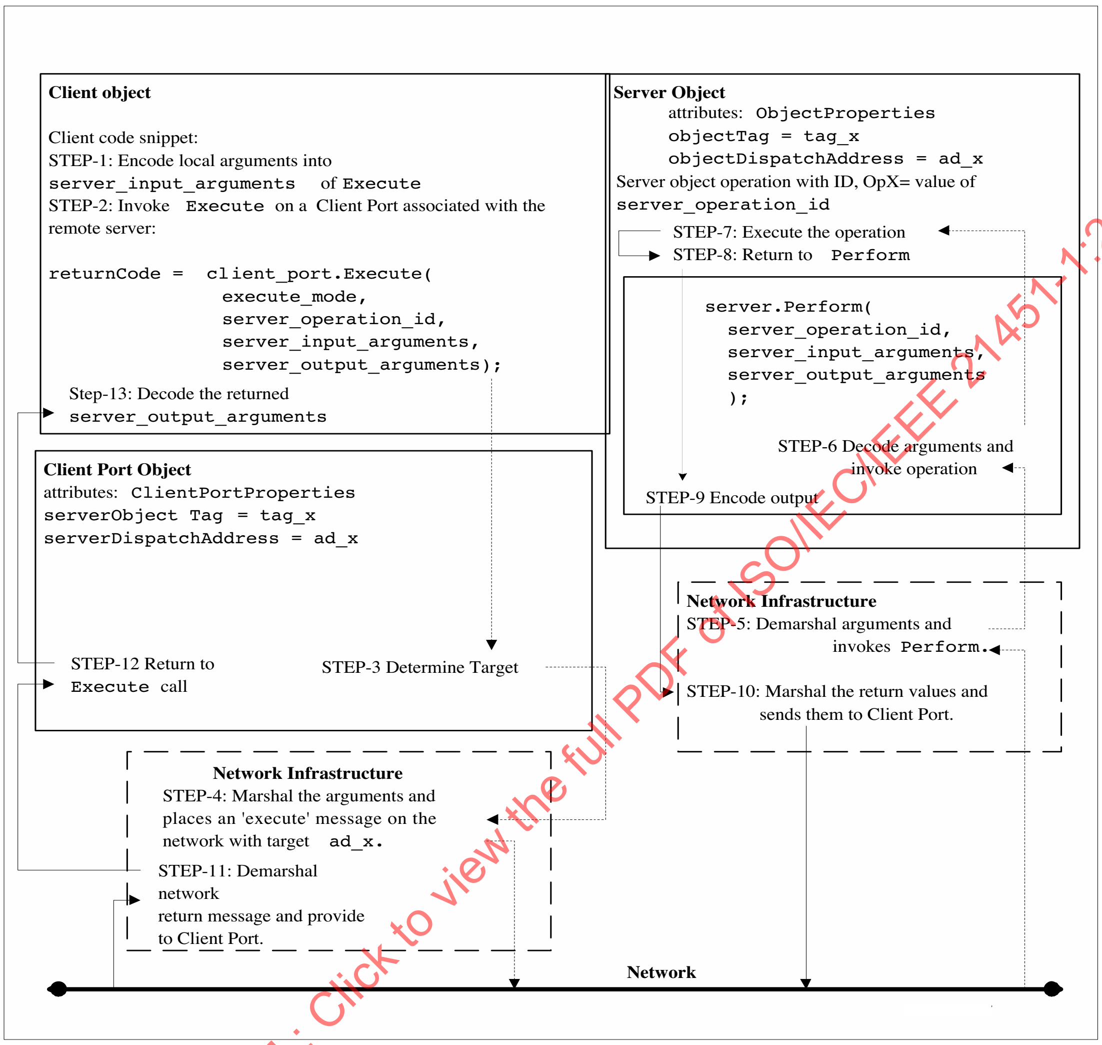
The behavioral steps of this clause shall be implemented consistent with the memory management specifications of Clause 15. Encoding and decoding shall follow the rules of Clause 14.

Step 5:

The server-side underlying network infrastructure when receiving a message whose target is a server in an NCAP on the network shall

— Identify the server-side recipient of the incoming message as indicated by the value of the Object Dispatch Address associated with the message

— Compare the Client Cached Block Cookie contained in the message to the Associated Block Cookie for the Server Object as described in 7.3. If the two cookies do not match, the underlying network infrastructure shall immediately skip to Step 10 without further action


Client object
Client code snippet:
STEP-1: Encode local arguments into server_input_arguments of Execute
STEP-2: Invoke Execute on a Client Port associated with the remote server:
Step-13: Decode the returned server_output_arguments
Client Port Object
attributes: ClientPortProperties
serverObject Tag = tag_x
serverDispatchAddress = ad_x
STEP-12 Return to Execute call
STEP-3 Determine Target
Network Infrastructure
STEP-4: Marshal the arguments and places an 'execute' message on the network with target ad_x.
STEP-11: Demarshal network return message and provide to Client Port.
Server Object
attributes: ObjectProperties
objectTag = tag_x
objectDispatchAddress = ad_x
Server object operation with ID, OpX= value of server_operation_id
STEP-7: Execute the operation
STEP-8: Return to Perform
STEP-6 Decode arguments and invoke operation
STEP-9 Encode output
Network Infrastructure
STEP-5: Demarshal arguments and invokes Perform.
STEP-10: Marshal the return values and sends them to Client Port.
Network

```
returnCode =  client_port.Execute(
                execute_mode,
                server_operation_id,
                server_input_arguments,
                server_output_arguments);
```

```
server.Perform(
  server_operation_id,
  server_input_arguments,
  server_output_arguments
  );
```

Figure 8—Client-server communication model

— Demarshal the target server operation identifier and the Array of encoded input arguments contained in the message from their on-the-wire format into the Operation ID, `server_operation_id`, and the Argument Array, `server_input_arguments`, required by the server-side `Perform` operation. The demarshaling shall take account of the endian and other processor-specific characteristics of the local environment

— Invoke `Perform` on the appropriate server-side Object, passing in the arguments `server_operation_id`, `server_input_arguments`, and a reference to an Argument Array, `server_output_arguments`, which will contain the target operation's output arguments in encoded form upon the return from `Perform`

Step 6:

When so invoked, the `Perform` operation of the server-side Object shall

— Validate the Server Object's `server_operation_id` and the arguments in `server_input_arguments`.

— If the argument `server_operation_id` does not represent a network-invokable operation on the Server Object, then `Perform` shall immediately return to the underlying network infrastructure the appropriate return code, see 8.2.3.3, and behavior continues at Step 10.

— Decode the server operation's input arguments from the `server_input_arguments` into local variables. If these arguments do not match the target operation's signature, then `Perform` shall immediately return to the underlying network infrastructure the appropriate return code, see 8.2.3.3, and behavior continues at Step 10.

— Invoke the target operation on the Server Object passing in the local variable input arguments and references to local variables for the operation's output arguments.

Step 7:

The Server Object shall provide the designated operation service.

Step 8:

The Server Object shall return to `Perform` with the appropriate `OpReturnCode` and the output argument values bound to the passed in local output variables.

Step 9:

`Perform` shall

— Encode the bound local output variables into the Argument Array, `server_output_arguments`

— Construct as return value the appropriate `ClientServerReturnCode;` see 8.2.3.3

— Return to the server-side underlying network infrastructure

Step 10:

The server-side underlying network infrastructure shall

— Marshal the Argument Array `server_output_arguments` returned from `Perform` into its on-the-wire format

— Provide to the client-side network infrastructure the following datums in a return message:

  — `server_output_arguments`

  — The `ClientServerReturnCode` return code

  — The current value of the Associated Block Cookie of the Server Object

If the execution of the server operation resulted in a change in the Associated Block Cookie of the Server Object, the new value shall be the current value.

NOTE—See Annex B for a detailed example of a complete client-server interaction.

8.2.3.3 Operation `Perform` return code behavior specification

Case 1: Normally when `Perform` returns a `ClientServerReturnCode` to the underlying network infrastructure, the elements of the `ClientServerReturnCode,` see 7.2.3.1.2, shall be assigned the values indicated in Table 19.

Table 19—Case 1 return

Field Name	Information
portCode	This field shall be assigned the MajorReturnCode enumeration value MJ_COMPLETE.
performCode	This field shall be assigned a value from the MajorReturnCode enumeration subject to the restrictions of 7.2.3.3.2.
operationMinorCode	This field shall be assigned the Minor Field of the OpReturnCode returned by the invoked operation.
operationMajorCode	This field shall be assigned the Major Field of the OpReturnCode returned by the invoked operation.

Case 2: If Step 5 of 8.2.3.2 indicates a mismatch of the Client Cached Block Cookie and the Associated Block Cookie for the Server Object, the appropriate return code sent to the Client Port as a result of Step 10 shall be based on `ClientServerReturnCode` element values indicated in the Table 20.

Table 20—Case 2 return

Field Name	Information
portCode	This field shall be assigned the MajorReturnCode enumeration value MJ_COMPLETE.
performCode	This field shall be assigned the value MJ_BLOCK_COOKIE_MISMATCH from the MajorReturnCode enumeration irrespective of any other errors detected.
operationMinorCode	This field shall be assigned the MinorReturnCode enumeration value MI_NO_ADDITIONAL_INFORMATION.
operationMajorCode	This field shall be assigned the MajorReturnCode enumeration value MJ_NO_RETURN_CODE.

Case 3: If Step 6 of 8.2.3.2 indicates that the argument `server_operation_id` is invalid for the Server Object, the appropriate return code sent to the Client Port as a result of Step 10, shall be based on the `ClientServerReturnCode` element values indicated in Table 21.

Table 21—Case 3 return

Field Name	Information
portCode	This field shall be assigned the MajorReturnCode enumeration value MJ_COMPLETE.
performCode	This field shall be assigned the MajorReturnCode enumeration value MJ_ILLEGAL_OPERATION.
operationMinorCode	This field shall be assigned the MinorReturnCode enumeration value MI_NO_ADDITIONAL_INFORMATION.
operationMajorCode	This field shall be assigned the MajorReturnCode enumeration value MJ_NO_RETURN_CODE.

Case 4: If Step 6 of 8.2.3.2 indicates that the `server_input_arguments` are invalid for the Server Object, the appropriate return code sent to the Client Port as a result of Step 10 shall be based on the `ClientServerReturnCode` element values indicated in Table 22.

Table 22—Case 4 return

Field Name	Information
`portCode`	This field shall be assigned the `MajorReturnCode` enumeration value `MJ_COMPLETE`.
`performCode`	This field shall be assigned the `MajorReturnCode` enumeration value `MJ_COMPLETE`.
`operationMinorCode`	This field shall be assigned the `MinorReturnCode` enumeration value appropriate to indicate the error detected. Example: — `MI_MISSING_INPUT` — `MI_INVALID_TYPE` — `MI_INVALID_VALUE`
`operationMajorCode`	This field shall be assigned the `MajorReturnCode` enumeration value `MJ_FAILED_INPUT_ARGUMENT`.

8.2.3.4 argument `object_tag` behavior specification

The `object_tag` argument shall be the Object Tag value of the Object. The Object Tag shall provide a network neutral reference to an Object. The Object Tag may be used as an aid in establishing the identity of Server Objects for purposes of client-server communication.

The management of Object Tag values is outside the scope of this standard. The behavior of systems that contain Objects having the same value for Object Tag instances is outside the scope of this standard.

The type of an Object Tag is Octet Array; see 6.2.3. Two Object Tag instances are the same if, and only if:

— The lengths of the Octet Arrays are identical

AND

— All corresponding octets of each Object Tag are identical

AND

— Neither has the NOT_SET value

The default value for an Object Tag shall be the default value for an Octet Array and shall be interpreted as NOT_SET. An Object Tag having the default value shall be considered to never have been set, and therefore incapable of aiding in establishing a communication connection.

Other than the comparison algorithm and the interpretation of the default value, there shall be no other dependency on the interpretation of each octet assumed for any operation or publication format under this standard.

Any “print form” interpretation of the octet values of an Object Tag is outside the scope of this standard.

NOTE—Object Tags are used in matching clients and servers to provide the necessary Object Dispatch Addresses to the clients. Configuration processes will need to compare the Object Tag of servers and the Server Object Tag of Client Ports using the comparison algorithm for Object Tags. Users and configuration tool developers are cautioned to be sure that any mappings of the human-readable forms of Object Tags onto the underlying Octet Array do not introduce ambiguities in this comparison. Of particular concern are the multiple ways of representing the same print form in some of the ISO 10646-1: 1993 two-byte character sets. Many users require that a minimum of 16 characters be supported for Object Tags.

8.2.3.5 argument `object_id` behavior specification

The `object_id` argument returns the Object ID of the Object. The Object ID shall have the property that a comparison of any two Object ID values for any two entities in an executing system shall unambiguously distinguish these two entities. No system dependence shall be based on the order or manner in which these Object ID values are generated

An Object ID is of type `ObjectID` that is defined as an Octet Array, see 6.2.3.

Two Object IDs shall be identical if and only if the lengths of the Octet Arrays are identical, and all corresponding octets of each Object ID are identical.

An Object ID consists of the following two fields defined in 8.2.3.5.1 and 8.2.3.5.2.

— `algorithm_identifier_field`

— `UUIDField`

8.2.3.5.1 field `algorithm_identifier_field` specification

The 0th octet of the Object ID Octet Array shall be an `algorithm_identifier_field`. The `algorithm_identifier_field` shall identify the algorithm used to define the second field of the Object ID. There shall be no requirement that the enumeration value correspond to any network interface technology associated with the NCAP Block unless correspondence is required to satisfy the conditions of the algorithm.

The `algorithm_identifier_field` shall consist of a single octet with allowed values defined by the enumeration in Table 23.

IDL: enumeration `UUIDAlgorithmID;`

Table 23—`UUIDAlgorithmID` enumeration[*]

Enumeration	Value	Definition
`AIF_CLOSED`	0	Closed system
`AIF_ETHER_DCE`	1	Ethernet using the DCE algorithm per Object
`AIF_ETHER_DCE_NCAP`	2	Ethernet using the DCE algorithm per NCAP with supplement ID
`AIF_ETHER_CUSTOM`	3	Ethernet using the custom algorithm
`AIF_FFBUS`	4	FOUNDATION™ fieldbus
`AIF_PROFIBUS`	5	Profibus™
`AIF_LON`	6	LonTalk™
`AIF_DNET`	7	DEVICENET™
`AIF_SDS`	8	Smart Distributed System
`AIF_CONTROLNET`	9	CONTROLNET™
`AIF_CANOPEN`	10	CANopen™
`AIF_1451_2`	11	IEEE 1451.2
	12–255	Reserved for issuance by IEEE

[*]The following information is given for the convenience of users of this standard and does not constitute an endorsement by the IEEE of these products.

For interface technologies not listed, it shall be the responsibility of the organization or standards body managing the interface technology's protocol to secure an enumeration value from the IEEE standards office.

Example: If an NCAP uses Profibus for the network, but selects `AIF_ETHER_DCE` for the `algorithm_identifier_field` value, the manufacturer must base the DCE algorithm on an Ethernet MAC address obtained from the IEEE. The manufacturer must guarantee that this MAC address is never used in an actual Ethernet device. An alternative is to purchase and destroy a device with an Ethernet MAC address.

8.2.3.5.2 field `UUIDField` specification

The remaining octets shall define an identifier, which shall be unique within the scope of the interface technology specified by the `algorithm_identifier_field`.

Until such time as the standardization organization responsible for each of the above interface technologies has defined an algorithm for assigning UUIDs that meet the requirements of this standard, one of the following algorithms shall be used to generate the `UUIDField`.

Algorithm 1: `algorithm_identifier_field` = `AIF_CLOSED`. The generation and management of the `UUIDField` and the resulting system behavior shall be the responsibility of the developer and is outside the scope of this standard. The Octet Array for an Object ID for this case shall be defined in Table 24.

Table 24—Algorithm 1 Octet Array

0th octet	Remaining octets
`AIF_CLOSED`	User-defined

Algorithm 2: `algorithm_identifier_field` = `AIF_ETHER_DCE`. For each Object, the generation of the `UUIDField` shall conform to the DCE algorithm [B6].

The Octet Array for an Object ID for this case shall be defined in Table 25.

Table 25—Algorithm 2 Octet Array

0th octet	Next 16 octets
`AIF_ETHER_DCE`	DCE algorithm generated UUIDField

Algorithm 3: `algorithm_identifier_field` = `AIF_ETHER_DCE_NCAP`. The `UUIDField` shall consist of two fields, a major UUID field followed by a minor UUID field. The generation of the major UUID field shall conform to the DCE algorithm [B6]. A single value of the major UUID field shall be shared by all Objects in the process space of the Local NCAP Block. For each such Object, the minor UUID field shall be unique within the scope of the Objects in the process space of the Local NCAP Block. The values assigned to the minor UUID field shall not be repeated except for constraints due to the length of the field. The nonrepeating characteristic of the minor UUID field values shall hold over power cycles, reboots, resets, and all other activities of the NCAP.

The Octet Array for an Object ID for this case shall be defined in Table 26.

Algorithm 4: `algorithm_identifier_field` = `AIF_ETHER_CUSTOM`. The `UUIDField` shall consist of two fields: A major UUID field followed by a minor UUID field.

Table 26—Algorithm 3 Octet Array

0th octet	Next 16 octets	Remaining octets
AIF_ETHER_DCE_NCAP	DCE algorithm generated UUIDField	Implementation defined minor UUID field

The major UUID field shall be an Ethernet™ MAC address. This address shall be a valid Ethernet MAC address guaranteed not to be used in any other device and is shared by all IEEE 1451.1 Objects on a given NCAP.

The minor UUID field shall be unique within the scope of the NCAP identified by the major field MAC address. The length of the minor UUID field is implementation dependent. The values assigned to the minor UUID field shall not be repeated except for constraints due to the length of the field. The nonrepeating characteristic of the minor UUID field values shall hold over power cycles, reboots, resets, and all other activities of the NCAP.

The Octet Array for an Object ID for this case shall be defined in Table 27.

Table 27—Algorithm 4 Octet Array

0th octet	Next 6 octets (major UUID field)	Remaining octets (minor UUID field)
AIF_ETHER_CUSTOM	Ethernet™ MAC address	implementation-defined minor UUID field

NOTE—Algorithms 2, 3, and 4 may be used by non-Ethernet interface technologies by obtaining valid Ethernet MAC addresses from the IEEE as described in the {DCE} standard [B6].

8.2.3.6 argument `object_name` behavior specification

The Object Name of an Object shall identify the intrinsic purpose or nature of the Object instance. This is in contrast with the purpose of the Object Tag, which is to provide a place for application communication binding information.

The `object_name` argument shall be set at the time the Object is instantiated to the Object Name of the Object. The Object Name of the Object shall be unique within the scope of its Owning Block Object. For example, if the Object is a Block and the Owning Block is the Local NCAP Block, then the Object Name would be unique among all Blocks directly Owned by the NCAP Block including the NCAP Block itself.

The management of user-defined values for Object Names shall be outside the scope of this standard.

Where this standard specifies the value of the Object Name for an instance of a class, this value shall be represented by using the IEEE 1451.1 character set defined in Annex F. If more than a single instance of such a class shares a common Owning Object, the uniqueness requirement shall be met by adding suffix consisting of an ordinal number represented in the IEEE 1451.1 character set.

Example: The Object Name for a Scalar Parameter instance Owned by an `IEEE1451_TransducerBlock` subclass instance may have a `String` form "`IEEE1451_ ScalarParameter2;`" see 9.5.2.4 and Annex F.

The String member values for the third such Parameter instance (ordinal number 2) are

`characterSet` = 255 (i.e., SCS_IEEE1451DOT1)

`characterCode`	= 0 (i.e., SCC_OCTET1)
`language`	= 255 (i.e., SL_IEEE)
`stringData`	= an Octet Array of length 2 with the 0th octet value = 16 (decimal), and the next octet value = 2 (decimal)

Where this standard does not specify a specific Object Name for an instance of a class, the Object Name value may be represented in any appropriate character set.

NOTE—There are at least three general models for generating Object Names.

a) Based on the design of the class along with a serialization number supplied by the Local NCAP Block at instantiation time. This might lead to Object Names such as Transform-1, Transform-2, etc.

b) Based on information derivable from the NCAP environment that is present at instantiation time. For example, when instantiating a Transducer Block, the physical interface being represented is known and could be the basis for a name such as `port-1-transducer-block.`

c) Based on information obtainable from a source external to the NCAP but present or obtainable at instantiation time. For example, a system might make use of a configuration file, a name server, or a physical interface on an NCAP, for example, as the means of communicating this information.

8.2.3.7 argument `dispatch_address` behavior specification

The `dispatch_address` argument shall be assigned the value of the Object Dispatch Address of a Server Object. The Object Dispatch Address shall provide an unambiguous reference to that Object such that when provided by the Base Client Port to the client-side network infrastructure, a message can be sent to the Server Object by the underlying network. The syntax and the semantics of Object Dispatch Addresses are specific to each network's communication protocol and can be specific to each IEEE 1451.1 implementation supporting that network protocol. The management policy for generating and assigning Object Dispatch Addresses shall be uniform for each specific network technology used in a system. The management policies and specification of Object Dispatch Addresses are outside the scope of this standard.

9. Block classes

9.1 Block abstract class

Abstract Class

Class: `IEEE1451_Block`

Parent Class: `IEEE1451_Entity`

Class ID: 1.1.1

Description: The Block abstract class shall be the root for the class hierarchy of all Block Objects.

Class summary:

Network Visible operations (see Table 28).

Local operations (see Table 29).

Publications: There are no publications defined for this class.

Table 28—`IEEE1451_Block Network` Visible operations

Operation Name	Requirement	Operation ID
`GetGroupIDs`	(m)	4096
`SetGroupIDs`	(m)	4097
`GetBlockMajorState`	(m)	4098
`GetBlockManufacturerID`	(m)	4099
`GetBlockModelNumber`	(m)	4100
`GetBlockVersion`	(m)	4101
`GoActive`	(m)	4102
`GoInactive`	(m)	4103
`Initialize`	(m)	4104
`Reset`	(m)	4105
`GetNetworkVisibleServerObjectProperties`	(m)	4106

Table 29—`IEEE1451_Block` Local operations

Operation Name	Requirement
`RegisterNotifyOnUpdate`	(o)
`DeregisterNotifyOnUpdate`	(o)

Subscriptions: There are no subscriptions defined for this class.

9.1.1 Operations specifications: Network Visible

9.1.1.1 Operation `GetGroupIDs` specification

```
IDL: OpReturnCode GetGroupIDs(
            out OctetArray group_ids);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.1.1.1.1 argument `group_ids` specification

The `group_ids` argument value shall be a set of identifiers representing the sets of Objects of which this Block instance is a member. Set membership specification is outside the scope of this standard. Each member octet of the Octet Array shall represent the identifier for a single group of which this Object is a member. The management of these identifiers is outside the scope of this standard.

NOTE—The `group_ids` values of Blocks may be used by application developers to identify which Blocks are involved in implementing some aspect of application behavior. For example, all Blocks involved in a particular control group could be given a common `group_ids` value.

9.1.1.2 Operation `SetGroupIDs` specification

```
IDL: OpReturnCode SetGroupIDs(in OctetArray group_ids);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.1.1.3 Operation `GetBlockMajorState` specification

```
IDL: OpReturnCode GetBlockMajorState(
            out UInteger8 block_major_state);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.1.1.3.1 argument `block_major_state` specification

The `block_major_state` argument value shall represent the current Block Major State of a Block. The allowed values for the Block Major State shall be defined by the enumeration shown in Table 30.

IDL: enumeration `BlockMajorState;`

Table 30—`BlockMajorState` enumeration

Enumeration	Value
`BL_UNINITIALIZED`	0
`BL_INACTIVE`	1
`BL_ACTIVE`	2
Reserved	3–255

9.1.1.4 Operation `GetBlockManufacturerID` specification

```
IDL: OpReturnCode GetBlockManufacturerID(
            out String block_manufacturer_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.1.1.4.1 argument `block_manufacturer_id` specification

The `block_manufacturer_id` argument value shall identify the manufacturer of the Block. The specification of manufacturer identification is outside the scope of this standard.

9.1.1.5 Operation `GetBlockModelNumber` specification

```
IDL: OpReturnCode GetBlockModelNumber(
            out String block_model_number);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.1.1.5.1 argument `block_model_number` specification

The `block_model_number` argument value shall be an identifier assigned by the manufacturer to distinguish different implementations of the class by the manufacturer. The scope of `block_model_number` instances shall be the `block_manufacturer_id`. The specification of `block_model_number` instances shall be the responsibility of the manufacturer and is outside the scope of this standard.

9.1.1.6 Operation `GetBlockVersion` specification

```
IDL: OpReturnCode GetBlockVersion(
            out String block_software_version);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.1.1.6.1 argument `block_software_version` specification

The `block_software_version` argument value shall be an identifier assigned by the manufacturer to distinguish different implementations of the model by the manufacturer. The scope of `block_software_version` shall be the `block_model_number`. The specification of `block_software_version` instances shall be the responsibility of the manufacturer and is outside the scope of this standard.

9.1.1.7 Operation `GoActive` specification

```
IDL: OpReturnCode GoActive();
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.1.1.8 Operation `GoInactive` specification

```
IDL: OpReturnCode GoInactive( );
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.1.1.9 Operation `Initialize` specification

```
IDL: OpReturnCode Initialize( );
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.1.1.10 Operation `Reset` specification

```
IDL: OpReturnCode Reset( );
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.1.1.11 Operation `GetNetworkVisibleServerObjectProperties` specification

```
IDL: OpReturnCode GetNetworkVisibleServerObjectProperties(
            out ObjectTag this_block_object_tag,
            out ObjectPropertiesArray server_object_properties);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.1.1.11.1 argument `this_block_object_tag` specification

The `this_block_object_tag` argument value shall be the current value of the Object Tag of the target Block executing the operation.

9.1.1.11.2 argument `server_object_properties` specification

Each of the Array elements of the `server_object_properties` argument value is an `ObjectProperties` data structure containing members

— `objectTag`

— `owningBlockObjectTag`

— `objectDispatchAddress`

— `objectName`

— `blockCookie`

The `server_object_properties` argument value shall contain one such data structure for each Object as required by 9.1.3.5.

The member values of `objectTag`, `objectDispatchAddress`, and `objectName` members shall be Object Tag, Object Dispatch Address, and Object Name, respectively, for a Server Object `<specific object>.` The member value of `owningBlockObjectTag` shall be the Object Tag of the Owning Block of `<specific object>`. The `blockCookie` member value shall be the Associated Block Cookie of `<specific object>`; see 7.3.

9.1.2 Operations specifications: Local

9.1.2.1 Local operation `RegisterNotifyOnUpdate` specification

```
IDL: OpReturnCode RegisterNotifyOnUpdate(
            in <local operation reference> notification_operation,
            in UInteger16 registration_id);
```

There are no operation specific additions to the Minor Field of the return code enumeration.

9.1.2.1.1 argument `notification_operation` specification

The `notification_operation` argument value shall be a `<local operation reference>` to the local operation of the registering object that shall be invoked to signal notification of class-specific internal state changes in the Block; see 9.1.3.4. The signature of the referenced `notification_operation` shall be

```
OpReturnCode <local operation name>(
            in UInteger16 registration_id,
            in TimeRepresentation timestamp);
```

9.1.2.1.2 argument `registration_id` specification

The `registration_id` argument value shall be an identifier used by the registering object to identify callbacks based on this registration operation.

9.1.2.1.3 argument `timestamp` specification

The `timestamp` argument value shall be the occurrence time of the class-specific state change mandating the notification.

9.1.2.2 Local operation `DeregisterNotifyOnUpdate` specification

```
IDL: OpReturnCode DeregisterNotifyOnUpdate(
             in <local operation reference> notification_operation,
             in UInteger16 registration_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.1.3 Common Block behavior

9.1.3.1 Concurrency requirements

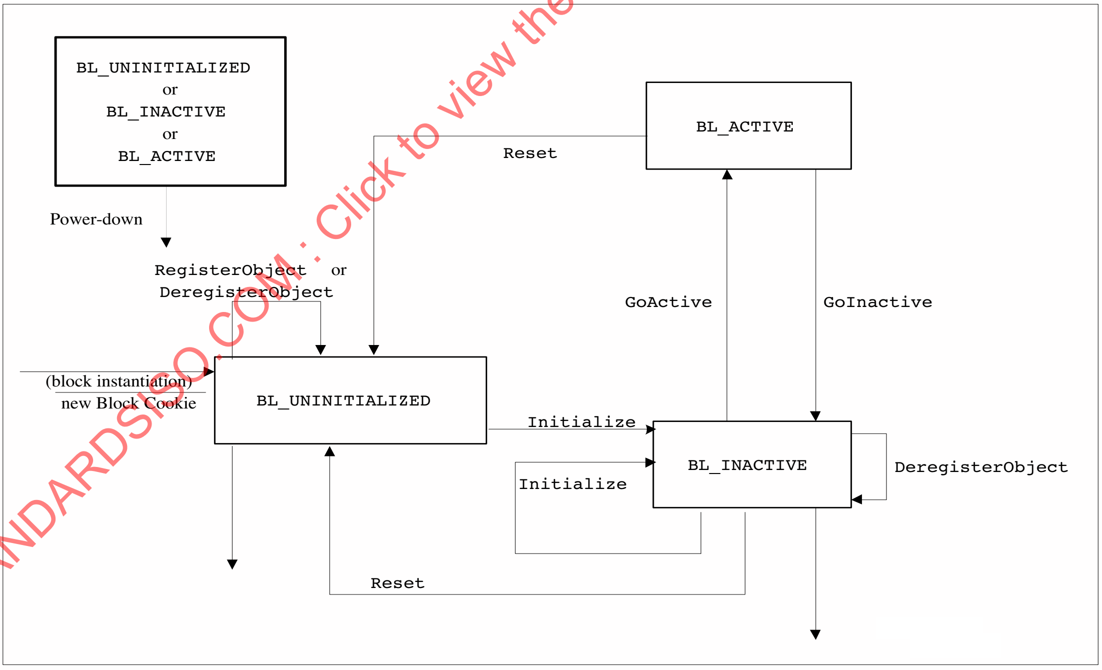
The `Reset` operation may support Precedence Concurrency.

9.1.3.2 Block state behavior specification

All Block Objects shall be controlled by the state machine shown in Figure 9.

Subclasses may subset states providing any substates and associated transitions shall be contained within the states defined by this clause, and respond to all transitions applicable to the containing state. If a subclass defines substates of any Block Major State, the subclass definition shall include accessor operations to return the current substate. Such accessor operations shall have the same signature as `GetBlockMajorState`, namely

```
IDL: OpReturnCode <operation name>(out UInteger8 substate);
```



BL_UNINITIALIZED or BL_INACTIVE or BL_ACTIVE
Power-down
RegisterObject or DeregisterObject
Reset
BL_ACTIVE
GoActive
GoInactive
(block instantiation) new Block Cookie
BL_UNINITIALIZED
Initialize
Initialize
BL_INACTIVE
DeregisterObject
Reset

Figure 9—State machine for the Block life cycle

The mechanisms for the creation or destruction of a Block are outside the scope of this standard.

Newly created Blocks that are to be Network Visible shall be registered by using the `RegisterObject` operation on the Local NCAP Block.

Blocks so registered shall be deregistered using the `DeregisterObject` operation on the Local NCAP Block before the Block is destroyed by the unspecified mechanisms.

Unless otherwise stated in this standard, there shall be no requirement that Blocks be made Network Visible and therefore registered.

The operations of a Block Object permitted in each defined Block Major State shall be restricted as outlined in 9.1.3.2.1 through 9.1.3.2.4.

9.1.3.2.1 `BL_UNINITIALIZED` state restrictions

The `BL_UNINITIALIZED` state shall be reserved for local activities related to bringing the Block Object into existence and performing any related Local preparations needed for the Block to function.

The following restriction on the behavior of an instance of a subclass of the `IEEE1451_Block` class shall be observed in the `BL_UNINITIALIZED` state:

— Operations defined by a subclass of the `IEEE1451_Block` class shall not be operational unless specifically allowed by the subclass specification.

The following restrictions on the behavior of an instance of a subclass of the `IEEE1451_Block` class shall be observed in the `BL_UNINITIALIZED` state. These restrictions shall also apply to all objects Owned by this Block instance

— Only local operations necessary to allow the Block instance to change its state from `BL_UNINITIALIZED` to `BL_INACTIVE` may be operational on the instance or invoked by the instance unless further restricted by a subclass definition.

— The `Perform` function shall not be operational.

— Network communications involving the Block shall not be operational.

— Operations defined on the instance or invoked by the instance that result in changes in a transducer state except for the purpose of the communication configuration or internal configuration of the instance shall not be operational.

— All existing Block Objects Owned by the Block instance shall be in the `BL_UNINITIALIZED` state.

— All non-Block Objects Owned by the Block instance shall obey the restrictions defined for the `BL_UNINITIALIZED` state.

9.1.3.2.2 `BL_INACTIVE` state restrictions

The `BL_INACTIVE` state shall be reserved for activities related to

— Configuration of the network communication properties of the Block and its Owned objects

— Initialization, that is bringing the Block Object and its Owned objects into a known state in preparation for the transition into the `BL_ACTIVE` state

— Diagnosis and maintenance of the Block Object

The following restriction on the behavior of an instance of a subclass of the `IEEE1451_Block` class shall be observed in the `BL_INACTIVE` state:

— Operations defined by a subclass of the IEEE1451_Block class shall not be operational unless specifically allowed by the subclass specification.

The following restrictions on the behavior of an instance of a subclass of the IEEE1451_Block class shall be observed in the BL_INACTIVE state. These restrictions shall also apply to all objects Owned by this Block instance.

— Operations defined on the instance or invoked by the instance dealing with the configuration of the network communications involving the Block and its Owned objects may be operational.

— Operations defined on the instance or invoked by the instance dealing with the initialization or configuration of the Block or its Owned objects may be operational.

— Diagnostic or maintenance related operations defined on the instance or invoked by the instance may be operational.

— Operations defined on the instance or invoked by the instance that results in changes in a transducer state except for the above purposes shall not be operational.

— Operations defined on the instance or invoked by the instance relating to the normal application function performed by the Block shall not be operational.

— All existing Block Objects Owned by the Block instance shall be in the BL_UNINITIALIZED or the BL_INACTIVE states.

— All non-Block Objects Owned by the Block instance shall obey the restrictions defined for either the BL_UNINITIALIZED or the BL_INACTIVE states.

9.1.3.2.3 BL_ACTIVE state restrictions

The BL_ACTIVE state shall be reserved for activities related to the normal application function of the Block.

The following restriction on the behavior of an instance of a subclass of the IEEE1451_Block class shall be observed in the BL_ACTIVE state:

— Operations defined by a subclass of the IEEE1451_Block class shall not be operational unless specifically allowed by the subclass specification

The following restrictions on the behavior of an instance of a subclass of the IEEE1451_Block class shall be observed in the BL_ACTIVE state. These restrictions shall also apply to all objects Owned by this Block instance.

— Operations defined on the instance or invoked by the instance dealing with the configuration of the network communications involving the Block and its Owned objects shall not be operational.

— Operations defined on the instance or invoked by the instance dealing with the initialization or configuration of the Block or its Owned objects shall not be operational.

— Diagnostic- or maintenance-related operations defined on the instance or invoked by the instance may be operational.

— Operations defined on the instance or invoked by the instance relating to the normal application function performed by the Block may be operational.

— All existing Block Objects Owned by the Block instance may be in the BL_UNINITIALIZED, the BL_INACTIVE, or the BL_ACTIVE states.

— All non-Block Objects Owned by the Block instance shall obey the restrictions defined for either the `BL_UNINITIALIZED`, the `BL_INACTIVE`, or the `BL_ACTIVE` states.

9.1.3.2.4 Specific Block operation restrictions based on state

In addition to and conformant with the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3, the allowed operations defined by this class shall be restricted as defined in Table 31. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 31—`IEEE1451_Block` class specific restrictions

Operation	Block Object's major state value		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
All operations except those in the following rows	Local invocation only	Operational	Operational
`SetObjectTag`, `SetGroupIDs`, `Initialize`	Local invocation only	Operational	Not operational
`GoActive`, `GoInactive`, `Perform`	Not operational	Operational	Operational

9.1.3.3 Block Cookie behavior specification

All Network Visible Block Objects, and only Block Objects, have a Block Cookie. The properties of the Block Cookie shall be as specified in 7.3.

9.1.3.4 Notification operations behavior specifications

`RegisterNotifyOnUpdate` and `DeregisterNotifyOnUpdate` shall both be Interface Only Implementations, or shall both be Full Implementations if so designated by a subclass.

A Full Implementation of the notification update behavior shall be as follows:

— A local Client object, (the local_client_object), may register a `<local operation reference>` with any local Block (the local_block). The `<local operation reference>` shall be an `<update notification operation>` of the local_client_object. The registration is accomplished via the local_block's `RegisterNotifyOnUpdate` operation.

— The local_block shall invoke the `<update notification operation>` on all registered local_client_objects whenever the class-specific internal state of the Block has changed.

— This registration requires maintaining an association between the `<local operation reference>` and a `registration_id`. The generation of `registration_id` numbers shall be the responsibility of the `local_client_object`. If the `local_client_object` needs to differentiate between notifications from different objects, all current `registration_id` instances of the `local_client_object` shall be unique; otherwise, there shall be no requirement for uniqueness.

9.1.3.5 Operation `GetNetworkVisibleServerObjectProperties` behavior specification

The `GetNetworkVisibleServerObjectProperties` operation shall provide the specified information for Network Visible Objects Directly or Indirectly Owned by the Block (identified by `this_block_object_tag),` as well as the Block itself provided that the Block is itself Network Visible. In the case of a Local NCAP Block`,` this ownership would cover all Network Visible Entity Objects, existing in the process address space of the Local NCAP Block.

This operation may be used in some configuration scenarios to allow an external entity to discover the potential Client Port Server Object Tag, Object Dispatch Address, and Block Cookie bindings; see Annex D. This information may be used to establish communication with Server Objects supported by the target NCAP Block Object.

The recursive nature of this operation may be used to determine the Objects included in the Network Visible interface specification of any Block.

NOTE—This operation provides the same information about an object as the operation `GetObjectProperties`, 8.2.1.7, but only for Network Visible Objects. In addition, it returns the same information for all Objects Directly or Indirectly Owned whereas `GetObjectProperties` only returns the information for the target Object itself.

9.2 NCAP Block class

Class: `IEEE1451_NCAPBlock`

Parent Class: `IEEE1451_Block`

Class ID: 1.1.1.1

Description: The NCAP Block class provides resources and operations within an NCAP process to support Block, Service, and Component management. This support includes

— Registration

— Deregistration

— Initialization and startup

— Shutdown

The NCAP Block within a process is the key source of system configuration and bookkeeping information about its Network Visible Owned objects.

Provision is made to specify the identity of a configuration tool for NCAP Blocks that wish to use name server or similar technologies as part of system configuration.

Class summary:

Network Visible operations (see Table 32).

Local operations (see Table 33).

Publications (see Table 34).

Subscriptions (see Table 35).

Table 32—`IEEE1451_NCAPBlock` Network Visible operations

Operation Name	Requirement	Operation ID
`GetNCAPBlockState`	(m)	6144
`GetNCAPManufacturerID`	(m)	6145
`GetNCAPModelNumber`	(m)	6146
`GetNCAPSerialNumber`	(m)	6147
`GetNCAPOSVersion`	(m)	6148
`GetClientPortProperties`	(m)	6149
`SetClientPortServerObjectBindings`	(m)	6150
`GetConfigurationToolAddress`	(o)	6151
`SetConfigurationToolAddress`	(o)	6152
`IgnoreRequestNCAPBlockAnnouncement`	(m)	6153
`RespondToRequestNCAPBlockAnnouncement`	(m)	6154
`RebootNCAPBlock`	(m)	6155
`ResetOwnedBlocks`	(m)	6156

Table 33—`IEEE1451_NCAPBlock` Local operations

Operation Name	Requirement
`RegisterObject`	(o)
`DeregisterObject`	(o)
`GetNewObjectID`	(o)
`GetBlockCookie`	(m)
`ChangeBlockCookie`	(o)

Table 34—`IEEE1451_NCAPBlock` Publications

Publication Key (Publisher Port Object Name, same as formal name of publication)	Requirement

`PSK_NCAPBLOCK_ANNOUNCEMENT`
`(NCAPBlock_Announcement)`
	(m)

`PSK_NETWORK_VISIBLE_SERVER_OBJECT_PROPERTIES`
`(Network_Visible_Server_Object_Properties)`
	(m)

Table 35—`IEEE1451_NCAPBlock` Subscriptions

Subscription Key (Subscriber Port Object Name, same as formal name of publication)	Requirement

`PSK_REQUEST_NCAPBLOCK_ANNOUNCEMENT`
`(Request_NCAPBlock_Announcement)`
	(m)

`PSK_FORCE_NCAPBLOCK_ANNOUNCEMENT`
`(Force_NCAPBlock_Announcement)`
	(m)

`PSK_REQUEST_NETWORK_VISIBLE_SERVER_OBJECT_PROPERTIES`
`(Request_Network_Visible_Server_Object_Properties)`
	(m)

`PSK_NCAPBLOCK_GO_ACTIVE (NCAPBlock_Go_Active)`	(m)

9.2.1 Operation specifications: Network Visible

9.2.1.1 Operation `GetNCAPBlockState` specification

```
IDL: OpReturnCode GetNCAPBlockState(
            out UInteger8 ncap_block_state);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.2.1.1.1 argument `ncap_block_state` specification

The `ncap_block_state` argument value shall represent the current substate of the Block as depicted in the behavior clause. The allowed values of `ncap_block_state` shall be defined by the enumeration shown in Table 36.

```
IDL: enumeration NCAPBlockState;
```

Table 36—`NCAPBlockState` enumeration

Enumeration	Value
NB_INITIALIZED	0
NB_ERROR	1
Reserved	2–255

9.2.1.2 Operation `GetNCAPManufacturerID` specification

```
IDL: OpReturnCode GetNCAPManufacturerID(
            out String ncap_manufacturer_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.2.1.2.1 argument `ncap_manufacturer_id` specification

The `ncap_manufacturer_id` argument value shall identify the manufacturer of the NCAP. The specification of manufacturer identification is outside the scope of this standard.

9.2.1.3 Operation `GetNCAPModelNumber` specification

```
IDL: OpReturnCode GetNCAPModelNumber
            (out String ncap_model_number);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.2.1.3.1 argument `ncap_model_number` specification

The `ncap_model_number` argument value shall be an identifier assigned by the manufacturer to distinguish different NCAP implementations of the manufacturer. The scope of NCAP model numbers shall be the `ncap_manufacturer_id`. The specification of `ncap_model_number` instances shall be the responsibility of the manufacturer and is outside the scope of this standard.

9.2.1.4 Operation **GetNCAPSerialNumber** specification

```
IDL: OpReturnCode GetNCAPSerialNumber(
            out String ncap_serial_number);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.2.1.4.1 argument **ncap_serial_number** specification

The ncap_serial_number argument value shall be an identifier assigned by the manufacturer to distinguish different instances of NCAP implementations of the manufacturer. The scope of NCAP serial numbers shall be the ncap_model_number. The specification of NCAP serial numbers shall be the responsibility of the manufacturer and is outside the scope of this standard.

9.2.1.5 Operation **GetNCAPOSVersion** specification

```
IDL: OpReturnCode GetNCAPOSVersion
            (out String ncap_os_version);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.2.1.5.1 argument **ncap_os_version** specification

The ncap_os_version argument value shall be an identifier assigned by the manufacturer to specify the operating system used by the NCAP. The specification of ncap_os_version values shall be the responsibility of the manufacturer and is outside the scope of this standard.

9.2.1.6 Operation **GetClientPortProperties** specification

```
IDL: OpReturnCode GetClientPortProperties(
           out ObjectTag this_ncap_block_object_tag,
           out ClientPortPropertiesArray client_port_properties);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.2.1.6.1 argument **this_ncap_block_object_tag** specification

The this_ncap_block_object_tag argument value shall be the Object Tag of the Local NCAP Block supporting this operation.

NOTE—Since the consequences of obtaining incorrect binding information are so severe, this argument is returned to allow clients to easily verify that the information returned is from the intended source.

9.2.1.6.2 argument **client_port_properties** specification

Each member of the client_port_properties argument value shall represent one of the Network Visible Base Client Ports Owned by the Local NCAP Block identified by this_ncap_block_object_tag. All such Base Client Ports shall be so represented. Each of the Array elements of the client_port_properties argument is a ClientPortProperties data structure containing members

— clientPortObjectTag: The Object Tag of the referenced Client Port

— clientPortName: The Object Name of the referenced Client Port

— `clientPortDispatchAddress:` The Object Dispatch Address that enables communication with the referenced Client Port

— `serverObjectTag:` The current value of the Server Object Tag of the referenced Client Port

— `serverDispatchAddress:` The current value of the Object Dispatch Address associated with the Server Object Tag

9.2.1.7 Operation `SetClientPortServerObjectBindings` specification

```
IDL: OpReturnCode SetClientPortServerObjectBindings(
             in ObjectTag this_ncap_block_object_tag,
             in ObjectPropertiesArray client_port_server_properties);
```

The Minor Field of the return code enumeration for this operation shall be defined by the enumeration in Table 37.

IDL: enumeration `SetClientPortServerObjectBindingsReturn;`

Table 37—`SetClientPortServerObjectBindingsReturn` enumeration

Enumeration	Value
ST_NO_ADDITIONAL_INFORMATION	0
ST_MEMORY_ALLOCATION_ERROR	1
ST_MISSING_INPUT	2
ST_INVALID_TYPE	3
ST_INVALID_VALUE	4
ST_COMPUTATION_ERROR	5
ST_UNRESOLVED_SERVER_OBJECT_TAGS_REMAIN	6
ST_INCONSISTENT_DATA	7
ST_UNRESOLVED_AND_INCONSISTENT	8
Reserved	9–255

The meaning of the first six members of this enumeration shall be identical to the meaning of the first six members of the `MinorReturnCode` enumeration; see 7.2.3.2.1.

9.2.1.7.1 argument `this_ncap_block_object_tag` specification

The `this_ncap_block_object_tag` argument value shall be the current value of the Object Tag of the NCAP Block supporting this operation.

NOTE—Since the consequences of obtaining incorrect binding information are so severe, this argument is returned to allow clients to easily verify that the information returned is from the intended source.

9.2.1.7.2 argument `client_port_server_properties` specification

The `client_port_server_properties` argument value shall be an Array of elements of type `ObjectProperties`.

Each of the Array elements of the `client_port_server_properties` argument describes a Server Object in terms of the Server Object's `ObjectProperties` data structure members

- `objectTag`
- `owningBlockObjectTag`
- `objectDispatchAddress`
- `objectName`
- `blockCookie`

The values of these members are specified in 9.1.1.11.2.

9.2.1.8 Operation `GetConfigurationToolAddress` specification

```
IDL: OpReturnCode GetConfigurationToolAddress(
           out ObjectDispatchAddress configuration_tool_address);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.2.1.8.1 argument `configuration_tool_address` specification

The `configuration_tool_address` argument value shall be the value of the Object Dispatch Address of the object implementing the configuration tool.

9.2.1.9 Operation `SetConfigurationToolAddress` specification

```
IDL: OpReturnCode SetConfigurationToolAddress(
           in ObjectDispatchAddress configuration_tool_address);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.2.1.10 Operation `IgnoreRequestNCAPBlockAnnouncement` specification

```
IDL: OpReturnCode IgnoreRequestNCAPBlockAnnouncement( );
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.2.1.11 Operation `RespondToRequestNCAPBlockAnnouncement` specification

```
IDL: OpReturnCode RespondToRequestNCAPBlockAnnouncement( );
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.2.1.12 Operation `RebootNCAPBlock` specification

```
IDL: void RebootNCAPBlock( );
```

There shall be no return defined for this operation.

9.2.1.13 Operation `ResetOwnedBlocks` specification

```
IDL: OpReturnCode ResetOwnedBlocks( );
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.2.2 Operation specifications: Local

9.2.2.1 Local operation `RegisterObject` specification

```
IDL: OpReturnCode RegisterObject(
           in <local object reference> object_reference,
           in <local object reference>
                 owning_block_object_reference,
           out DispatchAddress object_dispatch_address);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.2.2.1.1 argument `object_reference` specification

The `object_reference` argument value shall be a `<local object reference>` that shall enable local invocations of Object operations on the Object being registered.

9.2.2.1.2 argument `owning_block_object_reference` specification

The `owning_block_object_reference` argument value shall be a `<local object reference>` that shall enable local invocations of Object operations on the Block Owning the Object being registered.

9.2.2.1.3 argument `object_dispatch_address` specification

The `object_dispatch_address` argument value shall be the value of the Object Dispatch Address of the Object being registered.

9.2.2.2 Local operation `DeregisterObject` specification

```
IDL: OpReturnCode DeregisterObject(
           in <local object reference> object_reference);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.2.2.2.1 argument `object_reference` specification

The `object_reference` argument value shall be the `<local object reference>` of the Object being deregistered.

9.2.2.3 Operation `GetNewObjectID` specification

```
IDL: OpReturnCode GetNewObjectID(
           out ObjectID object_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.2.2.3.1 argument `object_id` specification

The `object_id` argument value shall be the new current value of the Object ID for the Object invoking the operation.

9.2.2.4 Local operation `GetBlockCookie` specification

```
IDL: OpReturnCode GetBlockCookie(
           in <local object reference> block_reference,
           out UInteger16 block_cookie);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.2.2.4.1 argument `block_reference` specification

The `block_reference` argument value shall be the `<local object reference>` of the Block for which the Block Cookie is requested.

9.2.2.4.2 argument `block_cookie` specification

The `block_cookie` argument value shall be the current value of the Block Cookie of the referenced Block; see 7.3.

9.2.2.5 Local operation `ChangeBlockCookie` specification

```
IDL: OpReturnCode ChangeBlockCookie(
           in <local object reference> block_reference);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.2.2.5.1 argument `block_reference` specification

The `block_reference` argument value shall be the `<local object reference>` of the Block for which the Block Cookie change is requested.

9.2.3 Publications

9.2.3.1 Publication `NCAPBlock_Announcement` specification

Description: This publication provides for a notification of the existence of a NCAP Block Object within a system.

Publication Key: `PSK_NCAPBLOCK_ANNOUNCEMENT`

Publication Topic: Not applicable

Publisher Port Object Name: `NCAPBlock_Announcement`

The Publisher Port Object Name shall be represented in the IEEE 1451.1 character set defined in Annex F.

Publication Contents (see Table 38).

Table 38—`NCAPBlock_Announcement` Publication contents

Argument Array Member	Member Argument `TypeCode` corresponding to type	Argument Name
0	`ObjectTag`	`ncap_block_object_tag`
1	`ObjectDispatchAddress`	`ncap_block_dispatch_address`

9.2.3.1.1 argument ncap_block_object_tag specification

The ncap_block_object_tag argument value shall be the current value of the Object Tag of the publishing Local NCAP Block.

9.2.3.1.2 argument ncap_block_dispatch_address specification

The ncap_block_dispatch_address argument value shall be the value of the Object Dispatch Address of the publishing Local NCAP Block.

9.2.3.2 Publication Network_Visible_Server_Object_Properties specification

Description: This publication provides for a notification of the identity of the Local NCAP Block and the Object Tag, Object Dispatch Address pairs it supports.

Publication Key: PSK_NETWORK_VISIBLE_SERVER_OBJECT_PROPERTIES

Publication Topic: Not applicable

Publisher Port Object Name: Network_Visible_Server_Object_Properties

The Publisher Port Object Name shall be represented in the IEEE 1451.1 character set defined in Annex F.

Publication Contents (see Table 39).

Table 39—Network_Visible_Server_Object_Properties Publication contents

Argument Array Member	Member Argument TypeCode corresponding to type	Argument Name
0	ObjectTag	ncap_block_object_tag
1	ObjectDispatchAddress	ncap_block_dispatch_address
2	ObjectPropertiesArray	server_object_properties

9.2.3.2.1 argument ncap_block_object_tag specification

The ncap_block_object_tag argument value shall be the current value of the Object Tag of the publishing Local NCAP Block.

9.2.3.2.2 argument ncap_block_dispatch_address specification

The ncap_block_dispatch_address argument value shall be the value of the Object Dispatch Address of the publishing Local NCAP Block.

9.2.3.2.3 argument server_object_properties specification

The server_object_properties argument value shall be the same server_object_properties value that would be returned by invoking the operation GetNetworkVisibleServerObjectProperties on the Local NCAP Block identified by ncap_block_object_tag.

9.2.4 NCAP Block subscription

9.2.4.1 Subscription to the `Request_NCAPBlock_Announcement` publication specification

Description: This subscription shall notify registered Subscribers of the receipt of a publication with Publication Key `PSK_REQUEST_NCAPBLOCK_ANNOUNCEMENT`.

Subscription Key: `PSK_REQUEST_NCAPBLOCK_ANNOUNCEMENT`

Subscription Qualifier: Not applicable

Subscriber Port Object Name: `Request_NCAPBlock_Announcement`

The Subscriber Port Object Name shall be represented in the IEEE 1451.1 character set defined in Annex F.

Related publication: `Request_NCAPBlock_Announcement`

Description: This publication is issued by an object to request NCAP Blocks to announce their presence; see 9.2.3.1.

Publication Key: `PSK_REQUEST_NCAPBLOCK_ANNOUNCEMENT`

Publication Topic: Not applicable

Publication Contents: Not applicable. This publication shall not have any contents.

9.2.4.2 Subscription to the `Force_NCAPBlock_Announcement` publication specification

Description: This subscription shall notify registered Subscribers of the receipt of a publication with Publication Key `PSK_FORCE_NCAPBLOCK_ANNOUNCEMENT`

Subscription Key: `PSK_FORCE_NCAPBLOCK_ANNOUNCEMENT`

Subscription Qualifier: Not applicable

Subscriber Port Object Name: `Force_NCAPBlock_Announcement`

The Subscriber Port Object Name shall be represented in the IEEE 1451.1 character set defined in Annex F.

Related publication: `Force_NCAPBlock_Announcement`

Description: This publication is issued by an object to force NCAP Blocks to announce their presence.

Publication Key: `PSK_FORCE_NCAPBLOCK_ANNOUNCEMENT`

Publication Topic: Not applicable

Publication Contents: Not applicable. This publication shall not have any contents.

9.2.4.3 Subscription to the `Request_Network_Visible_Server_Object_Properties` publication specification

Description: This subscription shall notify registered Subscribers of the receipt of a publication with Publication Key `PSK_REQUEST_NETWORK_VISIBLE_SERVER_OBJECT_PROPERTIES`.

Subscription Key: PSK_REQUEST_NETWORK_VISIBLE_SERVER_OBJECT_PROPERTIES

Subscription Qualifier: Not applicable

Subscriber Port Object Name:
Request_Network_Visible_Server_Object_Properties

The Subscriber Port Object Name shall be represented in the IEEE 1451.1 character set defined in Annex F.

Related publication: Request_Network_Visible_Server_Object_Properties

Description: This publication is issued by an object to force NCAP Blocks to publish the properties of any Server Object matching one of the server_object_tags member values contained in the publication, see 9.2.5.7.

Publication Key: PSK_REQUEST_NETWORK_VISIBLE_SERVER_OBJECT_PROPERTIES

Publication Topic: Not applicable

Publication Contents (see Table 40).

Table 40—REQUEST_NETWORK_VISIBLE_SERVER_OBJECT_PROPERTIES Publication contents

Argument Array Member	Member Argument TypeCode corresponding to type	Argument Name
0	ObjectTag	ncap_block_object_tag
1	ObjectDispatchAddress	ncap_block_dispatch_address
2	ObjectTagArray	server_object_tags

9.2.4.3.1 argument ncap_block_object_tag specification

The ncap_block_object_tag argument value shall be the current value of the Object Tag of the publishing NCAP Block Object.

9.2.4.3.2 argument ncap_block_dispatch_address specification

The ncap_block_dispatch_address argument value shall be the value of the Object Dispatch Address of the publishing NCAP Block Object.

9.2.4.3.3 argument server_object_tags specification

The server_object_tags argument value shall consist of the current Server Object Tag values for all Base Client Port Objects of the publishing node for which corresponding Object Dispatch Address values are sought.

9.2.4.4 Subscription to the NCAPBlock_Go_Active publication specification

Description: This subscription shall notify registered Subscribers of the receipt of a publication with Publication Key PSK_NCAPBLOCK_GO_ACTIVE issued by an object Owned by an NCAP Block Object other than the one Owning this Port.

Subscription Key: PSK_NCAPBLOCK_GO_ACTIVE

Subscription Qualifier: Not applicable

Subscriber Port Object Name: NCAPBlock_Go_Active

The Subscriber Port Object Name shall be represented in the IEEE 1451.1 character set defined in Annex F.

Related publication: NCAPBlock_Go_Active

Description: This publication is issued by an object to request NCAP Blocks to transition to the BL_ACTIVE state; see 9.2.5.7.

Publication Key: PSK_NCAPBLOCK_GO_ACTIVE

Publication Topic: Not applicable

Publication Contents: Not applicable. This publication shall not have any contents.

9.2.5 NCAP Block class behavior

9.2.5.1 Concurrency requirements

The RebootNCAPBlock and ResetOwnedBlocks operations shall support Precedence Concurrency.

9.2.5.2 NCAP Block state behavior specification

The state machine for the IEEE1451_NCAPBlock class is identical to that of the IEEE1451_Block class, see 9.1.3.2, except that the BL_INACTIVE state has been substated; see Figure 10.

The NCAP Block state machine substates BL_INACTIVE to provide the states NB_INITIALIZED and NB_ERROR.

The initial transition from the BL_UNINITIALIZED state to the NB_INITIALIZED state shall be caused by implementation-specific mechanisms within the NCAP Block or the underlying operating system. This initial transition shall not be invokable from the network.

"Fail" is an internally generated transition that may be executed as appropriate to enter the NB_ERROR substate.

Block operations, such as GoActive may also be generated internally by the NCAP Block itself. The GoInactive operation shall cause a transition to the NB_ERROR substate of BL_INACTIVE if the NCAP Block detects error conditions that invalidate the specifications of the Block.

In addition to behavior restrictions specified for all Blocks; see 9.1.3, the behavior of an NCAP Block Object shall be restricted per 9.2.5.2.1

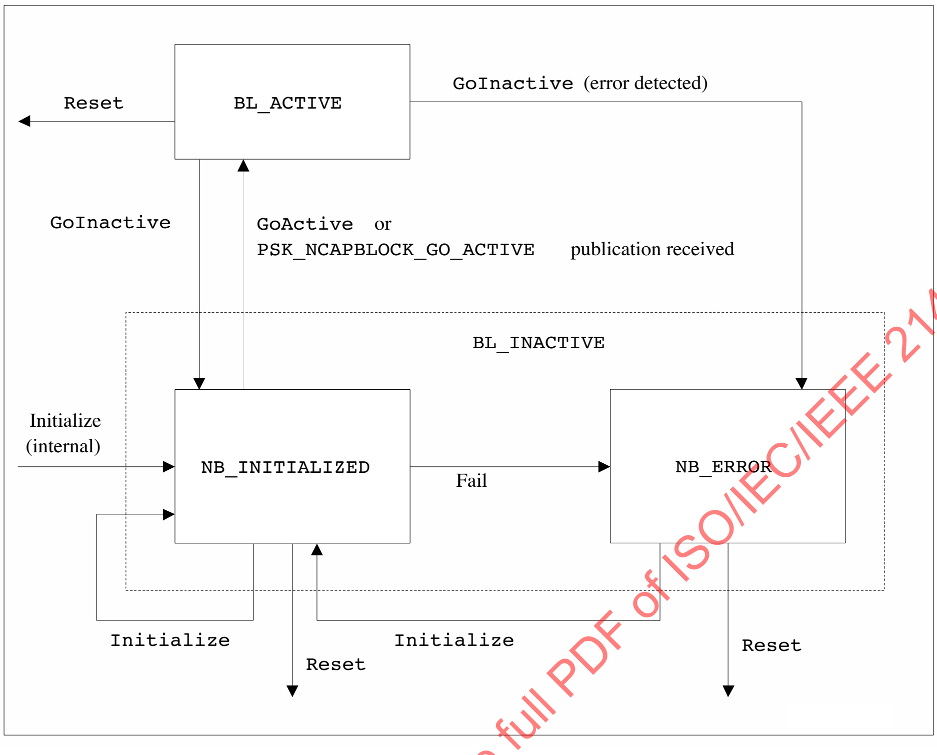


Figure 10—State Machine for the NCAP Block

9.2.5.2.1 Specific NCAP Block operation restrictions based on state

In addition to and conformant with the restrictions of 9.1.3.2.1, 9.1.3.2.2, 9.1.3.2.3, and 9.1.3.2.4, the allowed operations defined by this class shall be restricted as defined in Table 41. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, 9.1.3.2.3, and 9.1.3.2.4.

Table 41—`IEEE1451_NCAPBlock` class specific restrictions

Operation	Block object's major state value		
	BL_UNINITIALIZED	**BL_INACTIVE**	**BL_ACTIVE**
All operations except those in the following row	Local invocation only	Operational	Operational
`SetConfigurationToolAddress`	Local invocation only	Operational	Not operational
Publication of publication list A	Not operational	Operational	Operational
Subscription acceptance of publication list B	Not operational	Operational	Operational

In interpreting these clauses, the application supported by an NCAP Block includes the configuration of other objects in the process space. These activities shall be legal in both the `BL_INACTIVE` and `BL_ACTIVE` states of the NCAP Block. In contrast, the configuration of the NCAP Block itself shall not be done in the `BL_ACTIVE` state.

Publication list A shall consist of the following publications:

— `NCAPBlock_Announcement`

— `Network_Visible_Server_Object_Properties`

Publication list B shall consist of the following publications:

— `Request_NCAPBlock_Announcement`

— `Force_NCAPBlock_Announcement`

— `Request_Network_Visible_Server_Object_Properties`

— `NCAPBlock_Go_Active`

9.2.5.3 Operation `RebootNCAPBlock` behavior specification

The `RebootNCAPBlock` operation shall cause the NCAP Block Object and all objects Directly or Indirectly Owned by the NCAP Block Object to be placed in the state that would exist after a normal powerup of the supporting NCAP. The order of application of these state changes is outside the scope of this standard.

An implementation may provide mechanisms for rebooting the entire NCAP operating environment that may include a power cycle of the device. The implementation of this behavior is outside the scope of this standard.

9.2.5.4 Operation `ResetOwnedBlocks` behavior specification

The `ResetOwnedBlocks` operation shall cause all Block Objects Directly or Indirectly Owned by this NCAP Block Object to behave as though each such Block had received a `Reset` operation request as defined for the class of each object. The order of application of such `Reset` operations is outside the scope of this standard. This operation shall not reset the NCAP Block itself.

9.2.5.5 NCAP Block's Block Cookie behavior specification

The Block Cookie of the NCAP Block shall be changed whenever a change has occurred, that would result in a different set of binding information to be produced by the operations `GetClientPortProperties` or `GetNetworkVisibleServerObjectProperties`.

The Block Cookie of the NCAP Block shall be changed whenever the Block Major State on the NCAP Block changes.

9.2.5.6 Association of the Server Object Tag with the Server Object's Object Dispatch Address

The Local NCAP Block shall be responsible for associating the Server Object Tag of each of its Owned, Network Visible Base Client Ports with the Server Object's Object Dispatch Address.

The necessary information for forming this association may be provided to the Local NCAP Block by external objects or it may be acquired by the Local NCAP Block from external objects. This information consists of a set of `ObjectProperties` structures for the Server Objects whose Object Tags match the Server Object Tag of the Network Visible Base Client Ports Owned by the Local NCAP Block.

Upon obtaining this information the following associations shall be made:

— From the set of `ObjectProperties` structures select those corresponding to Server Objects for which the `objectTag` entry matches the Server Object Tag of the Network Visible Base Client Port Objects Directly or Indirectly Owned by the Local NCAP Block.

— For each such match, form an association between the `objectDispatchAddress` member of the `ObjectProperties` structure and the corresponding Server Object Tag of a Base Client Port so as to enable the Port to communicate with its associated Server Object.

— Where required by the implementation, for each such match form an association between the `objectName`, `blockCookie`, and `owningBlockObjectTag` members of the `ObjectProperties` structure and the corresponding Server Object Tag of a Base Client Port so as to enable the Port to meet the requirements for client-server communication.

If these associations are made via the invocation of the `SetClientPortServerObjectBindings` operation on the Local NCAP Block

— Return with a return code Minor Field value of `ST_UNRESOLVED_SERVER_OBJECT_TAGS_REMAIN` if after application of the provided information there are still Server Object Tags on the NCAP Block's Owned Base Client Ports for which these associations have not been made.

— Return with a return code Minor Field value of `ST_INCONSISTENT_DATA` if inconsistencies in the association information are found, for example, two Server Objects with the same Object Tag value.

— Return with a return code Minor Field value of `ST_UNRESOLVED_AND_INCONSISTENT` if both conditions obtain.

The Local NCAP Block may obtain or be provided with the information necessary to form these associations using combinations of the following client-server operations to and from external objects or the following subscriptions and publications to and from external objects. Examples of the use of these mechanisms to obtain this association information are presented in Annex D.

— By publishing the publication `Request_NCAPBlock_Announcement` and subscribing to the publication `NCAPBlock_Announcement` to determine the external NCAP Blocks in the system

— By invoking the operation `IgnoreRequestNCAPBlockAnnouncement` on external NCAP Blocks to contain message storms in response to the `Request_NCAPBlock_Announcement` publication

— By invoking the operation `RespondToRequestNCAPBlockAnnouncement` on external NCAP Blocks to reactivate recipients of the `IgnoreRequestNCAPBlockAnnouncement` server operation request

— By publishing the publication `Force_NCAPBlock_Announcement` to force the publication of the `NCAPBlock_Announcement` publication even from recipients of the `IgnoreRequestNCAPBlockAnnouncement` server operation request

— By publishing the publication `Request_Network_Visible_Server_Object_Properties` and subscribing to the `Network_Visible_Server_Object_Properties` publication

— By invoking the operation `GetNetworkVisibleServerObjectProperties` on external NCAP Blocks

— By responding to the operation request SetClientPortServerObjectBindings from external objects or a third party

9.2.5.7 NCAP Block publishing and subscription behavior specification

The NCAP Block Object may publish the publication NCAPBlock_Announcement according to a system-defined policy outside the scope of this standard. The NCAPBlock_Announcement publication is used to indicate the presence of the NCAP to other entities in a distributed system.

The state machine of Figure 11 and text define the required publication behavior.

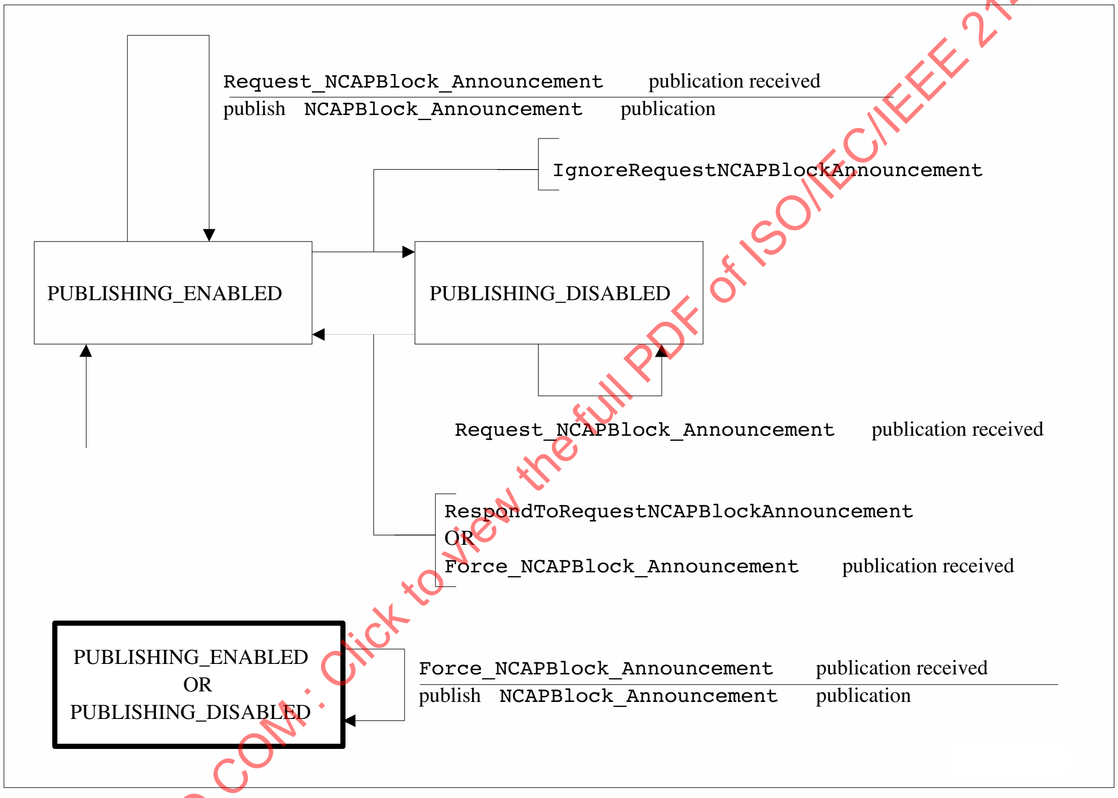

Request_NCAPBlock_Announcement publication received
publish NCAPBlock_Announcement publication
IgnoreRequestNCAPBlockAnnouncement
PUBLISHING_ENABLED
PUBLISHING_DISABLED
Request_NCAPBlock_Announcement publication received
RespondToRequestNCAPBlockAnnouncement
OR
Force_NCAPBlock_Announcement publication received
PUBLISHING_ENABLED
OR
PUBLISHING_DISABLED
Force_NCAPBlock_Announcement publication received
publish NCAPBlock_Announcement publication

Figure 11—State machine defining publication of NCAP Block announcements

Subject to the restrictions of 9.2.5.2.1, the state machine–defined behavior for NCAPBlock_Announcement publications shall be active in all Block Major States, BL_UNINITIALIZED, BL_INACTIVE, and BL_ACTIVE of the Local NCAP Block. When the Block is created by mechanisms outside the scope of this standard, the entry state shall be PUBLISHING_ENABLED, as illustrated by the entry transition.

The Local NCAP Block shall publish the publication NCAPBlock_Announcement once for each notification that the publication Force_NCAPBlock_Announcement has been received. In addition, the receipt of this publication shall cause the Local NCAP Block to behave in the future as though the operation RespondToRequestNCAPBlockAnnouncement had been called on the Local NCAP Block.

The Local NCAP Block shall publish the publication NCAPBlock_Announcement once for each notification that the publication Request_NCAPBlock_Announcement has been received and the state is PUBLISHING_ENABLED.

The Local NCAP Block shall publish the publication Network_Visible_Server_Object_Properties once for each notification that the publication Request_Network_Visible_Server_Object_Properties has been received provided that at least one of the Object Tag values in the server_object_tags field of the received Request_Network_Visible_Server_Object_Properties publication matches an Object Tag on a Network Visible Object Owned by the Local NCAP Block; see 8.2.3.4.

Notification of the receipt of the publication NCAPBlock_Go_Active shall cause the receiving Local NCAP Block to behave as if a GoActive operation had been invoked on the Local NCAP Block.

9.2.5.8 Startup mechanism behavior specification

The Local NCAP Block shall Own two Component Group Objects

— The Permanent Startup Set

— The Configurable Startup Set

The Object Tag values of these Component Group Objects shall be NOT_SET on instantiation.

The Component Group member Objects shall be Block Objects Owned by the Local NCAP Block.

The Object Names of these Component Group Objects shall be represented in the IEEE 1451.1 character set defined in Annex F.

9.2.5.8.1 Permanent Startup Set behavior specification

The Object Name shall be Permanent_Startup_Set. The set shall contain as members only Blocks Owned by the Local NCAP Block. The Local NCAP Block shall cause the members of this set to transition from the BL_UNINITIALIZED to the BL_INACTIVE state when the Local NCAP Block transitions from the BL_UNINITIALIZED to the BL_INACTIVE state. Such members shall not be deletable from the Permanent Startup Set. The AddMember, SetMembers, and DeleteMember operations on the Permanent Startup Set Component Group Object shall return MJ_NOP_OPERATION.

This set may include all such required Blocks. If there is an implementation policy where Blocks cause their Owned Blocks to go through these transitions, then the set need include only the Blocks Directly Owned by the Local NCAP Block.

9.2.5.8.2 Configurable Startup Set behavior specification

The Object Name shall be Configurable_Startup_Set. The set shall contain as members only Blocks Owned by the Local NCAP Block and not in the Permanent Startup Set. The Local NCAP Block shall cause the members of this set to transition from the BL_UNINITIALIZED to the BL_INACTIVE state when the Local NCAP Block transitions from the BL_UNINITIALIZED to the BL_INACTIVE state.

This set may include all such required Blocks. If there is an implementation policy where Blocks cause their Owned Blocks to go through these transitions, then the set need include only the Blocks Directly Owned by the Local NCAP Block. It is recommended that this startup set be implemented in nonvolatile storage.

9.2.5.9 Operation GoActive behavior specification

Subject to the restrictions of 9.2.5.2, the invocation of the GoActive operation on the Local NCAP Block

— Shall cause the Local NCAP Block to transition to the BL_ACTIVE state

— May cause the invocation of the `GoActive` operation on Blocks not visible to the network as defined by implementation-specific means internal to the NCAP

— Shall cause the invocation of the `GoActive` operation on all Blocks that are members of the Permanent Startup Set followed by the invocation of the `GoActive` operation on all Blocks that are members of the Configurable Startup Set

The order of invocation of `GoActive` on the Permanent Startup Set member Blocks and the Configurable Startup Set member Blocks is implementation dependent. No system behavior shall depend on the order of invocation.

If the Local NCAP Block receives a failure return from any of the `GoActive` operations issued to the Permanent Startup Set Blocks or the Configurable Startup Set Blocks, the Local NCAP Block shall transition to the `NB_ERROR` state.

9.2.5.10 Operation `GetNewObjectID` behavior specification

— The Local NCAP Block shall provide an Object ID for local Objects via a call to `GetNewObjectID`. The value shall be generated as defined in 8.2.3.5.

— IEEE 1451 NCAPs that support a fixed set of Object instances may use an Interface Only Implementation of `GetNewObjectID`.

— Implementations that provide for “lazy” evaluation of Object ID values shall provide a Full Implementation of `GetNewObjectID`.

9.2.5.11 Restrictions on the operations `GetConfigurationToolAddress` and `SetConfigurationToolAddress`

Both the `GetConfigurationToolAddress` and `SetConfigurationToolAddress` operations shall either have a Full Implementation if the NCAP Block Object supports this function; otherwise, both shall have an Interface Only Implementation.

9.2.5.12 Object creation, destruction, registration, and deregistration behavior specification

Every NCAP process that contains Entity Objects shall also contain a single NCAP Block, the Local NCAP Block; see 5.1.2.2.

The mechanism for the specification of the set of objects contained in a process, and the order and method of creation or destruction of these objects for a given process in an NCAP is implementation dependent and outside the scope of this standard.

Objects created that are to be Network Visible shall be registered with the NCAP Block by the use of the `RegisterObject` operation.

Registered Objects destroyed shall be deregistered by the use of the `DeregisterObject` operation before they are destroyed.

IEEE 1451 NCAPs that support a fixed set of Network Visible Object instances may use an Interface Only Implementation of `RegisterObject` and `DeregisterObject`.

9.2.5.13 Operation `GetBlockCookie` behavior specification

If the object referenced by `block_reference` is a Block Object, the operation shall

— Return the Block Cookie of the referenced Block

If the referenced object is not a Block Object, the operation shall

— Return a major return code field of `MJ_FAILED_INPUT_ARGUMENT`

— Return a minor return code field of `MI_INVALID_TYPE`

— Return the NOT_SET value for the `block_cookie`; see 7.3.2.2

NOTE—One of the common uses of the `GetBlockCookie` operation will be for Objects to obtain the current value of their Associated Block Cookie. For this purpose, Objects must know the `<local object reference>` of their Owning Block. The mechanism for determining this `<local object reference>` is outside the scope of this standard.

9.2.5.14 Operation `ChangeBlockCookie` behavior specification

Invocation of this operation shall result in the Block Cookie of the Block identified by `block_reference` being changed. These changes shall be subject to restrictions of 7.3. This operation shall produce this behavior if and only if the `block_reference` refers to a Block Object. In all other cases, the operation shall return `MJ_FAILED_INPUT_ARGUMENT`. This operation may have an Interface Only Implementation if the device is such that the occasion for changing the Block Cookie can never arise.

9.3 Function Block class

Abstract class

Class: `IEEE1451_FunctionBlock`

Parent Class: `IEEE1451_Block`

Class ID: 1.1.1.2

Description: The Function Block class shall be the root for the class hierarchy of all Function Block Objects. The Function Block is the primary mechanism for the abstraction and packaging of application functionality.

Class summary:

Network Visible operations (see Table 42).

Table 42—`IEEE1451_FunctionBlock` Network Visible operations

Operation Name	Requirement	Operation ID
`GetFunctionBlockState`	(m)	6157
`Start`	(o)	6158
`Clear`	(o)	6159
`Pause`	(o)	6160
`Resume`	(o)	6161

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

9.3.1 Operation specifications: Network Visible

9.3.1.1 Operation `GetFunctionBlockState` specification

```
IDL: OpReturnCode GetFunctionBlockState(
           out UInteger8 function_block_state);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.3.1.1.1 argument `function_block_state` specification

The `function_block_state` argument value shall be the current value of the substate of the Block as depicted in the behavior clause. The allowed values of `function_block_state` shall be defined by the enumeration in Table 43.

IDL: `enumeration FunctionBlockState;`

Table 43—`FunctionBlockState` enumeration

Enumeration	Value
FB_IDLE	0
FB_RUNNING	1
FB_STOPPED	2
Reserved	3–255

9.3.1.2 Operation `Start` specification

```
IDL: OpReturnCode Start( );
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.3.1.3 Operation `Clear` specification

```
IDL: OpReturnCode Clear( );
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.3.1.4 Operation `Pause` specification

```
IDL: OpReturnCode Pause( );
```

There are no operation specific additions to the Minor Field of the return code enumeration.

9.3.1.5 Operation `Resume` specification

```
IDL: OpReturnCode Resume( );
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.3.2 Function Block class behavior

9.3.2.1 State behavior specification

The state machine for the `IEEE1451_FunctionBlock` class is identical to that of the `IEEE1451_Block` class except that the `BL_ACTIVE` state has been substated as illustrated in Figure 12.

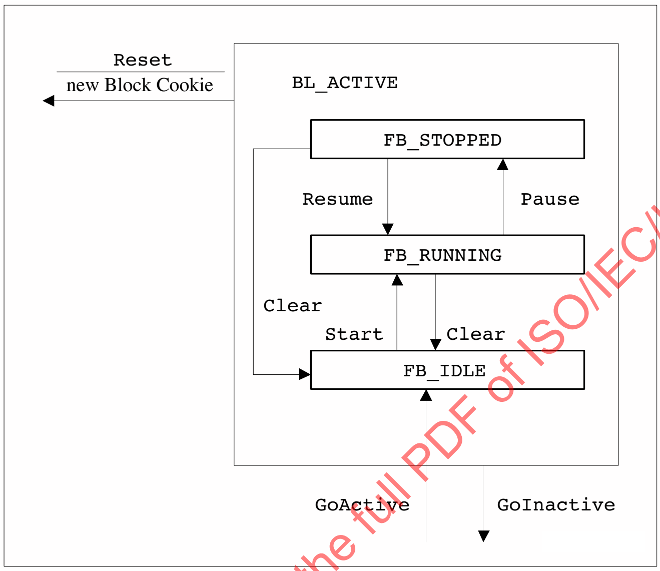


Figure 12—State machine for a Function Block

The `Start` operation may be generated internally.

The `Pause` operation may take time to execute but shall leave the Block in a resumable state.

The behavior of the Function Block Object shall be restricted as specified in 9.3.2.1.1, 9.3.2.1.2, and 9.3.2.1.3.

9.3.2.1.1 `FB_IDLE` state restrictions

No Block functionality that can change the state of any object external to the Block shall be operative.

9.3.2.1.2 `FB_RUNNING` state restrictions

All functionality shall be operative.

9.3.2.1.3 `FB_STOPPED` state restrictions

All functionality shall be inoperative except that necessary for the execution of operations defined by the class for the `BL_ACTIVE` or `FB_STOPPED` states.

9.3.2.2 Specific Function Block operation restrictions based on state

In addition to and conformant with the restrictions of 9.1.3.2.1, 9.1.3.2.2, 9.1.3.2.3, and 9.1.3.2.4, the allowed operations defined by this class shall be restricted as defined in Table 44. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, 9.1.3.2.3, and 9.1.3.2.4.

Table 44—`IEEE1451_Function Block` class specific restrictions

Operation	Block object's major state value		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
All operations	Local invocation only	Operational	Operational

9.3.2.3 `Start`, `Clear`, `Pause`, and `Resume` operation restrictions

The operations `Start`, `Clear`, `Pause`, and `Resume` shall all be Interface Only Implementations if the Function Block substates have no useful meaning in an implementation, otherwise these operations shall have a Full Implementation.

For those cases where an Interface Only Implementation is permitted and implemented, `GetFunctionBlockState` shall return `FB_RUNNING` and the Block shall enter the `FB_RUNNING` state as a result of a `GoActive` operation.

9.4 Base Transducer Block abstract class

Abstract Class

Class: `IEEE1451_BaseTransducerBlock`

Parent Class: `IEEE1451_Block`

Class ID: 1.1.1.3

Description: The Base Transducer Block class shall be the root for the class hierarchy of all Transducer Block Objects.

Class summary:

Network Visible operations (see Table 45).

Table 45—`IEEE1451_BaseTransducerBlock` Network Visible operations

Operation Name	Requirement	Operation ID
`IORead`	(o)	6162
`IOWrite`	(o)	6163
`SetIOControl`	(o)	6164
`GetIOStatus`	(o)	6165

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

9.4.1 Operation specifications: Network Visible

9.4.1.1 Operation `IORead` specification

```
IDL: OpReturnCode IORead(
              in ArgumentArray io_input_arguments,
              out ArgumentArray io_output_arguments);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.4.1.1.1 argument `io_input_arguments` specification

The specifications for this argument are class-specific.

9.4.1.1.2 argument `io_output_arguments` specification

The specifications for this argument are class-specific.

9.4.1.2 Operation `IOWrite` specification

```
IDL: OpReturnCode IOWrite(
              in ArgumentArray io_input_arguments,
              out ArgumentArray io_output_arguments);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.4.1.2.1 argument `io_input_arguments` specification

The specifications for this argument are class-specific.

9.4.1.2.2 argument `io_output_arguments` specification

The specifications for this argument are class-specific.

9.4.1.3 Operation `SetIOControl` specification

```
IDL: OpReturnCode SetIOControl(
              in ArgumentArray control_arguments);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.4.1.3.1 argument `control_arguments` specification

The specifications for this argument are class-specific.

9.4.1.4 Operation `GetIOStatus` specification

```
IDL: OpReturnCode GetIOStatus(
              in ArgumentArray io_input_arguments,
              out ArgumentArray status);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.4.1.4.1 argument `io_input_arguments` specification

The specifications for this argument are class-specific.

9.4.1.4.2 argument `status` specification

The specifications for this argument are class-specific.

9.4.2 Base Transducer Block class behavior

9.4.2.1 State behavior specification

The behavior of the `IEEE1451_BaseTransducerBlock` is defined in Figure 13.

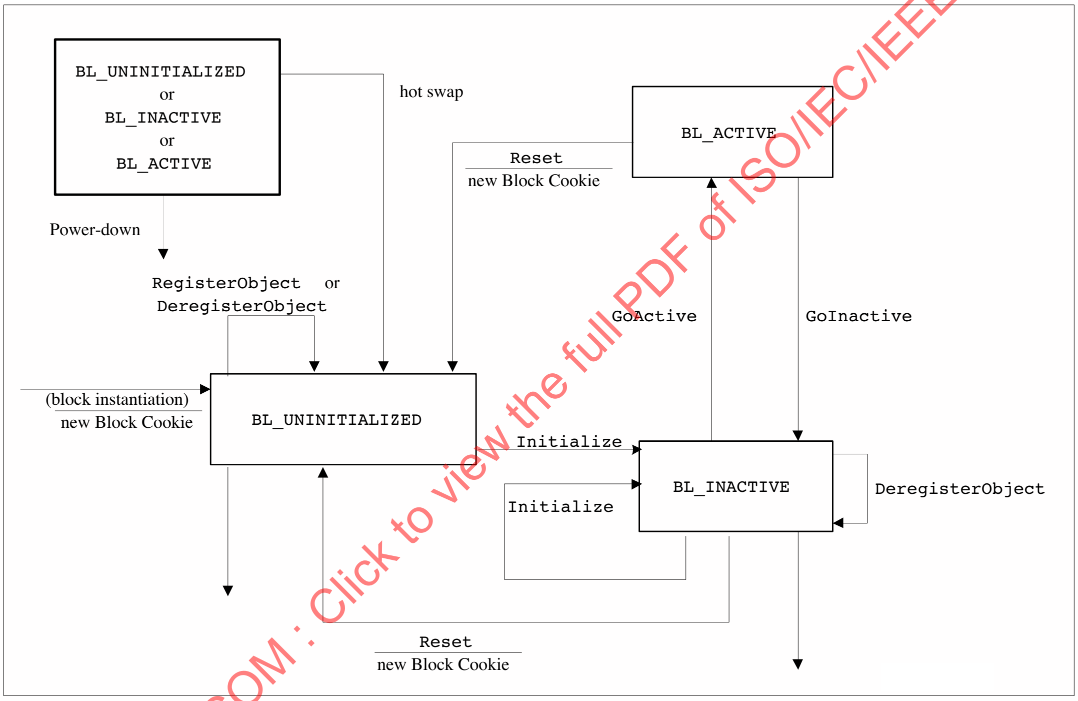


Figure 13—State machine for a Base Transducer Block

The behavior added to that inherited from the `IEEE1451_Block` class is the hot swap transition to `BL_UNINITIALIZED`. If the implementation is able to detect a disconnect and connect at the physical interface abstracted by the Transducer Block, it shall term this a hot swap event and force the Transducer Block through the initialization procedure.

The behavior of the Base Transducer Block Object shall be restricted as defined in 9.4.2.1.1 and 9.4.2.2.

9.4.2.1.1 Specific Base Transducer Block operation restrictions based on state

In addition to and conformant with the restrictions of 9.1.3.2.1, 9.1.3.2.2, 9.1.3.2.3, and 9.1.3.2.4, the allowed operations defined by this class shall be restricted as defined in Table 46. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, 9.1.3.2.3, and 9.1.3.2.4.

Table 46—`IEEE1451_BaseTransducerBlock` class specific restrictions

Operation	Block Object's major state value		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
All operations	Local invocation only	Operational	Operational

9.4.2.2 `IORead`, `IOWrite`, `SetIOControl`, and `GetIOStatus` operation restrictions

These operations shall be Interface Only Implementations, or Full Implementations as designated by the subclass.

9.5 Transducer Block abstract class

Abstract Class

Class: `IEEE1451_TransducerBlock`

Parent Class: `IEEE1451_BaseTransducerBlock`

Class ID: 1.1.1.3.1

Description: The Transducer Block class shall be the root for the class hierarchy of all Transducer Block Objects in the family of transducers specified by IEEE 1451.X standards.

Class summary:

Network Visible operations (see Table 47).

Table 47—`IEEE1451_TransducerBlock` Network Visible operations

Operation Name	Requirement	Operation ID
`EnableCorrections`	(o)	8192
`DisableCorrections`	(o)	8193
`GetCorrectionMode`	(m)	8194
`GetLastUpdateTimestamp`	(o)	8195
`GetUpdateTimestampUncertainty`	(o)	8196
`GetNumberOfTransducerChannels`	(m)	8197
`GetMinimumSamplingPeriod`	(m)	8198
`GetChannelParameterObjectTags`	(m)	8199
`GetParameterObjectChannelNumbers`	(m)	8200
`GetUnrepresentedChannelNumbers`	(m)	8201
`UpdateAll`	(m)	8202

Inherited operations with additional specifications for this class (see Table 48).

Table 48—**`IEEE1451_TransducerBlock`** inherited operations

Operation Name	Requirement
`RegisterNotifyOnUpdate`	(m)
`DeregisterNotifyOnUpdate`	(m)

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

9.5.1 Operation specifications: Network Visible

9.5.1.1 Operation **`EnableCorrections`** specification

```
IDL: OpReturnCode EnableCorrections( );
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.5.1.2 Operation **`DisableCorrections`** specification

```
IDL: OpReturnCode DisableCorrections( );
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.5.1.3 Operation **`GetCorrectionMode`** specification

```
IDL: OpReturnCode GetCorrectionMode(
              out UInteger8 correction_mode);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.5.1.3.1 argument **`correction_mode`** specification

The `correction_mode` argument value shall be the current value of an attribute that defines the application of any provided corrections for the calibration of transducers represented by the Network Visible Public Transducers Owned by this Block. The allowed values of this argument shall be defined by the enumeration in Table 49.

IDL: enumeration `CorrectionMode;`

Table 49—**`CorrectionMode`** enumeration

Enumeration	Value
`TB_CORRECTED`	0
`TB_UNCORRECTED`	1
Reserved	2–255

9.5.1.4 Operation `GetLastUpdateTimestamp` specification

```
IDL: OpReturnCode GetLastUpdateTimestamp(
           out TimeRepresentation update_timestamp);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.5.1.4.1 argument `update_timestamp` specification

The `update_timestamp` argument value shall be the time of the last update of any of the Block's Public Transducers.

9.5.1.5 Operation `GetUpdateTimestampUncertainty` specification

```
IDL: OpReturnCode GetUpdateTimestampUncertainty(
           out Uncertainty update_timestamp_uncertainty);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.5.1.5.1 argument `update_timestamp_uncertainty` specification

The `update_timestamp_uncertainty` argument value shall be the value of an attribute that defines the uncertainty in the `update_timestamp`.

The values shall be defined during the initialization phase of the Block State Machine. The value shall include uncertainty in the underlying time base of the NCAP or system, and errors in generating the timestamp in the NCAP. The `update_timestamp_uncertainty` shall be based on time expressed in seconds.

9.5.1.6 Operation `GetNumberOfTransducerChannels` specification

```
IDL: OpReturnCode GetNumberOfTransducerChannels(
           out UInteger16 number_of_transducer_channels);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.5.1.6.1 argument `number_of_transducer_channels` specification

The `number_of_transducer_channels` argument value shall be the number of implemented channels on the physical transducer interface, exclusive of any global channels. Implemented channels are those providing functioning behavior but not those that may be placeholders for future expansion or similar purposes.

9.5.1.7 Operation `GetMinimumSamplingPeriod` specification

```
IDL: OpReturnCode GetMinimumSamplingPeriod(
           out TimeRepresentation minimum_sampling_period);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.5.1.7.1 argument `minimum_sampling_period` specification

The `minimum_sampling_period` argument value shall be the minimum required time, measured in units of seconds, between successive invocations of the `UpdateAll` operation. This value shall also be a safe value for the minimum time between reads or writes on a Parameter associated with this Block. The actual operational value of the minimum time between samples may be increased over the value of `minimum_sampling_period` by the time required for processing within the Transducer Block, and may be adversely affected by available processor cycles and other NCAP resources.

9.5.1.8 Operation `GetChannelParameterObjectTags` specification

```
IDL: OpReturnCode GetChannelParameterObjectTags(
           in UInteger16 channel_number,
           out ObjectTagArray parameter_object_tags);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.5.1.8.1 argument `channel_number` specification

The `channel_number` argument value shall be a number N designating the channel of interest where

$0 < N \leq$ `number_of_transducer_channels`

9.5.1.8.2 argument `parameter_object_tags` specification

The `parameter_object_tags` argument value shall be an Array of Object Tags identifying the Public Transducers that use the `channel_number` channel. Each member of the `parameter_object_tags` Array shall be the Object Tag returned by the `GetObjectTag` operation on the Public Transducer Object.

9.5.1.9 Operation `GetParameterObjectChannelNumbers` specification

```
IDL: OpReturnCode GetParameterObjectChannelNumbers(
           in ObjectTag parameter_object_tag,
           out UInteger16Array channel_numbers);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.5.1.9.1 argument `parameter_object_tag` specification

The `parameter_object_tag` argument value shall be the current value of the Object Tag identifying the Public Transducer for which the corresponding channel numbers are required.

9.5.1.9.2 argument `channel_numbers` specification

The `channel_numbers` argument value shall be the physical interface channel numbers for the implemented physical interface channels represented by the designated Public Transducer.

9.5.1.10 Operation `GetUnrepresentedChannelNumbers` specification

```
IDL: OpReturnCode GetUnrepresentedChannelNumbers(
           out UInteger16Array unrepresented_channel_numbers);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.5.1.10.1 argument `unrepresented_channel_numbers` specification

The `unrepresented_channel_numbers` argument shall be the Array of numbers N_i, each Array member value N_i representing a channel present at the physical interface that is not represented by a Public Transducer where

$$0 < N_i \leq \texttt{number\_of\_transducer\_channels}$$

9.5.1.10.2 Operation `UpdateAll` specification

```
IDL: OpReturnCode UpdateAll(  );
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

9.5.2 Transducer Block class behavior

9.5.2.1 Behavior overview

NOTE—IEEE 1451.X Transducers may provide multiple channels, each channel serving an individual transducer. For each channel, considerable information specifying the measurement or actuation properties of the transducer, such as units and calibration, is provided in data structures named TEDS. There may be a variety of transducer types in an IEEE 1451.X STIM.

The `IEEE1451_TransducerBlock` models each of the transducer channels by exposing as a Network Visible Object one or more instances of a subclass of the Component class associated with the channel. These interface Objects are termed Public Transducers. During the initialization phase of the Block Major State life cycle, the Transducer Block establishes the mapping between the individual channels of the IEEE 1451.X Transducer and the Public Transducers of the Transducer Block. Each of these Public Transducers represent IEEE 1451.X specified information associated with the channel or channels represented by the object.

This model of STIM's and the NCAP's Transducer Block is illustrated in Figure 14 for a four-channel STIM. The STIM and STIM interface elements of this model actually present may vary with the specific IEEE 1451.X standard or with particular STIMs.

Channel number 0, zero, shall be reserved for communication to the STIM as a whole and shall not be represented as a Public Transducer.

IEEE 1451.X STIMs are modeled to have a combination of input and output converters each associated with a register, (STIM: register-1 to register-4 in the figure). These registers are accessed via the IEEE 1451.X physical interface as a result of actions taken by the Transducer Block. STIM control manages the STIM side control of data transport and the triggering of the various registers in response to trigger signals from the Transducer Block when this feature is part of the IEEE 1451.X specification. These registers agree with the corresponding physical world values as determined by the converters only after any supported triggering operation.

The Transducer Block is modeled to contain a register, (raw data-1 to raw data-4 in the figure), corresponding to each STIM register. These two sets of registers agree only after an exchange of values over the interface. A second set of registers, the engineering data registers of the figure, contains values mapping the contents of the raw data registers using the correction information provided by the STIM TEDS. If this function is not supported in a particular IEEE 1451.X standard then these two sets of registers may be modeled as a single set of registers. These engineering data registers may be modeled as the "currently held values" of a Physical Parameter used as the Public Transducer; see Figure 16 and Figure 17.

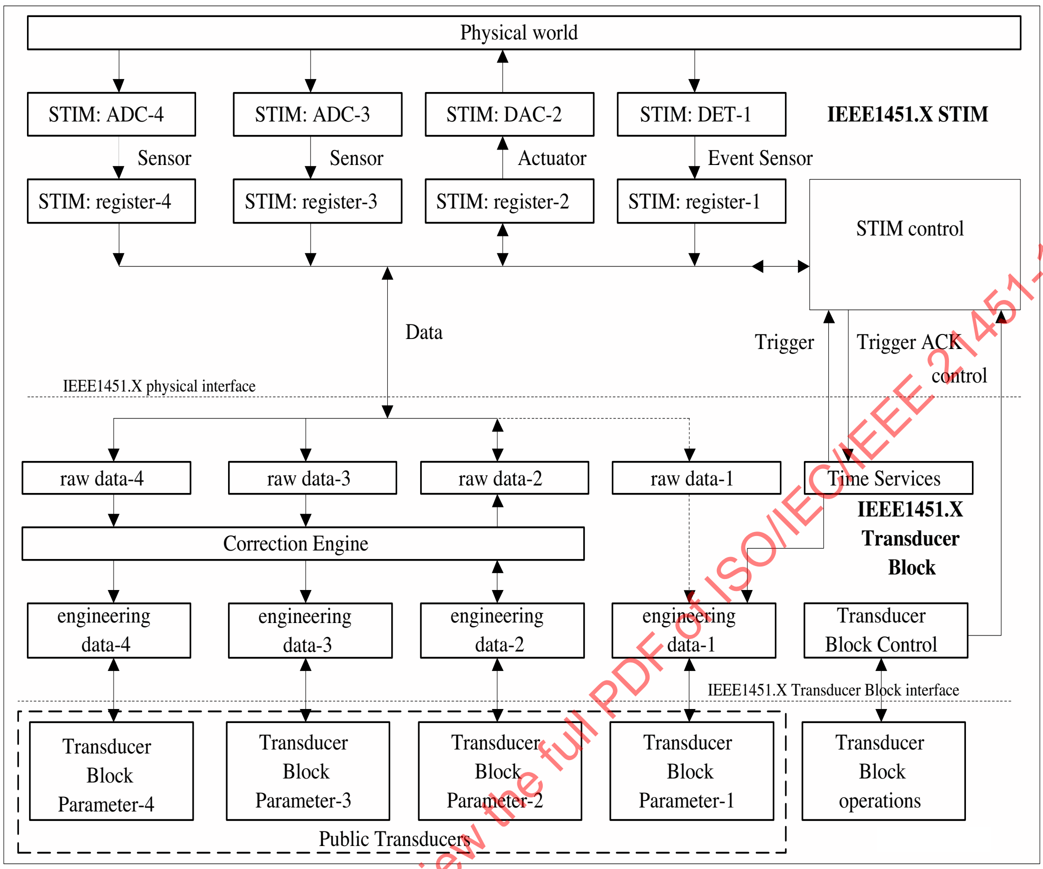


Figure 14—Model of an IEEE 1451.X STIM and Transducer Block

9.5.2.2 Specific Transducer Block operation restrictions based on state

In addition to and conformant with the restrictions of 9.1.3.2.1, 9.1.3.2.2, 9.1.3.2.3, and 9.1.3.2.4, the allowed operations defined by this class shall be restricted as defined in Table 50. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, 9.1.3.2.3, and 9.1.3.2.4.

Table 50—IEEE1451_TransducerBlock class specific restrictions

Operation	Block object's major state value		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
All operations except those in the following row	Local invocation only	Operational	Operational
`EnableCorrections`, `DisableCorrections`	Local invocation only	Operational	Not operational

9.5.2.3 Initialization behavior of Transducer Blocks

During the initialization of a Transducer Block, zero or more instances of Parameters, Files, Component Groups, and Event Generator Publisher Ports shall be instantiated and may be registered to create the Network Visible interface appropriate to the specific transducer. This activity shall be successfully completed before entering the `BL_INACTIVE` state defined for the Block.

The selection of the interface Objects and the assignment of their Object Names during registration or instantiation of those Objects shall be based on information supplied from the IEEE 1451.X TEDS and the following clauses.

9.5.2.3.1 Required Files and their naming conventions

The IEEE 1451.X-defined TEDS data structures shall be represented by this Transducer Block class as an Object of class `IEEE1451_PartitionedFile` or an `IEEE1451_File.`

9.5.2.3.2 Properties of Files required for Transducer Blocks

The contents of these Files shall deliver the exact representations and information as defined in TEDS specification of each IEEE 1451.X standard. The File Object Names shall be class specific. The File Object Name shall be the name returned by the `GetObjectName` operation on the File Object. Partitioned Files shall be used to represent channel-specific information. The `partition_id` shall correspond to the IEEE 1451.X channel number for which the TEDS is sought. Information pertaining to the entire STIM may use an ordinary File.

9.5.2.3.3 Transducer Block Channel representation specifications

The mapping of IEEE 1451.X channels onto Component Objects shall be class specific.

A Vector Parameter shall be used to represent a collection of IEEE 1451.X channels if the TEDS grouping information indicates that these channels represent scalar spatial components of a physical vector quantity.

All other groupings shall be represented by one and only one of the following techniques:

— By Scalar Parameter representation of each channel with the grouping indicated in a Component Group Object Owned by the Transducer Block

— By a Vector Parameter of the appropriate dimension

Each such group defined for a Transducer Block Object shall be represented in a single Component Group Object.

Channels not represented either by a Vector Parameter or as a member of a group may be represented by a Scalar Parameter.

9.5.2.4 Restrictions on Object Names for Public Transducers

Naming rules for the Object Name returned by the operation `GetObjectName` for a Parameter serving as a Public Transducer shall be class specific, subject to the following restrictions:

— Object Names shall correspond to relevant information in the TEDS, if defined.

— Otherwise the Object Name of a Parameter shall consist of a sequence of characters designating the Parameter class followed by an ordinal number assigned starting with the value 0 for the first

Parameter named on the basis of this alternative. For this alternative, the String shall be represented in the IEEE 1451.1 language.

9.5.2.5 Restriction on Object Names for Component Group Objects associated with Transducer Blocks

Naming rules for the Object Name returned by the operation `GetObjectName` for a Component Group shall be class-specific subject to the following restrictions:

— Object Names shall correspond to relevant information in the TEDS if defined

— Otherwise the Object Name of the group shall consist of a sequence of characters designating the Component Group class followed by an ordinal number assigned starting with the value 0, for the first group named on the basis of this alternative. For this alternative, the String shall be represented in the IEEE 1451.1 language.

9.5.2.6 Notification operations behavior specifications

An update semantics operation on a Public Transducer or an `UpdateAll` on the Transducer Block itself shall result in the activation of any notification operations registered by a `RegisterNotifyOnUpdate` operation on

— The affected Parameters

— The Transducer Block itself

The `RegisterNotifyOnUpdate` and `DeregisterNotifyOnUpdate` operations inherited from the `IEEE1451_Block` class shall both be Full Implementations on this class and any subclass of this class.

The `RegisterNotifyOnUpdate` and `DeregisterNotifyOnUpdate` operations on any Object of class `IEEE1451_ParameterWithUpdate` or `IEEE1451_TimeParameter` Owned by a Block of this class and any subclass of this class shall both be Full Implementations.

9.5.2.7 Update behavior of Transducer Blocks

The relationship of reading, writing, and updating shall be as defined in the specification of the IEEE 1451.X Transducer Block. The use of `UpdateAll` is strongly recommended for any application that requires that the values in the Public Transducers represent a collection of readings made at the same time.

IEEE 1451.X supports two modes of update

— Individual channel

— Group

9.5.2.7.1 Individual channel update behavior specification

Individual channel updating shall be activated by an `UpdateAndRead` or `WriteAndUpdate` of the Public Transducer associated with a channel.

9.5.2.7.2 Group update behavior specification

Group update shall be activated by invoking the `UpdateAll` operation and results in all channels being updated.

9.5.2.8 Restrictions on the operations related to timestamps

The values returned by the GetLastTimestamp operation on a Parameter used as a Public Transducer shall be the timestamp generated in connection with any update operation affecting the value of that Parameter. The Transducer Block operations GetLastUpdateTimestamp and GetUpdateTimestampUncertainty may both be Interface Only Implementations if the implementation does not provide the ability to timestamp events. Otherwise, both shall be Full Implementations. The value returned by GetLastUpdateTimestamp on the Transducer Block shall be the timestamp associated with the last transducer value update. This holds whether the update is a result of an UpdateAll or an operation on a single channel of the Transducer Block, and irrespective of whether the channel is represented by a Public Transducer or is accessed by operations inherited from Base Transducer.

9.5.2.9 Correction state behavior specification

The state machine for the IEEE1451_TransducerBlock class is identical to that of the IEEE1451_Block class, see 9.1.3.2, except that the BL_INACTIVE and BL_ACTIVE states have been substated as illustrated in Figure 15.

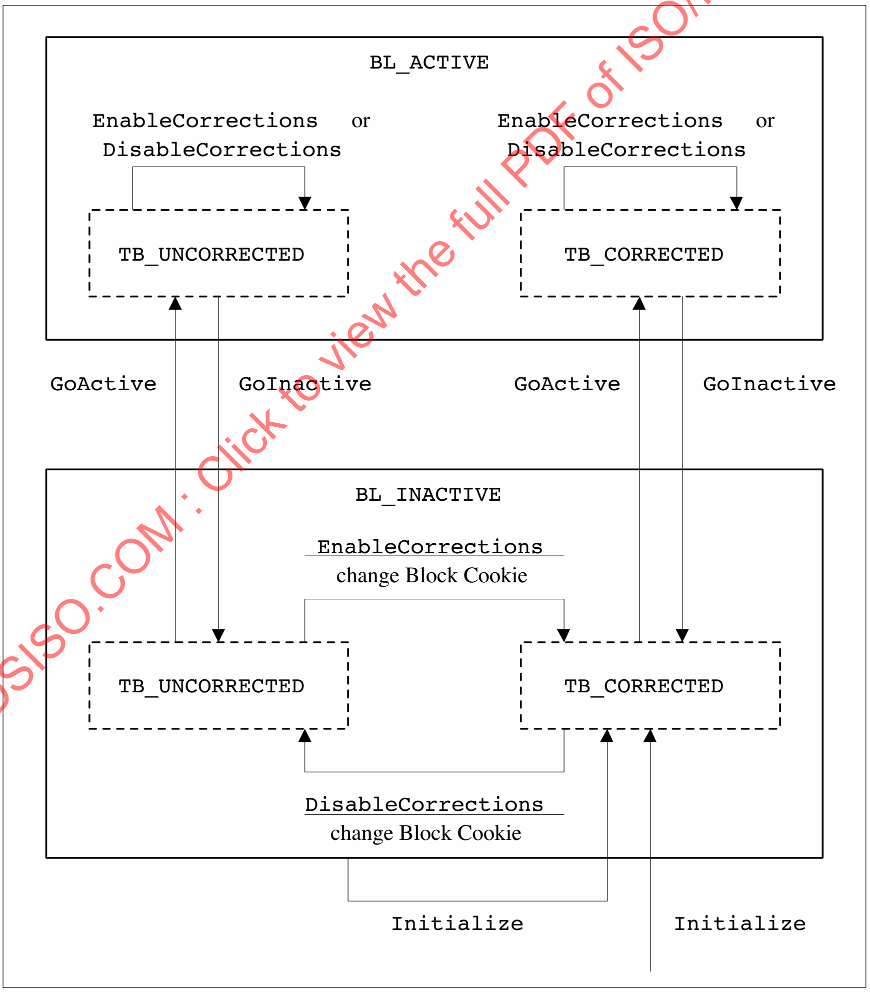


Figure 15—Correction state machine for a Transducer Block

The transition between the TB_UNCORRECTED and TB_CORRECTED states shall result in a change in the Transducer Block's Block Cookie. The initial BL_INACTIVE substate shall be TB_CORRECTED.

The behavior of the Block shall be restricted as specified in 9.5.2.9.1 and 9.5.2.9.2.

9.5.2.9.1 `TB_CORRECTED` state restrictions

The values visible at the Public Transducer interfaces shall be subjected to the appropriate subclass-specific corrections.

9.5.2.9.2 `TB_UNCORRECTED` state restrictions

The values visible at the Public Transducer interfaces shall not be subjected to the subclass-specific corrections.

The correction state machine may reflect both corrections performed within the Transducer Block and corrections performed within the transducer itself. These choices are subclass specific and possibly transducer specific.

The operations `EnableCorrections` and `DisableCorrections` shall both be an Interface Only Implementation if the Transducer Block does not control any correction functionality in an implementation. Otherwise, these operations shall be a Full Implementation.

In all cases `GetCorrectionMode` shall return

— `TB_UNCORRECTED` or `TB_CORRECTED` as appropriate for `Full Implementations` of `EnableCorrections` and `DisableCorrections`

— `TB_UNCORRECTED` for Interface Only Implementations of `EnableCorrections` and `DisableCorrections`

The correction state machine applies to the transducer as a whole. If an implementation with several transducer channels permits some channels to be corrected while others are uncorrected, the Transducer Block shall be implemented to place all channels in either the corrected or uncorrected mode consistent with the state machine. Any individual channel correction behavior shall be subclass specific.

NOTE—The datatype and units of a Public Transducer may change between the `TB_CORRECTED` and `TB_UNCORRECTED` states. This is the reason for the change of Block Cookie shown in the state machine diagram.

9.6 Dot2 Transducer Block class

Class: `IEEE1451_Dot2TransducerBlock`

Parent Class: `IEEE1451_TransducerBlock`

Class ID: 1.1.1.3.1.1

Description: The Dot2 Transducer Block class provides an interface to transducers supporting the IEEE 1451.2 Smart Transducer Interface standard.

This standard provides a place in the class hierarchy for Transducer Blocks suitable for use with the standard IEEE 1451.2. Currently, the remainder of the class definition is found in Annex H of this standard.

9.7 Dot3 Transducer Block class

Class: `IEEE1451_Dot3TransducerBlock`

Parent Class: `IEEE1451_TransducerBlock`

Class ID: 1.1.1.3.1.2

Description: This standard provides a place in the class hierarchy for Transducer Blocks suitable for use with the proposed IEEE 1451.3 transducer standard, when approved. The remainder of the class definition will be found in that standard.

9.8 Dot4 Transducer Block class

Class: `IEEE1451_Dot4TransducerBlock`

Parent Class: `IEEE1451_TransducerBlock`

Class ID: 1.1.1.3.1.3

Description: This standard provides a place in the class hierarchy for Transducer Blocks suitable for use with the proposed IEEE 1451.4 transducer standard when approved. The remainder of the class definition will be found in that standard.

10. Component classes

10.1 Component abstract class

Abstract Class

Class: `IEEE1451_Component`

Parent Class: `IEEE1451_Entity`

Class ID: 1.1.2

Description: The Component abstract class shall be the root for the class hierarchy of all Component Objects.

Class summary:

Local Operations (see Table 51).

Table 51—`IEEE1451_Component` Local operations

Operation Name	Requirement
`SpecifyRuleBasis`	(m)

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

10.1.1 Operation specifications: Local

10.1.1.1 Local operation `SpecifyRuleBasis` specification

IDL: `OpReturnCode SpecifyRuleBasis(`**`in`**` UInteger8 rule_basis);`

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.1.1.1.1 argument `rule_basis` specification

The `rule_basis` argument value shall specify the set of rules governing the Object's behavior. The value of this argument shall be taken from the `BlockMajorState` enumeration; see 9.1.1.3.1.

10.1.2 Component class behavior

10.1.2.1 Operation `SpecifyRuleBasis` specification

The `SpecifyRuleBasis` operation invoked on an Object T whose class is a subclass of Component shall be defined by the following rules:

— A successful execution of the operation shall cause the Object T to obey the set of behavior restrictions designated by the argument `rule_basis`. These sets of restrictions are those defined for each of the Object's Owning Block's Block Major State values, see 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3 or 9.2.5.2.1 depending on whether the Owning Block is an NCAP Block or only a Block. The designation of the rule sets shall be as defined in Table 52.

Table 52—`rule_basis` semantics

Rule basis value	Use restriction set defined for Block Major State value
`BL_UNINITIALIZED`	`BL_UNINITIALIZED`
`BL_INACTIVE`	`BL_INACTIVE`
`BL_ACTIVE`	`BL_ACTIVE`

The operation shall be invoked only under conditions defined in Table 53.

Table 53—`SpecifyRuleBasis` state based restrictions

rule_basis value	Block Major State of Owning Block of Object T		
	BL_UNINITIALIZED	**BL_INACTIVE**	**BL_ACTIVE**
BL_UNINITIALIZED	Allowed	Allowed	Allowed
BL_INACTIVE	Not allowed	Allowed	Allowed
BL_ACTIVE	Not allowed	Not allowed	Allowed

NOTE—A common use for this operation is to promote orderly startup and shutdown of a Block and its Owned objects. For example, on startup, a Block in the BL_INACTIVE state would first transition to the BL_ACTIVE state and then issue the SpecifyRuleBasis operation with a rule_basis value of BL_ACTIVE to each of its Owned Component objects. During shutdown, the Block in the BL_ACTIVE state would first issue the SpecifyRuleBasis operation with a rule_basis value of BL_INACTIVE to each of its Owned Component objects before transitioning to the BL_INACTIVE state.

10.1.2.2 Specific Component operation restrictions based on state

In addition to and conformant with the restrictions of 10.1.2.1, the allowed operations defined on a Component instance shall be restricted as defined in Table 54. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 54—IEEE1451_Component class specific restrictions

Operation	Specified value of rule_basis		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
All operations defined by this class except those in the following rows	Local invocation only	Operational	Operational
SetObjectTag	Local invocation only	Operational	Not operational
Perform	Not operational	Operational	Operational

The default value for rule_basis shall be BL_UNINITIALIZED.

10.2 Parameter class

Class: IEEE1451_Parameter

Parent Class: IEEE1451_Component

Class ID: 1.1.2.1

Description: The Parameter class is used to model Network Visible variables and to provide a means for accessing them.

Class summary:

Network Visible operations (see Table 55).

Table 55—IEEE1451_Parameter Network Visible operations

Operation Name	Requirement	Operation ID
Read	(m)	6166
Write	(o)	6167

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

10.2.1 Operation specifications: Network Visible

10.2.1.1 Operation `Read` specification

```
IDL: OpReturnCode Read(out ArgumentArray data);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.2.1.1.1 argument `data` specification

The value of the Parameter accessed by this operation shall be the sequence of values of the Argument members in the Argument Array `data`. Depending on the Parameter’s class, the Parameter’s value may be a single number, a time-value pair, a sequence of numbers, etc.

10.2.1.2 Operation `Write` specification

```
IDL: OpReturnCode Write(in ArgumentArray data);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.2.2 Parameter class behavior

10.2.2.1 Specific Parameter operation restrictions based on state

In addition to and conformant with the restrictions of 10.1.2.2, the allowed operations defined on a Parameter instance shall be restricted as defined in Table 56. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2 and 9.1.3.2.3.

Table 56—`IEEE1451_Parameter` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	**BL_INACTIVE**	**BL_ACTIVE**
All operations defined by this class	Local invocation only	Operational	Operational

10.2.2.2 Restrictions on the operation `Write`

The `Write` operation may be an Interface Only Implementation if the Parameter is read only; otherwise, it shall be a Full Implementation.

10.2.2.3 Update and value behavior of the operations `Read` and `Write`

The behavior of a `Read` operation shall be as follows:

— A `Read` returns the current value held by the Parameter Object encoded into the output argument Argument Array.

— The current value held by the Parameter Object is updated asynchronously with respect to the `Read` operation by subclass-specific means. The update is from a subclass-specific source.

The behavior of a Write operation shall be as follows:

— A Write changes the current value held by the Parameter Object to the value encoded in the input argument Argument Array.

— A subclass-specific target is updated asynchronously with respect to the Write operation by subclass-specific means. The target is updated to the current value held by the Parameter Object.

10.3 Parameter With Update class

Class: IEEE1451_ParameterWithUpdate

Parent Class: IEEE1451_Parameter

Class ID: 1.1.2.1.1

Description: The Parameter With Update class is used to model Network Visible variables, and to provide a means for accessing the variable. The Parameter With Update has an associated mechanism that supports an update action involving the variable.

Class summary:

Network Visible operations (see Table 57).

Table 57—IEEE1451_ParameterWithUpdate Network Visible operations

Operation Name	Requirement	Operation ID
UpdateAndRead	(m)	8203
WriteAndUpdate	(o)	8204
ReadBlockUntilUpdate	(m)	8205
WriteBlockUntilUpdate	(o)	8206
GetLastTimestamp	(o)	8207

Local Operations (see Table 58).

Table 58—IEEE1451_ParameterWithUpdate Local operations

Operation Name	Requirement
RegisterNotifyOnUpdate	(o)
DeregisterNotifyOnUpdate	(o)

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

10.3.1 Operation specifications: Network Visible

10.3.1.1 Operation `UpdateAndRead` specification

```
IDL: OpReturnCode UpdateAndRead (out ArgumentArray data);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.3.1.1.1 argument `data` specification

The value of the Parameter accessed by this operation shall be the sequence of values of the Argument members in the Argument Array `data`. Depending on the Parameter class, the Parameter's value may be a single number, a time-value pair, a sequence of numbers, etc.

10.3.1.2 Operation `WriteAndUpdate` specification

```
IDL: OpReturnCode WriteAndUpdate(in ArgumentArray data);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.3.1.3 Operation `ReadBlockUntilUpdate` specification

```
IDL: OpReturnCode ReadBlockUntilUpdate (out ArgumentArray data);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.3.1.4 Operation `WriteBlockUntilUpdate` specification

```
IDL: OpReturnCode WriteBlockUntilUpdate (in ArgumentArray data);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.3.1.5 Operation `GetLastTimestamp` specification

```
IDL: OpReturnCode GetLastTimestamp (
          out TimeRepresentation last_timestamp);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.3.1.5.1 argument `last_timestamp` specification

The `last_timestamp` argument value shall be the time at which the value of the Parameter was last updated. If no timestamp is available or if there is no meaningful value that can be assigned, then the value of `last_timestamp` shall be the default value for `TimeRepresentation`.

10.3.2 Operations specifications: Local

10.3.2.1 Local operation `RegisterNotifyOnUpdate` specification

```
IDL: OpReturnCode RegisterNotifyOnUpdate(
          in <local operation reference>
              notification_operation,
          in UInteger16 registration_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.3.2.1.1 argument `notification_operation` specification

The `notification_operation` argument value shall be a local reference to the local operation of the registering object that shall be invoked to signal notification. The signature of the referenced `notification_operation` shall be

```
OpReturnCode <local operation name>(
           in UInteger16 registration_id,
           in TimeRepresentation timestamp);
```

10.3.2.1.2 argument `timestamp` specification

The `timestamp` argument value shall be the occurrence time of the class-specific state change, mandating the notification.

10.3.2.1.3 argument `registration_id` specification

The `registration_id` argument value shall be an identifier generated by the object registering for update to distinguish among registrations with different target objects.

10.3.2.2 Local operation `DeregisterNotifyOnUpdate` specification

```
IDL: OpReturnCode DeregisterNotifyOnUpdate(
           in <local operation reference>
               notification_operation,
           in UInteger16 registration_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.3.3 Parameter With Update class behavior

10.3.3.1 Specific Parameter With Update operation restrictions based on state

In addition to and conformant with the restrictions of 10.2.2.1, the allowed operations defined on a Parameter With Update instance shall be restricted as defined in Table 59. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 59—`IEEE1451_ParameterWithUpdate` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	**BL_INACTIVE**	**BL_ACTIVE**
All operations defined by this class	Local invocation only	Operational	Operational

10.3.3.2 Parameter value and update behavior for the operations `Read` and `Write`

For purposes of this clause, a Read operation shall include the `Read` operation inherited from the Parameter class and the `UpdateAndRead` and `ReadBlockUntilUpdate` operations of this class.

For purposes of this clause, a Write operation shall include the `Write` operation inherited from the Parameter class, and the `WriteAndUpdate` and `WriteBlockUntilUpdate` operations of this class.

Read operations:

A Read operation shall return as its output argument, `data`, the current value held by the Parameter Object encoded into an Argument Array.

The updating of the current value held by the Parameter Object shall be governed by the following:

— The current value held by the Parameter Object is updated by a subclass-specific mechanism. This mechanism obtains values used to update the current Parameter value from a subclass-specific source. For example, the mechanism might involve the reading of update values from a sensor associated with the Parameter.

— The time of this update shall be retained as the `last_timestamp` value.

— The invocation of the `notification_operation` on objects registered for this service shall occur following the update.

Write operations:

A Write operation shall change the current value held by the Parameter Object to the value, encoded into an Argument Array, provided in the input argument, `data`, of the operation.

The disposition of the current value held by the Parameter Object shall be governed by the following:

— A subclass-specific target is updated by a subclass-specific mechanism. This mechanism takes the current Parameter value and updates the value of the subclass-specific target. For example, the mechanism might involve the setting of the value of an actuator associated with the Parameter.

— The time of this update shall be retained as the `last_timestamp` value.

— The invocation of the `notification_operation` on objects registered for this service shall occur following the update.

10.3.3.2.1 Behavior of the `Read` and `Write` operations

The `Read` and `Write` operations shall be subject to the following restriction:

There are no temporal restrictions relating the invocation of these operations and the update process other than the concurrency requirements of 7.2.4.2.

For the `Read` and `Write` operations, the update behavior may be asynchronous to and independent of the `Read` and `Write` operations and is subclass specific. The invocation of the `notification_operation` shall be related to the update not the `Read` or `Write`. Subclass implementations may choose to notify or not for reads on a Parameter that normally updates based on writes. For example, a Parameter representing an actuator might notify after a `Write` but not after a `Read`.

10.3.3.2.2 Behavior of the `UpdateAndRead` and `WriteAndUpdate` operations

The `UpdateAndRead` and `WriteAndUpdate` operations shall be subject to the following restrictions:

— The relationship of the update mechanism behavior and the invocation of these operations shall be as specified in the state diagram of Figure 16.

— Other than the causality requirements specified by Figure 16, and the concurrency requirements of 7.2.4.2, the temporal relationship between the update mechanism and the operation invocation are outside the scope of this standard.

The `WriteAndUpdate` operation may be an Interface Only Implementation if the Parameter is "read only;" otherwise, it shall be a Full Implementation.

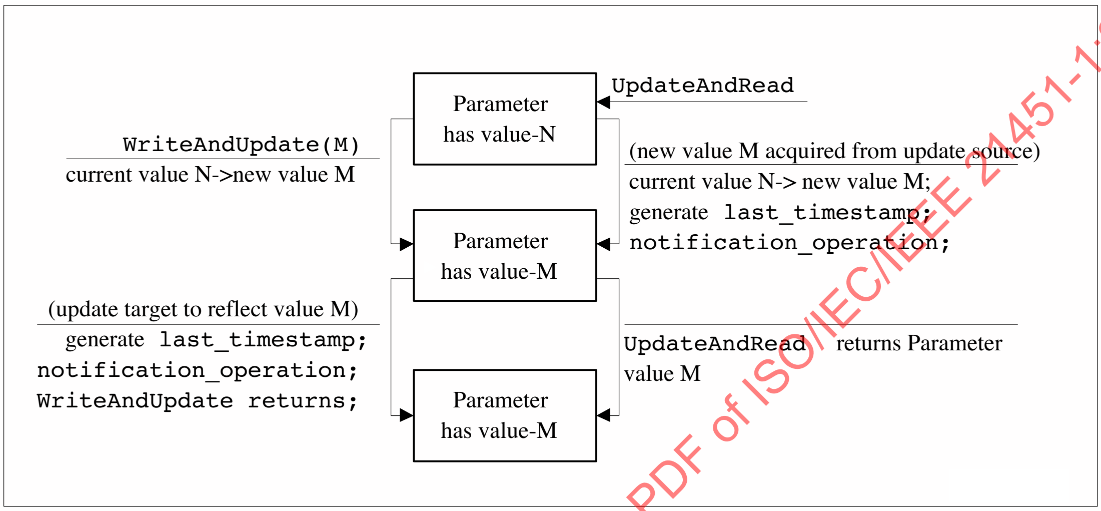


Figure 16—Time sequence behavior of `UpdateAndRead` and `WriteAndUpdate`

10.3.3.2.3 Behavior of the `ReadBlockUntilUpdate` and `WriteBlockUntilUpdate` operations

The `ReadBlockUntilUpdate` and `WriteBlockUntilUpdate` operations shall be subject to the following restrictions:

— The relationship of the update mechanism behavior and the invocation of these operations shall be as specified in the state diagram of Figure 17.

— Other than the causality requirements specified by Figure 17, and the concurrency requirements of 7.2.4.2, the temporal behavior of the update mechanism may be asynchronous with respect to the invocation of the operations.

The state machine specification of Figure 17 does not mandate a causal relationship between the invocation of the operation and the update process. The only relationship specified is the blocking behavior of the operation calls. Asynchronous updates of the Parameter value may occur at any time by means unrelated to these operations.

The `WriteBlockUntilUpdate` operation may be an Interface Only Implementation if the Parameter is "read only;" otherwise, it shall be a Full Implementation.

10.3.3.3 Notification operations behavior specifications

`RegisterNotifyOnUpdate` and `DeregisterNotifyOnUpdate` shall both be Interface Only Implementations, or shall both be Full Implementations as designated by a subclass definition. The default shall be a Full Implementation.

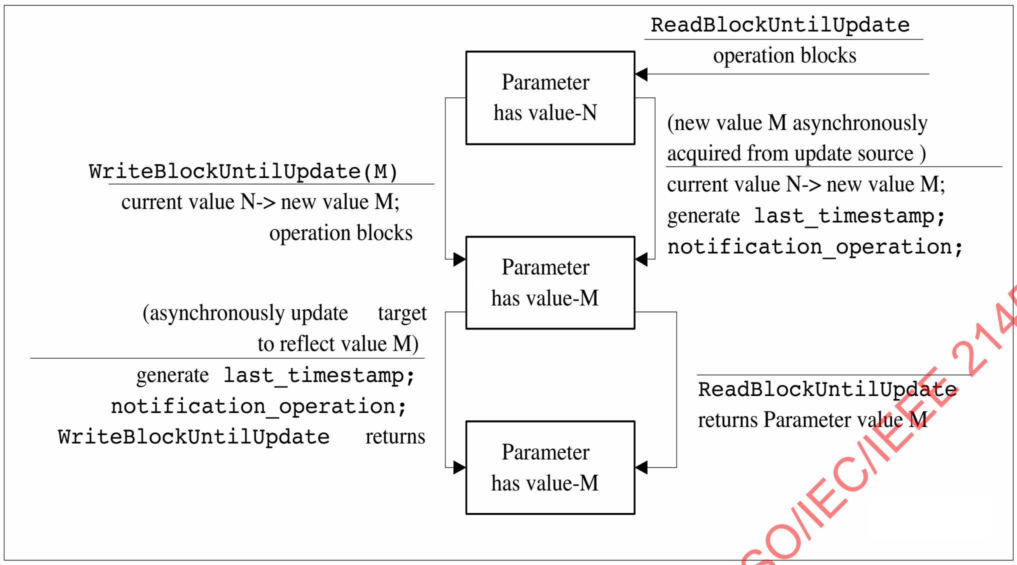


Figure 17—Time sequence behavior of `ReadBlockUntilUpdate` and `WriteBlockUntilUpdate`

10.4 Physical Parameter abstract class

Abstract Class

Class: `IEEE1451_PhysicalParameter`

Parent Class: `IEEE1451_ParameterWithUpdate`

Class ID: 1.1.2.1.1.1

Description: The Physical Parameter class and its subclasses are used to represent Network Visible variables, modeled by the Parameter With Update class that directly or indirectly represent the physical world. The Physical Parameter provides the information necessary to interpret a measurement or actuation.

Class summary:

Network Visible operations (see Table 60).

Table 60—`IEEE1451_PhysicalParameter` Network Visible operations

Operation Name	Requirement	Operation ID
`GetPhysicalParameterType`	(m)	10249
`GetMetadata`	(m)	10250
`SetMetadata`	(o)	10251
`GetInterpretation`	(m)	10252

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

10.4.1 Operation specification: Network Visible

10.4.1.1 Operation `GetPhysicalParameterType` specification

```
IDL: OpReturnCode GetPhysicalParameterType (
              out UInteger8 parameter_type);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.4.1.1.1 argument `parameter_type` specification

The `parameter_type` argument value shall be the current value of the Physical Parameter's Physical Parameter Type. The Physical Parameter Type shall indicate how to interpret the data and metadata associated with this Parameter. The Physical Parameter Type shall be set when the Parameter Object is instantiated and may not be changed during system operation. The allowed values of `parameter_type` shall be taken from the enumeration shown in Table 61.

IDL: enumeration `PhysicalParameterType;`

Table 61—`PhysicalParameterType` enumeration

Enumeration	Value
PP_SCALAR_ANALOG	0
PP_SCALAR_DISCRETE	1
PP_SCALAR_DIGITAL	2
PP_SCALAR_ANALOG_SERIES	3
PP_SCALAR_DISCRETE_SERIES	4
PP_SCALAR_DIGITAL_SERIES	5
PP_VECTOR_ANALOG	6
PP_VECTOR_DISCRETE	7
PP_VECTOR_DIGITAL	8
PP_VECTOR_ANALOG_SERIES	9
PP_VECTOR_DISCRETE_SERIES	10
PP_VECTOR_DIGITAL_SERIES	11
Reserved	12–127
Open to industry	128–255

NOTE—There is no `SetPhysicalParameterType` since the Physical Parameter Type must be set at instantiation time.

10.4.1.2 Operation `GetMetadata` specification

```
IDL: OpReturnCode GetMetadata(
              out PhysicalParameterMetadata metadata);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.4.1.2.1 argument `metadata` specification

The value of the `metadata` argument shall represent the metadata pertaining to the Parameter's value. A Physical Parameter's metadata is Physical Parameter Type dependent. The specifications of the allowed formats for metadata are defined in 6.2.15. The specifications of the allowed values for metadata are defined in this class definition and in the definitions of subclasses of this class.

10.4.1.3 Operation `SetMetadata` specification

```
IDL: OpReturnCode SetMetadata(
          in PhysicalParameterMetadata metadata);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

For some uses of this class, one or more of the fields of `metadata` may be read only, and must not be set by this operation. The Physical Parameters Owned by an `IEEE1451_Dot2TransducerBlock` class Object are an example since the underlying information may be read only from the transducer itself. These restrictions may also apply to operations that access specific fields represented by `metadata`.

10.4.1.4 Operation `GetInterpretation` specification

```
IDL: OpReturnCode GetInterpretation(
          out UInteger8 parameter_interpretation,
          out UInteger8 buffering);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.4.1.4.1 argument `parameter_interpretation` specification

The `parameter_interpretation` argument value shall be selected from the enumeration in Table 62. The value of `parameter_interpretation` may also be set via the `SetMetadata` operation on this class.

Table 62—ParameterInterpretation enumeration

Enumeration	Value	Meaning
PI_ACTUATOR	0	An actuator value
PI_SENSOR	1	A sensor reading
PI_COMPUTATION	2	The result of a computation
PI_CONTROL_SETPOINT	3	A driving term for control
PI_ALARM_SETPOINT	4	A threshold term for alarms
PI_CONTROL_BANDGAP	5	A band-defining limit for control
PI_ALARM_BANDGAP	6	A band-defining limit for alarms
PI_CONFIGURATION	7	A configuration parameter of an algorithm or process
PI_USER_DEFINED	8	Unspecified application-specific use
Reserved	9–127	
Open to industry	128–255	

IDL: enumeration `ParameterInterpretation;`

10.4.1.4.2 argument `buffering` specification

The `buffering` argument value shall be taken from the enumeration in Table 63.

IDL: enumeration `ParameterBuffering;`

Table 63—ParameterBuffering enumeration

Enumeration	Value	Meaning
`PB_NORMAL`	0	There is no queuing of Parameter values
`PB_BUFFERED`	1	There is queuing of Parameter values
Reserved	2–127	
Open to industry	128–255	

10.4.2 Physical Parameter class behavior

10.4.2.1 Specific Physical Parameter operation restrictions based on state

In addition to and conformant with the restrictions of 10.3.3.1, the allowed operations defined on a Physical Parameter instance shall be restricted as defined in Table 64. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 64—`IEEE1451_PhysicalParameter` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
All operations defined by this class except those in the following row	Local invocation only	Operational	Operational
`SetMetadata`	Local invocation only	Operational	Not operational

10.4.2.2 Operation `GetPhysicalParameterType` behavior specification

The Physical Parameter Type whose value shall be the `parameter_type` returned in the output argument of the `GetPhysicalParameterType` operation shall convey the syntax, interpretation, and behavior of a Parameter.

It is recommended that the value of Physical Parameter Type also convey certain application semantics as follows:

— `PP_SCALAR_ANALOG`: This Physical Parameter Type is recommended for use when representing single values of physical quantities that are without dimension and are continuous.

NOTE—Temperature, pH, and speed (but not velocity) are examples of physical quantities for which `PP_SCALAR_ANALOG` is appropriate. Such physical quantities typically have SI-defined units.

— `PP_SCALAR_DISCRETE`: This Physical Parameter Type is recommended for use in representing single values of physical quantities that are without dimension and have an integer representation.

NOTE—A counter output is an example of a physical quantity for which `PP_SCALAR_DISCRETE` is appropriate. Such physical quantities may or may not have SI-defined units.

— `PP_SCALAR_DIGITAL`: This Physical Parameter Type is recommended for use when representing single values of physical quantities that are without dimension and are not represented as integers.

NOTE—A proximity switch state or a bar code are examples of physical quantities for which PP_SCALAR_DISCRETE is appropriate. Such physical quantities typically are not covered by SI-defined units.

— PP_SCALAR_ANALOG_SERIES: This Physical Parameter Type is recommended for use in representing a series of PP_SCALAR_ANALOG quantities evaluated at a uniform series of intervals with respect to some physical quantity.

NOTE—Time series, frequency response, and mass spectra are examples where a series representation is appropriate.

— PP_SCALAR_DISCRETE_SERIES: This Physical Parameter Type is recommended for use in representing a series of PP_SCALAR_DISCRETE quantities evaluated at a uniform series of intervals of a different physical quantity.

— PP_SCALAR_DIGITAL_SERIES: This Physical Parameter Type is recommended for use in representing a series of PP_SCALAR_DIGITAL quantities evaluated at a uniform series of intervals of a different physical quantity.

— PP_VECTOR_ANALOG, PP_VECTOR_DISCRETE, PP_VECTOR_DIGITAL, PP_VECTOR_ANALOG_SERIES, PP_VECTOR_DISCRETE_SERIES, and PP_VECTOR_DIGITAL_SERIES: These Physical Parameter Type instances are recommended for use under the same circumstances as the analog, discrete, and digital Physical Parameter Type instances, but where the physical quantity represented has dimension.

NOTE—Acceleration, velocity, torque, and electric fields are examples of physical quantities for which VECTOR types are appropriate. The dimensions of such physical quantities usually reflect spatial coordinates. Other quantities may be usefully represented as vectors, for example, RGB color coordinates, but may also be represented as a collection of scalars. The vector types are useful even for representing a single axis of a multidimensional vector. For example, a single-axis accelerometer may be usefully represented as a vector of dimension 1.

10.4.2.3 Operation GetInterpretation behavior specification

10.4.2.3.1 argument parameter_interpretation behavior specification

The parameter_interpretation argument value returned by GetInterpretation shall indicate the semantic interpretation to be placed on the value of the Parameter itself.

10.4.2.3.2 argument buffering behavior specification

The buffering argument value shall indicate the relationship of the value and its corresponding timestamp to the most recent update of the Parameter. A PB_NORMAL value shall signify that the value and timestamp correspond to the most recent update of the Parameter's current value for a sensor and that the most recently written value will be sent to the physical world on the next update. A PB_BUFFERED value shall indicate that the Parameter supports a queue and that the time of update corresponds to a value not at the head of the queue. The depth of the queue is implementation specific. If implementations provide a queue, the queue shall maintain the correct relationship between the values and update timestamps for each member of the queue.

10.4.2.4 Behavior of the operations Read, Write, UpdateAndRead, WriteAndUpdate, ReadBlockUntilUpdate, WriteBlockUntilUpdate

The signatures of Read, Write, UpdateAndRead, WriteAndUpdate, ReadBlockUntilUpdate, and WriteBlockUntilUpdate indicate a return argument with a formal name data and of type ArgumentArray.

For Physical Parameter instances, the members of the Argument Array, data, shall be

0th member Argument

- — The 0th member Argument's `TypeCode` shall be `PHYSICAL_PARAMETER_DATA_TC`.
- — The value of the 0th member Argument shall be an instance of the union data structure, `PhysicalParameterData`. From 6.2.15, the union's value will be either a `PhysicalParameterSingletonData` or a `PhysicalParameterSeriesData` data structure. The discriminant of the `PhysicalParameterData` union is a member of the enumeration `PhysicalParameterType.` The discriminant's value is subclass specific.

Remaining Argument Array members: The definitions are subclass specific.

NOTE—For the subclasses of `IEEE1451_PhysicalParameter` defined by this standard, there are no members of the Argument Array, `data,` beyond the 0th.

10.4.2.5 Operations `GetMetadata` behavior specifications common to all Parameter types

The `metadata` returned by `GetMetadata` is represented by an instance of the union data structure `PhysicalParameterMetadata` whose discriminant is a member of the enumeration `PhysicalParameterType` and whose value is a Physical Parameter Type specific data structure; see 6.2.15.

The discriminate and allowed values and semantics of the members of these Physical Parameter Type specific data structures which occur as values of the `PhysicalParameterMetadata` union shall be restricted per 10.4.2.5.1 through 10.4.2.5.7.

10.4.2.5.1 discriminate of `PhysicalParameterMetadata` behavior specification

The discriminate of the `PhysicalParameterMetadata` union shall have the value of the output argument, `parameter_type,` returned by the `GetPhysicalParameterType` operation on the Parameter.

10.4.2.5.2 member `parameterName` behavior specification

The `parameterName` member of the type-specific data structure shall have the value returned in the output argument, `object_name`, by the `GetObjectName` operation on the Parameter. This member is common to all data structure types that are members of the union type `PhysicalParameterMetadata`.

10.4.2.5.3 member `parameterInterpretation` behavior specification

The `parameterInterpretation` member of the type-specific data structure shall have the value returned in the output argument, `parameter_interpretation,` by the `GetInterpretation` operation on the Parameter. This member is common to all data structure types that are members of the union type `PhysicalParameterMetadata`.

10.4.2.5.4 member `buffering` behavior specification

The `buffering` member of the type-specific data structure shall have the value of the output argument, `buffering,` returned by the `GetInterpretation` operation on the Parameter. This member is common to all data structure types that are members of the union type `PhysicalParameterMetadata`.

10.4.2.5.5 member `datatype` behavior specification

The `datatype` member is common to all data structure types that are members of the union type `PhysicalParameterMetadata`. The value returned in the output argument, `value_datatype`, by the `GetDatatype` operation on the defined subclasses of this class shall be the same as the value of this member. The allowed value for this member shall be a member of the `TypeCode` enumeration and shall be Physical Parameter Type dependent as defined in Table 65.

The columns indicate the Physical Parameter Type and the rows indicate the range of datatypes available to express the data value of the Parameter. Only those types marked by an X shall be used for a particular Physical Parameter Type.

The value of `datatype` shall be taken from the subset of the enumeration `TypeCode` as specified in the second column of the table.

10.4.2.5.6 Allowed `TypeCode` values and datatypes for various values of Physical Parameter Type

The TypeCode values and datatypes that are allowed for various values of Physical Parameter Type are given in Table 65.

For the `BitSequence` and `BitSequenceArray` types

— A bit value of 1 shall correspond to a Boolean value of `TRUE`

— A bit value of 0 shall correspond to a Boolean value of `FALSE`

In the case of Series Parameters, all members of the series shall be represented by the same datatype.

For Physical Parameter Type values of

— `PP_SCALAR_DISCRETE`

— `PP_SCALAR_DIGITAL`

— `PP_SCALAR_ANALOG_SERIES`

— `PP_SCALAR_DISCRETE_SERIES`

— `PP_SCALAR_DIGITAL_SERIES`

the value of `datatype` shall indicate the datatype in which the data value of the Scalar Parameter is represented.

Table 65—Allowed `TypeCode` values and datatypes

Data type	Type Code value	PP_SCALAR_ANALOG	PP_SCALAR_DISCRETE	PP_SCALAR_DIGITAL	PP_SCALAR_ANALOG_SERIES	PP_SCALAR_DISCRETE_SERIES	PP_SCALAR_DIGITAL_SERIES	PP_VECTOR_ANALOG	PP_VECTOR_DISCRETE	PP_VECTOR_DIGITAL	PP_VECTOR_ANALOG_SERIES	PP_VECTOR_DISCRETE_SERIES	PP_VECTOR_DIGITAL_SERIES
Boolean	BOOLEAN_TC			X						X			
Integer8	INTEGER8_TC	X	X					X	X				
UInteger8	UINTEGER8_TC	X	X					X	X				
Integer16	INTEGER16_TC	X	X					X	X				
UInteger16	UINTEGER16_TC	X	X					X	X				
Integer32	INTEGER32_TC	X	X					X	X				
UInteger32	UINTEGER32_TC	X	X					X	X				
Integer64	INTEGER64_TC	X	X					X	X				
UInteger64	UINTEGER64_TC	X	X					X	X				
Float32	FLOAT32_TC	X						X					
Float64	FLOAT64_TC	X						X					
BitSequence	BIT_SEQUENCE_TC			X						X			
BooleanArray	BOOLEAN_ARRAY_TC						X						X
Integer8Array	INTEGER8_ARRAY_TC				X	X					X	X	
UInteger8Array	UINTEGER8_ARRAY_TC				X	X					X	X	
Integer16Array	INTEGER16_ARRAY_TC				X	X					X	X	
UInteger16Array	UINTEGER16_ARRAY_TC				X	X					X	X	
Integer32Array	INTEGER32_ARRAY_TC				X	X					X	X	
UInteger32Array	UINTEGER32_ARRAY_TC				X	X					X	X	
Integer64Array	INTEGER64_ARRAY_TC				X	X					X	X	
UInteger64Array	UINTEGER64_ARRAY_TC				X	X					X	X	
Float32Array	FLOAT32_ARRAY_TC				X						X		
Float64Array	FLOAT64_ARRAY_TC				X						X		
BitSequenceArray	BIT_SEQUENCE_ARRAY_TC						X						X

For Physical Parameter Type values of

— PP_VECTOR_ANALOG
— PP_VECTOR_DISCRETE
— PP_VECTOR_DIGITAL
— PP_VECTOR_ANALOG_SERIES
— PP_VECTOR_DISCRETE_SERIES
— PP_VECTOR_DIGITAL_SERIES

the value of datatype shall be an Array of TypeCode enumeration values represented in a UInteger8Array. For the vector datatypes, each member of the UInteger8Array shall specify the datatype in which the data value of the corresponding dimension of the Vector Parameter is represented. That is, the jth member of the UInteger8Array shall be the TypeCode for the jth vector dimension's value.

10.4.2.5.7 member units behavior specification

The units member of the type-specific data structure shall have the value of the output argument, value_units, returned by the GetUnits operation on an Object whose class is a defined subclass of this class. This member is common to all data structure types that are members of the union type PhysicalParameterMetadata. In the case of Series Parameters, all members of the series shall be represented in the same units.

For Physical Parameter Type values of

— PP_SCALAR_ANALOG
— PP_SCALAR_DISCRETE
— PP_SCALAR_DIGITAL
— PP_SCALAR_ANALOG_SERIES
— PP_SCALAR_DISCRETE_SERIES
— PP_SCALAR_DIGITAL_SERIES

the value of units is represented by the type Units. The value shall indicate the units in which the data value of the Scalar Parameter is represented.

For Physical Parameter Type values of

— PP_VECTOR_ANALOG
— PP_VECTOR_DISCRETE
— PP_VECTOR_DIGITAL
— PP_VECTOR_ANALOG_SERIES
— PP_VECTOR_DISCRETE_SERIES
— PP_VECTOR_DIGITAL_SERIES

the value of units is represented by the type UnitsArray. In this case, each member of the UnitsArray shall specify the units in which the data value of the corresponding dimension of the Vector Parameter is represented. That is, the jth member of the UnitsArray shall be the units for the jth vector dimension.

10.4.2.6 Operation GetMetadata behavior specifications common to all Series Parameter classes

The metadata returned by GetMetadata is represented by the union data structure PhysicalParameterMetadata, whose value is a Physical Parameter Type specific data structure; see 6.2.15.

The allowed values and semantics of the members of this Physical Parameter Type specific data structure shall be restricted as specified in 10.4.2.6.1 through 10.4.2.6.5 for Physical Parameter Type values of:

— PP_SCALAR_ANALOG_SERIES

— PP_SCALAR_DISCRETE_SERIES

— PP_SCALAR_DIGITAL_SERIES

— PP_VECTOR_ANALOG_SERIES

— PP_VECTOR_DISCRETE_SERIES

— PP_VECTOR_DIGITAL_SERIES

10.4.2.6.1 member abscissaUnits behavior specification

The value returned in the output argument, abscissa_units, by the GetAbscissaUnits operation on the defined series subclasses of this class shall be the same as the value of this member. This member, abscissaUnits, is common to all member data structures of the type PhysicalParameterMetadata selected by the values of Physical Parameter Type specified in 10.4.2.6. The abscissa data values of the series shall be represented in abscissaUnits.

10.4.2.6.2 member abscissaIncrement behavior specification

The value returned in the output argument, abscissa_increment, by the GetAbscissaIncrement operation on the defined series subclasses of this class shall be the same as the value of this member. This member, abscissaIncrement, is common to all member data structures of the type PhysicalParameterMetadata selected by the values of Physical Parameter Type specified in 10.4.2.6. The abscissaIncrement shall be the difference between two successive abscissa values of the series.

10.4.2.6.3 member abscissaOrigin behavior specification

The value returned in the output argument, abscissa_origin, by the GetAbscissaOrigin operation on the defined series subclasses of this class shall be the same as the value of this member. This member, abscissaOrigin, is common to all member data structures of the type PhysicalParameterMetadata selected by the values of Physical Parameter Type specified in 10.4.2.6. The abscissaOrigin shall be the abscissa value of the 0th, that is the initial, member of the series.

10.4.2.6.4 member abscissaIncrementUncertainty behavior specification

The abscissaIncrementUncertainty member is common to all member data structures of the type PhysicalParameterMetadata selected by the values of Physical Parameter Type specified in 10.4.2.6. The abscissaIncrementUncertainty shall represent the uncertainty of the value of abscissaIncrement.

10.4.2.6.5 member `abscissaOriginUncertainty` behavior specification

The `abscissaOriginUncertainty` member is common to all member data structures of the type `PhysicalParameterMetadata` selected by the values of Physical Parameter Type specified in 10.4.2.6. The `abscissaOriginUncertainty` shall represent the uncertainty of the value of `abscissaOrigin`.

10.4.2.7 Operation `GetMetadata` behavior specifications common to all analog Parameter types

The `metadata` returned by `GetMetadata` is represented by the union data structure `PhysicalParameterMetadata` whose value is a Physical Parameter Type specific data structure; see 6.2.15.

The allowed values and semantics of the members of this Physical Parameter Type specific data structure shall be restricted as specified in 10.4.2.7.1, 10.4.2.7.2, and 10.4.2.7.3 for Physical Parameter Type values of:

— `PP_SCALAR_ANALOG`

— `PP_SCALAR_ANALOG_SERIES`

— `PP_VECTOR_ANALOG`

— `PP_VECTOR_ANALOG_SERIES`

10.4.2.7.1 member `uncertainty` behavior specification

This member is common to all member data structures of the type `PhysicalParameterMetadata` selected by the values of Physical Parameter Type specified in 10.4.2.7.

In the case of Series Parameters, the same `uncertainty` value shall apply to all members of the series.

For Physical Parameter Type values of `PP_SCALAR_ANALOG` and `PP_SCALAR_ANALOG_SERIES`, the value of `uncertainty` shall represent the uncertainty of the data value of the Scalar Parameter.

For Physical Parameter Type values of `PP_VECTOR_ANALOG` and `PP_VECTOR_ANALOG_SERIES`, `uncertainty` is represented by the type `UncertaintyArray`. In this case, each member of the Array shall represent the uncertainty of the data value of the corresponding dimension of the Vector Parameter. That is, the jth member of the Array shall be the uncertainty for the jth vector dimension.

10.4.2.7.2 member `upperLimit` behavior specification

This member is common to all member data structures of the type `PhysicalParameterMetadata` selected by the values of Physical Parameter Type specified in 10.4.2.7.

In the case of Series Parameters, the same `upperLimit` value shall apply to all members of the series.

For Physical Parameter Type values of `PP_SCALAR_ANALOG` and `PP_SCALAR_ANALOG_SERIES`, the interpretation of the `upperLimit` member is application specific. `upperLimit` is a union of type `Argument` whose value shall have the datatype and units of the `datatype` and `units` members of the Parameter's metadata.

For Physical Parameter Type values of `PP_VECTOR_ANALOG` and `PP_VECTOR_ANALOG_SERIES`, `upperLimit` is represented by the type `ArgumentArray`. In this case, each member of the Array shall represent the upper limit of the data value of the corresponding dimension of the Vector Parameter. That is, the jth member of the Array shall be the upper limit for the jth vector dimension. The value of each Argument member of upperLimit shall have the datatype and units of the datatype and units members of the corresponding dimension of the Parameter's metadata. This member is common to all relevant data structures.

10.4.2.7.3 member lowerLimit behavior specification

This member is common to all member data structures of the type PhysicalParameterMetadata selected by the values of Physical Parameter Type specified in 10.4.2.7.

In the case of Series Parameters, the same lowerLimit value shall apply to all members of the series.

For Physical Parameter Type values of PP_SCALAR_ANALOG and PP_SCALAR_ANALOG_SERIES, the interpretation of the lowerLimit member is application specific. lowerLimit is a union of type Argument whose value shall have the datatype and units of the datatype and units members of the Parameter's metadata.

For Physical Parameter Type values of PP_VECTOR_ANALOG and PP_VECTOR_ANALOG_SERIES, lowerLimit is represented by the type ArgumentArray. In this case, each member of the Array shall represent the lower limit of the data value of the corresponding dimension of the Vector Parameter. That is, the jth member of the Array shall be the lower limit for the jth vector dimension. The value of each Argument member of lowerLimit shall have the datatype and units of the datatype and units members of the corresponding dimension of the Parameter's metadata. This member is common to all relevant data structures.

10.4.2.8 Operation GetMetadata behavior specifications common to all discrete Parameter types

The metadata returned by GetMetadata is represented by the data structure PhysicalParameterMetadata that is Physical Parameter Type specific; see 6.2.15.

The allowed values and semantics of the members of this data structure shall be restricted as specified in 10.4.2.8.1 and 10.4.2.8.2 for Physical Parameter Type values of

— PP_SCALAR_DISCRETE

— PP_SCALAR_DISCRETE_SERIES

— PP_VECTOR_DISCRETE

— PP_VECTOR_DISCRETE_SERIES

10.4.2.8.1 member upperLimit behavior specification

This member is common to all member data structures of the type PhysicalParameterMetadata selected by the values of Physical Parameter Type specified in 10.4.2.8.

In the case of Series Parameters, the same upperLimit value shall apply to all members of the series.

For Physical Parameter Type values of PP_SCALAR_DISCRETE and PP_SCALAR_DISCRETE_SERIES, the interpretation of the upperLimit member is application specific. upperLimit is a union of type Argument whose value shall have the datatype and units of the datatype and units members of the Parameter's metadata.

For Physical Parameter Type values of PP_VECTOR_DISCRETE and PP_VECTOR_DISCRETE_SERIES, upperLimit is represented by the type ArgumentArray. In this case, each member of the Array shall represent the upper limit of the data value of the corresponding dimension of the Vector Parameter. That is, the jth member of the Array shall be the upper limit for the jth vector dimension. The value of each Argument member of upperLimit shall have the datatype and units of the datatype and units members of the corresponding dimension of the Parameter's metadata.

10.4.2.8.2 member lowerLimit behavior specification

This member is common to all member data structures of the type PhysicalParameterMetadata selected by the values of Physical Parameter Type specified in 10.4.2.8.

In the case of Series Parameters, the same lowerLimit value shall apply to all members of the series.

For Physical Parameter Type values of PP_SCALAR_DISCRETE and PP_SCALAR_DISCRETE_SERIES, the interpretation of the lowerLimit member is application specific. lowerLimit is a union of type Argument whose value shall have the datatype and units of the datatype and units members of the Parameter's metadata.

For Physical Parameter Type values of PP_VECTOR_DISCRETE and PP_VECTOR_DISCRETE_SERIES, lowerLimit is represented by the type ArgumentArray. In this case, each member of the Array shall represent the lower limit of the data value of the corresponding dimension of the Vector Parameter. That is, the jth member of the Array shall be the lower limit for the jth vector dimension. The value of each Argument member of lowerLimit shall have the datatype and units of the datatype and units members of the corresponding dimension of the Parameter's metadata.

10.4.2.9 Operation GetMetadata behavior specifications common to all digital Parameter types

The metadata returned by GetMetadata is represented by a data structure that is Physical Parameter Type specific; see 6.2.15.

The allowed values and semantics of the members of this data structure shall be restricted as specified in 10.4.2.9.1, 10.4.2.9.2, and 10.4.2.9.3 for Physical Parameter Type values of

— PP_SCALAR_DIGITAL
— PP_SCALAR_DIGITAL_SERIES
— PP_VECTOR_DIGITAL
— PP_VECTOR_DIGITAL_SERIES

10.4.2.9.1 member numberOfOctets behavior specification

This member is common to all member data structures of the type PhysicalParameterMetadata selected by the values of Physical Parameter Type specified in 10.4.2.9.

In the case of Series Parameters, the same numberOfOctets value shall apply to all members of the series.

For Physical Parameter Type values of PP_SCALAR_DIGITAL and PP_SCALAR_DIGITAL_SERIES, the value of numberOfOctets shall be a UInteger16 whose value shall be the number of octets in the digital representation of the value of the Scalar Parameter.

For Physical Parameter Type values of PP_VECTOR_DIGITAL and PP_VECTOR_DIGITAL_SERIES, numberOfOctets is represented by the type UInteger16Array. In this case, each member of the Array shall represent the number of octets in the digital representation of the value of the corresponding dimension of the Vector Parameter. That is, the jth member of the Array shall be the number of octets for the jth vector dimension.

10.4.2.9.2 member numberOfSignificantBits behavior specification

This member is common to all member data structures of the type PhysicalParameterMetadata selected by the values of Physical Parameter Type specified in 10.4.2.9.

In the case of Series Parameters, the same numberOfSignificantBits value shall apply to all members of the series.

The total number of significant bits of the value is calculated as follows:

Total number of significant bits =

```
                    numberOfSignificantBits + 8(numberOfOctets –1)
```

For Physical Parameter Type values of PP_SCALAR_DIGITAL and PP_SCALAR_DIGITAL_SERIES, and a digital representation with a datatype BitSequence, numberOfSignificantBits shall be a UInteger16 whose value shall be the total number of significant bits in octet[last] of the data value for a left-justified representation, or octet[0] for a right-justified representation. For this case, the value shall be either right or left justified. Nonjustified BitSequence representations shall not be permitted. There shall be no requirement that all bits of the BitSequence in fact be significant to an application. numberOfSignificantBits provides a mechanism for computing the length of the representation.

For a datatype of Boolean, numberOfSignificantBits shall be set to the value 1.

For Physical Parameter Type values of PP_VECTOR_DIGITAL and PP_VECTOR_DIGITAL_SERIES, numberOfSignificantBits is represented by the type UInteger16Array. In this case, each member of the Array shall represent the number of significant bits in the appropriate octet of the value, of the corresponding dimension of the Vector Parameter. That is, the jth member of the Array shall be the number of significant bits for the jth vector dimension. This member is common to all relevant data structures.

10.4.2.9.3 member rightJustifiedFlag behavior specification

This member is common to all member data structures of the type PhysicalParameterMetadata selected by the values of Physical Parameter Type specified in 10.4.2.9.

In the case of Series Parameters, the same rightJustifiedFlag value shall apply to all members of the series.

For Physical Parameter Type values of PP_SCALAR_DIGITAL and PP_SCALAR_DIGITAL_SERIES, and a digital representation with a datatype BitSequence

— rightJustifiedFlag shall be TRUE if the significant bits of the Parameter value are right justified; that is, the last bit in octet[last] is significant.

— rightJustifiedFlag shall be FALSE if the significant bits of the Parameter value are left justified; that is, the most significant bit in octet[0] is significant.

For Physical Parameter Type values of PP_VECTOR_DIGITAL and PP_VECTOR_DIGITAL_SERIES, rightJustifiedFlag is represented by the type BooleanArray. In this case, each member of the

Array shall represent the `rightJustifiedFlag` applicable to the value of the corresponding dimension of the Vector Parameter. That is, the jth member of the Array shall be the `rightJustifiedFlag` for the jth vector dimension.

10.4.2.10 Operation `SetMetadata` behavior specification

The `SetMetadata` operation may be an Interface Only Implementation if the Parameter metadata is "read only;" otherwise, it shall be a Full Implementation.

10.5 Scalar Parameter class

Class: `IEEE1451_ScalarParameter`

Parent Class: `IEEE1451_PhysicalParameter`

Class ID: 1.1.2.1.1.1.1

Description: The Scalar Parameter class is used to model physical world quantities that do not have dimensions or orientation associated with them, and are appropriately represented as mathematical scalars.

Class summary:

Network Visible operations (see Table 66).

Table 66—`IEEE1451_ScalarParameter` Network Visible operations

Operation Name	Requirement	Operation ID
`GetDatatype`	(m)	12288
`SetDatatype`	(o)	12289
`GetUnits`	(m)	12290
`SetUnits`	(o)	12291

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

10.5.1 Operation specifications: Network Visible

10.5.1.1 Operation `GetDatatype` specification

```
IDL: OpReturnCode GetDatatype(out UInteger8 value_datatype);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.5.1.1.1 argument `value_datatype` specification

The `value_datatype` argument value shall be as specified in 10.4.2.5.5 subject to the restrictions on the value of Physical Parameter Type allowed for Objects of this class.

10.5.1.2 Operation `SetDatatype` specification

```
IDL: OpReturnCode SetDatatype(in UInteger8 value_datatype);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.5.1.3 Operation `GetUnits` specification

```
IDL: OpReturnCode GetUnits(out Units value_units);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.5.1.3.1 argument `value_units` specification

The `value_units` argument value shall be the units of the value of the Parameter as returned by `GetMetadata`.

10.5.1.4 Operation `SetUnits` specification

```
IDL: OpReturnCode SetUnits(in Units value_units);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.5.2 Scalar Parameter class behavior

10.5.2.1 Specific Scalar Parameter operation restrictions based on state

In addition to and conformant with the restrictions of 10.4.2.1, the allowed operations defined on a Scalar Parameter instance shall be restricted as defined in the Table 67. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 67—`IEEE1451_ScalarParameter` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
`GetDatatype`, `GetUnits`	Local invocation only	Operational	Operational
`SetDatatype`, `SetUnits`	Local invocation only	Operational	Not operational

10.5.2.2 Operations `SetDatatype` and `SetUnits` behavior specifications

The `SetDatatype` and `SetUnits` operation may both be an Interface Only Implementation if the Parameter metadata is "read only;" otherwise, they both shall be a Full Implementation.

10.5.2.3 Data structure semantics

10.5.2.3.1 Restriction on the value of Physical Parameter Type

The allowed values for Physical Parameter Type for this class are

— `PP_SCALAR_ANALOG`

— `PP_SCALAR_DISCRETE`

— `PP_SCALAR_DIGITAL`

The structure and interpretation of both data and metadata is Physical Parameter Type dependent.

10.5.2.3.2 argument `data` behavior specifications for the read and write operations

For the scalar datatypes, the interpretation of the 0th and only member of Argument Array, `data` of the various read and write operations shall be as follows (see 10.4.2.4):

— The `TypeCode` discriminant of the Argument shall be `PHYSICAL_PARAMETER_DATA_TC`. The union `PhysicalParameterData`, which is the value of the Argument, shall have discriminant `PP_SCALAR_ANALOG`, `PP_SCALAR_DISCRETE`, or `PP_SCALAR_DIGITAL`. In all three cases, the value of the `PhysicalParameterData` union is a `PhysicalParameterSingletonData` structure with members defined per 6.2.15 as follows:

— The value field is of type `ArgumentArray`.

— There shall be only one Argument in this Array, member Argument 0. This Argument shall have value a datum whose datatype is that returned by the `GetDatatype` operation. This datum shall represent the value of the Parameter.

— The `timestamp` field shall represent the time at which the value of the Parameter was updated.

These relationships are shown schematically in Figure 18.

10.5.2.3.3 metadata behavior specifications pertaining to Parameters

— `PP_SCALAR_ANALOG:` For the scalar analog datatype, the metadata shall be represented by the `ScalarAnalogMetadata` structure.

— `PP_SCALAR_DISCRETE:` For scalar discrete datatypes, the metadata shall be represented by the `ScalarDiscreteMetadata` structure.

— `PP_SCALAR_DIGITAL:` For scalar digital datatypes, the metadata shall be represented by the `ScalarDigitalMetadata` structure.

The interpretation of the fields of these data structures shall be as specified in 10.4.2.

10.6 Scalar Series Parameter class

Class: `IEEE1451_ScalarSeriesParameter`

Parent Class: `IEEE1451_ScalarParameter`

Class ID: 1.1.2.1.1.1.1.1

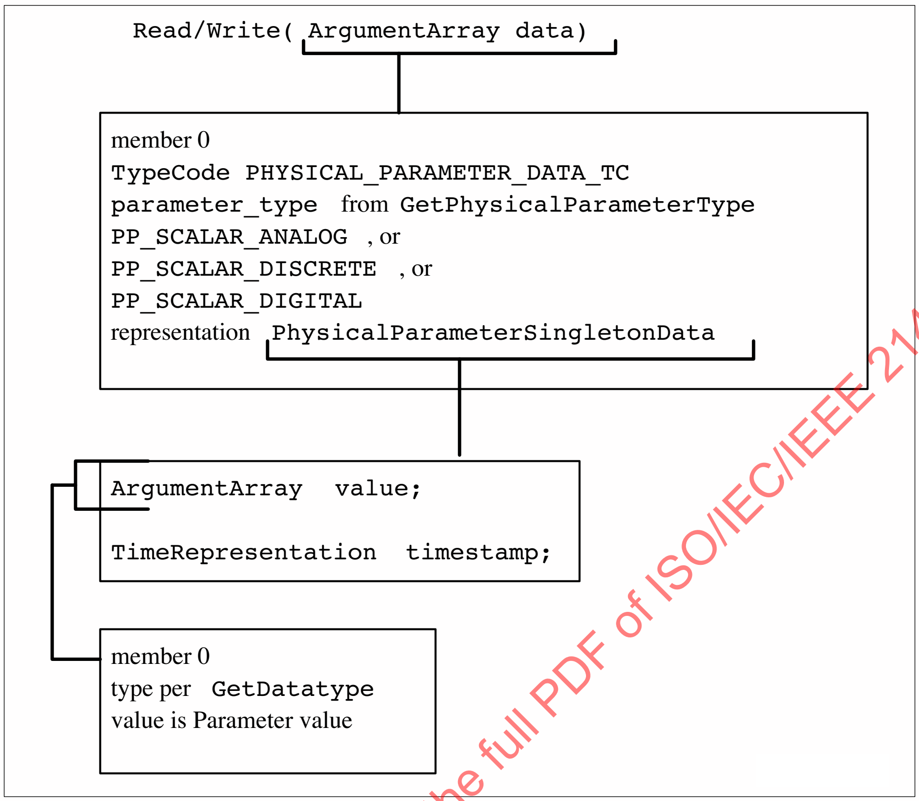

Read/Write(ArgumentArray data)
member 0
TypeCode PHYSICAL_PARAMETER_DATA_TC
parameter_type from GetPhysicalParameterType
PP_SCALAR_ANALOG , or
PP_SCALAR_DISCRETE , or
PP_SCALAR_DIGITAL
representation PhysicalParameterSingletonData
ArgumentArray value;
TimeRepresentation timestamp;
member 0
type per GetDatatype
value is Parameter value

Figure 18—Scalar Parameter data representation

Description: The Scalar Series Parameter class is used to model physical world quantities, best modeled as a succession of scalars evenly distributed along some dimension. Examples of such quantities are time series, fourier transforms, and mass spectra.

Class summary:

Network Visible operations (see Table 68).

Table 68—`IEEE1451_ScalarSeriesParameter` Network Visible operations

Operation Name	Requirement	Operation ID
`GetAbscissaUnits`	(m)	14336
`SetAbscissaUnits`	(o)	14337
`GetAbscissaIncrement`	(m)	14338
`SetAbscissaIncrement`	(o)	14339
`GetAbscissaOrigin`	(m)	14340
`SetAbscissaOrigin`	(o)	14341

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

10.6.1 Operation specifications: Network Visible

10.6.1.1 Operation GetAbscissaUnits specification

```
IDL: OpReturnCode GetAbscissaUnits(out Units abscissa_units);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.6.1.1.1 argument abscissa_units specification

The abscissa_units argument value shall be the units of the abscissa_increment and abscissa_origin values.

10.6.1.2 Operation SetAbscissaUnits specification

```
IDL: OpReturnCode SetAbscissaUnits(in Units abscissa_units);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.6.1.3 Operation GetAbscissaIncrement specification

```
IDL: OpReturnCode GetAbscissaIncrement(
          out Argument abscissa_increment);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.6.1.3.1 argument abscissa_increment specification

The value of the abscissa_increment argument shall be the increment in the designated abscissa_units between each member of the series. Negative values of abscissa_increment are allowed. The datatype of the value of this argument shall be the same datatype as would be used if the incremented variable were a measured value represented as a Parameter, for example, TimeRepresentation for time.

10.6.1.4 Operation SetAbscissaIncrement specification

```
IDL: OpReturnCode SetAbscissaIncrement(
          in Argument abscissa_increment);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.6.1.5 Operation GetAbscissaOrigin specification

```
IDL: OpReturnCode GetAbscissaOrigin(
          out Argument abscissa_origin);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.6.1.5.1 argument abscissa_origin specification

The value of the abscissa_origin argument shall be the starting value of the abscissa. This starting value is the abscissa value corresponding to the value of the 0th member Argument of the Argument Array, data, the output argument of the Read operation on the Parameter. abscissa_origin shall be represented in the designated abscissa_units and of the same datatype as abscissa_increment.

10.6.1.6 Operation `SetAbscissaOrigin` specification

```
IDL: OpReturnCode SetAbscissaOrigin(in Argument
          abscissa_origin);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.6.2 Scalar Series Parameter class behavior

10.6.2.1 Specific Scalar Series Parameter operation restrictions based on state

In addition to and conformant with the restrictions of 10.5.2.1, the allowed operations defined on a Scalar Series Parameter instance shall be restricted as defined in Table 69. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 69—`IEEE1451_ScalarSeriesParameter` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_ UNINITIALIZED	**BL_ INACTIVE**	**BL_ ACTIVE**
`GetAbscissaUnits`, `GetAbscissaIncrement`, `GetAbscissaOrigin`	Local invocation only	Operational	Operational
`SetAbscissaUnits`, `SetAbscissaIncrement`, `SetAbscissaOrigin`	Local invocation only	Operational	Not operational

10.6.2.2 Operation `SetAbscissaUnits` behavior specification

The `SetAbscissaUnits` operation may be an Interface Only Implementation if the Parameter metadata is “read only;” otherwise, it shall be a Full Implementation.

10.6.2.3 Operations `SetAbscissaIncrement` and `SetAbscissaOrigin` behavior specifications

The `SetAbscissaIncrement` and `SetAbscissaOrigin` operations may be Interface Only Implementations if these aspects of the Parameter are “read only;” otherwise, they shall have Full Implementations.

10.6.2.4 Data structure semantics

10.6.2.4.1 Restriction on the value of Physical Parameter Type

The allowed values for Physical Parameter Type for this class are

— `PP_SCALAR_ANALOG_SERIES`

— `PP_SCALAR_DISCRETE_SERIES`

— `PP_SCALAR_DIGITAL_SERIES`

The structure and interpretation of both data and metadata is Physical Parameter Type dependent.

10.6.2.4.2 Argument `data` behavior specifications for the read and write operation of the Parameter

For the scalar series datatypes, the value of the 0th and only member of the Argument Array `data` of the various Read and Write operations shall be as follows (see 10.4.2.4):

— The `TypeCode` discriminant of the Argument shall be `PHYSICAL_PARAMETER_DATA_TC`. The union `PhysicalParameterData`, which is the value of the Argument, shall have discriminant `PP_SCALAR_ANALOG_SERIES`, `PP_SCALAR_DISCRETE_SERIES`, or `PP_SCALAR_DIGITAL_SERIES`. In all three cases, the value of the `PhysicalParameterData` union is a `PhysicalParameterSeriesData` structure with members defined per 6.2.15 as follows:

— The value field is of type `ArgumentArray` defined as follows:

  — There shall be only one Argument in this Array, member Argument 0. This Argument's value shall have the datatype returned by the `GetDatatype` operation.

  — The type of this value shall be an Array, `value_array`, of a type allowed by 10.4.2.5.6, and it shall represent the value of the Parameter.

  — An Array element of `value_array` shall represent the value of the ith Parameter value of the series where i shall be the Array member ordinal starting at i = 0.

  — If "length" is the length of the Array, i < length.

  — The 0th Array element of the `value_array` shall be the value corresponding to the `abscissaOrigin` field.

  — The `timestamp` field shall represent the time at which the value field, that is, the entire series representation, was updated.

  — The `abscissaIncrement` field shall be the value in the output argument, `abscissa_increment`, returned by the `GetAbscissaIncrement` operation.

  — The `abscissaOrigin` field shall be the value in the output argument, `abscissa_origin`, returned by the `GetAbscissaOrigin` operation.

These relationships as shown schematically in Figure 19.

10.6.2.4.3 metadata behavior specifications associated with the Parameter

— `PP_SCALAR_ANALOG_SERIES`: For the scalar analog series datatype, the metadata shall be represented by the `ScalarAnalogSeriesMetadata` structure.

— `PP_SCALAR_DISCRETE_SERIES`: For scalar discrete series datatypes, the metadata shall be represented by the `ScalarDiscreteSeriesMetadata` structure.

— `PP_SCALAR_DIGITAL_SERIES`: For scalar digital series datatypes, the metadata shall be represented by the `ScalarDigitalSeriesMetadata` structure.

The interpretation of the fields of these data structures shall be as specified in 10.4.2.

10.6.2.5 Member `abscissaIncrement` behavior specification

The value of a Scalar Series Parameter, that is the ordinate values, shall represent the values of the Parameter corresponding to successive uniform intervals of an abscissa variable. The increment between each successive abscissa value shall be the value of the member `abscissaIncrement`. The actual value of a given abscissa value corresponding to a particular ordinate value shall be determined by the `abscissaOrigin` member value added to the multiple of `abscissaIncrement` member value appropriate to the term in the series.

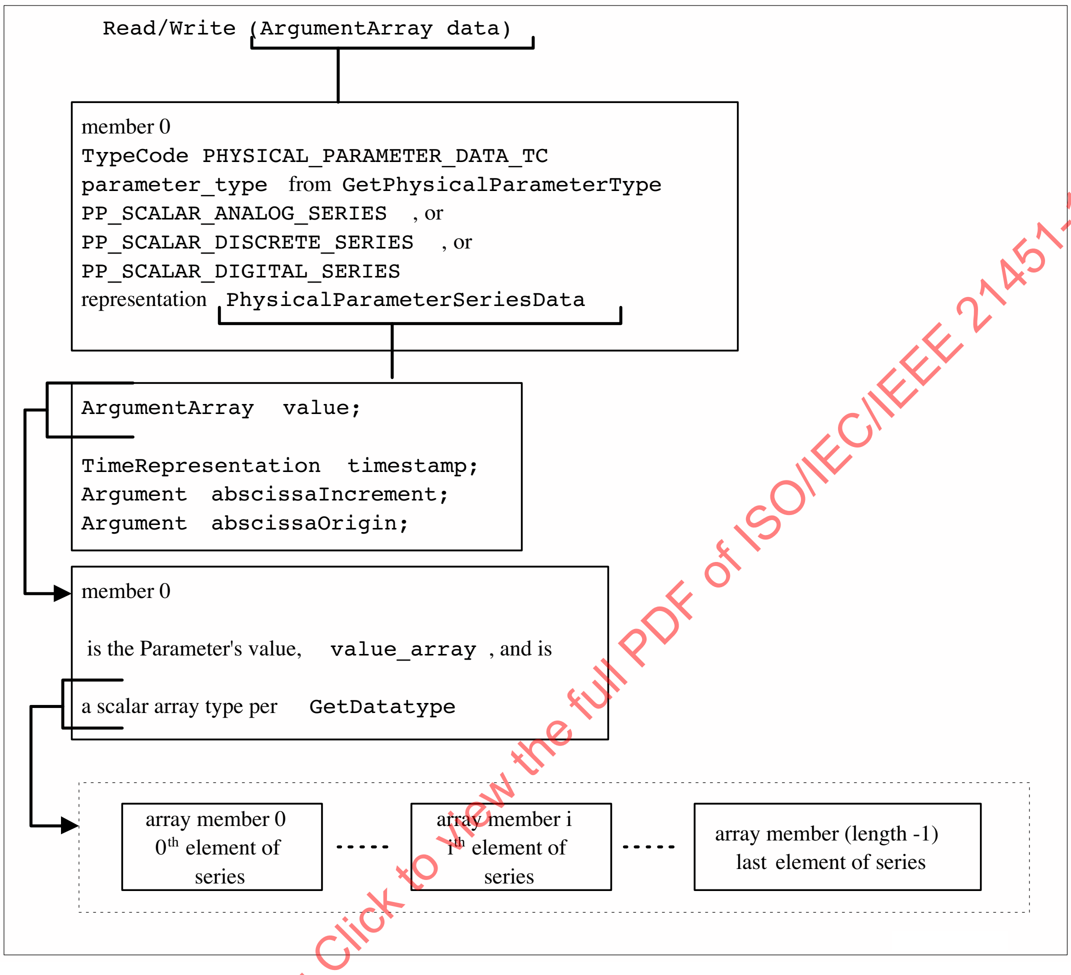

Read/Write (ArgumentArray data)
member 0
TypeCode PHYSICAL_PARAMETER_DATA_TC
parameter_type from GetPhysicalParameterType
PP_SCALAR_ANALOG_SERIES , or
PP_SCALAR_DISCRETE_SERIES , or
PP_SCALAR_DIGITAL_SERIES
representation PhysicalParameterSeriesData
ArgumentArray value;
TimeRepresentation timestamp;
Argument abscissaIncrement;
Argument abscissaOrigin;
member 0
is the Parameter's value, value_array , and is
a scalar array type per GetDatatype
array member 0
0th element of series
array member i
ith element of series
array member (length -1)
last element of series

Figure 19—Scalar Series Parameter data representation

10.7 Vector Parameter class

Class: `IEEE1451_VectorParameter`

Parent Class: `IEEE1451_PhysicalParameter`

Class ID: 1.1.2.1.1.1.2

Description: The Vector Parameter class is used to model physical world quantities that have multiple dimensions and perhaps orientation associated with them, and are appropriately represented as mathematical vectors. Examples of such quantities are electric field, acceleration, and torque, and arbitrary relations such as temperature/pressure pairs. This class may be used for single-axis vectors, for example, a single-axis accelerometer, to convey the correct physical interpretation.

Class summary:

Network Visible operations (see Table 70).

Table 70—`IEEE1451_VectorParameter` Network Visible operations

Operation Name	Requirement	Operation ID
`GetDimension`	(m)	12292
`SetDimension`	(o)	12293
`GetDatatype`	(m)	12294
`SetDatatype`	(o)	12295
`GetUnits`	(m)	12296
`SetUnits`	(o)	12297

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

10.7.1 Operation specifications: Network Visible

10.7.1.1 Operation `GetDimension` specification

```
IDL: OpReturnCode GetDimension(out UInteger16 dimension);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.7.1.1.1 argument `dimension` specification

The dimension shall be the dimensionality, in the mathematical sense, of the `data` argument of the Read and Write operations on the Object. The dimensionality shall be greater than 0 and shall indicate that the Object represents a `dimension`-dimensional vector.

10.7.1.2 Operation `SetDimension` specification

```
IDL: OpReturnCode SetDimension(in UInteger16 dimension);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.7.1.3 Operation `GetDatatype` specification

```
IDL: OpReturnCode GetDatatype(
          out UInteger8Array value_datatype);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.7.1.3.1 argument `value_datatype` specification

The `value_datatype` argument value shall be as specified in 10.4.2.5.5 subject to the restrictions on the value of Physical Parameter Type allowed for Objects of this class.

10.7.1.4 Operation `SetDatatype` specification

```
IDL: OpReturnCode SetDatatype(in UInteger8Array value_datatype);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.7.1.5 Operation `GetUnits` specification

```
IDL: OpReturnCode GetUnits(out UnitsArray value_units);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.7.1.5.1 argument `value_units` specification

The `value_units` argument value shall be an Array of `Units` of length `dimension`. Each member of the Array represents the units of the value of the Argument that is the corresponding member of the Parameter's Argument Array `data` value.

10.7.1.6 Operation `SetUnits` specification

```
IDL: OpReturnCode SetUnits(in UnitsArray value_units);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.7.2 Vector Parameter class behavior

10.7.2.1 Specific Vector Parameter operation restrictions based on state

In addition to and conformant with the restrictions of 10.4.2.1, the allowed operations defined on a Vector Parameter instance shall be restricted as defined in Table 71. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 71—`IEEE1451_VectorParameter` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
`GetDimension`, `GetDatatype`, `GetUnits`	Local invocation only	Operational	Operational
`SetDimension`, `SetDatatype`, `SetUnits`	Local invocation only	Operational	Not operational

10.7.2.2 Operation `SetDimension` behavior specification

The `SetDimension` operation may be an Interface Only Implementation if the Parameter metadata is "read only;" otherwise, it shall be a Full Implementation.

10.7.2.3 Operation `SetDatatype` behavior specification

The `SetDatatype` operation may be an Interface Only Implementation if the Parameter metadata is "read only;” otherwise, it shall be a Full Implementation.

10.7.2.4 Operation `SetUnits` behavior specification

The `SetUnits` operation may be an Interface Only Implementation if the Parameter metadata is “read only;” otherwise, it shall be a Full Implementation.

10.7.2.5 Data structure semantics

10.7.2.5.1 Restrictions on the value of Physical Parameter Type

The allowed values for Physical Parameter Type for this class are

— `PP_VECTOR_ANALOG`

— `PP_VECTOR_DISCRETE`

— `PP_VECTOR_DIGITAL`

The structure and interpretation of both data and metadata is Physical Parameter Type dependent.

10.7.2.5.2 argument `data` behavior specifications for the read and write operations of the Parameter

For the vector datatypes, the Argument Array, `data`, that is the argument of the various `Read` and `Write` operations, shall be as follows (see 10.4.2.4):

— The Argument Array, `data`, shall be of length 1.

— The `TypeCode` discriminant of the 0th member Argument of `data` shall be `PHYSICAL_PARAMETER_DATA_TC`. The union `PhysicalParameterData`, which is the value of this Argument, shall have discriminant `PP_VECTOR_ANALOG`, `PP_VECTOR_DISCRETE` or `PP_VECTOR_DIGITAL`. In all three cases, the value of the `PhysicalParameterData` union is a `PhysicalParameterSingletonData` structure with members defined according to 6.2.15 as follows:

  — The value field of the `PhysicalParameterSingletonData` structure is of type `ArgumentArray`. This Argument Array shall be of length `dimension`. Each Argument member of the Argument Array shall represent a single dimension of the vector.

  — The value of the jth member Argument of the Argument Array, the jth value, shall be the value of the jth dimension of the Vector Parameter.

  — The jth value shall have datatype corresponding to the `TypeCode` that is the value of the jth member of the Array of `TypeCode` values returned by the `GetDatatype` operation on the vector.

  — The jth value shall have units the value of the jth member of the `UnitsArray` returned by the `GetUnits` operation on the vector.

  — The length of all these Arrays shall be one less than the dimension of the vector. Hence j < `dimension`.

— The `timestamp` field of the `PhysicalParameterSingletonData` structure shall be of datatype `TimeRepresentation`, and its value shall be the time at which the structure’s `value` field was last updated.

These relationships are shown schematically in Figure 20.

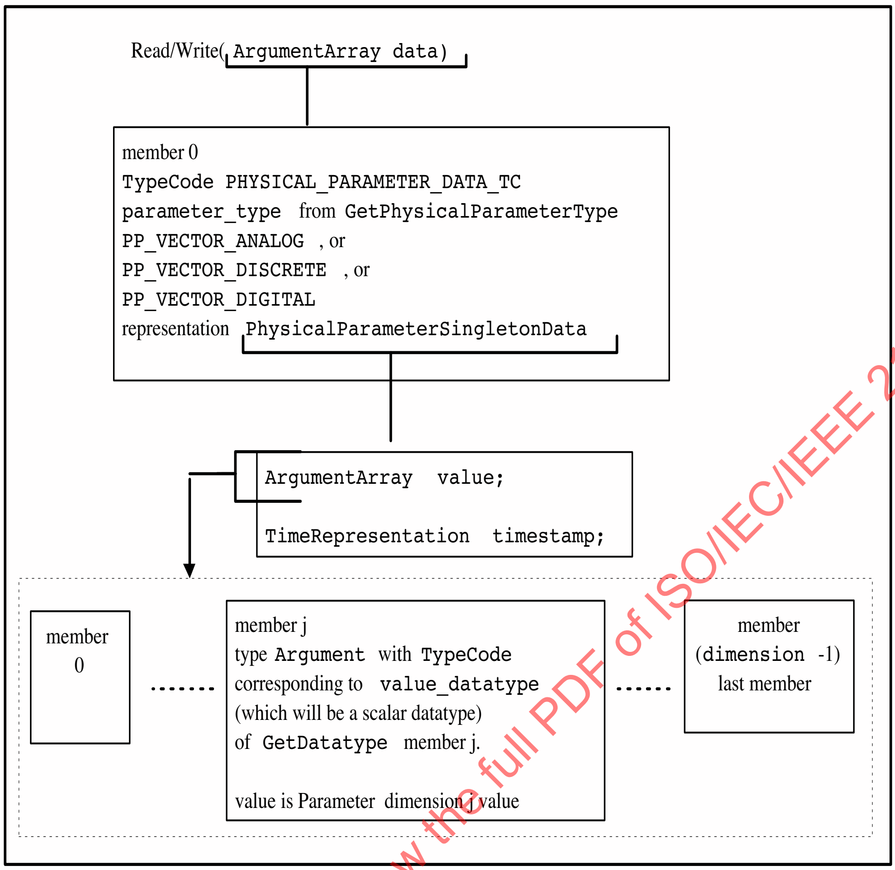

Read/Write(ArgumentArray data)
member 0
TypeCode PHYSICAL_PARAMETER_DATA_TC
parameter_type from GetPhysicalParameterType
PP_VECTOR_ANALOG , or
PP_VECTOR_DISCRETE , or
PP_VECTOR_DIGITAL
representation PhysicalParameterSingletonData
ArgumentArray value;
TimeRepresentation timestamp;
member 0
member j
type Argument with TypeCode
corresponding to value_datatype
(which will be a scalar datatype)
of GetDatatype member j.
value is Parameter dimension j value
member
(dimension -1)
last member

Figure 20—Vector Parameter data representation

10.7.2.5.3 member `dimension` behavior specification

The vector's dimension shall have value the value returned in the output argument `dimension` by the operation `GetDimension`. All Array types defined in the vector's data and metadata structures shall be of length equal to the vector's dimension. The value of the `dimension` field of the metadata structure returned by the `GetMetadata` operation shall be the vector's dimension.

The semantics of the vector's dimension shall be defined by the value of the `coordinateSystem` field of the metadata structure returned by `GetMetadata` operation. The allowed values of the `coordinateSystem` field shall be taken from the `CoordinateSystem` enumeration defined in Table 72.

IDL: enumeration `CoordinateSystem;`

10.7.2.5.4 metadata behavior specifications associated with the Parameter

`PP_VECTOR_ANALOG:` For vector analog datatypes, the metadata shall be represented by the `VectorAnalogMetadata` structure.

`PP_VECTOR_DISCRETE:` For vector discrete datatypes, the metadata shall be represented by the `VectorDiscreteMetadata` structure.

`PP_VECTOR_DIGITAL:` For vector digital datatypes, the metadata shall be represented by the `VectorDigitalMetadata` structure.

The interpretation of the fields of these data structures shall be as specified in 10.4.2.

Table 72—`CoordinateSystem` enumeration

Enumeration	Value	Meaning
`CC_ARBITRARY`	0	Starting with the 0th argument of the value, the values represent dimensions of a user-defined vector.
`CC_CARTESIAN`	1	Starting with the 0th argument of the value, the values represent the x, y, and z components of a right-handed cartesian coordinate space.
`CC_CYLINDRICAL`	2	Starting with the 0th argument of the value, the values represent the r, Θ , and z components of a right-handed cylindrical coordinate space.
`CC_SPHERICAL`	3	Starting with the 0th argument of the value, the values represent the r, Θ , and Φ components of a right-handed spherical coordinate space.
`CC_PLANETARY`	4	Starting with the 0th argument of the value, the values represent the latitude, longitude, and elevation components of a planetary coordinate space.
`CC_ORIENTATION`	5	Starting with the 0th argument of the value, the values represent the roll, pitch, and yaw components of the angular orientation with respect to a defined spatial direction.
Reserved	6–127	
Open to industry	128–255	

10.8 Vector Series Parameter class

Class: `IEEE1451_VectorSeriesParameter`

Parent Class: `IEEE1451_VectorParameter`

Class ID: 1.1.2.1.1.1.2.1

Description: The Vector Series Parameter class is used to model a uniform series of physical world quantities that have dimensions and orientation associated with them and are appropriately represented as mathematical vectors. Examples of such quantities are electric field, acceleration, and torque and arbitrary relations such as temperature/pressure pairs. This class may be used for single-axis vectors, for example, a single-axis accelerometer, to convey the correct physical interpretation.

Class summary:

Network Visible operations (see Table 73).

Table 73—`IEEE1451_VectorSeriesParameter` Network Visible operations

Operation Name	Requirement	Operation ID
`GetAbscissaUnits`	(m)	14342
`SetAbscissaUnits`	(o)	14343
`GetAbscissaIncrement`	(m)	14344
`SetAbscissaIncrement`	(o)	14345
`GetAbscissaOrigin`	(m)	14346
`SetAbscissaOrigin`	(o)	14347

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

10.8.1 Operation specifications: Network Visible

10.8.1.1 Operation `GetAbscissaUnits` specification

```
IDL: OpReturnCode GetAbscissaUnits(out Units abscissa_units);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.8.1.1.1 argument `abscissa_units` specification

The `abscissa_units` argument value shall be the units of the `abscissa_increment` and `abscissa_origin`.

10.8.1.2 Operation `SetAbscissaUnits` specification

```
IDL: OpReturnCode SetAbscissaUnits(in Units abscissa_units);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.8.1.3 Operation `GetAbscissaIncrement` specification

```
IDL: OpReturnCode GetAbscissaIncrement(
          out Argument abscissa_increment);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.8.1.3.1 argument `abscissa_increment` specification

The `abscissa_increment` argument value shall be the increment in the designated `abscissa_units` between each member of the series. Negative values of `abscissa_increment` are allowed. The datatype of the value of the argument shall be the same datatype as would be used if the incremented abscissa variable were a measured value represented as a Parameter, for example, `TimeRepresentation` for an abscissa that represents time.

10.8.1.4 Operation `SetAbscissaIncrement` specification

```
IDL: OpReturnCode SetAbscissaIncrement(
          in Argument abscissa_increment);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.8.1.5 Operation `GetAbscissaOrigin` specification

```
IDL: OpReturnCode GetAbscissaOrigin(
          out Argument abscissa_origin);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.8.1.5.1 argument `abscissa_origin` specification

The value of the `abscissa_origin` argument value shall be the starting value of the abscissa. This starting value is the abscissa value corresponding to the value of the 0th member Argument of the Argument Array, `data`, the output argument of the `Read` operation on the Parameter. `abscissa_origin` shall be represented in the designated `abscissa_units` and of the same datatype as `abscissa_increment`.

10.8.1.6 11.Operation `SetAbscissaOrigin` specification

```
IDL: OpReturnCode SetAbscissaOrigin(in Argument abscissa_origin);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.8.2 Vector Series Parameter class behavior

10.8.2.1 Specific Vector Series Parameter operation restrictions based on state

In addition to and conformant with the restrictions of 10.7.2.1, the allowed operations defined on a Vector Series Parameter instance shall be restricted as defined in Table 74. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 74—`IEEE1451_VectorSeriesParameter` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_ UNINITIALIZED	**BL_ INACTIVE**	**BL_ ACTIVE**
`GetAbscissaUnits`, `GetAbscissaIncrement`, `GetAbscissaOrigin`	Local invocation only	Operational	Operational
`SetAbscissaUnits`, `SetAbscissaIncrement`, `SetAbscissaOrigin`	Local invocation only	Operational	Not operational

10.8.2.2 Operation `SetAbscissaUnits` behavior specification

The `SetAbscissaUnits` operation may be an Interface Only Implementation if the Parameter metadata is “read only;” otherwise, it shall be a Full Implementation.

10.8.2.3 Operations `SetAbscissaIncrement` and `SetAbscissaOrigin` behavior specifications

The `SetAbscissaIncrement` and `SetAbscissaOrigin` operations may be Interface Only Implementations if these aspects of the Parameter are “read only;” otherwise, they shall have Full Implementations.

10.8.2.4 Data structure semantics

10.8.2.4.1 Restrictions on the value of Physical Parameter Type

The allowed values for Physical Parameter Type for this class are

— PP_VECTOR_ANALOG_SERIES

— PP_VECTOR_DISCRETE_SERIES

— PP_VECTOR_DIGITAL_SERIES

The structure and interpretation of both data and metadata is Physical Parameter Type dependent.

10.8.2.4.2 Argument data behavior specifications for the read and write operations of the Parameter

For the vector series datatypes, the Argument Array, data, that is the argument of the various Read and Write operations shall be as follows; see 10.4.2.4:

— The Argument Array, data, shall be of length 1

— The TypeCode discriminant of the 0th member Argument of data shall be PHYSICAL_PARAMETER_DATA_TC. The union PhysicalParameterData, which is the value of this Argument, shall have discriminant PP_VECTOR_ANALOG_SERIES, PP_VECTOR_DISCRETE_SERIES, or PP_VECTOR_DIGITAL_SERIES. In all three cases, the value of the PhysicalParameterData union is a PhysicalParameterSeriesData structure with members defined per 6.2.15 as follows:

  — The value field of the PhysicalParameterSeriesData structure is of type ArgumentArray. This Argument Array shall be of length dimension. Each Argument member of the Argument Array shall represent a single dimension of the vector.

  — The value of the jth member Argument of the Argument Array, value-dimension-j-array, shall be an Array of length the number of vectors in the series. The ith member of this Array, value-dimension-j-array[i] shall contain the value of the jth dimension of the ith vector in the series.

  — The basic datatype of the Array, value-dimension-j-array, shall be that corresponding to the TypeCode value of the jth member of the TypeCode Array returned by the GetDatatype operation on the Parameter.

  — The units of each member of value-dimension-j-array shall be those of the jth member of the UnitsArray returned by the GetUnits operation on the Parameter.

  — The 0th Array member of each value-dimension-j-array shall be the value of the jth dimension of the vector corresponding to the abscissaOrigin field of the PhysicalParameterSeriesData structure.

— The timestamp field of the PhysicalParameterSeriesData structure shall represent the time at which the value field—that is, the entire vector series—was updated.

— The Argument in the abscissaIncrement field of the PhysicalParameterSeriesData structure shall have as value the value returned in the output argument, abscissa_increment, by the GetAbscissaIncrement operation on the Vector Series Parameter.

— The Argument in the abscissaOrigin field of the PhysicalParameterSeriesData structure shall have as value the value returned in the output argument, abscissa_origin, by the GetAbscissaOrigin operation on the Vector Series Parameter.

These relationships are shown schematically in Figure 21.

10.8.2.4.3 metadata behavior specifications associated with the Parameter

PP_VECTOR_ANALOG_SERIES: For vector analog series datatypes, the metadata shall be represented by the VectorAnalogSeriesMetadata structure.

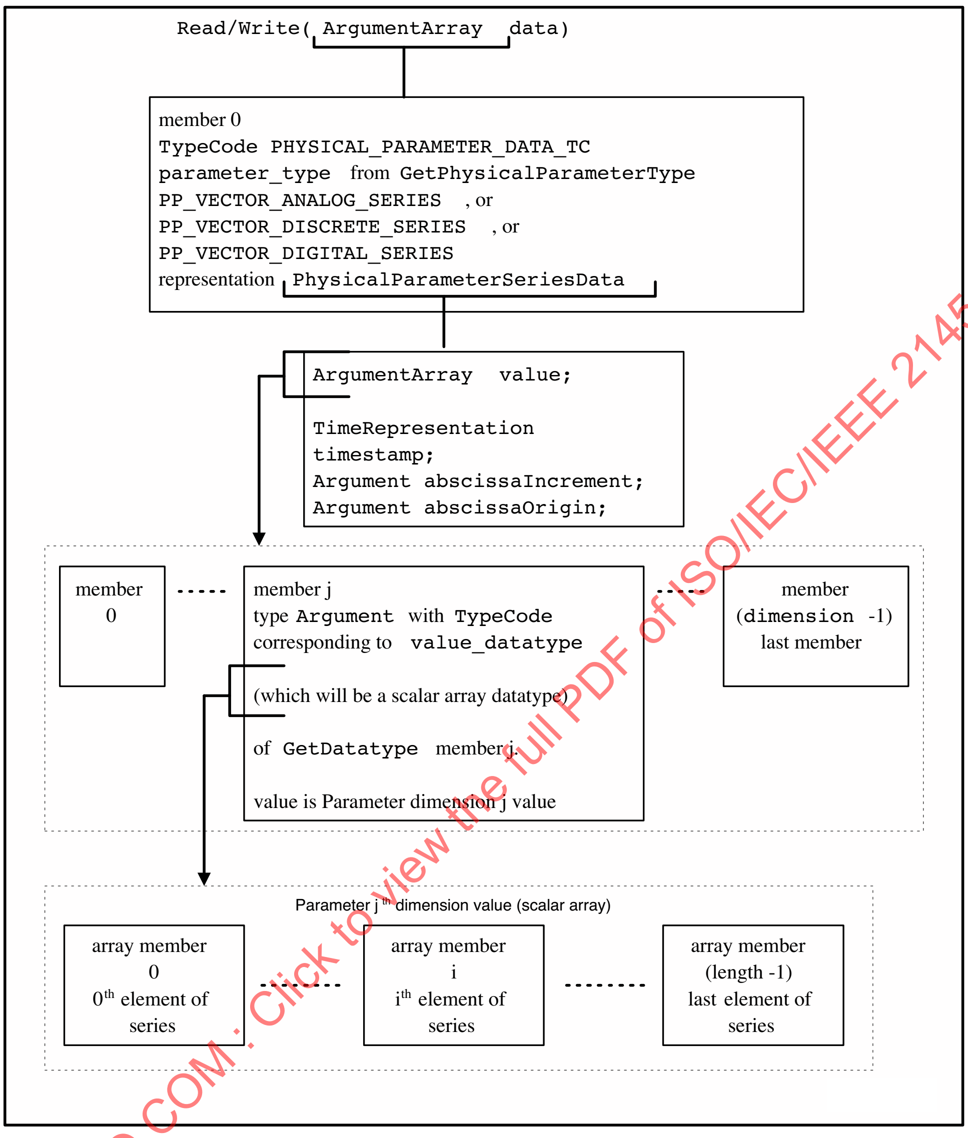

Read/Write(ArgumentArray data)
member 0
TypeCode PHYSICAL_PARAMETER_DATA_TC
parameter_type from GetPhysicalParameterType
PP_VECTOR_ANALOG_SERIES , or
PP_VECTOR_DISCRETE_SERIES , or
PP_VECTOR_DIGITAL_SERIES
representation PhysicalParameterSeriesData
ArgumentArray value;
TimeRepresentation timestamp;
Argument abscissaIncrement;
Argument abscissaOrigin;
member 0
member j
type Argument with TypeCode
corresponding to value_datatype
(which will be a scalar array datatype)
of GetDatatype member j.
value is Parameter dimension j value
member (dimension -1) last member
Parameter j th dimension value (scalar array)
array member 0 0th element of series
array member i ith element of series
array member (length -1) last element of series

Figure 21—Vector Series Parameter data representation

`PP_VECTOR_DISCRETE_SERIES:` For vector discrete series datatypes, the metadata shall be represented by the `VectorDiscreteSeriesMetadata` structure.

`PP_VECTOR_DIGITAL_SERIES:` For vector digital series datatypes, the metadata shall be represented by the `VectorDigitalSeriesMetadata` structure.

The interpretation of the fields of these data structures shall be as specified in 10.4.2.

10.8.2.5 Member `abscissaIncrement` behavior specification

The series of vectors represented as described in 10.8.2.4.2 by the Argument Array in the `value` field of the `PhysicalParameterSeriesData` structure, the ordinate values of the Parameter, shall be the value of the Parameter corresponding to successive uniform intervals of an abscissa variable. The increment between each successive abscissa value shall be the value of member `abscissaIncrement`. The actual value of a given abscissa value corresponding to a particular ordinate value shall be determined by the `abscissaOrigin` member value added to a multiple of the value of the member `abscissaIncrement.` This multiple `is determined by the` ordinate value's position in the series.

10.9 Time Parameter class

Class: `IEEE1451_TimeParameter`

Parent Class: `IEEE1451_Parameter`

Class ID: 1.1.2.1.2

Description: The Time Parameter class may be used to represent time parametric values. The purpose of the Time Parameter class and its subclasses is to model Network Visible variables that directly or indirectly represent the time of some event, or the duration between two events, where the significant characteristic of the event is the time rather than some other value.

Class summary:

Network Visible operations (see Table 75).

Table 75—`IEEE1451_TimeParameter` Network Visible operations

Operation Name	Requirement	Operation ID
`GetUncertainty`	(m)	8208
`GetTimeType`	(m)	8209
`GetEpochRepresentation`	(m)	8210
`GetEpoch`	(m)	8211

Local Operations (see Table 76).

Table 76—`IEEE1451_TimeParameter` Local operations

Operation Name	Requirement
`RegisterNotifyOnUpdate`	(o)
`DeregisterNotifyOnUpdate`	(o)

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

10.9.1 Operation specification: Network Visible

10.9.1.1 Operation `GetUncertainty` specification

```
IDL: OpReturnCode GetUncertainty(out Uncertainty uncertainty);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.9.1.1.1 argument `uncertainty` specification

The `uncertainty` argument value shall be based on time, expressed in seconds, and shall represent the uncertainty of the value of the Parameter.

10.9.1.2 Operation `GetTimeType` specification

```
IDL: OpReturnCode GetTimeType(out UInteger8 time_type);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.9.1.2.1 argument `time_type` specification

The `time_type` argument value shall be taken from the `TimeType` enumeration shown in Table 77, and shall define the interpretation of the value of the Parameter.

IDL: enumeration `TimeType;`

Table 77—`TimeType` enumeration

Enumeration	Value	Meaning
`TT_TIMESTAMP`	0	The time value is a timestamp marking the time with respect to an epoch.
`TT_TIME_DURATION`	1	The value represents the difference between two timestamps.
Reserved	2–255	

10.9.1.3 Operation `GetEpochRepresentation` specification

```
IDL: OpReturnCode GetEpochRepresentation(
         out UInteger8 epoch_representation);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.9.1.3.1 argument `epoch_representation` specification

The `epoch_representation` argument value shall be taken from the `TimeEpoch` enumeration; see 13.2.1.6. `epoch_representation` defines the method of specifying the epoch or origin of the time scale on which the value of the Parameter is based.

10.9.1.4 Operation `GetEpoch` specification

```
IDL: OpReturnCode GetEpoch(out TimeRepresentation epoch);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.9.1.4.1 argument `epoch` specification

The `epoch` argument value shall represent the origin of the timescale on which the value of the Parameter is based.

10.9.2 Operations specifications: Local

10.9.2.1 Local operation `RegisterNotifyOnUpdate` specification

```
IDL: OpReturnCode RegisterNotifyOnUpdate(
           in <local operation reference>
               notification_operation,
           in UInteger16 registration_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.9.2.1.1 argument `notification_operation` specification

The `notification_operation` argument value shall be a local reference to the local operation of the registering object that shall be invoked to signal notification. The signature of the referenced `notification_operation` shall be

```
OpReturnCode <local operation name>(
           in UInteger16 registration_id,
           in TimeRepresentation timestamp);
```

10.9.2.1.2 argument `timestamp` specification

The `timestamp` argument value shall be the occurrence time of the class-specific change, mandating the notification.

10.9.2.1.3 argument `registration_id` specification

The `registration_id` argument value shall be an identifier generated by the object registering for update to distinguish among registrations with different target objects.

10.9.2.2 Local operation `DeregisterNotifyOnUpdate` specification

```
IDL: OpReturnCode DeregisterNotifyOnUpdate(
           in <local operation reference>
               notification_operation,
           in UInteger16 registration_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.9.3 Time Parameter class behavior

10.9.3.1 Specific Time Parameter operation restrictions based on state

In addition to and conformant with the restrictions of 10.2.2.1, the allowed operations defined on a Time Parameter instance shall be restricted as defined in Table 78. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 78—**IEEE1451_TimeParameter** class specific restrictions

Operation	Specified value of rule_basis		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
All operations defined by this class	Local invocation only	Operational	Operational

10.9.3.2 Operations Read and Write behavior specifications

The value of the 0th Argument member of the Argument Array argument of the Read or Write operations inherited from the IEEE1451_Parameter class shall be the value of the time represented by this Parameter.

10.9.3.3 Notification operations behavior specifications

The local notification_operation shall be invoked for all registered operations, whenever the value of the Time Parameter is altered.

RegisterNotifyOnUpdate and DeregisterNotifyOnUpdate shall both be Interface Only Implementations, or shall both be Full Implementations as designated by a subclass definition. The default shall be a Full Implementation.

10.9.3.4 arguments time_type, epoch, and epoch_representation behavior specifications

The allowed values for the time_type, epoch_representation, and epoch arguments shall be as shown in Table 79 and case statements.

Table 79—Time representation restrictions

Time type	Epoch Representation	Epoch
TT_TIME_DURATION	TE_NOT_DEFINED	Cases 1 and 2 shall apply
TT_TIMESTAMP	TE_NOT_DEFINED	Cases 1 and 3 shall apply
	TE_UTC	Cases 1 and 4 shall apply
	TE_USER_DEFINED	Case 5 shall apply
	(open to industry)	Case 6 shall apply

Case 1: The value of epoch is the default value for the TimeRepresentation type.

Case 2: The concept on an epoch is not relevant to a measure of the difference between two timestamps.

Case 3: The epoch is either undefined or not known. No interpretation of the value of the Parameter is possible on the basis of these values. The interpretation must be specified by other means outside the scope of this standard. This interpretation shall be documented by the creator of any code using this option.

Case 4: The epoch is the UTC epoch; see 13.2.1.7.

Case 5: The epoch is specified by the value of the epoch argument. The value of epoch is itself a timestamp relative to some origin selected by the user. It is recommended that the value of epoch be represented on a UTC timescale. The interpretation of the epoch value shall be documented by the creator of any code using this option.

Case 6: The correct interpretation of the epoch and therefore of the value of the Parameter itself shall be documented by the creator of the extension to the `TimeEpoch` enumeration.

When the epoch is defined, the value of the Parameter represents a timestamp on a timescale whose origin is given by the epoch. In the case of the UTC epoch, this timescale origin is fixed by international standard; see [B7] for a complete discussion.

10.10 Action class

Class: `IEEE1451_Action`

Parent Class: `IEEE1451_Component`

Class ID: 1.1.2.2

Description: The Action class provides a model to represent activities that alter system state and that require significant time to execute compared to other activities in the system.

Class summary:

Network Visible operations (see Table 80).

Table 80—`IEEE1451_Action` Network Visible variables

Operation Name	Requirement	Operation ID
`GetActionFailedTimeoutDuration`	(m)	6168
`InvokeTransaction`	(m)	6169
`GetActionState`	(m)	6170
`AbortTransaction`	(m)	6171
`ReleaseTransaction`	(m)	6172
`ForceAcquireTransaction`	(m)	6173

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

10.10.1 Operation specifications: Network Visible

10.10.1.1 Operation `GetActionFailedTimeoutDuration` specification

```
IDL: OpReturnCode GetActionFailedTimeoutDuration(
             out TimeRepresentation
                 action_failed_timeout_duration);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.10.1.1.1 argument `action_failed_timeout_duration` specification

The `action_failed_timeout_duration` argument value shall be the time duration after which the Action is considered to have failed. A value of 0 shall indicate that the Action's timeout is infinite, that is the Action may continue indefinitely and still retain the intended behavior of the artifact modeled by the Action. A negative value shall be considered an argument error.

10.10.1.2 Operation `InvokeTransaction` specification

```
IDL: OpReturnCode InvokeTransaction(
           in ArgumentArray input_arguments,
           out UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.10.1.2.1 argument `input_arguments` specification

The value of the Argument members of `input_arguments` shall be the input arguments for the Action's `InvokeTransaction` operation.

10.10.1.2.2 argument `transaction_id` specification

The `transaction_id` argument value shall identify a particular invocation of the Action.

10.10.1.3 Operation `GetActionState` specification

```
IDL: OpReturnCode GetActionState(out UInteger8 action_state);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.10.1.3.1 argument `action_state` specification

The `action_state` argument value shall be defined by the following enumeration, shown in Table 81, and shall reflect the current state of the Action.

IDL: enumeration `ActionState;`

Table 81—`ActionState` enumeration

Enumeration	Value	Meaning
`AC_IDLE`	0	Any invoked action has completed and has been released.
`AC_EXECUTING`	1	An invoked action is still in progress.
`AC_COMPLETED`	2	An invoked action has been completed, but not released by the client.
`AC_FAILED`	3	The Component has detected an error, the timeout has expired, or an `AbortTransaction` has been invoked.
Reserved	4–255	

10.10.1.4 Operation `AbortTransaction` specification

```
IDL: OpReturnCode AbortTransaction(in UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.10.1.5 Operation `ReleaseTransaction` specification

```
IDL: OpReturnCode ReleaseTransaction(
           in UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.10.1.6 Operation `ForceAcquireTransaction` specification

```
IDL: OpReturnCode ForceAcquireTransaction(
           out UInteger16 new_transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.10.1.6.1 argument `new_transaction_id` specification

The `new_transaction_id` argument value shall identify a new value for the `transaction_id` of the Action.

10.10.2 Action class behavior

10.10.2.1 Specific Action operation restrictions based on state

In addition to and conformant with the restrictions of 10.1.2.2, the allowed operations defined on an Action instance shall be restricted as defined in Table 82. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 82—`IEEE1451_Action` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	**BL_INACTIVE**	**BL_ACTIVE**
All operations defined by this class	Local invocation only	Operational	Operational

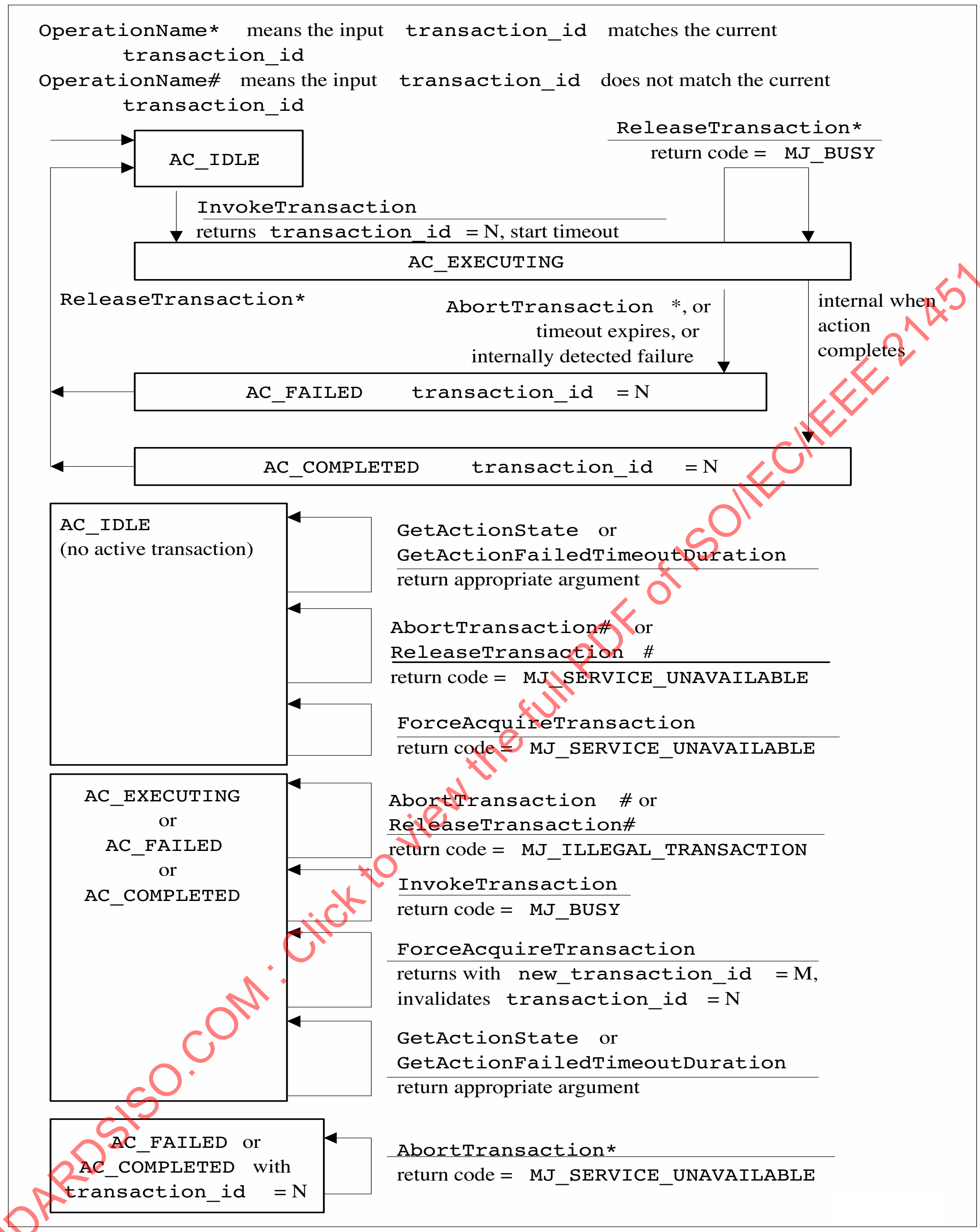
10.10.2.2 Concurrency requirements

The `AbortTransaction` and `ForceAcquireTransaction` operations shall support Precedence Concurrency.

The `GetActionState` operation shall support Active Concurrency.

10.10.2.3 State behavior specification

The state behavior of an Action shall be as shown in Figure 22.



OperationName* means the input transaction_id matches the current transaction_id
OperationName# means the input transaction_id does not match the current transaction_id
AC_IDLE
ReleaseTransaction* return code = MJ_BUSY
InvokeTransaction returns transaction_id = N, start timeout
AC_EXECUTING
ReleaseTransaction*
AbortTransaction *, or timeout expires, or internally detected failure
internal when action completes
AC_FAILED transaction_id = N
AC_COMPLETED transaction_id = N
AC_IDLE (no active transaction)
GetActionState or GetActionFailedTimeoutDuration return appropriate argument
AbortTransaction# or ReleaseTransaction # return code = MJ_SERVICE_UNAVAILABLE
ForceAcquireTransaction return code = MJ_SERVICE_UNAVAILABLE
AC_EXECUTING or AC_FAILED or AC_COMPLETED
AbortTransaction # or ReleaseTransaction# return code = MJ_ILLEGAL_TRANSACTION
InvokeTransaction return code = MJ_BUSY
ForceAcquireTransaction returns with new_transaction_id = M, invalidates transaction_id = N
GetActionState or GetActionFailedTimeoutDuration return appropriate argument
AC_FAILED or AC_COMPLETED with transaction_id = N
AbortTransaction* return code = MJ_SERVICE_UNAVAILABLE

Figure 22—State machine for an Action

10.11 File class

Class: `IEEE1451_File`

Parent Class: `IEEE1451_Component`

Class ID: 1.1.2.3

Description: The File class is an abstraction of a data resource. Files represent a block of memory, which may be opened, closed, read from, and written to.

Class summary:

Network Visible operations (see Table 83).

Table 83—`IEEE1451_File` Network Visible operations

Operation Name	Requirement	Operation ID
`OpenForRead`	(o)	6174
`OpenForWrite`	(o)	6175
`Read`	(o)	6176
`Write`	(o)	6177
`Close`	(m)	6178
`ForceClose`	(m)	6179
`GetFileState`	(m)	6180

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

10.11.1 Operation specifications: Network Visible

10.11.1.1 Operation `OpenForRead` specification

```
IDL: OpReturnCode OpenForRead(
          out UInteger16 transaction_id,
          out UInteger32 actual_image_size);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.11.1.1.1 argument `transaction_id` specification

The `transaction_id` argument value shall define the client invocation that opened this File for reading. This value may be used to enforce the required File state behavior.

10.11.1.1.2 argument `actual_image_size` specification

The `actual_image_size` argument value shall be the number of octets in the current stored File image. This argument shall be the maximum number of octets that may be transferred by a successful sequence of contiguous `Read` operations.

10.11.1.2 Operation `OpenForWrite` specification

```
IDL: OpReturnCode OpenForWrite(
          out UInteger16 transaction_id,
          out UInteger32 max_file_size);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.11.1.2.1 argument `transaction_id` specification

The `transaction_id` argument value shall define the client invocation that opened this File for writing. This value is used to enforce the required File state behavior.

10.11.1.2.2 argument `max_file_size` specification

The `max_file_size` argument value shall be the maximum number of octets that may be transferred by a successful contiguous sequence of `Write` operations.

10.11.1.3 Operation `Read` specification

```
IDL: OpReturnCode Read(
           in UInteger16 transaction_id,
           in UInteger32 requested_number_of_octets,
           out UInteger32 actual_number_of_octets_read,
           out OctetArray data);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.11.1.3.1 argument `transaction_id` specification

The `transaction_id` argument value identifies a particular instance of an `OpenForRead` operation.

10.11.1.3.2 argument `requested_number_of_octets` specification

The `requested_number_of_octets` argument value shall be the number of octets that the client is requesting from the File Object.

10.11.1.3.3 argument `actual_number_of_octets_read` specification

The `actual_number_of_octets_read` argument value shall indicate the number of octets actually returned to the client.

10.11.1.3.4 argument `data` specification

The `data` argument value shall be the portion of the File's data returned to the client.

10.11.1.4 Operation `Write` specification

```
IDL: OpReturnCode Write(
           in UInteger16 transaction_id,
           in UInteger32 requested_number_of_octets,
           in OctetArray data,
           out UInteger32 actual_number_of_octets_written);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.11.1.4.1 argument `transaction_id` specification

The `transaction_id` argument value identifies a particular instance of an `OpenForWrite` operation.

10.11.1.4.2 argument `requested_number_of_octets` specification

The `requested_number_of_octets` argument value shall be the number of octets that the client is requesting to write to the File Object.

10.11.1.4.3 argument `data` specification

The `data` argument value shall be the File contents information sent to the File Object.

10.11.1.4.4 argument `actual_number_of_octets_written` specification

The `actual_number_of_octets_written` argument value shall indicate the number of octets actually accepted and written by the File Object.

10.11.1.5 Operation `Close` specification

```
IDL: OpReturnCode Close(in UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.11.1.6 Operation `ForceClose` specification

```
IDL: OpReturnCode ForceClose( );
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.11.1.7 Operation `GetFileState` specification

```
IDL: OpReturnCode GetFileState(
          out UInteger8 file_state,
          out UInteger32 actual_image_size,
          out UInteger32 max_file_size);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.11.1.7.1 argument `file_state` specification

The `file_state` argument value shall be defined by the enumeration shown in Table 84.

IDL: enumeration `FileState;`

Table 84—`FileState` enumeration

Enumeration	Value	Meaning
`FL_CLOSED`	0	This File is closed.
`FL_OPENED_FOR_READ`	1	The File has been opened for `Read` operations.
`FL_OPENED_FOR_WRITE`	2	The File has been opened for `Write` operations.
Reserved	3–255	

10.11.2 File class behavior

10.11.2.1 Specific File operation restrictions based on state

In addition to and conformant with the restrictions of 10.1.2.2, the allowed operations defined on a File instance shall be restricted as defined in Table 85. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 85—`IEEE1451_File` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
All operations defined by this class	Local invocation only	Operational	Operational

10.11.2.2 Concurrency requirements

The `ForceClose` operation may support Precedence Concurrency.

10.11.2.3 Operations `OpenForRead` and `Read` behavior specifications

The `OpenForRead` and `Read` operations may either both be Interface Only Implementations if the File is “write only,” or they shall both be Full Implementations.

With a Full Implementation, the successful execution of the `OpenForRead` operation shall cause the first subsequent `Read` operation to start at the beginning of the File. Additional `Read` operations return the requested block of data in the File that immediately follows the last data returned.

The `actual_number_of_octets_read` argument, returned from a `Read` operation, shall be zero, if either of the following conditions is `TRUE:`

— The `requested_number_of_octets` is zero

— The total number of octets transferred by previous `Read` operations equals `max_file_size` for the File

10.11.2.4 Operations `OpenForWrite` and `Write` behavior specifications

The `OpenForWrite` and `Write` operations may either both be Interface Only Implementations if the File is “read only,” or they shall both be Full Implementations.

With a Full Implementation, the successful execution of the `OpenForWrite` operation shall cause the first subsequent `Write` operation to start at the beginning of the File. The first `Write` operation shall invalidate any data initially present in the File Object. Additional `Write` operations append the data to the File.

The `actual_number_of_octets_written` argument, returned from a `Write` operation, shall be zero if either of the following conditions is `TRUE:`

— The `requested_number_of_octets` is zero

— The total number of octets transferred by previous `Write` operations equals `max_file_size` for the File specified by the `OpenForWrite` operation

10.11.2.5 State behavior specification

The File behavior shall be as described by the state machine of Figure 23. Operations not defined on a state shall have no effect. The initial state of a File shall be `FL_CLOSED` as indicated by the entry transition of the state machine.

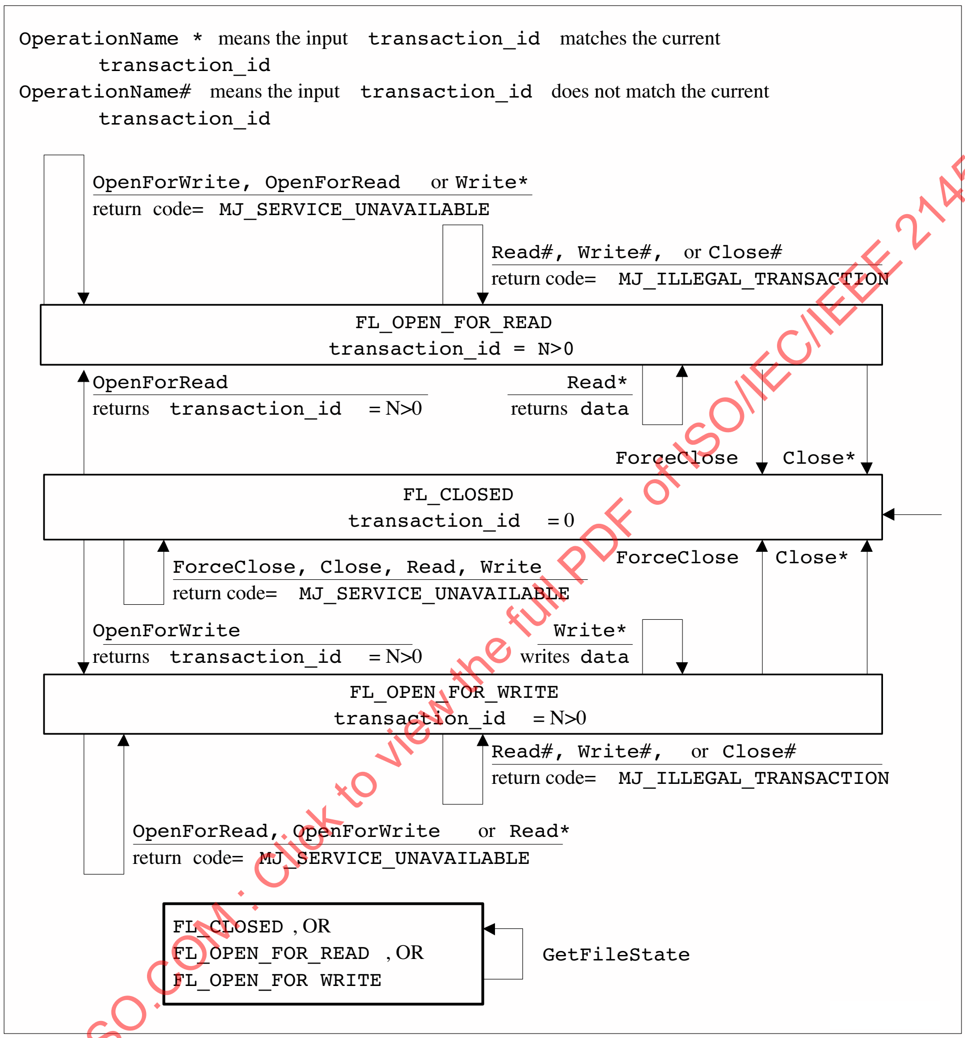

OperationName * means the input transaction_id matches the current transaction_id
OperationName# means the input transaction_id does not match the current transaction_id
OpenForWrite, OpenForRead or Write*
return code= MJ_SERVICE_UNAVAILABLE
Read#, Write#, or Close#
return code= MJ_ILLEGAL_TRANSACTION
FL_OPEN_FOR_READ
transaction_id = N>0
OpenForRead
returns transaction_id = N>0
Read*
returns data
ForceClose
Close*
FL_CLOSED
transaction_id = 0
ForceClose, Close, Read, Write
return code= MJ_SERVICE_UNAVAILABLE
ForceClose
Close*
OpenForWrite
returns transaction_id = N>0
Write*
writes data
FL_OPEN_FOR_WRITE
transaction_id = N>0
Read#, Write#, or Close#
return code= MJ_ILLEGAL_TRANSACTION
OpenForRead, OpenForWrite or Read*
return code= MJ_SERVICE_UNAVAILABLE
FL_CLOSED , OR
FL_OPEN_FOR_READ , OR
FL_OPEN_FOR WRITE
GetFileState

Figure 23—State machine for a File

10.11.2.5.1 argument `transaction_id` behavior specification

A valid `transaction_id` shall have the value NO_TRANSACTION following the successful execution of a `Close` or `ForceClose` operation.

The NO_TRANSACTION value shall be 0.

Two `transaction_id` values match if, and only if

— They have the same value, **AND**

— Neither is the NO_TRANSACTION value

10.11.2.6 Persistence behavior specification

The persistence properties of a File are outside the scope of this standard unless otherwise noted.

10.12 Partitioned File class

Class: `IEEE1451_PartitionedFile`

Parent Class: `IEEE1451_File`

Class ID: 1.1.2.3.1

Description: The Partitioned File class may be used for Files that are subdivided into a number of Partitions.

Class summary:

Network Visible operations (see Table 86).

Table 86—`IEEE1451_PartitionedFile` Network Visible operations

Operation Name	Requirement	Operation ID
`SeekPartition`	(m)	8212
`GetCurrentPartition`	(m)	8213
`GetNumberOfPartitions`	(m)	8214
`GetPartitionedFileSubstate`	(m)	8215

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

10.12.1 Operation specifications: Network Visible

10.12.1.1 Operation `SeekPartition` specification

```
IDL: OpReturnCode SeekPartition(
           in UInteger16 transaction_id,
           in UInteger16 partition_id,
           out UInteger32 actual_partition_image_size,
           out UInteger32 max_partition_size);
```

The Minor Field of the return code shall be taken from the enumeration shown in Table 87.

IDL: enumeration `PartitionReturn;`

The meanings of the first six members of this enumeration shall be identical to the meanings of the first six members of the `MinorReturnCode` enumeration; see 7.2.3.2.1. The member `PR_MISSING_PARTITION` shall signify that the Partition with the specified `partition_id` does not exist or could not be found.

Table 87—`PartitionReturn` enumeration

Enumeration	Value
`PR_NO_ADDITIONAL_INFORMATION`	0
`PR_MEMORY_ALLOCATION_ERROR`	1
`PR_MISSING_INPUT`	2
`PR_INVALID_TYPE`	3
`PR_INVALID_VALUE`	4
`PR_COMPUTATION_ERROR`	5
`PR_MISSING_PARTITION`	6
Reserved	7–255

10.12.1.1.1 argument `partition_id` specification

The `partition_id argument` value shall represent a Partitioned File Object specific identifier of some subportion of the File’s data space.

10.12.1.1.2 argument `actual_partition_image_size` specification

The `actual_partition_image_size` argument value shall be the number of octets currently stored in the Partition.

10.12.1.1.3 argument `max_partition_size` specification

The `max_partition_size` argument value shall be the maximum number of octets that can be stored in the Partition.

10.12.1.2 Operation `GetCurrentPartition` specification

```
IDL: OpReturnCode GetCurrentPartition(
           in UInteger16 transaction_id,
           out UInteger16 partition_id,
           out UInteger32 actual_partition_image_size,
           out UInteger32 max_partition_size);
```

The Minor Field of the return code shall be taken from the `PartitionReturn` enumeration.

10.12.1.3 Operation `GetNumberOfPartitions` specification

```
IDL: OpReturnCode GetNumberOfPartitions(
           in UInteger16 transaction_id,
           out UInteger16 number_of_partitions);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.12.1.3.1 argument `number_of_partitions` specification

The `number_of_partitions` argument value shall be the total number of Partitions of this File that can be accessed.

10.12.1.4 Operation `GetPartitionedFileSubstate` specification

```
IDL: OpReturnCode GetPartitionedFileSubstate(
          in UInteger16 transaction_id,
          out UInteger8 partition_state);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.12.1.4.1 argument `partition_state` specification

The `partition_state` argument value shall be take from the `PartitionedFileSubstate` enumeration shown in Table 88.

IDL: enumeration `PartitionedFileSubstate;`

Table 88—`PartitionedFileSubstate` enumeration

Enumeration	Value	Meaning
`PL_PARTITION_NOT_SET`	0	Partition not in readable or writable state
`PL_PARTITION_SET`	1	Partition is available for reading or writing
Reserved	2–255	

10.12.2 Partitioned File class behavior

10.12.2.1 Specific Partitioned File operation restrictions based on state

In addition to and conformant with the restrictions of 10.11.2.1, the allowed operations defined on a Partitioned File instance shall be restricted as defined in the Table 89. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 89—`IEEE1451_PartitionedFile` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
All operations defined by this class	Local invocation only	Operational	Operational

10.12.2.2 Partitioning behavior specification

The File consists of `number_of_partitions` subdivisions that may be addressed via the `SeekPartition` operation.

— The value of `number_of_partitions` shall be set at class instantiation.

— The assignment of `partition_id` values to the corresponding portions of the partitioned file shall be made at class instantiation.

— Valid `partition_id` values shall be in the range

$0 \le \texttt{partition\_id} < \texttt{number\_of\_partitions}$

— Void partitions, max_partition_size = 0, are allowed but can not be written to or read from.

— The following empty Partition condition is allowed, and such Partitions can be written to, or read from:

max_partition_size > 0

AND

actual_partition_image_size = 0

— Missing partition_id values within the range shall not be allowed.

A successful execution of the SeekPartition operation shall cause the first subsequent Read or Write operation (depending on whether the File was opened for reading or writing) to start at the beginning of the Partition.

10.12.2.3 Inherited operation OpenForRead behavior specification

The actual_image_size argument of the OpenForRead operation inherited from the File class shall be the sum of the actual_partition_image_size values for all Partitions in the File.

The OpenForRead and Read operations may either both be Interface Only Implementations if the File is "write only," or they shall both be Full Implementations.

With a Full Implementation, the successful execution of the OpenForRead operation followed by the successful execution of the SeekPartition operation shall cause the first subsequent Read operation to start at the beginning of the designated Partition of the File. Additional Read operations return the requested block of data in the designated Partition of the File that immediately follows the last data returned.

The actual_number_of_octets_read argument, returned from a Read operation, shall be zero, if either of the following conditions is TRUE:

— The requested_number_of_octets is zero.

— The total number of octets transferred by previous Read operations on the Partition equals max_partition_size for the Partition.

10.12.2.4 Inherited operation OpenForWrite behavior specification

The max_file_size argument of the OpenForWrite operation inherited from the File class shall be the sum of the max_partition_size values for all Partitions in the File.

The OpenForWrite and Write operations may either both be Interface Only Implementations if the File is "read only," or they shall both be Full Implementations.

With a Full Implementation, the successful execution of the OpenForWrite operation followed by the successful execution of the SeekPartition operation shall cause the first subsequent Write operation to start at the beginning of the designated Partition of the File. Additional Write operations transfer the requested block of data to the designated Partition of the File that immediately follows the last data written.

The actual_number_of_octets_written argument, returned from a Write operation, shall be zero, if either of the following conditions is TRUE:

— The requested_number_of_octets is zero.

— The total number of octets transferred by previous `Write` operations on the Partition equals `max_partition_size` for the Partition.

10.12.2.5 State behavior specification

The File behavior shall be as described by Figure 24. Operations not defined on a state shall have no effect.

If a `SeekPartition` operation is unsuccessful in placing the File such that the next `Read` or `Write` will operate starting at the beginning of the new Partition, failure shall be signaled by means of the `OpReturnCode` and the File Object shall be returned to the `PL_PARTITION_NOT_SET` state. In this case the `OpReturnCode`

— Major Field value shall be `MJ_FAILED_INPUT_ARGUMENT`

— Minor Field value shall be `PR_MISSING_PARTITION`

10.13 Component Group class

Class: `IEEE1451_ComponentGroup`

Parent Class: `IEEE1451_Component`

Class ID: 1.1.2.4

Description: The Component Group class provides a way to specify set membership relations between Objects in a system.

Class summary:

Network Visible operations (see Table 90).

Table 90—`IEEE1451_ComponentGroup` Network Visible operations

Operation Name	Requirement	Operation ID
`AddMember`	(m)	6181
`DeleteMember`	(m)	6182
`GetMembers`	(m)	6183
`SetMembers`	(m)	6184
`LookupMembersByName`	(m)	6185
`LookupMemberByDispatchAddress`	(m)	6186
`LookupMemberByObjectTag`	(m)	6187
`GetNumberOfMembers`	(m)	6188
`GetNextMember`	(m)	6189
`CancelIteration`	(m)	6190

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

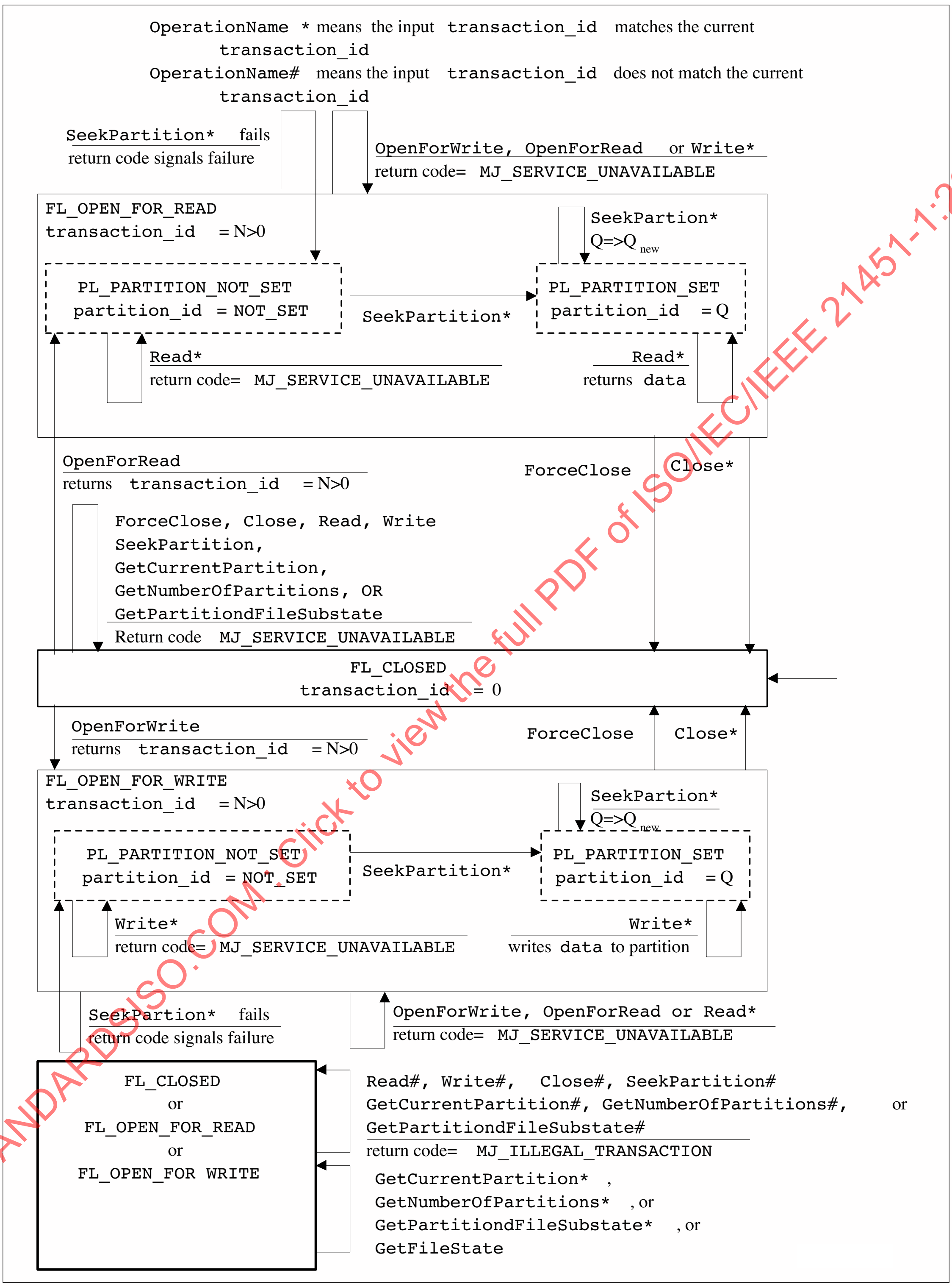

OperationName * means the input transaction_id matches the current transaction_id
OperationName# means the input transaction_id does not match the current transaction_id
SeekPartition* fails
return code signals failure
OpenForWrite, OpenForRead or Write*
return code= MJ_SERVICE_UNAVAILABLE
FL_OPEN_FOR_READ
transaction_id = N>0
SeekPartion*
Q=>Q new
PL_PARTITION_NOT_SET
partition_id = NOT_SET
SeekPartition*
PL_PARTITION_SET
partition_id = Q
Read*
return code= MJ_SERVICE_UNAVAILABLE
Read*
returns data
OpenForRead
returns transaction_id = N>0
ForceClose
Close*
ForceClose, Close, Read, Write
SeekPartition,
GetCurrentPartition,
GetNumberOfPartitions, OR
GetPartitiondFileSubstate
Return code MJ_SERVICE_UNAVAILABLE
FL_CLOSED
transaction_id = 0
OpenForWrite
returns transaction_id = N>0
ForceClose
Close*
FL_OPEN_FOR_WRITE
transaction_id = N>0
SeekPartion*
Q=>Q new
PL_PARTITION_NOT_SET
partition_id = NOT_SET
SeekPartition*
PL_PARTITION_SET
partition_id = Q
Write*
return code= MJ_SERVICE_UNAVAILABLE
Write*
writes data to partition
SeekPartion* fails
return code signals failure
OpenForWrite, OpenForRead or Read*
return code= MJ_SERVICE_UNAVAILABLE
FL_CLOSED
or
FL_OPEN_FOR_READ
or
FL_OPEN_FOR WRITE
Read#, Write#, Close#, SeekPartition#
GetCurrentPartition#, GetNumberOfPartitions#, or
GetPartitiondFileSubstate#
return code= MJ_ILLEGAL_TRANSACTION
GetCurrentPartition* ,
GetNumberOfPartitions* , or
GetPartitiondFileSubstate* , or
GetFileState

Figure 24—State machine for a Partitioned File

10.13.1 Operation specifications: Network Visible

10.13.1.1 Operation `AddMember` specification

```
IDL: OpReturnCode AddMember(
           in ObjectProperties member_properties);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.13.1.1.1 argument `member_properties` specification

The values of the fields of the `member_properties` structure shall be those of the Object being added to the group.

10.13.1.2 Operation `DeleteMember` specification

```
IDL: OpReturnCode DeleteMember(
           in ObjectProperties member_properties);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.13.1.2.1 argument `member_properties` specification

The values of the fields of the `member_properties` structure shall be those of the Object being deleted from the group.

10.13.1.3 Operation `GetMembers` specification

```
IDL: OpReturnCode GetMembers(
           out ObjectPropertiesArray members_properties);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.13.1.3.1 argument `members_properties` specification

Each member of the Array shall be an `ObjectProperties` structure for a group member.

10.13.1.4 Operation `SetMembers` specification

```
IDL: OpReturnCode SetMembers(
           in ObjectPropertiesArray members_properties);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.13.1.4.1 argument `members_properties` specification

Each member of the Array shall be an `ObjectProperties` structure for a member to be added to the group.

10.13.1.5 Operation `LookupMembersByName` specification

```
IDL: OpReturnCode LookupMembersByName(
           in String query_object_name,
           out ObjectPropertiesArray member_properties);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.13.1.5.1 argument `query_object_name` specification

The `query_object_name` argument value shall be the value of the Object Name of the Object to be sought within the group.

10.13.1.5.2 argument `member_properties` specification

Each member of the Array `member_properties` shall be an `ObjectProperties` structure describing a member Object with

`objectName` member value = `query_object_name`

NOTE—There is no requirement for global uniqueness of Object Names. Therefore, it is possible for multiple members to have the same `objectName` member values.

10.13.1.6 Operation `LookupMemberByDispatchAddress` specification

```
IDL: OpReturnCode LookupMemberByDispatchAddress(
           in ObjectDispatchAddress query_dispatch_address,
           out ObjectPropertiesArray member_properties);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.13.1.6.1 argument `query_dispatch_address` specification

The `query_dispatch_address` argument value shall be the Object Dispatch Address of the Object to be sought within the group.

10.13.1.6.2 argument `member_properties` specification

The `member_properties` argument value shall be an `ObjectProperties` structure describing the Object with

Object Dispatch Address = `query_dispatch_address.`

10.13.1.7 Operation `LookupMemberByObjectTag` specification

```
IDL: OpReturnCode LookupMemberByObjectTag(
           in ObjectTag query_object_tag,
           out ObjectPropertiesArray member_properties);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.13.1.7.1 argument `query_object_tag` specification

The value of the argument `query_object_tag` shall be the Object Tag of the Object to be sought within the group.

10.13.1.7.2 argument `member_properties` specification

Each `member_properties argument` shall be an `ObjectProperties` structure describing an Object with

Object Tag = `query_object_tag.`

10.13.1.8 Operation `GetNumberOfMembers` specification

```
IDL: OpReturnCode GetNumberOfMembers(
           out UInteger16 number_of_members);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.13.1.8.1 argument `number_of_members` specification

The `number_of_members` argument value shall be the number of Objects represented by the group.

10.13.1.9 Operation `GetNextMember` specification

```
IDL: OpReturnCode GetNextMember(
           in Boolean first_flag
           out ObjectProperties member_properties);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.13.1.9.1 argument `first_flag` specification

If the `first_flag` argument value is `TRUE`, the returned member is conceptually the first member of the group. It the argument is `FALSE`, the returned member is the next successive member.

NOTE—There is no specification on the order in which members are returned by `GetNextMember`. Successive iterations over the group membership may retrieve the members in a different order; see 10.13.2.2.

10.13.1.9.2 argument `member_properties` specification

The `member_properties` argument value shall be an `ObjectProperties` structure describing the member of the series. The default value for `ObjectProperties` shall indicate that there was no member.

10.13.1.9.3 Operation `CancelIteration` specification

```
IDL: OpReturnCode CancelIteration( );
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

10.13.2 Component Group class behavior

10.13.2.1 Specific Component Group operation restrictions based on state

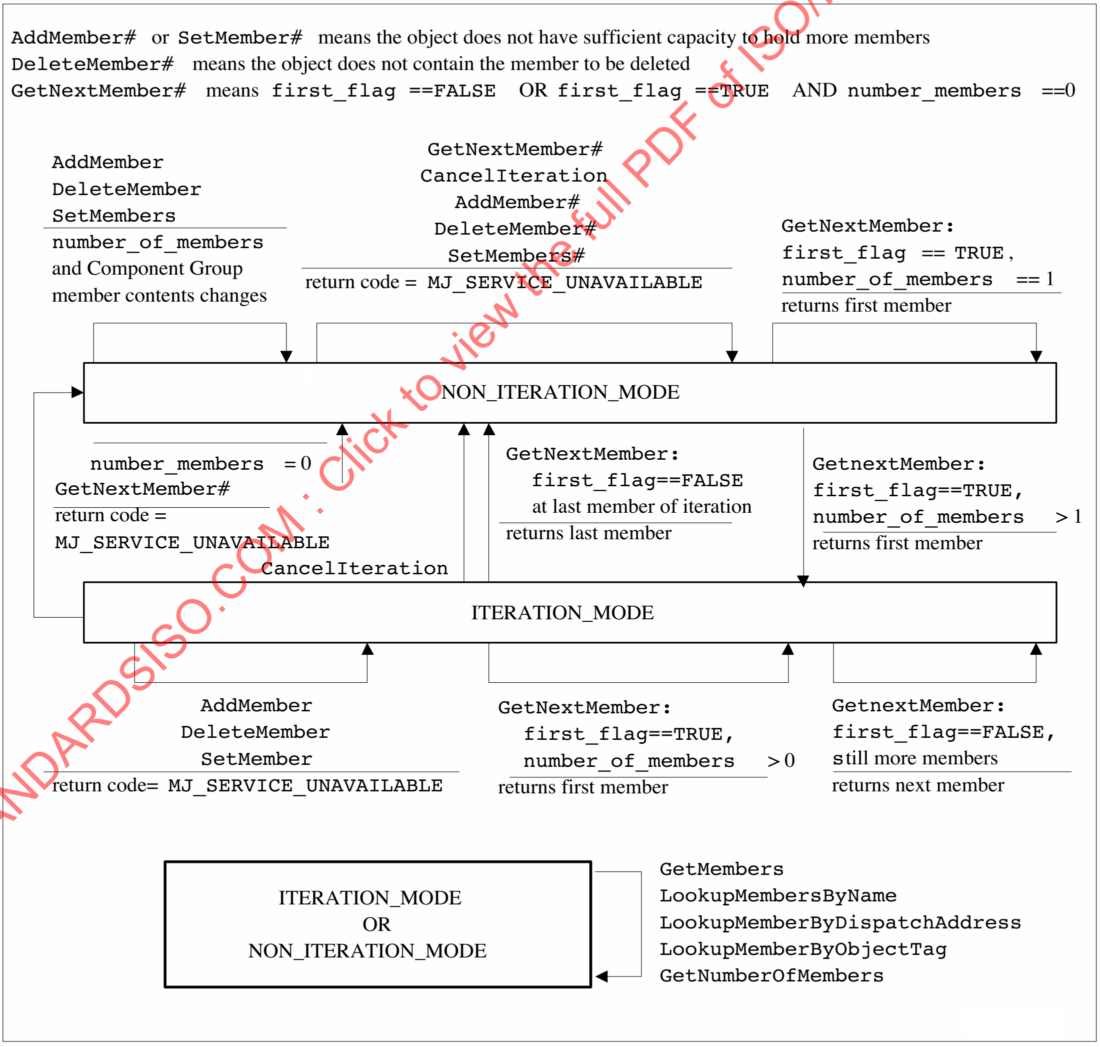
In addition to and conformant with the restrictions of 10.1.2.2, the allowed operations defined on a Component Group instance shall be restricted as defined in Table 91. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 91—IEEE1451_ComponentGroup class specific restrictions

Operation	Specified value of rule_basis		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
All operations defined by this class	Local invocation only	Operational	Operational

10.13.2.2 State behavior specification

The state behavior of the Component Group shall be defined by the state machine in Figure 25. The initial state shall be NON_ITERATION_MODE as illustrated by the entry transition of the state machine. First_flag = TRUE implies that the iteration over the members of the group is starting. There is no requirement that the order of members returned be related to the order in which members were added to the group. Applications must not assume any dependence on the order in which members' member_properties are returned.



AddMember# or SetMember# means the object does not have sufficient capacity to hold more members
DeleteMember# means the object does not contain the member to be deleted
GetNextMember# means first_flag ==FALSE OR first_flag ==TRUE AND number_members ==0
AddMember DeleteMember SetMembers / number_of_members and Component Group member contents changes
GetNextMember# CancelIteration AddMember# DeleteMember# SetMembers# / return code = MJ_SERVICE_UNAVAILABLE
GetNextMember: first_flag == TRUE, number_of_members == 1 / returns first member
NON_ITERATION_MODE
number_members = 0 GetNextMember# / return code = MJ_SERVICE_UNAVAILABLE
CancelIteration
GetNextMember: first_flag==FALSE at last member of iteration / returns last member
GetnextMember: first_flag==TRUE, number_of_members > 1 / returns first member
ITERATION_MODE
AddMember DeleteMember SetMember / return code= MJ_SERVICE_UNAVAILABLE
GetNextMember: first_flag==TRUE, number_of_members > 0 / returns first member
GetnextMember: first_flag==FALSE, still more members / returns next member
ITERATION_MODE OR NON_ITERATION_MODE
GetMembers LookupMembersByName LookupMemberByDispatchAddress LookupMemberByObjectTag GetNumberOfMembers

Figure 25—State machine for a Component Group

11. Service classes

11.1 Service abstract class

Abstract Class

Class: `IEEE1451_Service`

Parent Class: `IEEE1451_Entity`

Class ID: 1.1.3

Description: The Service abstract class shall be the root for the class hierarchy of all Service Objects. The Service classes represent Object types used to support communication and other aspects of block functionality.

Class summary:

Network Visible operations: There are no operations defined for this class.

Local Operations (see Table 92).

Table 92—`IEEE1451_Service` Local operations

Operation Name	Requirement
`SpecifyRuleBasis`	(m)

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

11.1.1 Operation specifications: Local

11.1.1.1 Local operation `SpecifyRuleBasis` specification

```
IDL: OpReturnCode SpecifyRuleBasis(in UInteger8 rule_basis);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.1.1.2 argument `rule_basis` specification

The `rule_basis` argument value shall specify the set of behavior rules governing the Object's behavior. The value of this argument shall be taken from the `BlockMajorState` enumeration; see 9.1.1.3.1.

11.1.2 Service class behavior

11.1.2.1 Operation `SpecifyRuleBasis` behavior specification

The `SpecifyRuleBasis` operation invoked on an Object T whose class is a subclass of Service shall be defined by the following rule:

A successful execution of the operation shall cause the Object T to obey the set of behavior restrictions designated by the argument `rule_basis`. These sets of restrictions are those defined for each of the Object's Owning Block's Block Major State values; see 9.1.3.2.1, 9.1.3.2.2, 9.1.3.2.3, or 9.2.5.2.1, depending on whether the Owning Block is an NCAP Block or only a Block.

The designation of the rule sets shall be as defined in Table 93.

Table 93—`rule_basis` restrictions

Rule basis value	Use restriction set defined for Block Major State value
BL_UNINITIALIZED	BL_UNINITIALIZED
BL_INACTIVE	BL_INACTIVE
BL_ACTIVE	BL_ACTIVE

The operation shall only be invoked under conditions defined in Table 94.

Table 94—`SpecifyRuleBasis` restrictions

rule_basis value	Block major state of Owning Block of Object T		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
BL_UNINITIALIZED	Allowed	Allowed	Allowed
BL_INACTIVE	Not allowed	Allowed	Allowed
BL_ACTIVE	Not allowed	Not allowed	Allowed

NOTE—A common use for this operation is to promote orderly startup and shutdown of a Block and its Owned objects. For example, on startup a Block in the `BL_INACTIVE` state would first transition to the `BL_ACTIVE` state and then issue the `SpecifyRuleBasis` operation with a `rule_basis` value of `BL_ACTIVE` to each of its Owned Service objects. During shutdown, the Block in the `BL_ACTIVE` state would first issue the `SpecifyRuleBasis` operation with a `rule_basis` value of `BL_INACTIVE` to each of its Owned Service objects before transitioning to the `BL_INACTIVE` state.

11.1.2.2 Specific Service operation restrictions based on state

In addition to and conformant with the restrictions of 11.1.2.1, the allowed operations defined on a Service instance shall be restricted as defined in Table 95. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 95—`IEEE1451_Service` class specific restrictions

Operation	Specified value of rule_basis		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
All operations defined by this class except those in the following rows	Local invocation only	Operational	Operational
SetObjectTag	Local invocation only	Operational	Not operational
Perform	Not operational	Operational	Operational

11.2 Base Port abstract class

Abstract Class

Class: `IEEE1451_BasePort`

Parent Class: `IEEE1451_Service`

Class ID: 1.1.3.1

Description: The Base Port abstract class shall be the root for the class hierarchy of all communication Port Objects used to send communications via the underlying network.

Class summary:

Network Visible operations (see Table 96).

Table 96—`IEEE1451_BasePort` Network Visible operations

Operation Name	Requirement	Operation ID
`SetTimeout`	(o)	6191
`GetTimeout`	(m)	6192
`SetMessagePriority`	(o)	6193
`GetMessagePriority`	(m)	6194

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

11.2.1 Operation specification: Network Visible

11.2.1.1 Operation `SetTimeout` specification

```
IDL: OpReturnCode SetTimeout(
            in TimeRepresentation client_timeout);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.2.1.2 argument `client_timeout` specification

The `client_timeout` argument value shall be the timeout associated with the Port. A negative timeout shall be considered an error.

11.2.1.3 Operation `GetTimeout` specification

```
IDL: OpReturnCode GetTimeout(
            out TimeRepresentation client_timeout);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.2.1.4 Operation `SetMessagePriority` specification

```
IDL: OpReturnCode SetMessagePriority(
          in UInteger8 message_priority);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.2.1.4.1 argument `message_priority` specification

The `message_priority` argument value shall be the `message_priority` for all client-server or publish-subscribe interactions emanating from the Port. The allowed values of `message_priority` shall be as defined in the enumeration shown in Table 97.

IDL: enumeration `MessagePriority;`

Table 97—`MessagePriority` enumeration

Enumeration	Value
MP_NORMAL	0
MP_EXPEDITE	1
Reserved	2–127
Open to industry	128–255

11.2.1.5 Operation `GetMessagePriority` specification

```
IDL: OpReturnCode GetMessagePriority(
          in UInteger8 message_priority);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.2.2 Base Port abstract class behavior

11.2.2.1 Specific Base Port operation restrictions based on state

In addition to and conformant with the restrictions of 11.1.2.2, the allowed operations defined on a Base Port shall be restricted as defined in Table 98. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 98—`IEEE1451_BasePort` class specific restrictions

Operation	Specified value of rule_basis		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
SetTimeout, SetMessagePriority	Local invocation only	Operational	Not operational
GetTimeout, GetMessagePriority	Local invocation only	Operational	Operational

11.2.2.2 Timeout behavior specification

Timeout behavior shall be subclass-specific with the following restrictions:

— The default value for `client_timeout` shall be 0

— A timeout value of 0 shall define a timeout that never expires

The operation `SetTimeout` may be an Interface Only Implementation if the underlying operating system does not support timeouts; otherwise, this operation shall have a Full Implementation.

With an Interface Only Implementation of `SetTimeout`, `GetTimeout` shall return the default value.

11.2.2.3 Message priority behavior specification

The `message_priority` shall define the urgency of message delivery requested of the underlying communication structure. The default value of `message_priority` shall be `MP_NORMAL`.

The operation `SetMessagePriority` may be an Interface Only Implementation if the underlying network infrastructure does not support delivery priority; otherwise, this operation shall have a Full Implementation.

With an Interface Only Implementation of `SetMessagePriority`, `GetMessagePriority` shall return the default value.

A `message_priority` of `MP_NORMAL` shall cause the network communication implementation to deliver messages from this Port without preference compared to other messages.

A `message_priority` of `MP_EXPEDITE` shall cause the network communication implementation to deliver messages from this Port with preference compared to normal priority messages.

11.3 Base Client Port abstract class

Abstract Class

Class: `IEEE1451_BaseClientPort`

Parent Class: `IEEE1451_BasePort`

Class ID: 1.1.3.1.1

Description: The Base Client Port abstract class shall be the root for the class hierarchy of all client-server communication client-side Port Objects.

Class summary:

Network Visible operations (see Table 99).

Table 99—`IEEE1451_BaseClientPort` Network Visible operations

Operation Name	Requirement	Operation ID
`SetServerObjectTag`	(m)	8216
`GetServerObjectTag`	(m)	8217

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

11.3.1 Operation specifications: Network Visible

11.3.1.1 Operation `SetServerObjectTag` specification

```
IDL: OpReturnCode SetServerObjectTag(
           in ObjectTag server_object_tag);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.3.1.1.1 argument `server_object_tag` specification

The `server_object_tag` argument value shall be the Object Tag associated with the remote Object, which is the intended target of an execute semantics operation on the Port.

11.3.1.2 Operation `GetServerObjectTag` specification

```
IDL: OpReturnCode GetServerObjectTag(
           out ObjectTag server_object_tag);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.3.2 Base Client Port abstract class behavior

11.3.2.1 Specific Base Client Port operation restrictions based on state

In addition to and conformant with the restrictions of 11.2.2.1, the allowed operations defined on a Base Client Port shall be restricted as defined in Table 100. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 100—`IEEE1451_BaseClientPort` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
`SetServerObjectTag`	Local invocation only	Operational	Not operational
`GetServerObjectTag`	Local invocation only	Operational	Operational

11.3.2.2 Communication behavior specification

The Port shall initiate an operation invocation request via the network infrastructure with the Server Object whose Object Dispatch Address has been provided based on the Server Object Tag of the Base Client Port. The Base Client Port's Server Object Tag shall be the Network Visible identifier that defines the target Object for client-server communications.

NOTE—NCAP Blocks provide a mechanism for identifying and providing to the Base Client Port, the Object Dispatch Address that corresponds to the Server Object Tag; see 9.2.5.6.

11.3.2.3 Block Cookie behavior specification

The network infrastructure, as part of the invocation of an operation on the server, shall be responsible for delivering the latest client-side received value for the server's Block Cookie. This value is termed the Client Cached Block Cookie. If a value is not available, the default Block Cookie value, NOT_SET (see 7.3.2.2) shall be delivered.

NOTE—This latter circumstance can occur if the Base Client Port is redirected to a different server and no value of the Block Cookie was provided as part of the redirection and no client-server call has yet been made.

The initial value of the target Server Object's Block Cookie may be provided to the Base Client Port's Local NCAP Block as part of the configuration process by means of the `SetClientPortServerObjectBindings` operation; see 9.2.5.6.

For each client-server interaction, the target Server Object returns the current value of its Associated Block Cookie to the client-side network infrastructure; see 8.2.3.2.

The initial value of the Client Cached Block Cookie shall be updated to the latest available value of the Server Object's Associated Block Cookie.

11.4 Client Port class

Class: `IEEE1451_ClientPort`

Parent Class: `IEEE1451_BaseClientPort`

Class ID: 1.1.3.1.1.1

Description: The Client Port class provides the client-side application interface to client-server communications. The class abstracts the details of the specific network. Two models of client-server communication are provided: blocking and "send and forget."

Class summary:

Local Operations (see Table 101).

Table 101—`IEEE1451_ClientPort` Local operations

Operation Name	Requirement
`Execute`	(m)

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

11.4.1 Operation specifications: Local

11.4.1.1 Local operation `Execute` specification

```
IDL: ClientServerReturnCode Execute(
             in UInteger8 execute_mode,
             in UInteger16 server_operation_id,
             in ArgumentArray server_input_arguments,
             out ArgumentArray server_output_arguments);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.4.1.1.1 argument `execute_mode` specification

The `execute_mode` argument value shall specify the return behavior of the clients call to `Execute`. The allowed values of `execute_mode` shall be as defined in the enumeration shown in Table 102.

IDL: enumeration `ExecuteMode;`

Table 102—`ExecuteMode` enumeration

Enumeration	Value
`EM_RETURN_VALUE`	0
`EM_NO_RETURN_VALUE`	1
Reserved	2–255

11.4.1.1.2 argument `server_operation_id` specification

The `server_operation_id` argument value is the Operation ID of the operation to be invoked on the Server Object.

11.4.1.1.3 argument `server_input_arguments` specification

The `server_input_arguments` argument value shall be the input arguments of the server operation, corresponding to the argument `server_operation_id`, encoded into an Argument Array.

11.4.1.1.4 argument `server_output_arguments` specification

This `server_output_arguments` argument value shall be a reference to an Argument Array into which the output arguments of the server operation, corresponding to the argument `server_operation_id`, shall be encoded.

11.4.2 Client Port class behavior

11.4.2.1 Specific Client Port operation restrictions based on state

In addition to and conformant with the restrictions of 11.3.2.1, the allowed operations defined on a Client Port shall be restricted as defined in Table 103. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 103—`IEEE1451_ClientPort` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
`Execute`	Not operational	Operational	Operational

11.4.2.2 Operation `Execute` behavior specification

The blocking behavior of the `Execute` call shall depend on the following possible values of `execute_mode`:

— `EM_RETURN_VALUE`

— `EM_NO_RETURN_VALUE`

11.4.2.2.1 Behavior specification in the `EM_RETURN_VALUE` state

The client shall be blocked, that is, execution of client code does not proceed, until the returned information has been delivered to the client, that is, the `Execute` call returns, or the `client_timeout` value for the Port has been exceeded

The Client Cached Block Cookie value shall be updated; see 11.3.2.3.

After the expiration of the client's timeout mechanism, any information returned to the client-side network infrastructure as a consequence of the `Execute` call shall be discarded. In this case, the Client Cached Block Cookie value shall remain unchanged.

11.4.2.2.2 Behavior specification in the `EM_NO_RETURN_VALUE` state

The client shall not be blocked; that is, the `Execute` call returns as soon as the operation request message is sent by the client-side network infrastructure.

Any information returned to the client-side network infrastructure as a consequence of the `Execute` call shall be discarded.

The Client Cached Block Cookie value shall remain unchanged.

11.4.2.3 Behavior of the `ClientServerReturnCode` for the `Execute` operations

`Execute` returns a `ClientServerReturnCode` to the client. The elements of the `ClientServerReturnCode`, see 7.2.3.1.2, shall be assigned values as follows.

If `execute_mode` is `EM_RETURN_VALUE,` the following values shall be used:

— `portCode`: This field shall be assigned a value from the `MajorReturnCode` enumeration subject to the restrictions of 7.2.3.3.1.

— `performCode`: This field shall be assigned the `performCode` field value of the `ClientServerReturnCode` returned by Server Object's `Perform`, or a value from the `MajorReturnCode` enumeration subject to the restrictions of 7.2.3.3.2.

— `operationMinorCode`: This field shall be assigned the `operationMinorCode` field value of the `ClientServerReturnCode` returned by `Perform.`

— `operationMajorCode`: This field shall be assigned the `operationMajorCode` field value of the `ClientServerReturnCode` returned by `Perform.`

If no return is received by the Client Port from `Perform` before the expiration of the Client Port timeout

— `portCode`: This field shall be assigned the `MajorReturnCode` enumeration value `MJ_OPERATION_TIMEOUT.`

— performCode and operationMajorCode: These fields shall be assigned the MajorReturnCode enumeration value MJ_NO_RETURN_CODE.

— operationMinorCode: This field shall be assigned the MinorReturnCode enumeration value MI_NO_ADDITIONAL_INFORMATION.

If execute_mode is EM_NO_RETURN_VALUE, the portCode, performCode, and operationMajorCode fields shall be assigned the value MJ_COMPLETE, and the operationMinorCode field shall be assigned the value MI_NO_ADDITIONAL_INFORMATION unless an error is detected in which case the appropriate error code shall be assigned.

11.4.2.4 Operation Execute behavior specification

The Execute operation is the client-side construct for producing network independence in a client-server communication model as illustrated in Figure 8. For details of server-side behavior, Steps 5, 6, 7, 8, 9, and 10 of the figure; see 8.2.3.2.

11.4.2.5 Client-server model: client-side Execute behavior specification

In the following the step numbers refer to the steps in Figure 8.

The behavioral steps of this clause shall be implemented consistent with the memory management specifications of Clause 15. Encoding and decoding shall follow the rules of Clause 14.

Step 1:

The client shall encode the local variables representing the input arguments of the target server operation into an Argument Array. These encoded arguments are the server_input_arguments argument of the Client Port's Execute operation.

The client shall be responsible for providing in the Execute call

— The execute_mode argument.

— The server_operation_id argument specifying the Operation ID of the target operation on the server.

— The server_input_arguments argument.

— A reference to a local Argument Array, server_output_arguments. This Array will contain the encoded output arguments from the server operation on the return from the Execute call.

Step 2:

The client invokes the Execute operation on a local Client Port that has been configured to communicate with the desired target Server Object.

Step 3:

The Client Port's Execute operation shall provide to the client-side network infrastructure

— The argument server_operation_id.

— The server_input_arguments Argument Array.

— The target Server Object's Object Dispatch Address. This address was provided to the Client Port during system configuration and is the value of the Port's Client Port Properties `serverDispatchAddress` member.

— Depending on the IEEE 1451.1 implementation, the Client Cached Block Cookie; see Step 4 below.

If `execute_mode` is `EM_RETURN_VALUE`, the `Execute` operation shall

— Start the call timeout mechanism.

— Block awaiting the return from the client-side network infrastructure. If the timeout expires before Step 12 is reached, the `Execute` operation shall return to the calling client with return code as specified in 11.4.2.3. In this case it is recommended that the output Argument Array returned be bound to a zero length Array.

If `execute_mode` is `EM_NO_RETURN_VALUE`, the `Execute` operation shall return immediately to the calling client with return code as specified in 11.4.2.3. In this case, it is recommended that the output Argument Array returned be bound to a zero length Array.

Step 4:

The client-side network infrastructure shall

— Marshal the arguments `server_operation_id`, `server_input_arguments`, and the Client Cached Block Cookie into their network-specific, on-the-wire formats. Depending on the IEEE 1451.1 implementation, the Client Cached Block Cookie may be provided either by the client-side network infrastructure or by the Client Port.

— Cause the delivery of a network message containing the marshaled data to the server-side network infrastructure.

Step 11:

If `execute_mode` was `EM_RETURN_VALUE` and the `Execute` operation has not timed out, the network infrastructure on the client-side shall demarshal the data in the return network message sent by the server-side, network infrastructure. This data includes

— The server operation's output arguments encoded into an Argument Array

— The server-side `ClientServerReturnCode`

— The current value of the target Server Object's Block Cookie; see 8.2.3.2

Depending on the IEEE 1451.1 implementation, the client-side network infrastructure shall either cache the returned Block Cookie or it shall provide the returned Block Cookie to the Client Port for caching; see Step 4 above.

The client-side network infrastructure shall provide the demarshaled, but encoded, server operation's output arguments and the server-side `ClientServerReturnCode` to the Client Port and unblock the blocked `Execute` operation.

If `execute_mode` was `EM_NO_RETURN_VALUE`, or the `Execute` operation has timed out, the clientside network infrastructure shall discard the returned message.

Step 12:

In the case that the `execute_mode` was `EM_RETURN_VALUE` and the `Execute` operation has not timed out, on resumption of execution the Client Port `Execute` operation shall

- Depending on the IEEE 1451.1 implementation, cache the returned Block Cookie; see Step 11 above
- Bind the server operation's encoded output arguments to the client-supplied Argument Array referenced by `server_output_arguments`
- Augment the server-side `ClientServerReturnCode` with the appropriate `portCode` field
- Return to the client

Step 13:

The client decodes `server_output_arguments` into local variables corresponding to the output arguments of the target server operation.

NOTE—See Annex B for a detailed example of a complete client-server interaction.

11.5 Asynchronous Client Port class

Class: `IEEE1451_AsynchronousClientPort`

Parent Class: `IEEE1451_BaseClientPort`

Class ID: 1.1.3.1.1.2

Description: The Asynchronous Client Port class provides client-side functionality for an asynchronous, nonblocking, client-server communication model.

Class summary:

Local operations (see Table 104).

Table 104—`IEEE1451_AsynchronousClientPort` Local operations

Operation Name	Requirement
`ExecuteAsynchronous`	(m)
`GetAsynchronousClientResultStatus`	(m)
`GetResult`	(m)
`AbortTransaction`	(m)
`ForceAcquireTransaction`	(m)

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

11.5.1 Operation specifications: Local

11.5.1.1 Local operation `ExecuteAsynchronous` specification

```
IDL: OpReturnCode ExecuteAsynchronous(
           in UInteger16 server_operation_id,
           in ArgumentArray server_input_arguments,
           out UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.5.1.1.1 argument `server_operation_id` specification

The `server_operation_id` argument value shall be the Operation ID of the operation to be invoked on the Server Object.

11.5.1.2 argument `server_input_arguments` specification

The `server_input_arguments` argument value shall be the input arguments specified by the server operation's signature, corresponding to the argument `server_operation_id` encoded into an Argument Array.

11.5.1.3 argument `transaction_id` specification

The `transaction_id` argument value shall identify this instance of the invocation of `ExecuteAsynchronous` on the Port. The scope of this identification argument is this Port.

11.5.1.4 Local operation `GetAsynchronousClientResultStatus` specification

```
IDL: OpReturnCode GetAsynchronousClientResultStatus(
           in UInteger16 transaction_id,
           out UInteger8 result_status);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.5.1.4.1 argument `transaction_id` specification

The `transaction_id` argument value shall identify the transaction for which status is requested.

11.5.1.4.2 argument `result_status` specification

The `result_status` argument value shall reflect status corresponding to the `transaction_id` argument. This status indicates the availability of the results expected from the server. The allowed values of `result_status` shall be selected from the enumeration shown in Table 105.

IDL: enumeration `AsynchronousClientResultStatus;`

11.5.1.5 Local operation `GetResult` specification

```
IDL: ClientServerReturnCode GetResult(
           in UInteger16 transaction_id,
           out ArgumentArray server_output_arguments);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

Table 105—`AsynchronousClientResultStatus` enumeration

Enumeration	Value	Meaning
`RS_TRANSACTION_COMPLETE`	0	The invocation of the `GetResult` operation will return without blocking (may occur when the Port is in the PORT ERROR or RESULTS AVAILABLE states).
`RS_TRANSACTION_PENDING`	1	The invocation of the `GetResult` will cause `GetResult` to block (may occur when the Port is in the PENDING state).
Reserved	2–255	

11.5.1.5.1 argument `server_output_arguments` specification

This `server_output_arguments` argument value shall be the output arguments specified by the signature of the server operation (corresponding to the `server_operation_id`), encoded into an Argument Array.

11.5.1.6 Local operation `AbortTransaction` specification

```
IDL: OpReturnCode AbortTransaction(
           in UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.5.1.7 Local operation `ForceAcquireTransaction` specification

```
IDL: OpReturnCode ForceAcquireTransaction(
           out UInteger16 new_transaction_id,
           out UInteger16 current_server_operation_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.5.1.7.1 argument `new_transaction_id` specification

The `new_transaction_id` argument value shall identify a new value for the `transaction_id` of the Port.

11.5.1.7.2 argument `current_server_operation_id` specification

The `current_server_operation_id` argument value shall be the Operation ID of the operation invoked on the Server Object during the transaction pre-empted by the invocation of this operation.

11.5.2 Asynchronous Client Port class behavior

11.5.2.1 Specific Asynchronous Client Port operation restrictions based on state

In addition to and conformant with the restrictions of 11.3.2.1, the allowed operations defined on an Asynchronous Client Port shall be restricted as defined in Table 106. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 106—`AsynchronousClientPort` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
All operations defined by this class except those in the following row	Local invocation only	Operational	Operational
`ExecuteAsynchronous`	Not operational	Operational	Operational

11.5.2.2 Concurrency behavior specification

The `AbortTransaction` and `ForceAcquireTransaction` operations shall support Precedence Concurrency.

The `GetResult` and `GetAsynchronousClientResultStatus` operations shall support Active Concurrency.

11.5.2.3 State behavior specification

The state behavior of the Asynchronous Client Port shall be as shown in Figure 26.

11.5.2.4 Transaction behavior specification

A valid `transaction_id` shall be marked as NO_TRANSACTION when any of the following occur (see also 11.5.2.7 and 11.5.2.9):

— `GetResult` returns to the client

— Successful invocation of `AbortTransaction`

The NO_TRANSACTION value shall be 0.

Two transaction IDs match if, and only if

— They have the same value **AND**

— Neither is the NO_TRANSACTION value

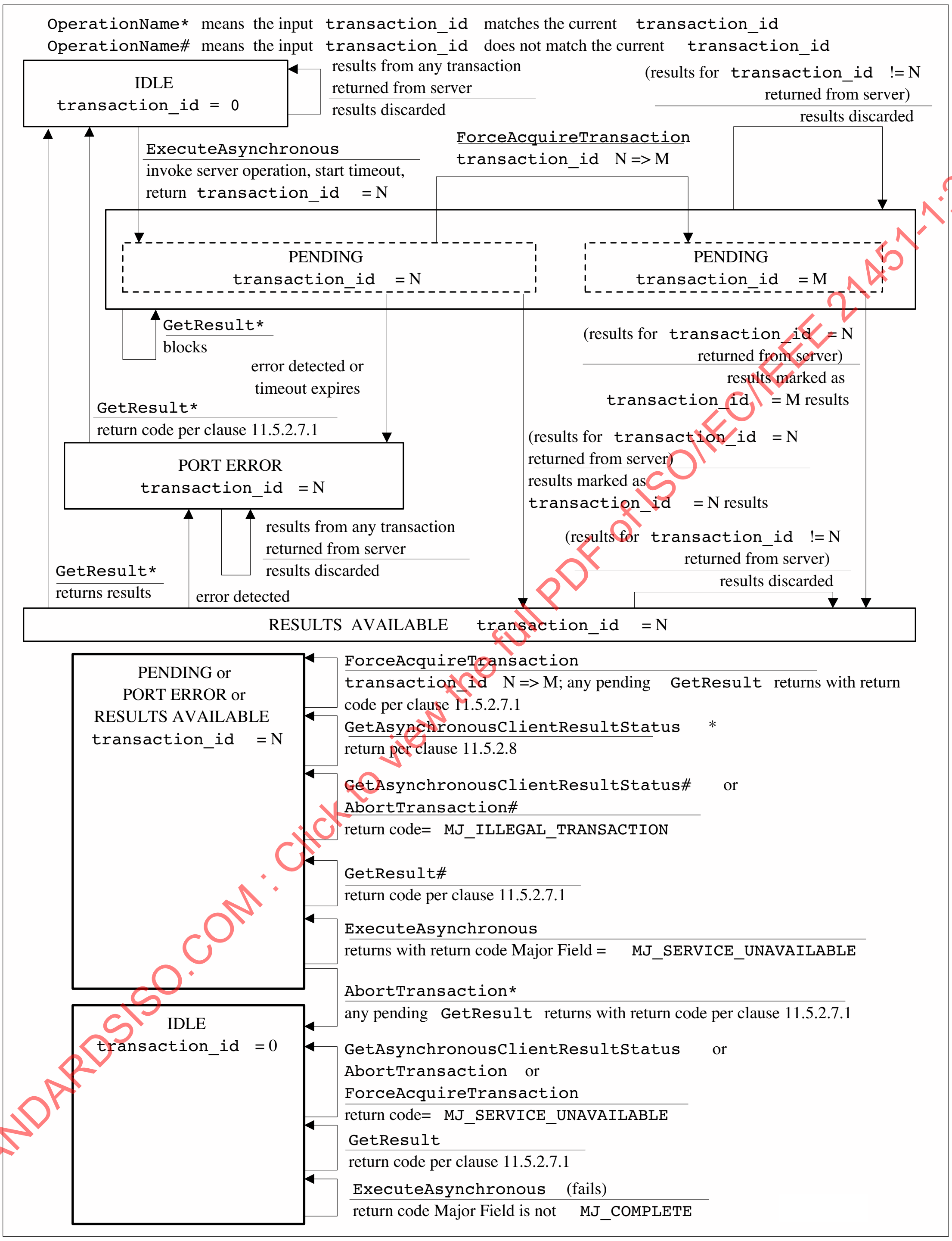
11.5.2.5 Operations `ExecuteAsynchronous` behavior specification

The `ExecuteAsynchronous` operation is the client-side construct for producing network independence in a client-server, asynchronous communication model as illustrated in Figure 27. The details of server-side behavior, Steps 5, 6, 7, 8, 9, and 10 on the right side of the figure are identical to those specified for the corresponding Steps in 8.2.3.2.

11.5.2.6 Client-server model: client-side `ExecuteAsynchronous` behavior specification

In the following the step numbers refer to the steps in Figure 27.

The behavioral steps of this clause shall be implemented consistently with the memory management specifications of Clause 15. Encoding and decoding shall follow the rules of Clause 14.



OperationName* means the input transaction_id matches the current transaction_id
OperationName# means the input transaction_id does not match the current transaction_id
IDLE transaction_id = 0
results from any transaction returned from server
results discarded
(results for transaction_id != N returned from server)
results discarded
ExecuteAsynchronous
invoke server operation, start timeout, return transaction_id = N
ForceAcquireTransaction
transaction_id N => M
PENDING transaction_id = N
PENDING transaction_id = M
GetResult*
blocks
error detected or timeout expires
GetResult*
return code per clause 11.5.2.7.1
(results for transaction_id = N returned from server)
results marked as transaction_id = M results
(results for transaction_id = N returned from server)
results marked as transaction_id = N results
PORT ERROR transaction_id = N
results from any transaction returned from server
results discarded
(results for transaction_id != N returned from server)
results discarded
GetResult*
returns results
error detected
RESULTS AVAILABLE transaction_id = N
PENDING or PORT ERROR or RESULTS AVAILABLE transaction_id = N
ForceAcquireTransaction
transaction_id N => M; any pending GetResult returns with return code per clause 11.5.2.7.1
GetAsynchronousClientResultStatus *
return per clause 11.5.2.8
GetAsynchronousClientResultStatus# or AbortTransaction#
return code= MJ_ILLEGAL_TRANSACTION
GetResult#
return code per clause 11.5.2.7.1
ExecuteAsynchronous
returns with return code Major Field = MJ_SERVICE_UNAVAILABLE
AbortTransaction*
any pending GetResult returns with return code per clause 11.5.2.7.1
IDLE transaction_id = 0
GetAsynchronousClientResultStatus or AbortTransaction or ForceAcquireTransaction
return code= MJ_SERVICE_UNAVAILABLE
GetResult
return code per clause 11.5.2.7.1
ExecuteAsynchronous (fails)
return code Major Field is not MJ_COMPLETE

Figure 26—State machine for an Asynchronous Client Port

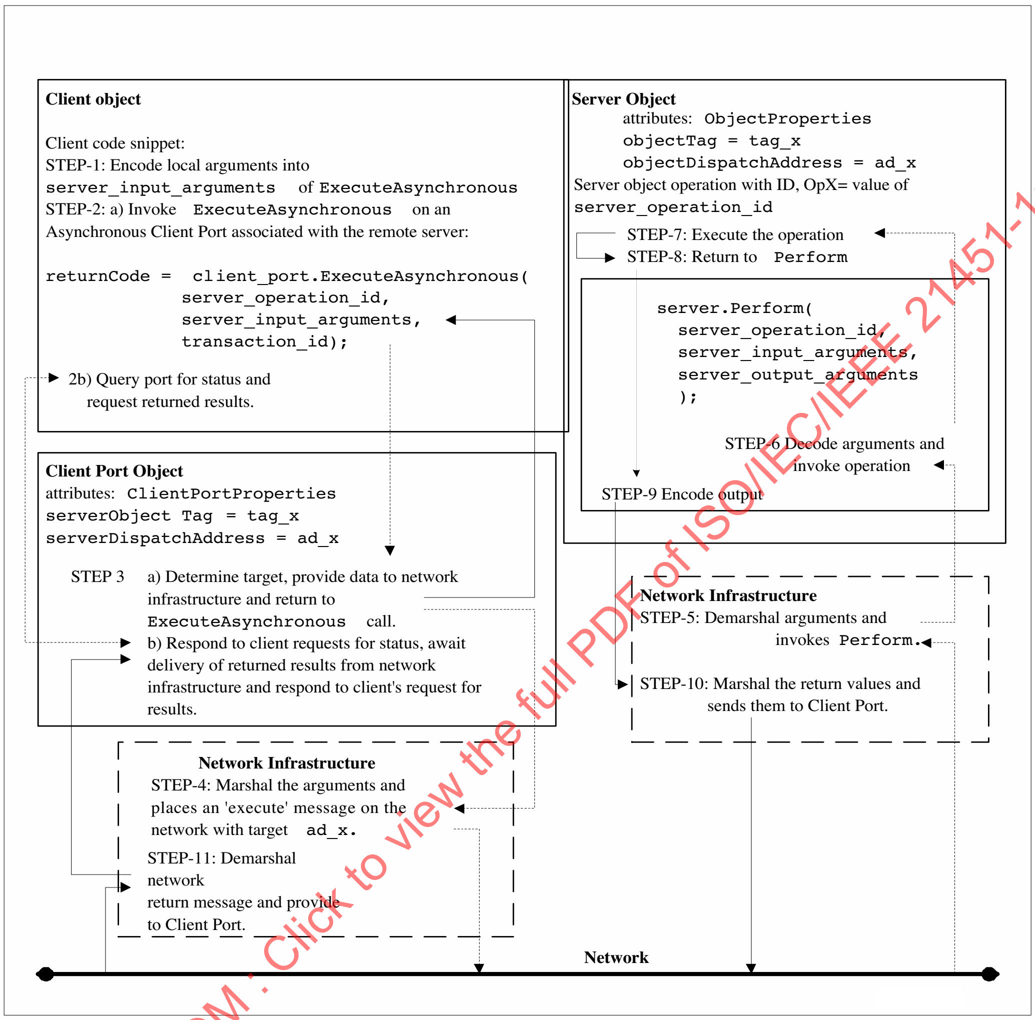

Client object
Client code snippet:
STEP-1: Encode local arguments into server_input_arguments of ExecuteAsynchronous
STEP-2: a) Invoke ExecuteAsynchronous on an Asynchronous Client Port associated with the remote server:
returnCode = client_port.ExecuteAsynchronous(server_operation_id, server_input_arguments, transaction_id);
2b) Query port for status and request returned results.
Client Port Object
attributes: ClientPortProperties
serverObject Tag = tag_x
serverDispatchAddress = ad_x
STEP 3 a) Determine target, provide data to network infrastructure and return to ExecuteAsynchronous call.
b) Respond to client requests for status, await delivery of returned results from network infrastructure and respond to client's request for results.
Network Infrastructure
STEP-4: Marshal the arguments and places an 'execute' message on the network with target ad_x.
STEP-11: Demarshal network return message and provide to Client Port.
Server Object
attributes: ObjectProperties
objectTag = tag_x
objectDispatchAddress = ad_x
Server object operation with ID, OpX= value of server_operation_id
STEP-7: Execute the operation
STEP-8: Return to Perform
server.Perform(server_operation_id, server_input_arguments, server_output_arguments);
STEP-6 Decode arguments and invoke operation
STEP-9 Encode output
Network Infrastructure
STEP-5: Demarshal arguments and invokes Perform.
STEP-10: Marshal the return values and sends them to Client Port.
Network

Figure 27—Asynchronous client-server communication model

Step 1:

The client shall encode the local variables representing the input arguments of the target remote server operation into an Argument Array. These encoded arguments are the `server_input_arguments` argument of the Asynchronous Client Port's `ExecuteAsynchronous` operation.

The client shall be responsible for providing in the `ExecuteAsynchronous` call

— The `server_operation_id` argument specifying the Operation ID of the target operation on the server

— The `server_input_arguments` argument

— A reference to a local variable representing the `transaction_id` argument

Step 2:

— The client invokes the ExecuteAsynchronous operation on a local Asynchronous Client Port that has been configured to communicate with the desired target Server Object. This call shall return as soon as the Port initiates an asynchronous client-server transaction.

— The client then proceeds with other activities. These activities may include invoking the `GetResult` or `AbortTransaction` operations on the Asynchronous Client Port.

Step 3:

a) The Asynchronous Client Port's `ExecuteAsynchronous` operation shall

  — Provide to the client-side network infrastructure

    — The argument `server_operation_id.`

    — The `server_input_arguments` Argument Array.

    — The target Server Object's Object Dispatch Address. This address was provided to the Asynchronous Client Port during system configuration and is the target Server Object's Object Dispatch Address.

    — Depending on the IEEE 1451.1 implementation, the Client Cached Block Cookie; see Step 4 below.

  — Request that the client-side network infrastructure deliver a network message requesting the remote service to the server-side network infrastructure.

  — Start the transaction timeout mechanism.

  — Return to the client with a valid `transaction_id` and an appropriate `OpReturnCode.`

b) The Asynchronous Client Port shall then go into a mode where it can

  — Respond to client requests for the completion status of the server operation

  — Respond to a client request for the returned results of the remote operation

  — Respond to a client request to abort the transaction

  — Respond to a local, third-party request to force acquire the transaction

  — Monitor the transaction timeout mechanism

  — Accept the returned remote operation's results from the client-side network infrastructure.

If a request that the transaction be aborted comes from a client that holds a valid `transaction_id`, then the Asynchronous Client Port shall invalidate the current `transaction_id` and return the appropriate `OpReturnCode` to the caller. In this case, the asynchronous client-server transaction is completed.

If a local third-party object invokes a `ForceAcquireTransaction` on the Port, the Port shall invalidate its current `transaction_id` and provide the caller with a new, valid `transaction_id`. In this case, the caller becomes the new client for the ongoing transaction.

If the client-side network infrastructure provides the Port with the remote operation's results and the transaction has timed out or the transaction has been aborted, then the Port shall discard the returned results. Otherwise, the Asynchronous Client Port shall augment the server-side `ClientServerReturnCode` with the appropriate `portCode` field.

If the client holds a valid `transaction_id` and requests the operation's results

— If the remote operation's results have been returned to the Asynchronous Client Port, then the Port shall supply the encoded results to the calling client and the asynchronous client-server transaction is completed.

— If the server operation's results have not been returned to the Port and the transaction has not timed out or been aborted, then the request results call shall block, awaiting either the return of the results, a transaction timeout, the aborting of the transaction, or the force acquire of the transaction.

Step 4:

The client-side network infrastructure shall

— Marshal the arguments `server_operation_id` and `server_input_arguments` and the Client Cached Block Cookie into their network-specific, on-the-wire formats. Depending on the IEEE 1451.1 implementation, the Client Cached Block Cookie may be provided either by the clientside network infrastructure or by the Asynchronous Client Port.

— Cause the delivery of a network message containing the marshaled data to the server-side network infrastructure.

Step 11:

The client-side network infrastructure shall demarshal the data in the return network message sent by the server-side network infrastructure. This data includes

— The server operation's output arguments encoded into an Argument Array

— The server-side `ClientServerReturnCode`

— The current value of the target Server Object's Block Cookie

Depending on the IEEE 1451.1 implementation, the client-side network infrastructure shall either cache the returned Block Cookie or it shall provide the returned Block Cookie to the Asynchronous Client Port for caching; see Step 4 above.

The network infrastructure shall provide the demarshaled, but encoded, server operation's output arguments and the server-side `ClientServerReturnCode` to the Asynchronous Client Port.

It is possible that a result from a prior transaction will be received during the execution of a new transaction. Implementers shall ensure that the results of the prior transaction are disregarded. The mechanism for enforcing this behavior is outside the scope of this standard.

NOTE—This circumstance might appear as the result of the following sequence of events: invocation of `ExecuteAsynchronous` (with transaction_id 2); `timeout`, `AbortTransaction`; invocation of `ExecuteAsynchronous` (with transaction_id 3), return of results from transaction_id 2.

11.5.2.7 Operation `GetResult` behavior specification

The behavior of this operation shall depend on the Port status.

When `GetResult` returns, the Port `transaction_id` shall be marked as NO_TRANSACTION and the internal Asynchronous Client Port state corresponding to the transaction shall be released.

If subsequent to an invocation of ExecuteAsynchronous that returns transaction_id = N, a ForceAcquireTransaction successfully completes and returns a new_transaction_id = M, an invocation of GetResult with a transaction_id of M shall

— Follow the rules of the state machine of Figure 26.

— Return the server results corresponding to transaction_id = N if they become available

If GetResult returns as a consequence of a successful completion of the AbortTransaction operation, the server_output_arguments shall be bound to a zero length Argument Array.

11.5.2.7.1 Behavior specification of the ClientServerReturnCode for the operation GetResult

GetResult returns a ClientServerReturnCode to the client. The elements of the ClientServerReturnCode, see 7.2.3.1.2, shall be assigned the following values, except when the return is a result of an AbortTransaction or ForceAcquireTransaction operation

— portCode: This field shall be assigned a value from the MajorReturnCode enumeration subject to the restrictions of 7.2.3.3.1 and Table 107.

— performCode: This field shall be assigned the performCode field value of the ClientServerReturnCode returned to the Port by Perform or a value from the MajorReturnCode enumeration subject to the restrictions of 7.2.3.3.2 and Table 107.

— operationMajorCode and operationMinorCode fields shall be assigned values as indicated in Table 107.

Table 107—GetResult return codes

Port state details	portCode	operationMajorCode
	(performCode)	(operationMinorCode)
RESULTS AVAILABLE server results available	MJ_COMPLETE	As returned from server
	(As returned from server)	(As returned from server)
PORT ERROR Asynchronous Client Port timeout	MJ_OPERATION_TIMEOUT	MJ_NO_RETURN_CODE
	(MJ_NO_RETURN_CODE)	(MI_NO_ADDITIONAL_INFORMATION)
PENDING	N/A	N/A
	(N/A)	(N/A)
PORT ERROR not due to timeout	MJ_FAILED_NON_SPECIFIC Unless more appropriate information is available	As returned from server or if no return MJ_NO_RETURN_CODE
	(As returned from server or if no return; MJ_NO_RETURN_CODE)	(MI_NO_ADDITIONAL_INFORMATION)
IDLE	MJ_SERVICE_UNAVAILABLE	MJ_NO_RETURN_CODE
	(MJ_NO_RETURN_CODE)	(MI_NO_ADDITIONAL_INFORMATION)
Call in any non-IDLE state with illegal transaction	MJ_ILLEGAL_TRANSACTION	MJ_NO_RETURN_CODE
	(MJ_NO_RETURN_CODE)	(MI_NO_ADDITIONAL_INFORMATION)

When the return of GetResult is the result of an AbortTransaction or a ForceAcquireTransaction operation, the ClientServerReturnCode fields shall be assigned as follows:

— portCode: MJ_OPERATION_INTERRUPTED
— performCode: MJ_NO_RETURN_CODE
— operationMajorCode: MJ_NO_RETURN_CODE
— operationMinorCode: MI_NO_ADDITIONAL_INFORMATION

11.5.2.8 Operation GetAsynchronousClientResultStatus behavior specification

The allowed values for the result_status argument returned by GetAsynchronousClientResultStatus behavior shall be restricted based on the state of the Asynchronous Client Port, see 11.5.2.3, as indicated in Table 108.

Table 108—result_status restrictions

Enumeration	States	Meaning
RS_TRANSACTION_COMPLETE	RESULTS AVAILABLE	The Asynchronous Client Port has received the output arguments of the remote operation. These arguments may be retrieved by using the GetResult operation.
RS_TRANSACTION_COMPLETE	PORT ERROR	The Port is in an error state. The returned results are meaningless.
RS_TRANSACTION_PENDING	PENDING	The Asynchronous Client Port has not received the output arguments of the remote operation. Invocation of GetResult will cause GetResult to block.
RS_TRANSACTION_PENDING	Any non-IDLE state when the call has an invalid transaction_id	The Major Field of the OpReturnCode shall be MJ_ILLEGAL_TRANSACTION.
RS_TRANSACTION_PENDING	IDLE	The Major Field of the OpReturnCode shall be MJ_SERVICE_UNAVAILABLE.

11.5.2.9 Operation AbortTransaction behavior specification

The successful AbortTransaction operation shall cause any returns from the remote server operation to be discarded. The Port transaction_id shall be marked as NO_TRANSACTION and the corresponding transaction-state of the Asynchronous Client Port shall be released.

The AbortTransaction operation acts only on the Port. Any effect on the server shall be subclass implementation–dependent and outside the scope of this standard.

The return code Major Field values for an invocation AbortTransaction operation shall be as defined in Table 109.

Table 109—AbortTransaction Major Field restrictions

States	Major Field
RESULTS AVAILABLE	MJ_COMPLETE
PENDING PORT ERROR	MJ_COMPLETE
Any non-IDLE state when the call has an invalid transaction_id	MJ_ILLEGAL_TRANSACTION
IDLE	MJ_SERVICE_UNAVAILABLE

11.5.2.10 Operation `ForceAcquireTransaction` behavior specification

The `ForceAcquireTransaction` operation shall cause the current `transaction_id` to be replaced by a new value that is returned to the caller. Any server results returned as the result of the immediately preceding invocation of `ExecuteAsynchronous` shall be treated as if invoked under the new `transaction_id`. Any pending `GetResult` operations shall return as specified in 11.5.2.7.1.

This operation shall have no result if invoked in the IDLE state.

The return code Major Field values for an invocation `ForceAcquireTransaction` operation shall be as defined in Table 110.

Table 110—`ForceAcquireTransaction` Major Field restrictions

States	Major Field
RESULTS AVAILABLE PENDING PORT ERROR	`MJ_COMPLETE`
IDLE	`MJ_SERVICE_UNAVAILABLE`

NOTE—See Annex B for a detailed example of a complete client-server interaction.

11.6 Base Publisher Port abstract class

Abstract Class

Class: `IEEE1451_BasePublisherPort`

Parent Class: `IEEE1451_BasePort`

Class ID: 1.1.3.1.2

Description: The Base Publisher Port class provides basic publisher-side functionality for its subclasses.

Class summary:

Network Visible operations (see Table 111).

Table 111—`IEEE1451_BasePublisherPort` Network Visible operations

Operation Name	Requirement	Operation ID
`SetPublicationTopic`	(o)	8218
`GetPublicationTopic`	(o)	8219
`GetPublicationKey`	(m)	8220
`SetPublicationDomain`	(m)	8221
`GetPublicationDomain`	(m)	8222

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

11.6.1 Operation specifications: Network Visible

11.6.1.1 Operation `SetPublicationTopic` specification

```
IDL: OpReturnCode SetPublicationTopic(
           in PublicationTopic publication_topic);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.6.1.1.1 argument `publication_topic` specification

The `publication_topic` argument value shall be the current value of the Publication Topic for the Port. Publication Topic is a semantic identifier associated with the publication. The properties and allowed values for Publication Topic shall be as specified in 12.3.2 and 12.3.4.

11.6.1.2 Operation `GetPublicationTopic` specification

```
IDL: OpReturnCode GetPublicationTopic(
           out PublicationTopic publication_topic);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.6.1.3 Operation `GetPublicationKey` specification

```
IDL: OpReturnCode GetPublicationKey(
           out UInteger8 publication_key);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.6.1.3.1 argument `publication_key` specification

The `publication_key` argument value shall be the current value of the Publication Key. The properties and allowed values for Publication Keys shall be as specified in 12.3.2 and 12.3.3.

11.6.1.4 Operation `SetPublicationDomain` specification

```
IDL: OpReturnCode SetPublicationDomain(
           in PubSubDomain publication_domain);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.6.1.4.1 argument `publication_domain` specification

The `publication_domain` argument value shall be the current Publication Domain of the publication. Publication Domains define the scope of the publication's distribution. The properties and allowed values for Publication Domains shall be as specified in 12.3.5.

11.6.1.5 Operation `GetPublicationDomain` specification

```
IDL: OpReturnCode GetPublicationDomain(
           out PubSubDomain publication_domain);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.6.2 Operation specifications: Local

11.6.2.1 Local publishing operations

Any local publishing operations are subclass specific. Any such publishing operations shall return an `OpReturnCode` Minor Field value taken from the enumeration shown in Table 112 and the restriction following:

IDL: enumeration `PublicationContentsReturn;`

Table 112—**`PublicationContentsReturn`** enumeration

Enumeration	Value	Meaning
`PC_NO_ADDITIONAL_INFORMATION`	0	See restriction
`PC_MEMORY_ALLOCATION_ERROR`	1	See restriction
`PC_MISSING_INPUT`	2	See restriction
`PC_INVALID_TYPE`	3	See restriction
`PC_INVALID_VALUE`	4	See restriction
`PC_COMPUTATION_ERROR`	5	See restriction
`PC_EMPTY_DOMAIN`	6	The Domain is empty.
`PC_KEY_NOT_SET`	7	The Publication Key has not been set.
`PC_TOPIC_NOT_SET`	8	The Publication Topic has not been set and the Publication Key is not terminal.
`PC_TOPIC_KEY_CONFLICT`	9	The Publication Topic has been set and the Publication Key is terminal.
`PC_ILLEGAL_KEY`	10	The Publication Key is illegal for the type of Port or for the specific publication operation invoked.
`PC_ILLEGAL_STATE`	11	The Port has detected an illegal internal state.
Reserved	12–255	

Restriction—The meaning of the first six members of the enumerations shall be identical to the meaning of the first six members of the `MinorReturnCode` enumeration; see 7.2.3.2.1.

11.6.3 Publisher Port attributes

Publication Key: Except where otherwise noted, the management of Publication Key values is outside the scope of this standard. The mechanism of setting the Publication Key is outside of this standard.

Publication Topic: Defined by the system configuration.

Publication Domain: Defined by the system configuration.

Publication Contents: The syntax of the Publication Contents is Publication Key specific. The semantics of Publication Contents is Publisher specific.

Publisher Port: Object Name; see 8.2.3.6.

11.6.4 Base Publisher Port class behavior

11.6.4.1 Specific Base Publisher Port operation restrictions based on state

In addition to and conformant with the restrictions of 11.2.2.1, the allowed operations defined on a Base Publisher Port shall be restricted as defined in Table 113. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 113—`IEEE1451_BasePublisherPort` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	**BL_INACTIVE**	**BL_ACTIVE**
`SetPublicationTopic`, `SetPublicationDomain`	Local invocation only	Operational	Not operational
`GetPublicationTopic`, `GetPublicationKey`, `GetPublicationDomain`	Local invocation only	Operational	Operational

11.6.4.2 Operations `SetPublicationTopic` and `GetPublicationTopic` behavior specification

`SetPublicationTopic` and `GetPublicationTopic` shall both have a Full Implementation for all Port Objects whose Publication Key value indicates that the Publication Key is not terminal; see 12.3.2.

`SetPublicationTopic` and `GetPublicationTopic` may both have an Interface Only Implementation if a Port Object's Publication Key value indicates that the Publication Key is terminal; see 12.3.2.

Restrictions on Publication Topics based on whether the Publication Key is or is not terminal are found in 12.3.4.

11.7 Publisher Port class

Class: `IEEE1451_PublisherPort`

Parent Class: `IEEE1451_BasePublisherPort`

Class ID: 1.1.3.1.2.1

Description: The Publisher Port class provides publisher-side functionality for a publish-subscribe communication model.

Class summary:

Local operations (see Table 114).

Table 114—`IEEE1451_PublisherPort` Local operations

Operation Name	Requirement
`Publish`	(m)

Publications: Publications may be defined for this class.

Subscriptions: There are no subscriptions defined for this class.

11.7.1 Operation specifications: Local

11.7.1.1 Local operation `Publish` specification

```
IDL: OpReturnCode Publish(
           in ArgumentArray publication_contents);
```

The Minor Field values of `OpReturnCode` shall be taken from the `PublicationContentsReturn` enumeration.

11.7.1.1.1 argument `publication_contents` specification

The `publication_contents` argument value shall be the Publisher-provided information to be included in the Publication Contents of the publication.

11.7.2 Publisher Port class behavior

11.7.2.1 Specific Publisher Port operation restrictions based on state

In addition to and conformant with the restrictions of 11.6.4.1, the allowed operations defined on a Publisher Port instance shall be restricted as defined in Table 115. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 115—`IEEE1451_PublisherPort` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
`Publish`	Not operational	Operational	Operational

11.7.2.2 Publication restrictions

Publishers may use a Port of this class for Publication Key values that define publications for which information about the Publisher may not be requested by Subscribers. The allowed values of Publication Key for which this Port shall be used are specified in 12.3.3 as Class A key values. For these Publication Key values

- — The publication shall be published under the terms of 12.2, if and only if the Publication Key is a member of Class A.
- — If the Publication Key is not a member of Class A, the `Publish` operation shall return with a `MajorReturnCode` value of `MJ_SERVICE_UNAVAILABLE` and a `MinorReturnCode` value of `PC_ILLEGAL_KEY`.

11.7.2.3 Publication behavior specification

The Publisher shall be responsible for encoding local Publisher variables into the `publication_contents` Argument Array of the `Publish` operation.

11.8 Self Identifying Publisher Port class

Class: `IEEE1451_SelfIdentifyingPublisherPort`

Parent Class: `IEEE1451_BasePublisherPort`

Class ID: 1.1.3.1.2.2

Description: The Self Identifying Publisher Port class provides publisher-side functionality for a publish-subscribe communication model with operations to allow the subscriber to establish communication with the publisher, and the publisher to notify subscribers of changes in the publication policy.

Class summary:

Network Visible operations (see Table 116).

Table 116—IEEE1451_SelfIdentifyingPublisherPort Network Visible operations

Operation Name	Requirement	Operation ID
`GetPublisherMetadata`	(m)	10253
`PublishPublisherMetadata`	(m)	10254

Local operations (see Table 117).

Table 117—IEEE1451_SelfIdentifyingPublisherPort Local operations

Operation Name	Requirement
`PublishWithIdentification`	(m)
`RegisterPublisher`	(m)
`DeregisterPublisher`	(m)

Publications: A publication may be defined for this class.

Subscriptions: There are no subscriptions defined for this class.

11.8.1 Operation specifications: Network Visible

11.8.1.1 Operation `GetPublisherMetadata` specification

```
IDL: OpReturnCode GetPublisherMetadata(
           in UInteger16 publication_id,
           in UInteger16 cached_publication_change_id,
           out ArgumentArray publisher_metadata);
```

The Minor Field enumeration for this operation shall be defined in Table 118.

IDL: enumeration `PublisherMetadataReturn;`

Table 118—PublisherMetadataReturn enumeration

Enumeration	Value
CS_NO_ADDITIONAL_INFORMATION	0
CS_MEMORY_ALLOCATION_ERROR	1
CS_MISSING_INPUT	2
CS_INVALID_TYPE	3
CS_INVALID_VALUE	4
CS_COMPUTATION_ERROR	5
CS_INFORMATION_NOT_AVAILABLE	6
Reserved	7–255

The meaning of the first six members of this enumeration shall be identical to the meaning of the first six members of the `MinorReturnCode` enumeration; see 7.2.3.2.1.

11.8.1.1.1 argument `publication_id` specification

The `publication_id` argument value shall be the value of the `publicationID` field of the `publisher_identification_information` Argument of any publications issued from this Self Identifying Publisher Port.

11.8.1.1.2 argument `cached_publication_change_id` specification

The `cached_publication_change_id` argument value shall be the current Subscriber cached value of the Publication Change ID received in the publication for which the `publisher_metadata` is being requested. The Publication Change ID shall be the value of the `publicationChangeID` field of the `publisher_identification_information` Argument of any publications issued from this Self Identifying Publisher Port.

11.8.1.1.3 argument `publisher_metadata` specification

The `publisher_metadata` argument value shall contain information describing the publication and the Publisher. The syntax and semantics of this information is both Publisher and publication specific.

11.8.1.2 Operation `PublishPublisherMetadata` specification

```
IDL: OpReturnCode PublishPublisherMetadata(
             in UInteger16 publication_id,
             in UInteger16 cached_publication_change_id);
```

The Minor Field enumeration for this operation shall be defined by the `PublisherMetadataReturn` enumeration.

11.8.2 Operation specifications: Local

11.8.2.1 Local operation `PublishWithIdentification` specification

```
IDL: OpReturnCode PublishWithIdentification(
           in ArgumentArray publication_contents);
```

The Minor Field values of `OpReturnCode` shall be taken from the `PublicationContentsReturn` enumeration.

11.8.2.1.1 argument `publication_contents` specification

The `publication_contents` argument value shall be the Publisher provided information to be included in the Publication Contents of the publication.

11.8.2.2 Local operation `RegisterPublisher` specification

```
IDL: OpReturnCode RegisterPublisher(
           in <local operation reference>
              callback_operation_reference,
           out UInteger16 publication_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.8.2.2.1 argument `callback_operation_reference` specification

The `callback_operation_reference` argument value shall be a local reference to a local operation of the registering Publisher object that shall be invoked to signal a request for `publisher_metadata`. The signature of the referenced callback operation shall be

```
OpReturnCode <local operation name>(
           in UInteger16 publication_id,
           in Boolean request_client_server_flag,
           in UInteger16 cached_publication_change_id,
           out ArgumentArray publisher_metadata);
```

11.8.2.2.1.1 argument `publication_id` specification

The `publication_id` argument of the callback operation shall be the value provided as an input argument in either the `PublishPublisherMetadata` or `GetPublisherMetadata` operations invoked on this Self Identifying Publisher Port; see 11.8.3.3.

11.8.2.2.1.2 argument `request_client_server_flag` specification

The `request_client_server_flag` argument value shall define the method of response to the request for `publisher_metadata`.

— `TRUE` shall indicate that the Subscriber call was for the `GetPublisherMetadata` operation, that the metadata is expected via the client-server return, and that no publication of metadata is requested.

— `FALSE` shall indicate that the Subscriber call was for the `PublishPublisherMetadata` operation and that no data is expected via the client-server return.

11.8.2.2.1.3 argument `cached_publication_change_id` specification

The `cached_publication_change_id` argument value shall be the value provided by the Subscriber invoking either the `GetPublisherMetadata` or the `PublishPublisherMetadata` operations. This value may be used by the Publisher to determine the specific metadata of interest to the Subscriber. The specifics of this determination are outside the scope of this standard.

11.8.2.2.1.4 argument `publisher_metadata` specification

The `publisher_metadata` argument value shall be the metadata associated with the publication defined by the arguments `publication_id` and `cached_publication_change_id`. This metadata is the metadata that would be published by using the `PublishWithIdentification` operation with one of the following values for `content_code`:

— `PCC_METADATA`

— `PCC_BOTH_META_AND_NORMAL_DATA`

— `PCC_GROUPED_METADATA`

— `PCC_GROUPED_BOTH_META_AND_NORMAL_DATA`

11.8.2.2.2 argument `publication_id` specification

The `publication_id` output argument value of the `RegisterPublisher` operation shall be a distinct value assigned to the registering Publisher for each instance of `<local operation reference>` it registers with the Self Identifying Publisher Port.

11.8.2.3 Local operation `DeregisterPublisher` specification

```
IDL: OpReturnCode DeregisterPublisher(
             in <local operation reference>
                callback_operation_reference,
             in UInteger16 publication_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.8.3 Self Identifying Publisher Port class behavior

11.8.3.1 Specific Self Identifying Publisher Port operation restrictions based on state

In addition to and conformant with the restrictions of 11.6.4.1, the allowed operations defined on a Self Identifying Publisher Port instance shall be restricted as defined in Table 119. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

11.8.3.2 Publication restrictions

Publishers may use a Port of this class for Publication Key values that define publications for which additional information may be requested of the Publisher. The allowed values of Publication Key for which this Port shall be used with the `PublishWithIdentification` operation are specified in 12.3.3 as Class B key values.

Table 119—IEEE1451_SelfIdentifyingPublisherPort class specific restrictions

Operation	Specified value of rule_basis		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
GetPublisherMetadata, RegisterPublisher, DeregisterPublisher	Local invocation only	Operational	Operational
PublishPublisherMetadata, PublishWithIdentification	Not operational	Operational	Operational

For these Publication Key values

— The local PublishWithIdentification operation shall be used.

— Publishers shall be registered with the Port using the operation RegisterPublisher.

— The publication shall be published under the terms of 12.2, if and only if the Publisher is properly registered and the Publication Key is a member of Class B.

— Error condition 1: If the Publisher is not properly registered, the PublishWithIdentification operation shall return with a MajorReturnCode value of MJ_SERVICE_UNAVAILABLE and a MinorReturnCode value of PC_ILLEGAL_STATE.

— Error condition 2: If the Publication Key is not a member of Class B, the PublishWithIdentification operation shall return with a MajorReturnCode value of MJ_SERVICE_UNAVAILABLE and a MinorReturnCode value of PC_ILLEGAL_KEY.

If both of the previous two error conditions obtain, the MinorReturnCode shall be PC_ILLEGAL_STATE.

The Publication Key value PSK_EVENT_NOTIFICATION shall not be used with a Port of class IEEE1451_SelfIdentifyingPublisherPort. If specified in the subclass definition, the Publication Key value PSK_EVENT_NOTIFICATION may be used with a Port that is a subclass of IEEE1451_SelfIdentifyingPublisherPort.

11.8.3.3 Operations GetPublisherMetadata and PublishPublisherMetadata behavior specification

The invocation of GetPublisherMetadata or the PublishPublisherMetadata shall follow all of the specifications for client-server communication.

The invocation of the GetPublisherMetadata or the PublishPublisherMetadata operations shall result in the Self Identifying Publisher Port invoking the callback operation on the Publisher identified by the publication_id argument.

An invocation on the Publisher object of the callback operation shall cause the Publisher to

— Return the requested Publisher information via the out argument publisher_metadata of the callback operation if the request_client_server_flag argument is TRUE. The Self Identifying Publisher Port shall then return this information to the requesting client via the normal client-server mechanisms.

— Publish the Publisher information via the normal invocation of PublishWithIdentification if the request_client_server_flag argument is FALSE. In this case, the Argument Array output argument publisher_metadata of the callback operation shall have as value the default value for an Argument Array.

The MinorReturnCode shall be CS_INFORMATION_NOT_AVAILABLE and the MajorReturnCode shall be MJ_SERVICE_UNAVAILABLE if the Publisher can not provide the requested information.

11.8.3.4 Operation PublishWithIdentification behavior specification

The Argument Array publication_contents shall be passed to the Self Identifying Publisher Port by the Publisher and shall be as defined in Table 120.

The Publication Contents of the publication as delivered to the network infrastructure shall be defined in Table 120.

Table 120—publication_contents definition

Argument Array Member	Member Argument TypeCode corresponding to type	Argument Name
0	PublisherInformation	publisher_identification_information
1	UInteger8	content_code
Remaining arguments	Argument	application_specific_contents

11.8.3.4.1 argument publisher_identification_information behavior specification

The 0th member of the Publication Contents Argument Array shall be the PublisherInformation structure, publisher_identification_information. This member shall be encoded by the Publisher into an Argument. The values of the fields of this structure shall be set as follows:

— portObjectTag: The Self Identifying Publisher Port shall set the encoded value of this field to the value of its Object Tag.

— publicationID: The Publisher shall set this field to the value of its publication_id established by the RegisterPublisher operation.

— publicationChangeID: The Publisher shall set this field to the value of its Publication Change ID.

11.8.3.4.2 Publication Change ID behavior specification

The Publication Change ID shall be a Publisher-defined and -maintained identifier associated with Publisher-specific metadata concerning the semantics of the publication. A change in the value of the Publication Change ID may be used to indicate to Subscribers that the metadata associated with the publication has changed. The circumstances indicating the need for such a change are outside the scope of this standard.

11.8.3.4.3 argument `content_code` behavior specification

The Publication Contents semantics and format shall be defined by the `content_code`. These `content_code` dependent formats shall be specific to each publication. The value of `content_code` shall be set and encoded by the Publisher

The allowed value of the `content_code` shall be taken from the `PublicationContentCode` enumeration as shown in Table 121.

IDL: enumeration `PublicationContentCode;`

Table 121—`PublicationContentCode` enumeration

Enumeration	Value	Meaning
`PCC_NORMAL_DATA`	0	The usual contents of the publication for the defined topic.
`PCC_METADATA`	1	The information requested as a result of the invocation of the `PublishPublisherMetadata` operations.
`PCC_BOTH_META_AND_NORMAL_DATA`	2	The publication contains both the meta and normal data, defined however, for the application or publication.
`PCC_GROUPED_NORMAL_DATA`	3	Same as 0 but for a group of similarly formatted data.
`PCC_GROUPED_METADATA`	4	Same as 1 but for a group of similarly formatted metadata.
`PCC_GROUPED_BOTH_META_AND_NORMAL_DATA`	5	Same as 2 but for a group of similarly formatted meta and normal data.
Reserved values	6–127	
Open to industry	128–255	

11.8.3.4.4 argument `application_specific_contents` specification

The `application_specific_contents` argument value shall be the application specific Publisher defined information provided by the Publisher. The Publisher shall encode this information into Argument Array member 2 through the final member Argument of the Publication Contents Argument Array.

The Port shall pass the Publication Contents Argument Array to the underlying network infrastructure to be published.

11.9 Event Generator Publisher Port class

Class: `IEEE1451_EventGeneratorPublisherPort`

Parent Class: `IEEE1451_SelfIdentifyingPublisherPort`

Class ID: 1.1.3.1.2.2.1

Description: The Event Generator Publisher Port class may be used to allow events internal to the operation of a block to result in the publication of an event record.

Class summary:

Network Visible operations (see Table 122).

Table 122—`IEEE1451_EventGeneratorPublisherPort` Network Visible operations

Operation Name	Requirement	Operation ID
`GetEventGeneratorState`	(m)	12298
`SetEventSequenceNumber`	(m)	12299
`GetEventSequenceNumber`	(m)	12300
`SetResponseTag`	(m)	12301
`GetResponseTag`	(m)	12302
`GetLastTimestamp`	(m)	12303
`EnableEventPublication`	(m)	12304
`DisableEventPublication`	(m)	12305

Publications: A publication with Publication Key value of `PSK_EVENT_NOTIFICATION` is defined for this class.

Subscriptions: There are no subscriptions defined for this class.

11.9.1 Operation specifications: Network Visible

11.9.1.1 Operation `GetEventGeneratorState` specification

```
IDL: OpReturnCode GetEventGeneratorState(
           out UInteger8 event_generator_state);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.9.1.1.1 argument `event_generator_state` specification

The `event_generator_state` argument value shall be defined by the following enumeration shown in Table 123.

IDL: enumeration `EventGeneratorState;`

Table 123—`EventGeneratorState` enumeration

Enumeration	Value
`EG_DISABLED`	0
`EG_ENABLED`	1
Reserved	2–255

11.9.1.2 Operation `SetEventSequenceNumber` specification

```
IDL: OpReturnCode SetEventSequenceNumber(
           in UInteger32 event_sequence_number);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.9.1.2.1 argument `event_sequence_number` specification

The `event_sequence_number` argument value shall order the publication of event records from this Event Generator Publisher Port.

11.9.1.3 Operation `GetEventSequenceNumber` specification

```
IDL: OpReturnCode GetEventSequenceNumber(
           out UInteger32 event_sequence_number);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.9.1.4 Operation `SetResponseTag` specification

```
IDL: OpReturnCode SetResponseTag(
           in ObjectTag response_object_tag);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.9.1.4.1 argument `response_object_tag` specification

The `response_object_tag` argument value shall be the current value of the Object Tag of the object that shall receive any response to this event by its receiving Subscribers. The management of `response_object_tag` values is outside the scope of this standard.

The purpose of the `response_object_tag` is to allow application system integrators to designate an object to handle selected application functionality required by the posting of a publication by the Event Generator Publisher Port.

11.9.1.5 Operation `GetResponseTag` specification

```
IDL: OpReturnCode GetResponseTag(
           out ObjectTag response_object_tag);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.9.1.6 Operation `GetLastTimestamp` specification

```
IDL: OpReturnCode GetLastTimestamp(
           out TimeRepresentation last_event_timestamp);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.9.1.6.1 argument `last_event_timestamp` specification

The `last_event_timestamp` argument value shall indicate the time at which the last event activating this Event Generator Publisher Port occurred, irrespective of whether the detection of the event resulted in the publication of an event record.

11.9.1.7 Operation `EnableEventPublication` specification

```
IDL: OpReturnCode EnableEventPublication( );
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.9.1.8 Operation `DisableEventPublication` specification

```
IDL: OpReturnCode DisableEventPublication( );
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.9.2 Event Generator Publisher Port class behavior

11.9.2.1 Specific Event Generator Publisher Port operation restrictions based on state

In addition to and conformant with the restrictions of 11.8.3.1, the allowed operations defined on an Event Generator Publisher Port instance shall be restricted as defined in Table 124. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 124—`IEEE1451_EventGeneratorPublisherPort` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
All operations defined by this class except those in the following row	Local invocation only	Operational	Operational
`SetEventSequenceNumber`, `SetResponseTag`	Local invocation only	Operational	Not operational

11.9.2.2 Operational behavior specification

Implementers may cause an event record to be published containing `optional_arguments`. The specifics of what constitutes an event, and how an event is detected, are outside the scope of this standard.

The event detection mechanism, that is the Publisher, shall invoke the inherited `PublishWithIdentification` operation to cause the event record to be published by the Event Generator Publisher Port.

The implementation shall define the semantics of the underlying event and the means for detection.

The definition of `optional_arguments` is application-specific and is outside the scope of this standard.

11.9.2.3 argument event_sequence_number behavior specification

The event_sequence_number shall be maintained by the Port and incremented by one each time an event record is published. The current value may be accessed by the SetEventSequenceNumber and GetEventSequenceNumber operations.

11.9.2.4 argument response_object_tag behavior specification

The response_object_tag argument shall be the Object Tag of the object that shall receive any response to the posting of a publication by the Event Generator Publisher Port. This tag value shall be maintained by the Port.

The response_object_tag value equal to the default value for an Object Tag shall indicate that no responses shall be accepted.

The specification of the results of a response is outside the scope of this standard.

11.9.2.5 Operations GetLastTimestamp behavior specification

GetLastTimestamp may be an Interface Only Implementation if the implementation does not provide the ability to timestamp events; otherwise, it shall be a Full Implementation.

The most recent value of the event_detection_time shall be available from the Port as last_event_timestamp. The last_event_timestamp shall be available via the GetLastTimestamp operation irrespective of the state of the Event Generator Publisher Port.

The event_detection_time shall be the time at which the underlying event was detected by the event detection mechanism.

11.9.2.6 argument event_name behavior specification

The event_name argument of the Publication Contents shall represent the name of the event. The management of this argument is outside the scope of this standard.

11.9.2.7 Publication semantics

The Publication Key for the publication issued by this Port shall be PSK_EVENT_NOTIFICATION.

The content_code argument of PublishWithIdentification shall be either PCC_NORMAL_DATA or shall be user-defined.

The Publication Contents for content_code values other than PCC_NORMAL_DATA is application dependent and is outside the scope of this standard.

11.9.2.7.1 argument publication_contents behavior specification

The Argument Array publication_contents for content_code PCC_NORMAL_DATA passed to the Port by the Publisher defines the Publication Contents of the publication. The form of the Publication Contents Argument Array shall be as defined in Table 125.

The publisher_identification_information and content_code members shall be provided as defined in the parent class; see 11.8.3.4.

The Publisher shall provide the values for the event_detection_time and event_name.

Table 125—Event Generator `publication_contents` definition

Argument Member	Member Argument **TypeCode** corresponding to type	Value
0	`PublisherInformation`	`publisher_identification_information`
1	`UInteger8`	`content_code`
2	`UInteger32`	`event_sequence_number`
3	`ObjectTag`	`response_object_tag`
4	`TimeRepresentation`	`event_detection_time`
5	`String`	`event_name`
Remaining	`Argument`	`optional_arguments`

The Port shall provide the values for the `event_sequence_number` and `response_object_tag`.

The Publisher shall provide any `optional_arguments` variables.

Encoding of the Publication Contents Argument Array shall follow the rules of Clause 14.

11.9.2.8 State behavior specification

The state behavior of an Event Generator Publisher Port shall be as defined in Figure 28.

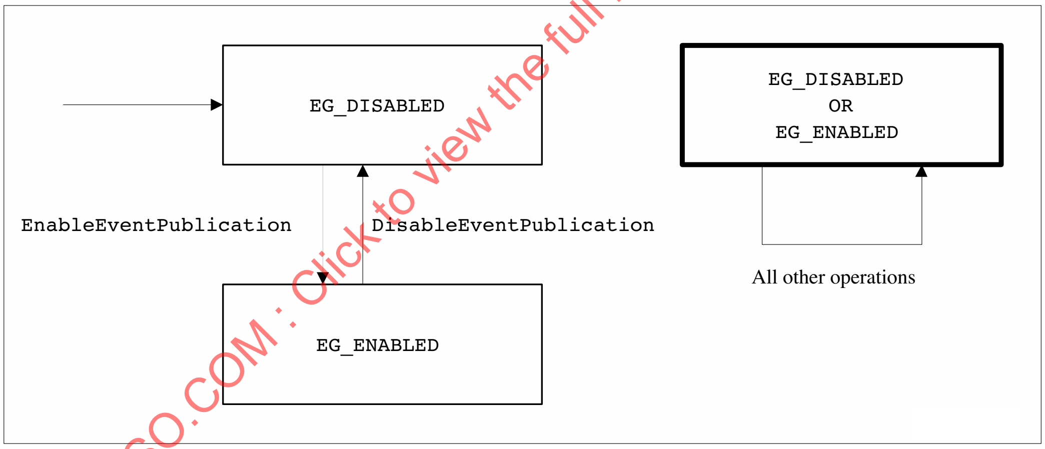


Figure 28—State machine for an Event Generator Publisher Port

The initial state of the Event Generator Publisher Port shall be the `EG_DISABLED` state as indicated by the entry transition in the state machine.

The publication of event records shall be as defined in Table 126.

Table 126—Event Generator Publisher Port state restrictions

State	Meaning
`EG_DISABLED`	No event records shall be published.
`EG_ENABLED`	Event records shall be published.

11.10 Subscriber Port class

Class: `IEEE1451_SubscriberPort`

Parent Class: `IEEE1451_Service`

Class ID: 1.1.3.2

Description: The Subscriber Port class provides objects with a mechanism for subscribing to publications.

Class summary:

Network Visible operations (see Table 127).

Table 127—`IEEE1451_SubscriberPort` Network Visible operations

Operation Name	Requirement	Operation ID
`SetSubscriptionQualifier`	(m)	6195
`GetSubscriptionQualifier`	(m)	6196
`GetSubscriptionKey`	(m)	6197
`SetSubscriptionDomain`	(m)	6198
`GetSubscriptionDomain`	(m)	6199

Local Operations (see Table 128).

Table 128—`IEEE1451_SubscriberPort` Local operations

Operation Name	Requirement
`AddSubscriber`	(m)
`DeleteSubscriber`	(m)

Publications: There are no publications defined for this class.

Subscriptions: Subscription may be defined for this class.

11.10.1 Operation specifications: Network Visible

11.10.1.1 Operation `SetSubscriptionQualifier` specification

```
IDL: OpReturnCode SetSubscriptionQualifier(
              in SubscriptionQualifier subscription_qualifier);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.10.1.1.1 argument `subscription_qualifier` specification

The `subscription_qualifier` argument value shall be the current value of the Port's Subscription Qualifier. The Subscription Qualifier is used in the determination of which publications are to be accepted by the Port. The properties and allowed values for Subscription Qualifiers shall be as specified in 12.3.2 and 12.3.4.

11.10.1.2 Operation `GetSubscriptionQualifier` specification

```
IDL: OpReturnCode GetSubscriptionQualifier(
           out SubscriptionQualifier subscription_qualifier);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.10.1.3 Operation `GetSubscriptionKey` specification

```
IDL: OpReturnCode GetSubscriptionKey(
           out UInteger8 subscription_key);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.10.1.3.1 argument `subscription_key` specification

The `subscription_key` argument value shall be the current value of the Port's Subscription Key. The properties and allowed values for Subscription Keys shall be as specified in 12.3.2 and 12.3.3.

11.10.1.4 Operation `SetSubscriptionDomain` specification

```
IDL: OpReturnCode SetSubscriptionDomain(
           in PubSubDomain subscription_domain);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.10.1.4.1 argument `subscription_domain` specification

The `subscription_domain` argument shall be the current value of the Subscription Domain defining a set of candidate publications to be accepted by the Port; see Clause 12. The properties and allowed values for Subscription Domain shall be as specified in 12.3.5.

11.10.1.5 Operation `GetSubscriptionDomain` specification

```
IDL: OpReturnCode GetSubscriptionDomain(
           out PubSubDomain subscription_domain);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.10.2 Operation specifications: Local

11.10.2.1 Local operation `AddSubscriber` specification

```
IDL: OpReturnCode AddSubscriber(
           in <local operation reference>
              notification_operation_reference,
           in UInteger16 subscription_id);
```

The Minor Field enumeration for this operation shall be defined by the `PublicationContentsReturn` enumeration; see 11.6.2.1.

11.10.2.1.1 argument `notification_operation_reference` specification

The `notification_operation_reference` argument value shall be a `<local operation reference>` to the local operation of the registering Subscriber object that shall be invoked to signal that a requested publication has been received. The signature of the operation shall be

```
void <local operation name>(
    in UInteger16 subscription_id,
    in UInteger8 publishing_port_publication_key,
    in PublicationTopic
       publishing_port_publication_topic,
    in ArgumentArray publication_contents);
```

11.10.2.1.1.1 argument `subscription_id` specification

The `subscription_id` argument value of the callback `<local operation name>` shall be the Subscriber-defined alias for the Publication Topic defined by `AddSubscriber`.

11.10.2.1.1.2 argument `publishing_port_publication_key` specification

The `publishing_port_publication_key` argument value shall be the actual Publication Key that the Publisher used when issuing the publication.

11.10.2.1.1.3 argument `publishing_port_publication_topic` specification

The `publishing_port_publication_topic` argument value shall be the actual Publication Topic that the Publisher used when issuing the publication.

11.10.2.1.1.4 argument `publication_contents` specification

The `publication_contents` argument value shall be the Publication Contents of the received publication.

11.10.2.1.2 argument `subscription_id` specification

The `subscription_id` argument value of the `AddSubscriber` operation shall be a Subscriber-defined alias for the Publication Topic.

11.10.2.2 Local operation `DeleteSubscriber` specification

```
IDL: OpReturnCode DeleteSubscriber(
           in <local operation reference>
              notification_operation_reference,
           in UInteger16 subscription_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.10.3 Subscriber Port class behavior

11.10.3.1 Specific Subscriber Port operation restrictions based on state

In addition to and conformant with the restrictions of 11.1.2.2, the allowed operations defined on a Subscriber Port instance shall be restricted as defined in Table 129. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 129—`IEEE1451_SubscriberPort` class specific state

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	**BL_INACTIVE**	**BL_ACTIVE**
All operations defined by this class except those in the following row	Local invocation only	Operational	Not operational
`GetSubscriptionQualifier,` `GetSubscriptionKey,` `GetSubscriptionDomain,` `AddSubscriber,` `DeleteSubscriber`	Local invocation only	Operational	Operational

11.10.3.2 Subscription receipt, demarshaling, decoding and notification behavior specification

The selection of publications shall be as defined in 12.3.4.

The network infrastructure supporting the Subscriber Port shall be responsible for demarshaling the received

— Publication Contents

— Publication Topic

— Publication Key

— Publication Domain

from the network-specific, on-the-wire format, into the appropriate datatypes and delivering this information to the appropriate Subscriber Ports.

If a qualified publication is received by a Subscriber Port, all registered Subscribers shall be notified via the callback operations established by the `AddSubscriber` operation.

The Subscriber shall be responsible for decoding the Publication Contents received as an Argument Array via the callback operation into appropriate local variables.

The decoding of the Publication Contents shall be based on the format of the contents of the publication as defined by the `publishing_port_publication_topic` and `publishing_port_publication_key`.

11.10.3.3 Role of identifiers in subscribing with this Port

`portObjectTag`, `publicationID`, and `publicationChangeID` information may be present as part of the Publication Contents if the subscription is to a publication issued by a Self Identifying Publisher Port; see 11.8.

For publications from an ordinary Publisher Port, this information is not available.

An example of a publish-subscribe communication is found in Annex C.

11.11 Mutex Service class

Class: `IEEE1451_MutexService`

Parent Class: `IEEE1451_Service`

Class ID: 1.1.3.3

Description: The Mutex Service class provides mutual exclusion capability.

Class summary:

Network Visible operations (see Table 130).

Table 130—`IEEE1451_MutexService` Network Visible operations

Operation Name	Requirement	Operation ID
`Lock`	(m)	6200
`Unlock`	(m)	6201
`TryLock`	(m)	6202
`IsLocked`	(m)	6203
`ForceAcquireLock`	(m)	6204

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

11.11.1 Operation specifications: Network Visible

11.11.1.1 Operation `Lock` specification

```
IDL: OpReturnCode Lock(
           in TimeRepresentation timeout,
           out UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.11.1.1.1 argument `timeout` specification

The `timeout` argument value shall be the maximum time that the client shall be blocked before the operation returns.

11.11.1.1.2 argument `transaction_id` specification

The `transaction_id` argument value shall be a value generated by the Mutex Service.

11.11.1.2 Operation `Unlock` specification

```
IDL: OpReturnCode Unlock(in UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.11.1.3 Operation `TryLock`

```
IDL: OpReturnCode TryLock(out UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.11.1.4 Operation `IsLocked` specification

```
IDL:: OpReturnCode IsLocked(out Boolean mutex_status);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.11.1.4.1 argument `mutex_status` specification

The `mutex_status` argument value shall be `TRUE` if the Mutex Service is LOCKED, otherwise the value shall be `FALSE`.

11.11.1.5 Operation `ForceAcquireLock` specification

```
IDL: OpReturnCode ForceAcquireLock(
          out UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.11.2 Mutex Service class behavior

11.11.2.1 Specific Mutex Service operation restrictions based on state

In addition to and conformant with the restrictions of 11.1.2.2, the allowed operations defined on a Mutex Service instance shall be restricted as defined in Table 131. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 131—`IEEE1451_MutexService` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	**BL_INACTIVE**	**BL_ACTIVE**
All operations defined by this class	Local invocation only	Operational	Operational

11.11.2.2 Overview of Mutex behavior

The Mutex Service is always in one of the following two states:

- UNLOCKED
- LOCKED

11.11.2.2.1 Operation `Unlock` behavior specification

The `Unlock` operation on a Mutex Service in the LOCKED state shall unlock the Mutex Service, provided the `transaction_id` values match. The call shall return immediately. If any `Lock` operations are blocked on the formerly LOCKED Mutex Service, one and only one of them shall be unblocked and shall return with a new transaction_id. An attempt to unlock an already UNLOCKED Mutex Service shall return immediately.

11.11.2.2.2 Operation Lock behavior specification

The Lock operation on an UNLOCKED Mutex Service shall lock the Mutex Service and return a transaction_id value that shall be different from prior transaction_id values. If an attempt to lock a Mutex Service that is already in the LOCKED-state is made, the call shall block until the Mutex Service is UNLOCKED and the specific Lock operation call is the one selected to be unblocked and receive the new transaction_id, or the call timeout expires.

11.11.2.2.3 Behavior of the operation TryLock

The TryLock operation on an UNLOCKED Mutex Service shall lock the Mutex Service and return a transaction_id value that shall be different from prior transaction_id values. If the TryLock operation is invoked on a LOCKED Mutex Service, the call shall return with the return code MJ_SERVICE_UNAVAILABLE.

11.11.2.2.4 Operation ForceAcquireLock behavior specification

A ForceAcquireLock operation shall leave the Mutex Service LOCKED, invalidates the current transaction_id, and returns a transaction_id that shall be different from prior transaction_id values. An attempt to ForceAcquireLock the lock of an UNLOCKED Mutex Service shall return immediately.

11.11.2.3 State behavior specification

The state behavior of the Mutex Service shall be as defined Figure 29.

The initial state for a Mutex Service shall be the UNLOCKED state as indicated by the entry transition of the state machine.

All state transitions for the Mutex Service shall be atomic. Where there are multiple actions associated with the transition, the result of the transition shall be exactly as though these actions executed without interference from Concurrent Execution of any operation on any object in the process space.

Unless otherwise indicated in the state diagram, when calls return the MajorReturnCode field shall be MJ_COMPLETE and the MinorReturnCode field shall be MI_NO_ADDITIONAL_INFORMATION.

A timeout value of 0 shall indicate that the Mutex Service timeout never expires.

If more than a single client is blocked on a LOCKED Mutex Service when a successful Unlock operation is invoked, there shall be no requirement designating which client to unblock unless otherwise stated in a subclass specification.

It is recommended that, within the numerical range constraints of the datatype, transaction_id values not be reused.

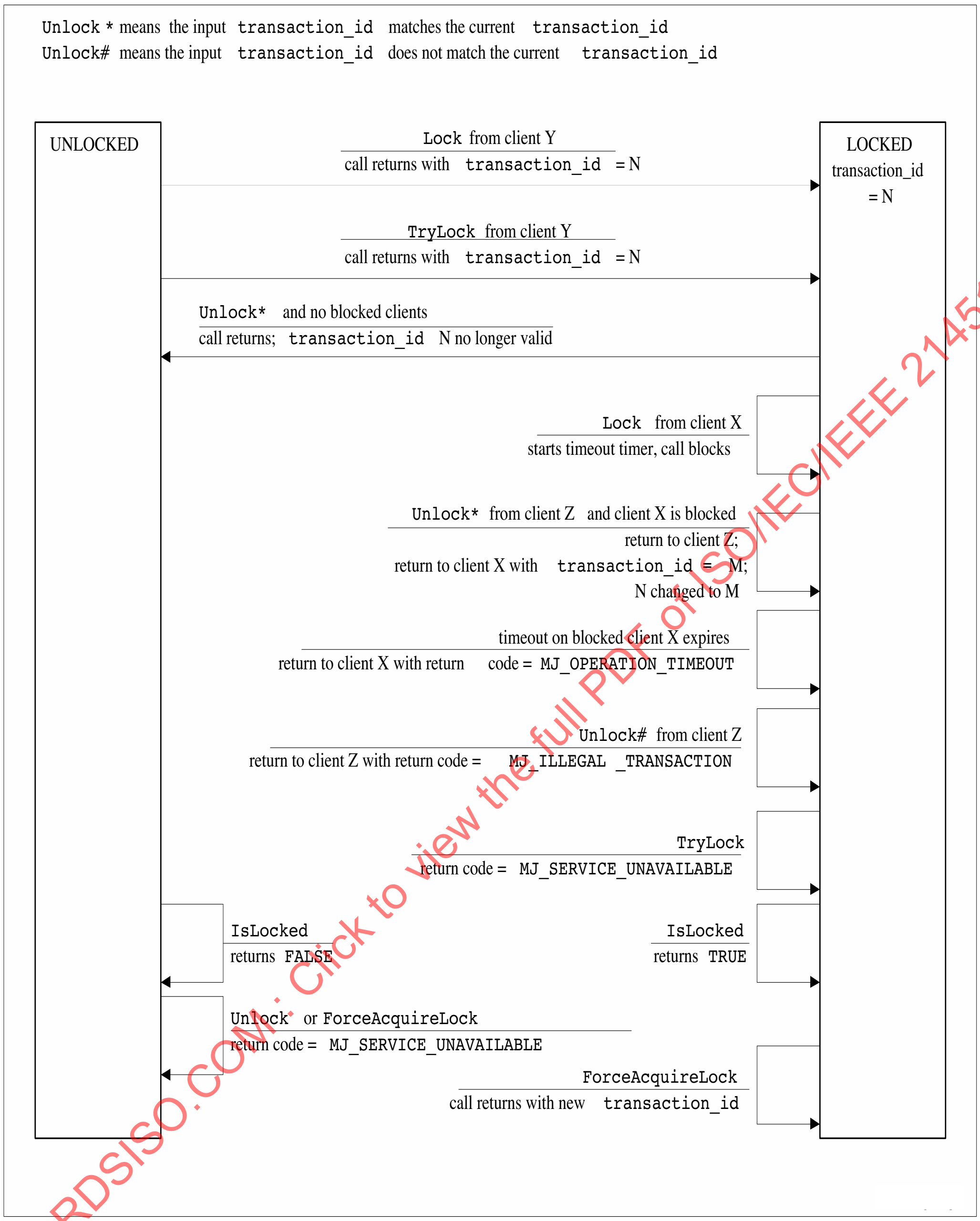

Unlock * means the input transaction_id matches the current transaction_id
Unlock# means the input transaction_id does not match the current transaction_id
UNLOCKED
LOCKED transaction_id = N
Lock from client Y
call returns with transaction_id = N
TryLock from client Y
call returns with transaction_id = N
Unlock* and no blocked clients
call returns; transaction_id N no longer valid
Lock from client X
starts timeout timer, call blocks
Unlock* from client Z and client X is blocked
return to client Z;
return to client X with transaction_id = M;
N changed to M
timeout on blocked client X expires
return to client X with return code = MJ_OPERATION_TIMEOUT
Unlock# from client Z
return to client Z with return code = MJ_ILLEGAL _TRANSACTION
TryLock
return code = MJ_SERVICE_UNAVAILABLE
IsLocked
returns FALSE
IsLocked
returns TRUE
Unlock* or ForceAcquireLock
return code = MJ_SERVICE_UNAVAILABLE
ForceAcquireLock
call returns with new transaction_id

Figure 29—State machine for a Mutex Service

11.12 Condition Variable Service class

Class: `IEEE1451_ConditionVariableService`

Parent Class: `IEEE1451_Service`

Class ID: 1.1.3.4

Description: The Condition Variable Service class provides the capability for ordering concurrent activities.

Class summary:

Network Visible operations (see Table 132).

Publications: There are no publications defined for this class.

Subscriptions: There are no subscriptions defined for this class.

Table 132—`IEEE1451_ConditionVariableService` Network Visible operations

Operation Name	Requirement	Operation ID
`Lock`	(m)	6205
`Unlock`	(m)	6206
`TryLock`	(m)	6207
`SetPredicateState`	(m)	6208
`Wait`	(m)	6209
`SignalOne`	(m)	6210
`SignalAll`	(m)	6211
`IsLocked`	(m)	6212
`GetPredicateState`	(m)	6213
`ForceAcquireLock`	(m)	6214
`ClearAllPendingWaits`	(m)	6215

11.12.1 Operation specifications: Network Visible

11.12.1.1 Operation `Lock` specification

```
IDL: OpReturnCode Lock(
           in TimeRepresentation lock_timeout,
           out UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.12.1.1.1 argument `lock_timeout` specification

The `lock_timeout` argument value shall be the maximum time that the client shall be blocked before a return.

11.12.1.1.2 argument `transaction_id` specification

The `transaction_id` argument value shall be a value generated by the Condition Variable Service.

11.12.1.2 Operation `Unlock` specification

```
IDL: OpReturnCode Unlock(in UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.12.1.3 Operation `TryLock` specification

```
IDL: OpReturnCode TryLock(out UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.12.1.4 Operation `SetPredicateState` specification

```
IDL: OpReturnCode SetPredicateState(
           in Boolean predicate_state,
           in UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.12.1.4.1 argument `predicate_state` specification

The `predicate_state` argument value shall be the desired state of the Condition Variable Service's predicate.

11.12.1.5 Operation `Wait` specification

```
IDL: OpReturnCode Wait(
           in TimeRepresentation wait_timeout,
           out UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.12.1.5.1 argument `wait_timeout` specification

The `wait_timeout` argument value shall be the maximum time that the client shall be blocked before a return.

11.12.1.6 Operation `SignalOne` specification

```
IDL: OpReturnCode SignalOne(in UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.12.1.7 Operation `SignalAll` specification

```
IDL: OpReturnCode SignalAll(in UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.12.1.8 Operation `IsLocked` specification

```
IDL: OpReturnCode IsLocked(out Boolean mutex_status);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.12.1.8.1 argument `mutex_status` specification

The `mutex_status` argument value shall indicate the status of the mutex protecting the Condition Variable Service.

11.12.1.9 Operation `GetPredicateState` specification

```
IDL: OpReturnCode GetPredicateState(
          out Boolean predicate_state);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.12.1.9.1 argument `predicate_state` specification

The `predicate_state` argument value shall be the value of the current state of the Condition Variable Service's predicate.

11.12.1.10 Operation `ForceAcquireLock` specification

```
IDL: OpReturnCode ForceAcquireLock(
          out UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.12.1.11 Operation `ClearAllPendingWaits` specification

```
IDL: OpReturnCode ClearAllPendingWaits(
          in UInteger16 transaction_id);
```

There are no operation-specific additions to the Minor Field of the return code enumeration.

11.12.2 Condition Variable Service class behavior

11.12.2.1 Specific Condition Variable Service operation restrictions based on state

In addition to and conformant with the restrictions of 11.1.2.2, the allowed operations defined on a Condition Variable Service instance shall be restricted as defined in Table 133. Where an operation is indicated as operational, it still shall be restricted to specific uses defined by the restrictions of 9.1.3.2.1, 9.1.3.2.2, and 9.1.3.2.3.

Table 133—`IEEE1451_ConditionVariableService` class specific restrictions

Operation	Specified value of `rule_basis`		
	BL_UNINITIALIZED	BL_INACTIVE	BL_ACTIVE
All operations defined by this class	Local invocation only	Operational	Operational

11.12.2.2 Overview of Condition Variable Service behavior

This Service is the application interface to a mechanism for controlling the ordering of activities between code segments executing in distinct NCAP processes. This mechanism consists of a Boolean state variable, termed the predicate, a mutex, and an internal mechanism for supporting a collection of blocked `Wait` calls. This internal mechanism is termed the “collection” in this clause.

The Condition Variable Service’s predicate is a Boolean with states `TRUE` and `FALSE`. The state of the predicate shall be returned by the `GetPredicateState` operation.

The behavior of the mutex portion is exactly as for the Mutex Service with respect to `Lock`, `Unlock`, `TryLock`, and `ForceAcquireLock`. A client in possession of the lock `transaction_id` may change the predicate’s state by using the `SetPredicateState` operation.

Clients can invoke the `Wait` operation on the Service. Conceptually, when a `Wait` is invoked, a state machine shall be created in the collection to manage the execution of the `Wait` operation. There shall be one such conceptual state machine for every invocation of `Wait`.

Each of these state machines, when invoked, shall attempt to secure the mutex lock and if successful shall check the state of the predicate. If the predicate is `TRUE` then the `Wait` call shall return with a new `transaction_id` and its state machine shall be removed from the collection. If the predicate is `FALSE` then the `Wait` call shall block.

A `Wait` state machine that is in this blocked state shall remain so until it receives a signal or a `ClearAllPendingWaits` operation is invoked.

Signals may be issued in two ways

— By a client in possession of the `transaction_id` via the `SignalOne` call. This operation shall signal one of the state machines in the collection. There shall be no requirement for ordering the selection of which state machine to apply the `SignalOne` call.

— By a client in possession of the `transaction_id` via the `SignalAll` call. This operation shall signal all of the state machines in the collection. There shall be no requirement for ordering the signaling of the members of the collection.

When a blocked state machine in the collection is signaled it shall attempt to lock the mutex. If it is successful, it shall check the state of the predicate and act as follows:

— If the predicate is `TRUE` then the `Wait` call shall return with a new `transaction_id` and its state machine shall be removed from the collection.

— If the predicate is `FALSE` then the `Wait` call shall reblock.

If the `Lock` call unblocks with an abnormal return code on the mutex, the `Wait` call shall return with the appropriate return code. Whenever `Wait` returns to the client, its state machine shall be removed from the collection.

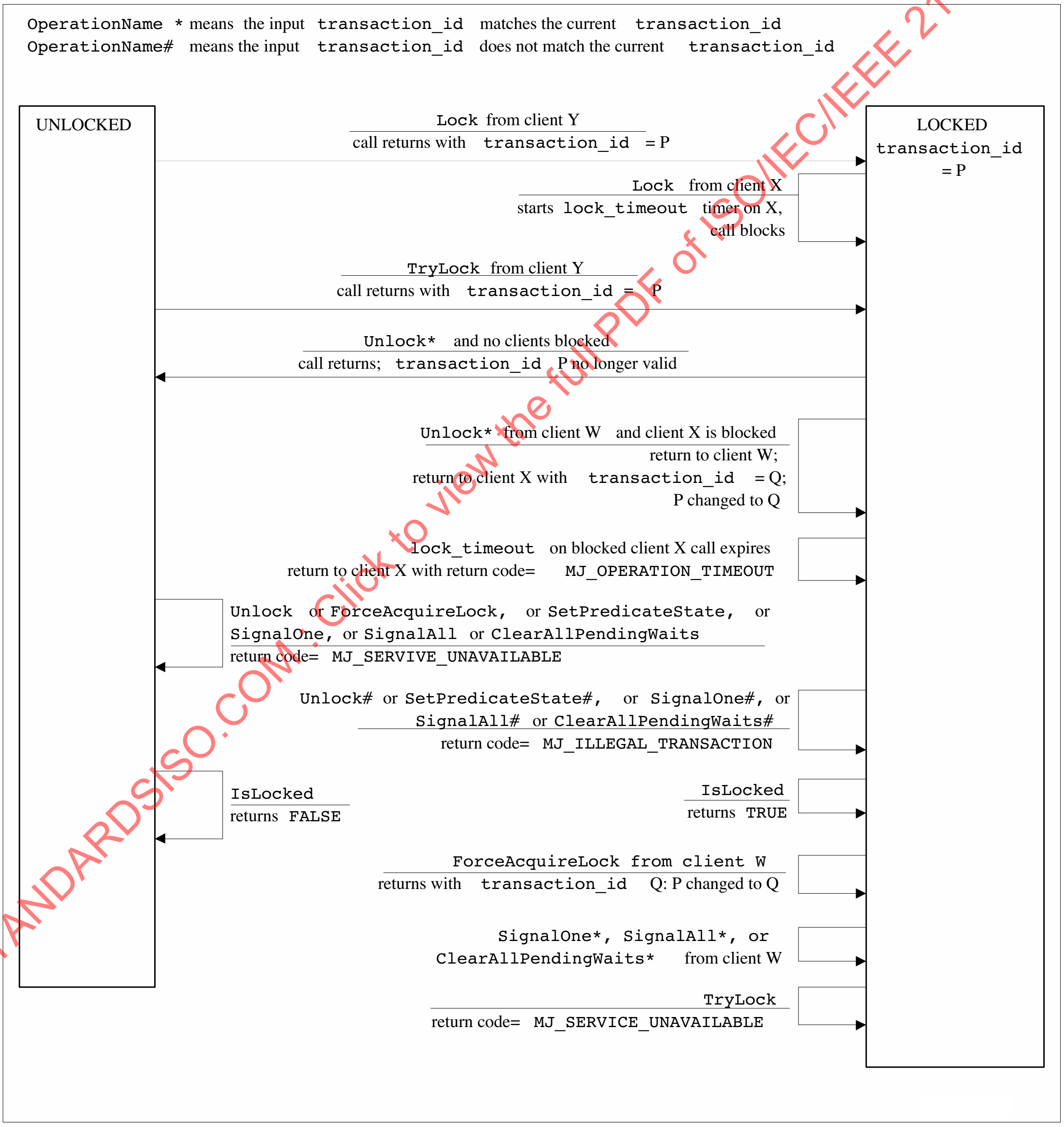
A client may force the acquisition of the mutex lock by the invocation of `ForceAcquireLock`. This operation shall return a new `transaction_id` to the client and shall cause any outstanding `transaction_id` to be invalid.

A client holding a valid `transaction_id` may invoke the `ClearAllPendingWaits` operation. This operation shall cause all pending `Wait` calls to unblock and return to their respective clients.

The collection manages timeouts such that the `wait_timeout` value supplied by each `Wait` call shall be the maximum timeout before `Wait` returns with the appropriate return code and its state machine is removed from the collection. The state machine of each `Wait` coordinates the `lock_timeout` values provided in requests by the state machine to secure the lock on the mutex in such a way as to produce the following overall timeout behavior. `lock_timeout` values shall be selected such that the value is less than any unexpired time remaining on the `wait_timeout`.

11.12.2.3 State behavior specification

The state behavior of the mutex portion of the Condition Variable Service mechanism shall be as defined in Figure 30, for those mutex operations not dependent on the state of the predicate.



OperationName * means the input transaction_id matches the current transaction_id
OperationName# means the input transaction_id does not match the current transaction_id
UNLOCKED
LOCKED transaction_id = P
Lock from client Y / call returns with transaction_id = P
Lock from client X / starts lock_timeout timer on X, call blocks
TryLock from client Y / call returns with transaction_id = P
Unlock* and no clients blocked / call returns; transaction_id P no longer valid
Unlock* from client W and client X is blocked / return to client W; return to client X with transaction_id = Q; P changed to Q
lock_timeout on blocked client X call expires / return to client X with return code= MJ_OPERATION_TIMEOUT
Unlock or ForceAcquireLock, or SetPredicateState, or SignalOne, or SignalAll or ClearAllPendingWaits / return code= MJ_SERVIVE_UNAVAILABLE
Unlock# or SetPredicateState#, or SignalOne#, or SignalAll# or ClearAllPendingWaits# / return code= MJ_ILLEGAL_TRANSACTION
IsLocked / returns FALSE
IsLocked / returns TRUE
ForceAcquireLock from client W / returns with transaction_id Q: P changed to Q
SignalOne*, SignalAll*, or ClearAllPendingWaits* from client W
TryLock / return code= MJ_SERVICE_UNAVAILABLE

Figure 30—Predicate independent mutex state machine for a Condition Variable Service

The state behavior of the mutex portion of the Condition Variable Service mechanism shall be as defined in Figure 31, for those mutex operations that are dependent on the state of the predicate.

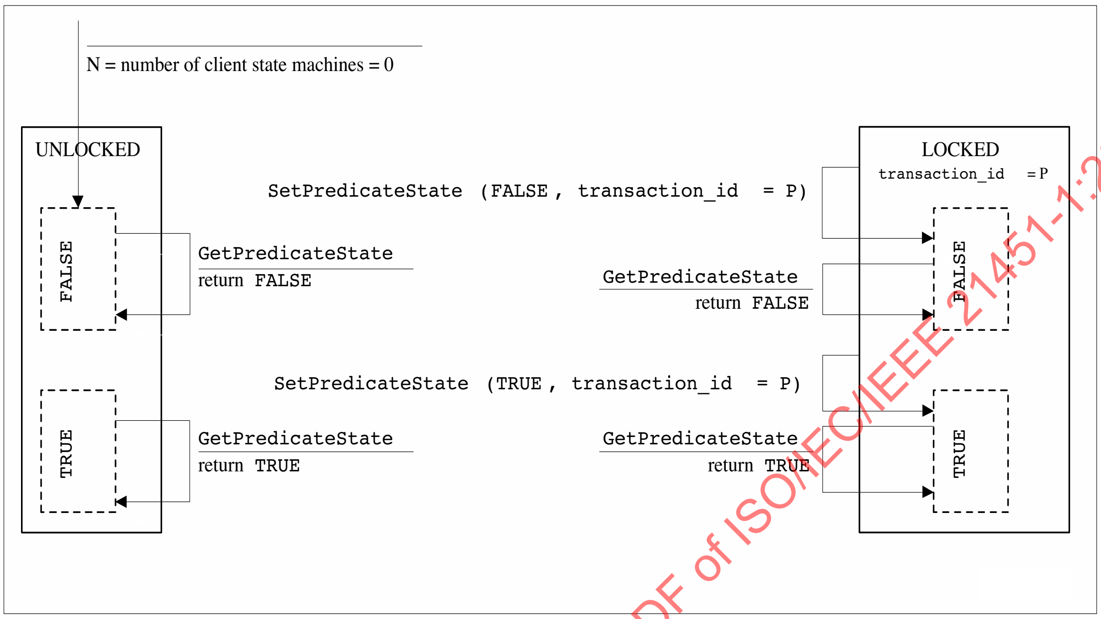


Figure 31 — Predicate dependent mutex state machine for a Condition Variable Service

When a client invokes the `Wait` operation on the Condition Variable Service, a thread of control defined by the state machine in Figure 32 shall be established as a member of the collection. This thread of control makes `Lock`, `Unlock`, and `GetPredicateState` calls on the mutex associated with the Condition Variable Service.

There may be N such state machines in the collection running concurrently where N is implementation-specific. When the Condition Variable Service Object is instantiated, the default predicate state shall be UNLOCKED and there shall be no pending `Wait` state machines in the collection.

The state machines that are members of the collection, each of which represents a `Wait`, call on the Service shall behave as defined in Figure 32.

Unless otherwise indicated in the state diagram, when calls return the `MajorReturnCode` field shall be `MJ_COMPLETE` and the `MinorReturnCode` field shall be `MI_NO_ADDITIONAL_INFORMATION`.

All state transitions for the `IEEE1451_ConditionVariableService` shall be atomic. Where there are multiple actions associated with the transition, the result of the transition shall be exactly as though these actions executed without interference from Concurrent Execution of any operation on any object in the process space.

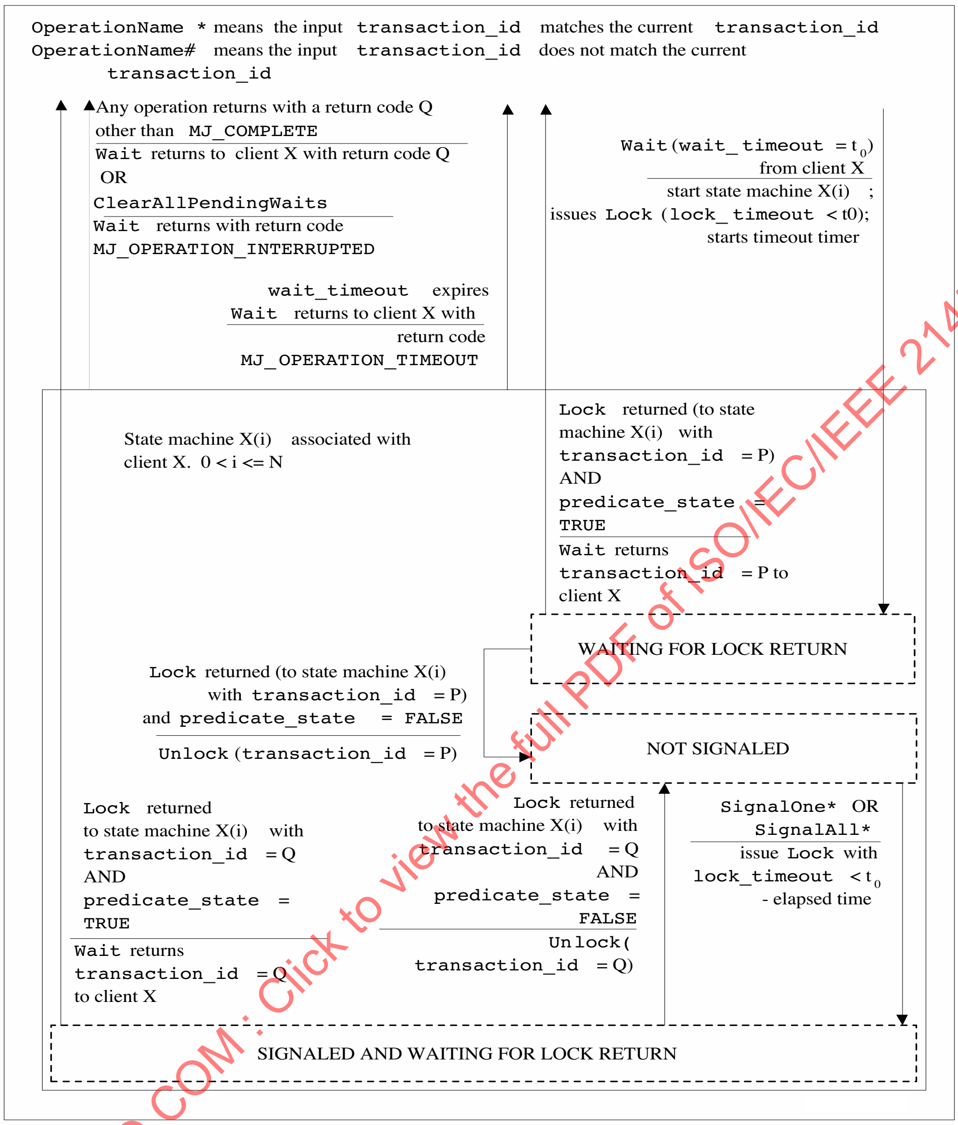

OperationName * means the input transaction_id matches the current transaction_id
OperationName# means the input transaction_id does not match the current transaction_id
Any operation returns with a return code Q other than MJ_COMPLETE
Wait returns to client X with return code Q
OR
ClearAllPendingWaits
Wait returns with return code MJ_OPERATION_INTERRUPTED
wait_timeout expires
Wait returns to client X with return code MJ_OPERATION_TIMEOUT
Wait(wait_timeout = t0) from client X
start state machine X(i); issues Lock (lock_timeout < t0); starts timeout timer
State machine X(i) associated with client X. 0 < i <= N
Lock returned (to state machine X(i) with transaction_id = P) AND predicate_state = TRUE
Wait returns transaction_id = P to client X
WAITING FOR LOCK RETURN
Lock returned (to state machine X(i) with transaction_id = P) and predicate_state = FALSE
Unlock(transaction_id = P)
NOT SIGNALED
Lock returned to state machine X(i) with transaction_id = Q AND predicate_state = TRUE
Wait returns transaction_id = Q to client X
Lock returned to state machine X(i) with transaction_id = Q AND predicate_state = FALSE
Unlock(transaction_id = Q)
SignalOne* OR SignalAll*
issue Lock with lock_timeout < t0 - elapsed time
SIGNALED AND WAITING FOR LOCK RETURN

Figure 32—Wait state machine for a Condition Variable Service

12. Publication semantics

12.1 Overview

12.1.1 Main components of publications

Publications have four main components

— A Publication Key that may be used to define syntax and semantics of the publication

— A Publication Topic that may be used to further define syntax and semantics or may be used to define the semantics of the interaction between Publishers and Subscribers with respect to acceptance of publications

— Publication Contents that may be used to contain application or class-specific information

— A Publication Domain that defines the distribution scope for the publication

12.1.2 Selection of publications by subscribers

Subscriber Ports select publications on the basis of three main selectors

— A Subscription Key that is used to select against Publication Key values

— A Subscription Qualifier that may be used to select against Publication Topic values

— A Subscription Domain that defines the acceptance scope for receiving publications

12.2 Publishing operational behavior

The behavioral steps of this clause shall be implemented consistent with the memory management specifications of Clause 15. Encoding and decoding shall follow the rules of Clause 14.

The Argument Array, `publication_contents` passed to the Port by the Publisher shall be of the correct length to properly accommodate the contents. The number, type, and semantics of the member Arguments of the Argument Array `publication_contents` are publication-specific.

For Self Identifying Publisher Ports, the Port augments the received `publication_contents` Argument Array with Port-specific information to complete the encoding of the Publication Contents.

The Port shall pass the Publication Contents Argument Array to the underlying network infrastructure to be published.

The network infrastructure supporting the Publisher Port shall be responsible for marshaling

— The Publication Contents

— The Publication Topic

— The Publication Key

— The Publication Domain

into the on-the-wire representation appropriate for the underlying network communications.

The issuance of publications shall depend on the values of the Publication Domain, the Publication Key, and possibly the Publication Topic, according to the rules specified in Table 134. The return code columns indicate the values for the fields of the `OpReturnCode` of the publish semantics operation initiating the publication`.`

If permitted by the above constraints, the invocation of a local operation with publish semantics shall cause the issuance of a publication with the Publication Topic and Publication Key defined for the Port and Publication Contents defined by the caller. The publication shall be published into the Publication Domain defined for the Port.

Table 134—Publication rules

Publication Domain	Publication Key	Publication Topic	Publication shall be issued	Major Return Code (Minor Return Code)
EMPTY_DOMAIN	Any value	Any value	NO	MJ_SERVICE_UNAVAILABLE (PC_EMPTY_DOMAIN)
Not the EMPTY_DOMAIN	PSK_NOT_SET	Any value	NO	MJ_SERVICE_UNAVAILABLE (PC_KEY_NOT_SET)
Not the EMPTY_DOMAIN	Any "terminal = no" value except PSK_NOT_SET	Any value except NOT_SET	YES	MJ_COMPLETE or as appropriate. (MI_NO_ADDITIONAL_INFORMATION or as appropriate.)
Not the EMPTY_DOMAIN	Any "terminal = no" value except PSK_NOT_SET	NOT_SET	NO	MJ_SERVICE_UNAVAILABLE (PC_TOPIC_NOT_SET)
Not the EMPTY_DOMAIN	Any "terminal = yes" value	Any value except NOT_SET	NO	MJ_SERVICE_UNAVAILABLE (PC_TOPIC_NOT_SET)
Not the EMPTY_DOMAIN	Any "terminal = yes" value	NOT_SET	YES	MJ_COMPLETE or as appropriate. (MI_NO_ADDITIONAL_INFORMATION or as appropriate)

12.3 Structure of publications

12.3.1 Publication Contents

The contents of a publication shall be of type ArgumentArray. The TypeCode and value of each member Argument of the Argument Array are specific to each publication.

12.3.2 Publication Keys and Subscription Keys

Values of Publication Key and Subscription Key shall be taken from the enumeration PubSubKey.

Values of Publication Key and Subscription Key indicated in the PubSubKey enumeration shown in Table 135 as Fixed Key = no, may

— Be set when the Publisher or Subscriber Port is instantiated

— Be set by Publishers or Subscribers via a implementation-specific local calls to the Publisher or Subscriber Ports, respectively

— Be modified by Publishers or Subscribers via implementation-specific local calls to the Publisher or Subscriber Ports, respectively

The behavior of systems where Publication Key or Subscription Key values have been modified after a system has been configured is outside the scope of this standard. Such modification is not recommended.

Values of Publication Key or Subscription Key, indicated in the PubSubKey enumeration shown in Table 135 as Fixed Key = yes, shall

— Be set when the Publisher or Subscriber Ports, respectively, are instantiated

— Not be modified

Publication Key and Subscription Key shall have a default value: PSK_NOT_SET.

The Publication Key value PSK_ANY_KEY shall not be used.

The Subscription Key value `PSK_ANY_KEY` should be used with caution. The behavior of systems where this value is used is outside the scope of this standard.

IDL: enumeration `PubSubKey;`

Table 135—`PubSubKey` enumeration

Enumeration	Value	Fixed Key	Terminal
PSK_NOT_SET	0	No	No
PSK_USER_DEFINED_PUBLICATION_TOPIC	1	No	No
PSK_NCAPBLOCK_ANNOUNCEMENT	2	Yes	Yes
PSK_NETWORK_VISIBLE_SERVER_OBJECT_PROPERTIES	3	Yes	Yes
PSK_REQUEST_NCAPBLOCK_ANNOUNCEMENT	4	Yes	Yes
PSK_FORCE_NCAPBLOCK_ANNOUNCEMENT	5	Yes	Yes
PSK_REQUEST_NETWORK_VISIBLE_SERVER_OBJECT_PROPERTIES	6	Yes	Yes
PSK_NCAPBlOCK_GO_ACTIVE	7	Yes	No
PSK_TIMER_TICK	8	No	No
PSK_REQUEST_TIMER_PROPERTIES	9	No	No
PSK_TIMER_PROPERTIES	10	No	No
PSK_PHYSICAL_PARAMETRIC_DATA	11	No	No
Reserved	12–63		
PSK_USER_DEFINED_PUBLISHER_IDENTIFYING_PUBLICATION	64	No	No
PSK_EVENT_NOTIFICATION	65	No	No
PSK_PHYSICAL_PARAMETRIC_DATA_PUBLISHER_IDENTIFYING	66	No	No
Reserved	67–127		
Open to industry	128–191		
Open to industry	192–254		
PSK_ANY_KEY	255	Yes	No

12.3.3 Publisher Port restrictions based on Publication Keys

The class of Publisher Port used for each Publication Key shall be defined by Table 136.

Publications with Publication Key values of Port class A in this table shall use ports of class `IEEE1451_PublisherPort` or a subclass thereof.

Publications with Publication Key values of Port class B in this table shall use ports of class `IEEE1451_SelfIdentifyingPublisherPort` or a subclass thereof.

12.3.4 Publication Topics and Subscription Qualifiers

Both Publication Topic and Subscription Qualifier are of type `OctetArray`.

Table 136—Publisher Key, Port Class relationship

PubSubKey enumeration	Value	Port class
PSK_NOT_SET	0	N/A
PSK_USER_DEFINED_PUBLICATION_TOPIC	1	A
PSK_NCAPBLOCK_ANNOUNCEMENT	2	
PSK_NETWORK_VISIBLE_SERVER_OBJECT_PROPERTIES	3	
PSK_REQUEST_NCAPBLOCK_ANNOUNCEMENT	4	
PSK_FORCE_NCAPBLOCK_ANNOUNCEMENT	5	
PSK_REQUEST_NETWORK_VISIBLE_SERVER_OBJECT_PROPERTIES	6	
PSK_NCAPBLOCK_GO_ACTIVE	7	
PSK_TIMER_TICK	8	
PSK_REQUEST_TIMER_PROPERTIES	9	
PSK_TIMER_PROPERTIES	10	
PSK_PHYSICAL_PARAMETRIC_DATA	11	
Reserved	12–63	
PSK_USER_DEFINED_PUBLISHER_IDENTIFYING_PUBLICATION	64	B
PSK_EVENT_NOTIFICATION	65	
PSK_PHYSICAL_PARAMETRIC_DATA_PUBLISHER_IDENTIFYING	66	
Reserved	67–127	
Open to industry	128–191	A
Open to industry	192–254	B
PSK_ANY_KEY	255	N/A

The default value for the Publication Topic and the Subscription Qualifier shall be the zero length Octet Array. This default value shall be interpreted as the NOT_SET value.

Publisher Ports and Subscriber Ports that have keys indicated as “terminal = yes” in the `PubSubKey` enumeration shown in Table 135 shall restrict the values of their Publication Topic and Subscription Qualifier to the NOT_SET value.

For those that have keys indicated as “terminal = no”, Publication Topic and Subscription Qualifier shall be available for definition and use by IEEE 1451.1 component and application developers.

The values for each octet in a Publication Topic or Subscription Qualifier may assume any value.

Publication Topic and Subscription Qualifier octet values selected from the `Wildcard` enumeration shown in Table 137 have special meaning with respect to the matching criteria.

IDL: enumeration `Wildcard;`

Table 137—Wildcard enumeration

Enumeration	Value	Meaning
`WC_ANY_OCTET`	254	Wildcard: match to any octet.
`WC_ANY_OCTET_ARRAY`	255	Wildcard: match to any Octet Array.
Reserved	0–253	

12.3.4.1 Matching criteria used to select publications

A Subscriber Port shall accept a publication if and only if

— The Domain Match = MATCH

AND

— The Key Match = MATCH

AND

— The Topic Match = MATCH

The value of Domain Match is defined in 12.3.5.

The value of Key Match shall be as defined in the Key Match Table 138.

Table 138—Key Match

Subscription Key value	Key Match
`PSK_NOT_SET`	NO MATCH
Not the same value as the Publication Key.	NO MATCH
Same value as the Publication Key, but not `PSK_NOT_SET.`	MATCH
`PSK_ANY_KEY`	MATCH

An octet O_P in a Publication Topic shall match an octet O_S in a Subscription Qualifier as indicated in Table 139.

Table 139—Topic, Qualifier match table

$O_S \backslash O_P$	WC_ANY_OCTET	WC_ANY_ OCTET_ARRAY	Octet does not exist	Any other value
`WC_ANY_OCTET`	MATCH	MATCH	NO MATCH	MATCH
`WC_ANY_OCTET_ARRAY`	MATCH	MATCH	MATCH	MATCH
Octet does not exist	NO MATCH	MATCH	MATCH	NO MATCH
Any other value	MATCH	MATCH	NO MATCH	MATCH iff $O_P = O_S$

For the default Subscription Qualifier value, NOT_SET, the “Octet does not exist” condition shall apply to all octets.

The value of the “Topic Match” condition shall be defined by the following algorithm:

Step 1: Start at the 0th Octet of both the Publication Topic and the Subscription Qualifier, do an Octet-to-Octet match.

Step 2: Continue matching until

— There is a nonmatch. In this case, the overall topic-to-qualifier match fails

— There is a match and at least one of the Octets is WC_ANY_OCTET_ARRAY. In this case, the overall topic-to-qualifier match succeeds

— All of the Octets match pairwise. In this case, the overall topic-to-qualifier match succeeds.

NOTE—The combinations of Publication Key and Publication Topic values in 12.2 preclude the issuance of a publication that is of no concern to the subscription acceptance algorithm.

Table 139 illustrates the operation of the topic-matching algorithm.

Table 139—Match example

Topic (or qualifier)	**ABC**	**ABCD**	**ABCD**	*****	**ABCD**	**ABCD**	**ABCD**	**NOT_SET**	**AB**	**AB**
Qualifier (or topic)	ABC	ABC	A??D	Any value	A*	B*	???	A?*	ABC*	AB*
Match ?	YES	NO	YES	YES	YES	NO	NO	NO	NO	YES

* = WC_ANY_OCTET_ARRAY
? = WC_ANY_OCTET
“Topic” refers to a Publication Topic and “Qualifier” refers to a Subscription Qualifier.

12.3.4.2 Restrictions on Publication Topic and Subscription Qualifier interpretation

There shall be no dependency on the interpretation of each octet of the Octet Array assumed by any operation or publication form under this standard outside those interpretations defined in Clause 12.

Any “print form” interpretation of the octet values of a Publication Topic or Subscription Qualifier is outside the scope of this standard.

NOTE—Publication Topics and Subscription Qualifiers are used in matching Publishers and Subscribers to establish the configurable aspects of publication. Configuration processes will need to compare or specify the Publication Topic of Publisher Ports and the Subscription Qualifier of Subscriber Ports. Users and configuration tool developers are cautioned to be sure that any implementation mappings of any human-readable forms of the Publication Topic or Subscription Qualifier onto the underlying Octet Array do not introduce ambiguities in the matching criteria. Of particular concern are the multiple ways of representing the same print form in some of the ISO 10646 multiple octet character sets [ISO/IEC 10646-1: 1993 and ISO/IEC DIS 10646-2].

12.3.5 Domains

Publication Domain and Subscription Domain values are of type PubSubDomain that is represented by 64 bit fields. Each of these bits shall correspond to a single logical Domain. The management of Domains is outside the scope of this standard.

The FULL_DOMAIN shall correspond to all bits set to TRUE. An EMPTY_DOMAIN shall correspond to all bits set to FALSE. The FULL_DOMAIN shall be the default value for Domains.

The match condition "Domain Match" between a Publication Domain and a Subscription Domain shall be MATCH if, and only if, the bitwise AND operation on the two Domains is TRUE. That is if, and only if, the logical intersection of the publication and subscription Domains is not the EMPTY_DOMAIN.

The purpose of Domains is to provide a scope for publications.

13. Defined publications

The following are publications not otherwise defined in connection with a class.

13.1 Publication `Timer_Tick` specification

Description: The `Timer_Tick` publication is used to distribute the occurrence of time intervals measured on the clock of the publisher to other objects in the system.

Publication Key: `PSK_TIMER_TICK`

Publication Topic: User-defined

Publisher Port Object Name: It is recommended that the Port Object Name be `Timer_Tick`

If the Port's name is `Timer_Tick` or `Timer_TickX`, where X is an ordinal number, the Publisher Port's Object Name shall be represented in the IEEE 1451.1 character set defined in Annex F.

13.1.1 Publication Contents

The Arguments of the Publication Contents Argument Array structure shall be as shown in Table 141.

Table 141—`Timer_Tick` Publication Contents

Argument Array Member	Member Argument TypeCode corresponding to type	Argument Name
0	`UInteger32`	`major_tick_number`
1	`UInteger32`	`minor_tick_number`
2	`TimeRepresentation`	(Optional) `last_major_tick_timestamp`

13.1.1.1 argument `major_tick_number` specification

The value of `major_tick_number` shall order events defining major time intervals.

13.1.1.2 argument `minor_tick_number` specification

The value of `minor_tick_number` shall order events defining minor time intervals.

13.1.1.3 argument `last_major_tick_timestamp` specification

The value of the optional `last_major_tick_timestamp` shall specify the time of occurrence of the major time interval designated by the current `major_tick_number.` The `last_major_tick_timestamp` shall

— Specify the time of occurrence of the major time interval designated by the current `major_tick_number`

— Be relative to the `epoch`; see 13.2.1

13.1.2 Publication `Timer_Tick` behavior

This `Timer_Tick` publication shall be used if a pattern of major and minor time intervals is to be established within a Publication Domain. Such a pattern shall consist of ordered events separated by a time interval `duration_of_major_tick`. The specification of means for generating such time intervals is outside the scope of this standard.

The major time interval shall be divided into `number_of_minor_ticks_per_major_tick` equally spaced ordered events. The `minor_tick_number` shall be zero for the minor tick interval which starts at a major tick event.

NOTE—The largest `minor_tick_number` is therefore one less than the `number_of_minor_ticks_per_major_tick`.

13.2 Publication `Timer_Properties` specification

Description: The `Timer_Properties` publication is used to distribute the additional data, describing the properties of the time intervals distributed by the `Timer_Tick` publication.

Publication Key: `PSK_TIMER_PROPERTIES`

Publisher Port Object Name: It is recommended that the Port's Object Name be `Timer_Properties`

If the name is `Timer_Properties` or `Timer_PropertiesX,` where X is an ordinal number, the Publisher Port's Object Name shall be represented in the IEEE 1451.1 character set defined in Annex F.

13.2.1 Publication Contents

The Argument members of the Publication Contents Argument Array shall be shown in Table 142.

13.2.1.1 argument `major_tick_number` specification

The value of `major_tick_number` shall order events defining major time intervals.

13.2.1.2 argument `minor_tick_number` specification

The value of `minor_tick_number` shall order events defining minor time intervals.

13.2.1.3 argument `last_major_tick_timestamp` specification

The value of `last_major_tick_timestamp` shall be the value of the time of occurrence of the last major tick event. If the time of occurrence is not available, the default value for the

Table 142—`Timer_Properties` Publication Contents

Argument Array Member	Member Argument TypeCode corresponding to type	Argument Name
0	`UInteger32`	`major_tick_number`
1	`UInteger32`	`minor_tick_number`
2	`TimeRepresentation`	`last_major_tick_timestamp`
3	`TimeRepresentation`	`duration_of_major_tick`
4	`UInteger32`	`number_of_minor_ticks_per_major_tick`
5	`UInteger8`	`epoch_representation`
6	`TimeRepresentation`	`epoch`
7	`Uncertainty`	`time_uncertainty`

`TimeRepresentation` type encoded into the argument `last_major_tick_timestamp` shall be used.

13.2.1.4 argument `duration_of_major_tick` specification

The value of `duration_of_major_tick` shall be the time interval between major ticks.

13.2.1.5 argument `number_of_minor_ticks_per_major_tick` specification

The value of `number_of_minor_ticks_per_major_tick` shall be the number of minor ticks between each major tick.

13.2.1.6 argument `epoch_representation` specification

The allowed values for the value of `epoch_representation` shall be defined by the `TimeEpoch` enumeration shown in Table 143. This enumeration defines the method of specifying the epoch (origin of the timescale) on which the values of `last_major_tick_timestamp` are based.

IDL: enumeration `TimeEpoch;`

Table 143—TimeEpoch enumeration

Enumeration	Value	Meaning
`TE_NOT_DEFINED`	0	The epoch is either not defined or not known.
`TE_UTC`	1	The epoch shall be the UTC defined epoch.
`TE_USER_DEFINED`	2	The epoch shall be defined by the user.
Reserved	3–127	
Open to industry	128–255	

13.2.1.7 argument epoch specification

The value of epoch shall be the origin of the timescale on which the values of last_major_tick_timestamp are based.

For an epoch_representation value of TE_UTC, the epoch is 0h MJD 40587.0, which corresponds to the time 0h on 1 January 1970 according to the Gregorian calendar [B7].

13.2.1.8 argument time_uncertainty specification

The value of time_uncertainty shall be an Uncertainty data structure and shall represent the error bounds on the all times associated with Timer_Tick publications. The time_uncertainty shall be based on time expressed in seconds.

13.2.2 Publication Timer_Properties behavior

The Timer_Properties publication shall be issued once for each receipt via a suitable Subscriber Port of the publication Request_Timer_Properties.

13.3 Publication Request_Timer_Properties specification

Description: The Request_Timer_Properties publication is used to request the publication of Timer_Properties.

Publication Key: PSK_REQUEST_TIMER_PROPERTIES

Publication Topic: User-defined

Publisher Port Object Name: It is recommended that the Port's Object Name be Request_Timer_Properties

If the name is Request_Timer_Properties or Request_Timer_PropertiesX where X is an ordinal number, the Publisher Port's Object Name shall be represented in the IEEE 1451.1 character set defined in Annex F.

13.3.1 Publication Contents

This publication shall not have any contents.

13.3.2 Publication Request_Timer_Properties behavior

The Timer_Properties publication shall be issued once for each receipt via a suitable Subscriber Port of the publication Request_Timer_Properties.

13.4 Publication Physical_Parametric_Data specification

Description: The Physical_Parametric_Data publication is used to distribute data that, in a client-server model, would be represented by an Object whose class is a subclass of IEEE1451_PhysicalParameter or a group of such Objects.

Publication Key: PSK_PHYSICAL_PARAMETRIC_DATA

Publication Topic: User-defined

Publisher Port Object Name: It is recommended that the Port's Object Name be `Physical_Parametric_Data`

If the name is `Physical_Parametric_Data` or `Physical_Parametric_DataX`, where X is an ordinal number, the Publisher Port's Object Name shall be represented in the IEEE 1451.1 character set defined in Annex F.

13.4.1 Publication Contents for a single Parameter

The Argument elements of the Publication Contents Argument Array structure shall be shown in Table 144.

Table 144—`PHYSICAL_PARAMETRIC_DATA` Single parameter Publication Contents

Argument Array Member	Member Argument TypeCode corresponding to type	Argument Name
0	`UInteger8`	`content_code`
1	`PhysicalParameterData`	`physical_parameter_data`
2	`PhysicalParameterMetadata`	`physical_parameter_metadata`

13.4.1.1 argument `content_code` specification

The value of `content_code` shall be a member of the following subset of the `PublicationContentCode` enumeration (see 11.8.3.4.3):

— `PCC_NORMAL_DATA`

— `PCC_METADATA`

— `PCC_BOTH_META_AND_NORMAL_DATA`

13.4.1.2 argument `physical_parameter_data` specification

The value of `physical_parameter_data` shall be a `PhysicalParameterData` union structure containing the published value of the Parameter. This union has as discriminant the `PhysicalParameterType` of the Physical Parameter whose information is being published. The value of the union is either a `PhysicalParameterSingletonData` structure or a `PhysicalParameterSeriesData` structure.

The value of `physical_parameter_data` shall be the `PhysicalParameterData` union structure returned as the 0th member of the output Argument Array returned by a `Read` operation on the Parameter whose value is being published.

This member Argument of the publication shall be the Argument with `TypeCode EMPTY_TC` in the case where the `content_code` Argument value is `PCC_METADATA`.

13.4.1.3 argument `physical_parameter_metadata` specification

The value of `physical_parameter_metadata` shall be a `PhysicalParameterMetadata` union structure containing the published value of the Parameter's metadata. This union has as discriminant the `PhysicalParameterType` of the Physical Parameter whose information is being published. The published physical_parameter_metadata shall be the same as that obtained by a GetMetadata on the Physical Parameter.

This member Argument of the publication shall not be present in the case where the content_code is PCC_NORMAL_DATA. That is, in this case the publication's content consists of a two element Argument Array whose first element contains the content_code PCC_NORMAL_DATA and whose second element contains the physical_parameter_data for the Parameter.

13.4.2 Publication Contents for multiple Parameters

The Argument elements of the Publication Contents Argument Array structure shall be shown in Table 145.

Table 145—Physical_Parameter_Data multiple parameter Publication Contents

Argument Array Member	Member Argument TypeCode corresponding to type	Argument Name
0	UInteger8	content_code
1	ArgumentArray	physical_parameter_datums
2	PhysicalParameterMetadataArray	physical_parameter_metadatums

13.4.2.1 argument content_code specification

The value of content_code shall be a member of the following subset of the PublicationContentCode enumeration (see 11.8.3.4.3):

— PCC_GROUPED_NORMAL_DATA

— PCC_GROUPED_METADATA

— PCC_GROUPED_BOTH_META_AND_NORMAL_DATA

13.4.2.2 argument physical_parameter_datums specification

The value of physical_parameter_datums shall be an Argument Array each element of which has as a value, a PhysicalParameterData union structure containing the published value of one of the Parameters in the group. The order of the Arguments in the Argument Array, that is the order of the group members' values, shall be the same for all publications of the specific Parameter group. This order is determined by the Publishers.

Each such PhysicalParameterData union structure contains the published value of a Parameter. This union has as discriminant the PhysicalParameterType of the Physical Parameter whose information is being published. The value of the union is either a PhysicalParameterSingletonData structure or a PhysicalParameterSeriesData structure.

The value of each such PhysicalParameterData union structure shall be the PhysicalParameterData union structure returned as the 0th member of the output Argument Array returned by a Read operation on the Parameter whose value is being published as this member Argument.

This member Argument of the publication shall be the Argument with TypeCode EMPTY_TC in the case where the content_code is PCC_GROUPED_METADATA.

13.4.2.2.1 argument `physical_parameter_metadatums` specification

The value of `physical_parameter_metadatums` shall be a `PhysicalParameterMetadataArray.` Each element of the Array is a `PhysicalParameterMetadata` union structure containing the metadata of one of the Parameters in the group. The ith element of `physical_parameter_metadatums` and the ith element of `physical_parameter_datums` shall correspond to the same group member Parameter. The contents of each element of the Array shall be the same as that obtained by a `GetMetadata` operation on the associated Physical Parameter.

This member Argument of the publication shall not be present in the case where the `content_code` is `PCC_GROUPED_NORMAL_DATA`.

13.5 Publication `Physical_Parametric_ Data_Publisher_Identifying` specification

Description: The `Physical_Parametric_Data_Publisher_Identifying` publication is used to distribute data that, in a client-server model, would be represented by an Object whose class is a subclass of `IEEE1451_PhysicalParameter` or a group of such Objects.

Publication Key:

`PSK_PHYSICAL_PARAMETRIC_DATA_PUBLISHER_IDENTIFYING`

Publication Topic: User-defined

Publisher Port Object Name: It is recommended that the Port's Object Name be `Physical_Parametric_Data_Publisher_Identifying.`

If the name is `Physical_Parametric_Data_Publisher_Identifying` or `Physical_Parametric_Data_Publisher_IdentifyingX`, where X is an ordinal number, the Publisher Port's Object Name shall be represented in the IEEE 1451.1 character set defined in Annex F.

13.5.1 Publication Contents for a single Parameter

The Arguments of the Publication Contents Argument Array structure shall be shown in Table 146.

Table 146—`Physical_Parametric_Data_Publisher_Identifying` single parameter Publication Contents

Argument Array Member	Argument Member TypeCode corresponding to type	Argument Name
0	`PublisherInformation`	`publisher_identification_information`
1	`UInteger8`	`content_code`
2	`PhysicalParameterData`	`physical_parameter_data`
3	`PhysicalParameterMetadata`	`physical_parameter_metadata`

The publisher_identification_information shall have value a PublisherInformation structure as defined in 11.8.3.4.1. The Array elements 1, 2, and 3 shall be the same as elements 0, 1, and 2 of a Physical_Parametric_Data publication, respectively, as defined in 13.4.1.

13.5.2 Publication Contents for multiple Parameters

The Arguments of the Publication Contents Argument Array structure shall be shown in Table 147.

Table 147—Physical_Parametric_Data_Publisher_Identifying multiple parameter Publication Contents

Argument Array Member	Argument Member TypeCode corresponding to type	Argument Name
0	PublisherInformation	publisher_identification_information
1	UInteger8	content_code
2	ArgumentArray	physical_parameter_datums
3	PhysicalParameterMetadataArray	physical_parameter_metadatums

The publisher_identification_information shall have a value PublisherInformation structure as defined in 11.8.3.4.1. The Array elements 1, 2, and 3 shall be the same as elements 0, 1, and 2 of a Physical_Parametric_Data publication, respectively, as defined in 13.4.2.

14. Encode and decode rules

14.1 Argument encoding and decoding

14.1.1 Client responsibilities

In an IEEE 1451.1 system client-server communication, the client shall be responsible for

— Encoding the input arguments appearing in the requested Server Object operation's signature. These input arguments shall be encoded from their primitive or derived datatypes into the Argument Array used as the input argument for the Execute or ExecuteAsynchronous call on the Client Port or Asynchronous Client Port, respectively, associated with the target Server Object

— Decoding the Argument Array returned from the Execute or GetResult call on the Client Port or Asynchronous Client Port, respectively. The returned Argument Array shall be decoded into the primitive or derived datatypes of the output arguments appearing in the target Server Object operation's signature

14.1.2 Server Object responsibilities

In an IEEE 1451.1 system client-server communication, the Server Object shall be responsible for

— Decoding the input Argument Array used in the call to its Perform operation into the primitive or derived datatypes appearing in the requested server operation's signature

— Encoding the output arguments appearing in the requested server operation's signature from their primitive or derived datatypes into the Argument Array used as the output arguments in the `Perform` call

14.1.3 Publisher responsibilities

In an IEEE 1451.1 system publish-subscribe communication, the Publisher shall be responsible for encoding a publication from its composition of primitive or derived datatypes to the Argument Array that is the `publication_contents` argument of a `Publish` or `PublishWithIdentification` operation.

14.1.4 Subscriber responsibilities

IEEE 1451.1 Application Subscribers shall be responsible for decoding a publication from the Argument Array `publication_contents` delivered as an argument of the callback operation to registered Subscribers back into the primitive or derived datatypes comprising the Publication Contents.

In order to support interoperability of IEEE 1451.1 NCAP nodes implemented in different processors, operating systems, and/or programming languages, the use of the algorithms specified in this clause to perform the encode/decode of the arguments appearing in the server operations and the publications specified in the IEEE 1451.1 standard shall be required.

The encode and decode algorithms for the arguments and publications specified in this standard are very simple since the datatypes of all arguments appearing in the signatures of IEEE 1451.1-defined operations and the members of all IEEE 1451.1-specified publications are IEEE 1451.1 datatypes.

For an IEEE 1451.1 subclass that defines operation signatures or publications using datatypes other than the IEEE 1451.1-specified primitive or derived datatypes, the subclass definition shall include the encoding and decoding algorithms for those signatures or publications. These algorithms shall encode or decode between the class-specific datatypes appearing in the signatures or publication and IEEE 1451.1 datatypes represented in the Argument Array used in client-server and publish-subscribe communications. If such a class-specific datatype includes as a member an IEEE 1451.1-specified primitive or derived datatype, the encoding and decoding algorithms for the class-specific datatype shall agree in their encoding and decoding of this member with the rules specified in Clause 14.

In Clause 14, the term “value of the Argument” shall be interpreted according to 6.2.14.

The declaration, storage allocation, and storage deallocation for all of datums related to argument and publication encoding and decoding shall follow the memory management rules of Clause 15.

14.2 Client-server argument encoding and decoding

NOTE—In implementing the encode/decode rules, note that 6.2.1 mandates that implementations provide a mechanism for knowing the length of arrays. This information will be needed in implementing the encode/decode mechanisms.

14.2.1 Client-side encoding and decoding rules

The signature of the remote operation being invoked by the client is of the following form:

```
OpReturnCode <Operation>(
           in type_0_in input_argument_0,
           ...,
           in type_i_in input_argument_i,
           ...,
           in type_last_in input_argument_last,
           out type_0_out output_argument_0,
           ...,
           out type_j_out output_argument_j,
           ...,
           out type_last_out output_argument_last);
```

The signatures of `Execute`, `ExecuteAsynchronous`, and `GetResult` are as follows:

```
ClientServerReturnCode Execute(
           in UInteger8 execute_mode,
           in UInteger16 server_operation_id,
           in ArgumentArray server_input_arguments,
           out ArgumentArray server_output_arguments);

OpReturnCode ExecuteAsynchronous(
           in UInteger16 server_operation_id,
           in ArgumentArray server_input_arguments,
           out UInteger16 transaction_id);

ClientServerReturnCode GetResult(
           in UInteger16 transaction_id,
           out ArgumentArray server_output_arguments);
```

Encoding:

Prior to the invocation by a client of the `Execute` or `ExecuteAsynchronous` operation on a Client Port or Asynchronous Client Port, respectively, the client shall use the following encoding algorithm to encode the input arguments for the requested server operation into the Argument Array, `server_input_arguments`.

Starting with `input_argument_0`

— The `TypeCode` field of the 0th member Argument of `server_input_arguments` shall be assigned the `TypeCode` corresponding to `type_0_in`

— The value of the 0th member Argument of `server_input_arguments` shall be assigned the value of `input_argument_0`

— Repeat in turn for each input Argument

Decoding:

Following the return to the client from the `Execute` or `GetResult` operation on the Client Port or Asynchronous Client Port, respectively, the client shall use the following decoding algorithm to decode the returned Argument Array, `server_output_arguments` into the server operation's output arguments.

Starting with the 0th member Argument of `server_output_arguments`

— The value of `output_argument_0` shall be assigned the value of that Argument. The value shall be represented in the datatype `type_0_out`.

— Repeat in turn for each output Argument.

14.2.2 Server-side encoding and decoding rules

The signature of the server operation being invoked by the client is that defined in 14.2.1.

The signature of `Perform` is of the following form:

```
ClientServerReturnCode Perform(
           in UInteger16 server_operation_id,
           in ArgumentArray server_input_arguments,
           out ArgumentArray server_output_arguments);
```

Decoding:

Following the call to `Perform` from the underlying network infrastructure, `Perform` shall use the following decoding algorithm to decode the Argument Array, `server_input_arguments`, passed to `Perform` into the target operations' input arguments.

Starting with the 0th member Argument of `server_input_arguments`

— The value of `input_argument_0` shall be assigned the value of that Argument. This value shall be represented in the datatype `type_0_in`

— Repeat in turn for each member Argument of `server_input_arguments`

Encoding:

Following the return to `Perform` from the server operation, `Perform` shall use the following encoding algorithm to encode the operations output arguments into the Argument Array, `server_output_arguments` passed to `Perform` by the underlying network infrastructure.

Starting with 0th member Argument of `server_output_arguments`

— The `TypeCode` field of the 0th member Argument of `server_output_arguments` shall be assigned the `TypeCode` corresponding to `type_0_out`

— The value of the 0th member Argument of `server_output_arguments` shall be assigned the value of `output_argument_0`

— Repeat in turn for each output Argument

14.3 Publish-side argument encoding

14.3.1 Publisher-side encoding rules

There are two publishing operations

— `Publish` on an Publisher Port

— `PublishWithIdentification` on a Self Identifying Publisher Port

Argument encoding for these two operations shall be as specified in the following clauses.

14.3.1.1 Publishing using the `Publish` operation

The contents of a publication published using the `Publish` operation on a Publisher Port Object consists of a sequence of publication members where each member is an IEEE 1451.1 primitive or derived datatype

```
type_0 publication_member_0,
...,
type_i publication_member_i,
...,
type_last publication_member_last
```

Here, `type_i` is the datatype of the ith publication member.

The signature of the `Publish` operation is as follows:

```
OpReturnCode Publish(in ArgumentArray publication_contents);
```

Prior to invoking the `Publish` operation, the Publisher shall be responsible for encoding the publication's publication members into the member Arguments of the Argument Array, `publication_contents`. The Publisher shall use the following algorithm to encode the Argument Array.

Encoding:

Starting with `publication_member_0`

— The `TypeCode` field of the 0th member Argument of the Argument Array shall be assigned the `TypeCode` corresponding to `type_0`

— The value of the 0th member Argument of the Argument Array shall be assigned the value of `publication_member_0`

— Repeat in turn for each publication member

14.3.1.2 Publishing using the `PublishWithIdentification` operation on a Self-Identifying Publisher Port

The contents of a publication published with the `PublishWithIdentification` operation on a Self-Identifying Publisher Port Object consists of (see 11.8.3.4)

— A datum of type `PublisherInformation` followed by

— A datum of type `UInteger8` representing a member of the `PublicationContentCode` enumeration giving the publication's `content_code` followed by

— A sequence of publication members where each member is an IEEE 1451.1 primitive or derived datatype

```
type_0 publication_member_0,
...,
type_i publication_member_i,
...,
type_last publication_member_last
```

Here, `type_i` is the datatype of the ith publication member.

The signature of the `PublishWithIdentification` operation on a Self Identifying Publisher Port is as follows:

```
OpReturnCode PublishWithIdentification(
           in ArgumentArray publication_contents);
```

Encoding:

Prior to invoking the PublishWithIdentification operation, the Publisher shall be responsible for encoding the publication's publication members into the member Arguments of the Argument Array, publication_contents. The Publisher shall use the following algorithm to encode the Argument Array:

Step 1: The Publisher defined fields, publicationID and publicationChangeID of the publisher_identification_information structure shall be assigned values as defined in 11.8.3.4.

Step 2: The TypeCode field of member Argument 0 of publication_contents shall be assigned the value PUBLISHER_INFORMATION_TC.

Step 3: The value of member Argument 0 of publication_contents shall be assigned the value of publisher_identification_information.

Step 4: The TypeCode field of member Argument 1 of publication_contents shall be assigned the value UINTEGER8_TC.

Step 5: The value of member Argument 1 of publication_contents shall be assigned the value of content_code.

Step 6: Starting with publication_member_0:

Step 7: The TypeCode field of the 2nd member Argument of publication_contents shall be assigned the TypeCode corresponding to type_0.

Step 8: The value of the 2nd member Argument of publication_contents shall be assigned the value of publication_member_0.

Step 9: Repeat Steps 7 and 8 in turn for each remaining publication member.

The Port shall be responsible for assigning and encoding the value of the portObjectTag member field of publisher_identification_information into the corresponding member field of member Argument 0 of the publication_contents Argument Array.

14.3.1.3 Publishing using the PublishWithIdentification operation on an Event Generator Publisher Port

The contents of a publication published with the PublishWithIdentification operation on an Event Generator Publisher Port Object (see 11.9.2.7.1) consists of

— A datum of type PublisherInformation

— A datum of type UInteger8 representing a member of the PublicationContentCode enumeration giving the publication's content_code

— A datum of type UInteger32 representing an event_sequence_number

— A datum of type ObjectTag representing the response_object_tag

— A datum of type TimeRepresentation representing the event_detection_time

— A datum of type String representing the event_name

— A sequence of zero or more optional publication members where each member is an IEEE 1451.1 primitive or derived datatype

```
type_0 optional_publication_member_0,
...,
type_i optional_publication_member_i,
...,
type_last optional_publication_member_last
```

Here, `type_i` is the datatype of the ith optional publication member.

The signatures of the `PublishWithIdentification` operation is as follows:

```
OpReturnCode PublishWithIdentification(

            in ArgumentArray publication_contents);
```

Encoding:

Prior to invoking the `PublishWithIdentification` operation, the Publisher shall be responsible for encoding the publication members into the member Arguments of the Argument Array, `publication_contents`. The Publisher shall use the following algorithm to encode the Argument Array.

Step 1: The Publisher defined fields, `publicationID` and `publicationChangeID` of the `publisher_identification_information` structure, shall be assigned values according to 11.8.3.4.

Step 2: The `TypeCode` field of member Argument 0 of `publication_contents` shall be assigned the value `PUBLISHER_INFORMATION_TC.`

Step 3: The value of member Argument 0 of `publication_contents` shall be assigned the value of `publisher_identification_information.`

Step 4: The `TypeCode` field of member Argument 1 of `publication_contents` shall be assigned the value `UINTEGER8_TC.`

Step 5: The value of member Argument 1 of `publication_contents` shall be assigned the value of `content_code`.

Step 6: The `TypeCode` field of member Argument 2 of `publication_contents` shall be assigned the value `UINTEGER32_TC.`

Step 7: The value of member Argument 2 of `publication_contents` shall be assigned by the publishing Port.

Step 8: The `TypeCode` field of member Argument 3 of `publication_contents` shall be assigned the value `OBJECT_TAG_TC.`

Step 9: The value of member Argument 3 of `publication_contents` shall be assigned by the publishing Port.

Step 10: The `TypeCode` field of member Argument number 4 `publication_contents` shall be assigned the value `TIME_REPRESENTATION_TC.`

Step 11: The value of member Argument 4 of `publication_contents` shall be assigned the value `event_detection_time.`

Step 12: The `TypeCode` field of member Argument number 5 of `publication_contents` shall be assigned the value `STRING_TC`.

Step 13: The value of member Argument 5 of `publication_contents` shall be assigned the value `event_name.`

Step 14: Starting with `optional_publication_member_0`:

Step 15: The `TypeCode` field of member Argument 6 of `publication_contents` shall be assigned the `TypeCode` corresponding to `type_0`.

Step 16: The value of member Argument 6 of `publication_contents` shall be assigned the value of `publication_member_0`.

Step 17: Repeat Steps 15 and 16 in turn for each remaining `optional_publication_member`.

The publishing Port shall be responsible for assigning and encoding the value of

— The `objectTag` member field of `publisher_identification_information` into the corresponding member field of member Argument 0 of the `publication_contents` Argument Array received from the Publisher.

— The `event_sequence_number` as the value of member Argument 2 of the `publication_contents` Argument Array received from the Publisher.

— The `response_object_tag` as the value of member Argument 3 of the `publication_contents` Argument Array received from the Publisher.

14.4 Subscriber-side argument decoding

The Subscriber declares a set of local variables for the received publication, identified by its Publication Key and Publication Topic. The publication members are

```
type_0 publication_member_0,
...,
type_i publication_member_i,
...,
type_last publication_member_last
```

Here, `type_i` is the `datatype` of the ith member in the publication.

The signature of the `local subscription callback` operations is

```
void(
  in UInteger16 subscription_id,
  in UInteger8 publishing_port_publication_key,
  in PublicationTopic
     publishing_port_publication_topic,
  in ArgumentArray publication_contents);
```

The number and the datatypes of publication members encoded in the Argument Array, `publication_contents`, is identified by

— The `publishing_port_publication_key`

— The `publishing_port_publication_topic`

The three publication types defined by this standard are publications published using

— A Publisher Port

— A Self Identifying Publisher Port

— An Event Generator Publisher Port

14.4.1 Decoding publications published from a Publisher Port

For publications published using a Publisher Port, `publication_contents` is an Argument Array with each member corresponding directly to the publication members.

14.4.2 Decoding publication published from a Self Identifying Publisher Port

For publications published using an Self Identifying Publisher Port, the Argument members of the Argument Array `publication_contents are` defined in Table 148 (see 11.8.3.4):

Table 148—Self Identifying Publication Contents

Argument Array Member	Member `TypeCode` corresponding to type	Argument Name
0	`PublisherInformation`	`publisher_identification_information`
1	`UInteger8`	`content_code`
Remaining members	Datatype of the corresponding publication member.	`application_specific_contents`

14.4.3 Decoding publications published from an Event Generator Publisher Port

For publications published using an Event Generator Publisher Port, the Argument members of the `publication_contents` Argument Array are defined in Table 149; see 11.9.2.7.1.

Table 149—Event Generator Publication Contents

Argument Member	Member `TypeCode` corresponding to type	Argument Name
0	`PublisherInformation`	`publisher_identification_information`
1	`UInteger8`	`content_code`
2	`UInteger32`	`event_sequence_number`
3	`ObjectTag`	`response_object_tag`
4	`TimeRepresentation`	`event_detection_time`
5	`String`	`event_name`
Remaining members	Datatype of the corresponding publication member.	`optional_arguments`

Decoding:

In all three cases, the Subscriber shall be responsible for decoding the Argument Array `publication_contents`.

Case 1:

If the value of the input argument, `publishing_port_publication_key`, of the Subscriber callback operation signifies that the publication was published via the `Publish` operation, the Subscriber shall use the following decoding algorithm to decode the Argument Array, `publication_contents`:

Starting with the 0th member Argument of `publication_contents:`

Step 1: The value of `publication_member_0` shall be assigned the value of the Argument. This value shall be represented in the datatype corresponding to `type_0.`

Step 2: Repeat in turn for each Argument member of `publication_contents.`

Case 2:

If the value of the input argument, `publishing_port_publication_key`, of the subscriber callback operation signifies that the publication was published via the `PublishWithIdentification` operation, using an Self Identifying Publisher Port, the Subscriber shall use the following decoding algorithm to decode the Argument Array, `publication_contents`:

Step 1: The value of a local variable of datatype `PublisherInformation` representing the Publisher's identification information shall be assigned the value of the 0th member Argument of `publication_contents.`

Step 2: The value of a local variable of datatype `UInteger8` representing the value of the publication's `content_code` shall be assigned the value of the 1st member Argument of `publication_contents.`

Step 3: Starting with the 2nd member Argument of `publication_contents`:

Step 3a: The value of `publication_member_0` shall be assigned the value of the Argument. This value shall be represented in the `datatype type_0`.

Step 3b: Repeat Step 3a in turn for each of the remaining member Arguments of `publication_contents.`

Case 3:

If the value of the input argument, `publishing_port_publication_key`, of the subscriber callback operation signifies that the publication was published via the `PublishWithIdentification` operation using an Event Generator Publisher Port, the Subscriber shall use the following decoding algorithm to decode the Argument Array, `publication_contents`:

Step 1: The value of a local variable of datatype `PublisherInformation` representing the `publisher_identification_information` shall be assigned the value of the 0th member Argument of `publication_contents`.

Step 2: The value of a local variable of datatype `UInteger8` representing the value of the publication's `content_code` shall be assigned the value of the 1st member Argument of `publication_contents.`

Step 3: The value of a local variable of datatype `UInteger32` representing the `event_sequence_number` shall be assigned the value of the 2nd member Argument of `publication_contents`.

Step 4: The value of a local variable of datatype `ObjectTag` representing the value of the `response_object_tag` shall be assigned the value of the 3rd member Argument of `publication_contents.`

Step 5: The value of a local variable of datatype `TimeRepresentation` representing the `event_detection_time` shall be assigned the value of the 4th member Argument of `publication_contents.`

Step 6: The value of a local variable of datatype `String` representing the value of the `event_name` shall be assigned the value of the 5th member Argument of `publication_contents.`

Step 7: Starting with the 6th member Argument of `publication_contents:`

Step 7a: The value of `optional_publication_member_0` shall be assigned the value of the Argument. This value shall be represented in the `datatype type_0.`

Step 7b: Repeat Step 7a in turn for each of the remaining member Arguments of `publication_contents`.

15. Memory management rules

15.1 Applicability of memory management rules

An implementation of IEEE 1451.1 in a programming language where the program is responsible for allocating and deallocating memory for nonprimitive datatypes shall adhere to the memory management rules defined in this clause.

15.2 In process memory management

Memory management for component interactions within a single NCAP process shall be the responsibility of IEEE 1451.1 implementers and IEEE 1451.1 application developers. The remainder of Clause 15 defines the memory management rules for network communication–related operations.

15.3 Simple datatype memory management

For the IEEE 1451.1 simple primitive datatypes defined in 6.1.1, any necessary memory management shall be the responsibility of the code block in which they are declared.

15.4 Nonsimple datatype memory management

The store for the nonsimple IEEE 1451.1 datatypes used in network communications shall be managed by the various components that participate in such communications.

15.4.1 Client-server memory management

The flow of data in a client-server network communication is illustrated in Figure 33.

The memory management responsibility assignments for components involved in client-server communications shall be as defined in Table 150. The responsibility assignments are the same for both synchronous and asynchronous client-server communications.

The key numbers are those given in Figure 33.

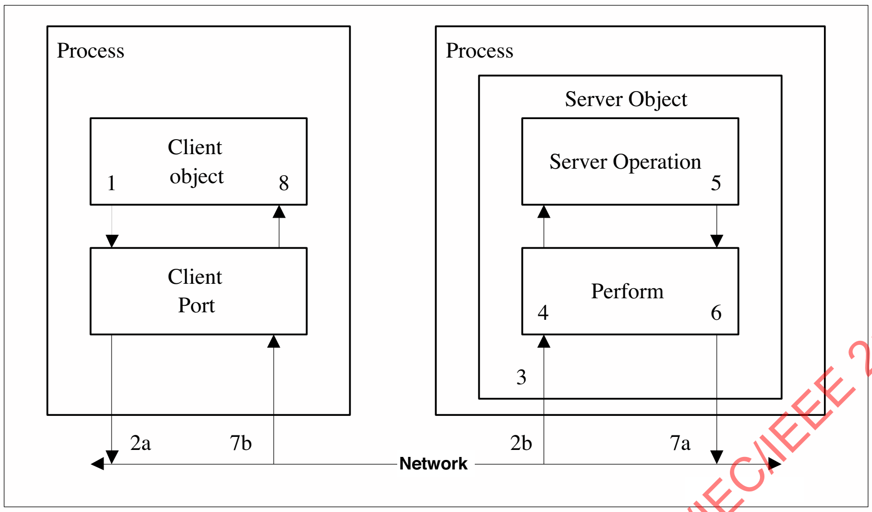


Figure 33—Client-server communication

15.4.2 Publish-subscribe memory management

The flow of data in a publish-subscribe network communication is illustrated in Figure 34.

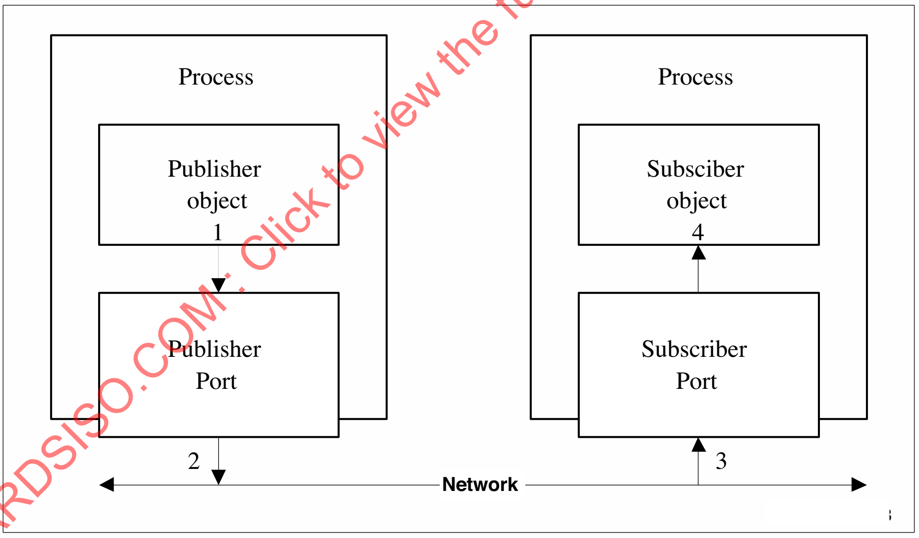


Figure 34—Publish-subscribe communication

The memory management responsibility assignments for components involved in publish-subscribe communications shall be as defined in Table 151. Table 151 applies to publications made using either ports of class `IEEE1451_PublisherPort`, or `IEEE1451_SelfIdentifyingPublisherPort` or subclasses thereof.

In the case of a Self Identifying Publisher Port, Table 151 specifies the memory management of the publication aspects of the communication. Any use of the self-identifying features use client-server communications and shall follow the memory management rules for such communications.

The key numbers are those given in Figure 34.

Table 150—Client-server memory management

Key #	Operation	Declaration responsibility	Store allocation responsibility	Store deallocation responsibility
1	Client: Invoke the Client Port's or Asynchronous Client Port's `Execute` or `ExecuteAsynchronous` operation, respectively	—Argument Array `server_input_arguments` —Member Arguments of `server_input_arguments` —Reference to Argument Array `server_output_arguments`	—Argument Array `server_input_arguments` —Member Arguments of `server_input_arguments`	
2a	Client-side Network Infrastructure: Marshal onto network	Intermediate store for marshaling data onto the network	Intermediate store for marshaling data onto the network	Intermediate store for marshaling data onto the network
2b	Server-side Network Infrastructure: Demarshal from network	Intermediate store for demarshaling data from the network	Intermediate store for demarshaling data from the network	Intermediate store for demarshaling data from the network
3	Server-side Network infrastructure: Invoke the Server Object's `Perform`	—Argument Array `server_input_arguments` —Member Arguments of `server_input_arguments` —Reference to Argument Array `server_output_arguments`	—Argument Array `server_input_arguments` —Member Arguments of `server_input_arguments`	
4	`Perform`: Invokes server operation	—Server operation input arguments —References to server operation output arguments	Server operation input arguments	
5	Server operation executes and return to `Perform`	Intermediate store for operation	Intermediate store for operation. Server operation output arguments if needed (e.g., argument not a simple datatype)	Intermediate store for operation
6	`Perform` returns to server-side network infrastructure	Member Arguments of `server_output_arguments`	—Argument Array `server_output_argument` —Member Arguments of `server_output_arguments`	—Server operation input arguments —Server operation output arguments (may delegate deallocation responsibility for heap allocated server output arguments to the Network Infrastructure in 7a)
7a	Server-side Network Infrastructure: Marshal onto network	Intermediate store for marshaling output data onto the network	Intermediate store for marshaling output data onto the network	—Argument Array `server_input_arguments` —Member Arguments of `server_input_arguments` —Intermediate store for marshaling output data onto the network —Argument Array `server_output_arguments` —Member Arguments of `server_output_arguments`
7b	Client-side Network Infrastructure: Demarshal from network	—Intermediate store for demarshaling output data from the network —Member Arguments of `server_output_arguments`	—Intermediate store for demarshaling output data from the network —Argument Array `server_output_arguments` —Member Arguments of `server_output_arguments`	Intermediate store for demarshaling data from the network
8	Client Port: Return to client			—Argument Array `server_input_arguments` —Member Arguments of `server_input_arguments` —Argument Array `server_output_arguments` —Member Arguments of `server_output_arguments`

Table 151—Publish-subscribe memory management

Key #	Operation	Responsibility
1	Publisher invokes `Publish` or `PublishWithIdentification` on the Publishing Port	The Publisher declares, allocates, and deallocates all store for the publication’s Publication Contents Argument Array.
2	Publishing side Network Infrastructure: Marshal onto network	The Publication side Network Infrastructure declares, allocates, and deallocates any intermediate store used in marshaling the publication onto the network.
3	Subscriber-side Network Infrastructure: Demarshal from network	The Subscriber-side Network Infrastructure declares, allocates, and deallocates any intermediate store used in demarshaling the publication from the network.
4	Subscriber Port: Callback Subscribers	The Subscriber Port declares and allocates the store for the received publication and invokes its subscribers’ callback operations. It deallocates the store for the received publication, but not until all of the callbacks to its Subscribers have returned.

15.4.3 Mutex and Condition Variable Service memory management

Mutex Service and Condition Variable Service Objects are application interfaces to IEEE 1451.1 implementation provided mutex and condition variable functionality, respectively. The management of the store for these Mutex Service and Condition Variable Services is outside of the scope of this standard.

16. Conformance

16.1 Conformance objective

The philosophy underlying the conformance requirements of this clause is to provide the structure necessary to raise the level of interoperability of systems built to this standard, while leaving opportunity open for continued technical improvement and differentiation.

An IEEE 1451.1-conformant system provides the following benefits, not usually found in nonconforming systems:

— A uniform design model for system implementation

— Portable Application System designs

— A uniform and network independent set of operations for system configuration

— Network-independent models for system communication

— A network-independent abstraction layer and encode decode rules that isolate applications from the details of network communications

— Network-independent models for implementing application functionality

— A uniform information model for representing physical parametric data

— Uniform models for managing and representing event data, parametric data, and bulk data

— Uniform models for managing and representing time

— Uniform models for intranode concurrency management and Components to manage internode concurrency

— Uniform models for memory management

In order not to unduly constrain application developers, in particular when integrating legacy systems with IEEE 1451.1 systems, IEEE 1451.1 conformance is defined for subsystems. Such a subsystem can constitute an entire system.

16.2 Definition of conformance terms

The following definitions for the following terms shall apply to all conformance clauses:

— IEEE 1451.1 class or subclass

— IEEE 1451.1 Object

— Subsystem

— Application subsystem

— Exists in the application subsystem

— Support

— IEEE 1451.X Transducer

— Communications

— IEEE 1451.1 Communication

— Network Communications

— Interact with the physical world

16.2.1 Conformance definition of the term IEEE 1451.1 class

The term “IEEE 1451.1 class” shall be interpreted as the class `IEEE 1451_Root` or any subclass thereof whether specified by this standard or by users.

16.2.2 Conformance definition of the term IEEE 1451.1 Object

The term “IEEE 1451.1 Object” shall mean an object whose class is an IEEE 1451.1 class.

16.2.3 Conformance definition of the term subsystem

The term “subsystem” of a system shall mean a subset of the system. Only a portion of the subsystem, possibly a null portion, need interact with other system entities. The subsystem may be the entire system.

16.2.4 Conformance definition of the term application subsystem

The term “application subsystem” shall mean all vendor- and user-supplied hardware, firmware, and software that implements or supports

— The end user application and application communications

— The configuration of the application and its application communications

— The maintenance of the application and its application communications

An application subsystem may include objects whose classes are user-defined subclasses of the IEEE 1451.1-specified classes as well as non-IEEE 1451.1 objects.

16.2.5 Conformance definition of the term exists in the application subsystem

For an IEEE 1451.1 Object in an application subsystem, the term “exists in the application subsystem” shall mean that

— The object is, or can be made operational in the application subsystem, see 5.1.3, via some sequence of operations

OR

— The object is or can be made operational in the application subsystem via a sequence of operations or procedures outside of the scope of this standard. The operations or procedures to be considered shall include but are not limited to power cycling of the device, the introduction of code in any form via any means, interaction with other objects, interaction with transducers, or by use of device-specific operator interfaces

16.2.6 Conformance definition of the term support

Given an application subsystem, the term “support” shall mean that for every IEEE 1451.1 Object that exists in the application subsystem all of the following conditions shall hold for the object’s class:

— The implementation of the class shall include

  — All of the IEEE 1451.1-required behavior for the class including all required behavior inherited from parent classes following the class hierarchy up to and including `IEEE1451_Root`

  — All of the IEEE 1451.1-required operations for the class including all operations inherited from parent classes following the class hierarchy up to and including `IEEE 1451_Root`

  — All of the IEEE 1451.1-required publications or subscriptions for the class including all publications or subscriptions inherited from parent classes following the class hierarchy up to and including `IEEE 1451_Root`

  — All non-class-specific requirements of the IEEE 1451.1 standard

— The IEEE 1451.1 datatypes specified in the signature of any Network Visible operation of the class or in the format of any publication processed by the class shall be encoded and decoded following the rules of Clause 14.

— Any user-defined datatypes that appear in the signature of a Network Visible operation of the class or in the format of any publication processed by the class shall be encoded and decoded to and from a sequence of datums of type `Argument`. They shall follow rules that shall be included as part of the class specification. This sequence of datums shall be assigned to specific elements of the appropriate Argument Array appearing in the signature of `Perform`, `Execute`, `ExecuteAsynchronous`, `GetResult,` or in the Publication Contents of a publication

— The implementation shall follow the Memory Management requirements of Clause 15.

There is no requirement that an implementation provide support for a class if no instance exists in the application subsystem.

16.2.7 Conformance definition of the term IEEE 1451.X Transducer

An "IEEE 1451.X Transducer" is a transducer based on one of the IEEE 1451 family of transducer interface standards, for example, [IEEE 1451.2]. The X refers to the suffix of the relevant standard.

16.2.8 Conformance definition of the term Communication

The term "Communication" shall mean the transfer of information between two objects in a system. The mechanism that provides this information transfer shall be termed the Communication infrastructure.

16.2.9 Conformance definition of the term IEEE 1451.1 Communication

The term "IEEE 1451.1 Communication" shall mean a Communication using mechanisms that shall be correctly interpreted by

— The `Perform` operation of an Object acting as a server whose class is a subclass of `IEEE1451_Entity`

— An Object whose class is a subclass of `IEEE1451_BaseClientPort`

— An Object whose class is a subclass of `IEEE1451_BasePublisherPort`

— An Object whose class is a subclass of `IEEE1451_SubscriberPort`

16.2.10 Conformance definition of the term IEEE 1451.1 Network Communications

The term "IEEE 1451.1 Network Communication" shall mean an IEEE 1451.1 Communication between objects in distinct process spaces either within a single NCAP or over the network between two NCAPs.

An IEEE 1451.1 Communication does not have to be an IEEE 1451.1 Network Communication, if both communication endpoints reside in the same process space; see 5.2.

An IEEE 1451.1 Communication between two process spaces in the same NCAP may use techniques such as shared memory not normally regarded as "networks." For purposes of conformance to this standard, all such techniques shall be regarded as networks and shall meet all of the conformance requirements associated with IEEE 1451.1 Network Communication.

16.2.11 Conformance definition of the term interaction with the physical world

The phrase "interaction with the physical world" shall be interpreted as a communication, in either direction, between an object in a process executing on an NCAP and a transducer, physically connected to that NCAP.

16.3 Conformance requirements

This clause defines the requirements that shall be met by a subsystem for it to be IEEE 1451.1 conformant.

16.3.1 Requirements for an IEEE 1451.1 subsystem

The overall requirements are stated in this clause and additional more detailed requirements are stated in 16.3.2, 16.3.3, 16.3.4, 16.3.5, 16.3.6, and 16.3.7.

A subsystem shall be deemed IEEE 1451.1-conformant if and only if

— The construction requirements of 16.3.2 are met

— The subsystem is constructed such that all objects in the subsystem Directly or Indirectly Owned by NCAP Block objects execute on NCAPs that are IEEE 1451.1 conformant according to 16.3.3

— All Network Communications involving the subsystem are implemented with IEEE 1451.1 conformant network implementations according to 16.3.7

— All networks used by the subsystem for IEEE 1451.1 Communications and that use a common network protocol shall also use the same on-the-wire format as the basis for marshaling and demarshaling of IEEE 1451.1 Communications

16.3.2 Construction requirements for IEEE 1451.1 conformance

An IEEE 1451.1 conformant subsystem shall meet the requirements of 16.3.2.1, 16.3.2.2, and 16.3.2.3.

16.3.2.1 Object ownership requirements

— Each subsystem code module shall execute in an NCAP process where the process contains precisely one instance of an `IEEE1451_NCAPBlock` class or subclass thereof. These NCAP Block instances shall be a part of the conformant subsystem.

— Any IEEE 1451.1 Object that is a part of the conformant subsystem and any non-IEEE 1451.1 object that is both part of the conformant subsystem and that participates in an IEEE 1451.1 Communication shall each be Directly or Indirectly Owned by the unique instance of an NCAP Block in each object's process space.

— Any object that is part of the conformant subsystem that interacts with the physical world shall be Directly or Indirectly Owned by the unique instance of an NCAP Block in each object's process space.

16.3.2.2 Interactions with the physical world

All conformant subsystem interactions with the physical world shall meet one of the following requirements:

— The interaction shall be between a transducer connected to an NCAP and an instance of a subclass of `IEEE1451_BaseTransducerBlock` executing in a process on the NCAP. The Transducer Block Object shall be a part of the conformant subsystem. This clause is intended for interactions with that portion of the physical world comprising those parts of the application plant being measured or controlled.

— The interaction shall be between a transducer connected to an NCAP and an instance of a subclass of `IEEE1451_Block` executing in a process on the NCAP. This instance Object shall be a part of the conformant subsystem. This clause is intended for interactions between a Function Block or an NCAP Block and that portion of the physical world comprising HMI transducers—e.g., keyboards, displays, printers, files—or other input or output devices not normally considered part of the plant.

16.3.2.3 Communications

All Communications involving an object that is part of a conformant subsystem shall meet the following requirements:

— If the object participates in an IEEE 1451.1 Communication then it shall be one of the following:

  — An instance of a subclass of `IEEE1451_Entity` acting as a server via its `Perform` operation
  OR

  - An instance of a subclass of `IEEE1451_BaseClientPort`
    OR
  - An instance of a subclass of `IEEE1451_BasePublisherPort`
    OR
  - An instance of the `IEEE1451_SubscriberPort` class or subclass thereof
- If the Communication is between the object that is part of the conformant subsystem and an object that is not part of the conformant subsystem, the Communication shall be an IEEE 1451.1 Communication
- If the Communication is between two objects each of which is a part of the conformant subsystem and the two objects reside in different processes, then the communication shall be an IEEE 1451.1 Network Communication

16.3.3 Requirements for IEEE 1451 NCAPs

An NCAP shall be deemed conformant to IEEE 1451.1 provided

- It supports each IEEE 1451.1 class for which an instance exists in the application subsystem.
- If any transducer implementing one of the IEEE 1451 family of transducer standards is used with the application subsystem, for example, [IEEE 1451.2], the application subsystem shall conform to the requirements of 16.3.6.
- It provides conformance documentation that meets the requirements of 16.3.4 for all supported classes.
- It supports the conformance requirements of 16.3.5 for the minimum configuration of an IEEE 1451.1 NCAP.

16.3.4 Conformance documentation requirements for supported classes

An implementation of the standard is always in the context of

- A specific NCAP with its operating system
- A specific network
- A specific programming language

The documentation requirements are given with respect to this implementation context.

In this clause, the implementation's programming language is denoted by $\mathcal{P}$.

16.3.4.1 Datatype and reference documentation

The datatype documentation requirements for a conformant IEEE 1451.1 implementation are

- For each primitive datatype defined in the standard, the mapping of that datatype to a datatype in $\mathcal{P}$ shall be documented.
- For each derived datatype defined in the standard, the mapping of that datatype to constructs in $\mathcal{P}$ shall be documented.
- For each application developer visible datatype used in the implementation which is not an IEEE 1451.1-specified datatype, the following documentation shall be provided:
  - The IDL specification of that datatype.

    — The mapping of the datatype to constructs in $\mathcal{P}$.
    — The encoding and decoding rules for the datatype. That is, the rules by which the datatype is encoded/decoded to/from a sequence of Argument datatypes.
- — For all application-developer-visible derived datatypes defined in the implementation
    - — If $\mathcal{P}$ uses header files (for example, $\mathcal{P}$ is C or C++), the implementation shall provide header files defining the derived datatypes.
    - — If $\mathcal{P}$ does not use header files but does use some type of interface construct for defining types (for example, $\mathcal{P}$ is Java), the implementation shall provide interface definitions defining the derived datatypes.
- — The implementation shall document how an application accesses the members of an IEEE 1451.1 Array datatype and obtain the Array's length.
- — The implementation shall document how an application determines prior to access, that an attempt to access the value of the IEEE 1451.1 discriminated union datatype will fail in the event that no value has been bound to the union's discriminate and value.
- — Unless $\mathcal{P}$ directly provides a mechanism for accessing the members of a derived datatype, the implementation shall describe how an application does access such members

The documentation requirements for references in a conformant IEEE 1451.1 implementation are

- — Documentation shall be provided for the syntax and the semantics of the implementation's network Object Dispatch Address reference type.
- — The mapping of the reference `<local object reference>` to a construct in $\mathcal{P}$ shall be documented.
- — The mapping of the reference `<local operation reference>` to a construct, or constructs, in $\mathcal{P}$ shall be documented.

16.3.4.2 Object class documentation

The object class documentation requirements for an IEEE 1451.1 implementation are

- — The implementation shall provide a list of all supported classes, both IEEE 1451.1-specified classes and implementation-provided specializations of those classes.
- — The implementation shall provide a list of all IEEE 1451.1-specified classes that are not supported.
- — If $\mathcal{P}$ supports either header files or some type of interface construct, the implementation shall provide header files or interface definitions for each application-developer-visible object class supported by the implementation. This includes, in particular, the IEEE 1451.1-specified classes.
- — If $\mathcal{P}$ supports neither header files or interface constructs, but does support other than pass-by-value calling semantics, then the implementation shall provide for each operation of each application-developer-visible object class supported by the implementation, the representation of the operation's arguments as they occur in an actual call to the operation.
- — For each implementation-provided specialization of an IEEE 1451.1-specified class, the implementation shall provide an IDL specification of the specialized class. For each implementation-provided specialization of an IEEE 1451.1-specified class, if the specialized class has operations in addition to those inherited from the parent class, the implementation shall provide a behavioral description for each such operation.
- — For each IEEE 1451.1-specified class that has optional operations, which of these optional operations have an Interface Only Implementation and which have Full Implementations shall be documented.