Date: November 2012

ISO/IEC C++ 2003 Language DDS PSM (DDS-PSM-Cxx)

v1.0

OMG Document Number: ptc/2012-11-11

Standard document URL: http://www.omg.org/spec/DDS-PSM-Cxx/1.0

Associated File(s)*: http://www.omg.org/spec/DDS-PSM-Cxx/20121003

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* original file: mars/2010-11-02

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Preface

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Typographical Conventions

The type styles shown below are used in this document to distinguish programming statements from ordinary English. However, these conventions are not used in tables or section headings where no distinction is necessary.

imes/imes New Roman - 10 pt.: Standard body text

Helvetica/Arial - 10 pt. Bold: OMG Interface Definition Language (OMG IDL) and syntax elements.

Courier - 10 pt. Bold: Programming language elements.

Helvetica/Arial - 10 pt: Exceptions

NOTE: Terms that appear in italics are defined in the glossary. Italic text also represents the name of a document, specification, or other publication.

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 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 Acknowledgements

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 submission takes a complete 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.

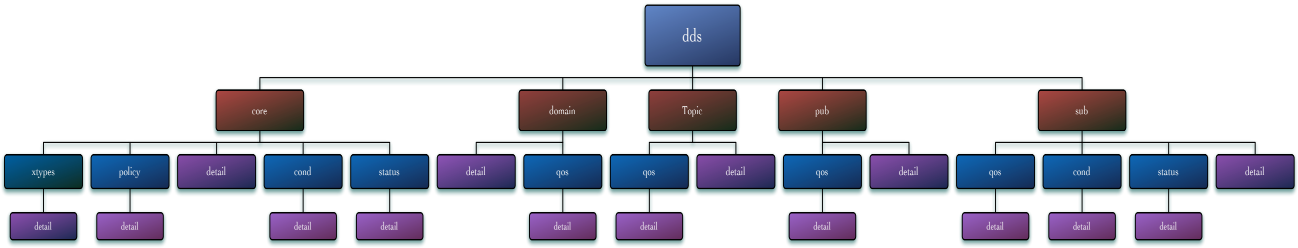


Figure 7.1 – Standard Packages Organization

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.

- The entire DDS API can be included at once:
  - #include <dds/dds.hpp>
- Individual DDS modules can be included. These headers have the form dds/module/ddsmodule.hpp. For example:
  - #include <dds/pub/ddspub.hpp>
- 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
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 section 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, distinguish- ing 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); [1]
6.1.1.1.1.1 ST attribute; **6.1.1.1.1.2** 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); **[2]**

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 section describes the most important classes of the package. The full list of mandatory classes is included in the appendix.

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.

The table below lists all the DDS PIM classes that have reference semantics:

Namespace		Class
dds	core	• Entity • Condition • GuardCondition • ReadCondition • QueryCondition • Waitset
	domain	• DomainParticipant
	pub	• AnyDataWriter • Publisher

		• DataWriter
	sub	• AnyDataReader • Subscriber • DataReader • SharedSamples
	topic	• AnyTopic • Topic

Table 7.2 – DDS Classes with Reference semantics

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 meth- ods, and in general does not rely on inheritance but as opposed exploits delegation.

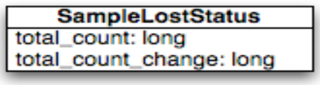
Since the DDS API requires at times to pass DDS entities without exposing the complete type, while other times requires to store in containers list of objects of different types, the DDS-PSM- Cxx provides a selection of “Any” types.

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 Section 7.4 with the following ex-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

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

Table 7.3 – Mapping between PIM Error Codes and C++ Exceptions

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 Section 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 const-ness 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 section 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 section 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 Section 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 section provides a simple yet representative example demonstrating the ISO/IEC mapping for DDS types.

Topic Type Declaration (IDL)	C++ Reprentation
`` 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.` `};`