Date: November 2013

ISO/IEC C++ 2003 Language DDS PSM

Version 1.0

OMG Document Number: formal/2013-11-01
Standard document URL: http://www.omg.org/spec/DDS-PSM-Cxx/
Machine Consumable File(s)*:
Normative:
http://www.omg.org/spec/DDS-PSM-Cxx/20121110/sources
http://www.omg.org/spec/DDS-PSM-Cxx/20121110/api-documentation

---

USE OF SPECIFICATION - TERMS, CONDITIONS & NOTICES

The material in this document details an Object Management Group specification in accordance with the terms, conditions and notices set forth below. This document does not represent a commitment to implement any portion of this specification in any company's products. The information contained in this document is subject to change without notice.

LICENSES

The companies listed above have granted to the Object Management Group, Inc. (OMG) a nonexclusive, royalty-free, paid up, worldwide license to copy and distribute this document and to modify this document and distribute copies of the modified version. Each of the copyright holders listed above has agreed that no person shall be deemed to have infringed the copyright in the included material of any such copyright holder by reason of having used the specification set forth herein or having conformed any computer software to the specification.

Subject to all of the terms and conditions below, the owners of the copyright in this specification hereby grant you a fully-paid up, non-exclusive, nontransferable, perpetual, worldwide license (without the right to sublicense), to use this specification to create and distribute software and special purpose specifications that are based upon this specification, and to use, copy, and distribute this specification as provided under the Copyright Act; provided that: (1) both the copyright notice identified above and this permission notice appear on any copies of this specification; (2) the use of the specifications is for informational purposes and will not be copied or posted on any network computer or broadcast in any media and will not be otherwise resold or transferred for commercial purposes; and (3) no modifications are made to this specification. This limited permission automatically terminates without notice if you breach any of these terms or conditions. Upon termination, you will destroy immediately any copies of the specifications in your possession or control.

PATENTS

The attention of adopters is directed to the possibility that compliance with or adoption of OMG specifications may require use of an invention covered by patent rights. OMG shall not be responsible for identifying patents for which a license may be required by any OMG specification, or for conducting legal inquiries into the legal validity or scope of those patents that are brought to its attention. OMG specifications are prospective and advisory only. Prospective users are responsible for protecting themselves against liability for infringement of patents.

GENERAL USE RESTRICTIONS

Any unauthorized use of this specification may violate copyright laws, trademark laws, and communications regulations and statutes. This document contains information which is protected by copyright. All Rights Reserved. No part of this work covered by copyright herein may be reproduced or used in any form or by any means--graphic, electronic, or mechanical, including photocopying, recording, taping, or information storage and retrieval systems--without permission of the copyright owner.

DISCLAIMER OF WARRANTY

WHILE THIS PUBLICATION IS BELIEVED TO BE ACCURATE, IT IS PROVIDED "AS IS" AND MAY CONTAIN ERRORS OR MISPRINTS. THE OBJECT MANAGEMENT GROUP AND THE COMPANIES LISTED ABOVE MAKE NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARD TO THIS PUBLICATION, INCLUDING BUT NOT LIMITED TO ANY WARRANTY OF TITLE OR OWNERSHIP, IMPLIED WARRANTY OF MERCHANTABILITY OR WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE OR USE. IN NO EVENT SHALL THE OBJECT MANAGEMENT GROUP OR ANY OF THE COMPANIES LISTED ABOVE BE LIABLE FOR ERRORS CONTAINED HEREIN OR FOR DIRECT, INDIRECT, INCIDENTAL, SPECIAL, CONSEQUENTIAL, RELIANCE OR COVER DAMAGES, INCLUDING LOSS OF PROFITS, REVENUE, DATA OR USE, INCURRED BY ANY USER OR ANY THIRD PARTY IN CONNECTION WITH THE FURNISHING, PERFORMANCE, OR USE OF THIS MATERIAL, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

The entire risk as to the quality and performance of software developed using this specification is borne by you. This disclaimer of warranty constitutes an essential part of the license granted to you to use this specification.

RESTRICTED RIGHTS LEGEND

Use, duplication or disclosure by the U.S. Government is subject to the restrictions set forth in subparagraph (c) (1) (ii) of The Rights in Technical Data and Computer Software Clause at DFARS 252.227-7013 or in subparagraph (c)(1) and (2) of the Commercial Computer Software - Restricted Rights clauses at 48 C.F.R. 52.227-19 or as specified in 48 C.F.R. 227-7202-2 of the DoD F.A.R. Supplement and its successors, or as specified in 48 C.F.R. 12.212 of the Federal Acquisition Regulations and its successors, as applicable. The specification copyright owners are as indicated above and may be contacted through the Object Management Group, 109 Highland Avenue, Needham, MA 02494, U.S.A.

TRADEMARKS

IMM®, MDA®, Model Driven Architecture®, UML®, UML Cube logo®, OMG Logo®, CORBA® and XMI® are registered trademarks of the Object Management Group, Inc., and Object Management Group™, OMG™ , Unified Modeling Language™, Model Driven Architecture Logo™, Model Driven Architecture Diagram™, CORBA logos™, XMI Logo™, CWM™, CWM Logo™, IIOP™ , MOF™ , OMG Interface Definition Language (IDL)™, and SysML™ are trademarks of the Object Management Group. All other products or company names mentioned are used for identification purposes only, and may be trademarks of their respective owners.

COMPLIANCE

The copyright holders listed above acknowledge that the Object Management Group (acting itself or through its designees) is and shall at all times be the sole entity that may authorize developers, suppliers and sellers of computer software to use certification marks, trademarks or other special designations to indicate compliance with these materials.

Software developed under the terms of this license may claim compliance or conformance with this specification if and only if the software compliance is of a nature fully matching the applicable compliance points as stated in the specification. Software developed only partially matching the applicable compliance points may claim only that the software was based on this specification, but may not claim compliance or conformance with this specification. In the event that testing suites are implemented or approved by Object Management Group, Inc., software developed using this specification may claim compliance or conformance with the specification only if the software satisfactorily completes the testing suites.

Table of Contents

OMG’s Issue Reporting Procedure

All OMG specifications are subject to continuous review and improvement. As part of this process we encourage readers to report any ambiguities, inconsistencies, or inaccuracies they may find by completing the Issue Reporting Form listed on the main web page *http://www.omg.org*, under Documents, Report a Bug/Issue (http://www.omg.org/report_issue.htm).

Preface

About the Object Management Group

OMG

Founded in 1989, the Object Management Group, Inc. (OMG) is an open membership, not-for-profit computer industry standards consortium that produces and maintains computer industry specifications for interoperable, portable and reusable enterprise applications in distributed, heterogeneous environments. Membership includes Information Technology vendors, end users, government agencies and academia.

OMG member companies write, adopt, and maintain its specifications following a mature, open process. OMG's specifications implement the Model Driven Architecture® (MDA®), maximizing ROI through a full-lifecycle approach to enterprise integration that covers multiple operating systems, programming languages, middleware and networking infrastructures, and software development environments. OMG's specifications include: UML® (Unified Modeling Language™); CORBA® (Common Object Request Broker Architecture); CWM™ (Common Warehouse Metamodel); and industry-specific standards for dozens of vertical markets.

More information on the OMG is available at *http://www.omg.org/*.

OMG Specifications

As noted, OMG specifications address middleware, modeling and vertical domain frameworks. All OMG Formal Specifications are available from this URL:

http://www.omg.org/spec

Specifications are organized by the following categories:

Business Modeling Specifications

Middleware Specifications

- **CORBA/IIOP**
- **Data Distribution Services**
- **Specialized CORBA**

IDL/Language Mapping Specifications

Modeling and Metadata Specifications

- **UML, MOF, CWM, XMI**
- **UML Profile**

Modernization Specifications

Platform Independent Model (PIM), Platform Specific Model (PSM), Interface Specifications

- **CORBAServices**
- **CORBAFacilities**

OMG Domain Specifications

CORBA Embedded Intelligence Specifications

CORBA Security Specifications

All of OMG's formal specifications may be downloaded without charge from our website. (Products implementing OMG specifications are available from individual suppliers.) Copies of specifications, available in PostScript and PDF format, may be obtained from the Specifications Catalog cited above or by contacting the Object Management Group, Inc. at:

OMG Headquarters
109 Highland Avenue
Needham, MA 02494
USA
Tel: +1-781-444-0404
Fax: +1-781-444-0320
Email: *pubs@omg.org*

Certain OMG specifications are also available as ISO standards. Please consult *http://www.iso.org*

Issues

The reader is encouraged to report any technical or editing issues/problems with this specification to *http://www.omg.org/report_issue.htm*.

1 Scope

The purpose of this document is to specify the ISO/IEC C++ PSM for DDS. This new PSM provides a new C++ API for programming DDS which is clear, simple, expressive, safe, efficient, extensible, and portable. The ISO/IEC-C++ PSM does not impact on-the-wire interoperability with other language mappings. The PSM API is defined by means of a set of C++ header files.

This PSM includes all DCPS conformance profiles defined in the DDS specification. In addition, it includes platform-specific mappings for:

- The programming interface specified by [DDS-XTypes]
- Accessing QoS profiles such as are specified in [DDS-CCM]

This specification only addresses the DCPS layer of the DDS specification. The optional DLRL layer may be addressed separately in a future specification. This specification also introduces a new C++ mapping for the DDS type system as specified in the Extensible and Dynamic Topic Types Specification [REF].

2 Conformance

This specification consists of this document as well as a set of C++ header files, references on the cover page. Both are normative. In the event of a conflict between them, the latter shall prevail.

2.1 Conformance Profiles

Conformance to this specification parallels conformance to the DDS specification itself and consists of the same conformance levels. For example, an implementation may conform to the DDS Minimum Profile with respect to this PSM, meaning that all of the programming interfaces identified by the DDS specification as pertaining to that conformance level must be implemented in this PSM. The one exception to this rule is the Object Model Profile, which defines the Data Local Reconstruction Layer (DLRL); DLRL is outside of the scope of this PSM.

In addition to the conformance level defined in the DDS specification itself, this PSM recognizes and implements the Extensible and Dynamic Types conformance level for DDS defined by the Extensible and Dynamic Topic Types for DDS specification.

This PSM furthermore defines methods to create Entities and to set their QoS based on the XML QoS libraries and profiles defined by the DDS for Lightweight CCM specification. Implementations that support these XML QoS profiles shall implement these operations fully; other implementations shall indicate failure with the DDS-standard UNSUPPORTED error. The Plain Language Binding for C++ defined in this specification represents an optional conformance point. Implementers may support either this Language Binding or the previously defined Plain Language Binding for C++ defined in [DDS-XTypes].

2.2 Programming Interfaces

Conformance to the C++ programming interfaces consists of the following conditions:

- The file names and relative locations of all C++ headers within the “dds” directory are normative. Those headers within “detail” subdirectories are excepted; they are not normative.

- All public symbol names within the ::dds:: namespace and its contained namespaces, including those names introduced into those namespaces by means of typedef declarations, are normative. Those names within “detail” namespaces are excepted; they are not normative.
- The distribution of the normative symbol names among the normative headers is itself normative, such that a source file that includes the header in which a given name is declared will continue to compile when that header is replaced with the corresponding header from a different DDS implementation.

The remainder of the files, declarations, and definitions contained within this specification’s C++ programming interfaces constitute a reference implementation and a set of examples. They are not normative.

Conforming implementations shall not define implementation-specific extension programming interfaces within normative namespaces. They may, however, specialize normative templates defined by this specification.

3 Normative References

The following normative documents contain provisions that, through reference in this text, constitute provisions of this specification. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply.

- [C99] C Programming Language (ISO/IEC 9899:1999)
- [C++] C++ Programming Language (ISO/IEC 14882:2003)
- [DDS] Data Distribution Service for Real-Time Systems Specification, version 1.2 (OMG document formal/2007-01-01)
- [DDS-XTypes] Extensible and Dynamic Topic Types, version 1.0 Beta 1 (OMG document ptc/2010-05-12)
- [DDS-CCM] DDS for Lightweight CCM, version 1.0 Beta 1 (OMG document ptc/2009-02-02)

4 Terms and Definitions

For the purposes of this specification, the following terms and definitions apply.

Data Centric Publish-Subscribe (DCPS)

The mandatory portion of the DDS specification used to provide the functionality required for an application to publish and subscribe to the values of data objects.

Data Distribution Service for Real-Time Systems (DDS)

An OMG distributed data communications specification that allows Quality of Service policies to be specified for data timeliness and reliability. It is independent of implementation languages.

Data Local Reconstruction Layer

The optional portion of the DDS specification used to provide the functionality required for an application for direct access to data exchanged at the DCPS layer. This later builds upon the DCPS layer.

Platform-Independent Model (PIM)

An abstract definition of a facility, often expressed with the aid of formal or semi-formal modeling languages such as OMG UML that does not depend on any particular implementation technology.

Platform-Specific Model (PSM)

A concrete definition of a facility, typically based on a corresponding PIM, in which all implementation-specific dependencies have been resolved.

5 Symbols

This specification leverages some symbols of common usage whose meaning is reported in the table below.

Symbol	Meaning
<:	The symbol "<:" is the commonly used symbol to denote subtyping. Given two programming language type T and Q, we can say that Q <: T if any occurrence of T can be replaced by Q.
Foo<+T>	When Foo is a class parameterized on the type T, we use the notation Foo<+T> to indicate that Foo is covariant in T. This means that given Q <: T then Foo<Q> <: Foo<T> When no annotation is provided then the class is supposed to be invariant.
Foo<-T>	When Foo is a class parameterized on the type T, we use the notation Foo<- T> to indicate that Foo is contra-variant in T. This means that given Q <: T then Foo<T> <: Foo<Q> When no annotation is provided then the class is supposed to be invariant.
Foo<T>	When foo is non-variant in T.

6 Additional Information

6.1 Acknowledgments

The following companies submitted this specification:

- PrismTech Corporation, Ltd.
- Real-Time Innovations, Inc. (RTI)

7 ISO/IEC C++ Language DDS PSM (DDS-PSM-Cxx)

7.1 Overview

The “ISO/IEC C++ Language DDS PSM” (DDS-PSM-Cxx) was motivated by mainly two reasons. First the IDL-derived C++ API for DDS does not integrate well with the C++ language and it does not leverage some of the features provided by the C++ language today universally sup- ported by C++ compilers. Second, the current IDL-derived PSM suffers from the gap existing between the features available in IDL and those available in a programming language such as C++. Some examples of this gap are as simple as method overloading, yet, there are many other examples that we could make in comparing the expressiveness power of IDL versus that of native C++.

As a result this specification takes a completely fresh look at how a native C++ PSM can be derived from the DDS PIM. In doing so, it tries to balance two forces - derive an API that is as simple and safe as possible while retaining the structure of the PIM. This specification does not require C++11 features for its implementation, yet it is designed to enable the use of C++11 features, such as the auto keyword, range-based for loops, etc.

7.2 Specification Organization

The DDS-PSM-Cxx API is organized around namespaces that match the different modules defined by the DDS v1.2 PIM (see Figure 7.1). The dds::core - as implied by its name - provides core abstractions that are used throughout the API, such as the Time and Duration, the Policies, and the definition of reference and value types. The specification defines type constructors, i.e., parameterized class, that delegate their behavior to a delegate type parameter. The standard API is turned into an implementation by properly instantiating these type constructors with implementation provided delegates. The "detail" sub-packages visible in Figure 7.1, are intended to store the "link" between the standard API and the vendor implementation. The content of the detail sub-package is provided as a guideline and does not constitute a point of compliance.

The DDS-PSM-Cxx organizes DDS classes as a set of packages that maximize the coherence and minimize the dependencies across packages. This organization minimizes API dependencies and reduce the include files required by publish, or subscribe, only applications speeding up compilation times.

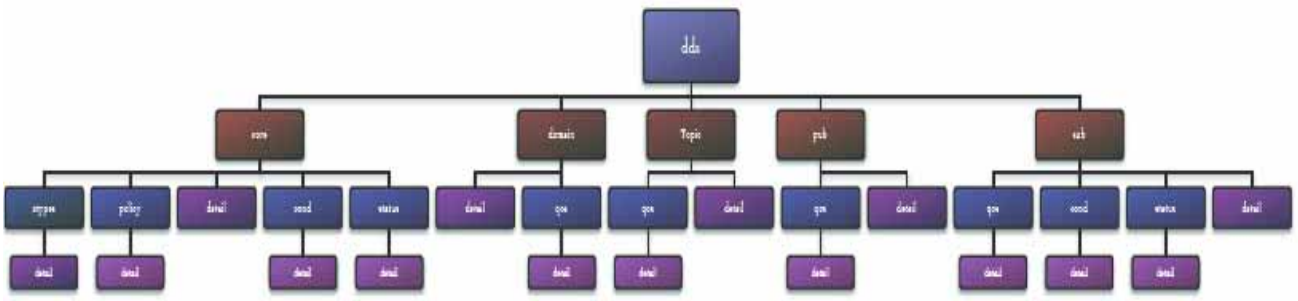


Figure 7.1 - Standard Packages Organization

For instance if we take as an example the type constructor TInstanceHandle, specified in the file dds/core/ TInstanceHandle.hpp as:

```
namespace dds {
   namespace core {
      template <typename DELEGATE> class TInstanceHandle ;
   }
}
```

Then its instantiation is to be defined by the implementor of the API within the dds::core::delegate namespace as something like:

```
namespace dds {
   namespace core {
      namespace detail {
       typedef dds::core::TInstanceHandle<foo::core::InstanceHandleDelegate>
       InstanceHandle;
   }
}
```

This instantiation of the type constructor TInstanceHandle is then used by the standard API in the dds/core/InstanceHandle.hpp file to define the standard instance handle as:

```
namespace dds {
   namespace core {
      typedef detail::InstanceHandle InstanceHandle;
   }
}
```

Under no circumstances a vendor shall change the public API defined by this specification. The only action performed by type constructor is to delegate their implementation to the DELEGATE template parameter. It is the DELEGATE type that provides the actual implementation and that encapsulate vendor extensions. The DDS-PSM-Cxx API provides a standard way of accessing vendor specific extensions.

Application source code imports the DDS API by including one or more header files from the dds/ directory hierarchy. There are three ways to do this, depending on how the application programmer wishes to manage file dependencies.

1. The entire DDS API can be included at once:
   - #include <dds/dds.hpp>
2. Individual DDS modules can be included. These headers have the form dds/module/ddsmodule.hpp. For example:
   - #include <dds/pub/ddspub.hpp>
3. Individual types can be included. These headers have the form dds/module/ClassName.hpp. For example:
   - #include <dds/pub/DataWriter.hpp>

7.3 Concurrency, Reentrancy and Exception Safety

It is expected that most Service implementations will support multi-threaded environments. Therefore, for the sake of portability, this PSM constrains the level of thread and exception safety that applications may expect:

- All DataReader and DataWriter operations shall be reentrant.
- Loand-based read/take operation shall be exception safe.

- Constructors and copy-assignment operators of normative classes that inherit from Value<D> and the Value<D> template itself shall preferably be exception safe. Deviation from this norm should be carefully noted on vendor documentation.
- All Topic (and other TopicDescription extension interfaces), Publisher, Subscriber, and DomainParticipant operations shall be reentrant with the exception that close may not be called on a given object concurrently with any other call of any method on that object or on any contained object.
- All DomainParticipantFactory operations shall be reentrant with the exception that DomainParticipantFactory.close may not be called on a given object concurrently with any other call of any method on that object or on any contained object.
- All WaitSet and Condition (including Condition extension interfaces) operations shall be reentrant with the exception that their close() operations may not be invoked concurrently with any other method on the same object.
- Code within a DDS listener callback may not safely call any method on any DDS Entity but the one on which the status change occurred.
- Any method of any value type may be non-reentrant.

A Service implementation may choose to provide unspecified stronger guarantees than the rules above.

7.4 General Rules for Mapping the DDS PIM to the DDS-PSM-Cxx

This specification defines some general rules to map DDS PIM classes to DDS-PSM-Cxx classes. These rules are applicable to a subset of classes, luckily the most numerous, while special mapping is required for some of the DDS entities as described below.

7.4.1 MappingClasses

As a general rule all classes included in the DDS PIM have to be mapped into a C++ class. The specific nature of this class depends on whether the DDS PIM element has reference or value semantics.

Note – An implication of this mapping is that no DDS PIM class ever maps to a C++ struct.

7.4.2 Mapping Primitive and Container Types

The table below provides a complete mapping between the types defined and used by the DDS PIM and the corresponding types used by the DDS-PSM-Cxx.

Table 7.1 - Primitive and Container Types Mapping

DDS Type	C++ Type
Boolean	bool
Char8	char
Char32	wchar_t
Byte	uint8_t
Int16	int16_t
UInt16	uint16_t
Int32	int32_t

Table 7.1 - Primitive and Container Types Mapping

UInt32	uint32_t
Int64	int64_t
UInt64	uint64_t
Float64	double
Float128	long double
Float32	float
string<Char8>	std::string
string<Char32>	std::wstring
sequence<T>	std::vector<T>
map<K, V>	std::map<K, V>
T[N]	dds::core::array<T, N>

The above fixed-size integer types shall conform to the types of the same names as defined by [C99] in the header stdint.h.

- The presence of these types shall not be construed to require that DDS implementations only support [C99]-compliant platforms. Implementations for non-[C99]-compliant platforms shall provide their own conformant integer type definitions.
- It shall not be construed to imply the existence of any other definitions that would be found in the header stdint.h on a [C99]-compliant platform or even the existence of that header itself.

Note that these types are defined in the global namespace, not in the std namespace. In addition, it is worth noticing that bounded and unbounded sequence types map to the same C++ types.

The DDS Array type is mapped to the dds::core::array type which is specified to conform with the std::array type specified as part of C++11, exception made for the move operators.

7.4.3 Mapping Enumerations

Native enumerations in C++ are not safe. This specification maps DDS enumerations to a safe enumeration class defined as follows:

```
namespace dds {
  namespace core {
    template<typename def, typename inner = typename def::type>
    class safe_enum : public def
    {
      typedef typename def::type type;
      inner val;

    public:

      safe_enum(type v) : val(v) {}
      inner underlying() const { return val; }

      bool operator == (const safe_enum & s) const;
      bool operator != (const safe_enum & s) const;
```

```
    bool operator <  (const safe_enum & s) const;
    bool operator <= (const safe_enum & s) const;
    bool operator >  (const safe_enum & s) const;
    bool operator >= (const safe_enum & s) const;
  };
 }
}
```

Below we provide an example of how implementations of this specification have to the safe_enum class to map DDS enumeration. For convenience we use IDL to express a DDS enumeration.

DDS Type	**C++ Type**

enum Color {
GREEN,
WHITE,
RED
};
	enum Color_def__ {
	GREEN,
	WHITE,
	RED
	};
	
	typedef dds::core::safe_enum<Color_def> Color;

Notice that this enumeration provides scoped names and leads to code that is equivalent to those written using C++11 enumeration classes. As such, for C++11 compilers, implementers may choose to map enumeration to C++11 enumeration classes.

7.4.4 Mapping Unions

DDS unions mapping is the same as the one defined by the IDL2C++11 specification as defined in 6.13.2 of the document ptc/2012-04-03. This choice is compatible with the use of C++03 and aligns the mapping of DDS types to that of IDL.

7.4.5 Mapping Parameters Passing and Parameters Return Rules

The DDS PIM defines parameters as being either IN/OUT/INOUT depending on whether the parameter has no side effect, is used only for side effect, or whether it provides data that then is changed by the invoked method. Likewise the PIM defines return types.

The table below provides a mapping between IN/OUT/INOUT for a generic type T, distinguishing between primitive and non-primitive types. To this end, container types are considered as non-primitive types.

PIM Native Type Parameter	**DDS-PSM-Cxx Native Type Parameter**
IN T	T
OUT T	T&
INOUT T	T&

PIM Native Return Type	DDS-PSM-Cxx Native Return Type
T	T

PIM Type Parameter	DDS-PSM-Cxx Type Parameter
IN T	const T&
OUT T	T&
INOUT T	T&

PIM Native Return Type	DDS-PSM-Cxx Native Return Type
T	One of the following, depending on wether the return parameter is an attribute or not. • T • const T&

7.4.6 Mapping Attributes

Attributes defined by DDS PIM classes have to be mapped into:

- Implementation-defined state,
- Getter and setter methods named after the attribute, and
- A constructor argument that allows initializing the attribute.

Getter/Setter methods shall be declared as described in the following table.

Attribute Type	Getter/Setter Signature
NT attribute; Where **NT** is a native.	**NT** attribute(); void attribute(**NT** attrib);

CT attribute;
Where CT is a constructed type (e.g., a struct)
	CT& attribute();
	const **CT&** attribute() const;
	void attribute(const **CT&** attrib);

ST attribute;
Where ST is a sequence type (e.g., a string, sequence, map, arrays, etc.)
	ST& attribute();
	const **ST&** attribute() const;
	void attribute(const **ST&** attrib);

7.5 Core Package

The core package of the ISO/IEC C++ PSM for DDS (DDS-PSM-Cxx) defines the classes at the foundation of the API object model as well as all the DDS types used by all other modules. This sub clause describes the most important classes of the package.

7.5.1 Object Model

The ISO/IEC C++ PSM for DDS (DDS-PSM-Cxx) is based on an object model that is structured in two different kinds of object types: reference-types and value-types.

7.5.1.1 Reference Types

All objects that have a reference-type have an associated shallow (polymorphic) assignment operator that simply changes the value of the reference. Furthermore reference-types are safe, meaning that under no circumstances can a reference point to an invalid object. At any single point in time a reference can either refer to the null object or to a valid object.

The semantics for Reference types is defined by the DDS-PSM-Cxx class dds::core::Reference. In the context of this specification the semantics implied by the ReferenceType is mandatory, yet the implementation provided as part of this standard is provided to show one possible way of implementing this semantics.

All DDS-PSM-Cxx reference-types store references to a delegate. To avoid imposing too many constraints on the actual implementation of the DDS-PSM-Cxx standard while ensuring that efficiency can be retained, all DDS-PSM-Cxx reference-types are template classes whose parameter is the DELEGATE. Each vendor will plug-in his implementation simply by providing a file that instantiates the DDS-PSM-Cxx API with its own delegates. Furthermore, by using this approach, the same API can be used without changes on multiple implementations. At the limit, it is possible for end-users to program to the OMG provided DDS-PSM-Cxx and then switch from one DDS to another by simply switching to use his own mapping file and his libraries. Finally, the PSM also provides weak references.

Table 7.2 lists all the DDS PIM classes that have reference semantics.

Table 7.2 - DDS Classes with Reference semantics

Namespace		Class
dds	core	• Entity • Condition • GuardCondition • ReadCondition • QueryCondition • Waitset
	pomain	• DomainParticipant
	pub	• AnyDataWriter • Publisher • DataWriter
	sub	• AnyDataReader • Subscriber • DataReader • SharedSamples
	topic	• AnyTopic • Topic

7.5.1.2 Resource for Reference Types

Instances of reference types are created using C++ constructors. The trivial constructor is not defined for reference types, the only alternative to properly constructing a reference is to initialize it to a null reference by assigning dds::core::null.

Resource management for some reference types might involve relatively heavyweight operating- system resources—such as e.g., threads, mutexes, and network sockets—in addition to memory. These objects therefore provide a method close() that shall halt network communication (in the case of entities) and dispose of any appropriate operating-system resources.

Users of this PSM are recommended to call close on objects of all reference types once they are finished using them. In addition, implementations may automatically close objects that they deem to be no longer in use, subject to the following restrictions:

- Any object to which the application has a direct reference (not including a WeakRefer- ence) is still in use.
- Any entity with a non-null listener is still in use.
- Any object that has been explicitly retained is still in use
- The creator of any object that is still in use is itself still in use.

7.5.2 Value Types

All objects that have a value-type have a deep-copy assignment and copy construction semantics. It should also be pointed out that value-types are not “pure-value-types” in the sense that they are immutable (as in functional programming languages). The DDS-PSM-Cxx makes value-types mutable to limit the number of copies as well limit the time-overhead necessary to change a value-type (note that for immutable value-types the only form of change is to create a new value- type).

The DDS-PSM-Cxx models all DDS PIM classes beyond what is listed in Table 7.2 as value- types. In other terms, QoS, Policy, Statuses, and Topic samples are all modeled as value-types.

7.5.3 Any Types

The DDS-PSM-Cxx has been designed to take advantage of the compile time polymorphism provided by C++ templates. As such, the whole standard interface only has a few virtual methods, and in general does not rely on inheritance but as opposed exploits delegation.

Since the DDS API requires at times to pass DDS entities without exposing the complete type, while other times requires to store in containers list of objects of different types, the DDS-PSM-Cxx provides a selection of “Any” types.

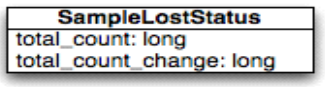
These Any types safely store references in generic container objects without losing type information while at the same time exposing some type-independent operations.

7.5.4 Status Classes

The DDS-PSM-Cxx mapping for the status classes as defined in the DDS v1.2 specification is obtained by applying the generic mapping rules described in 7.4 with the following caption – inheritance from the root status class has been ignored.

The reason for ignoring the inheritance from the root Status class is that this super-class does not provide any common behavior, or common state.

Status classes are part of the dds::core::status namespace. As an example, consider the following PIM Status class:



Based on the mapping rules defined so far, the associated DDS-PSM-Cxx class would be the following:

```
namespace dds { namespace core { namespace status {
template <typename D>
class SampleLostStatus : public  dds::core::Value<D>{
public:
   SampleLostStatus();
   SampleLostStatus(uint32_t total_count, uint32_t total_count_change);
```

```
public:
   uint32_t total_count() const;
   uint32_t& total_count();
   void total_count(uint32_t total_count);
}; } } }
```

The full set of status classes is includes in the mandatory standard headers in the file dds/core/status/Status.hpp.

7.5.5 Error Codes

Table 7.3 - Mapping between PIM Error Codes and C++ Exception

DDS PIM Return Code	DDS-PSM-Cxx Exception Class	Std C++ Parent Exception
RETCODE_OK	Normal return; no exception	
RETCODE_NO_DATA	An informational state attached to a normal return; no exception	
RETCODE_ERROR	Error	std::logic_error
RETCODE_BAD_PARAMETER	InvalidArgumentError	std::invalid_argument
RETCODE_TIMEOUT	TimeoutError	std::runtime_error
RETCODE_UNSUPPORTED	UnsupportedError	std::logic_error
RETCODE_ALREADY_DELETED	AlreadyClosedError	std::logic_error
RETCODE_ILLEGAL_OPERATION	IllegalOperationError	std::logic_error
RETCODE_NOT_ENABLED	NotEnabledError	std::logic_error
RETCODE_PRECONDITION_NOT_MET	PreconditionNotMetError	std::logic_error
RETCODE_IMMUTABLE_POLICY	ImmutablePolicyError	std::logic_error
RETCODE_INCONSISTENT_POLICY	InconsistentPolicyError	std::logic_error
RETCODE_OUT_OF_RESOURCES	OutOfResourcesError	std::runtime_error

The DDS-PSM-Cxx maps error codes to C++ exceptions defined in the dds::core namespace and inheriting from a base Exception class and the appropriate standard C++ exception. Table 7.3 lists the mapping between error codes as defined in the DDS PIM and C++ exceptions as used in this specification. Exceptions have value semantics, this means have to always have deep copy semantics. The full list of exceptions is included in the file dds/core/Exceptions.hpp.

7.5.6 Time and Duration

This PSM maps the DDS Time_t and Duration_t types into the value types Time and Duration respectively. In addition to providing their seconds and nanoseconds state through accessor and mutator methods, these classes provide a small number of convenience operations:

- Time object scan be incremented by durations expressed as seconds, nanoseconds, milliseconds, or Duration objects.
- Time object scan be converted to and from times expressed in milliseconds (or other units) as integer types.
- Duration objects can be incremented by durations expressed as seconds, nanoseconds, milliseconds, or Duration objects.
- Duration objects can be converted to and from durations expressed in milliseconds(or other units) as integer types.

7.6 QoS Packages

The QoS package provides all definitions for Policy and QoS.The DDS-PSM-Cxx provide extensible policy and extensible QoS. This means that vendor can easily add additional attributes to policy as well as new policies to Qos. All of this without requiring changes in the public API. As explained above, the PSM uses the “operator ->”, or equivalently the “delegate()” method to access vendor-specific extensions.

7.6.1 Policy Classes

The DDS-PSM-Cxx mapping for the policy classes as defined in the DDS v1.2 specification is obtained by applying the generic mapping rules described in 7.4 with the following guidelines:

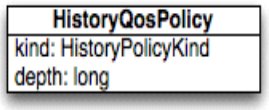
- the inheritance from the root Policy class has been ignored
- the trailing “QosPolicy” has to be discarded from the name as redundant.
- Policy kind is represented with a C++ enumeration and an associated constructor type as shown in the example below.

Policy classes are part of the dds::qos namespace and the Policy Name and Policy ID are to be provided by specialization of the following trait classes:

```
namespace dds { namespace qos {
  template <typename Policy>
  class policy_id {
  public:
    enum {
      id = -1
    };
  };
  template <typename Policy>
  class policy_name {
  };

} }
```

As an example let’s consider the following Policy class as modeled in the DDS PIM:



This would map to the following set of types:

```
namespace dds { namespace qos {

 struct HistoryKind_def {
  enum Type {
   KEEP_LAST,
```

```
    KEEP_ALL
  };
 };

 typedef dds::core::safe_enum<HistoryKind_def> HistoryKind;
} }

namespace dds { namespace qos {
template <typename D>
class THistory : public dds::core::Value<D> {

public:
   THistory();

   THistory(HistoryKind kind, int32_t depth);

   HistoryKind::Type kind() const;
   HistoryKind::Type& kind();
   THistory& kind(HistoryKind kind);

   int32_t depth() const;
   int32_t& depth();
   THistory& depth(int32_t depth);

  static History KeepAll();
  static History KeepLast(uint32_t depth);
};
} }
```

As shown in the example above, when a policy presents a variability that is captured at a PIM- Level by a kind, the DDS-PSM-Cxx captures this variability into two ways, first it associates an enumeration with the Policy defining a code for the variation (as it was done in the IDL PSM), then, it defines a set of helper methods to construct the possible variants. The full set of policies is included in the mandatory standard headers in the file dds/qos/Policy.hpp.

7.6.2 Entity Class

The Entity class is the root for all DDS entities, as specified in the DDS v1.2 specification. Since an Entity is a reference type, its resources are automatically managed by the middleware. Specifically, the resources associated with the entity will be reclaimed either when the number of live reference from the user application to the entity drops to zero, or when the user explicitly invokes the method close.

7.6.2.1 QoS and Profiles

This specification introduces the concept of a QosProvider to load a QoS configuration from an URI. The URI is used to deduce both the protocol to be used to access the QoS configuration as well as the format in which it is expressed. As an example, from the URI ” the QosProvider would deduce that the configuration is accessible as a file on the local filesystem and that it is expressed in xml format.

Implementation of this specification shall support at very least file URIs and XML format compliant with the QoS-Profile defined in the DDS for Lightweight CCM specification [DDS-CCM].

```
template <typename DELEGATE>
class dds::core::qos::TQosProvider : public dds::core::Reference<DELEGATE> {
public:
  explicit TQosProvider(const std::string& uri, const std::string& profile);

   explicit TQosProvider(const std::string& uri);

   dds::domain::qos::DomainParticipantQos
   participant_qos();

   dds::domain::qos::DomainParticipantQos
   participant_qos(const std::string& id);


   dds::topic::qos::TopicQos
   topic_qos();

   dds::topic::qos::TopicQos
   topic_qos(const std::string& id);


   dds::sub::qos::SubscriberQos
   subscriber_qos();

   dds::sub::qos::SubscriberQos
   subscriber_qos(const std::string& id);

   dds::sub::qos::DataReaderQos
   datareader_qos();

   dds::sub::qos::DataReaderQos
   datareader_qos(const std::string& id);

   dds::pub::qos::PublisherQos
   publisher_qos();

   dds::pub::qos::PublisherQos
   publisher_qos(const std::string& id);

   dds::pub::qos::DataWriterQos
   datawriter_qos();

   dds::pub::qos::DataWriterQos
   datawriter_qos(const std::string& id);
};
```

Below a non mandatory example showing how the QosProvider can be used:

```
dds::core::qos::QosProvider qos_provider("file:///smwr/hdd/config-qos.xml",
                                        "myprofile");
DataReader<ShapeType> dr(sub, topic, qos_provider.datareader_qos());
```

7.7 Domain Package

The domain package defines the DomainParticipantFactory, DomainParticipant, and DomainParticipantListener. For a complete reference see the standard header files.

7.8 Topic Package

The topic packaged defines the classes related to topic management. As such it provides definitions for the Topic, TopicDescription, ContentFilteredTopic, MultiTopic, and the TopicListener.

The topic class is parameterized in the topic type and transparently performs the registration of type support.

If we consider the RadarTrack topic type used in the example above, we can create a topic for this type as follows:

```
DomainParticipant dp(domainId);

dds::topic::Topic<RadarTrack> topic(dp, "RadarTrackTopic");
```

If the topic is to be created with a QoS different from the default, than the code above would be:

```
DomainParticipant dp(domainId);

dds::qos::TopicQos tqos = dp.default_topic_qos();

tqos << Reliability::Reliable() << Ownership::Exclusive();

dds::topic::Topic<RadarTrack> topic(dp, "RadarTrackTopic", tqos);
```

7.9 Pub Package

The publication (pub) package defines all the classes associated with the production of data. As such, it defines the Publisher, the DataWriter and their associated listeners as well as any types.

The mandatory classes are specified in the standard header files. Below, we focus on the specifics of the DataWriter class.

7.9.1 DataWriter Class

The DataWriter class is parameterized with respect to the delegate and the topic type that it writes. The class provides several different overloaded methods for writing data by providing single samples or iterators over samples.

7.10 Sub Package

The subscription (sub) package defines all the classes associated with the consumption of data. As such, it defines the Subscriber, the DataReader and their associated listeners as well as any types. The mandatory classes are specified in the standard header files. Below, we focus on the specifics of the DataReader class.

7.11 Extensible and Dynamic Type Support Package

The Extensible and Dynamic Type Support (xtypes) package defines all the classes associated with the definition of extensible topics, such as annotations and the definition and manipulation of dynamic types. As such, this package introduces all classes necessary for describing dynamic types and their attributes, creating and annotating them.

7.12 C++11 Compatibility

This specification relies on C++03 features only. However, to improve its efficiency and usability in a C++11 environment, it provides built-in support for some C++11 features, such as initializer lists.

Below we list the set of features required by this specification to enable some of the C++11 extensions:

- A move(LoanedSamples<T>&) function shall be defined in the same namespace as LoanedSamples<T> that behaves identical to std::move.
- LoanedSamples<T> and SharedSamples<T> shall provide member cbegin() and cend() functions, which return const_iterator irrespective of the constness of the object.

When targeting a C++11 environment implementations compliant with this specification shall follow these additional rules:

- LoanedSamples<T> shall be implemented as a first-class move-only type using move operations. A representative example is std::uniqe_ptr.
- LoanedSamples<T> and SharedSamples<T> shall provide namespace level begin() and end() functions to facilitate use of range-based for loop.
- dds::core::array shall be a template typedef to std::array.
- Enumerations shall use built-in type-safe enumerations with enum class syntax.
- Move operations (move constructor and move assign) shall be provided for all Value<DELEGATE> types.
- Plain language binding shall be augmented as follows
  - Generated code for complex types shall use move operations (move-assignment, move-constructor) as defined in idl2cpp11 (ptc/2012-04-03) struct type mapping.
  - Structures containing arrays shall use a const-reference parameter for arrays as opposed to pass-by-value.
  - A namespace level swap(t1) and a member swap shall be provided for each generated class.
  - Move-assign, move-constructor, and member swap functions, and namespace-level swap may provide noexcept specification to allow efficient and exception-safe resizing of standard containers.

7.13 Examples

7.13.1 C++03 Example

This sub clause provides an example for full application writing and reading RadarTracks topics.

```
// ================== DataWriter ==================
 try {
      DomainId id = 0;
      DomainParticipant dp(id);

      pub::qos::PublisherQos pqos;
      pqos << policy::Partition("Tracks");

      pub::Publisher pub(dp, pqos);

      topic::qos::TopicQos tqos;
      tqos << policy::Reliability::Reliable()
           << policy::Durability::Transient()
           << policy::History::KeepLast(10)
           << policy::TransportPriority(14);


      dds::topic::Topic<RadarTrack> topic(dp, "TrackTopic", tqos);

      pub::qos::DataWriterQos dwqos(tqos);

      pub::DataWriter<RadarTrack> dw(pub, topic, dwqos);

      RadarTrack track("alpha", 100, 200);

      dw.write(track);
      // or
      dw << track;



 } catch (const dds::core::Exception& e) { }

// ================== DataReader==================


try {
      DomainId id = 0;
      DomainParticipant dp(id);

      sub::qos::SubscriberQos sqos;
      sqos << policy::Partition("Tracks");

      sub::Subscriber sub(dp, sqos);

      topic::qos::TopicQos tqos = dp.default_topic_qos();
      tqos << policy::Reliability::Reliable()
           << policy::Durability::Transient()
           << policy::History::KeepLast(10)
           << policy::TransportPriority(14);
```

```
    dds::topic::Topic<RadarTrack> topic(dp, "TrackTopic", tqos);

    sub::qos::DataReaderQos dwqos(tqos);

    sub::DataReader<RadarTrack> dr(sub, topic, drqos);

    std::vector< Samples<RadarTrack> > samples(MY_MAX_LEN);
    dr.read(samples.begin(), MY_MAX_LEN);


} catch (const dds::core::Exception& e) { }
```

7.13.2 C++11 Example

While not requiring C++11 the DDS-PSM-Cxx API described in this specification has built-in support for some of the most interesting C++11 features.

```
// ================== DataWriter ==================
 try {
    DomainId id = 0;
    DomainParticipant dp(id);

    pub::qos::PublisherQos pqos;
    pqos << policy::Partition("Tracks");

    pub::Publisher pub(dp, pqos);

    topic::qos::TopicQos tqos = dp.default_topic_qos();
    tqos << policy::Reliability::Reliable()
        << policy::Durability::Transient()
        << policy::History::KeepLast(10)
        << policy::TransportPriority(14);

    dds::topic::Topic<RadarTrack> topic(dp, "TrackTopic", tqos);

    pub::qos::DataWriterQos dwqos(tqos);

    pub::DataWriter<RadarTrack> dw(pub, topic, dwqos);

    RadarTrack track("alpha", 100, 200);

    dw.write(track);
    // or
    dw << track;


} catch (const dds::core::Exception& e) { }
```

```
  // ================== DataReader==================

  try {
        DomainId id = 0;
        DomainParticipant dp(id);

        sub::qos::SubscriberQos sqos;
        sqos << policy::Partition("Tracks");

        sub::Subscriber sub(dp, sqos);


        topic::qos::TopicQos tqos = dp.default_topic_qos();
        tqos << policy::Reliability::Reliable()
             << policy::Durability::Transient()
             << policy::History::KeepLast(10)
             << policy::TransportPriority(14);


        dds::topic::Topic<RadarTrack> topic(dp, "TrackTopic", tqos);

        sub::qos::DataReaderQos dwqos(tqos);

        sub::DataReader<RadarTrack> dr(sub, topic, drqos);


        auto samples =
  dr.select()
     .max_samples(100)
     .data(dds::sub::status::DataState::new_data())
       take();

        for (auto s : samples) {
       std::cout << samples.data() << std::endl;
}
   } catch (const dds::core::Exception& e) { }
```

8 Improved Plain Language Binding for C++

8.1 Type Mapping

The type system for DDS topic types is defined by the Extensible and Dynamic Topic Types for DDS specification [DDS-XTypes].

This sub clause defines the set of rules to be used in order to map abstract DDS topic types into C++ types that can be used by application programmers. Those aspects of the DDS Type System that are not addressed below are as specified in the Plain Language Binding as defined by [DDS- XTypes] (which in turn is defined in terms of an IDL-to-C++ mapping).

8.1.1 Mapping Aggregation Types

DDS aggregation types shall be mapped to a C++ class. Contained attributes shall be encapsulated. Accessors shall be provided following the rules described in 7.4. The representation of internal state is unspecified.

8.1.2 Mapping Primitive and Collection Types

IDL primitive and collection types used to define a topic type shall be mapped to C++ following the rules listed in Table 7.1.

8.1.3 Mapping Enumerations

IDL enumerations shall be mapped into C++ enumerations with exactly the same enumeration name and enumeration constants.

8.1.4 Mapping Optional Attributes

Attributes annotated though the @Optional annotation are mapped to a template instantiation of the class dds::core::optional<T> with T equal to the type attribute would normally map as per the rules specified above.

8.1.5 Mapping Shared Attributes

Attributes annotated through the @Shared annotation are mapped to a pointer of the type they would normally map as per the rules specified above.

8.2 Example

This sub clause provides a simple yet representative example demonstrating the ISO/IEC mapping for DDS types.

Topic Type Declaration (IDL)	C++ Representation

typedef sequence<octet>
plot_t;
 	
struct RadarTrack {
string id;
long x;
long y;
long z; //@Optional
plot_t plot; //@Shared
};
	typedef std::vector<uint8_t> plot_t
	
	class RadarTrack {
	public:
	typedef
	typename smart_ptr_traits<plot_t>::ref_type
	plot_ref_t;
	
	public:
	RadarTrack();
	RadarTrack(const std::string& id,
	int32_t x, int32_t y,
	int32_t z,
	std::vector<uint8_t>* plot);
	public:
	// Notice that sequence type
	// are not returned by const reference
	// to avoid forcing copies when needing
	// to change just one element.
	// This is unfortunate, but a necessary
	// tradeoff.
	std::string& id() const;
	void id(const std::string& s);
	
	int32_t x() const;
	void x(int32_t v);
	
	int32_t y() const;
	void y(int32_t v);
	
	dds::core::optional<int32_t>& z() const;
	void z(int32_t v);
	void z(const
	dds::core::optional<int32_t>& z)
	
	const plot_ref_t& plot() const;
	void plot(plot_ref_t pr)
	
	// State representation is implementation
	// dependent.
	
	};