
**Health informatics — Personal health
device communication —**

Part 10207:

**Domain information and service
model for service-oriented point-of-
care medical device communication**

*Informatique de santé — Communication entre dispositifs de santé
personnels —*

*Partie 10207: Informations de domaine et modèle de services pour la
communication orientée services entre dispositifs médicaux sur le site
des soins*



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Abstract: Within the context of the ISO/IEEE 11073™ family of standards for point-of-care medical device communication, a Participant Model derived from the ISO/IEEE11073-10201 Domain Information Model is provided in this standard. The Participant Model specifies the structure of medical information objects. This standard also defines an abstract Communication Model to support the exchange of medical information objects. All elements of the Participant Model and Communication Model are specified using XML Schema. Core subjects of the Participant Model comprise modelling of medical device-related data, e.g., measurements and settings, alert systems, contextual information (e.g., patient demographics and location information), remote control, and archival information. Model extensibility is provided inherently through the use of XML Schema.

Keywords: alert systems, IEEE 11073-10207™, medical device communication, patient, point-of-care, remote control, service-oriented architecture, XML Schema

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Introduction

This introduction is not part of IEEE Std 11073-10207-2017, Health informatics—Point-of-care medical device communication—Part 10207: Domain Information and Service Model for Service-Oriented Point-of-Care Medical Device Communication.

ISO/IEEE 11073 standards enable communication between medical devices and external computer systems. They provide automatic and detailed electronic data capture of patient vital signs information and device operational data. The primary goals of these standards are to

- Provide real-time, plug-and-play interoperability for patient-connected medical devices.
- Facilitate the efficient exchange of vital signs and medical device data, acquired at the point of care, in all health care environments.

“Real-time” means that data from multiple devices can be retrieved, time correlated, and displayed or processed in fractions of a second. “Plug-and-play” means that all the clinician has to do is make the connection—the systems automatically detect, configure, and communicate without any other human interaction.

“Efficient exchange of medical device data” means that information that is captured at the point of care (e.g., patient vital signs data) can be archived, retrieved, and processed by many different types of applications without extensive software and equipment support and without needless loss of information. The standards are especially targeted at acute and continuing care devices, such as patient monitors, ventilators, infusion pumps, and electrocardiogram (EKG) devices. This family of standards can be layered together to provide connectivity optimized for the specific devices being interfaced.

Note that normative statements of requirements are presented in this standard in the following manner:

Rnnnn: Statement text here.

where "nnnn" is replaced by a number that is unique among the requirements in this standard and thereby forms a unique requirement identifier, for example,

R0007: All HANDLES SHALL be unique within one MDIB sequence of a SERVICE PROVIDER.

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Health informatics—Point-of-care medical device communication**Part 10207: Domain Information and Service Model for Service-Oriented Point-of-Care Medical Device Communication****1. Overview****1.1 Scope**

The scope of this standard is the definition and structuring of information that is communicated in a distributed system of point-of-care medical devices and medical information technology (IT) systems in which medical data needs to be exchanged or networked point-of-care medical devices need to be controlled. The standard provides a Participant Model and Communication Model derived from the IEEE 11073™ Domain Information Model (IEEE 11073-10201™ DIM). Furthermore, it utilizes the IEEE 11073 Nomenclature (IEEE 11073-10101™) and supports other coding systems to convey the semantics of any information elements.¹

The definition of network transport mechanisms is outside the scope of this standard.

1.2 Purpose

The purpose of this standard is to enable vendors of point-of-care medical devices and medical IT systems to constitute networked medical device applications from the perspective of domain experts. Therefore, this standard provides tools to virtually model point-of-care medical devices. Moreover, it defines a service-oriented architecture to access those networked-based point-of-care medical devices.

¹ Information on normative references can be found in Clause 2.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used; therefore, each referenced document is cited in text, and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEC 60050-482:2004, International Electrotechnical Vocabulary – Part 482: Primary and secondary cells and batteries.²

IEEE Std 11073-10101a™-2015, Health informatics—Point-of-care medical device communication—Part 10101: Nomenclature, Amendment 1: Additional Definitions.^{3,4}

ISO/IEEE 11073-10101:2004, Health informatics — Point-of-care medical device communication — Part 10101: Nomenclature.⁵

ISO/IEEE 11073-10201:2004, Health informatics — Point-of-care medical device communication — Part 10201: Domain information model.

² IEC publications are available from the International Electrotechnical Commission (<http://www.iec.ch>) and the American National Standards Institute (<http://www.ansi.org/>).

³ The IEEE standards or products referred to in Clause 2 are trademarks owned by The Institute of Electrical and Electronics Engineers, Incorporated.

⁴ IEEE publications are available from The Institute of Electrical and Electronics Engineers (<http://standards.ieee.org/>).

⁵ ISO publications are available from the International Organization for Standardization (<http://www.iso.org/>) and the American National Standards Institute (<http://www.ansi.org/>).

3. Definitions and notational conventions

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.⁶ Any word in capital letters refers to the technical use defined in this clause. In any other case, no special spelling is given.

ALERT CONDITION: State of the ALERT SYSTEM when it has determined that a potential or actual HAZARDOUS SITUATION exists for which OPERATOR awareness or response is required.

NOTE—See also IEC 60601-1-8 (2014) [B1].^{7,8}

ALERT SIGNAL DELEGATION: Capability of a POC MEDICAL DEVICE to let another PARTICIPANT generate a POC MEDICAL DEVICE's ALERT SIGNAL as primary ALERT SIGNAL in order to indicate the presence of an ALERT CONDITION on the POC MEDICAL DEVICE.

ALERT SIGNAL: Type of signal generated by the ALERT SYSTEM to indicate the presence (or occurrence) of an ALERT CONDITION.

NOTE—See also IEC 60601-1-8 (2014) [B1].

ALERT SYSTEM: Part of a POC MEDICAL DEVICE that detects ALERT CONDITIONS and, as appropriate, generates ALERT SIGNALS.

NOTE—See also IEC 60601-1-8 (2014) [B1].

ALERT: Synonym for the combination of patient-related physiological alarms, technical alarms, and equipment user advisory signals.

ATTRIBUTE: XML attribute as defined in eXtensible Markup Language .

NOTE—See XML [B5].

BASIC INTEGRATED CLINICAL ENVIRONMENT PROTOCOL SPECIFICATION (BICEPS): Non-normative name of IEEE Std 11073-10207.

BICEPS BINDING: Specification that defines how to connect BICEPS to a transport protocol layer.

CHANNEL: Abstraction for a logical or physical grouping of METRICs that allows hierarchical information organization.

CODE: Identifier used to semantically describe an entity within a CODING SYSTEM.

CODED VALUE: Value that utilizes a CODING SYSTEM and a CODE to semantically describe a certain object within the MEDICAL DATA INFORMATION BASE (MDIB). In general, CODED VALUES are based on standardized terminologies to increase interoperability.

CODING SYSTEM: Set of CODEs.

⁶ *IEEE Standards Dictionary Online* is available at <http://dictionary.ieee.org>.

⁷ The numbers in brackets correspond to the numbers of the bibliography in Annex E.

⁸ Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

CONTAINMENT TREE ENTRY: Node of the CONTAINMENT TREE that encloses descriptive and state information.

CONTAINMENT TREE: Device configuration and capability description of an MEDICAL DEVICE SYSTEM (MDS) that represents a POC MEDICAL DEVICE and is conceivable as a four-layered tree.

CONTEXT: Abstraction of a component of a POC MEDICAL DEVICE that defines the relationship of a POC MEDICAL DEVICE with its usage environment. Technically, a CONTEXT can be understood as a token that is shared between two or more POC MEDICAL DEVICES to let them know they are “talking about the same things.”

DELEGABLE ALERT SIGNAL: ALERT SIGNAL that takes part in the ALERT SIGNAL DELEGATION process. It is controlled by a PARTICIPANT.

DEVICE COMPONENT: Term used to describe the characteristics of a medical-related component of a POC MEDICAL DEVICE. A DEVICE COMPONENT can be a physical component that is integrated inside the device, a removable physical component, or a nonphysical component that allows physiological measurement data and its derived data to be grouped in a hierarchical information organization.

NOTE—See also pm:AbstractDeviceComponentDescriptor and pm:AbstractComplexDeviceComponentDescriptor.

ELEMENT: XML element as defined in eXtensible Markup Language.

NOTE—See XML [B5].

FALLBACK ALERT SIGNAL: ALERT SIGNAL that is emitted by a POC MEDICAL DEVICE when a DELEGABLE ALERT SIGNAL is not confirmed by the generating PARTICIPANT in time, i.e., it exceeds a confirmation timeout.

HANDLE: Term used to uniquely identify a certain object within the MEDICAL DATA INFORMATION BASE (MDIB) without designating any semantics.

HAZARDOUS SITUATION: Situation when people are exposed to a hazard or when property or the environment is threatened. A HAZARDOUS SITUATION exists when a vulnerable entity is exposed to a hazard.

NOTE—See also ISO 14971:2007 [B2].

MEDICAL DATA INFORMATION BASE (MDIB): Structured collection of any data objects that are provided by a particular POC MEDICAL DEVICE. MDIB includes descriptive and state information.

MEDICAL DEVICE SYSTEM (MDS): Abstraction of a system comprising one or more medical functions. In the context of IEEE Std 11073-10207, the term is specifically used as an object-oriented abstraction of a POC MEDICAL DEVICE that provides medical information in the form of information objects that are defined in IEEE Std 11073-10207.

MESSAGE: Set of data in a specific format that is exchanged between two PARTICIPANTS.

METRIC: Abstraction of a component of a POC MEDICAL DEVICE that is able to generate or store direct and derived, quantitative and qualitative biosignal measurements, settings, and status values.

PARTICIPANT: Any network node that is part of a SERVICE-ORIENTED MEDICAL DEVICE SYSTEM (SOMDS) and exchanges information by means of a service-oriented architecture. A PARTICIPANT can be either a SERVICE PROVIDER or a SERVICE CONSUMER.

POC ENVIRONMENT: Environment encompassing a particular diagnostic, bed, or treatment area that is specific to one patient and usually including the systems and personnel that are involved in the acute monitoring and treatment of the patient.

POC MEDICAL DEVICE: Point of care (POC) medical device that directly interacts with, monitors, provides treatment to, or is in some way associated with a single patient. For IEEE Std 11073-10207, the scope of POC MEDICAL DEVICES is further limited to patient-connected medical devices that provide support for electronic communication.

RESPONSIBLE ORGANIZATION: Entity that is accountable for the use and maintenance of a POC MEDICAL DEVICE.

SERVICE CONSUMER: Participant that utilizes at least one SERVICE.

SERVICE INTERFACE: Set of SERVICE OPERATIONS that is provided by a SERVICE to describe its capabilities.

SERVICE OPERATION: Single operation that can be executed remotely at a SERVICE PROVIDER.

SERVICE PERSONNEL: Individuals or entity accountable to the RESPONSIBLE ORGANIZATION for installing, assembling, maintaining, or repairing a POC MEDICAL DEVICE.

SERVICE PROVIDER: Participant that provides at least one SERVICE. A SERVICE PROVIDER can be hosted on the POC MEDICAL DEVICE itself or on an external appliance (e.g., converter box) or information technology (IT) system (e.g., aggregator).

SERVICE: Part of a software system in a SERVICE-ORIENTED MEDICAL DEVICE SYSTEM (SOMDS) that exposes functional capabilities on a communication backbone.

SERVICE-ORIENTED MEDICAL DEVICE SYSTEM (SOMDS): Instance of a distributed system that implements a service-oriented architecture composed of SERVICE PROVIDERS and SERVICE CONSUMERS as defined for IEEE Std 11073-10207.

TYPE: Complex or simple type definition as defined in eXtensible Markup Language Schema.

NOTE—See XML Schema [B8].

VIRTUAL MEDICAL DEVICE (VMD): Abstraction for a medical-related subsystem (e.g., hardware or even pure software) of a POC MEDICAL DEVICE.

3.2 Notational conventions

3.2.1 General

This standard defines a Participant Model and a Communication Model that comprises a Message Model, Service Model, and Discovery Model. Both the Participant Model and Communication Model can be extended using the mechanisms defined in the Extension Model.

Class diagrams, sequence diagrams, component diagrams, and state machine diagrams follow the Unified Modeling Language (UML) notation. Beyond UML diagrams, the following subclauses describe notational conventions used to describe and reference XML Schema types.

3.2.2 XML Schema namespaces

Annex A, Annex B, and Annex C include an XML Schema [B8] to describe an Extension Model, the object hierarchy, and ATTRIBUTES of an MDIB instance as well as a set of MESSAGE structures that is used to request MDIB objects. The MDIB object hierarchy and ATTRIBUTES are also known as the Participant Model. The set of MESSAGE structures is also known as the Message Model. All models possess dedicated XML namespaces (see XML Namespaces [B6]). These are defined in Table 1.

Table 1—Namespace mapping of Extension, Participant, and Message Models

Namespace prefix	URI	Model part
ext	http://standards.ieee.org/downloads/11073/11073-10207-2017/extension	Extension Model
pm	http://standards.ieee.org/downloads/11073/11073-10207-2017/participant	Participant Model
msg	http://standards.ieee.org/downloads/11073/11073-10207-2017/message	Message Model

This standard also uses the XML namespace prefix “xsd” to point to the XML Schema namespace specified in XML Schema [B8]:

`http://www.w3.org/2001/XMLSchema`

3.2.3 XML Schema referencing

References to TYPE or ELEMENT definitions of the XML Schema are made by using the corresponding QName (see XML Namespaces [B6]). To reference a nested TYPE definition, the QName is enhanced with a chain of QNames and unqualified ATTRIBUTE names, each separated by XPath delimiters (see XPath [B7]). Examples:

- pm:Handle points to the *Handle* TYPE defined in the Participant Model.
- msg:OperationInvokedReport/msg:ReportPart/@OperationTarget points to the ATTRIBUTE *OperationTarget* that is defined as part of the *ReportPart*, which is included in the *OperationInvokedReport*. Since the QName prefix is msg, the referenced TYPE refers to the Message Model.
- ./@ActivationDuration refers to an ATTRIBUTE within an arbitrary TYPE definition.

Throughout the XML Schema, a camel case notation is used:

- Every artifact begins with a capital letter (e.g., “Handle”)
- Names are separated by a capital letter (e.g., “ActivationState”)
- Abbreviations are denoted in camel case (e.g., “VmdDescriptor”)

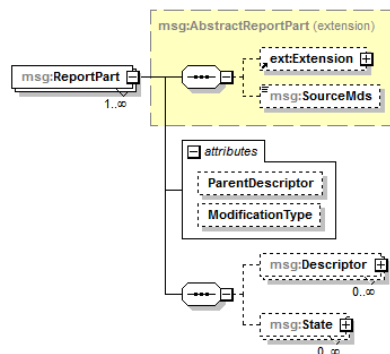
3.2.4 XML Schema type description

Any XML Schema type that is defined in Annex A, Annex B, and Annex C, follows a certain layout. The subclause title corresponds to the type name. Beneath the title the XML Schema type is defined, which is in accordance to XML Schema either “element,” “attribute,” “simpleType,” or “complexType.” Every type is explained in more detail by a properties table (see Table 2).

Table 2—Description of XML Schema type properties

Property name	Description
Type	Type name, including inheritance information if applicable.
Children	List of child elements of the XML Schema type.
Used by	A list of elements and complex types in which the XML Schema type is used.
Attributes	List of attributes defined by the XML Schema type.
Documentation	General description of the data type.
Constraints	Special restrictions to contents, e.g., valid values for enumerations.
Properties	If given, the minimum and maximum occurrence of the XML Schema type.
Use	Usage: “opt” for optional, “req” for required.

Beyond those properties, element and complex type definitions include a picture that describes the structure of the data type graphically. An example is given in Figure 1. The box on the left side describes the data type name and its cardinality. Connected by a solid line are the super types in a yellow box, followed by the attributes and child elements. There are two kinds of boxes. Solid lined boxes are required data fields and dotted lined boxes are optional data fields. If a child element count has a particular range, this range is noted as a cardinality at the bottom right of the box. A plus sign at the right of a solid-lined or dotted box signalizes the existence of child element or attribute definitions that are not shown for sake of brevity.

**Figure 1—Example XML Schema element type structure**

4. Introduction to BICEPS

BICEPS comprises three major parts: a Participant Model, a Communication Model, a Discovery Model as well as nonfunctional requirements. Altogether, these parts are also known as BICEPS. Figure 2 illustrates a decomposition of BICEPS and brings them into logical relation. The diagram shows two perspectives: from the medical domain, known as “Domain Perspective,” and from the IT network, known as “Network Perspective.” The Domain Perspective deals with modeling of medical device systems from a domain point of view, whereas the Network Perspective deals with exchanging medical device information in an abstract communication backbone.

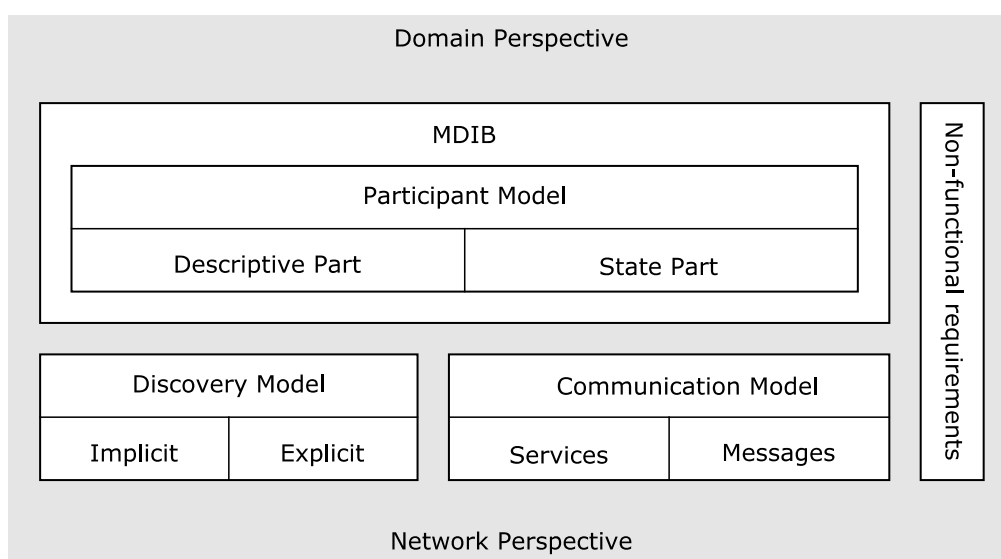


Figure 2—BICEPS component decomposition

The domain perspective pertains to the MDIB, which includes the Participant Model (see Clause 5). The Participant Model consists of a descriptive (mainly static) and a state part (volatile). By defining the MDIB, a SERVICE PROVIDER is able to define a virtual representation of its measurements, settings, alert systems, and contextual information. The Participant Model does not define a communication MESSAGE or ELEMENT for every possible kind of measurement data, setting data, contextual information or remote invocation command, but rather provides an extensibility mechanism that makes it possible for a PARTICIPANT to convey additional data in a MESSAGE or to transmit a completely new type of MESSAGE.

The Participant Model is closely related to the 11073 Domain Information Model (IEEE 11073-10201 DIM), but it is not an exact copy of it. As the Participant Model has been designed with the idea in mind to specify only the essential data structures and MESSAGES that are needed in a distributed system of medical devices in a POC ENVIRONMENT, only a subset of the packages of the IEEE 11073-10201 DIM are used to be included in the Participant Model. Those packages as well as those that have not been included into BICEPS are shown in Table 3. Whenever this specification reuses a term from IEEE 11073-10201, it is considered semantically the same, though described in another notation than, e.g., ASN.1.

Table 3—IEEE 11073-10201 DIM packages that are in scope and out of scope of BICEPS

IEEE 11073-10201 DIM packages	Covered by BICEPS?
Medical	yes
Alert	yes
Control	yes
System	yes
Patient	yes
Archival	yes
Extended Services	no
Communication	no

The network perspective pertains to the Communication Model (see Clause 7) and Discovery Model (see Clause 9). Both conflate into a SOMDS to provide service discovery, data exchange and remote control between PARTICIPANTS.

Access to the MDIB is established by using a set of SERVICE OPERATIONS. These operations can be used by SERVICE CONSUMERS to exchange MESSAGES with SERVICE PROVIDERS by either requesting them explicitly or subscribing to events that occur on a SERVICE PROVIDER side.

In order to support plug-and-play in a SOMDS, the SERVICES of a SERVICE PROVIDER have to be discovered by potential SERVICE CONSUMERS. The BICEPS Discovery Model defines two discovery modes:

- Explicit discovery
- Implicit discovery

Explicit discovery is based on search messages that are sent to a group of network nodes and that might contain matching criteria of what a SERVICE CONSUMER is interested in. Moreover, plug-and-play is only possible if a suitable data transport foundation is defined. The discovery elements in this standard shape the requirements to a transport layer, only.

In contrast to this, implicit discovery is based on messages that are communicated by a SERVICE PROVIDER when it enters or leaves the network or if something in its context has changed substantially.

BICEPS also defines a set of nonfunctional requirements that can be used to specify the SERVICE PROVIDER's requirements with regard to patient safety, cybersecurity, and clinical effectiveness as well as regulatory requirements (see Clause 10).

5. Participant Model

5.1 Overview

The scope of this clause is the definition of a model that allows the description of the capabilities as well as the expression of the current state of a POC MEDICAL DEVICE, which acts as a PARTICIPANT in a SOMDS. The complete model is defined in Annex B.

5.2 Background

5.2.1 General

BICEPS makes use of the MDIB concept as defined in IEEE 11073-10201 (Clause 6). The MDIB represents a structured collection of instances of managed medical objects representing, e.g., the vital signs information provided by a particular medical device. BICEPS defines the MDIB as a twofold database: the descriptive part and the state part (see Figure 3). The descriptive part comprises a hierarchy of descriptors to establish relationships between managed medical objects. Moreover, it includes the mostly static attributes that are expressed by a POC MEDICAL DEVICE. The state part is the dynamic counterpart of the descriptive part in the MDIB hierarchy. It includes volatile information (like observed measurement values) in form of a flat list of elements corresponding to the objects in the description.

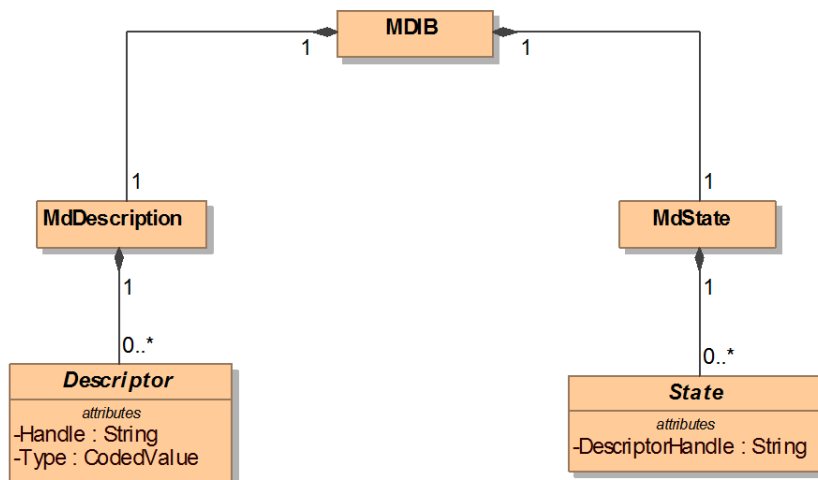


Figure 3—Descriptive and state part of the MDIB
(Every descriptor is referenced by DescriptorHandle in State.)

5.2.2 Handle

Any pm:AbstractDescriptor or pm:AbstractState that is included in an MDIB instance, is identifiable by a HANDLE (also see pm:Handle) or reference to an object with a HANDLE (see pm:HandleRef). It allows for explicit identification.

R0007: All HANDLEs SHALL be unique within one MDIB sequence of a SERVICE PROVIDER.

NOTE—The MDIB sequence is defined in 5.2.5.6.

R0105: A HANDLE SHALL consist of characters that match only valid Unicode codes greater than U+0020, except for U+FFFD (replacement character).

R0098: If a SERVICE PROVIDER removes and reinserts a CONTAINMENT TREE ENTRY from / into the CONTAINMENT TREE within one MDIB sequence, and the CONTAINMENT TREE ENTRY has the same HANDLE, it SHALL be of the same XML Schema datatype.

R0137: A SERVICE PROVIDER SHALL NOT change the HANDLE of a CONTAINMENT TREE ENTRY within one MDIB sequence.

R0138: If a SERVICE PROVIDER removes a CONTAINMENT TREE ENTRY from the CONTAINMENT TREE and reinserts the same CONTAINMENT TREE ENTRY into the CONTAINMENT TREE within one MDIB sequence, the CONTAINMENT TREE ENTRY SHALL have the same handle.

NOTE—From R0098 it follows that a CONTAINMENT TREE ENTRY that disappears and appears again can change any of its ATTRIBUTES and ELEMENTs except for the XML Schema datatype.

R0099: If a SERVICE PROVIDER removes and reinserts the same CONTAINMENT TREE ENTRY of an element in the CONTAINMENT TREE beyond one MDIB sequence, it SHOULD use the same HANDLE for that CONTAINMENT TREE ENTRY.

NOTE—R0099 implies that with a new MDIB sequence a handle might be assigned to another element in the CONTAINMENT TREE. Therefore, after an MDIB sequence has changed, a SERVICE CONSUMER cannot make any assumptions regarding the previous relation between a HANDLE and an element in the CONTAINMENT TREE.

R0102: If a SERVICE CONSUMER detects that an MDIB sequence has changed, it SHALL not combine current CONTAINMENT TREE information with prior CONTAINMENT TREE information based on the HANDLE.

NOTE—As stated in R0099, a SERVICE PROVIDER might have reassigned a HANDLE during an MDIB sequence change. Nevertheless, a SERVICE CONSUMER is allowed to combine the information with prior information based on other metadata. However, to make sure that no obsolete information is utilized, it is strongly encouraged to re-request the whole MDIB after a MDIB sequence change.

5.2.3 Coded value

A HANDLE does not convey any semantical information. To semantically describe objects within the MDIB, this standard introduces CODED VALUEs (see pm:CodedValue). A CODED VALUE consists of a CODING SYSTEM (see pm:CodedValue/@CodingSystem) and a CODE (see pm:CodedValue/@Code).

R0008: A SERVICE PROVIDER SHOULD use standardized values for CODE and CODING SYSTEM in order to specialize a CONTAINMENT TREE ENTRY if available.

R0128: A SERVICE PROVIDER SHOULD use the ISO/IEEE 11073-10101 and IEEE 11073-10101a-2015 nomenclature whenever there is an appropriate CODE available.

NOTE—The pm:CodedValue ELEMENT defines the ISO/IEEE 11073-10101 nomenclature as the default CODING SYSTEM.

5.2.4 Instance identifier

5.2.4.1 General

Instance identifiers are defined in `pm:InstanceIdentifier`. Every instance identifier is associated with a single object or entity within a given virtual or physical system and is constituted from a root and an extension. The root value references a system, in which the extension values are unique and valid.

5.2.4.2 Encoding of unknown elements

In situations where an extension is known, but the root is not known, the implied value of a nonexistent root is a null-flavor “unknown.”

R0135: A PARTICIPANT SHALL encode the instance identifier root by the URI “biceps.uri.unk” if and only if its value is unknown.

5.2.5 MDIB versioning

5.2.5.1 General

The MDIB provides various version ATTRIBUTES to allow detection of outdated data and to allow provision of a CONTAINMENT TREE history (accessible through the ARCHIVE SERVICE).

NOTE—An informative example for change tracking can be found in D.2.

5.2.5.2 Descriptor version

Any TYPE that is derived from `pm:AbstractDescriptor`, possesses the `pm:AbstractDescriptor/@DescriptorVersion` ATTRIBUTE. The following requirements describe in which cases a descriptor version change is applied.

R0033: A SERVICE PROVIDER SHALL increment `pm:AbstractDescriptor/@DescriptorVersion` by 1 if a direct child descriptor is added or deleted.

NOTE—From R0033 follows that adding or deleting of a descriptor only increments the descriptor version of its direct parent. The version increment does not propagate upwards to other ancestors in the CONTAINMENT TREE.

R0034: A SERVICE PROVIDER SHALL increment `pm:AbstractDescriptor/@DescriptorVersion` by 1 if the content of a child ELEMENT or an ATTRIBUTE of the descriptor have changed and if the child ELEMENT itself is not derived from `pm:AbstractDescriptor`.

NOTE 1—A child ELEMENT refers to the child in an XML document tree.

NOTE 2—`pm:AbstractDescriptor` is exempted from R0034 because every parent descriptor owns a dedicated descriptor version that is not meant to be affected by updates in any child descriptor. If `pm:AbstractDescriptor` would not be exempted from R0034, then any update of a child descriptor would propagate changes up to the root descriptor of the MDIB.

5.2.5.3 State version

Any TYPE that is derived from `pm:AbstractState`, possesses the `pm:AbstractState/@StateVersion` ATTRIBUTE. The following requirements describe in which cases a state version change is applied.

R0038: A SERVICE PROVIDER SHALL increment `pm:AbstractState/@StateVersion` by 1 if the content of a child ELEMENT or an ATTRIBUTE of the state has changed.

NOTE—A child ELEMENT refers to the child in an XML document tree.

5.2.5.4 MdDescription version

The descriptive part of the MDIB possesses the `pm:MdDescription/@DescriptionVersion` ATTRIBUTE.

R0043: A SERVICE PROVIDER SHALL increment `pm:MdDescription/@DescriptionVersion` every time any descendent descriptor of `pm:MdDescription` is added or removed, and every time `pm:AbstractDescriptor/@DescriptorVersion` of a descendent descriptor changes.

5.2.5.5 MdState version

The state part of the MDIB possesses the `pm:MdState/@StateVersion` ATTRIBUTE.

R0045: A SERVICE PROVIDER SHALL increment the `pm:MdState/@StateVersion` every time `pm:AbstractState/@StateVersion` of a descendent state in `pm:MdState` changes.

5.2.5.6 MDIB version

The MDIB version follows the concept of WS-Discovery's AppSequence ELEMENT (see 5.3 in WS-Discovery [B3]) and is described in `pm:MdibVersionGroup`. The sequence identifier defined in `pm:MdibVersionGroup` is used to discriminate different sequences of versions. In addition to that, the instance identifier can be used to establish an order between different sequences.

R0046: A SERVICE PROVIDER SHALL increment `pm:MdibVersionGroup/@MdibVersion` by 1 every time `pm:MdDescription/@DescriptionVersion` or `pm:MdState/@StateVersion` have changed.

NOTE—Devices that are not capable of maintaining the `pm:MdibVersionGroup/@MdibVersion` number can reset it after each power cycle.

R0047: If a SERVICE PROVIDER resets `pm:MdibVersionGroup/@MdibVersion`, all other `pm:VersionCounter` instances SHALL also be reset.

R0117: A SERVICE PROVIDER SHALL assign a new MDIB sequence identifier after it has reset `pm:MdibVersionGroup/@MdibVersion`.

NOTE 1—A new MDIB sequence identifier is defined as a unique identifier that has never been used before by a SERVICE PROVIDER.

NOTE 2—The MDIB sequence identifier and instance identifier are explained in `pm:MdibVersionGroup`.

5.3 Descriptive part

5.3.1 General

The descriptive part of the MDIB describes the capabilities a POC MEDICAL DEVICE possesses. Any TYPE that constitutes a part of the hierarchy in the MDIB, is derived from a descriptor TYPE (see pm:AbstractDescriptor). The descriptor concept facilitates interoperable communication between PARTICIPANTS by introducing typed device information based on standardized nomenclatures. A minimum set of descriptive ELEMENTs and ATTRIBUTEs is declared as mandatory to help ensure interoperability and compliance of medical issues. Derived descriptor TYPEs possess some optional ELEMENTs and ATTRIBUTEs, which are included to describe the system and its capabilities in more detail.

R0010: A SERVICE PROVIDER SHALL describe the information provisioning and remote control capabilities of its represented POC MEDICAL DEVICES using the pm:MdDescription structure.

NOTE—The set of MDS CONTAINMENT TREES in pm:MdDescription might be empty at a certain point in time. This is the case if, e.g., the SERVICE PROVIDER acts as an aggregator of POC MEDICAL DEVICES and none of the devices it manages are available at that point in time.

Figure 4 shows the general structure of a CONTAINMENT TREE as a UML class diagram. It visualizes the hierarchical relationship between the descriptors that are defined in this standard. SystemContext and AlertSystem include further child descriptors. For the sake of simplicity these children are omitted in Figure 4 and moved to Figure 5 and Figure 9.

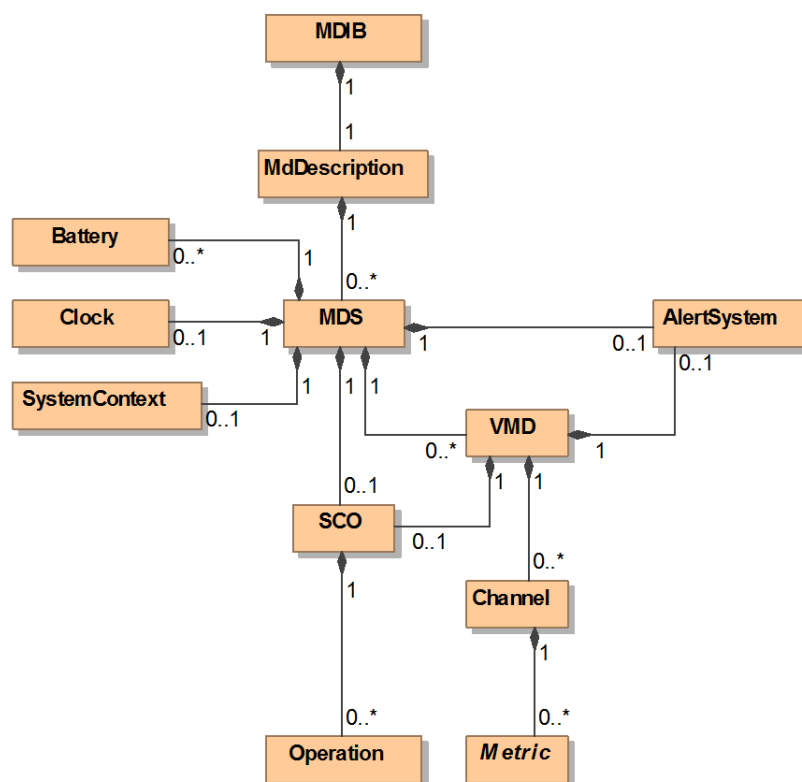


Figure 4—General BICEPS CONTAINMENT TREE overview

5.3.2 MDIB

The MDIB is the top level ELEMENT that includes the structural descriptor information. Beyond the structural descriptor information, the MDIB also includes corresponding states (omitted in Figure 4).

5.3.3 MdDescription

MdDescription is a container to group MDS descriptors, see pm:MdDescription.

5.3.4 MDS

A pm:MdDescription MAY possess zero or more pm:MdsDescriptor objects. The pm:MdsDescriptor object is depicted in Figure 3 as MDS.

NOTE—In contrast to ISO/IEEE 11073-10201, there exists no dedicated CompositeMDS. A CompositeMDS can be modeled by adding multiple MDSs to the MDIB. The compositional relationship between the MDS instances is maintained by the system context information of each MDS.

5.3.5 Clock

An MDS MAY support a clock object to provide timestamp and time synchronization information (see pm:MdsDescriptor/pm:Clock).

NOTE—In general, POC MEDICAL DEVICES will possess a clock object; otherwise, they will not be able to keep or provide time information.

5.3.6 Battery

An MDS MAY support zero or more battery objects to provide battery-related information (see pm:MdsDescriptor/pm:Battery).

5.3.7 SystemContext

A POC MEDICAL DEVICE MAY provide contextual information to let SERVICE CONSUMERS verify if a requested SERVICE PROVIDER share the same working context in terms of, e.g., a location or patient that the POC MEDICAL DEVICE is associated with. Figure 5 shows an overview of available contexts and their relationship.

NOTE—Except for the patient and location context, all context descriptors can be present multiple times. Thereby it is possible to represent, for example, different perspectives on a workflow (multiple descriptors), each of which can contain multiple workflow steps (multiple states). An example is one pm:WorkflowContextDescriptor with pm:WorkflowContextDescriptor/pm:Type representing a hospital stay with one pm:WorkflowContextState where pm:WorkflowContextState/pm:Category represents an emergency care procedure and one pm:WorkflowContextState where pm:WorkflowContextState/pm:Category represents an Surgical Procedure. In this example, the first pm:WorkflowContextState has a pm:WorkflowContextState/@ContextAssociation of “Dis” as this workflow state has been finished already and the later has a pm:WorkflowContextState/@ContextAssociation of “Assoc” as this workflow state is currently executed.

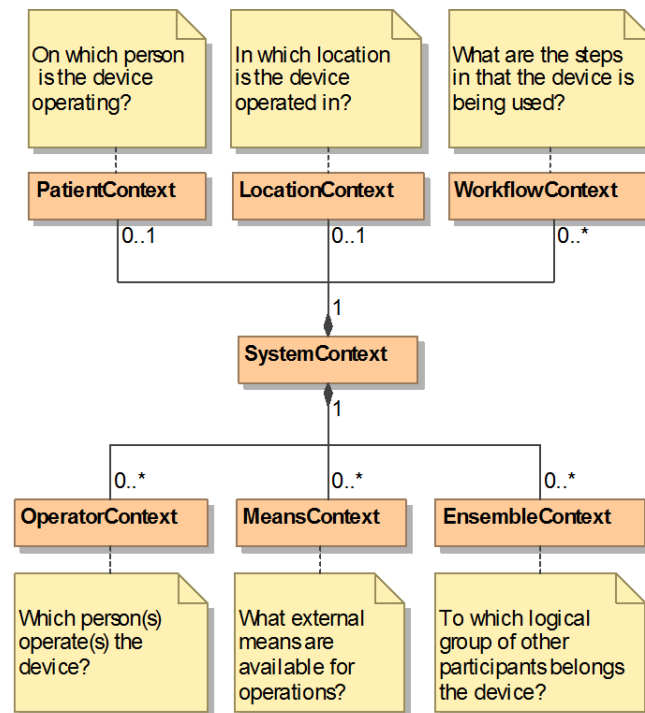


Figure 5—Contextual information that may be handled by a POC MEDICAL DEVICE

BICEPS defines six flavors of contextual information. For each contextual information a dedicated descriptor is included in pm: MdsDescriptor/pm:SystemContext:

- PatientContext (see pm:PatientContextDescriptor)
- LocationContext (see pm:LocationContextDescriptor)
- WorkflowContext (see pm:WorkflowContextDescriptor)
- OperatorContext (see pm:OperatorContextDescriptor)
- MeansContext (see pm:MeansContextDescriptor)
- EnsembleContext (see pm:EnsembleContextDescriptor)

R0013: A SERVICE PROVIDER SHALL NOT express a capability to handle a specific kind of contextual information if it is not able to validate the contextual information either directly or indirectly.

NOTE 1—A context is called being handled, if a POC MEDICAL DEVICE or SERVICE PROVIDER is capable of validating, that it is operated in the context provided by the information accessible in the MDIB. Validation of contextual information may afford operator interaction or may rely solely on information provided by the act of proposing the contextual information. Example: a surgeon (i.e., an operator) has to confirm patient data (provided in the MDIB by a patient context) on the graphical user interface of a POC MEDICAL DEVICE. Confirming the patient data can be considered as a kind of validation.

NOTE 2—As not all POC MEDICAL DEVICES are able to handle all kinds of contextual information, an MDS is able to express which kinds of contextual information can be handled by the POC MEDICAL DEVICE. If a SERVICE PROVIDER is capable of validating the contextual information without the POC MEDICAL DEVICE that the contextual information is related to, this is called direct validation. If the SERVICE PROVIDER utilizes the POC MEDICAL DEVICE for validating contextual information for that medical device, this is called indirect validation.

R0014: If a SERVICE PROVIDER or POC MEDICAL DEVICE is, e.g., capable of determining to which patient the POC MEDICAL DEVICE is currently connected to, this capability SHOULD be expressed in the MDS context with a `pm:PatientContextDescriptor`.

R0015: If a SERVICE PROVIDER or POC MEDICAL DEVICE is, e.g., capable of determining in which location the POC MEDICAL DEVICE is currently operated, this capability SHOULD be expressed in the MDS context with a `pm:LocationContextDescriptor`.

R0016: If a SERVICE PROVIDER or POC MEDICAL DEVICE is, e.g., capable of determining in which clinical workflow the POC MEDICAL DEVICE is currently participating, this capability SHOULD be expressed in the MDS context with a `pm:WorkflowContextDescriptor`.

R0017: If a SERVICE PROVIDER or POC MEDICAL DEVICE is, e.g., capable of determining who is currently operating the POC MEDICAL DEVICE, this capability SHOULD be expressed in the MDS context with a `pm:OperatorContextDescriptor`.

R0018: If a SERVICE PROVIDER or POC MEDICAL DEVICE is, e.g., capable of determining which virtual or physical means the POC MEDICAL DEVICE is using, this capability SHOULD be expressed in the MDS context with a `pm:MeansContextDescriptor`.

NOTE—An example for a virtual means is a license from a pool of licenses. An example for a physical means could be a docking station that the POC MEDICAL DEVICE is connected to.

R0019: If a SERVICE PROVIDER or POC MEDICAL DEVICE is, e.g., capable of determining in which logical group the POC MEDICAL DEVICE is currently operated, this capability SHOULD be expressed in the MDS context with a `pm:EnsembleContextDescriptor`.

NOTE—A logical group is, e.g., a temporal group based on a treatment session or spatial group that is not affixed to one location.

R0106: Any context descriptor SHALL NOT be removed from or added to the MDIB during runtime, except if the hosting MDS is removed or added to the MDIB.

NOTE 1—The existence of context descriptors defines whether a SERVICE PROVIDER supports processing a particular kind of contexts. Either a SERVICE PROVIDER is able to process a kind of context or it is not. Therefore, it makes no sense to remove or add context descriptors during runtime, except in the case when a whole MDS is removed or added to the MDIB.

NOTE 2—By not allowing context descriptors to appear or disappear during runtime, an implementation can make assumptions on the availability of contexts. This can ease implementation.

5.3.8 SCO

A POC MEDICAL DEVICE allows SERVICE CONSUMERS to request remote control commands by means of the service control object (SCO). The SCO MAY possess a set of operations that the SERVICE PROVIDER offers to SERVICE CONSUMERS to allow modification of MDIB objects. The class diagram of remote control commands is given in 5.3.9.

5.3.9 Operation

The SCO includes zero or more operations. The underlying Operation types are depicted in Figure 6, whereby

- Operation is the base type, defined in `pm:AbstractOperationDescriptor`
- SetValue is defined in `pm:SetValueOperationDescriptor`
- SetString is defined in see `pm:SetStringOperationDescriptor`

- Activate is defined in pm:ActivateOperationDescriptor
- SetContextState is defined in see pm: SetContextStateOperationDescriptor
- SetMetricState is defined in pm:SetMetricStateOperationDescriptor
- SetComponentState is defined in see pm:SetComponentStateOperationDescriptor
- SetAlertState is defined in see pm:SetAlertStateOperationDescriptor

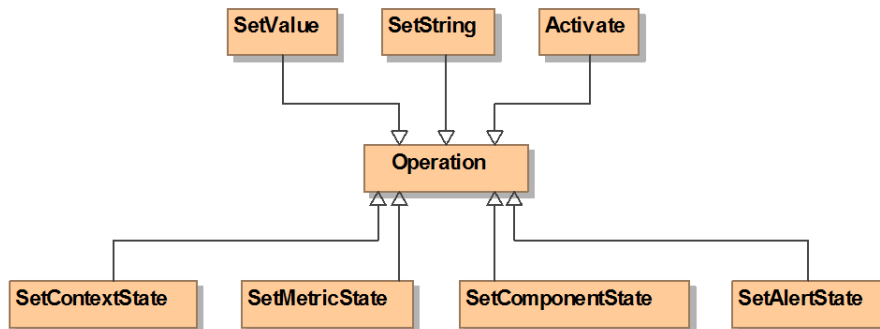


Figure 6—Operation specializations used to remote control a POC MEDICAL DEVICE

R0011: A SERVICE PROVIDER SHOULD describe all offered remote invocation capabilities using the pm:ScoDescriptor structure in pm:MdsDescriptor/pm:Sco.

5.3.10 VMD

As defined in ISO/IEEE 11073-10201, the VMD is an abstraction for a medical-related subsystem (e.g., hardware or even pure software) of a POC MEDICAL DEVICE (see pm:VmdDescriptor). The VMD MAY capture zero or more pm:ChannelDescriptor objects.

NOTE—As defined by the XML Schema, BICEPS allows a fixed CONTAINMENT TREE only, i.e., an MDIB always provides a fixed MDS to VMD to channel structure. Metrics can only be appended in channels.

5.3.11 Channel

Channel is defined in pm:ChannelDescriptor and is used to group metric objects. A channel MAY contain zero or more pm:AbstractMetricDescriptor objects.

NOTE—Since only channels are able to possess metrics, at least one channel is required to include metrics in the MDIB. This is in contrast to ISO/IEEE 11073-10201, in which the “Channel object is not mandatory for representation of Metric objects in a VMD.”

5.3.12 Metric

5.3.12.1 General

Metric is a generalized type for all objects representing direct and derived biosignal measurements and settings. The set of Metric types is illustrated in Figure 7, whereby

- Metric is the base type, defined in pm:AbstractMetricDescriptor
- StringMetric is defined in pm:StringMetricDescriptor

- EnumMetric is a subtype of StringMetric and defined in pm:EnumStringMetricDescriptor
- NumericMetric is defined in pm:NumericMetricDescriptor
- RealTimeSampleArrayMetric is defined in pm:RealTimeSampleArrayMetricDescriptor

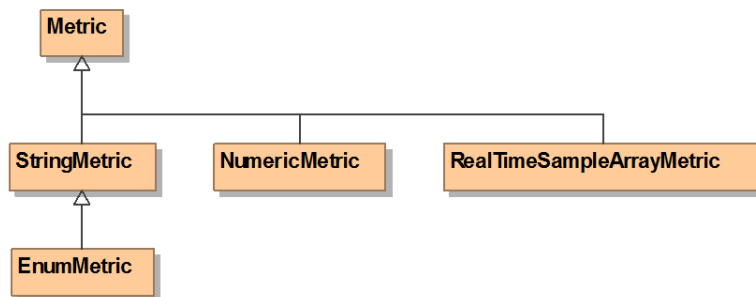


Figure 7—Metric specializations used to constitute biosignal measurements and settings

5.3.12.2 Time-related attributes

Metric values come with different time-related ATTRIBUTES to derive different temporal relationships between sequences of measurement. In Figure 8, vertical lines that are connected with horizontal lines, illustrate time periods. Single vertical lines illustrate points in time. DeterminationPeriod is the maximum time distance between two consecutive measured metric values (expressed by time points t and $t+1$, with $t < t+1$). In between DeterminationPeriod, there are time points and periods that designate specific parts of the determination process. A normative outline is given in Annex B:

- pm:AbstractMetricDescriptor/@DeterminationPeriod
- pm:AbstractMetricValue/@StartTime
- pm:AbstractMetricValue/@StopTime
- pm:AbstractMetricValue/@DeterminationTime
- pm:AbstractMetricDescriptor/@MaxMeasurementTime
- pm:AbstractMetricDescriptor/@MaxDelayTime

Beyond those ATTRIBUTES, pm:AbstractMetricState/@ActiveDeterminationPeriod designates a temporary or more-frequent changing determination period. The pm:AbstractMetricState/@ActiveDeterminationPeriod ATTRIBUTE overrides the pm:AbstractMetricDescriptor/@DeterminationPeriod period.

LifeTimePeriod is defined in pm:AbstractMetricDescriptor/@LifeTimePeriod. It designates the time period until a measured metric value is not usable anymore and can be overwritten by pm:AbstractMetricState/@LifeTimePeriod.

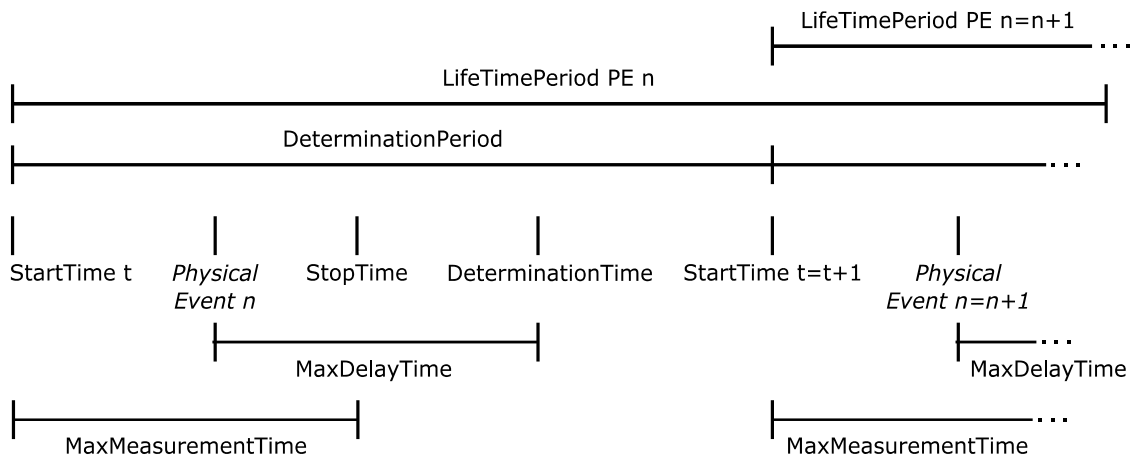


Figure 8—Logical relationship between time points and time periods provided by METRICs
 (PE refers to “Physical Event.”)

5.3.12.3 Detect obsolete metric values

A SERVICE CONSUMER MAY check if a METRIC value is outdated based on `pm:AbstractMetricDescriptor/@DeterminationPeriod` and `msg:Retrievability/@UpdatePeriod`. Table 4 illustrates in which relation of `pm:AbstractMetricDescriptor/pm:Availability` and `msg:Retrievability` the determination period and update period can be used to determine if a METRIC value is outdated.

NOTE—It is not sensible for a SERVICE CONSUMER to use `LifeTimePeriod` to determine if a METRIC value update has not been received. `LifeTimePeriod` is used only to determine if a METRIC is not useful anymore in terms of the physiological measure (also see `pm:AbstractMetricDescriptor/@LifeTimePeriod`).

Table 4—Metric availability and retrievability matrix to detect outdated METRICs

Retrievability	Availability	
	Continuous	Intermittent
Periodic	The full set of all periodic METRICs is sent via <code>msg:PeriodicMetricReport</code> , based on <code>msg:Retrievability/@UpdatePeriod</code> .	The full set of all periodic METRICs is sent via <code>msg:PeriodicMetricReport</code> , based on <code>msg:Retrievability/@UpdatePeriod</code> .
Episodic	A METRIC update is expected every time its determination period ends. The update is receivable by <code>msg:EpisodicMetricReport</code> .	The determination period is not an indicator for expected updates. It is up to the SERVICE CONSUMER how to react on unexpectedly missing METRIC updates.

5.3.13 AlertSystem

MDS and VMD objects MAY include an alert system, which in turn detects alert conditions and generates alert signals. Figure 9 shows the relation of alert systems, alert conditions and alert signals, whereby

- AlertSystem is defined in `pm:AlertSystemDescriptor`
- AlertCondition is defined in `pm:AlertConditionDescriptor`
- LimitAlertCondition is a subtype of AlertCondition and defined in `pm:LimitAlertConditionDescriptor`
- AlertSignal is defined in `pm:AlertSignalDescriptor`

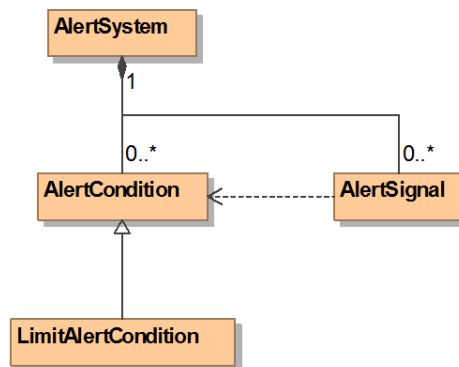


Figure 9—Alert system entities and their relationships

5.4 State part

5.4.1 General

The state part of the MDIB describes the current state of a POC MEDICAL DEVICE at a given point in time. Any TYPE that constitutes such volatile information is derived from a common state TYPE (see pm:AbstractState).

R0021: A SERVICE PROVIDER SHALL describe the state of a POC MEDICAL DEVICE at a given point in time using the pm:MdState structure.

5.4.2 Mapping between descriptor and state

R0023: For each state in pm:MdState a SERVICE PROVIDER SHALL provide a descriptor in pm:MdDescription. Every state in pm:MdState SHALL reference its descriptor by using the pm:AbstractState/@DescriptorHandle ATTRIBUTE.

In general, every concrete descriptor/state pair matches the following naming scheme to establish a relationship: [Object Name]State is related to [Object Name]Descriptor. Examples:

- pm:NumericMetricState is related to pm:NumericMetricDescriptor.
- pm:ChannelState is related to pm:ChannelDescriptor.
- pm:PatientContextState is related to pm:PatientContextDescriptor.

5.4.3 Single state vs. multi-state

Descriptors are allowed to possess either exactly one state (i.e., a single state, see pm:AbstractState), or zero or more states. In the latter case, a state is called a multi-state (see pm:AbstractMultiState). Figure 10 depicts the single state relationship at the top and the multi-state relationship the bottom of the image. It also shows that multi-states are a specialization of single states.

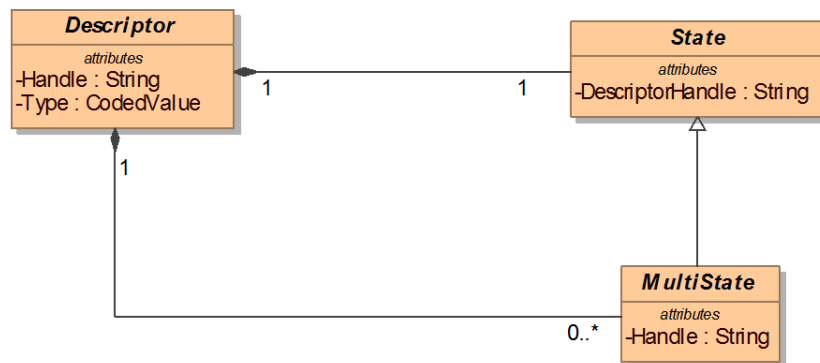


Figure 10—Relationship between descriptors, states, and multi-states

R0097: Any state that is derived from `pm:AbstractMultiState` SHALL possess a **HANDLE** that uniquely identifies the state.

NOTE 1—This is equivalent to descriptors, whereby descriptor and state HANDLES are disjunctive due to R0007.

NOTE 2—BICEPS introduces context states as the only multi-states (see `pm:AbstractContextState`).

NOTE 3—Single states need no **HANDLE** because they are uniquely identifiable by their corresponding descriptor (see `pm:AbstractState/@DescriptorHandle`).

5.4.4 Context state

R0125: A SERVICE PROVIDER SHALL use `pm:AbstractContextState/@ContextAssociation` to announce which context state it is currently associated with.

R0124: A SERVICE PROVIDER SHALL be associated with a maximum of one patient context state of a particular patient context descriptor at a time.

R0133: A SERVICE PROVIDER SHALL be associated with a maximum of one location context state of a particular location context descriptor at a time.

NOTE—This allows a SERVICE PROVIDER to be associated with multiple workflow steps, ensembles, means or operators. In contrast, a device can only be in one location and associated with only one patient.

5.4.5 BindingMdbVersion and UnbindingMdbVersion

Context states enclose the ATTRIBUTES `pm:AbstractContextState/@BindingMdbVersion` and `pm:AbstractContextState/@UnbindingMdbVersion`, which provide version information on when a context state was associated and disassociated (see `pm:AbstractContextState`). These referenced version numbers SHOULD be used to gain contextual information of any other states in the MDIB by comparing `pm:AbstractContextState/@BindingMdbVersion` and `pm:AbstractContextState/@UnbindingMdbVersion`.

A state *S* can be considered as bounded to a specific context state *CS*, if

$$\text{BindingMdbVersion}(\text{CS}) \leq \text{MdbVersion}(\text{S}) < \text{UnbindingMdbVersion}(\text{CS})$$

5.4.6 Device component and metric activation

DEVICE COMPONENTs and METRICs come with an activation state (see pm:ComponentActivation) to describe the current operating status of a CONTAINMENT TREE ENTRY within the MDIB. Figure 11 illustrates the finite state machine that SHOULD be adopted for pm:ComponentActivation. This state machine is only a recommendation of how transitions between states can be modeled.

NOTE—Devices can decide to not provide every state of pm:ComponentActivation and will therefore support only a subset of the finite state machine given in Figure 11.

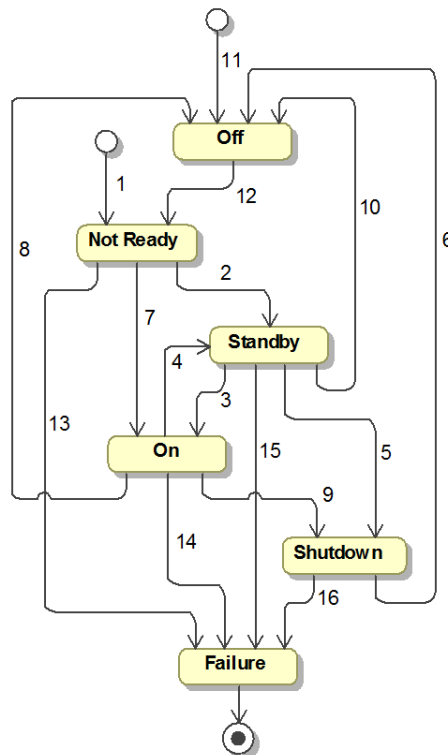


Figure 11 —Finite state machine of pm:ComponentActivation

The following semantics are applied to the transition numbers in Figure 11: the DEVICE COMPONENT or METRIC

- 1) Is made available, but needs initialization.
- 2) Has completed initialization and does not operate at the moment.
- 3) Has been activated and is operating now.
- 4) Does not operate, but is available for operation.
- 5) Is intended to be unavailable for operation and needs a shutdown phase.
- 6) Has been made unavailable for operation.
- 7) Has completed initialization and is operating.
- 8) Has been made unavailable for operation.
- 9) Is intended to be unavailable for operation and needs a shutdown phase.
- 10) Has been made unavailable for operation.
- 11) Is intended to be unavailable for its intended use, e.g., turned off or not plugged in.
- 12) Is made available, but needs initialization
- 13) Has detected a failure during initialization.
- 14) Has detected a failure during operation.

- 15) Has detected a failure during standby.
- 16) Has detected a failure during shutdown.

NOTE—A shutdown phase could be for example a monitoring device that is about to be turned off, but still exposes its SERVICES on the network.

R0025: If pm:AbstractDeviceComponentState/@ActivationState is intended to be switched to “Off,” then every activation state of the component’s children SHALL be made inactive in advance. Inactive means that any pm:AbstractDeviceComponentState/@ActivationState is “Off,” any pm:AbstractAlertState/@ActivationState is “Off,” and any pm:AbstractOperationState/@OperationMode is “NA” (not available).

NOTE—From this it follows that any child component cannot be activated if a parent component is in state “Off.”

R0110: A pm:ComponentActivation MAY start in another state than the initial ones defined in Figure 11.

NOTE—This depends on which state is observed by a SERVICE PROVIDER the first time it builds the MDIB.

R0131: If a component is recovered from a failure, its activation state is REQUIRED to start in an initial state as depicted in Figure 11.

R0132: If a component is recovered from a failure, the MDIB is REQUIRED to have a new MDIB sequence identifier assigned.

5.4.7 Metric activation state

Some METRIC categories (pm:AbstractMetricDescriptor/pm:MetricCategory) enclose a specific interpretation of the pm:ComponentActivation states and SHALL be applied according to Table 5, Table 6, and Table 7.

NOTE—METRIC categories that are not listed in Table 5, Table 6, and Table 7 are not affected by special interpretation. In that case the description in pm:ComponentActivation applies.

Table 5—Component activation of measurement METRICs

pm:AbstractMetricDescriptor/pm:MetricCategory equals “Msrmt”	
pm:AbstractMetricDescriptor/ pm:ActivationState is	Interpretation
On	The measurement is performed according to pm:AbstractMetricDescriptor/@DeterminationPeriod.
NotRdy	The measurement is currently initializing. As no measurement is performed during that phase, there is no determined value available.
StndBy	The measurement has been initialized, but is not being performed. Examples: the whole MDS is in standby mode or the current configuration, e.g., ventilation mode, does not include the determination of the measurement. As no measurement is performed during that phase, there is no new determined value available, but the last determined value could be present.
Shtdn	The measurement is currently de-initializing. As no measurement is performed during that phase, there is no determined value available.
Off	The measurement is not performed and is de-initialized. As no measurement is performed during that phase, there is no determined value available.
Fail	The measurement sensor has failed. As no measurement can be performed during that phase, there is no determined value available.

Table 6—Component activation of setting METRICS

pm:AbstractMetricDescriptor/pm:MetricCategory equals “Set”	
pm:AbstractMetricDescriptor/ pm:ActivationState is	Interpretation
On	The setting is applied and according to pm:AbstractMetricDescriptor/@DeterminationPeriod reapplied.
NotRdy	The setting is currently initializing. As the setting is not applied during that phase, there is no value available.
StndBy	The setting has been initialized, but it is not being applied. Examples: the whole MDS is in standby mode or the current configuration does not include the application of the setting. If the setting has been initialized, there is a value that is applied if the encompassing METRIC is activated.
Shtdn	The setting is currently de-initializing. As the setting is not applied during that phase, there is not value available.
Off	The setting is not applied and is de-initialized. As the setting is not applied during that phase, there is no value available.
Fail	The setting cannot be applied due to a failure. As the setting cannot be applied during that phase, there is no value available.

Table 7—Component activation of calculation METRICS

pm:AbstractMetricDescriptor/pm:MetricCategory equals “Clc”	
pm:AbstractMetricDescriptor/ pm:ActivationState is	Interpretation
On	The calculation is performed according to pm:AbstractMetricDescriptor/@DeterminationPeriod.
NotRdy	The calculation is currently initializing. As no calculation is performed during that phase, there is no determined value available.
StndBy	The calculation has been initialized, but is not being performed. Examples: the whole MDS is in standby mode or that the current configuration does not include the determination of the calculation. As no calculation is performed during that phase, there is no a new determined value available, but the last determined value could be present.
Shtdn	The calculation is currently de-initializing. As no calculation is performed during that phase, there is no determined value available.
Off	The calculation is not performed and is de-initialized. As no calculation is performed during that phase, there is no determined value available.
Fail	The calculation algorithm has failed. As no calculation can be performed during that phase, there is no determined value available.

5.4.8 SCO operation activation state

Any state that is derived from pm:AbstractOperationState, has a mandatory ATTRIBUTE pm:AbstractOperationState/@OperatingMode of TYPE pm:OperatingMode to control the accessibility of a service operation.

R0026: A SERVICE PROVIDER SHALL use pm:AbstractOperationState/@OperatingMode to enable or disable the accessibility of the referenced operation according to the description in pm:OperatingMode.

R0027: A SERVICE PROVIDER SHALL ensure that a disabled operation is not accessible for remote invocation.

R0028: A SERVICE PROVIDER MAY enable a referenced operation even if the activation state of the CONTAINMENT TREE ENTRY that is referenced by pm:AbstractOperationDescriptor/@OperationTarget, is indicating a nonoperating mode.

NOTE—R0028 is defined in accordance to R0025. From R0025 it follows that an operation is not necessarily not available even if the targeted object's activation state is off.

5.4.9 Alert state

5.4.9.1 General

Alert related states (i.e., derived from pm:AbstractAlertState) provide an alert activation (see pm:AlertActivation) to define if an alert component is operating (“On”), paused (“Psd”) or not operating (“Off”).

R0116: The activation state of pm:AlertSystemState SHALL result in an activation state of pm:AlertConditionState and pm:AlertSignalState according to Table 8.

Table 8—Relationship between alert activation states
(Read as <left column> implies <right column>.)

pm:AlertSystemState/@ActivationState	pm:AlertConditionState/@ActivationState pm:AlertSignalState/@ActivationState
“Off”	- Condition activation is “off” - Signal activation is “off”
“On”	- Condition activation accepts any value - Signal activation accepts any value
“Psd”	- Condition activation is “Psd” - Signal activation is “Psd”

5.4.9.2 Alert condition presence

A pm:AlertConditionState/@Presence indicates that an alert condition is fulfilled (“true”) or not (“false”).

R0029: If pm:AlertConditionState/@Presence switches to “true,” a SERVICE PROVIDER SHALL ensure that the state's ActivationState and the parent pm:AlertSystemState/@ActivationState ATTRIBUTES are “On.”

5.4.9.3 Present alarm conditions

The pm:AlertSystemState ELEMENT includes a list of HANDLE references to active physiological and technical alarm conditions.

R0113: If pm:AlertConditionState/@Presence is "true" for any physiological alarm condition or technical alarm condition, then the HANDLE of the corresponding ALERT CONDITION SHALL be added to pm:AlertSystemState/@PresentPhysiologicalAlarmConditions or pm:AlertSystemState/@PresentTechnicalAlarmConditions, respectively.

NOTE—Some SERVICE CONSUMER might not need to read and understand the details of the pm:AlertCondition-State element, but to only have an overview of all present alarm conditions. Hence, the physiological and technical alarm condition lists might be used as a shortcut to not read pm:AlertConditionState/@Presence of every single alert condition by those SERVICE CONSUMERS.

R0139: A change to pm:AlertConditionState/@Presence of an ALERT CONDITION SHALL always be delivered together with an ALERT SYSTEM state update within one msg:AbstractAlertReport MESSAGE.

NOTE—R0139 guarantees that the states tracked by a SERVICE CONSUMER are not going to be out of synchronization.

5.4.9.4 Valid alert attribute combinations

The alert signal generation is affected by many conditions and is strongly use-case dependent. Table 9 shows a list of valid combinations of alert activation states, ALERT CONDITION presence, and ALERT SIGNAL presence.

Table 9—Valid combinations of alert activation states, alert condition presence, and alert signal presence

ALERT SYSTEM ActivationState	ALERT CONDITION ActivationState	ALERT CONDITION Presence	ALERT SIGNAL ActivationState	ALERT SIGNAL Presence	Valid? (yes/no)
Off	any	any	any	any	yes
On	Off	any	any	any	yes
On	On	false	Off	Off	yes
On	On	false	Off	Latch	no
On	On	false	Off	Ack	no
On	On	false	Off	On	no
On	On	false	On	Off	yes
On	On	false	On	On	no
On	On	false	On	Latch	yes
On	On	false	On	Ack	no
On	On	false	Psd	On	no
On	On	false	Psd	Off	yes
On	On	false	Psd	Latch	no
On	On	false	Psd	Ack	no
On	On	true	Off	any	yes
On	On	true	On	Off	no ^a
On	On	true	On	On	yes
On	On	true	On	Latch	no ^b
On	On	true	On	Ack	yes
On	On	true	Psd	On	no
On	On	true	Psd	Off	yes
On	On	true	Psd	Latch	no
On	On	true	Psd	Ack	no
On	Psd	any	any	any	yes
Psd	any	any	any	any	yes

^a The combination is valid while the ALERT SIGNAL generation delay is not expired.

^b The combination is valid while the ALERT SIGNAL generation delay is not expired.

R0114: A SERVICE PROVIDER SHALL only produce combinations of pm:AlertSystemState/@ActivationState, pm:AlertConditionState/@ActivationState, pm:AlertSignalState/@ActivationState, pm:AlertConditionState/@Presence, and pm:AlertSignalState/@Presence that are valid according to Table 9.

NOTE 1—A description of the table entries is given in Table 10.

NOTE 2—For the sake of brevity, Table 9 only shows meaningful combinations. Combinations that do not create a meaningful behavior are valid but excluded from the table. Example: if ALERT SYSTEM ActivationState is “Off,” then any other field is allowed to be populated with any value without breaking validity. Nevertheless, it is not sensible to interpret those fields, since the whole ALERT SYSTEM is turned off.

Table 10—Description of table entries of Table 9

Table column entries	Description
On/Off/Psd/Latch/Ack/true/false	Values as defined in pm:AlertActivation, pm:AlertConditionState/@Presence, and pm:AlertSignalState/@Presence
any	Can be any value; no value is sensibly derivable.

Since pm:AlertSignalState/@Presence depends on pm:AlertSignalState/@ActivationState, pm:AlertSignalState/@ActivationState has a higher priority than pm:AlertSignalState/@Presence.

R0129: While pm:AlertConditionState/@ActivationState is “Off,” a SERVICE CONSUMER SHALL NOT interpret pm:AlertConditionState/@Presence.

R0115: While pm:AlertSignalState/@ActivationState is “Off,” a SERVICE CONSUMER SHALL NOT interpret pm:AlertSignalState/@Presence.

R0130: While pm:AlertSystemState/@ActivationState is “Off,” a SERVICE CONSUMER SHALL NOT interpret any properties of any child pm:AlertConditionState and pm:AlertSignalState.