
Data Distribution Service for Real-time Systems Specification

December 2004
Version 1.0
formal/04-12-02



An Adopted Specification of the Object Management Group, Inc.

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Preface

Object Management Group

The Object Management Group, Inc. (OMG) is an international organization supported by over 600 members, including information system vendors, software developers and users. Founded in 1989, the OMG promotes the theory and practice of object-oriented technology in software development. The organization's charter includes the establishment of industry guidelines and object management specifications to provide a common framework for application development. Primary goals are the reusability, portability, and interoperability of object-based software in distributed, heterogeneous environments. Conformance to these specifications will make it possible to develop a heterogeneous applications environment across all major hardware platforms and operating systems.

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The OMG documentation is organized as follows:

OMG Modeling Specifications

Includes the UML, MOF, XMI, and CWM specifications.

OMG Middleware Specifications

Includes CORBA/IIOP, IDL/Language Mappings, Specialized CORBA specifications, and CORBA Component Model (CCM).

Platform Specific Model and Interface Specifications

Includes CORBA services, CORBA facilities, OMG Domain specifications, OMG Embedded Intelligence specifications, and OMG Security specifications.

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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.

Helvetica bold - OMG Interface Definition Language (OMG IDL) and syntax elements.

Courier bold - Programming language elements.

Helvetica - Exceptions

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

Acknowledgments

The following companies submitted and/or supported parts of this specification:

- Objective Interface Systems, Inc.
- Real-Time Innovations, Inc.
- THALES
- The Mitre Corporation
- University of Toronto

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1.1 Introduction

This specification describes two levels of interfaces:

- A lower DCPS (Data-Centric Publish-Subscribe) level that is targeted towards the efficient delivery of the proper information to the proper recipients.
- An optional higher DLRL (Data Local Reconstruction Layer) level, which allows for a simple integration of the Service into the application layer.

The expected application domains require DCPS to be high-performance and predictable as well as efficient in its use of resources. To meet these requirements it is important that the interfaces are designed in such a way that they:

- allow the middleware to pre-allocate resources so that dynamic resource allocation can be reduced to the minimum,
- avoid properties that may require the use of unbounded or hard-to-predict resources, and
- minimize the need to make copies of the data.

Even at the DCPS level, typed interfaces (i.e., interfaces that take into account the actual data types) are preferred to the extent possible. Typed interfaces offer the following advantages:

- They are simpler to use: the programmer directly manipulates constructs that naturally represent the data.
- They are safer to use: verifications can be performed at compile time.
- They can be more efficient: the execution code can rely on the knowledge of the exact data type it has in advance, to e.g., pre-allocate resources.

It should be noted that the decision to use typed interfaces implies the need for a generation tool to translate type descriptions into appropriate interfaces and implementations that fill the gap between the typed interfaces and the generic middleware.

QoS (Quality of Service) is a general concept that is used to specify the behavior of a service. Programming service behavior by means of QoS settings offers the advantage that the application developer only indicates ‘what’ is wanted rather than ‘how’ this QoS should be achieved. Generally speaking, QoS is comprised of several QoS policies. Each QoS policy is then an independent description that associates a name with a value. Describing QoS by means of a list of independent QoS policies gives rise to more flexibility.

This specification is designed to allow a clear separation between the publish and the subscribe sides, so that an application process that only participates as a publisher can embed just what strictly relates to publication. Similarly, an application process that participates only as a subscriber can embed only what strictly relates to subscription.

1.2 Purpose

Many real-time applications have a requirement to model some of their communication patterns as a pure data-centric exchange, where applications publish (supply or stream) “data” which is then available to the remote applications that are interested in it. Relevant real-time applications can be found in C4I, industrial automation, distributed control and simulation, telecom equipment control, sensor networks, and network management systems. More generally, any application requiring (selective) information dissemination is a candidate for a data-driven network architecture.

Predictable distribution of data with minimal overhead is of primary concern to these real-time applications. Since it is not feasible to infinitely extend the needed resources, it is important to be able to specify the available resources and provide policies that allow the middleware to align the resources to the most critical requirements. This necessity translates into the ability to control Quality of Service (QoS) properties that affect predictability, overhead, and resource utilization.

The need to scale to hundreds or thousands of publishers and subscribers in a robust manner is also an important requirement. This is actually not only a requirement of scalability but also a requirement of flexibility: on many of these systems, applications

are added with no need/possibility to reconstruct the whole system. Data-centric communications decouples senders from receivers; the less coupled the publishers and the subscribers are, the easier these extensions become.

Distributed shared memory is a classic model that provides data-centric exchanges. However, this model is difficult to implement efficiently over a network and does not offer the required scalability and flexibility. Therefore, another model, the ***Data-Centric Publish-Subscribe (DCPS)*** model, has become popular in many real-time applications. This model builds on the concept of a “global data space” that is accessible to all interested applications. Applications that want to contribute information to this data space declare their intent to become “Publishers.” Similarly, applications that want to access portions of this data space declare their intent to become “Subscribers.” Each time a Publisher posts new data into this “global data space,” the middleware propagates the information to all interested Subscribers.

Underlying any data-centric publish subscribe system is a *data model*. This model defines the “global data space” and specifies how Publishers and Subscribers refer to portions of this space. The data-model can be as simple as a set of unrelated *data-structures*, each identified by a *topic* and a *type*. The topic provides an identifier that uniquely identifies some data items within the global data space¹. The type provides structural information needed to tell the middleware how to manipulate the data and allows the middleware to provide a level of type safety. However, the target applications often require a higher-level data model that allows expression of aggregation and coherence relationships among data elements.

Another common need is a ***Data Local Reconstruction Layer (DLRL)*** that automatically reconstructs the data locally from the updates and allows the application to access the data ‘as if’ it were local. In that case, the middleware not only propagates the information to all interested subscribers but also updates a local copy of the information.

There are commercially-available products that implement DCPS fully and the DLRL partially (among them, NDDS from Real-Time Innovations and Splice from THALES Naval Nederland); however, these products are proprietary and do not offer standardized interfaces and behavior that would allow portability of the applications built upon them. ***The purpose of this specification is to offer those standardized interfaces and behavior.***

1. In addition to topic and type, it is sometimes desirable for subscriptions to further refine the data they are interested in based on the content of the data itself. These so called content-based subscriptions are gaining popularity in large-scale systems.

Data-Centric Publish-Subscribe (DCPS)

2

Contents

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This chapter describes the mandatory DCPS layer. The DCPS layer provides the functionality required for an application to publish and subscribe to the values of data objects. It allows:

- publishing applications to identify the data objects they intend to publish, and then provide values for these objects.
- subscribing applications to identify which data objects they are interested in, and then access their data values.
- applications to define topics, to attach type information to the topics, to create publisher and subscriber entities, to attach QoS policies to all these entities and, in summary, to make all these entities operate.

The description is organized into two subsections:

- The Platform Independent Model (PIM)
- The Platform Specific Model (PSM) for the OMG IDL platform based on the PIM.

2.1 Platform Independent Model (PIM)

2.1.1 Overview and Design Rationale

2.1.1.1 Format and conventions

The purpose of this subsection is to provide an operational overview of the DCPS PIM. To do so, it introduces many terms. Some of them are common terms whose meaning, in the context of publish-subscribe, is different from common usage. In cases where it is deemed appropriate, such terms will be *italicized*. Other terms are unique to publish-subscribe and/or to this specification, and are incorporated as key elements of the Class Model. The first time such terms are used, they will be formatted with ***Bold-italics***¹. Subsequent occurrences may not be highlighted in any way.

In addition to the UML diagrams, all the classes that constitute the Service are documented using tables. The format used to document these classes is shown below:

<i><class name></i>		
attributes		
<attribute name>	<attribute type>	
...	...	
operations		
<operation name>		<return type>
	<parameter>	<parameter type>

...		...

The operation <parameter> can contain the modifier “in,” “out,” or “inout” ahead of the parameter name. If this modifier is omitted, it is implied that the parameter is an “in” parameter.

In some cases the operation parameters or return value(s) are a collection with elements of a given <type>. This is indicated with the notation “<type> []”. This notation does not imply that it will be implemented as an array. The actual implementation is defined by the PSM: it may end up being mapped to a sequence, a list, or other kind of collection.

For example, the class named ‘MyClass’ below has a single attribute, named ‘my_attribute’ of type ‘long’ and a single operation ‘my_operation’ that returns a long. The operation takes four parameters. The first, ‘param1’, is an output parameter of type

-
1. In this case, the written name is exactly the one of the corresponding class, which forbids the use of the plural. In case this would lead to ambiguity, it has been followed by ‘objects’ to state that there may not be only one of these.

long; the second, 'param2,' an input-output parameter of type long; the third, 'param3,' is an input parameter (the "in" modifier is implied by omission) of type long; and the fourth, 'param4,' is also an input parameter of type collection of longs².

<i>MyClass</i>		
attributes		
my_attribute	long	
operations		
my_operation		long
	out: param1	long
	inout: param2	long
	param3	long
	in: param4	long []

At the PIM level we have modeled errors as operation return codes typed ***ReturnCode_t***. Each PSM may map these to either return codes or exceptions. The complete list of return codes is indicated below.

<i>Return codes</i>	
OK	Successful return.
ERROR	Generic, unspecified error.
BAD_PARAMETER	Illegal parameter value.
UNSUPPORTED	Unsupported operation. Can only be returned by operations that are optional.
ALREADY_DELETED	The object target of this operation has already been deleted.
OUT_OF_RESOURCES	Service ran out of the resources needed to complete the operation.
NOT_ENABLED	Operation invoked on an <i>Entity</i> that is not yet enabled.
IMMUTABLE_POLICY	Application attempted to modify an immutable <i>QoSPolicy</i> .
INCONSISTENT_POLICY	Application specified a set of policies that are not consistent with each other.
PRECONDITION_NOT_MET	A pre-condition for the operation was not met.
TIMEOUT	The operation timed out.
NO_DATA	Indicates a transient situation where the operation did not return any data but there is no inherent error.

2. That is, a collection where the type of each element is 'long.'

Any operation with return type *ReturnCode_t* may return OK or ERROR. Any operation that takes an input parameter may additionally return BAD_PARAMETER. Any operation on an object created from any of the factories may additionally return ALREADY_DELETED. Any operation that is stated as optional may additionally return UNSUPPORTED. The return codes OK, ERROR, ALREADY_DELETED, UNSUPPORTED, and BAD_PARAMETER are the standard return codes and the specification won't mention them explicitly for each operation. Operations that may return any of the additional (non-standard) error codes above will state so explicitly.

It is an error for an application to use an Entity that has already been deleted by means of the corresponding delete operation on the factory. If an application does this, the result is unspecified and will depend on the implementation and the PSM. In the cases where the implementation can detect the use of a deleted entity, the operation should fail and return ALREADY_DELETED.

2.1.1.2 Conceptual Outline

2.1.1.2.1 Overview

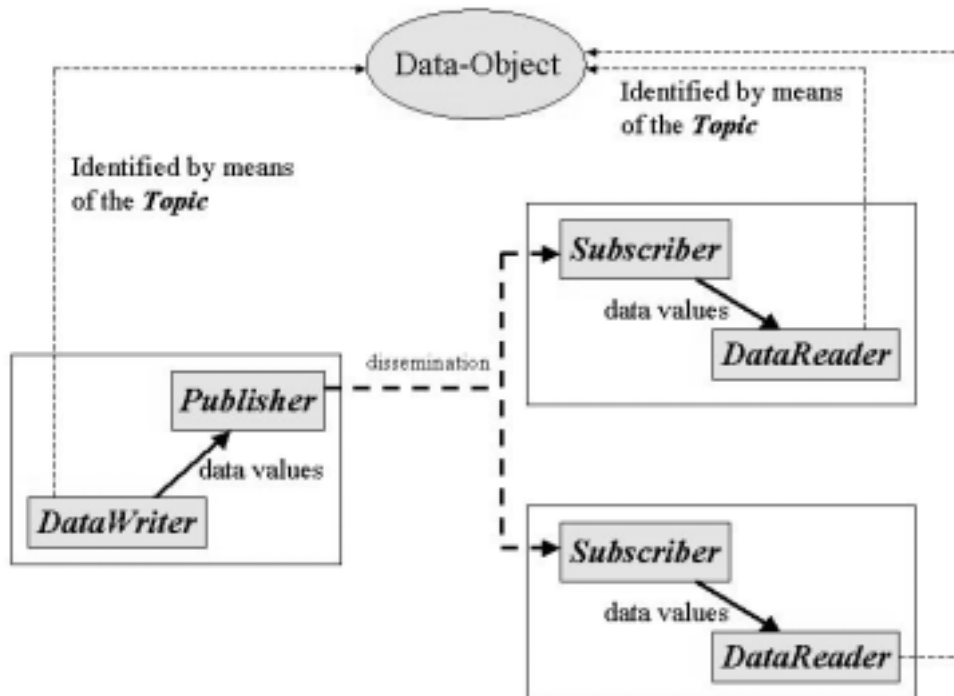


Figure 2-1 Overview

Information flows with the aid of the following constructs³: *Publisher* and *DataWriter* on the sending side, *Subscriber* and *DataReader* on the receiving side.

- A **Publisher** is an object responsible for data distribution. It may publish data of different data types. A **DataWriter** acts as a typed⁴ accessor to a publisher. The **DataWriter** is the object the application must use to communicate to a publisher the existence and value of data-objects of a given type. When data-object values have been communicated to the publisher through the appropriate data-writer, it is the publisher's responsibility to perform the distribution (the publisher will do this according to its own QoS, or the QoS attached to the corresponding data-writer). A publication is defined by the association of a data-writer to a publisher. This association expresses the intent of the application to publish the data described by the data-writer in the context provided by the publisher.
- A **Subscriber** is an object responsible for receiving published data and making it available (according to the Subscriber's QoS) to the receiving application. It may receive and dispatch data of different specified types. To access the received data, the application must use a typed **DataReader** attached to the subscriber. Thus, a *subscription* is defined by the association of a data-reader with a subscriber. This association expresses the intent of the application to subscribe to the data described by the data-reader in the context provided by the subscriber.

Topic objects conceptually fit between publications and subscriptions. Publications must be known in such a way that subscriptions can refer to them unambiguously. A **Topic** is meant to fulfill that purpose: it associates a name (unique in the domain⁵), a data-type, and QoS related to the data itself. In addition to the topic QoS, the QoS of the **DataWriter** associated with that **Topic** and the QoS of the **Publisher** associated to the **DataWriter** control the behavior on the publisher's side, while the corresponding **Topic**, **DataReader**, and **Subscriber** QoS control the behavior on the subscriber's side.

When an application wishes to publish data of a given type, it must create a **Publisher** (or reuse an already created one) and a **DataWriter** with all the characteristics of the desired publication. Similarly, when an application wishes to receive data, it must create a **Subscriber** (or reuse an already created one) and a **DataReader** to define the subscription.

2.1.1.2.2 Overall Conceptual Model

The overall conceptual model is shown in Figure 2-2 on page 2-7. Notice that all the main communication objects (the specializations of **Entity**) follow unified patterns of:

-
3. All those constructs are local to the application part. Actually they play the role of *proxies* to the service.
 4. 'typed' means that each **DataWriter** object is dedicated to one application data-type.
 5. Broadly speaking, a domain represents the set of applications that are communicating with each other. This concept is defined more precisely in Section 2.1.1.2.2, "Overall Conceptual Model and Section 2.1.2.2.1, "DomainParticipant Class.

- Supporting QoS (made up of several *QoSPolicy*) - QoS provides a generic mechanism for the application to control the behavior of the Service and tailor it to its needs. Each *Entity* supports its own specialized kind of QoS policies. The complete list of QoS policies and their meaning is described in Section 2.1.3, “Supported QoS,” on page 2-89.
- Accepting a *Listener*⁶ - listeners provide a generic mechanism for the middleware to notify the application of relevant asynchronous events, such as arrival of data corresponding to a subscription, violation of a QoS setting, etc. Each DCPS entity supports its own specialized kind of listener. Listeners are related to changes in status conditions. This relationship is described in Section 2.1.4, “Listeners, Conditions and Wait-sets,” on page 2-115.
- Accepting a *StatusCondition* (and a set of *ReadCondition* objects for the *DataReader*) - conditions (in conjunction with *WaitSet* objects) provide support for an alternate communication style between the middleware and the application (i.e., wait-based rather than notification-based). The complete set of status conditions is described in Section 2.1.4, “Listeners, Conditions and Wait-sets,” on page 2-115.

All these DCPS entities are attached to a *DomainParticipant*. A domain participant represents the local membership of the application in a domain. A *domain* is a distributed concept that links all the applications able to communicate with each other. It represents a communication plane: only the publishers and the subscribers attached to the same *domain* may interact.

DomainEntity is an intermediate object whose only purpose is to state that a *DomainParticipant* cannot contain other domain participants.

6. This specification made the choice of allowing the attachment of only one Listener per entity (instead of a list of them). The reason for that choice is that this allows a much simpler (and, thus, more efficient) implementation as far as the middleware is concerned. Moreover, if it were required, implementing a listener that, when triggered, triggers in return attached 'sub-listeners', can be easily done by the application.

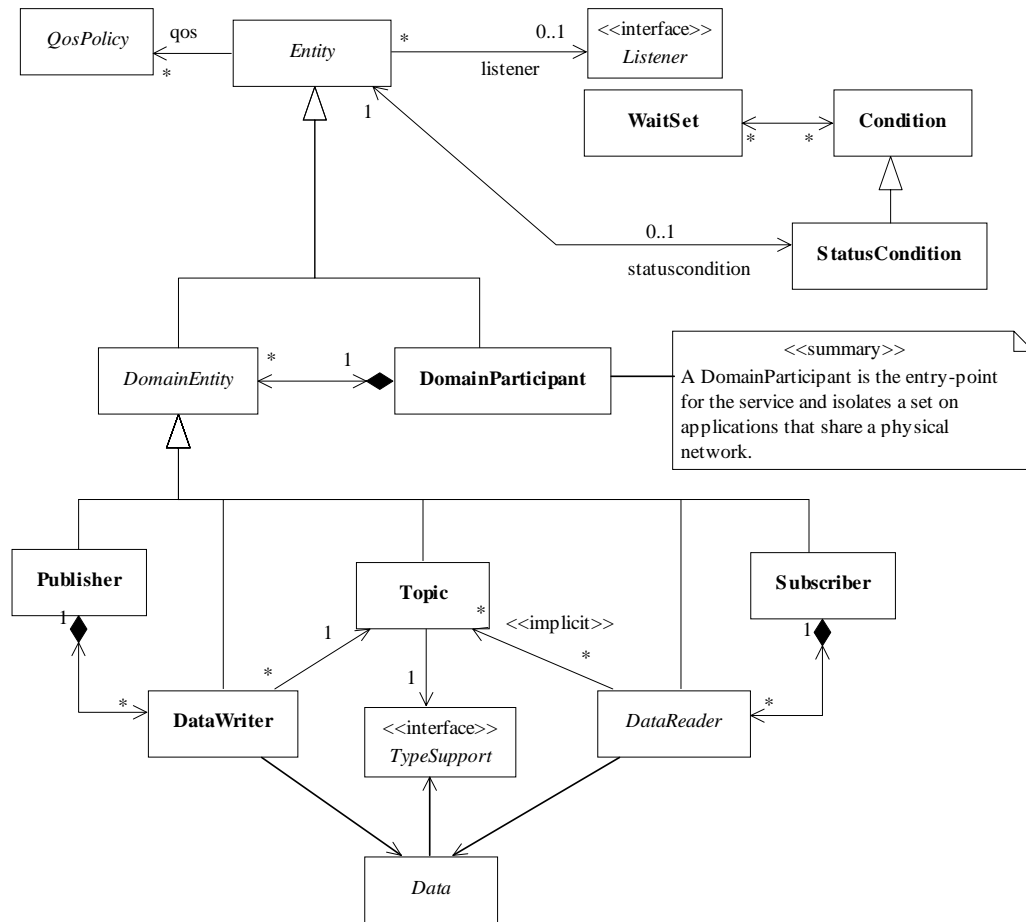


Figure 2-2 DCPS conceptual model

At the DCPS level, data types represent information that is sent atomically⁷. For performance reasons, only plain data structures are handled by this level.

By default, each data modification is propagated individually, independently, and uncorrelated with other modifications. However, an application may request that several modifications be sent as a whole and interpreted as such at the recipient side. This functionality is offered on a *Publisher/Subscriber* basis. That is, these relationships can only be specified among *DataWriter* objects attached to the same *Publisher* and retrieved among *DataReader* objects attached to the same *Subscriber*.

7. Note that the optional DLRL layer provides the means to break data-objects into separate elements, each sent atomically.

By definition, a **Topic** corresponds to a single data type. However, several topics may refer to the same data type. Therefore, a **Topic** identifies data of a single type, ranging from one single instance to a whole collection of instances of that given type. This is shown in Figure 2-3 for the hypothetical data-type “Foo.”

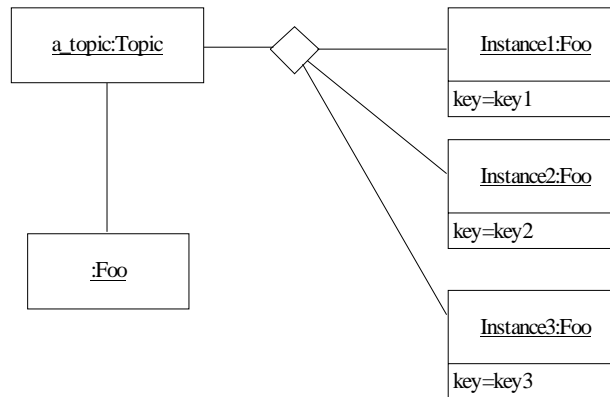


Figure 2-3 A topic can identify a collection of data-object instances

In case a set of instances is gathered under the same topic, different instances must be distinguishable. This is achieved by means of the values of some data fields that form the **key** to that data set. The **key** description (i.e., the list of data fields whose value forms the key) has to be indicated to the middleware. The rule is simple: *different data values with the same key value represent successive values for the same instance, while different data values with different key values represent different instances*. If no key is provided, the data set associated with the **Topic** is restricted to a single instance.

Topics need to be known by the middleware and potentially propagated. **Topic** objects are created using the create operations provided by **DomainParticipant**.

The interaction style is straightforward on the publisher’s side: when the application decides that it wants to make data available for publication, it calls the appropriate operation on the related **DataWriter** (this, in turn, will trigger its **Publisher**).

On the subscriber’s side however, there are more choices: relevant information may arrive when the application is busy doing something else or when the application is just waiting for that information. Therefore, depending on the way the application is designed, asynchronous notifications or synchronous access may be more appropriate. Both interaction modes are allowed, a **Listener** is used to provide a callback for synchronous access and a **WaitSet** associated with one or several **Condition** objects provides asynchronous data access.

The same synchronous and asynchronous interaction modes can also be used to access changes that affect the middleware communication status. For instance, this may occur when the middleware asynchronously detects an inconsistency. In addition, other

middleware information that may be relevant to the application (such as the list of the existing topics) is made available by means of built-in topics that the application can access as plain application data, using built-in⁸ data-readers.

2.1.2 PIM Description

The DCPS is comprised of five modules:

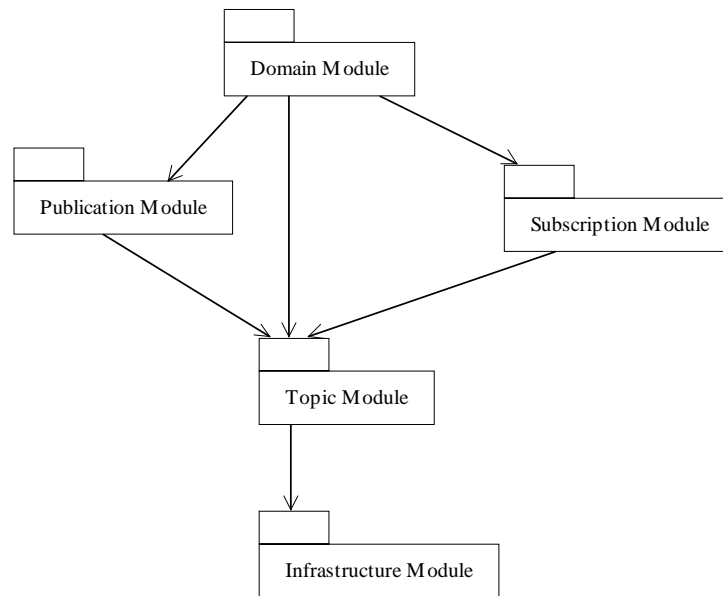


Figure 2-4 DCPS module breakdown

- **The Infrastructure Module** defines the abstract classes and the interfaces that are refined by the other modules. It also provides support for the two interaction styles (notification- and wait- based) with the middleware.
- **The Domain Module** contains the *DomainParticipant* class that acts as an entry-point of the Service and acts as a factory for many of the classes. The *DomainParticipant* also acts as a container for the other objects that make up the Service.
- **The Topic-Definition Module** contains the *Topic*, *ContentFilteredTopic*, and *MultiTopic* classes, the *TopicListener* interface, and more generally, all that is needed by the application to define *Topic* objects and attach QoS policies to them.

8. These built-in data-readers should be provided with every implementation of the service. They are further described in Section 2.1.5, “Built-in Topics,” on page 2-128.

- The Publication Module contains the *Publisher* and *DataWriter* classes as well as the *PublisherListener* and *DataWriterListener* interfaces, and more generally, all that is needed on the publication side.
- The Subscription Module contains the *Subscriber*, *DataReader*, *ReadCondition*, and *QueryCondition* classes, as well as the *SubscriberListener* and *DataReaderListener* interfaces, and more generally, all that is needed on the subscription side.

At the PIM level, we have chosen to model any entity as a class or interface. It should be noted, however, that this does not mean that any of them will be translated into an IDL interface. In general, we have chosen to model as interfaces the entities that the application will have to extend to interact with the Service. The remaining entities have been modeled as classes.

2.1.2.1 Infrastructure Module

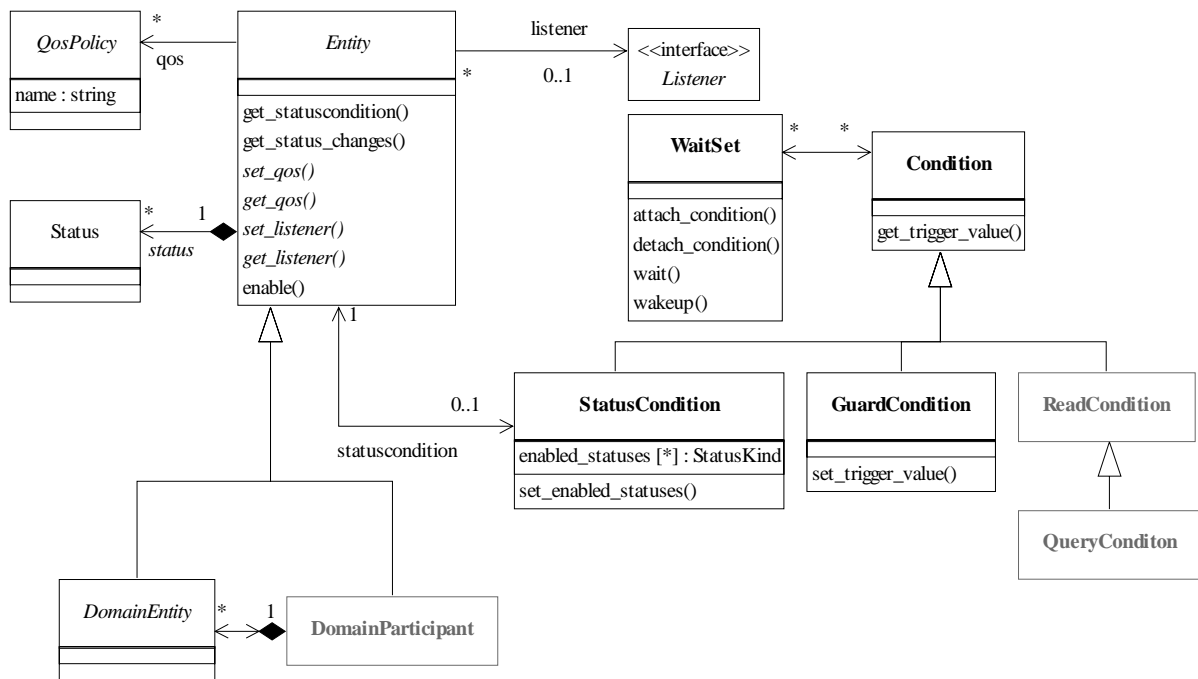


Figure 2-5 Class model of the DCPS Infrastructure Module

The DCPS Infrastructure Module is comprised of the following classifiers:

- Entity
- DomainEntity
- QosPolicy
- Listener
- Status

- WaitSet
- Condition
- GuardCondition
- StatusCondition

2.1.2.1.1 Entity Class

This class is the abstract base class for all the DCPS objects that support QoS policies, a listener, and a status condition.

Entity		
no attributes		
operations		
abstract set_qos		ReturnCode_t
	qos_list	QosPolicy []
abstract get_qos		QosPolicy []
abstract set_listener		ReturnCode_t
	a_listener	Listener
	mask	StatusKind []
abstract get_listener		Listener
get_statuscondition		StatusCondition
get_status_changes		StatusKind []
enable		ReturnCode_t

StatusKind is an enumerated type that identifies each concrete **Status** type.

The following sections explain all the operations in detail.

2.1.2.1.1.1 set_qos (abstract)

This operation is used to set the QoS policies of the **Entity**. This operation must be provided by each of the derived **Entity** classes (**DomainParticipant**, **Topic**, **Publisher**, **DataWriter**, **Subscriber**, **DataReader**) so that the policies that are meaningful to each **Entity** can be set.

The set of policies specified as the **qos_list** parameter are applied on top of the existing QoS, replacing the values of any policies previously set.

As described in Section 2.1.3, “Supported QoS,” on page 2-89, certain policies are “immutable:” they can only be set at **Entity** creation time, or before the entity is made enabled. If **set_qos** is invoked after the **Entity** is enabled and it attempts to change the value of an “immutable” policy, the operation will fail and it returns IMMUTABLE_POLICY.

Section 2.1.3, “Supported QoS,” on page 2-89 also describes that certain values of QoS policies can be incompatible with the settings of the other policies. The *set_qos* operation will also fail if it specifies a set of values that once combined with the existing values would result in an inconsistent set of policies. In this case, the return value is `INCONSISTENT_POLICY`.

The existing set of policies are only changed if the *set_qos* operation succeeds. This is indicated by the `OK` return value. In all other cases, none of the policies is modified.

Possible error codes returned in addition to the standard ones:
`INCONSISTENT_POLICY`, `IMMUTABLE_POLICY`.

2.1.2.1.1.2 *get_qos* (abstract)

This operation allows access to the existing set of QoS policies for the *Entity*. This operation must be provided by each of the derived *Entity* classes (*DomainParticipant*, *Topic*, *Publisher*, *DataWriter*, *Subscriber*, *DataReader*) so that the policies meaningful to the particular *Entity* are retrieved.

2.1.2.1.1.3 *set_listener* (abstract)

This operation installs a *Listener* on the *Entity*. The listener will only be invoked on the changes of communication status indicated by the specified *mask*.

Only one listener can be attached to each *Entity*. If a listener was already set, the operation *set_listener* will replace it with the new one.

This operation must be provided by each of the derived *Entity* classes (*DomainParticipant*, *Topic*, *Publisher*, *DataWriter*, *Subscriber*, *DataReader*) so that the listener is of the concrete type suitable to the particular *Entity*.

2.1.2.1.1.4 *get_listener* (abstract)

This operation allows access to the existing *Listener* attached to the *Entity*.

This operation must be provided by each of the derived *Entity* classes (*DomainParticipant*, *Topic*, *Publisher*, *DataWriter*, *Subscriber*, *DataReader*) so that the listener is of the concrete type suitable to the particular *Entity*.

2.1.2.1.1.5 *get_statuscondition*

This operation allows access to the *StatusCondition* (Section 2.1.2.1.9) associated with the *Entity*. The returned condition can then be added to a *WaitSet* (Section 2.1.2.1.6) so that the application can wait for specific status changes that affect the *Entity*.

2.1.2.1.1.6 *get_status_changes*

This operation retrieves the list of communication statuses in the *Entity* that are ‘triggered.’ That is, the list of statuses whose value has changed since the last time the application read the status. The precise definition of the ‘triggered’ state of communication statuses is given in Section 2.1.4.2, “Changes in Status,” on page 2-120.

When the entity is first created or if the entity is not enabled, all communication statuses are in the “untriggered” state so the list returned by the *get_status_changes* operation will be empty.

2.1.2.1.1.7 *enable*

This operation enables the *Entity*. *Entity* objects can be created either enabled or disabled. This is controlled by the value of the ENTITY_FACTORY Qos policy (Section 2.1.3.19) on the corresponding factory for the *Entity*.

The default setting of ENTITY_FACTORY is such that, by default, it is not necessary to explicitly call *enable* on newly created entities (see Section 2.1.3.19).

The *enable* operation is idempotent. Calling *enable* on an already enabled *Entity* returns OK and has no effect.

If an *Entity* has not yet been enabled, the only operations that can be invoked on it are the ones to set or get the QoS policies and the listener, the ones that get the *StatusCondition*, and the ‘factory’ operations that create other entities. Other operations will return the error NOT_ENABLED.

Entities created from a factory that is disabled, are created disabled regardless of the setting of the ENTITY_FACTORY Qos policy.

Calling *enable* on an *Entity* whose factory is not enabled will fail and return PRECONDITION_NOT_MET.

If the ENTITY_FACTORY Qos policy has *autoenable_created_entities* set to TRUE, the *enable* operation on the factory will automatically enable all entities created from the factory.

The *Listeners* associated with an entity are not called until the entity is enabled. Conditions associated with an entity that is not enabled are “inactive,” that is, have a *trigger_value*==FALSE (see Section 2.1.4.4).

2.1.2.1.2 *DomainEntity Class*

DomainEntity is the abstract base class for all DCPS entities, except for the *DomainParticipant*. Its sole purpose is to express that *DomainParticipant* is a special kind of *Entity*, which acts as a container of all other *Entity*, but itself cannot contain other *DomainParticipant*.

<i>DomainEntity</i>
no attributes
no operations

2.1.2.1.3 *QosPolicy* Class

This class is the abstract root for all the QoS policies.

<i>QosPolicy</i>	
attributes	
name	string
no operations	

It provides the basic mechanism for an application to specify quality of service parameters. It has an attribute ***name*** that is used to identify uniquely each QoS policy. All concrete ***QosPolicy*** classes derive from this root and include a ***value*** whose type depends on the concrete QoS policy.

The type of a ***QosPolicy*** value may be atomic, such as an integer or float, or compound (a structure). Compound types are used whenever multiple parameters must be set coherently to define a consistent value for a ***QosPolicy***.

Each ***Entity*** can be configured with a list of ***QosPolicy***. However, any ***Entity*** cannot support any ***QosPolicy***. For instance, a ***DomainParticipant*** supports different ***QosPolicy*** than a ***Topic*** or a ***Publisher***.

QosPolicy can be set when the ***Entity*** is created, or modified with the ***set_qos*** method. Each ***QosPolicy*** in the list is treated independently from the others. This approach has the advantage of being very extensible. However, there may be cases where several policies are in conflict. Consistency checking is performed each time the policies are modified via the ***set_qos*** operation.

When a policy is changed after being set to a given value, it is not required that the new value be applied instantaneously; the Service is allowed to apply it after a transition phase. In addition, some ***QosPolicy*** have “immutable” semantics meaning that they can only be specified either at ***Entity*** creation time or else prior to calling the ***enable*** operation on the ***Entity***.

Section 2.1.3, “Supported QoS,” on page 2-89 provides the list of all ***QosPolicy***, their meaning, characteristics and possible values, as well as the concrete ***Entity*** to which they apply.

2.1.2.1.4 *Listener* Interface

Listener is the abstract root for all ***Listener*** interfaces. All the supported kinds of concrete ***Listener*** interfaces (one per concrete ***Entity***: ***DomainParticipant***, ***Topic***, ***Publisher***, ***DataWriter***, ***Subscriber***, and ***DataReader***) derive from this root and add methods whose prototype depends on the concrete ***Listener***.

<i>Listener</i>	
no attributes	
no operations	

See Section 2.1.4.3, “Access through Listeners,” on page 2-121 for the list of defined listener interfaces. Listener interfaces provide a mechanism for the Service to asynchronously inform the application of relevant changes in the communication status.

2.1.2.1.5 Status Class

Status is the abstract root class for all communication status objects. All concrete kinds of *Status* classes specialize this class.

Status	
no attributes	
no operations	

Each concrete *Entity* is associated with a set of *Status* objects whose value represents the “communication status” of that entity. These status values can be accessed with corresponding methods on the *Entity*. The changes on these status values are the ones that both cause activation of the corresponding *StatusCondition* objects and trigger invocation of the proper *Listener* objects to asynchronously inform the application.

Status objects and their relationship to *Listener* and *Condition* objects are detailed in Section 2.1.4.1, “Communication Status,” on page 2-116.

2.1.2.1.6 WaitSet Class

A *WaitSet* object allows an application to wait until one or more of the attached *Condition* objects has a *trigger_value* of *TRUE* or else until the timeout expires.

WaitSet		
no attributes		
operations		
attach_condition		ReturnCode_t
	a_condition	Condition
detach_condition		ReturnCode_t
	a_condition	Condition
wait		ReturnCode_t
	out: active_conditions	Condition []
	timeout	Duration_t
get_conditions		ReturnCode_t
	out: attached_conditions	Condition []

WaitSet has no factory. It is created as an object directly by the natural means in each language binding (e.g., using “new” in C++ or Java). This is because it is not necessarily associated with a single *DomainParticipant* and could be used to wait on *Condition* objects associated with different *DomainParticipant* objects.

The following sections explain all the operations in detail.

2.1.2.1.6.1 *attach_condition*

Attaches a **Condition** to the **WaitSet**.

It is possible to attach a **Condition** on a **WaitSet** that is currently being waited upon (via the **wait** operation). In this case, if the **Condition** has a **trigger_value** of TRUE, then attaching the condition will unblock the **WaitSet**.

Possible error codes returned in addition to the standard ones: OUT_OF_RESOURCES.

2.1.2.1.6.2 *detach_condition*

Detaches a **Condition** from the **WaitSet**.

If the **Condition** was not attached to the **WaitSet**, the operation will return BAD_PARAMETER.

Possible error codes returned in addition to the standard ones: BAD_PARAMETER.

2.1.2.1.6.3 *wait*

This operation allows an application thread to wait for the occurrence of certain conditions. If none of the conditions attached to the **WaitSet** have a **trigger_value** of TRUE, the wait operation will block suspending the calling thread.

The result of the **wait** operation is the list of all the attached conditions that have a **trigger_value** of TRUE (i.e., the conditions that unblocked the wait).

The wait operation takes a **timeout** argument that specifies the maximum duration for the wait. If this duration is exceeded and none of the attached **Condition** objects is true, **wait** will also return with the return code OK. In this case, the resulting list of conditions will be empty.

It is not allowed for more than one application thread to be waiting on the same **WaitSet**. If the **wait** operation is invoked on a **WaitSet** that already has a thread blocking on it, the operation will return immediately with the value PRECONDITION_NOT_MET.

2.1.2.1.6.4 *get_conditions*

This operation retrieves the list of attached conditions.

2.1.2.1.7 *Condition Class*

A **Condition** is a root class for all the conditions that may be attached to a **WaitSet**. This basic class is specialized in three classes that are known by the middleware:

GuardCondition (Section 2.1.2.1.8), **StatusCondition** (Section 2.1.2.1.9), and **ReadCondition** (Section 2.1.2.5.8).

Condition		
no attributes		
operations		
get_trigger_value		boolean

A *Condition* has a *trigger_value* that can be TRUE or FALSE and is set automatically by the Service.

2.1.2.1.7.1 *get_trigger_value*

This operation retrieves the *trigger_value* of the *Condition*.

2.1.2.1.8 *GuardCondition Class*

A *GuardCondition* object is a specific *Condition* whose *trigger_value* is completely under the control of the application.

<i>GuardCondition</i>		
no attributes		
operations		
<i>set_trigger_value</i>		void
	<i>value</i>	boolean

GuardCondition has no factory. It is created as an object directly by the natural means in each language binding (e.g., using “new” in C++ or Java). When first created the *trigger_value* is set to FALSE.

The purpose of the *GuardCondition* is to provide the means for the application to manually wakeup a *WaitSet*. This is accomplished by attaching the *GuardCondition* to the *WaitSet* and then setting the *trigger_value* by means of the *set_trigger_value* operation.

2.1.2.1.8.1 *set_trigger_value*

This operation sets the *trigger_value* of the *GuardCondition*.

WaitSet objects behavior depends on the changes of the *trigger_value* of their attached conditions. Therefore, any *WaitSet* to which is attached the *GuardCondition* is potentially affected by this operation.

2.1.2.1.9 *StatusCondition Class*

A *StatusCondition* object is a specific *Condition* that is associated with each *Entity*.

<i>StatusCondition</i>		
no attributes		
operations		
<i>set_enabled_statuses</i>		ReturnCode_t
	mask	StatusKind []
<i>get_enabled_statuses</i>		StatusKind []
<i>get_entity</i>		Entity

The *trigger_value* of the *StatusCondition* depends on the communication status of that entity (e.g., arrival of data, loss of information, etc.), ‘filtered’ by the set of *enabled_statuses* on the *StatusCondition*.

The *enabled_statuses* and its relation to *Listener* and *WaitSet* is detailed in Trigger State of the *StatusCondition*.

2.1.2.1.9.1 *set_enabled_statuses*

This operation defines the list of communication statuses that are taken into account to determine the *trigger_value* of the *StatusCondition*. This operation may change the *trigger_value* of the *StatusCondition*.

WaitSet objects behavior depend on the changes of the *trigger_value* of their attached conditions. Therefore, any *WaitSet* to which the *StatusCondition* is attached is potentially affected by this operation.

If this function is not invoked, the default list of enabled statuses includes all the statuses.

2.1.2.1.9.2 *get_enabled_statuses*

This operation retrieves the list of communication statuses that are taken into account to determine the *trigger_value* of the *StatusCondition*. This operation returns the statuses that were explicitly set on the last call to *set_enabled_statuses* or, if *set_enabled_statuses* was never called, the default list (see Section 2.1.2.1.9.1).

2.1.2.1.9.3 *get_entity*

This operation returns the *Entity* associated with the *StatusCondition*. Note that there is exactly one *Entity* associated with each *StatusCondition*.

2.1.2.2 Domain Module

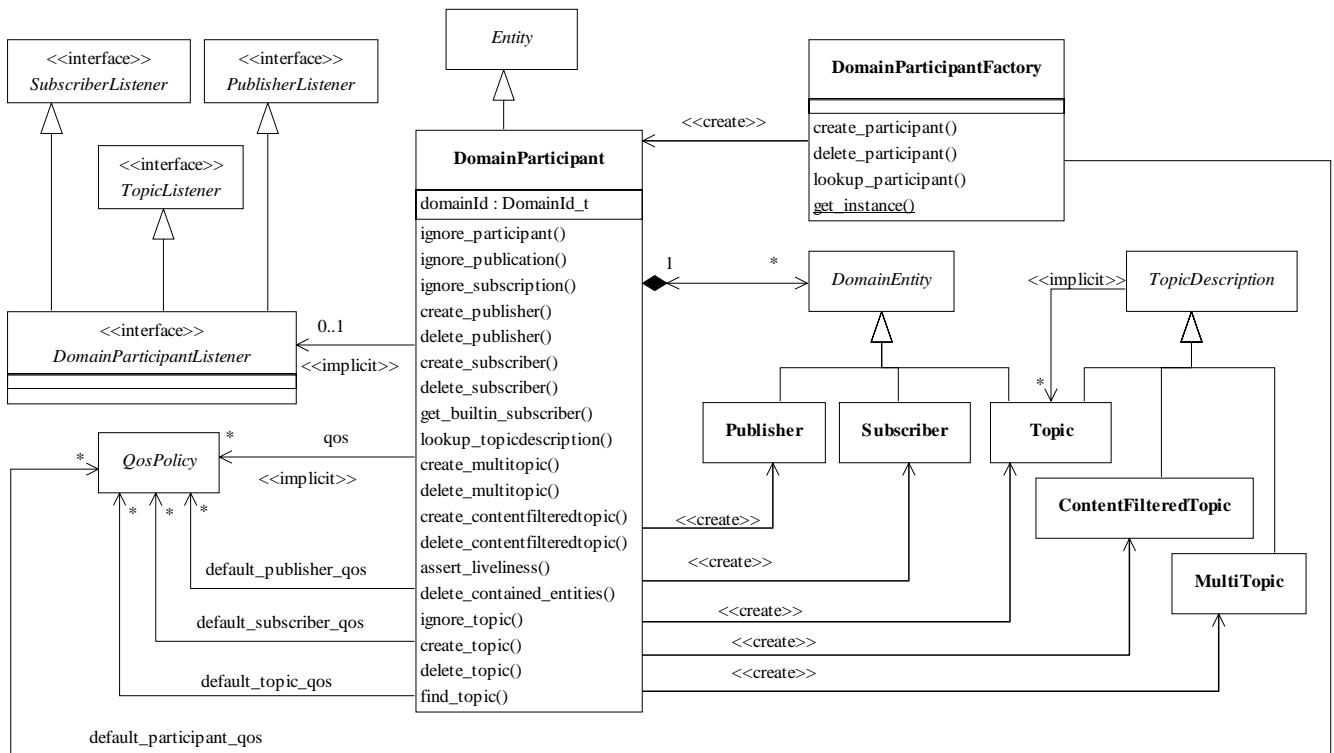


Figure 2-6 Class model of the DCPS Domain Module

The DCPS Domain Module is comprised of the following classes:

- `DomainParticipant`
- `DomainParticipantFactory`
- `DomainParticipantListener`

2.1.2.2.1 DomainParticipant Class

The *DomainParticipant* object plays several roles:

- It acts as a container for all other *Entity* objects.
- It acts as factory for the *Publisher*, *Subscriber*, *Topic*, and *MultiTopic Entity* objects.
- It represents the participation of the application on a communication plane that isolates applications running on the same set of physical computers from each other. A domain establishes a “virtual network” linking all applications that share the same *domainId*⁹ and isolating them from applications running on different domains. In this way, several independent distributed applications can coexist in the same physical network without interfering, or even being aware of each other.

- It provides administration services in the domain, offering operations that allow the application to ‘ignore’ locally any information about a given participant (*ignore_participant*), publication (*ignore_publication*), subscription (*ignore_subscription*), or topic (*ignore_topic*).

<i>DomainParticipant</i>		
no attributes		
operations		
(inherited) get_qos		QosPolicy []
(inherited) set_qos		ReturnCode_t
	qos_list	QosPolicy []
(inherited) get_listener		Listener
(inherited) set_listener		ReturnCode_t
	a_listener	Listener
	mask	StatusKind []
create_publisher		Publisher
	qos_list	QosPolicy []
	a_listener	PublisherListener
delete_publisher		ReturnCode_t
	a_publisher	Publisher
create_subscriber		Subscriber
	qos_list	QosPolicy []
	a_listener	SubscriberListener
delete_subscriber		ReturnCode_t
	a_subscriber	Subscriber
create_topic		Topic
	name	string
	type_name	string
	qos_list	QosPolicy []
	a_listener	TopicListener
delete_topic		ReturnCode_t
	a_topic	Topic
create_contentfilteredtopic		ContentFilteredTopic
	name	string
	related_topic	Topic
	filter_expression	string
	expression_parameters	string []
delete_contentfilteredtopic		ReturnCode_t

9. The actual format of the *domainId* is middleware specific. From the application point of view, it is a configuration parameter that appears only when the *DomainParticipant* is created.

	a_contentfilteredtopic	ContentFilteredTopic
create_multitopic		MultiTopic
	name	string
	type_name	string
	subscription_expression	string
	expression_parameters	string []
delete_multitopic		ReturnCode_t
	a_multitopic	MultiTopic
find_topic		Topic
	topic_name	string
	timeout	Duration_t
lookup_topicdescription		TopicDescription
	name	string
get_builtin_subscriber		Subscriber
ignore_participant		ReturnCode_t
	handle	InstanceHandle_t
ignore_topic		ReturnCode_t
	handle	InstanceHandle_t
ignore_publication		ReturnCode_t
	handle	InstanceHandle_t
ignore_subscription		ReturnCode_t
	handle	InstanceHandle_t
get_domain_id		DomainId_t
delete_contained_entities		ReturnCode_t
assert_liveliness		void
set_default_publisher_qos		ReturnCode_t
	qos_list	QosPolicy []
get_default_publisher_qos		void
	out: qos_list	QosPolicy []
set_default_subscriber_qos		ReturnCode_t
	qos_list	QosPolicy []
get_default_subscriber_qos		void
	out: qos_list	QosPolicy []
set_default_topic_qos		ReturnCode_t
	qos_list	QosPolicy []
get_default_topic_qos		void
	out: qos_list	QosPolicy []

The following sections explain all the operations in detail.

All the operations except the ones defined at the base-class level (namely, *set_qos*, *get_qos*, *set_listener*, *get_listener* and *enable*) may return the value NOT_ENABLED.

2.1.2.2.1.1 *create_publisher*

This operation creates a **Publisher** with the desired QoS policies and attaches to it the specified **PublisherListener**.

If the specified QoS policies are not consistent, the operation will fail and no **Publisher** will be created.

The special value `PUBLISHER_QOS_DEFAULT` can be used to indicate that the **Publisher** should be created with the default **Publisher** QoS set in the factory. The use of this value is equivalent to the application obtaining the default **Publisher** QoS by means of the operation *get_default_publisher_qos* (Section 2.1.2.2.1.21) and using the resulting QoS to create the **Publisher**.

The created **Publisher** belongs to the **DomainParticipant** that is its factory.

In case of failure, the operation will return a 'nil' value (as specified by the platform).

2.1.2.2.1.2 *delete_publisher*

This operation deletes an existing **Publisher**.

A **Publisher** cannot be deleted if it has any attached **DataWriter** objects. If *delete_publisher* is called on a **Publisher** with existing **DataWriter** objects, it will return `PRECONDITION_NOT_MET`.

The *delete_publisher* operation must be called on the same **DomainParticipant** object used to create the **Publisher**. If *delete_publisher* is called on a different **DomainParticipant** the operation will have no effect and it will return `PRECONDITION_NOT_MET`.

Possible error codes returned in addition to the standard ones:
`PRECONDITION_NOT_MET`.

2.1.2.2.1.3 *create_subscriber*

This operation creates a **Subscriber** with the desired QoS policies and attaches to it the specified **SubscriberListener**.

If the specified QoS policies are not consistent, the operation will fail and no **Subscriber** will be created.

The special value `SUBSCRIBER_QOS_DEFAULT` can be used to indicate that the **Subscriber** should be created with the default **Subscriber** QoS set in the factory. The use of this value is equivalent to the application obtaining the default **Subscriber** QoS by means of the operation *get_default_subscriber_qos* (Section 2.1.2.2.1.21) and using the resulting QoS to create the **Subscriber**.

The created **Subscriber** belongs to the **DomainParticipant** that is its factory.

In case of failure, the operation will return a 'nil' value (as specified by the platform).

2.1.2.2.1.4 *delete_subscriber*

This operation deletes an existing **Subscriber**.

A **Subscriber** cannot be deleted if it has any attached **DataReader** objects. If the **delete_subscriber** operation is called on a **Subscriber** with existing **DataReader** objects, it will return PRECONDITION_NOT_MET.

The **delete_subscriber** operation must be called on the same **DomainParticipant** object used to create the **Subscriber**. If **delete_subscriber** is called on a different **DomainParticipant** the operation will have no effect and it will return PRECONDITION_NOT_MET.

Possible error codes returned in addition to the standard ones:
PRECONDITION_NOT_MET.

2.1.2.2.1.5 create_topic

This operation creates a **Topic** with the desired QoS policies and attaches to it the specified **TopicListener**.

If the specified QoS policies are not consistent, the operation will fail and no **Topic** will be created.

The special value TOPIC_QOS_DEFAULT can be used to indicate that the **Topic** should be created with the default **Topic** QoS set in the factory. The use of this value is equivalent to the application obtaining the default **Topic** QoS by means of the operation **get_default_topic_qos** (Section 2.1.2.2.1.21) and using the resulting QoS to create the **Topic**.

The created **Topic** belongs to the **DomainParticipant** that is its factory.

The **Topic** is bound to a type described by the **type_name** argument. Prior to creating a **Topic** the type must have been registered with the Service. This is done using the **register_type** operation on a derived class of the **TypeSupport** interface as described in Section 2.1.2.3.6.

The implementation of **create_topic** will automatically perform a **lookup_topicdescription** for the specified **topic_name**. If a **Topic** is found, then the QoS and **type_name** of the found **Topic** are matched against the ones specified on the **create_topic** call. If there is an exact match, the existing **Topic** is returned. If there is no match the operation will fail. The consequence is that the application can never create more than one **Topic** with the same **topic_name** per **DomainParticipant**. Subsequent attempts will either return the existing **Topic** (i.e., behave like **find_topic**) or else fail.

If a **Topic** is obtained multiple times by means of a **create_topic**, it must also be deleted that same number of times using **delete_topic**.

In case of failure, the operation will return a 'nil' value (as specified by the platform).

2.1.2.2.1.6 delete_topic

This operation deletes a **Topic**.

The deletion of a **Topic** is not allowed if there are any existing **DataReader**, **DataWriter**, **ContentFilteredTopic**, or **MultiTopic** objects that are using the **Topic**. If the **delete_topic** operation is called on a **Topic** with any of these existing objects attached to it, it will return PRECONDITION_NOT_MET.

The *delete_topic* operation must be called on the same *DomainParticipant* object used to create the *Topic*. If *delete_topic* is called on a different *DomainParticipant*, the operation will have no effect and it will return PRECONDITION_NOT_MET.

Possible error codes returned in addition to the standard ones:
PRECONDITION_NOT_MET.

2.1.2.2.1.7 create_contentfilteredtopic

This operation creates a *ContentFilteredTopic*. As described in Section 2.1.2.3, “Topic-Definition Module,” on page 2-33, a *ContentFilteredTopic* can be used to do content-based subscriptions.

The related *Topic* being subscribed to is specified by means of the *topic_name* parameter. The *ContentFilteredTopic* only relates to samples published under that *Topic*, filtered according to their content. The filtering is done by means of evaluating a logical expression that involves the values of some of the data-fields in the sample. The logical expression is derived from the *filter_expression* and *expression_parameters* arguments.

The syntax of the filter expression and parameters is described in Appendix B.

In case of failure, the operation will return a ‘nil’ value (as specified by the platform).

2.1.2.2.1.8 delete_contentfilteredtopic

This operation deletes a *ContentFilteredTopic*.

The deletion of a *ContentFilteredTopic* is not allowed if there are any existing *DataReader* objects that are using the *ContentFilteredTopic*. If the *delete_contentfilteredtopic* operation is called on a *ContentFilteredTopic* with existing *DataReader* objects attached to it, it will return PRECONDITION_NOT_MET.

The *delete_contentfilteredtopic* operation must be called on the same *DomainParticipant* object used to create the *ContentFilteredTopic*. If *delete_contentfilteredtopic* is called on a different *DomainParticipant*, the operation will have no effect and it will return PRECONDITION_NOT_MET.

Possible error codes returned in addition to the standard ones:
PRECONDITION_NOT_MET.

2.1.2.2.1.9 create_multitopic

This operation creates a *MultiTopic*. As described in Section 2.1.2.3, “Topic-Definition Module,” on page 2-33 a *MultiTopic* can be used to subscribe to multiple topics and combine/filter the received data into a resulting type. In particular, *MultiTopic* provides a content-based subscription mechanism.

The resulting type is specified by the *type_name* argument. Prior to creating a *MultiTopic* the type must have been registered with the Service. This is done using the *register_type* operation on a derived class of the *TypeSupport* interface as described in Section 2.1.2.3.6.

The list of topics and the logic used to combine filter and re-arrange the information from each *Topic* are specified using the *subscription_expression* and *expression_parameters* arguments.

The syntax of the expression and parameters is described in Appendix B.

In case of failure, the operation will return a 'nil' value (as specified by the platform).

2.1.2.2.1.10 *delete_multitopic*

This operation deletes a *MultiTopic*.

The deletion of a *MultiTopic* is not allowed if there are any existing *DataReader* objects that are using the *MultiTopic*. If the *delete_multitopic* operation is called on a *MultiTopic* with existing *DataReader* objects attached to it, it will return PRECONDITION_NOT_MET.

The *delete_multitopic* operation must be called on the same *DomainParticipant* object used to create the *MultiTopic*. If *delete_multitopic* is called on a different *DomainParticipant*, the operation will have no effect and it will return PRECONDITION_NOT_MET.

Possible error codes returned in addition to the standard ones:
PRECONDITION_NOT_MET.

2.1.2.2.1.11 *find_topic*

The operation *find_topic* gives access to an existing (or ready to exist) enabled *Topic*, based on its name. The operation takes as arguments the *name* of the *Topic* and a *timeout*.

If a *Topic* of the same name already exists, it gives access to it, otherwise it waits (blocks the caller) until another mechanism creates it (or the specified timeout occurs). This other mechanism can be another thread, a configuration tool, or some other middleware service. Note that the *Topic* is a local object¹⁰ that acts as a 'proxy' to designate the global concept of topic. Middleware implementations could choose to propagate topics and make remotely created topics locally available.

A *Topic* obtained by means of *find_topic*, must also be deleted by means of *delete_topic* so that the local resources can be released. If a *Topic* is obtained multiple times by means of *find_topic* or *create_topic*, it must also be deleted that same number of times using *delete_topic*.

Regardless of whether the middleware chooses to propagate topics, the *delete_topic* operation deletes only the local proxy.

If the operation times-out, a 'nil' value (as specified by the platform) is returned.

10. All the objects that make up this specification are local objects that are actually proxies to the service to be used by the application.

2.1.2.2.1.12 *lookup_topicdescription*

The operation ***lookup_topicdescription*** gives access to an existing locally-created ***TopicDescription***, based on its name. The operation takes as argument the ***name*** of the ***TopicDescription***.

If a ***TopicDescription*** of the same name already exists, it gives access to it; otherwise it returns a 'nil' value. The operation never blocks.

The operation ***lookup_topicdescription*** may be used to locate any locally-created ***Topic***, ***ContentFilteredTopic***, and ***MultiTopic*** object.

If the operation fails to locate a ***TopicDescription*** a 'nil' value (as specified by the platform) is returned.

2.1.2.2.1.13 *get_builtin_subscriber*

This operation allows access to the built-in ***Subscriber***. Each ***DomainParticipant*** contains several built-in ***Topic*** objects as well as corresponding ***DataReader*** objects to access them. All these ***DataReader*** objects belong to a single built-in ***Subscriber***.

The built-in Topics are used to communicate information about other ***DomainParticipant***, ***Topic***, ***DataReader***, and ***DataWriter*** objects. These built-in objects are described in Section 2.1.5, "Built-in Topics," on page 2-128.

2.1.2.2.1.14 *ignore_participant*

This operation allows an application to instruct the Service to locally ignore a remote domain participant. From that point onwards the Service will locally behave as if the remote participant did not exist. This means it will ignore any ***Topic***, publication, or subscription that originates on that domain participant.

This operation can be used, in conjunction with the discovery of remote participants offered by means of the "DCPSParticipant" built-in ***Topic***, to provide e.g., access control. Application data can be associated with a ***DomainParticipant*** by means of the USER_DATA QoS policy. This application data is propagated as a field in the built-in topic and can be used by an application to implement its own access control policy. See Section 2.1.5, "Built-in Topics," on page 2-128 for more details on the built-in topics.

The domain participant to ignore is identified by the ***handle*** argument. This handle is the one that appears in the ***SampleInfo*** retrieved when reading the data-samples available for the built-in ***DataReader*** to the "DCPSParticipant" topic. The built-in ***DataReader*** is read with the same ***read/take*** operations used for any ***DataReader***. These data-accessing operations are described in Section 2.1.2.5, "Subscription Module," on page 2-55.

The ***ignore_participant*** operation is not required to be reversible. The Service offers no means to reverse it.

Possible error codes returned in addition to the standard ones: OUT_OF_RESOURCES.

2.1.2.2.1.15 *ignore_topic*

This operation allows an application to instruct the Service to locally ignore a ***Topic***. This means it will locally ignore any, publication, or subscription to the ***Topic***.

This operation can be used to save local resources when the application knows that it will never publish or subscribe to data under certain topics.

The **Topic** to ignore is identified by the **handle** argument. This handle is the one that appears in the **SampleInfo** retrieved when reading the data-samples from the built-in **DataReader** to the “DCPSTopic” topic.

The **ignore_topic** operation is not required to be reversible. The Service offers no means to reverse it.

Possible error codes returned in addition to the standard ones: OUT_OF_RESOURCES.

2.1.2.2.1.16 ignore_publication

This operation allows an application to instruct the Service to locally ignore a remote publication; a publication is defined by the association of a topic name, and user data and partition set on the **Publisher** (see the “DCPSPublication” built-in **Topic** in Section 2.1.5, “Built-in Topics,” on page 2-128). After this call, any data written related to that publication will be ignored.

The **DataWriter** to ignore is identified by the **handle** argument. This handle is the one that appears in the **SampleInfo** retrieved when reading the data-samples from the built-in **DataReader** to the “DCPSPublication” topic.

The **ignore_publication** operation is not required to be reversible. The Service offers no means to reverse it.

Possible error codes returned in addition to the standard ones: OUT_OF_RESOURCES.

2.1.2.2.1.17 ignore_subscription

This operation allows an application to instruct the Service to locally ignore a remote subscription; a subscription is defined by the association of a topic name, and user data and partition set on the **Subscriber** (see the “DCPSSubscription” built-in **Topic** in Section 2.1.5, “Built-in Topics,” on page 2-128). After this call, any data received related to that subscription will be ignored.

The **DataReader** to ignore is identified by the **handle** argument. This handle is the one that appears in the **SampleInfo** retrieved when reading the data-samples from the built-in **DataReader** to the “DCPSSubscription” topic.

The **ignore_subscription** operation is not required to be reversible. The Service offers no means to reverse it.

Possible error codes returned in addition to the standard ones: OUT_OF_RESOURCES.

2.1.2.2.1.18 delete_contained_entities

This operation deletes all the entities that were created by means of the “create” operations on the **DomainParticipant**. That is, it deletes all contained **Publisher**, **Subscriber**, **Topic**, **ContentFilteredTopic**, and **MultiTopic**.

Prior to deleting each contained entity, this operation will recursively call the corresponding *delete_contained_entities* operation on each contained entity (if applicable). This pattern is applied recursively. In this manner the operation *delete_contained_entities* on the *DomainParticipant* will end up deleting all the entities recursively contained in the *DomainParticipant*, that is also the *DataWriter*, *DataReader*, as well as the *QueryCondition* and *ReadCondition* objects belonging to the contained *DataReaders*.

Once *delete_contained_entities* returns successfully, the application may delete the *DomainParticipant* knowing that it has no contained entities.

2.1.2.2.1.19 *assert_liveliness*

This operation manually asserts the liveliness of the *DomainParticipant*. This is used in combination with the LIVELINESS QoS policy (see. Section 2.1.3, “Supported QoS,” on page 2-89) to indicate to the Service that the entity remains active.

This operation needs to only be used if the *DomainParticipant* contains *DataWriter* entities with the LIVELINESS set to MANUAL_BY_PARTICIPANT and it only affects the liveliness of those *DataWriter* entities. Otherwise, it has no effect.

Note – Writing data via the *write* operation on a *DataWriter* asserts liveliness on the *DataWriter* itself and its *DomainParticipant*. Consequently the use of *assert_liveliness* is only needed if the application is not writing data regularly.

Complete details are provided in Section 2.1.3.10, “LIVELINESS,” on page 2-107.

2.1.2.2.1.20 *set_default_publisher_qos*

This operation sets a default value of the *Publisher* QoS policies that will be used for newly created *Publisher* entities in the case where the QoS policies are not explicitly specified in the *create_publisher* operation.

This operation will check that the resulting policies are self consistent; if they are not the operation will have no effect and return INCONSISTENT_POLICY.

2.1.2.2.1.21 *get_default_publisher_qos*

This operation retrieves the default value of the *Publisher* QoS, that is, the QoS policies that will be used for newly created *Publisher* entities in the case where the QoS policies are not explicitly specified in the *create_publisher* operation.

The values retrieved *get_default_publisher_qos* will match the set of values specified on the last successful call to *set_default_publisher_qos*, or else, if the call was never made, the default values listed in the QoS table in “Supported QoS” on page 2-89.

2.1.2.2.1.22 *set_default_subscriber_qos*

This operation sets a default value of the *Subscriber* QoS policies that will be used for newly created *Subscriber* entities in the case where the QoS policies are not explicitly specified in the *create_subscriber* operation.

This operation will check that the resulting policies are self consistent; if they are not the operation will have no effect and return INCONSISTENT_POLICY.

2.1.2.2.1.23 *get_default_subscriber_qos*

This operation retrieves the default value of the **Subscriber** QoS, that is, the QoS policies that will be used for newly created **Subscriber** entities in the case where the QoS policies are not explicitly specified in the *create_subscriber* operation.

The values retrieved *get_default_subscriber_qos* will match the set of values specified on the last successful call to *set_default_subscriber_qos*, or else, if the call was never made, the default values listed in the QoS table in Section 2.1.3.

2.1.2.2.1.24 *set_default_topic_qos*

This operation sets a default value of the **Topic** QoS policies that will be used for newly created **Topic** entities in the case where the QoS policies are not explicitly specified in the *create_topic* operation.

This operation will check that the resulting policies are self consistent; if they are not the operation will have no effect and return INCONSISTENT_POLICY.

2.1.2.2.1.25 *get_default_topic_qos*

This operation retrieves the default value of the **Topic** QoS, that is, the QoS policies that will be used for newly created **Topic** entities in the case where the QoS policies are not explicitly specified in the *create_topic* operation.

The values retrieved *get_default_topic_qos* will match the set of values specified on the last successful call to *set_default_topic_qos*, or else, if the call was never made, the default values listed in the QoS table in “Supported QoS” on page 2-89.

2.1.2.2.2 *DomainParticipantFactory Class*

The sole purpose of this class is to allow the creation and destruction of **DomainParticipant** objects. **DomainParticipantFactory** itself has no factory. It is a pre-existing singleton object that can be accessed by means of the *get_instance* class operation on the **DomainParticipantFactory**.

<i>DomainParticipantFactory</i>		
no attributes		
operations		
<i>create_participant</i>		DomainParticipant
	domainId	DomainId_t
	qos_list	QosPolicy []
	a_listener	DomainParticipantListener
<i>delete_participant</i>		ReturnCode_t

	a_participant	DomainParticipant
get_instance		DomainParticipantFactory
lookup_participant		DomainParticipant
	domainId	DomainId_t
set_default_participant_qos		ReturnCode_t
	qos_list	QosPolicy []
get_default_participant_qos		void
	out: qos_list	QosPolicy []

The following sections give details about the operations.

2.1.2.2.2.1 create_participant

This operation creates a new **DomainParticipant** object. The **DomainParticipant** signifies that the calling application intends to join the Domain identified by the **domainId** argument.

If the specified QoS policies are not consistent, the operation will fail and no **DomainParticipant** will be created.

The special value PARTICIPANT_QOS_DEFAULT can be used to indicate that the **DomainParticipant** should be created with the default **DomainParticipant** QoS set in the factory. The use of this value is equivalent to the application obtaining the default **DomainParticipant** QoS by means of the operation **get_default_participant_qos** (Section 2.1.2.2.2.6) and using the resulting QoS to create the **DomainParticipant**.

In case of failure, the operation will return a 'nil' value (as specified by the platform).

2.1.2.2.2.2 delete_participant

This operation deletes an existing **DomainParticipant**. This operation can only be invoked if all domain entities belonging to the participant have already been deleted. Otherwise the error PRECONDITION_NOT_MET is returned.

Possible error codes returned in addition to the standard ones:
PRECONDITION_NOT_MET.

2.1.2.2.2.3 get_instance

This operation returns the **DomainParticipantFactory** singleton. The operation is idempotent, that is, it can be called multiple times without side-effects and it will return the same **DomainParticipantFactory** instance.

The pre-defined value **TheParticipantFactory** can also be used as an alias for the singleton factory returned by the operation **get_instance**.

2.1.2.2.2.4 lookup_participant

This operation retrieves a previously created **DomainParticipant** belonging to specified domainId. If no such **DomainParticipant** exists, the operation will return a 'nil' value.

If multiple *DomainParticipant* belonging to that *domainId* exist, then the operation will return one of them. It is not specified which one.

2.1.2.2.2.5 *set_default_participant_qos*

This operation sets a default value of the *DomainParticipant* QoS policies that will be used for newly created *DomainParticipant* entities in the case where the QoS policies are not explicitly specified in the *create_participant* operation.

This operation will check that the resulting policies are self consistent; if they are not, the operation will have no effect and return `INCONSISTENT_POLICY`.

2.1.2.2.2.6 *get_default_participant_qos*

This operation retrieves the default value of the *DomainParticipant* QoS, that is, the QoS policies that will be used for newly created *DomainParticipant* entities in the case where the QoS policies are not explicitly specified in the *create_participant* operation.

The values retrieved *get_default_participant_qos* will match the set of values specified on the last successful call to *set_default_participant_qos*, or else, if the call was never made, the default values listed in the QoS table in “Supported QoS” on page 2-89.

2.1.2.2.3 *DomainParticipantListener Interface*

This is the interface that can be implemented by an application-provided class and then registered with the *DomainParticipant* such that the application can be notified by the DCPS Service of relevant status changes.

The *DomainParticipantListener* interface extends all other *Listener* interfaces and has no additional operation beyond the ones defined by the more general listeners.

<i>DomainParticipantListener</i>		
no attributes		
operations		
<code>on_inconsistent_topic</code>		<code>void</code>
	<code>the_topic</code>	<code>Topic</code>
	<code>status</code>	<code>InconsistentTopicStatus</code>
<code>on_liveliness_lost</code>		<code>void</code>
	<code>the_writer</code>	<code>DataWriter</code>
	<code>status</code>	<code>LivelinessLostStatus</code>
<code>on_offered_deadline_missed</code>	<code>the_writer</code>	<code>DataWriter</code>
	<code>status</code>	<code>OfferedDeadlineMissedStatus</code>
<code>on_offered_incompatible_qos</code>	<code>the_writer</code>	<code>DataWriter</code>
	<code>status</code>	<code>OfferedIncompatibleQosStatus</code>
<code>on_data_on_readers</code>		<code>void</code>
	<code>the_subscriber</code>	<code>Subscriber</code>
<code>on_sample_lost</code>		<code>void</code>
	<code>the_reader</code>	<code>DataReader</code>

	status	SampleLostStatus
on_data_available		void
	the_reader	DataReader
on_sample_rejected		void
	the_reader	DataReader
	status	SampleRejectedStatus
on_liveliness_changed		void
	the_reader	DataReader
	status	LivelinessChangedStatus
on_requested_deadline_missed		void
	the_reader	DataReader
	status	RequestedDeadlineMissedStatus
on_requested_incompatible_qos		void
	the_reader	DataReader
	status	RequestedIncompatibleQosStatus
on_publication_match		void
	the_writer	DataWriter
	status	PublicationMatchStatus
on_subscription_match		void
	the_reader	DataReader
	status	SubscriptionMatchStatus

The purpose of the *DomainParticipantListener* is to be the listener of last resort that is notified of all status changes not captured by more specific listeners attached to the *DomainEntity* objects. When a relevant status change occurs, the DCPS Service will first attempt to notify the listener attached to the concerned *DomainEntity* if one is installed. Otherwise, the DCPS Service will notify the *Listener* attached to the *DomainParticipant*. The relationship between listeners is described in Section 2.1.4, “Listeners, Conditions and Wait-sets,” on page 2-115.

2.1.2.3 Topic-Definition Module

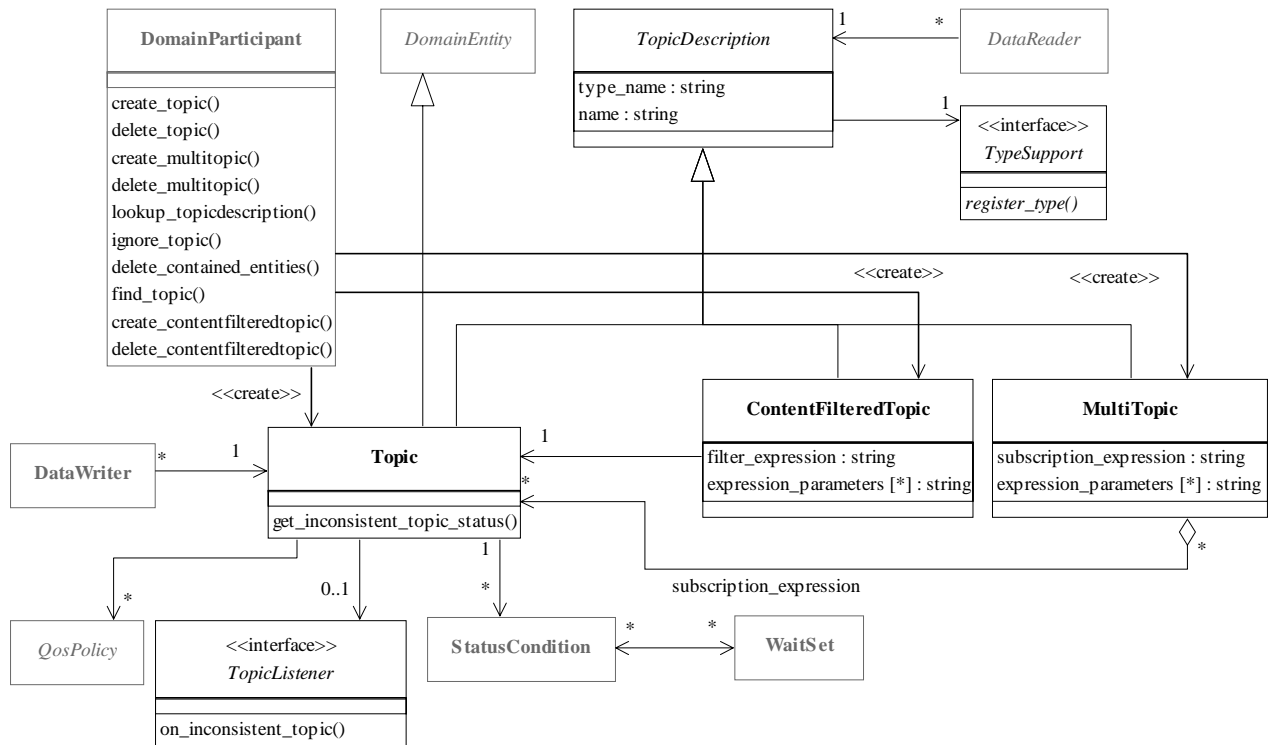


Figure 2-7 Class model of the DCPS Topic-definition Module

The Topic-Definition Module is comprised of the following classes:

- TopicDescription
- Topic
- ContentFilteredTopic
- MultiTopic
- TopicListener
- TypeSupport

2.1.2.3.1 *TopicDescription* Class

This class is an abstract class. It is the base class for *Topic*, *ContentFilteredTopic*, and *MultiTopic*.

<i>TopicDescription</i>		
no attributes		
operations		
get_participant		DomainParticipant
get_type_name		string
get_name		string

TopicDescription represents the fact that both publications and subscriptions are tied to a single data-type. Its attribute *type_name* defines a unique resulting type for the publication or the subscription and therefore creates an implicit association with a *TypeSupport*. *TopicDescription* has also a *name* that allows it to be retrieved locally.

2.1.2.3.1.1 *get_participant*

This operation returns the *DomainParticipant* to which the *TopicDescription* belongs.

2.1.2.3.1.2 *get_type_name*

This operation returns the *type_name* used to create the *TopicDescription*.

2.1.2.3.1.3 *get_name*

This operation returns the name used to create the *TopicDescription*.

2.1.2.3.2 *Topic* Class

Topic is the most basic description of the data to be published and subscribed.

<i>Topic</i>		
no attributes		
operations		
(inherited) get_qos		QosPolicy []
(inherited) set_qos		ReturnCode_t
	qos_list	QosPolicy []
(inherited) get_listener		Listener
(inherited) set_listener		ReturnCode_t
	a_listener	Listener
	mask	StatusKind []
get_type_name (inherited)		string
get_name (inherited)		string
get_inconsistent_topic_status		InconsistentTopicStatus

A **Topic** is identified by its *name*, which must be unique in the whole Domain. In addition (by virtue of extending **TopicDescription**) it fully specifies the type of the data that can be communicated when publishing or subscribing to the **Topic**.

Topic is the only **TopicDescription** that can be used for publications and therefore associated to a **DataWriter**.

All operations except for the base-class operations *set_qos*, *get_qos*, *set_listener*, *get_listener*, and *enable* may return the value NOT_ENABLED.

The following sections describe its operations.

2.1.2.3.2.1 *get_inconsistent_topic_status*

This method allows the application to retrieve the INCONSISTENT_TOPIC status of the **Topic**.

Each **DomainEntity** has a set of relevant communication statuses. A change of status causes the corresponding **Listener** to be invoked and can also be monitored by means of the associated **StatusCondition**.

The complete list of communication status, their values, and the **DomainEntities** they apply to is provided in Section 2.1.4.1, “Communication Status,” on page 2-116.

2.1.2.3.3 **ContentFilteredTopic Class**

ContentFilteredTopic is a specialization of **TopicDescription** that allows for content-based subscriptions.

ContentFilteredTopic		
no attributes		
operations		
get_type_name (inherited)		string
get_name (inherited)		string
get_related_topic		Topic
get_filter_expression		string
get_expression_parameters		string []
set_expression_parameters		ReturnCode_t
	expression_parameters	string []

ContentFilteredTopic describes a more sophisticated subscription that indicates the subscriber does not want to necessarily see all values of each instance published under the **Topic**. Rather, it wants to see only the values whose contents satisfy certain criteria. This class therefore can be used to request content-based subscriptions.

The selection of the content is done using the *filter_expression* with parameters *filter_parameters*.

- The *filter_expression* attribute is a string that specifies the criteria to select the data samples of interest. It is similar to the WHERE part of an SQL clause.
- The *expression_parameters* attribute is a sequence of strings that give values to the 'parameters' (i.e., "%n" tokens) in the *filter_expression*. The number of supplied parameters must fit with the requested values in the *filter_expression* (i.e., the number of %n tokens).

Appendix B describes the syntax of *filter_expression* and *expression_parameters*.

2.1.2.3.3.1 *get_related_topic*

This operation returns the *Topic* associated with the *ContentFilteredTopic*. That is, the *Topic* specified when the *ContentFilteredTopic* was created.

2.1.2.3.3.2 *get_filter_expression*

This operation returns the *filter_expression* associated with the *ContentFilteredTopic*. That is, the expression specified when the *ContentFilteredTopic* was created.

2.1.2.3.3.3 *get_expression_parameters*

This operation returns the *expression_parameters* associated with the *ContentFilteredTopic*. That is, the parameters specified on the last successful call to *set_expression_parameters*, or if *set_expression_parameters* was never called, the parameters specified when the *ContentFilteredTopic* was created.

2.1.2.3.3.4 *set_expression_parameters*

This operation changes the *expression_parameters* associated with the *ContentFilteredTopic*.

2.1.2.3.4 *MultiTopic Class [optional]*

MultiTopic is a specialization of *TopicDescription* that allows subscriptions to combine/filter/rearrange data coming from several topics.

<i>MultiTopic</i>		
no attributes		
operations		
get_type_name (inherited)		string
get_name (inherited)		string
get_subscription_expression		string
get_expression_parameters		string []
set_expression_parameters		ReturnCode_t
	expression_parameters	string []

MultiTopic allows a more sophisticated subscription that can select and combine data received from multiple topics into a single resulting type (specified by the inherited *type_name*). The data will then be filtered (selection) and possibly re-arranged (aggregation/projection) according to a *subscription_expression* with parameters *expression_parameters*.

- The *subscription_expression* is a string that identifies the selection and re-arrangement of data from the associated topics. It is similar to an SQL clause where the SELECT part provides the fields to be kept, the FROM part provides the names of the topics that are searched for those fields¹¹, and the WHERE clause gives the content filter. The Topics combined may have different types but they are restricted in that the type of the fields used for the NATURAL JOIN operation must be the same.
- The *expression_parameters* attribute is a sequence of strings that give values to the 'parameters' (i.e., "%n" tokens) in the *subscription_expression*. The number of supplied parameters must fit with the requested values in the *subscription_expression* (i.e., the number of %n tokens).
- *DataReader* entities associated with a **MultiTopic** are alerted of data modifications by the usual *Listener* or *Condition* mechanisms (see “Listeners, Conditions and Wait-sets” on page 2-115) whenever modifications occur to the data associated with any of the topics relevant to the **MultiTopic**.
- *DataReader* entities associated with a **MultiTopic** access instances that are “constructed” at the *DataReader* side from the instances written by multiple *DataWriter* entities. The **MultiTopic** access instance will begin to exist as soon as all the constituting *Topic* instances are in existence. The *view_state* and *instance_state* is computed from the corresponding states of the constituting instances:
 - The *view_state* (see *Section 2.1.2.5.1*) of the **MultiTopic** instance is NEW if at least one of the constituting instances has *view_state* = NEW, otherwise it will be NOT_NEW.
 - The *instance_state* (see *Section 2.1.2.5.1*) of the **MultiTopic** instance is “ALIVE” if the *instance_state* of all the constituting *Topic* instances is ALIVE. It is “NOT_ALIVE_DISPOSED” if at least one of the constituting *Topic* instances is NOT_ALIVE_DISPOSED. Otherwise it is NOT_ALIVE_NO_WRITERS.

Appendix B describes the syntax of *subscription_expression* and *expression_parameters*.

2.1.2.3.4.1 *get_subscription_expression*

This operation returns the *subscription_expression* associated with the **MultiTopic**. That is, the expression specified when the **MultiTopic** was created.

¹¹.It should be noted that in that case, the source for data may not be restricted to a single topic.

2.1.2.3.4.2 *get_expression_parameters*

This operation returns the *expression_parameters* associated with the *MultiTopic*. That is, the parameters specified on the last successful call to *set_expression_parameters*, or if *set_expression_parameters* was never called, the parameters specified when the *MultiTopic* was created.

2.1.2.3.4.3 *set_expression_parameters*

This operation changes the *expression_parameters* associated with the *MultiTopic*.

2.1.2.3.5 *TopicListener Interface*

Since *Topic* is a kind of *Entity*, it has the ability to have an associated listener. In this case, the associated listener should be of concrete type *TopicListener*.

<i>TopicListener</i>		
no attributes		
operations		
on_inconsistent_topic		void
	the_topic	Topic
	status	InconsistentTopicStatus

2.1.2.3.6 *TypeSupport Interface*

The *TypeSupport* interface is an abstract interface that has to be specialized for each concrete type that will be used by the application.

It is required that each implementation of the Service provides an automatic means to generate this type-specific class from a description of the type (using IDL for example in the OMG IDL mapping). A *TypeSupport* must be registered using the *register_type* operation on this type-specific class before it can be used to create *Topic* objects.

<i>TypeSupport</i>		
no attributes		
operations		
register_type		ReturnCode_t
	participant	DomainParticipant
	type_name	string

2.1.2.3.6.1 *register_type*

This operation allows an application to communicate to the Service the existence of a data type. The generated implementation of that operation embeds all the knowledge that has to be communicated to the middleware in order to make it able to manage the contents of data of that data type. This includes in particular the *key* definition that will allow the Service to distinguish different instances of the same type.

It is a pre-condition error to use the same *type_name* to register two different *TypeSupport* with the same *DomainParticipant*. If an application attempts this, the operation will fail and return PRECONDITION_NOT_MET. However, it is allowed to register the same *TypeSupport* multiple times with a *DomainParticipant* using the same or different values for the *type_name*. If *register_type* is called multiple times on the same *TypeSupport* with the same *DomainParticipant* and *type_name* the second (and subsequent) registrations are ignored but the operation returns OK.

Possible error codes returned in addition to the standard ones: OUT_OF_RESOURCES.

2.1.2.3.7 Derived Classes for Each Application Class

For each data class defined by the application, there is a number of specialized classes that are required to facilitate the type-safe interaction of the application with the Service.

It is required that each implementation of the Service provides an automatic means to generate all these type-specific classes. *TypeSupport* is one of the interfaces that these automatically-generated classes must implement. The complete set of automatic classes created for a hypothetical application named “Foo” are shown in Figure 2-8..

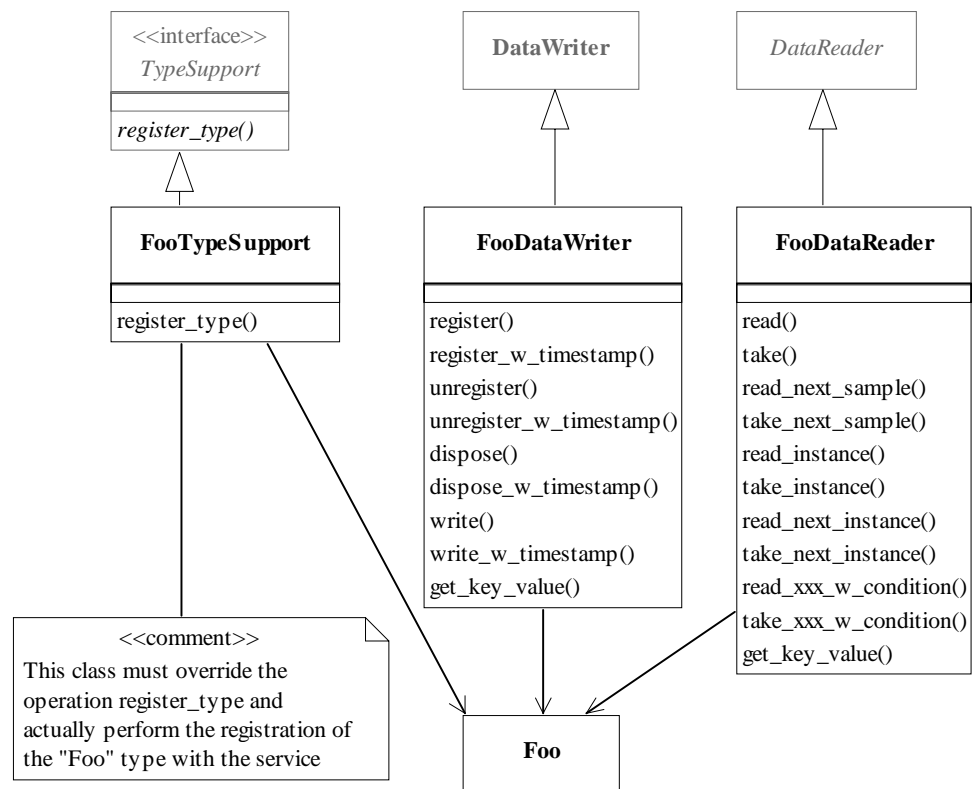


Figure 2-8 Classes auto-created for an application data type named Foo

2.1.2.4 Publication Module

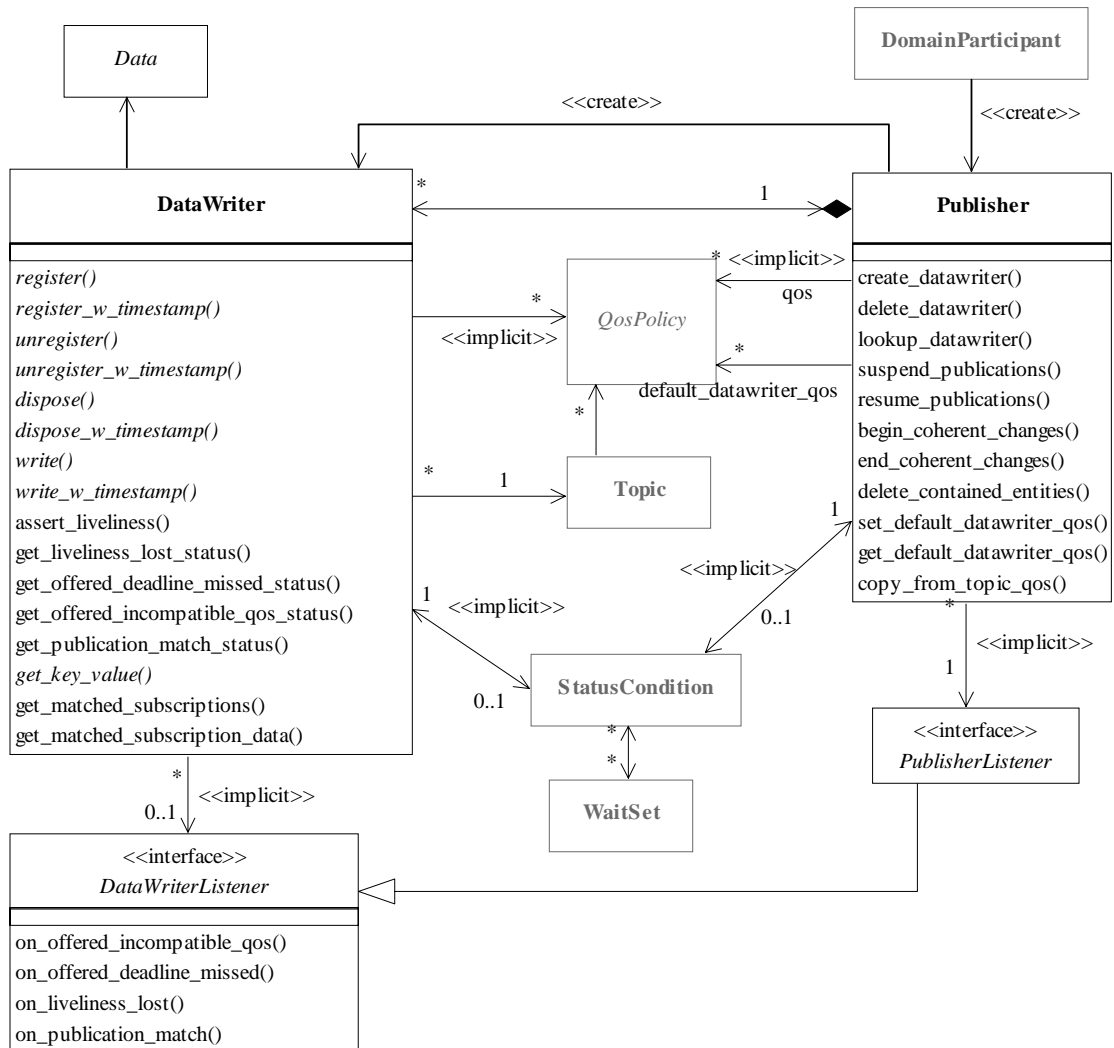


Figure 2-9 Class model of the DCPS Publication Module

The DCPS Publication Module is comprised of the following classifiers:

- Publisher
- DataWriter
- PublisherListener
- DataWriterListener

2.1.2.4.1 *Publisher* Class

A *Publisher* is the object responsible for the actual dissemination of publications.

<i>Publisher</i>		
no attributes		
operations		
(inherited) get_qos		QosPolicy []
(inherited) set_qos		ReturnCode_t
	qos_list	QosPolicy []
(inherited) get_listener		Listener
(inherited) set_listener		ReturnCode_t
	a_listener	Listener
	mask	StatusKind []
create_datawriter		DataWriter
	a_topic	Topic
	qos	QosPolicy []
	a_listener	DataWriterListener
delete_datawriter		ReturnCode_t
	a_datawriter	DataWriter
lookup_datawriter		DataWriter
	topic_name	string
suspend_publications		ReturnCode_t
resume_publications		ReturnCode_t
begin_coherent_changes		ReturnCode_t
end_coherent_changes		ReturnCode_t
get_participant		DomainParticipant
delete_contained_entities		ReturnCode_t
set_default_datawriter_qos		ReturnCode_t
	qos_list	QosPolicy []
get_default_datawriter_qos		void
	out: qos_list	QosPolicy []
copy_from_topic_qos		ReturnCode_t
	inout: datawriter_qos	QosPolicy []
	topic_qos	QosPolicy []

The *Publisher* acts on the behalf of one or several *DataWriter* objects that belong to it. When it is informed of a change to the data associated with one of its *DataWriter* objects, it decides when it is appropriate to actually send the data-update message. In making this decision, it considers any extra information that goes with the data (timestamp, writer, etc.) as well as the QoS of the *Publisher* and the *DataWriter*.

All operations except for the base-class operations *set_qos*, *get_qos*, *set_listener*, *get_listener* and *enable* may return the value NOT_ENABLED.

2.1.2.4.1.1 *set_listener* (from *Entity*)

By virtue of extending *Entity*, a *Publisher* can be attached to a *Listener* at creation time or later by using the *set_listener* operation. The *Listener* attached must extend *PublisherListener*. Listeners are described in Section 2.1.4, “Listeners, Conditions and Wait-sets,” on page 2-115.

2.1.2.4.1.2 *get_listener* (from *Entity*)

Retrieves the attached *PublisherListener*.

2.1.2.4.1.3 *set_qos* (from *Entity*)

By virtue of extending *Entity*, a *Publisher* can be given QoS at creation time or later by using the *set_qos* operation. See Section 2.1.3, “Supported QoS,” on page 2-89 for the QoS policies that may be set on a *Publisher*.

Possible error codes returned in addition to the standard ones: IMMUTABLE_POLICY, INCONSISTENT_POLICY.

2.1.2.4.1.4 *get_qos* (from *Entity*)

Allows access to the values of the QoS.

2.1.2.4.1.5 *create_datawriter*

This operation creates a *DataWriter*. The returned *DataWriter* will be attached and belongs to the *Publisher*.

The *DataWriter* returned by the *create_datawriter* operation will in fact be a derived class, specific to the data-type associated with the Topic. As described in Section 2.1.2.3.7, for each application-defined type “Foo” there is an implied, auto-generated class *FooDataWriter* that extends *DataWriter* and contains the operations to write data of type “Foo.”

In case of failure, the operation will return a ‘nil’ value (as specified by the platform).

Note that a common application pattern to construct the QoS for the *DataWriter* is to:

- Retrieve the QoS policies on the associated *Topic* by means of the *get_qos* operation on the *Topic*.
- Retrieve the default *DataWriter* qos by means of the *get_default_datawriter_qos* operation on the *Publisher*.
- Combine those two QoS policies and selectively modify policies as desired.
- Use the resulting QoS policies to construct the *DataWriter*.

The special value DATAWRITER_QOS_DEFAULT can be used to indicate that the *DataWriter* should be created with the default *DataWriter* QoS set in the factory. The use of this value is equivalent to the application obtaining the default *DataWriter* QoS by means of the operation *get_default_datawriter_qos* (Section 2.1.2.4.1.14) and using the resulting QoS to create the *DataWriter*.

The special value `DATAWRITER_QOS_USE_TOPIC_QOS` can be used to indicate that the *DataWriter* should be created with a combination of the default *DataWriter* QoS and the *Topic* QoS. The use of this value is equivalent to the application obtaining the default *DataWriter* QoS and the *Topic* QoS (by means of the operation `Topic::get_qos`) and then combining these two QoS using the operation `copy_from_topic_qos` whereby any policy that is set on the *Topic* QoS “overrides” the corresponding policy on the default QoS. The resulting QoS is then applied to the creation of the *DataWriter*.

2.1.2.4.1.6 *delete_datawriter*

This operation deletes a *DataWriter* that belongs to the *Publisher*.

The *delete_datawriter* operation must be called on the same *Publisher* object used to create the *DataWriter*. If *delete_datawriter* is called on a different *Publisher* the operation will have no effect and it will return `PRECONDITION_NOT_MET`.

The deletion of the *DataWriter* will automatically unregister all instances. Depending on the settings of the `WRITER_DATA_LIFECYCLE` QoSPolicy, the deletion of the *DataWriter* may also dispose all instances. Refer to Section 2.1.3.20 for details.

Possible error codes returned in addition to the standard ones:
`PRECONDITION_NOT_MET`.

2.1.2.4.1.7 *lookup_datawriter*

This operation retrieves a previously created *DataWriter* belonging to the *Publisher* that is attached to a *Topic* with a matching *topic_name*. If no such *DataWriter* exists, the operation will return 'nil.'

If multiple *DataWriter* attached to the *Publisher* satisfy this condition, then the operation will return one of them. It is not specified which one.

2.1.2.4.1.8 *suspend_publications*

This operation indicates to the Service that the application is about to make multiple modifications using *DataWriter* objects belonging to the *Publisher*.

It is a hint to the Service so it can optimize its performance by e.g., holding the dissemination of the modifications and then batching them.

It is not required that the Service use this hint in any way.

The use of this operation must be matched by a corresponding call to *resume_publications* indicating that the set of modifications has completed.

2.1.2.4.1.9 *resume_publications*

This operation indicates to the Service that the application has completed the multiple changes initiated by the previous *suspend_publications*. This is a hint to the Service that can be used by a Service implementation to e.g., batch all the modifications made since the *suspend_publications*.

The call to *resume_publications* must match a previous call to *suspend_publications*. Otherwise the operation will return the error `PRECONDITION_NOT_MET`.

Possible error codes returned in addition to the standard ones:
PRECONDITION_NOT_MET.

2.1.2.4.1.10 begin_coherent_changes

This operation requests that the application will begin a ‘coherent set’ of modifications using *DataWriter* objects attached to the *Publisher*. The ‘coherent set’ will be completed by a matching call to *end_coherent_changes*.

A ‘coherent set’ it is a set of modifications that must be propagated in such a way that they are interpreted at the receivers’ side as a consistent set of modifications; that is, the receiver will only be able to access the data after all the modifications in the set are available at the receiver end¹².

These calls can be nested. In that case, the coherent set terminates only with the last call to *end_coherent_changes*.

The support for ‘coherent changes’ enables a publishing application to change the value of several data-instances that could belong to the same or different topics and have those changes be seen ‘atomically’ by the readers. This is useful in cases where the values are inter-related. For example, if there are two data-instances representing the ‘altitude’ and ‘velocity vector’ of the same aircraft and both are changed, it may be useful to communicate those values in a way the reader can see both together; otherwise, it may erroneously interpret that the aircraft is on a collision course.

2.1.2.4.1.11 end_coherent_changes

This operation terminates the ‘coherent set’ initiated by the matching call to *begin_coherent_changes*. If there is no matching call to *begin_coherent_changes*, the operation will return the error PRECONDITION_NOT_MET.

Possible error codes returned in addition to the standard ones:
PRECONDITION_NOT_MET.

2.1.2.4.1.12 get_participant

This operation returns the *DomainParticipant* to which the *Publisher* belongs.

2.1.2.4.1.13 delete_contained_entities

This operation deletes all the entities that were created by means of the “create” operations on the *Publisher*. That is, it deletes all contained *DataWriter* objects.

Once *delete_contained_entities* returns successfully, the application may delete the *Publisher* knowing that it has no contained *DataWriter* objects.

12. This does not imply that the middleware has to encapsulate all the modifications in a single message; it only implies that the receiving applications will behave as if this was the case.

2.1.2.4.1.14 *set_default_datawriter_qos*

This operation sets a default value of the **DataWriter** QoS policies that will be used for newly created **DataWriter** entities in the case where the QoS policies are not explicitly specified in the *create_datawriter* operation.

This operation will check that the resulting policies are self consistent; if they are not, the operation will have no effect and return INCONSISTENT_POLICY.

2.1.2.4.1.15 *get_default_datawriter_qos*

This operation retrieves the default value of the **DataWriter** QoS, that is, the QoS policies that will be used for newly created **DataWriter** entities in the case where the QoS policies are not explicitly specified in the *create_datawriter* operation.

The values retrieved by *get_default_datawriter_qos* will match the set of values specified on the last successful call to *get_default_datawriter_qos*, or else, if the call was never made, the default values listed in the QoS table in “Supported QoS” on page 2-89.

2.1.2.4.1.16 *copy_from_topic_qos*

This operation copies the policies in the *topic_qos* to the corresponding policies in the *datawriter_qos_list* (replacing values in the *datawriter_qos_list*, if present).

This is a “convenience” operation most useful in combination with the operations *get_default_datawriter_qos* and *Topic::get_qos*. The operation *copy_from_topic_qos* can be used to merge the **DataWriter** default QoS policies with the corresponding ones on the **Topic**. The resulting QoS can then be used to create a new **DataWriter**, or set its QoS.

This operation does not check the resulting *datawriter_qos_list* for consistency. This is because the ‘merged’ *datawriter_qos_list* may not be the final one, as the application can still modify some policies prior to applying the policies to the **DataWriter**.

2.1.2.4.2 **DataWriter Class**

DataWriter allows the application to set the value of the data to be published under a given **Topic**.

DataWriter		
no attributes		
operations		
(inherited) <i>get_qos</i>		QosPolicy []
(inherited) <i>set_qos</i>		ReturnCode_t
	<i>qos_list</i>	QosPolicy []
(inherited) <i>get_listener</i>		Listener
(inherited) <i>set_listener</i>		ReturnCode_t
	<i>a_listener</i>	Listener
	<i>mask</i>	StatusKind []

register		InstanceHandle_t
	instance	Data
register_w_timestamp		InstanceHandle_t
	instance	Data
	timestamp	Time_t
unregister		ReturnCode_t
	instance	Data
	handle	InstanceHandle_t
unregister_w_timestamp		ReturnCode_t
	instance	Data
	handle	InstanceHandle_t
	timestamp	Time_t
get_key_value		ReturnCode_t
	inout: key_holder	Data
	handle	InstanceHandle_t
write		ReturnCode_t
	data	Data
	handle	InstanceHandle_t
write_w_timestamp		ReturnCode_t
	data	Data
	handle	InstanceHandle_t
	timestamp	Time_t
dispose		ReturnCode_t
	data	Data
	handle	InstanceHandle_t
dispose_w_timestamp		ReturnCode_t
	data	Data
	handle	InstanceHandle_t
	timestamp	Time_t
get_liveliness_lost_status		LivelinessLostStatus
get_offered_deadline_missed_status		OfferedDeadlineMissedStatus
get_offered_incompatible_qos_status		OfferedIncompatibleQosStatus
get_publication_match_status		PublicationMatchStatus
get_topic		Topic
get_publisher		Publisher
assert_liveliness		void
get_matched_subscription_data		ReturnCode_t
	inout: subscription_data	SubscriptionBuiltinTopicData
	subscription_handle	InstanceHandle_t
get_matched_subscriptions		ReturnCode_t
	inout: subscription_handles	InstanceHandle_t []

A *DataWriter* is attached to exactly one *Publisher* that acts as a factory for it.

A *DataWriter* is bound to exactly one *Topic* and therefore to exactly one data type. The *Topic* must exist prior to the *DataWriter*'s creation.

DataWriter is an abstract class. It must be specialized for each particular application data-type as shown in Figure 2-8 on page 2-39. The additional methods that must be defined in the auto-generated class for a hypothetical application type "Foo" are shown in the table below:

<i>FooDataWriter</i>		
no attributes		
operations		
register		InstanceHandle_t
	instance	Foo
register_w_timestamp		InstanceHandle_t
	instance	Foo
	timestamp	Time_t
unregister		ReturnCode_t
	instance	Foo
	handle	InstanceHandle_t
unregister_w_timestamp		ReturnCode_t
	instance	Foo
	handle	InstanceHandle_t
	timestamp	Time_t
get_key_value		ReturnCode_t
	inout: key_holder	Foo
	handle	InstanceHandle_t
write		ReturnCode_t
	instance_data	Foo
	handle	InstanceHandle_t
write_w_timestamp		ReturnCode_t
	instance_data	Foo
	handle	InstanceHandle_t
	timestamp	Time_t
dispose		ReturnCode_t
	instance	Foo
	handle	InstanceHandle_t
dispose_w_timestamp		ReturnCode_t
	instance	Foo
	handle	InstanceHandle_t
	timestamp	Time_t

All operations except for the base-class operations *set_qos*, *get_qos*, *set_listener*, *get_listener*, and *enable* may return the value NOT_ENABLED.

The following sections provide details on the methods.

2.1.2.4.2.1 *set_listener* (from Entity)

By virtue of extending *Entity*, a *DataWriter* can be attached to a *Listener* at creation time or later by using the *set_listener* operation. The attached *Listener* must extend *DataWriterListener*. Listeners are described in Section 2.1.4, “Listeners, Conditions and Wait-sets,” on page 2-115.

2.1.2.4.2.2 *get_listener* (from Entity)

Allows access to the attached *DataWriterListener*.

2.1.2.4.2.3 *set_qos* (from Entity)

By virtue of extending *Entity*, a *DataWriter* can be given QoS at creation time or later by using the *set_qos* operation. See. Section 2.1.3, “Supported QoS,” on page 2-89 for the QoS policies that may be set on a *DataWriter*.

Possible error codes returned in addition to the standard ones: IMMUTABLE_POLICY, INCONSISTENT_POLICY.

2.1.2.4.2.4 *get_qos* (from Entity)

Allows access to the values of the QoS.

2.1.2.4.2.5 *register*

This operation informs the Service that the application will be modifying a particular instance. It gives an opportunity to the Service to pre-configure itself to improve performance.

It takes as a parameter an instance (to get the key value) and returns a handle that can be used in successive write or dispose operations.

This operation should be invoked prior to calling any operation that modifies the instance, such as *write*, *write_w_timestamp*, *dispose*, and *dispose_w_timestamp*.

The special value HANDLE_NIL may be returned by the Service if it does not want to allocate any handle for that instance.

The operation *register* is idempotent. If it is called for an already registered instance, it just returns the already allocated handle. This may be used to lookup and retrieve the handle allocated to a given instance. The explicit use of this operation is optional as the application may call directly the *write* operation and specify a HANDLE_NIL to indicate that the ‘key’ should be examined to identify the instance.

2.1.2.4.2.6 *register_w_timestamp*

This operation performs the same function as *register* and can be used instead of *register* in the cases where the application desires to specify the value for the *source_timestamp*. The *source_timestamp* potentially affects the relative order in which readers observe events from multiple writers. For details see Section 2.1.3.16, “DESTINATION_ORDER,” on page 2-110 for the QoS policy DESTINATION_ORDER).

2.1.2.4.2.7 *unregister*

This operation reverses the action of *register*. It should only be called on an instance that is currently registered.

The operation *unregister* should be called just once per instance, regardless of how many times *register* was called for that instance.

This operation informs the Service that the *DataWriter* is not intending to modify any more of that data instance. This operation also indicates that the Service can locally remove all information regarding that instance. The application should not attempt to use the handle previously allocated to that instance after calling *unregister*.

The special value HANDLE_NIL can be used for the parameter *handle*. This indicates that the identity of the instance should be automatically deduced from the *instance_data* (by means of the key).

If *handle* is any value other than HANDLE_NIL, then it must correspond to the value returned by *register* when the instance (identified by its *key*) was registered. Then if there is no correspondence, the result of the operation is unspecified.

If after that the application wants to modify (write or dispose) the instance, it has to register it again or else use the special *handle* value HANDLE_NIL.

This operation does not indicate that the instance is deleted (that is the purpose of *dispose*). The operation *unregister* just indicates that the *DataWriter* no longer has ‘anything to say’ about the instance. *DataReader* objects that are reading the instance will eventually get an indication that their LIVELINESS_CHANGED status (as defined in Section 2.1.4.1) has changed.

This operation can affect the ownership of the data instance (as described in Section 2.1.3.8 and Section 2.1.3.22.1). If the *DataWriter* was the exclusive owner of the instance, then calling *unregister* will relinquish that ownership.

The operation must be called only on registered instances. Otherwise the operation will return the error PRECONDITION_NOT_MET.

Possible error codes returned in addition to the standard ones:
PRECONDITION_NOT_MET.

2.1.2.4.2.8 *unregister_w_timestamp*

This operation performs the same function as *unregister* and can be used instead of *unregister* in the cases where the application desires to specify the value for the *source_timestamp*. The *source_timestamp* potentially affects the relative order in which

readers observe events from multiple writers. For details see Section 2.1.3.16, “DESTINATION_ORDER,” on page 2-110 for the QoS policy DESTINATION_ORDER.

2.1.2.4.2.9 *get_key_value*

This operation can be used to retrieve the instance key that corresponds to an *instance_handle*. The operation will only fill the fields that form the key inside the *key_holder* instance.

2.1.2.4.2.10 *write*

This operation modifies the value of a data instance. When this operation is used, the Service will automatically supply the value of the *source_timestamp* that is made available to *DataReader* objects by means of the *source_timestamp* attribute inside the *SampleInfo* (see Section 2.1.2.5, “Subscription Module,” on page 2-55 for more details on data timestamps at reader side and Section 2.1.3.16, “DESTINATION_ORDER,” on page 2-110 for the QoS policy DESTINATION_ORDER).

This operation must be provided on the specialized class that is generated for the particular application data-type that is being written. That way the *data* argument holding the data has the proper application-defined type (e.g., ‘Foo’).

As a side effect, this operation asserts liveness on the *DataWriter* itself, the *Publisher*, and the *DomainParticipant*.

The special value HANDLE_NIL can be used for the parameter *handle*. This indicates the identity of the instance should be automatically deduced from the *instance_data* (by means of the key).

If *handle* is any value other than HANDLE_NIL, then it must correspond to the value returned by *register* when the instance (identified by its *key*) was registered. If there is no correspondence, the result of the operation is unspecified.

If the RELIABILITY *kind* is set to RELIABLE and the HISTORY *kind* is set to KEEP_ALL, the *write* operation on the *DataWriter* may block if the modification would cause data to be lost or else cause one of the limits specified in the RESOURCE_LIMITS to be exceeded. Under these circumstances, the RELIABILITY *max_blocking_time* configures the maximum time the *write* operation may block (waiting for space to become available). If *max_blocking_time* elapses before the *DataWriter* is able to store the modification without exceeding the limits, the *write* operation will fail and return TIMEOUT.

2.1.2.4.2.11 *write_w_timestamp*

This operation performs the same function as *write* except that it also provides the value for the *source_timestamp* that is made available to *DataReader* objects by means of the *source_timestamp* attribute inside the *SampleInfo* (see Section 2.1.2.5, “Subscription Module,” on page 2-55 for more details on data timestamps at reader side and Section 2.1.3.16, “DESTINATION_ORDER,” on page 2-110 for the QoS policy DESTINATION_ORDER).

Similar to *write*, this operation must also be provided on the specialized class that is generated for the particular application data-type that is being written.

2.1.2.4.2.12 *dispose*

This operation requests the middleware to delete the data (the actual deletion is postponed until there is no more use for that data in the whole system). In general, applications are made aware of the deletion by means of operations on the *DataReader* objects that already knew that instance¹³ (see Section 2.1.2.5, “Subscription Module,” on page 2-55 for more details).

This operation does not modify the value of the instance. The *instance* parameter is passed just for the purposes of identifying the instance.

When this operation is used, the Service will automatically supply the value of the *source_timestamp* that is made available to *DataReader* objects by means of the *source_timestamp* attribute inside the *SampleInfo*.

In addition, in case the DURABILITY QoS policy is TRANSIENT or PERSISTENT, the Service should take care to clean anything related to that instance so that late-joining applications would not see it.

The special value HANDLE_NIL can be used for the parameter *handle*. This indicates the identity of the instance should be automatically deduced from the *instance_data* (by means of the key).

If *handle* is any value other than HANDLE_NIL, then it must correspond to the value returned by *register* when the instance (identified by its *key*) was registered. Then if there is no correspondence, the result of the operation is unspecified.

The operation must be only called on registered instances. Otherwise the operation will return the error PRECONDITION_NOT_MET.

Possible error codes returned in addition to the standard ones:
PRECONDITION_NOT_MET.

2.1.2.4.2.13 *dispose_w_timestamp*

This operation performs the same functions as *dispose* except that the application provides the value for the *source_timestamp* that is made available to *DataReader* objects by means of the *source_timestamp* attribute inside the *SampleInfo* (see Section 2.1.2.5, “Subscription Module,” on page 2-55).

The operation must be only called on registered instances. Otherwise the operation will return the error PRECONDITION_NOT_MET.

Possible error codes returned in addition to the standard ones:
PRECONDITION_NOT_MET.

¹³DataReader objects that didn't know the instance will never see it.

2.1.2.4.2.14 *get_liveliness_lost_status*

This operation allows access to the LIVELINESS_LOST communication status. Communication statuses are described in section 2.1.4.1.

2.1.2.4.2.15 *get_offered_deadline_missed_status*

This operation allows access to the OFFERED_DEADLINE_MISSED communication status. Communication statuses are described in section 2.1.4.1.

2.1.2.4.2.16 *get_offered_incompatible_qos_status*

This operation allows access to the OFFERED_INCOMPATIBLE_QOS communication status. Communication statuses are described in section 2.1.4.1.

2.1.2.4.2.17 *get_publication_match_status*

This operation allows access to the PUBLICATION_MATCH_QOS communication status. Communication statuses are described in section 2.1.4.1.

2.1.2.4.2.18 *get_topic*

This operation returns the **Topic** associated with the **DataWriter**. This is the same **Topic** that was used to create the **DataWriter**.

2.1.2.4.2.19 *get_publisher*

This operation returns the **Publisher** to which the **DataWriter** belongs.

2.1.2.4.2.20 *assert_liveliness*

This operation manually asserts the liveliness of the **DataWriter**. This is used in combination with the LIVELINESS QoS policy (see Section 2.1.3, “Supported QoS,” on page 2-89) to indicate to the Service that the entity remains active.

This operation need only be used if the LIVELINESS setting is either MANUAL_BY_PARTICIPANT or MANUAL_BY_TOPIC. Otherwise, it has no effect.

Note – Writing data via the **write** operation on a **DataWriter** asserts liveliness on the **DataWriter** itself and its **DomainParticipant**. Consequently the use of **assert_liveliness** is only needed if the application is not writing data regularly.

Complete details are provided in Section 2.1.3.10, “LIVELINESS,” on page 2-107.

2.1.2.4.2.21 *get_matched_subscription_data*

This operation retrieves information on a subscription that is currently “associated” with the **DataWriter**; that is, a subscription with a matching **Topic** and compatible QoS that the application has not indicated should be “ignored” by means of the **DomainParticipant ignore_subscription** operation.

The *subscription_handle* must correspond to a subscription currently associated with the *DataWriter*, otherwise the operation will fail and return PRECONDITION_NOT_MET. The operation *get_matched_subscriptions* to find the subscriptions that are currently matched with the *DataWriter*.

The operation may also fail if the infrastructure does not hold the information necessary to fill in the *subscription_data*. In this case the operation will return UNSUPPORTED.

2.1.2.4.2.22 *get_matched_subscriptions*

This operation retrieves the list of subscriptions currently "associated" with the *DataWriter*; that is, subscriptions that have a matching *Topic* and compatible QoS that the application has not indicated should be "ignored" by means of the *DomainParticipant ignore_subscription* operation.

The operation may fail if the infrastructure does not locally maintain the connectivity information.

2.1.2.4.3 *PublisherListener Interface*

<i>PublisherListener</i>
no attributes
no operations

Since a *Publisher* is a kind of *Entity*, it has the ability to have a listener associated with it. In this case, the associated listener should be of concrete type *PublisherListener*. The use of this listener and its relationship to changes in the communication status of the *Publisher* is described in Section 2.1.4, "Listeners, Conditions and Wait-sets," on page 2-115.

2.1.2.4.4 *DataWriterListener* Interface

<i>DataWriterListener</i>		
no attributes		
operations		
on_liveliness_lost		void
	the_writer	DataWriter
	status	LivelinessLostStatus
on_offered_deadline_missed	the_writer	DataWriter
	status	OfferedDeadlineMissedStatus
on_offered_incompatible_qos	the_writer	DataWriter
	status	OfferedIncompatibleQosStatus
on_publication_match		
	the_writer	DataWriter
	status	PublicationMatchStatus

Since a *DataWriter* is a kind of *Entity*, it has the ability to have a listener associated with it. In this case, the associated listener should be of concrete type *DataWriterListener*. The use of this listener and its relationship to changes in the communication status of the *DataWriter* is described in Section 2.1.4, “Listeners, Conditions and Wait-sets,” on page 2-115.

2.1.2.4.5 *Concurrency Behavior*

This specification makes no assumption about the way the publishing application is designed. In particular, several *DataWriter* may operate in different threads. If they share the same *Publisher*, the middleware guarantees that its operations are thread-safe. However, it is not required that each requesting thread be treated in isolation from the others (leading e.g., to several isolated sets of coherent changes). If this is the desired behavior, the proper design is to create a *Publisher* for each thread.

2.1.2.5 Subscription Module

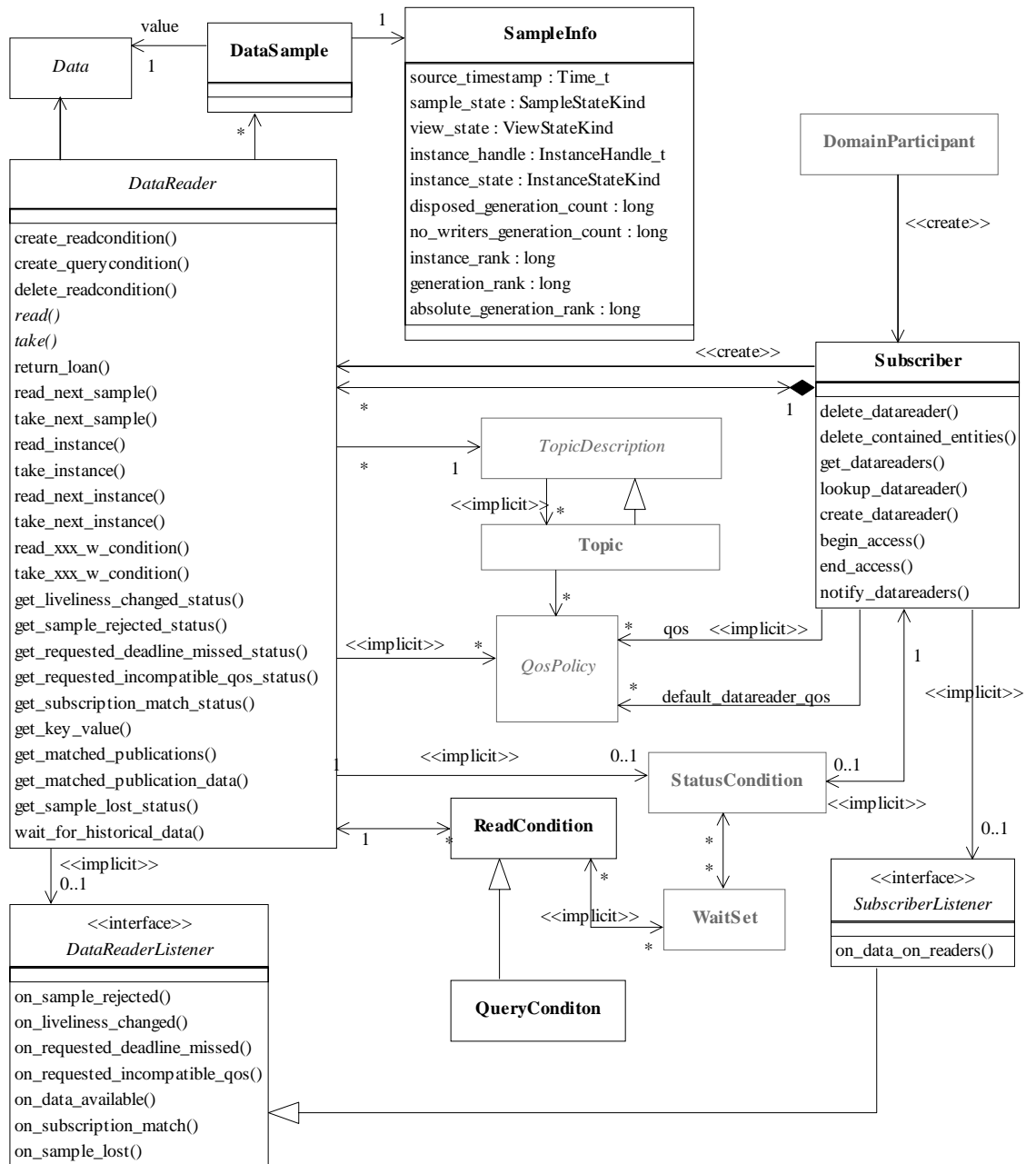


Figure 2-10 Class model of the DCPS Subscription Module

The Subscription Module is comprised of the following classifiers:

- Subscriber
- DataReader
- DataSample

- SampleInfo
- SubscriberListener
- DataReaderListener
- ReadCondition
- QueryCondition

The following section presents how the data can be accessed and introduces the *sample_state*, *view_state*, and *instance_state*. Section 2.1.2.5.2 (Subscriber Class) through Section 2.1.2.5.9 (QueryCondition Class) provide details on each class belonging to this module.

2.1.2.5.1 Access to the data

Data is made available to the application by the following operations on *DataReader* objects: *read*, *read_w_condition*, *take*, and *take_w_condition*. The general semantics of the “*read*” operations is that the application only gets access to the corresponding data¹⁴; the data remains the middleware’s responsibility and can be read again. The semantics of the “*take*” operations is that the application takes full responsibility for the data; that data will no longer be accessible to the *DataReader*. Consequently, it is possible for a *DataReader* to access the same sample multiple times but only if all previous accesses were *read* operations.

Each of these operations returns an ordered collection of *Data* values and associated *SampleInfo* objects. Each data value represents an atom of data information (i.e., a value for one instance). This collection may contain samples related to the same or different instances (identified by the *key*). Multiple samples can refer to the same instance if the settings of the HISTORY QoS (Section 2.1.3.17) allow for it.

The *SampleInfo* contains information pertaining to the associated *Data* value:

- The *sample_state* of the *Data* value (if the sample has already been READ or NOT_READ by that same *DataReader*).
- The *view_state* of the related instance (if the instance is NEW, or NOT_NEW for that *DataReader*) - see below.
- The *instance_state* of the related instance (if the instance is ALIVE, NOT_ALIVE_DISPOSED, or NOT_ALIVE_NO_WRITERS) – see below.
- The values of *disposed_generation_count* and *no_writers_generation_count* for the related instance at the time the sample was received. These counters indicate the number of times the instance had become ALIVE (with *instance_state*= ALIVE) at the time the sample was received – see below.

14. Meaning a precise instance value.

- The *sample_rank* and *generation_rank* of the sample within the returned sequence. These ranks provide a preview of the samples that follow within the sequence returned by the *read* or *take* operations.
- The *absolute_generation_rank* of the sample within the *DataReader*. This rank provides a preview of what is available within the *DataReader*.
- The *source_timestamp* of the sample. This is the time-stamp provided by the *DataWriter* at the time the sample was produced.

For each sample received, the middleware internally maintains a *sample_state* relative to each *DataReader*. The *sample_state* can either be READ or NOT_READ.

- READ indicates that the *DataReader* has already accessed that sample by means of *read*¹⁵.
- NOT_READ indicates that the *DataReader* has not accessed that sample before.

The *sample_state* will, in general, be different for each sample in the collection returned by *read* or *take*.

For each instance the middleware internally maintains an *instance_state*. The *instance_state* can be ALIVE, NOT_ALIVE_DISPOSED or NOT_ALIVE_NO_WRITERS.

- ALIVE indicates that (a) samples have been received for the instance, (b) there are live *DataWriter* entities writing the instance, and (c) the instance has not been explicitly disposed (or else more samples have been received after it was disposed).
- NOT_ALIVE_DISPOSED indicates the instance was explicitly disposed by a *DataWriter* by means of the *dispose* operation.
- NOT_ALIVE_NO_WRITERS indicates the instance has been declared as not-alive by the *DataReader* because it detected that there are no live *DataWriter* entities writing that instance.

The precise behavior events that cause the *instance_state* to change depends on the setting of the OWNERSHIP QoS:

- If OWNERSHIP is set to EXCLUSIVE, then the *instance_state* becomes NOT_ALIVE_DISPOSED only if the *DataWriter* that “owns” the instance¹⁶ explicitly disposes it. The *instance_state* becomes ALIVE again only if the *DataWriter* that owns the instance writes it.
- If OWNERSHIP is set to SHARED, then the *instance_state* becomes NOT_ALIVE_DISPOSED if any *DataWriter* explicitly disposes the instance. The *instance_state* becomes ALIVE as soon as any *DataWriter* writes the instance again.

15. Had the sample been accessed by *take* it would no longer be available to the *DataReader*.

16. The concept of “ownership” is described in Section 2.1.3.8, “OWNERSHIP,” on page 2-105.

The *instance_state* available in the *SampleInfo* is a snapshot of the *instance_state* of the instance at the time the collection was obtained (i.e., at the time *read* or *take* was called). The *instance_state* is therefore the same for all samples in the returned collection that refer to the same instance.

For each instance the middleware internally maintains two counts: the *disposed_generation_count* and *no_writers_generation_count*, relative to each *DataReader*:

- The *disposed_generation_count* and *no_writers_generation_count* are initialized to zero when the *DataReader* first detects the presence of a never-seen-before instance.
- The *disposed_generation_count* is incremented each time the *instance_state* of the corresponding instance changes from NOT_ALIVE_DISPOSED to ALIVE.
- The *no_writers_generation_count* is incremented each time the *instance_state* of the corresponding instance changes from NOT_ALIVE_NO_WRITERS to ALIVE.

The *disposed_generation_count* and *no_writers_generation_count* available in the *SampleInfo* capture a snapshot of the corresponding counters at the time the sample was received.

The *sample_rank* and *generation_rank* available in the *SampleInfo* are computed based solely on the actual samples in the ordered collection returned by *read* or *take*.

- The *sample_rank* indicates the number of samples of the same instance that follow the current one in the collection.
- The *generation_rank* available in the *SampleInfo* indicates the difference in ‘generations’ between the sample (S) and the **Most Recent Sample** of the same instance that appears **In** the returned **Collection** (MRSIC). That is, it counts the number of times the instance transitioned from not-alive to alive in the time from the reception of the S to the reception of MRSIC.

The *generation_rank* is computed using the formula:

$$\text{generation_rank} = (\text{MRSIC.disposed_generation_count} + \text{MRSIC.no_writers_generation_count}) - (\text{S.disposed_generation_count} + \text{S.no_writers_generation_count})$$

The *absolute_generation_rank* available in the *SampleInfo* indicates the difference in ‘generations’ between the sample (S) and the **Most Recent Sample** of the same instance that the middleware has received (MRS). That is, it counts the number of times the instance transitioned from not-alive to alive in the time from the reception of the S to the time when the *read* or *take* was called.

$$\text{absolute_generation_rank} = (\text{MRS.disposed_generation_count} + \text{MRS.no_writers_generation_count}) - (\text{S.disposed_generation_count} + \text{S.no_writers_generation_count})$$

These counters and ranks allow the application to distinguish samples belonging to different ‘generations’ of the instance. Note that it is possible for an instance to transition from not-alive to alive (and back) several times before the application accesses the data by means of *read* or *take*. In this case the returned collection may contain samples that cross generations (i.e., some samples were received before the instance became not-alive, other after the instance re-appeared again). Using the information in the *SampleInfo* the application can anticipate what other information regarding the same instance appears in the returned collection, as well as, in the infrastructure and thus make appropriate decisions. For example, an application desiring to only consider the most current sample for each instance would only look at samples with *sample_rank*==0. Similarly an application desiring to only consider samples that correspond to the latest generation in the collection will only look at samples with *generation_rank*==0. An application desiring only samples pertaining to the latest generation available will ignore samples for which *absolute_generation_rank* != 0. Other application-defined criteria may also be used.

For each instance (identified by the *key*), the middleware internally maintains a *view_state* relative to each *DataReader*. The *view_state* can either be NEW or NOT_NEW.

- NEW indicates that either this is the first time that the *DataReader* has ever accessed samples of that instance, or else that the *DataReader* has accessed previous samples of the instance, but the instance has since been reborn (i.e., become not-alive and then alive again). These two cases are distinguished by examining the *disposed_generation_count* and the *no_writers_generation_count*.
- NOT_NEW indicates that the *DataReader* has already accessed samples of the same instance and that the instance has not been reborn since.

The *view_state* available in the *SampleInfo* is a snapshot of *view_state* of the instance relative to the *DataReader* used to access the samples at the time the collection was obtained (i.e., at the time *read* or *take* was called). The *view_state* is therefore the same for all samples in the returned collection that refer to the same instance.

Once an instance has been detected as not having any “live” writers and all the samples associated with the instance are ‘taken’ from the *DataReader*, the middleware can reclaim all local resources regarding the instance. Future samples will be treated as ‘never seen.’

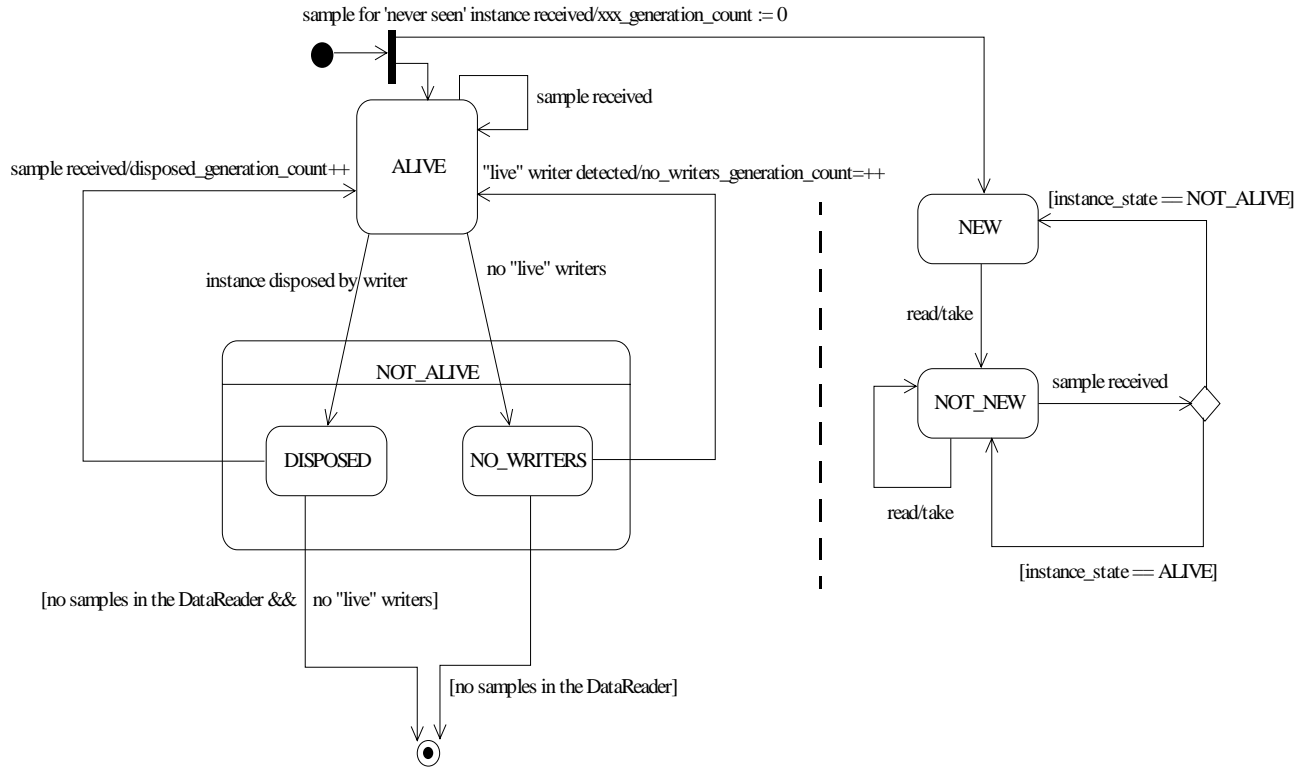


Figure 2-11 Statechart of the *instance_state* and *view_state* for a single instance.

The application accesses data by means of the operations *read* or *take* on the *DataReader*. These operations return an ordered collection of *DataSamples* consisting of a *SampleInfo* part and a *Data* part. The way the middleware builds this collection¹⁷ depends on QoS policies set on the *DataReader* and *Subscriber*, as well as the source timestamp of the samples, and the parameters passed to the *read/take* operations, namely: the desired

- sample states (i.e., READ, NOT_READ, or both).
- view states (i.e., NEW, NOT_NEW, or both).
- instance states (ALIVE, NOT_ALIVE_DISPOSED, NOT_ALIVE_NO_WRITERS, or a combination of these).

The *read* and *take* operations are non-blocking and just deliver what is currently available that matches the specified states.

17. i.e., the data-samples that are parts of the list as well as their order

The *read_w_condition* and *take_w_condition* operations take a *ReadCondition* object as a parameter instead of sample, view, and instance states. The behavior is that the samples returned will only be those for which the condition is TRUE. These operations, in conjunction with *ReadCondition* objects and a *WaitSet*, allow performing waiting reads (see below).

Once the data samples are available to the data readers, they can be read or taken by the application. The basic rule is that the application may do this in any order it wishes. This approach is very flexible and allows the application ultimate control. However, the application must use a specific access pattern in case it needs to retrieve samples in the proper order received, or it wants to access a complete set of coherent changes.

To access data coherently, or in order, the PRESENTATION QoS (explained in Section 2.1.3.5, “PRESENTATION,” on page 2-103) must be set properly and the application must conform to the access pattern described below. Otherwise, the application will still access the data but will not necessarily see all coherent changes together, nor will it see the changes in the proper order.

There is a general pattern that will provide both ordered and coherent access across multiple *DataReader*. This pattern will work for any settings of the PRESENTATION QoS. Simpler patterns may also work for specific settings of the QoS as described below.

1. **General pattern to access samples as a coherent set and/or in order across *DataWriter* entities.** This case applies when PRESENTATION QoS specifies “*access_scope*=GROUP.”
 - Upon notification to the *SubscriberListener* or following the similar *StatusCondition*¹⁸ enabled, the application uses *begin_access* on the *Subscriber* to indicate it will be accessing data through the *Subscriber*.
 - Then it calls get *get_datareaders* on the *Subscriber* to get the list of *DataReader* objects where data samples are available.
 - Following this it calls *read* or *take* on each *DataReader* in the same order returned to access all the relevant changes in the *DataReader*.
 - Once it has called *read* or *take* on all the readers, it calls *end_access*.

Note that if the PRESENTATION QoS policy specifies *ordered_access*=TRUE, then the list of *DataReader* may return the same reader several times. In this manner the correct sample order can be maintained among samples in different *DataReader* objects.

2. **Specialized pattern if no order or coherence needs to be maintained across *DataWriter* entities.** This case applies if PRESENTATION QoS policy specifies *access_scope* something other than GROUP.
 - In this case, it is not required for the application to call *begin_access* and *end_access*. However, doing so is not an error and it will have no effect.

18.I.e.: on *Subscriber* with mask referring to DATA_ON_READERS.

- The application accesses the data by calling *read* or *take*¹⁹ on each *DataReader* in any order it wishes.
 - The application can still call *get_datareaders* to determine which readers have data to be read, but it does not need to read all of them, nor read them in a particular order. Furthermore, the return of *get_datareaders* will be logically a “set” in the sense that the same reader will not appear twice, and the order of the readers returned is not specified.
3. **Specialized pattern if the application accesses the data within the *SubscriberListener*.** This case applies regardless of the PRESENTATION QoS policy when the application accesses the data inside the listener’s implementation of the *on_data_on_readers* operation.
- Similar to the previous case (2 above), it is not required for the application to call *begin_access* and *end_access*, but doing so has no effect.
 - The application can access data by calling *read* or *take*²⁰ on each *DataReader* in any order it wishes.
 - The application can also delegate the accessing of the data to the *DataReaderListener* objects installed on each *DataReader* by calling *notify_datareaders*.
 - Similar to the previous case (2 above), the application can still call *get_datareaders* to determine which readers have data to be read, but it does not need to read all of them, nor read them in a particular order. Furthermore, the return of *get_datareaders* will be logically a ‘set.’

2.1.2.5.2 *Subscriber Class*

A *Subscriber* is the object responsible for the actual reception of the data resulting from its subscriptions.

<i>Subscriber</i>		
no attributes		
operations		
(inherited) <i>get_qos</i>		QosPolicy []
(inherited) <i>set_qos</i>		ReturnCode_t
	<i>qos_list</i>	QosPolicy []
(inherited) <i>get_listener</i>		Listener
(inherited) <i>set_listener</i>		ReturnCode_t
	<i>a_listener</i>	Listener
	<i>mask</i>	StatusKind []
<i>create_datareader</i>		DataReader
	<i>a_topic</i>	TopicDescription

19.Or the variants *read_w_condition* and *take_w_condition*.

20.Or the variants *read_w_condition* and *take_w_condition*.

	qos	QosPolicy []
	a_listener	DataReaderListener
delete_datareader		ReturnCode_t
	a_datareader	DataReader
lookup_datareader		DataReader
	topic_name	string
begin_access		ReturnCode_t
end_access		ReturnCode_t
get_datareaders		ReturnCode_t
	out: readers	DataReader []
	sample_states	SampleStateKind []
	view_states	ViewStateKind []
	instance_states	InstanceStateKind []
notify_datareaders		void
get_sample_lost_status		SampleLostStatus
get_participant		DomainParticipant
delete_contained_entities		ReturnCode_t
set_default_datareader_qos		ReturnCode_t
	qos_list	QosPolicy []
get_default_datareader_qos		void
	out: qos_list	QosPolicy []
copy_from_topic_qos		ReturnCode_t
	inout: datareader_qos	QosPolicy []
	topic_qos	QosPolicy []

A **Subscriber** acts on the behalf of one or several **DataReader** objects that are related to it. When it receives data (from the other parts of the system), it builds the list of concerned **DataReader** objects, and then indicates to the application that data is available, through its listener or by enabling related conditions. The application can access the list of concerned **DataReader** objects through the operation **get_datareaders** and then access the data available though operations on the **DataReader**.

All operations except for the base-class operations **set_qos**, **get_qos**, **set_listener**, **get_listener**, and **enable** may return the value NOT_ENABLED.

2.1.2.5.2.1 set_listener (from Entity)

By virtue of extending **Entity**, a **Subscriber** can be attached to a **Listener** at creation time or later by using the **set_listener** operation. The **Listener** attached must extend **SubscriberListener**. Listeners are described in Section 2.1.4, “Listeners, Conditions and Wait-sets,” on page 2-115.

2.1.2.5.2.2 get_listener (from Entity)

Allows access to the attached **SubscriberListener**.

2.1.2.5.2.3 *set_qos* (from *Entity*)

By virtue of extending *Entity*, a *Subscriber* can be given QoS at creation time or later by using the *set_qos* operation. See Section 2.1.3, “Supported QoS,” on page 2-89 for the list of QoS policies that may be set on a *Subscriber*.

Possible error codes returned in addition to the standard ones: IMMUTABLE_POLICY, INCONSISTENT_POLICY.

2.1.2.5.2.4 *get_qos* (from *Entity*)

Allows access to the values of the QoS.

2.1.2.5.2.5 *create_datareader*

This operation creates a *DataReader*. The returned *DataReader* will be attached and belong to the *Subscriber*.

The *DataReader* returned by the *create_datareader* operation will in fact be a derived class, specific to the data-type associated with the Topic. As described in Section 2.1.2.3.7, for each application-defined type “Foo” there is an implied auto-generated class *FooDataReader* that extends *DataReader* and contains the operations to read data of type “Foo.”

In case of failure, the operation will return a ‘nil’ value (as specified by the platform).

Note that a common application pattern to construct the QoS for the *DataReader* is to:

- Retrieve the QoS policies on the associated *Topic* by means of the *get_qos* operation on the *Topic*.
- Retrieve the default *DataReader* qos by means of the *get_default_datareader_qos* operation on the *Subscriber*.
- Combine those two QoS policies and selectively modify policies as desired.
- Use the resulting QoS policies to construct the *DataReader*.

The special value `DATAREADER_QOS_DEFAULT` can be used to indicate that the *DataReader* should be created with the default *DataReader* QoS set in the factory. The use of this value is equivalent to the application obtaining the default *DataReader* QoS by means of the operation *get_default_datareader_qos* (Section 2.1.2.4.1.14) and using the resulting QoS to create the *DataReader*.

The special value `DATAWRITER_QOS_USE_TOPIC_QOS` can be used to indicate that the *DataReader* should be created with a combination of the default *DataReader* QoS and the *Topic* QoS. The use of this value is equivalent to the application obtaining the default *DataReader* QoS and the *Topic* QoS (by means of the operation *Topic::get_qos*) and then combining these two QoS using the operation *copy_from_topic_qos* whereby any policy that is set on the *Topic* QoS “overrides” the corresponding policy on the default QoS. The resulting QoS is then applied to the creation of the *DataReader*.

2.1.2.5.2.6 *delete_datareader*

This operation deletes a *DataReader* that belongs to the *Subscriber*. If the *DataReader* does not belong to the *Subscriber*, the operation returns the error `PRECONDITION_NOT_MET`.

The deletion of a *DataReader* is not allowed if there are any existing *ReadCondition* or *QueryCondition* objects that are attached to the *DataReader*. If the *delete_datareader* operation is called on a *DataReader* with any of these existing objects attached to it, it will return PRECONDITION_NOT_MET.

The *delete_datareader* operation must be called on the same *Subscriber* object used to create the *DataReader*. If *delete_datareader* is called on a different *Subscriber*, the operation will have no effect and it will return PRECONDITION_NOT_MET.

Possible error codes returned in addition to the standard ones:
PRECONDITION_NOT_MET.

2.1.2.5.2.7 *lookup_datareader*

This operation retrieves a previously-created *DataReader* belonging to the *Subscriber* that is attached to a *Topic* with a matching *topic_name*. If no such *DataReader* exists, the operation will return 'nil.'

If multiple *DataReader* attached to the *Subscriber* satisfy this condition, then the operation will return one of them. It is not specified which one.

The use of this operation on the built-in *Subscriber* allows access to the built-in *DataReader* entities for the built-in topics²¹.

2.1.2.5.2.8 *begin_access*

This operation indicates that the application is about to access the data samples in any of the *DataReader* objects attached to the *Subscriber*.

The application is required to use this operation only if PRESENTATION *QosPolicy* of the *Subscriber* to which the *DataReader* belongs has the *access_scope* set to 'GROUP.'

In the aforementioned case, the operation *begin_access* must be called prior to calling any of the sample-accessing operations, namely: *get_datareaders* on the *Subscriber* and *read*, *take*, *read_w_condition*, *take_w_condition* on any *DataReader*. Otherwise the sample-accessing operations will return the error PRECONDITION_NOT_MET. Once the application has finished accessing the data samples it must call *end_access*.

It is not required for the application to call *begin_access/end_access* if the PRESENTATION *QosPolicy* has the *access_scope* set to something other than 'GROUP.' Calling *begin_access/end_access* in this case is not considered an error and has no effect.

The calls to *begin_access/end_access* may be nested. In that case, the application must call *end_access* as many times as it called *begin_access*.

Possible error codes returned in addition to the standard ones:
PRECONDITION_NOT_MET.

²¹.See Section 2.1.5 for more details on built-in topics.

2.1.2.5.2.9 *end_access*

Indicates that the application has finished accessing the data samples in *DataReader* objects managed by the *Subscriber*.

This operation must be used to ‘close’ a corresponding *begin_access*.

After calling *end_access* the application should no longer access any of the *Data* or *SampleInfo* elements returned from the sample-accessing operations. This call must close a previous call to *begin_access* otherwise the operation will return the error PRECONDITION_NOT_MET.

Possible error codes returned in addition to the standard ones:
PRECONDITION_NOT_MET.

2.1.2.5.2.10 *get_datareaders*

This operation allows the application to access the *DataReader* objects that contain samples with the specified *sample_states*, *view_states*, and *instance_states*.

If the PRESENTATION *QoSPolicy* of the *Subscriber* to which the *DataReader* belongs has the *access_scope* set to ‘GROUP.’ This operation should only be invoked inside a *begin_access/end_access* block. Otherwise it will return the error PRECONDITION_NOT_MET.

Depending on the setting of the PRESENTATION QoS policy (see Section 2.1.3.5, “PRESENTATION,” on page 2-103), the returned collection of *DataReader* objects may be a ‘set’ containing each *DataReader* at most once in no specified order, or a ‘list’ containing each *DataReader* one or more times in a specific order.

1. If PRESENTATION *access_scope* is INSTANCE or TOPIC, the returned collection is a ‘set.’
2. If PRESENTATION *access_scope* is GROUP and *ordered_access* is set to TRUE, then the returned collection is a ‘list.’

This difference is due to the fact that in the second situation it is required to access samples belonging to different *DataReader* objects in a particular order. In this case, the application should process each *DataReader* in the same order it appears in the ‘list’ and read or take exactly one sample from each *DataReader*. The patterns that an application should use to access data is fully described in section 2.1.2.5.1 “Access to the data.”

2.1.2.5.2.11 *notify_datareaders*

This operation invokes the operation *on_data_available* on the *DataReaderListener* objects attached to contained *DataReader* entities containing samples with *SampleState* ‘NOT_READ’ and any *ViewState* and *InstanceState*.

This operation is typically invoked from the *on_data_on_readers* operation in the *SubscriberListener*. That way the *SubscriberListener* can delegate to the *DataReaderListener* objects the handling of the data.

2.1.2.5.2.12 *get_sample_lost_status*

This operation allows access to the SAMPLE_LOST communication status. Communication statuses are described in Section 2.1.4.1, “Communication Status,” on page 2-116.

2.1.2.5.2.13 *get_participant*

This operation returns the *DomainParticipant* to which the *Subscriber* belongs.

2.1.2.5.2.14 *delete_contained_entities*

This operation deletes all the entities that were created by means of the “create” operations on the *Subscriber*. That is, it deletes all contained *DataReader* objects. This pattern is applied recursively. In this manner the operation *delete_contained_entities* on the *Subscriber* will end up deleting all the entities recursively contained in the *Subscriber*, that is also the *QueryCondition* and *ReadCondition* objects belonging to the contained *DataReaders*.

Once *delete_contained_entities* returns successfully, the application may delete the *Subscriber* knowing that it has no contained *DataReader* objects.

2.1.2.5.2.15 *set_default_datareader_qos*

This operation sets a default value of the *DataReader* QoS policies that will be used for newly created *DataReader* entities in the case where the QoS policies are not explicitly specified in the *create_datareader* operation.

This operation will check that the resulting policies are self consistent; if they are not, the operation will have no effect and return INCONSISTENT_POLICY.

2.1.2.5.2.16 *get_default_datareader_qos*

This operation retrieves the default value of the *DataReader* QoS, that is, the QoS policies that will be used for newly created *DataReader* entities in the case where the QoS policies are not explicitly specified in the *create_datareader* operation.

The values retrieved *get_default_datareader_qos* will match the set of values specified on the last successful call to *get_default_datareader_qos*, or else, if the call was never made, the default values listed in the QoS table in “Supported QoS” on page 2-89.

2.1.2.5.2.17 *copy_from_topic_qos*

This operation copies the policies in the *topic_qos* to the corresponding policies in the *datareader_qos* (replacing values in the *datareader_qos*, if present).

This is a “convenience” operation most useful in combination with the operations *get_default_datareader_qos* and *Topic::get_qos*. The operation *copy_from_topic_qos* can be used to merge the *DataReader* default QoS policies with the corresponding ones on the *Topic*. The resulting QoS can then be used to create a new *DataReader*, or set its QoS.

This operation does not check the resulting *datawriter_qos* for consistency. This is because the ‘merged’ *datareader_qos* may not be the final one, as the application can still modify some policies prior to applying the policies to the *DataReader*.

2.1.2.5.3 *DataReader* Class

A *DataReader* allows the application (1) to declare the data it wishes to receive (i.e., make a subscription) and (2) to access the data received by the attached *Subscriber*.

<i>DataReader</i>		
no attributes		
operations		
(inherited) get_qos		QosPolicy []
(inherited) set_qos		ReturnCode_t
	qos_list	QosPolicy []
(inherited) get_listener		Listener
(inherited) set_listener		ReturnCode_t
	a_listener	Listener
	mask	StatusKind []
read		ReturnCode_t
	inout: data_values	Data []
	inout: sample_infos	SampleInfo []
	max_samples	long
	sample_states	SampleStateKind []
	view_states	ViewStateKind []
	instance_states	InstanceStateKind []
take		ReturnCode_t
	inout: data_values	Data []
	inout: sample_infos	SampleInfo []
	max_samples	long
	sample_states	SampleStateKind []
	view_states	ViewStateKind []
	instance_states	InstanceStateKind []
read_w_condition		ReturnCode_t
	inout: data_values	Data []
	inout: sample_infos	SampleInfo []
	max_samples	long
	a_condition	ReadCondition
take_w_condition		ReturnCode_t
	inout: data_values	Data []
	inout: sample_infos	SampleInfo []
	max_samples	long
	a_condition	ReadCondition
read_next_sample		ReturnCode_t

	inout: data_value	Data
	inout: sample_info	SampleInfo
take_next_sample		ReturnCode_t
	inout: data_value	Data
	inout: sample_info	SampleInfo
read_instance		ReturnCode_t
	inout: data_values	Data []
	inout: sample_infos	SampleInfo []
	max_samples	long
	a_handle	InstanceHandle_t
	sample_states	SampleStateKind []
	view_states	ViewStateKind []
	instance_states	InstanceStateKind []
take_instance		ReturnCode_t
	inout: data_values	Data []
	inout: sample_infos	SampleInfo []
	max_samples	long
	a_handle	InstanceHandle_t
	sample_states	SampleStateKind []
	view_states	ViewStateKind []
	instance_states	InstanceStateKind []
read_next_instance		ReturnCode_t
	inout: data_values	Data []
	inout: sample_infos	SampleInfo []
	max_samples	long
	previous_handle	InstanceHandle_t
	sample_states	SampleStateKind []
	view_states	ViewStateKind []
	instance_states	InstanceStateKind []
take_next_instance		ReturnCode_t
	inout: data_values	Data []
	inout: sample_infos	SampleInfo []
	max_samples	long
	previous_handle	InstanceHandle_t
	sample_states	SampleStateKind []
	view_states	ViewStateKind []
	instance_states	InstanceStateKind []
read_next_instance_w_condition		ReturnCode_t
	inout: data_values	Data []
	inout: sample_infos	SampleInfo []
	max_samples	long
	previous_handle	InstanceHandle_t
	a_condition	ReadCondition

take_next_instance_w_condition		ReturnCode_t
	inout: data_values	Data []
	inout: sample_infos	SampleInfo []
	max_samples	long
	previous_handle	InstanceHandle_t
	a_condition	ReadCondition
return_loan		ReturnCode_t
	inout: data_values	Data []
	inout: sample_infos	SampleInfo []
get_key_value		ReturnCode_t
	inout: key_holder	Data
	handle	InstanceHandle_t
create_readcondition		ReadCondition
	sample_states	SampleStateKind []
	view_states	ViewStateKind []
	instance_states	InstanceStateKind []
create_querycondition		QueryCondition
	sample_states	SampleStateKind []
	view_states	ViewStateKind []
	instance_states	InstanceStateKind []
	query_expression	string
	query_parameters	string []
delete_readcondition		ReturnCode_t
	a_condition	ReadCondition
get_liveliness_changed_status		LivelinessChangedStatus
get_requested_deadline_missed_status		RequestedDeadlineMissedStatus
get_requested_incompatible_qos_status		RequestedIncompatibleQosStatus
get_sample_rejected_status		SampleRejectedStatus
get_subscription_match_status		SubscriptionMatchStatus
get_topicedescription		TopicDescription
get_subscriber		Subscriber
delete_contained_entities		ReturnCode_t
wait_for_historical_data		ReturnCode_t
	max_wait	Duration_t
get_matched_publication_data		ReturnCode_t
	inout: publication_data	PublicationBuiltinTopicData
	publication_handle	InstanceHandle_t
get_matched_publications		ReturnCode_t
	inout: publication_handles	InstanceHandle_t []

A *DataReader* refers to exactly one *TopicDescription* (either a *Topic*, a *ContentFilteredTopic* or a *MultiTopic*) that identifies the data to be read. The subscription has a unique resulting type. The data-reader may give access to several instances of the resulting type, which can be distinguished from each other by their *key* (as described in Section 2.1.1.2.2).

DataReader is an abstract class. It must be specialized for each particular application data-type as shown in Figure 2-8. The additional methods that must be defined in the auto-generated class for a hypothetical application type “Foo” are shown in the table below:

<i>FooDataReader</i>		
no attributes		
operations		
read		ReturnCode_t
	inout: data_values	Foo []
	inout: sample_infos	SampleInfo []
	max_samples	long
	sample_states	SampleStateKind []
	view_states	ViewStateKind []
	instance_states	InstanceStateKind []
take		ReturnCode_t
	inout: data_values	Foo []
	inout: sample_infos	SampleInfo []
	max_samples	long
	sample_states	SampleStateKind []
	view_states	ViewStateKind []
	instance_states	InstanceStateKind []
read_w_condition		ReturnCode_t
	inout: data_values	Foo []
	inout: sample_info	SampleInfo []
	max_samples	long
	a_condition	ReadCondition
take_w_condition		ReturnCode_t
	inout: data_values	Foo []
	inout: sample_infos	SampleInfo []
	max_samples	long
	a_condition	ReadCondition
read_next_sample		ReturnCode_t
	inout: data_value	Foo
	inout: sample_info	SampleInfo
take_next_sample		ReturnCode_t
	inout: data_value	Foo
	inout: sample_info	SampleInfo

read_instance		ReturnCode_t
	inout: data_values	Foo []
	inout: sample_infos	SampleInfo []
	max_samples	long
	a_handle	InstanceHandle_t
	sample_states	SampleStateKind []
	view_states	ViewStateKind []
	instance_states	InstanceStateKind []
take_instance		ReturnCode_t
	inout: data_values	Foo []
	inout: sample_infos	SampleInfo []
	max_samples	long
	a_handle	InstanceHandle_t
	sample_states	SampleStateKind []
	view_states	ViewStateKind []
	instance_states	InstanceStateKind []
read_next_instance		ReturnCode_t
	inout: data_values	Foo []
	inout: sample_infos	SampleInfo []
	max_samples	long
	previous_handle	InstanceHandle_t
	sample_states	SampleStateKind []
	view_states	ViewStateKind []
	instance_states	InstanceStateKind []
take_next_instance		ReturnCode_t
	inout: data_values	Foo []
	inout: sample_infos	SampleInfo []
	max_samples	long
	previous_handle	InstanceHandle_t
	sample_states	SampleStateKind []
	view_states	ViewStateKind []
	instance_states	InstanceStateKind []
read_next_instance_w_condition		ReturnCode_t
	inout: data_values	Foo []
	inout: sample_infos	SampleInfo []
	max_samples	long
	previous_handle	InstanceHandle_t
	a_condition	ReadCondition
take_next_instance_w_condition		ReturnCode_t
	inout: data_values	Foo []
	inout: sample_infos	SampleInfo []
	max_samples	long

	previous_handle	InstanceHandle_t
	a_condition	ReadCondition
return_loan		ReturnCode_t
	inout: data_values	Foo []
	inout: sample_info	SampleInfo []
get_key_value		ReturnCode_t
	inout: key_holder	Foo
	handle	InstanceHandle_t

All operations except for the base-class operations *set_qos*, *get_qos*, *set_listener*, *get_listener*, and *enable* may return the error NOT_ENABLED.

All sample-accessing operations, namely all variants of *read*, *take* may return the error PRECONDITION_NOT_MET. The circumstances that result on this are described in Section 2.1.2.5.2.8.

The following sections give details on all the operations.

2.1.2.5.3.1 set_listener (from Entity)

By virtue of extending *Entity*, a *DataReader* can be attached to a *Listener* at creation time or later by using the *set_listener* operation. The *Listener* attached must extend *DataReaderListener*. Listeners are described in “Listeners, Conditions and Wait-sets” on page 2-115.

2.1.2.5.3.2 get_listener (from Entity)

Allows access to the attached *DataReaderListener*.

2.1.2.5.3.3 set_qos (from Entity)

By virtue of extending *Entity*, a *DataReader* can be given QoS at creation time or later by using the *set_qos* operation. See “Supported QoS” on page 2-89 for the list of QoS policies that may set on a *DataReader*.

Possible error codes returned in addition to the standard ones: IMMUTABLE_POLICY, INCONSISTENT_POLICY.

2.1.2.5.3.4 get_qos (from Entity)

Allows access to the values of the QoS.

2.1.2.5.3.5 create_readcondition

This operation creates a *ReadCondition*. The returned *ReadCondition* will be attached and belong to the *DataReader*.

In case of failure, the operation will return a ‘nil’ value (as specified by the platform).

2.1.2.5.3.6 *create_querycondition*

This operation creates a **QueryCondition**. The returned **QueryCondition** will be attached and belong to the **DataReader**.

The syntax of the **query_expression** and **query_parameters** parameters is described in Appendix B.

In case of failure, the operation will return a 'nil' value (as specified by the platform).

2.1.2.5.3.7 *delete_readcondition*

This operation deletes a **ReadCondition** attached to the **DataReader**. Since **QueryCondition** specializes **ReadCondition** it can also be used to delete a **QueryCondition**. If the **ReadCondition** is not attached to the **DataReader**, the operation will return the error PRECONDITION_NOT_MET.

Possible error codes returned in addition to the standard ones:
PRECONDITION_NOT_MET.

2.1.2.5.3.8 *read*

This operation accesses a collection of **Data** values from the **DataReader**. The size of the returned collection will be limited to the specified *max_samples*. The properties of the *data_values* collection and the setting of the PRESENTATION QoS policy (see Section 2.1.3.5) may impose further limits on the size of the returned 'list.'

1. If PRESENTATION **access_scope** is INSTANCE, then the returned collection is a 'list' where samples belonging to the same data-instance are consecutive.
2. If PRESENTATION **access_scope** is TOPIC and **ordered_access** is set to FALSE, then the returned collection is a 'list' where samples belonging to the same data-instance are consecutive.
3. If PRESENTATION **access_scope** is TOPIC and **ordered_access** is set to TRUE, then the returned collection is a 'list' where samples belonging to the same instance may or may not be consecutive. To preserve order it may be necessary to mix samples from different instances.
4. If PRESENTATION **access_scope** is GROUP and **ordered_access** is set to FALSE, then the returned collection is a 'list' where samples belonging to the same data instance are consecutive.
5. If PRESENTATION **access_scope** is GROUP and **ordered_access** is set to TRUE, then the returned collection contains at most one sample. The difference in this case is due to the fact that it is required that the application is able to read samples belonging to different **DataReader** objects in a specific order.

In any case, the relative order between the samples of one instance is consistent with the DESTINATION_ORDER **QosPolicy**:

- If DESTINATION_ORDER is BY_RECEPTION_TIMESTAMP, samples belonging to the same instances will appear in the relative order in which they were received (FIFO, earlier samples ahead of the later samples).

- If `DESTINATION_ORDER` is `BY_SOURCE_TIMESTAMP`, samples belonging to the same instances will appear in the relative order implied by the `source_timestamp` (FIFO, smaller values of `source_timestamp` ahead of the larger values).

In addition to the collection of samples, the **read** operation also uses a collection of **SampleInfo** structures (`sample_infos`), see Section 2.1.2.5.5.

The initial (input) properties of the `data_values` and `sample_infos` collections will determine the precise behavior of **read** operation. For the purposes of this description the collections are modeled as having three properties: the current-length (`len`), the maximum length (`max_len`), and whether the collection container owns the memory of the elements within (`owns`). PSM mappings that do not provide these facilities may need to change the signature of the **read** operation slightly to compensate for it.

The initial (input) values of the `len`, `max_len`, and `owns` properties for the `data_values` and `sample_infos` collections govern the behavior of the **read** operation as specified by the following rules:

1. The values of `len`, `max_len`, and `owns` for the two collections must be identical. Otherwise **read** will and return `PRECONDITION_NOT_MET`.
2. On successful output, the values of `len`, `max_len`, and `owns` will be the same for both collections.
3. If the input `max_len==0`, then the `data_values` and `sample_infos` collections will be filled with elements that are ‘loaned’ by the **DataReader**. On output, `owns` will be `FALSE`, `len` will be set to the number of values returned, and `max_len` will be set to a value verifying `max_len >= len`. The use of this variant allows for zero-copy²² access to the data and the application will need to “return the loan” to the **DataWriter** using the **return_loan** operation (see Section 2.1.2.5.3.20).
4. If the input `max_len>0` and the input `owns==FALSE`, then the **read** operation will fail and return `PRECONDITION_NOT_MET`. This avoids the potential hard-to-detect memory leaks caused by an application forgetting to “return the loan.”
5. If input `max_len>0` and the input `owns==TRUE`, then the **read** operation will copy the **Data** values and **SampleInfo** values into the elements already inside the collections. On output, `owns` will be `TRUE`, `len` will be set to the number of values copied, and `max_len` will remain unchanged. The use of this variant forces a copy but the application can control where the copy is placed and the application will not need to “return the loan.” The number of samples copied depends on the relative values of `max_len` and `max_samples`:
 - If `max_samples = LENGTH_UNLIMITED`, then at most `max_len` values will be copied. The use of this variant lets the application limit the number of samples returned to what the sequence can accommodate.

22.Assuming the implementation supports it.

- If *max_samples* \leq *max_len*, then at most *max_samples* values will be copied. The use of this variant lets the application limit the number of samples returned to fewer than what the sequence can accommodate.
- If *max_samples* $>$ *max_len*, then the **read** operation will fail and return `PRECONDITION_NOT_MET`. This avoids the potential confusion where the application expects to be able to access up to *max_samples*, but that number can never be returned, even if they are available in the **DataReader**, because the output sequence cannot accommodate them.

As described above, upon return the *data_values* and *sample_infos* collections may contain elements “loaned” from the **DataReader**. If this is the case, the application will need to use the **return_loan** operation (see Section 2.1.2.5.3.20) to return the “loan” once it is no longer using the **Data** in the collection. Upon return from **return_loan**, the collection will have *max_len*=0 and *owns*=FALSE.

The application can determine whether it is necessary to “return the loan” or not based on how the state of the collections when the read operation was called, or by accessing the ‘owns’ property. However, in many cases it may be simpler to always call **return_loan**, as this operation is harmless (i.e., leaves all elements unchanged) if the collection does not have a loan.

To avoid potential memory leaks, the implementation of the **Data** and **SampleInfo** collections should disallow changing the length of a collection for which *owns*=FALSE. Furthermore, deleting a collection for which *owns*=FALSE should be considered an error.

On output, the collection of **Data** values and the collection of **SampleInfo** structures are of the same length and are in a one-to-one correspondence. Each **SampleInfo** provides information, such as the *source_timestamp*, the *sample_state*, *view_state*, and *instance_state*, etc., about the corresponding sample.

Some elements in the returned collection may not have valid data. If the *instance_state* in the **SampleInfo** is `NOT_ALIVE_DISPOSED` or `NOT_ALIVE_NO_WRITERS`, then the last sample for that instance in the collection, that is, the one whose **SampleInfo** has *sample_rank*=0 does not contain valid data. Samples that contain no data do not count towards the limits imposed by the `RESOURCE_LIMITS` QoS policy.

The act of reading a sample sets its *sample_state* to `READ`. If the sample belongs to the most recent generation of the instance, it will also set the *view_state* of the instance to `NOT_NEW`. It will not affect the *instance_state* of the instance.

This operation must be provided on the specialized class that is generated for the particular application data-type that is being read.

If the **DataReader** has no samples that meet the constraints, the return value will be `NO_DATA`.

2.1.2.5.3.9 take

This operation accesses a collection of data-samples from the *DataReader* and a corresponding collection of *SampleInfo* structures. The operation will return either a ‘list’ of samples or else a single sample. This is controlled by the PRESENTATION *QosPolicy* using the same logic as for the *read* operation (see Section 2.1.2.5.3.8).

The act of taking a sample removes it from the *DataReader* so it cannot be ‘read’ or ‘taken’ again. If the sample belongs to the most recent generation of the instance, it will also set the *view_state* of the instance to NOT_NEW. It will not affect the *instance_state* of the instance.

The behavior of the *take* operation follows the same rules as the *read* operation regarding the pre-conditions and post-conditions for the *data_values* and *sample_infos* collections. Similar to *read*, the *take* operation may ‘loan’ elements to the output collections that must then be returned by means of *return_loan*. The only difference with *read* is that, as stated, the samples returned by take will no longer be accessible to successive calls to *read* or *take*.

Similar to *read*, this operation must be provided on the specialized class that is generated for the particular application data-type that is being taken.

If the *DataReader* has no samples that meet the constraints, the return value will be NO_DATA.

2.1.2.5.3.10 read_w_condition

This operation accesses via ‘read’ the samples that match the criteria specified in the *ReadCondition*. This operation is especially useful in combination with *QueryCondition* to filter data samples based on the content.

The specified *ReadCondition* must be attached to the *DataReader*; otherwise the operation will fail and return PRECONDITION_NOT_MET.

In case the *ReadCondition* is a ‘plain’ *ReadCondition* and not the specialized *QueryCondition*, the operation is equivalent to calling read and passing as *sample_states*, *view_states*, and *instance_states* the value of the corresponding attributes in the *read_condition*. Using this operation the application can avoid repeating the same parameters specified when creating the *ReadCondition*.

The samples are accessed with the same semantics as the *read* operation.

Similar to *read*, this operation must be provided on the specialized class that is generated for the particular application data-type that is being read.

If the *DataReader* has no samples that meet the constraints, the return value will be NO_DATA.

2.1.2.5.3.11 take_w_condition

This operation is analogous to *read_w_condition* except it accesses samples via the ‘take’ operation.

The specified **ReadCondition** must be attached to the **DataReader**; otherwise the operation will fail and return PRECONDITION_NOT_MET.

The samples are accessed with the same semantics as the **take** operation.

This operation is especially useful in combination with **QueryCondition** to filter data samples based on the content.

Similar to **take**, this operation must be provided on the specialized class that is generated for the particular application data-type that is being taken.

If the **DataReader** has no samples that meet the constraints, the return value will be NO_DATA.

2.1.2.5.3.12 read_next_sample

This operation copies the next, non-previously accessed **Data** value from the **DataReader**; the operation also copies the corresponding **SampleInfo**. The implied order among the samples stored in the **DataReader** is the same as for the **read** operation (section 2.1.2.5.3.8).

The **read_next_sample** operation is semantically equivalent to the **read** operation where the input **Data** sequence has *max_len*=1, the *sample_states*=NOT_READ, the *view_states*=ANY_VIEW_STATE, and the *instance_states*=ANY_INSTANCE_STATE.

The **read_next_sample** operation provides a simplified API to 'read' samples avoiding the need for the application to manage sequences and specify states.

If there is no unread data in the **DataReader**, the operation will return NO_DATA and nothing is copied.

2.1.2.5.3.13 take_next_sample

This operation copies the next, non-previously accessed **Data** value from the **DataReader** and 'removes' it from the **DataReader** so it is no longer accessible. The operation also copies the corresponding **SampleInfo**. This operation is analogous to the **read_next_sample** except for the fact that the sample is 'removed' from the **DataReader**.

The **take_next_sample** operation is semantically equivalent to the **take** operation where the input sequence has *max_len*=1, the *sample_states*=NOT_READ, the *view_states*=ANY_VIEW_STATE, and the *instance_states*=ANY_INSTANCE_STATE.

This operation provides a simplified API to 'take' samples avoiding the need for the application to manage sequences and specify states.

If there is no unread data in the **DataReader**, the operation will return NO_DATA and nothing is copied.

2.1.2.5.3.14 read_instance

This operation accesses a collection of **Data** values from the **DataReader**. The behavior is identical to **read** except that all samples returned belong to the single specified instance whose handle is *a_handle*.

Upon successful return, the **Data** collection will contain samples all belonging to the same instance. The corresponding **SampleInfo** verifies *instance_handle* == *a_handle*.

The semantics are the same as for the **read** operation, except in building the collection the **DataReader** will check that the sample belongs to the specified instance, otherwise it will not place the sample in the returned collection.

The behavior of the **read_instance** operation follows the same rules as the **read** operation regarding the pre-conditions and post-conditions for the *data_values* and *sample_infos* collections. Similar to **read**, the **read_instance** operation may 'loan' elements to the output collections which must then be returned by means of **return_loan**.

Similar to **read**, this operation must be provided on the specialized class that is generated for the particular application data-type that is being taken.

If the **DataReader** has no samples that meet the constraints, the return value will be NO_DATA.

2.1.2.5.3.15 take_instance

This operation accesses a collection of **Data** values from the **DataReader**. The behavior is identical to **take** except that all samples returned belong to the single specified instance whose handle is *a_handle*.

The semantics are the same as for the **take** operation, except in building the collection the **DataReader** will check that the sample belongs to the specified instance, otherwise it will not place the sample in the returned collection.

The behavior of the **take_instance** operation follows the same rules as the **read** operation regarding the pre-conditions and post-conditions for the *data_values* and *sample_infos* collections. Similar to **read**, the **take_instance** operation may 'loan' elements to the output collections that must then be returned by means of **return_loan**.

Similar to **read**, this operation must be provided on the specialized class that is generated for the particular application data-type that is being taken.

If the **DataReader** has no samples that meet the constraints, the return value will be NO_DATA.

2.1.2.5.3.16 read_next_instance

This operation accesses a collection of **Data** values from the **DataReader** where all the samples belong to a single instance. The behavior is similar to **read_instance** except that the actual instance is not directly specified. Rather the samples will all belong to the 'next' instance with *instance_handle* 'greater'²³ than the specified *previous_handle* that has available samples.

This operation implies the existence of some total order 'greater than' relationship between the instance handles. The specifics of this relationship are not important and are implementation specific. The important thing is that, according to the middleware, all

²³according to some service-defined order.

instances are ordered relative to each other. This ordering is between the instances, that is, it does not depend on the actual samples received or available. For the purposes of this explanation it is ‘as if’ each instance handle was represented as a unique integer.

The behavior of *read_next_instance* is ‘as if’ the *DataReader* invoked *read_instance* passing the smallest *instance_handle* among all the ones that (a) are greater than *previous_handle* and (b) have available samples (i.e., samples that meet the constraints imposed by the specified states).

The special value `HANDLE_NIL` is guaranteed to be ‘less than’ any valid *instance_handle*. So the use of the parameter value *previous_handle*==`HANDLE_NIL` will return the samples for the instance that has the smallest *instance_handle* among all the instances that contain available samples.

The behavior of the *read_instance* operation follows the same rules as the *read* operation regarding the pre-conditions and post-conditions for the *data_values* and *sample_infos* collections. Similar to *read*, the *read_instance* operation may ‘loan’ elements to the output collections that must then be returned by means of *return_loan*.

The operation *read_next_instance* is intended to be used in an application-driven iteration where the application starts by passing *previous_handle*==`HANDLE_NIL`, examines the samples returned, and then uses the *instance_handle* returned in the *SampleInfo* as the value of the *previous_handle* argument to the next call to *read_next_instance*. The iteration continues until *read_next_instance* returns the value `NO_DATA`.

The behavior of the *read_next_instance* operation follows the same rules as the *read* operation regarding the pre-conditions and post-conditions for the *data_values* and *sample_infos* collections. Similar to *read*, the *read_next_instance* operation may ‘loan’ elements to the output collections that must then be returned by means of *return_loan*.

Similar to *read*, this operation must be provided on the specialized class that is generated for the particular application data-type that is being taken.

If the *DataReader* has no samples that meet the constraints, the return value will be `NO_DATA`.

2.1.2.5.3.17 *take_next_instance*

This operation accesses a collection of *Data* values from the *DataReader* and ‘removes’ them from the *DataReader*.

This operation has the same behavior as *read_next_instance* except that the samples are ‘taken’ from the *DataReader* such that they are no longer accessible via subsequent ‘read’ or ‘take’ operations.

The behavior of the *take_next_instance* operation follows the same rules as the *read* operation regarding the pre-conditions and post-conditions for the *data_values* and *sample_infos* collections. Similar to *read*, the *take_next_instance* operation may ‘loan’ elements to the output collections that must then be returned by means of *return_loan*.

Similar to *read*, this operation must be provided on the specialized class that is generated for the particular application data-type that is being taken.

If the **DataReader** has no samples that meet the constraints, the return value will be NO_DATA.

2.1.2.5.3.18 *read_next_instance_w_condition*

This operation accesses a collection of **Data** values from the **DataReader**. The behavior is identical to **read_next_instance** except that all samples returned satisfy the specified condition. In other words, on success all returned samples belong to the same instance, and the instance is the instance with ‘smallest’ **instance_handle** among the ones that verify (a) **instance_handle** \geq *previous_handle* and (b) have samples for which the specified **ReadCondition** evaluates to TRUE.

The behavior of the **read_next_instance_w_condition** operation follows the same rules as the **read** operation regarding the pre-conditions and post-conditions for the *data_values* and *sample_infos* collections. Similar to **read**, the **read_next_instance_w_condition** operation may ‘loan’ elements to the output collections that must then be returned by means of **return_loan**.

Similar to **read**, this operation must be provided on the specialized class that is generated for the particular application data-type that is being taken.

If the **DataReader** has no samples that meet the constraints, the return value will be NO_DATA.

2.1.2.5.3.19 *take_next_instance_w_condition*

This operation accesses a collection of **Data** values from the **DataReader** and ‘removes’ them from the **DataReader**.

This operation has the same behavior as **read_next_instance_w_condition** except that the samples are ‘taken’ from the **DataReader** such that they are no longer accessible via subsequent ‘read’ or ‘take’ operations.

The behavior of the **take_next_instance_w_condition** operation follows the same rules as the **read** operation regarding the pre-conditions and post-conditions for the *data_values* and *sample_infos* collections. Similar to **read**, the **take_next_instance_w_condition** operation may ‘loan’ elements to the output collections, which must then be returned by means of **return_loan**.

Similar to **read**, this operation must be provided on the specialized class that is generated for the particular application data-type that is being taken.

If the **DataReader** has no samples that meet the constraints, the return value will be NO_DATA.

2.1.2.5.3.20 *return_loan*

This operation indicates to the **DataReader** that the application is done accessing the collection of *data_values* and *sample_infos* obtained by some earlier invocation of **read** or **take** on the **DataReader**.

The *data_values* and *sample_infos* must belong to a single related ‘pair;’ that is, they should correspond to a pair returned from a single call to *read* or *take*. The *data_values* and *sample_infos* must also have been obtained from the same *DataReader* to which they are returned. If either of these conditions is not met, the operation will fail and return PRECONDITION_NOT_MET.

The operation *return_loan* allows implementations of the *read* and *take* operations to “loan” buffers from the *DataReader* to the application and in this manner provide “zero-copy” access to the data. During the loan, the *DataReader* will guarantee that the data and sample-information are not modified.

It is not necessary for an application to return the loans immediately after the *read* or *take* calls. However, as these buffers correspond to internal resources inside the *DataReader*, the application should not retain them indefinitely.

The use of the *return_loan* operation is only necessary if the *read* or *take* calls “loaned” buffers to the application. As described in Section 2.1.2.5.3.8 this only occurs if the *data_values* and *sample_infos* collections had *max_len=0* at the time *read* or *take* was called. The application may also examine the ‘owns’ property of the collection to determine where there is an outstanding loan. However, calling *return_loan* on a collection that does not have a loan is safe and has no side effects.

If the collections had a loan, upon return from *return_loan* the collections will have *max_len=0*.

Similar to *read*, this operation must be provided on the specialized class that is generated for the particular application data-type that is being taken.

2.1.2.5.3.21 get_liveliness_changed_status

This operation allows access to the LIVELINESS_CHANGED communication status. Communication statuses are described in section 2.1.4.1.

2.1.2.5.3.22 get_requested_deadline_missed_status

This operation allows access to the REQUESTED_DEADLINE_MISSED communication status. Communication statuses are described in section 2.1.4.1.

2.1.2.5.3.23 get_requested_incompatible_qos_status

This operation allows access to the REQUESTED_INCOMPATIBLE_QOS communication status. Communication statuses are described in section 2.1.4.1.

2.1.2.5.3.24 get_sample_rejected_status

This operation allows access to the SAMPLE_REJECTED_STATUS communication status. Communication statuses are described in section 2.1.4.1.

2.1.2.5.3.25 get_subscription_match_status

This operation allows access to the SUBSCRIPTION_MATCH_STATUS communication status. Communication statuses are described in section 2.1.4.1.

2.1.2.5.3.26 *get_topicdescription*

This operation returns the **TopicDescription** associated with the **DataReader**. This is the same **TopicDescription** that was used to create the **DataReader**.

2.1.2.5.3.27 *get_subscriber*

This operation returns the **Subscriber** to which the **DataReader** belongs.

2.1.2.5.3.28 *get_key_value*

This operation can be used to retrieve the instance key that corresponds to an **instance_handle**. The operation will only fill the fields that form the key inside the **key_holder** instance.

2.1.2.5.3.29 *delete_contained_entities*

This operation deletes all the entities that were created by means of the “create” operations on the **DataReader**. That is, it deletes all contained **ReadCondition** and **QueryCondition** objects.

Once **delete_contained_entities** returns successfully, the application may delete the **DataReader** knowing that it has no contained **ReadCondition** and **QueryCondition** objects.

2.1.2.5.3.30 *wait_for_historical_data*

This operation is intended only for **DataReader** entities that have a non-VOLATILE PERSISTENCE QoS kind.

As soon as an application enables a non-VOLATILE **DataReader** it will start receiving both “historical” data, i.e., the data that was written prior to the time the **DataReader** joined the domain, as well as any new data written by the **DataWriter** entities. There are situations where the application logic may require the application to wait until all “historical” data is received. This is the purpose of the **wait_for_historical_data** operation.

The operation **wait_for_historical_data** blocks the calling thread until either all “historical” data is received, or else the duration specified by the **max_wait** parameter elapses, whichever happens first. A return value of OK indicates that all the “historical” data was received; a return value of TIMEOUT indicates that **max_wait** elapsed before all the data was received.

2.1.2.5.3.31 *get_matched_publication_data*

This operation retrieves information on a publication that is currently “associated” with the **DataReader**; that is, a publication with a matching **Topic** and compatible QoS that the application has not indicated should be “ignored” by means of the **DomainParticipant ignore_publication** operation.

The **publication_handle** must correspond to a publication currently associated with the **DataReader**; otherwise the operation will fail and return PRECONDITION_NOT_MET. The operation **get_matched_publications** to find the publications that are currently matched with the **DataReader**.

The operation may also fail if the infrastructure does not hold the information necessary to fill in the *publication_data*. In this case the operation will return UNSUPPORTED.

2.1.2.5.3.32 *get_matched_publications*

This operation retrieves the list of publications currently “associated” with the *DataReader*; that is, publications that have a matching *Topic* and compatible QoS that the application has not indicated should be “ignored” by means of the *DomainParticipant ignore_publication* operation.

The operation may fail if the infrastructure does not locally maintain the connectivity information.

2.1.2.5.4 *DataSample Class*

A *DataSample* represents an atom of data information (i.e., one value for one instance) as returned by *DataReader's* read/take operations. It consists of two parts: A *SampleInfo* and the *Data*.

2.1.2.5.5 *SampleInfo Class*

<i>SampleInfo</i>	
attributes	
sample_state	SampleStateKind
view_state	ViewStateKind
instance_state	InstanceStateKind
disposed_generation_count	long
no_writers_generation_count	long
sample_rank	long
generation_rank	long
absolute_generation_rank	long
source_timestamp	Time_t
instance_handle	InstanceHandle_t
No operations	

SampleInfo is the information that accompanies each sample that is ‘read’ or ‘taken.’ It contains the following information:

- The *sample_state* (READ or NOT_READ) that indicates whether or not the corresponding data sample has already been read.
- The *view_state*, (NEW, or NOT_NEW) that indicates whether the *DataReader* has already seen samples for the most-current generation of the related instance.
- The *instance_state* (ALIVE, NOT_ALIVE_DISPOSED, or NOT_ALIVE_NO_WRITERS) that indicates whether the instance is currently in existence or, if it has been disposed, the reason why it was disposed:
 - ALIVE if this instance is currently in existence.
 - NOT_ALIVE_DISPOSED if this instance was disposed by the *DataWriter*.

- **NOT_ALIVE_NO_WRITERS** if the instance has been disposed by the *DataReader* because none of the *DataWriter* objects currently “alive” (according to the LIVELINESS QoS) are writing the instance.
- The *disposed_generation_count* that indicates the number of times the instance had become alive after it was disposed explicitly by a *DataWriter*, at the time the sample was received.
- The *no_writers_generation_count* that indicates the number of times the instance had become alive after it was disposed because there were no writers, at the time the sample was received.
- The *sample_rank* that indicates the number of samples related to the same instance that follow in the collection returned by *read* or *take*.
- The *generation_rank* that indicates the generation difference (number of times the instance was disposed and become alive again) between the time the sample was received, and the time the most recent sample in the collection related to the same instance was received.
- The *absolute_generation_rank* that indicates the generation difference (number of times the instance was disposed and become alive again) between the time the sample was received, and the time the most recent sample (which may not be in the returned collection) related to the same instance was received.
- the *source_timestamp* that indicates the time provided by the *DataWriter* when the sample was written.
- the *instance_handle* that identifies locally the corresponding instance.

Refer to Section 2.1.2.5.1 for a detailed explanation of these states and ranks.

2.1.2.5.6 *SubscriberListener* Interface

<i>SubscriberListener</i>		
no attributes		
operations		
on_data_on_readers		void
	the_subscriber	Subscriber

Since a *Subscriber* is a kind of *Entity*, it has the ability to have an associated listener. In this case, the associated listener should be of concrete type *SubscriberListener*. Its definition can be found in Section 2.1.4, “Listeners, Conditions and Wait-sets,” on page 2-115.

2.1.2.5.7 *DataReaderListener* Interface

<i>DataReaderListener</i>		
no attributes		
operations		
on_data_available		void
	the_reader	DataReader
on_sample_rejected		void
	the_reader	DataReader
	status	SampleRejectedStatus
on_liveliness_changed		
	the_reader	DataReader
	status	LivelinessChangedStatus
on_requested_deadline_missed		void
	the_reader	DataReader
	status	RequestedDeadlineMissedStatus
on_requested_incompatible_qos		void
	the_reader	DataReader
	status	RequestedIncompatibleQosStatus
on_subscription_match		
	the_reader	DataReader
	status	SubscriptionMatchStatus
on_sample_lost		void
	the_reader	DataReader
	status	SampleLostStatus

Since a *DataReader* is a kind of *Entity*, it has the ability to have an associated listener. In this case, the associated listener should be of concrete type *DataReaderListener*. Its definition can be found in Section 2.1.4, “Listeners, Conditions and Wait-sets,” on page 2-115.

The operation *on_subscription_match* is intended to inform the application of the discovery of *DataWriter* entities that match the *DataReader*. Some implementations of the service may not propagate this information. In that case the DDS specification does not require this listener operation to be called.

2.1.2.5.8 *ReadCondition* Class

ReadCondition objects are conditions specifically dedicated to read operations and attached to one ***DataReader***.

<i>ReadCondition</i>	
no attributes	
operations	
get_datareader	DataReader
get_sample_state_mask	SampleStateKind []
get_view_state_mask	ViewStateKind []
get_instance_state_mask	InstanceStateKind []

ReadCondition objects allow an application to specify the data samples it is interested in (by specifying the desired sample-states, view-states, and instance-states). See the parameter definitions for ***DataReader's read/take*** operations.) This allows the middleware to enable the condition only when suitable information is available²⁴. They are to be used in conjunction with a ***WaitSet*** as normal conditions. More than one ***ReadCondition*** may be attached to the same ***DataReader***.

2.1.2.5.8.1 *get_datareader*

This operation returns the ***DataReader*** associated with the ***ReadCondition***. Note that there is exactly one ***DataReader*** associated with each ***ReadCondition***.

2.1.2.5.8.2 *get_sample_state_mask*

This operation returns the set of sample-states that are taken into account to determine the ***trigger_value*** of the ***ReadCondition***. These are the sample-states specified when the ***ReadCondition*** was created.

2.1.2.5.8.3 *get_view_state_mask*

This operation returns the set of view-states that are taken into account to determine the ***trigger_value*** of the ***ReadCondition***. These are the view-states specified when the ***ReadCondition*** was created.

2.1.2.5.8.4 *get_instance_state_mask*

This operation returns the set of instance-states that are taken into account to determine the ***trigger_value*** of the ***ReadCondition***. These are the instance-states specified when the ***ReadCondition*** was created.

24. For example, the application can specify that the condition must only be enabled when new instances are received by using the NEW view state.

2.1.2.5.9 QueryCondition Class

QueryCondition objects are specialized **ReadCondition** objects that allow the application to also specify a filter on the locally available data.

QueryCondition		
no attributes		
operations		
get_query_expression		string
get_query_arguments		string []
set_query_arguments		ReturnCode_t
	query_arguments	string []

The query (*query_expression*) is similar to an SQL WHERE clause and can be parameterized by arguments that are dynamically changeable by the *set_query_arguments* operation.

Precise syntax for the query expression can be found in Appendix B.

This feature is optional. In the cases where it is not supported, the **DataReader::create_querycondition** will return a 'nil' value (as specified by the platform).

2.1.2.5.9.1 get_query_expression

This operation returns the *query_expression* associated with the **QueryCondition**. That is, the expression specified when the **QueryCondition** was created.

2.1.2.5.9.2 get_query_arguments

This operation returns the *query_arguments* associated with the **QueryCondition**. That is, the parameters specified on the last successful call to *set_query_arguments*, or if *set_query_arguments* was never called, the arguments specified when the **QueryCondition** was created.

2.1.2.5.9.3 set_query_arguments

This operation changes the *query_arguments* associated with the **QueryCondition**.

2.1.3 Supported QoS

The Data-Distribution Service (DDS) relies on the use of QoS. A QoS (Quality of Service) is a set of characteristics that controls some aspect of the behavior of the DDS Service. QoS is comprised of individual QoS policies (objects of type deriving from *QosPolicy*).

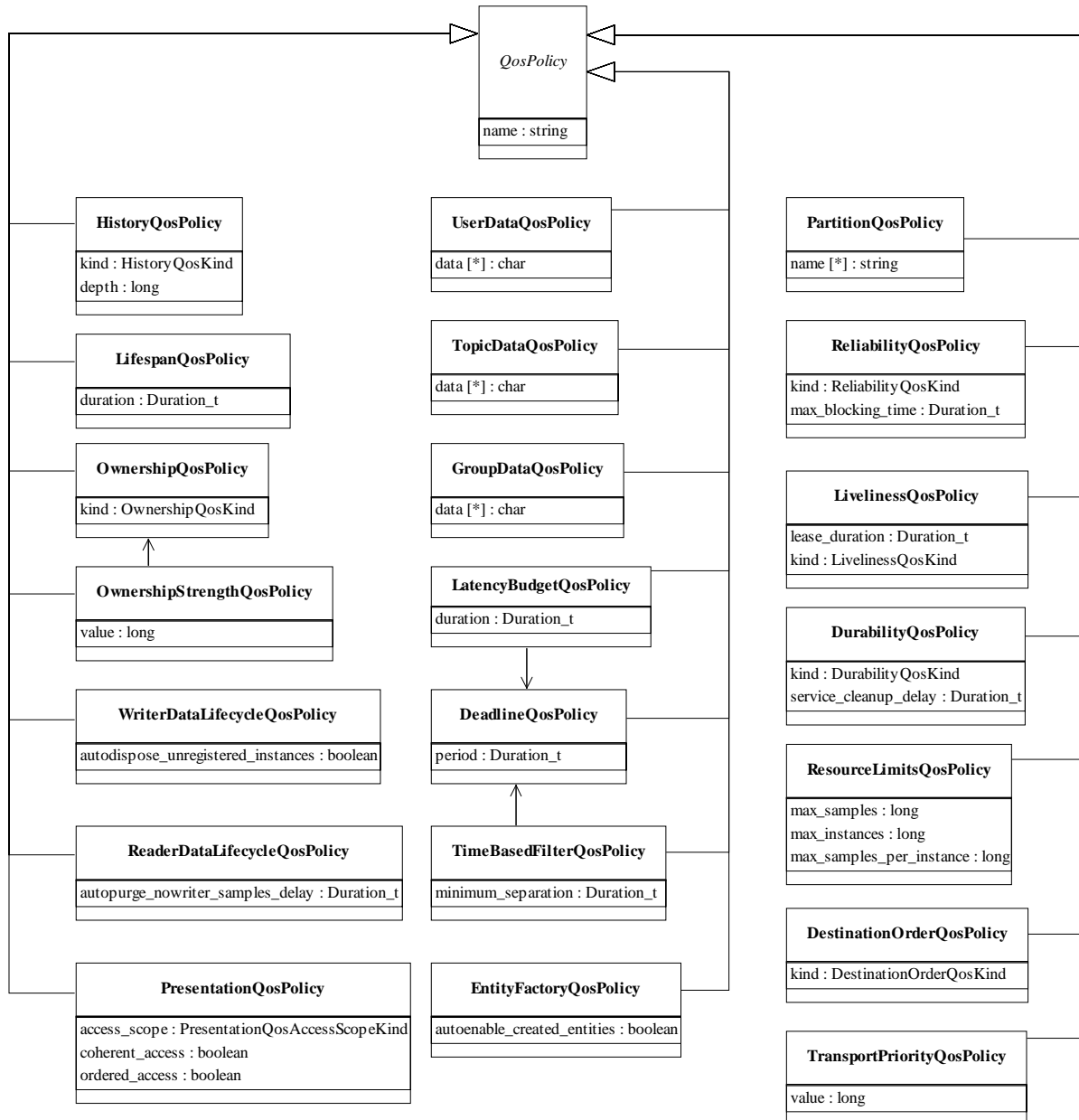


Figure 2-12 Supported QoS policies

QoS (i.e., a list of *QosPolicy* objects) may be associated with all *Entity* objects in the system such as *Topic*, *DataWriter*, *DataReader*, *Publisher*, *Subscriber*, and *DomainParticipant*.

Some *QosPolicy* values may not be compatible with other ones. These cases are described in the table below. When a set of *QosPolicy* is passed (*set_qos* operations), the set resulting from adding the new policies on top of the previous is checked for consistency. If the resulting QoS is inconsistent, the change of QoS operation fails and the previous values are retained.

In several cases, for communications to occur properly (or efficiently), a *QosPolicy* on the publisher side must be compatible with a corresponding policy on the subscriber side. For example, if a *Subscriber* requests to receive data reliably while the corresponding *Publisher* defines a best-effort policy, communication will not happen as requested. To address this issue and maintain the desirable de-coupling of publication and subscription as much as possible, the specification for *QosPolicy* follows the subscriber-requested, publisher-offered pattern. In this pattern, the subscriber side can specify a “requested” value for a particular *QosPolicy*. The Publisher side specifies an “offered” value for that *QosPolicy*. The Service will then determine whether the value requested by the subscriber side is compatible with what is offered by the publisher side. If the two policies are compatible, then communication will be established. If the two policies are not compatible, the Service will not establish communications between the two *Entity* objects and will record this fact by means of the OFFERED_INCOMPATIBLE_QOS on the publisher end and REQUESTED_INCOMPATIBLE_QOS on the subscriber end (see Section 2.1.4.1, “Communication Status,” on page 2-116). The application can detect this fact by means of a listener or conditions (see Section 2.1.4, “Listeners, Conditions and Wait-sets,” on page 2-115).

The *QosPolicy* objects that need to be set in a compatible manner between the publisher and subscriber ends are indicated by the setting of the ‘RxO²⁵’ property. An ‘RxO’ setting of:

- “Yes” indicates that the policy can be set both at the publishing and subscribing ends and the values must be set in a compatible manner. In this case the compatible values are explicitly defined.
- “No” indicates that the policy can be set both at the publishing and subscribing ends but the two settings are independent. That is, all combinations of values are compatible.
- “N/A” indicates that the policy can only be specified at either the publishing or the subscribing end, but not at both ends. So compatibility does not apply.

The ‘changeable’ property determines whether the *QosPolicy* can be changed after the *Entity* is enabled. In other words, a policy with ‘changeable’ setting of “NO” is considered “immutable” and can only be specified either at *Entity* creation time or else prior to calling the *enable* operation on the *Entity*.

25.Requested / Offered

The following tables give the list of supported *QosPolicy*: their name, semantics, possible values, and the *Entity* they apply to.

QosPolicy	Value	Meaning	Concerns	RxO	Changeable
USER_DATA	a sequence of octets	User data not known by the middleware, but distributed by means of built-in topics (see Section 2.1.5). The default value is an empty (zero-sized) sequence.	DomainParticipant, DataReader, DataWriter, Topic	No	Yes
TOPIC_DATA	a sequence of octets	User data not known by the middleware, but distributed by means of built-in topics (see Section 2.1.5). The default value is an empty (zero-sized) sequence.	Topic	No	Yes
GROUP_DATA	a sequence of octets	User data not known by the middleware, but distributed by means of built-in topics (see Section 2.1.5). The default value is an empty (zero-sized) sequence.	Publisher, Subscriber	No	Yes
DURABILITY	A “kind”: VOLATILE, TRANSIENT_LOCAL, TRANSIENT, or PERSISTENT And a duration “service_cleanup_delay”	This policy expresses if the data should 'outlive' their writing time.	Topic, DataReader, DataWriter	Yes	No
	VOLATILE	The Service does not need to keep any samples of data-instances on behalf of any <i>DataReader</i> that is not known by the <i>DataWriter</i> at the time the instance is written. In other words the Service will only attempt to provide the data to existing subscribers. This is the default kind.			

QoSPolicy	Value	Meaning	Concerns	RxO	Changeable
	TRANSIENT_LOCAL, TRANSIENT	The Service will attempt to keep some samples so that they can be delivered to any potential late-joining <i>DataReader</i> . Which particular samples are kept depends on other QoS such as HISTORY and RESOURCE_LIMITS. For TRANSIENT_LOCAL, the service is only required to keep the data in the memory of the <i>DataWriter</i> that wrote the data and the data is not required to survive the <i>DataWriter</i> . For TRANSIENT, the service is only required to keep the data in memory and not in permanent storage; but the data is not tied to the lifecycle of the <i>DataWriter</i> and will, in general, survive it. Support for TRANSIENT kind is optional.			
	PERSISTENT	[optional] Data is kept on permanent storage so that they can outlive a system session.			
	service_cleanup_delay	Only needed if kind is TRANSIENT or PERSISTENT. Controls when the service is able to remove all information regarding a data-instances. By default, zero			
PRESENTATION	An "access_scope": INSTANCE, TOPIC, GROUP And two booleans: "coherent_access" "ordered_access"	Specifies how the samples representing changes to data instances are presented to the subscribing application. This policy affects the application's ability to: specify and receive coherent changes see the relative order of changes. <i>access_scope</i> determines the largest scope spanning the entities for which the order and coherency of changes can be preserved. The two booleans control whether coherent access and ordered access are supported within the scope <i>access_scope</i> .	Publisher, Subscriber	Yes	No

QosPolicy	Value	Meaning	Concerns	RxO	Changeable
	INSTANCE	Scope spans only a single instance. Indicates that changes to one instance need not be coherent nor ordered with respect to changes to any other instance. In other words, order and coherent changes apply to each instance separately. This is the default <i>access_scope</i> .			
	TOPIC	Scope spans to all instances within the same DataWriter (or DataReader), but not across instances in different DataWriter (or DataReader).			
	GROUP	[optional] Scope spans to all instances belonging to DataWriter (or DataReader) entities within the same Publisher (or Subscriber).			
	coherent_access	Specifies support coherent access . That is, the ability to group a set of changes as a unit on the publishing end such that they are received as a unit at the subscribing end. The default setting of <i>coherent_access</i> is FALSE.			
	ordered_access	Specifies support for ordered access to the samples received at the subscription end. That is, the ability of the subscriber to see changes in the same order as they occurred on the publishing end. The default setting of <i>ordered_access</i> is FALSE.			
DEADLINE	A duration “period”	DataReader expects a new sample updating the value of each instance at least once every deadline period . DataWriter indicates that the application commits to write a new value (using the DataWriter) for each instance managed by the DataWriter at least once every deadline period . The default value of the deadline period is infinite.	Topic, DataReader, DataWriter	Yes	Yes

QoSPolicy	Value	Meaning	Concerns	RxO	Changeable
LATENCY_BUDGET	A duration "duration"	Specifies the maximum acceptable delay from the time the data is written until the data is inserted in the receiver's application-cache and the receiving application is notified of the fact. This policy is a hint to the Service, not something that must be monitored or enforced. The Service is not required to track or alert the user of any violation. The default value of the <i>duration</i> is zero indicating that the delay should be minimized.	Topic, DataReader, DataWriter	Yes	Yes
OWNERSHIP	A "kind" SHARED EXCLUSIVE	[optional] Specifies whether it is allowed for multiple <i>DataWriters</i> to write the same instance of the data and if so, how these modifications should be arbitrated	Topic	Yes	No
	SHARED	Indicates shared ownership for each instance. Multiple writers are allowed to update the same instance and all the updates are made available to the readers. In other words there is no concept of an "owner" for the instances. This is the default behavior if the OWNERSHIP QoS policy is not specified or supported.			
	EXCLUSIVE	Indicates each instance can only be owned by one <i>DataWriter</i> , but the owner of an instance can change dynamically. The selection of the owner is controlled by the setting of the OWNERSHIP_STRENGTH QoS policy. The owner is always set to be the highest-strength <i>DataWriter</i> object among the ones currently "active" (as determined by the LIVELINESS QoS).			

QoSPolicy	Value	Meaning	Concerns	RxO	Changeable
OWNERSHIP_STRENGTH	An integer “value”	<p>[optional] Specifies the value of the “strength” used to arbitrate among multiple <i>DataWriter</i> objects that attempt to modify the same instance of a data-object (identified by <i>Topic</i> + <i>key</i>).</p> <p>This policy only applies if the OWNERSHIP QoS policy is of <i>kind</i> EXCLUSIVE.</p> <p>The default value of the <i>ownership_strength</i> is zero.</p>	DataWriter	N/A	Yes
LIVELINESS	A “kind”: AUTOMATIC, MANUAL_BY_ PARTICIPANT, MANUAL_BY_ TOPIC and a duration “lease_duration”	<p>Determines the mechanism and parameters used by the application to determine whether an <i>Entity</i> is “active” (alive). The “liveliness” status of an Entity is used to maintain instance ownership in combination with the setting of the OWNERSHIP QoS policy. The application is also informed via listener when an <i>Entity</i> is no longer alive.</p> <p>The <i>DataReader</i> requests that liveliness of the writers is maintained by the requested means and loss of liveliness is detected with delay not to exceed the <i>lease_duration</i>.</p> <p>The <i>DataWriter</i> commits to signalling its liveliness using the stated means at intervals not to exceed the <i>lease_duration</i>.</p> <p>Listeners are used to notify the <i>DataReader</i> of loss of liveliness and <i>DataWriter</i> of violations to the liveliness contract.</p> <p>The default <i>kind</i> is AUTOMATIC and the default value of the <i>lease_duration</i> is infinite.</p>	Topic, DataReader, DataWriter	Yes	No
	AUTOMATIC	The infrastructure will automatically signal liveliness for the <i>DataWriters</i> at least as often as required by the <i>lease_duration</i> .			

QoSPolicy	Value	Meaning	Concerns	RxO	Changeable
	MANUAL modes	The user application takes responsibility to signal liveness to the Service using one of the mechanisms described in Section 2.1.3.10. Liveness must be asserted at least once every <i>lease_duration</i> otherwise the Service will assume the corresponding <i>Entity</i> is no longer “active/alive.”			
	MANUAL_BY_PARTICIPANT	The Service will assume that as long as at least one <i>Entity</i> within the <i>DomainParticipant</i> has asserted its liveness the other <i>Entities</i> in that same <i>DomainParticipant</i> are also alive.			
	MANUAL_BY_TOPIC	The Service will only assume liveness of the <i>DataWriter</i> if the application has asserted liveness of that <i>DataWriter</i> itself.			
TIME_BASED_FILTER	A duration "minimum_separation"	Filter that allows a <i>DataReader</i> to specify that it is interested only in (potentially) a subset of the values of the data. The filter states that the <i>DataReader</i> does not want to receive more than one value each <i>minimum_separation</i> , regardless of how fast the changes occur. By default <i>minimum_separation</i> =0 indicating <i>DataReader</i> is potentially interested in all values.	DataReader	N/A	Yes
PARTITION	A list of strings “name”	Set of strings that introduces a logical partition among the topics visible by the <i>Publisher</i> and <i>Subscriber</i> . A <i>DataWriter</i> within a <i>Publisher</i> only communicates with a <i>DataReader</i> in a <i>Subscriber</i> if (in addition to matching the <i>Topic</i> and having compatible QoS) the <i>Publisher</i> and <i>Subscriber</i> have a common partition name string. The default value is an empty (zero-sized) sequence. This is treated as a special value that matches any partition.	Publisher, Subscriber	No	Yes

QosPolicy	Value	Meaning	Concerns	RxO	Changeable
RELIABILITY	A "kind": RELIABLE, BEST_EFFORT and a duration "max_blocking_time"	Indicates the level of reliability offered/requested by the Service.	Topic, DataReader, DataWriter	Yes	No
	RELIABLE	Specifies the Service will attempt to deliver all samples in its history. Missed samples may be retried. In steady-state (no modifications communicated via the <i>DataWriter</i>) the middleware guarantees that all samples in the <i>DataWriter</i> history will eventually be delivered to the all <i>DataReader</i> ¹ objects. Outside steady state the HISTORY and RESOURCE_LIMITS policies will determine how samples become part of the history and whether samples can be discarded from it.			
	BEST_EFFORT	Indicates that it is acceptable to not retry propagation of any samples. Presumably new values for the samples are generated often enough that it is not necessary to re-send or acknowledge any samples. This is the default value.			
	max_blocking_time	This setting applies only to the case where kind=RELIABLE and the HISTORY is KEEP_ALL. The value of the <i>max_blocking_time</i> indicates the maximum time the operation <i>DataWriter::write</i> is allowed to block if the <i>DataWriter</i> does not have space to store the value written.			
TRANSPORT_PRIORITY	An integer "value"	This policy is a hint to the infrastructure as to how to set the priority of the underlying transport used to send the data. The default value of the <i>transport_priority</i> is zero.	Topic, DataWriter	N/A	Yes
LIFESPAN	A duration "duration"	Specifies the maximum duration of validity of the data written by the DataWriter. The default value of the lifespan <i>duration</i> is infinite.	Topic, DataWriter	N/A	Yes

QoSPolicy	Value	Meaning	Concerns	RxO	Changeable
DESTINATION_ORDER	A “kind”: BY_RECEPTION_TIMESTAMP, BY_SOURCE_TIMESTAMP	Controls the criteria used to determine the logical order among changes made by Publisher entities to the same instance of data (i.e., matching Topic and key). The default kind is BY_RECEPTION_TIMESTAMP.	Topic, DataReader	Yes	No
	BY_RECEPTION_TIMESTAMP	Indicates that data is ordered based on the reception time at each Subscriber . Since each subscriber may receive the data at different times there is no guaranteed that the changes will be seen in the same order. Consequently, it is possible for each subscriber to end up with a different final value for the data.			
	BY_SOURCE_TIMESTAMP	Indicates that data is ordered based on a time-stamp placed at the source (by the Service or by the application). In any case this guarantees a consistent final value for the data in all subscribers.			
HISTORY	A “kind”: KEEP_LAST, KEEP_ALL And an optional integer “depth”	Specifies the behavior of the Service in the case where the value of a sample changes (one or more times) before it can be successfully communicated to one or more existing subscribers. This QoS policy controls whether the Service should deliver only the most recent value, attempt to deliver all intermediate values, or do something in between. On the publishing side this policy controls the samples that should be maintained by the DataWriter on behalf of existing DataReader entities. The behavior with regards to a DataReader entities discovered after a sample is written is controlled by the DURABILITY QoS policy. On the subscribing side it controls the samples that should be maintained until the application “takes” them from the Service.	Topic, DataReader, DataWriter	No	No

QoSPolicy	Value	Meaning	Concerns	RxO	Changeable
	KEEP_LAST and optional integer “depth”	<p>On the publishing side, the Service will only attempt to keep the most recent “depth” samples of each instance of data (identified by its key) managed by the <i>DataWriter</i>.</p> <p>On the subscribing side, the <i>DataReader</i> will only attempt to keep the most recent “depth” samples received for each instance (identified by its <i>key</i>) until the application “takes” them via the <i>DataReader’s take</i> operation.</p> <p>KEEP_LAST is the default <i>kind</i>. The default value of <i>depth</i> is 1. If a value other than 1 is specified, it should be consistent with the settings of the RESOURCE_LIMITS QoS policy.</p>			
	KEEP_ALL	<p>On the publishing side, the Service will attempt to keep all samples (representing each value written) of each instance of data (identified by its <i>key</i>) managed by the <i>DataWriter</i> until they can be delivered to all subscribers.</p> <p>On the subscribing side, the Service will attempt to keep all samples of each instance of data (identified by its <i>key</i>) managed by the <i>DataReader</i>. These samples are kept until the application “takes” them from the Service via the <i>take</i> operation.</p> <p>The setting of <i>depth</i> has no effect. Its implied value is “INFINITE.”²</p>			
RESOURCE_LIMITS	Three integers: max_samples, max_instances, max_samples_per_ instance	Specifies the resources that the Service can consume in order to meet the requested QoS.	Topic, DataReader, DataWriter	No	No

QosPolicy	Value	Meaning	Concerns	RxO	Changeable
	max_samples	Specifies the maximum number of data-samples the <i>DataWriter</i> (or <i>DataReader</i>) can manage across all the instances associated with it. Represents the maximum samples the middleware can store for any one <i>DataWriter</i> (or <i>DataReader</i>). By default, unlimited.			
	max_instances	Represents the maximum number of instances <i>DataWriter</i> (or <i>DataReader</i>) can manage. By default, unlimited ³ .			
	max_samples_per_instance	Represents the maximum number of samples of any one instance a <i>DataWriter</i> (or <i>DataReader</i>) can manage. By default, unlimited ⁴ .			
ENTITY_FACTORY	A boolean: "autoenable_created_entities"	Controls the behavior of the entity when acting as a factory for other entities. In other words, configures the side-effects of the create_* and delete_* operations.	DomainParticipant, Publisher, Subscriber,	No	Yes
	autoenable_created_entities	Specifies whether the entity acting as a factory automatically enables the instances it creates. If <i>autoenable_created_entities</i> ==TRUE the factory will automatically enable each created Entity otherwise it will not. By default, TRUE.			
WRITER_DATA_LIFECYCLE	A boolean: "autodispose_unregistered_instances"	Specifies the behavior of the <i>DataWriter</i> with regards to the lifecycle of the data-instances it manages.	DataWriter	N/A	Yes
	autodispose_unregistered_instances	Controls whether a <i>DataWriter</i> will automatically dispose instances each time they are unregistered. The setting <i>autodispose_unregistered_instances</i> = TRUE indicates that unregistered instances will also be considered disposed. By default, TRUE.			

QoSPolicy	Value	Meaning	Concerns	RxO	Changeable
READER_DATA_LIFECYCLE	A duration “autopurge_nowriter_samples_delay”	Specifies the behavior of the <i>DataReader</i> with regards to the lifecycle of the data-instances it manages.	DataReader	N/A	Yes
	autopurge_nowriter_samples_delay	Indicates the duration the <i>DataReader</i> must retain information regarding instances that have the <i>view_state</i> NOT_ALIVE_NO_WRITERS. By default, unlimited.			

1. Subject to timeouts that indicate loss of communication with a particular subscriber.
2. In practice this will be limited by the settings of the RESOURCE_LIMITS QoS.
3. Actually, the limit will then be set by the max_samples
4. Actually, the limit will then be set by the max_samples

2.1.3.1 USER_DATA

The purpose of this QoS is to allow the application to attach additional information to the created *Entity* objects such that when a remote application discovers their existence it can access that information and use it for its own purposes. One possible use of this QoS is to attach security credentials or some other information that can be used by the remote application to authenticate the source. In combination with operations such as *ignore_participant*, *ignore_publication*, *ignore_subscription* and *ignore_topic*, these QoS can assist an application to define and enforce its own security policies. The use of this QoS is not limited to security, rather it offers a simple, yet flexible extensibility mechanism.

2.1.3.2 TOPIC_DATA

The purpose of this QoS is to allow the application to attach additional information to the created *Topic* such that when a remote application discovers their existence it can examine the information and use it in an application-defined way. In combination with the listeners on the *DataReader* and *DataWriter* as well as by means of operations such as *ignore_topic*, these QoS can assist an application to extend the provided QoS.

This QoS is very similar in intent to USER_DATA. They both concern *Topic*, *DataWriter*, and *DataReader* and are available by means of the built-in topics. Using separate QoS allows both to be set independently. The intended use is that the TOPIC_DATA would be primarily configured on the *Topic* and the USER_DATA primarily on the *DataReader/DataWriter*.

2.1.3.3 *GROUP_DATA*

The purpose of this QoS is to allow the application to attach additional information to the created *Publisher* or *Subscriber*. The value of the *GROUP_DATA* is available to the application on the *DataReader* and *DataWriter* entities and is propagated by means of the built-in topics.

This QoS can be used by an application combination with the *DataReaderListener* and *DataWriterListener* to implement matching policies similar to those of the *PARTITION* QoS except for the decision can be made based on an application-defined policy.

2.1.3.4 *DURABILITY*

The decoupling between *DataReader* and *DataWriter* offered by the Publish/Subscribe paradigm allows an application to write data even if there are no current readers on the network. Moreover, a *DataReader* that joins the network after some data has been written could potentially be interested in accessing the most current values of the data as well as potentially some history. This QoS policy controls whether the Service will actually make data available to late-joining readers. Note that although related, this does not strictly control what data the Service will maintain internally. That is, the Service may choose to maintain some data for its own purposes (e.g., flow control) and yet not make it available to late-joining readers if the *DURABILITY* QoS policy is set to *VOLATILE*.

The value offered is considered compatible with the value requested if and only if the inequality “offered *kind* \geq requested *kind*” evaluates to ‘TRUE.’ For the purposes of this inequality, the values of *DURABILITY kind* are considered ordered such that *VOLATILE* < *TRANSIENT_LOCAL* < *TRANSIENT* < *PERSISTENT*.

For the purpose of implementing the *DURABILITY* QoS kind *TRANSIENT* or *PERSISTENT*, the service behaves “as if” for each *Topic* that has *TRANSIENT* or *PERSISTENT* *DURABILITY* kind there was a corresponding “built-in” *DataReader* and *DataWriter* configured to have the same *DURABILITY* kind. In other words, it is “as if” somewhere in the system (possibly on a remote node) there was a “built-in durability *DataReader*” that subscribed to that *Topic* and a “built-in durability *DataWriter*” that published that *Topic* as needed for the new subscribers that join the system.

For each *Topic*, the built-in fictitious “persistence service” *DataReader* and *DataWriter* has its QoS configured from the *Topic* QoS of the corresponding *Topic*. In other words, it is “as-if” the service first did *find_topic* to access the *Topic*, and then used the QoS from the *Topic* to configure the fictitious built-in entities.

A consequence of this model is that the transient or persistence serviced can be configured by means of setting the proper QoS on the *Topic*.

For a given *Topic*, the usual request/offered semantics apply to the matching between any *DataWriter* in the system that writes the *Topic* and the built-in transient/persistent *DataReader* for that *Topic*; similarly for the built-in transient/persistent *DataWriter* for a *Topic* and any *DataReader* for the *Topic*. As a consequence, a *DataWriter* that has an

incompatible QoS with respect to what the *Topic* specified will not send its data to the transient/persistent service, and a *DataReader* that has an incompatible QoS with respect to the specified in the *Topic* will not get data from it.

Incompatibilities between local *DataReader/DataWriter* entities and the corresponding fictitious “built-in transient/persistent entities” cause the REQUESTED_INCOMPATIBLE_QOS/OFFERED_INCOMPATIBLE_QOS status to change and the corresponding *Listener* invocations and/or signaling of *Condition* and *WaitSet* objects as they would with non-fictitious entities.

The setting of the *service_cleanup_delay* controls when the TRANSIENT or PERSISTENT service is able to remove all information regarding a data-instance. Information on a data-instance is maintained until the following conditions are met:

1. the instance has been explicitly disposed (*instance_state* = NOT_ALIVE_DISPOSED), and
2. while in the NOT_ALIVE_DISPOSED state the system detects that there are no more “live” *DataWriter* entities writing the instance, that is, all existing writers either unregister the instance (call *unregister*) or lose their liveness, and
3. a time interval longer than *service_cleanup_delay* has elapsed since the moment the service detected that the previous two conditions were met.

The utility of the *service_cleanup_delay* is apparent in the situation where an application disposes an instance and it crashes before it has a chance to complete additional tasks related to the disposition. Upon re-start the application may ask for initial data to regain its state and the delay introduced by the *service_cleanup_delay* will allow the re-started application to receive the information on the disposed instance and complete the interrupted tasks.

2.1.3.5 PRESENTATION

This QoS policy controls the extent to which changes to data-instances can be made dependent on each other and also the kind of dependencies that can be propagated and maintained by the Service.

The setting of *coherent_access* controls whether the Service will preserve the groupings of changes made by the publishing application by means of the operations *begin_coherent_change* and *end_coherent_change*.

The setting of *ordered_access* controls whether the Service will preserve the order of changes.

The granularity is controlled by the setting of the *access_scope*.

If *coherent_access* is set, then the *access_scope* controls the maximum extent of coherent changes. The behavior is as follows:

- If *access_scope* is set to INSTANCE, the use of *begin_coherent_change* and *end_coherent_change* has no effect on how the subscriber can access the data because with the scope limited to each instance, changes to separate instances are considered independent and thus cannot be grouped by a coherent change.

- If *access_scope* is set to TOPIC, then coherent changes (indicated by their enclosure within calls to *begin_coherent_change* and *end_coherent_change*) will be made available as such to each remote *DataReader* independently. That is, changes made to instances within each individual *DataWriter* will be available as coherent with respect to other changes to instances in that same *DataWriter*, but will not be grouped with changes made to instances belonging to a different *DataWriter*.
- If *access_scope* is set to GROUP, then coherent changes made to instances through a *DataWriter* attached to a common *Publisher* are made available as a unit to remote subscribers.

If *ordered_access* is set, then the *access_scope* controls the maximum extent for which order will be preserved by the Service:

- If *access_scope* is set to INSTANCE (the lowest level), then changes to each instance are considered unordered relative to changes to any other instance. That means that changes (creations, deletions, modifications) made to two instances are not necessarily seen in the order they occur. This is the case even if it is the same application thread making the changes using the same *DataWriter*.
- If *access_scope* is set to TOPIC, changes (creations, deletions, modifications) made by a single *DataWriter* are made available to subscribers in the same order they occur. Changes made to instances through different *DataWriter* entities are not necessarily seen in the order they occur. This is the case, even if the changes are made by a single application thread using *DataWriter* objects attached to the same *Publisher*.
- Finally, if *access_scope* is set to GROUP, changes made to instances via *DataWriter* entities attached to the same *Publisher* object are made available to subscribers on the same order they occur.

Note that this QoS policy controls the scope at which related changes are made available to the subscriber. This means the subscriber can access the changes in a coherent manner and in the proper order; however, it does not necessarily imply that the *Subscriber will* indeed access the changes in the correct order. For that to occur, the application at the subscriber end must use the proper logic in reading the *DataReader* objects, as described in “Access to the data.”

The value offered is considered compatible with the value requested if and only if the following conditions are met:

1. The inequality “offered *access_scope* >= requested *access_scope*” evaluates to ‘TRUE.’ For the purposes of this inequality, the values of PRESENTATION *access_scope* are considered ordered such that INSTANCE < TOPIC < GROUP.
2. Requested *coherent_access* is FALSE, or else both offered and requested *coherent_access* are TRUE.
3. Requested *ordered_access* is FALSE, or else both offered and requested *ordered_access* are TRUE.

2.1.3.6 DEADLINE

This policy is useful for cases where a *Topic* is expected to have each instance updated periodically. On the publishing side this setting establishes a contract that the application must meet. On the subscribing side the setting establishes a minimum requirement for the remote publishers that are expected to supply the data values.

When the Service ‘matches’ a *DataWriter* and a *DataReader* it checks whether the settings are compatible (i.e., offered deadline *period* \leq requested deadline *period*) if they are not, the two entities are informed (via the listener or condition mechanism) of the incompatibility of the QoS settings and communication will not occur.

Assuming that the reader and writer ends have compatible settings, the fulfillment of this contract is monitored by the Service and the application is informed of any violations by means of the proper listener or condition.

The value offered is considered compatible with the value requested if and only if the inequality “offered deadline *period* \leq requested deadline *period*” evaluates to ‘TRUE.’

The setting of the DEADLINE policy must be set consistently with that of the TIME_BASED_PERIOD. For these two policies to be consistent the settings must be such that “deadline *period* \geq *minimum_separation*.” An attempt to set these policies in an inconsistent manner will cause the INCONSISTENT_POLICY status to change and any associated *Listeners/WaitSets* to be triggered.

2.1.3.7 LATENCY_BUDGET

This policy provides a means for the application to indicate to the middleware the “urgency” of the data-communication. By having a non-zero *duration* the Service can optimize its internal operation.

This policy is considered a hint. Therefore the Service will not fail to match a *DataReader* with a *DataWriter* due to incompatibility on this QoS, rather it will automatically adapt its behavior on the publishing end to meet the requirements of all subscribers. Consequently this QoS will never trigger an incompatible QoS notification, nor does it have any listeners associated with violations of the contract.

The value offered is considered compatible with the value requested if and only if the inequality “offered *duration* \leq requested *duration*” evaluates to ‘TRUE.’

2.1.3.8 OWNERSHIP

This policy controls whether the Service allows multiple *DataWriter* objects to update the same instance (identified by *Topic* + *key*) of a data-object.

This QoS policy only applies to *Topic* and not to *DataReader* or *DataWriter*. The reason for this is that it would make no sense for a *DataReader* or a *DataWriter* to override the setting in the *Topic*.

There are two kinds of OWNERSHIP selected by the setting of the *kind*: SHARED and EXCLUSIVE.

2.1.3.8.1 SHARED kind

This setting indicates that the Service does not enforce unique ownership for each instance. In this case, multiple writers can update the same data-object instance. The subscriber to the *Topic* will be able to access modifications from all *DataWriter* objects, subject to the settings of other QoS that may filter particular samples (e.g., the TIME_BASED_FILTER or HISTORY QoS policy). In any case there is no “filtering” of modifications made based on the identity of the *DataWriter* that causes the modification.

2.1.3.8.2 EXCLUSIVE kind

This setting indicates that each instance of a data-object can only be modified by one *DataWriter*. In other words, at any point in time a single *DataWriter* “owns” each instance and is the only one whose modifications will be visible to the *DataReader* objects. The owner is determined by selecting the *DataWriter* with the highest value of the *strength*²⁶ that is both “alive” as defined by the LIVELINESS QoS policy and has not violated its DEADLINE contract with regards to the data-instance. Ownership can therefore change as a result of (a) a *DataWriter* in the system with a higher value of the *strength* that modifies the instance, (b) a change in the *strength* value of the *DataWriter* that owns the instance, (c) a change in the liveliness of the *DataWriter* that owns the instance, and (d) a deadline with regards to the instance that is missed by the *DataWriter* that owns the instance.

The behavior of the system is as if the determination was made independently by each *DataReader*. Each *DataReader* may detect the change of ownership at a different time. It is not a requirement that at a particular point in time all the *DataReader* objects for that *Topic* have a consistent picture of who owns each instance.

It is also not a requirement that the *DataWriter* objects are aware of whether they own a particular instance. There is no error or notification given to a *DataWriter* that modifies an instance it does not currently own.

The requirements are chosen to (a) preserve the decoupling of publishers and subscriber, and (b) allow the policy to be implemented efficiently.

It is possible that multiple *DataWriter* objects with the same strength modify the same instance. If this occurs, the Service will pick one of the *DataWriter* objects as the “owner.” It is not specified how the owner is selected. However, it is required that the policy used to select the owner is such that all *DataReader* objects will make the same choice of the particular *DataWriter* that is the owner. It is also required that the owner remains the same until there is a change in *strength*, *liveliness*, the owner misses a *deadline* on the instance, or a new *DataWriter* with higher *strength* modifies the instance. The *DataReader* is also notified of this via a status change that is accessible by means of the *Listener* or *Condition* mechanisms.

Exclusive ownership is on an instance-by-instance basis. That is, a subscriber can receive values written by a lower strength *DataWriter* as long as they affect instances whose values have not been set by the higher-strength *DataWriter*.

26.The “strength” of a *DataWriter* is the value of its OWNERSHIP_STRENGTH QoS.

The value of the OWNERSHIP *kind* offered must exactly match the one requested or else they are considered incompatible.

2.1.3.9 OWNERSHIP_STRENGTH

This QoS policy should be used in combination with the OWNERSHIP policy. It only applies to the situation case where OWNERSHIP *kind* is set to EXCLUSIVE.

The value of the OWNERSHIP_STRENGTH is used to determine the ownership of a data-instance (identified by the key). The arbitration is performed by the *DataReader*. The rules used to perform the arbitration are described in Section 2.1.3.8.2.

2.1.3.10 LIVELINESS

This policy controls the mechanism and parameters used by the Service to ensure that particular entities on the network are still “alive.” The liveliness can also affect the ownership of a particular instance, as determined by the OWNERSHIP QoS policy.

This policy has several settings to support both data-objects that are updated periodically as well as those that are changed sporadically. It also allows customizing for different application requirements in terms of the kinds of failures that will be detected by the liveliness mechanism.

The AUTOMATIC liveliness setting is most appropriate for applications that only need to detect failures at the process-level²⁷, but not application-logic failures within a process. The Service takes responsibility for renewing the leases at the required rates and thus, as long as the local process where a *DomainParticipant* is running and the link connecting it to remote participants remains connected, the entities within the *DomainParticipant* will be considered alive. This requires the lowest overhead.

The MANUAL settings (MANUAL_BY_PARTICIPANT, MANUAL_BY_TOPIC), require the application on the publishing side to periodically assert the liveliness before the lease expires to indicate the corresponding *Entity* is still alive. The action can be explicit by calling the *assert_liveliness* operations, or implicit by writing some data.

The two possible manual settings control the granularity at which the application must assert liveliness.

- The setting MANUAL_BY_PARTICIPANT requires only that one *Entity* within the publisher is asserted to be alive to deduce all other *Entity* objects within the same *DomainParticipant* are also alive.
- The setting MANUAL_BY_TOPIC requires that at least one instance within the *DataWriter* is asserted.

The value offered is considered compatible with the value requested if and only if the following conditions are met:

27. Process here is used to mean an operating system-process as in an address space providing the context where a number of threads execute.

1. The inequality “offered *kind* >= requested *kind*” evaluates to ‘TRUE.’ For the purposes of this inequality, the values of LIVENESS *kind* are considered ordered such that:
AUTOMATIC < MANUAL_BY_PARTICIPANT < MANUAL_BY_TOPIC.
2. The inequality “offered *lease_duration* =< requested *lease_duration*” evaluates to TRUE.

2.1.3.11 TIME_BASED_FILTER

This policy allows a *DataReader* to indicate that it does not necessarily want to see all values of each instance published under the *Topic*. Rather, it wants to see at most one change every *minimum_separation* period.

The TIME_BASED_FILTER applies to each instance separately, that is, the constraint is that the *DataReader* does not want to see more than one sample of each instance per *minimum_separation* period.

This setting allows a *DataReader* to further decouple itself from the *DataWriter* objects. It can be used to protect applications that are running on a heterogeneous network where some nodes are capable of generating data much faster than others can consume it. It also accommodates the fact that for fast-changing data different subscribers may have different requirements as to how frequently they need to be notified of the most current values.

The setting of a TIME_BASED_FILTER, that is, the selection of a *minimum_separation* with a value greater than zero is compatible with all settings of the HISTORY and RELIABILITY QoS. The TIME_BASED_FILTER specifies the samples that are of interest to the *DataReader*. The HISTORY and RELIABILITY QoS affect the behavior of the middleware with respect to the samples that have been determined to be of interest to the *DataReader*, that is, they apply after the TIME_BASED_FILTER has been applied.

In the case where the reliability QoS kind is RELIABLE then in steady-state, defined as the situation where the *DataWriter* does not write new samples for a period “long” compared to the *minimum_separation*, the system should guarantee delivery the last sample to the *DataReader*.

2.1.3.12 PARTITION

This policy allows the introduction of a logical partition concept inside the ‘physical’ partition induced by a domain.

For a *DataReader* to see the changes made to an instance by a *DataWriter*, not only the *Topic* must match, but also they must share a common partition. Each string in the list that defines this QoS policy defines a partition name. A partition name may contain wildcards. Sharing a common partition means that one of the partition names matches.

Failure to match partitions is not considered an “incompatible” QoS and does not trigger any listeners nor conditions.

This policy is changeable. A change of this policy can potentially modify the “association” of existing *DataReader* and *DataWriter* entities. It may establish new “associations” that did not exist before, or break existing associations.

By default, *DataWriter* and *DataReader* objects belonging to *Publisher* or *Subscriber* that do not specify a PARTITION policy will participate in the default partition (whose name is "").

Partitions are different from creating *Entity* objects in different domains in several ways. First, entities belonging to different domains are completely isolated from each other; there is no traffic, meta-traffic or any other way for an application or the Service itself to see entities in a domain it does not belong to. Second, an *Entity* can only belong to one domain whereas an *Entity* can be in multiple partitions. Finally, as far as the DDS Service is concerned, each unique data instance is identified by the tuple (*domainId*, *Topic*, *key*). Therefore two *Entity* objects in different domains cannot refer to the same data instance. On the other hand, the same data-instance can be made available (published) or requested (subscribed) on one or more partitions.

2.1.3.13 RELIABILITY

This policy indicates the level of reliability requested by a *DataReader* or offered by a *DataWriter*. These levels are ordered, BEST_EFFORT being lower than RELIABLE. A *DataWriter* offering a level is implicitly offering all levels below.

The setting of this policy has a dependency on the setting of the HISTORY and RESOURCE_LIMITS policies. In case the RELIABILITY *kind* is set to RELIABLE and the HISTORY *kind* set to KEEP_ALL the *write* operation on the *DataWriter* may block if the modification would cause data to be lost or else cause one of the limits specified in the RESOURCE_LIMITS to be exceeded. Under these circumstances, the RELIABILITY *max_blocking_time* configures the maximum duration the *write* operation may block.

The value offered is considered compatible with the value requested if and only if the inequality “offered *kind* >= requested *kind*” evaluates to ‘TRUE.’ For the purposes of this inequality, the values of RELIABILITY *kind* are considered ordered such that BEST_EFFORT < RELIABLE.

2.1.3.14 TRANSPORT_PRIORITY

The purpose of this QoS is to allow the application to take advantage of transports capable of sending messages with different priorities.

This policy is considered a hint. The policy depends on the ability of the underlying transports to set a priority on the messages they send. As this is specific to each transport it is not possible to define the behavior generically. It is expected that during transport configuration the application would provide a mapping between the values of the TRANSPORT_PRIORITY set on *DataWriter* and the values meaningful to each transport. This mapping would then be used by the infrastructure when propagating the data written by the *DataWriter*.

2.1.3.15 LIFESPAN

The purpose of this QoS is to avoid delivering “stale” data to the application.

Each data sample written by the *DataWriter* has an associated ‘expiration time’ beyond which the data should not be delivered to any application. Once the sample expires, the data will be removed from the *DataReader* caches as well as from the transient and persistent information caches.

The ‘expiration time’ of each sample is computed by adding the duration specified by the LIFESPAN QoS to the *source timestamp*. As described in Section 2.1.2.4.2.10 and Section 2.1.2.4.2.11 the *source timestamp* is either automatically computed by the Service each time the *DataWriter write* operation is called, or else supplied by the application by means of the *write_w_timestamp* operation.

This QoS relies on the sender and receiving applications having their clocks sufficiently synchronized. If this is not the case and the Service can detect it, the *DataReader* is allowed to use the reception timestamp instead of the source timestamp in its computation of the ‘expiration time.’

2.1.3.16 DESTINATION_ORDER

This policy controls how each subscriber resolves the final value of a data instance that is written by multiple *DataWriter* objects (which may be associated with different *Publisher* objects) running on different nodes.

The setting BY_RECEPTION_TIMESTAMP indicates that, assuming the OWNERSHIP policy allows it, the latest received value for the instance should be the one whose value is kept. This is the default value.

The setting BY_SOURCE_TIMESTAMP indicates that, assuming the OWNERSHIP policy allows it, a timestamp placed at the source should be used. This is the only setting that, in the case of concurrent same-strength *DataWriter* objects updating the same instance, ensures all subscribers will end up with the same final value for the instance. The mechanism to set the source timestamp is middleware dependent.

The value offered is considered compatible with the value requested if and only if the inequality “offered *kind* >= requested *kind*” evaluates to ‘TRUE.’ For the purposes of this inequality, the values of DESTINATION_ORDER *kind* are considered ordered such that BY_RECEPTION_TIMESTAMP < BY_SOURCE_TIMESTAMP.

2.1.3.17 HISTORY

1. This policy controls the behavior of the Service when the value of an instance changes before it is finally communicated to some of its existing *DataReader* entities.
2. If the *kind* is set to KEEP_LAST, then the Service will only attempt to keep the latest values of the instance and discard the older ones. In this case, the value of *depth* regulates the maximum number of values (up to and including the most

current one) the Service will maintain and deliver. The default (and most common setting) for *depth* is one, indicating that only the most recent value should be delivered.

3. If the *kind* is set to KEEP_ALL, then the Service will attempt to maintain and deliver all the values of the instance to existing subscribers. The resources that the Service can use to keep this history are limited by the settings of the RESOURCE_LIMITS QoS. If the limit is reached, then the behavior of the Service will depend on the RELIABILITY QoS. If the reliability kind is BEST_EFFORT, then the old values will be discarded. If reliability is RELIABLE, then the Service will block the *DataWriter* until it can deliver the necessary old values to all subscribers.

The setting of HISTORY *depth* must be compatible with the RESOURCE_LIMITS *max_samples_per_instance*. For these two QoS to be compatible, they must verify that *depth* <= *max_samples_per_instance*.

2.1.3.18 RESOURCE_LIMITS

This policy controls the resources that the Service can use in order to meet the requirements imposed by the application and other QoS settings.

If the *DataWriter* objects are communicating samples faster than they are ultimately taken by the *DataReader* objects, the middleware will eventually hit against some of the QoS-imposed resource limits. Note that this may occur when just a single *DataReader* cannot keep up with its corresponding *DataWriter*. The behavior in this case depends on the setting for the RELIABILITY QoS. If reliability is BEST_EFFORT, then the Service is allowed to drop samples. If the reliability is RELIABLE, the Service will block the *DataWriter* or discard the sample at the *DataReader*²⁸ in order not to lose existing samples.

The setting of RESOURCE_LIMITS *max_samples_per_instance* must be compatible with the HISTORY *depth*. For these two QoS to be compatible, they must verify that *depth* <= *max_samples_per_instance*.

2.1.3.19 ENTITY_FACTORY

This policy controls the behavior of the *Entity* as a factory for other entities.

This policy concerns only *DomainParticipant* (as factory for *Publisher*, *Subscriber*, and *Topic*), *Publisher* (as factory for *DataWriter*), and *Subscriber* (as factory for *DataReader*).

This policy is mutable. A change in the policy affects only the entities created after the change; not the previously created entities.

²⁸.So that the sample can be re-sent at a later time.

The setting of *autoenable_created_entities* to TRUE indicates that the factory *create_<entity>* operation will automatically invoke the *enable* operation each time a new *Entity* is created. Therefore, the *Entity* returned by *create_<entity>* will already be enabled. A setting of FALSE indicates that the *Entity* will not be automatically enabled. The application will need to enable it explicitly by means of the *enable* operation (see Section 2.1.2.1.1.7).

The default setting of *autoenable_created_entities* = TRUE means that, by default, it is not necessary to explicitly call *enable* on newly created entities.

2.1.3.20 WRITER_DATA_LIFECYCLE

This policy controls the behavior of the *DataWriter* with regards to the lifecycle of the data-instances it manages, that is, the data-instances that have been either explicitly registered with the *DataWriter* using the *register* operations (see Section 2.1.2.4.2.5 and Section 2.1.2.4.2.6) or implicitly by directly writing the data (see Section 2.1.2.4.2.10 and Section 2.1.2.4.2.11).

The *autodispose_unregistered_instances* flag controls the behavior when the *DataWriter* unregisters an instance by means of the *unregister* operations (see Section 2.1.2.4.2.7 and Section 2.1.2.4.2.8):

- The setting '*autodispose_unregistered_instances* = FALSE' causes the *DataWriter* to dispose the instance each time it is unregistered. The behavior is identical to explicitly calling one of the *dispose* operations (Section 2.1.2.4.2.12 and Section 2.1.2.4.2.13) on the instance prior to calling the *unregister* operation.
- The setting '*autodispose_unregistered_instances* = FALSE' will not cause this automatic disposition upon unregistering. The application can still call one of the *dispose* operations prior to unregistering the instance and accomplish the same effect. Refer to Section 2.1.3.22.3 for a description of the consequences of disposing and unregistering instances.

Note that the deletion of a *DataWriter* automatically unregisters all data-instances it manages (Section 2.1.2.4.1.6). Therefore the setting of the *autodispose_unregistered_instances* flag will determine whether instances are ultimately disposed when the *DataWriter* is deleted either directly by means of the *Publisher::delete_datawriter* operation or indirectly as a consequence of calling *delete_contained_entities* on the *Publisher* or the *DomainParticipant* that contains the *DataWriter*.

2.1.3.21 READER_DATA_LIFECYCLE

This policy controls the behavior of the *DataReader* with regards to the lifecycle of the data-instances it manages, that is, the data-instances that have been received and for which the *DataReader* maintains some internal resources.

The *DataReader* internally maintains the samples that have not been taken by the application, subject to the constraints imposed by other QoS policies such as HISTORY and RESOURCE_LIMITS.

The *DataReader* also maintains information regarding the identity, *view_state* and *instance_state* of data-instances even after all samples have been ‘taken.’ This is needed to properly compute the states when future samples arrive.

Under normal circumstances the *DataReader* can only reclaim all resources for instances that *view_state* = NOT_ALIVE_NO_WRITERS and for which all samples have been ‘taken.’ This behavior can cause problems if the application “forgets” to ‘take’ those samples. The ‘untaken’ samples will prevent the *DataReader* from reclaiming the resources and they would remain in the *DataReader* indefinitely.

The *autopurge_nowriter_samples_delay* defines the maximum duration for which the *DataReader* will maintain information regarding an instance once its *view_state* becomes NOT_ALIVE_NO_WRITERS. After this time elapses, the *DataReader* will purge all internal information regarding the instance, any untaken samples will also be lost.

2.1.3.22 Relationship between registration, LIVELINESS, and OWNERSHIP

The need for registering/unregistering instances stems from two use cases:

- Ownership resolution on redundant systems.
- Detection of loss in topological connectivity.

These two use cases also illustrate the semantic differences between the *unregister* and *dispose* operations on a *DataWriter*.

2.1.3.22.1 Ownership resolution on redundant systems

It is expected that users may use DDS to set up redundant systems where multiple *DataWriter* entities are “capable” of writing the same instance. In this situation the *DataWriter* entities are configured such that:

- Either both are writing the instance “constantly” or
- else they use some mechanism to classify each other as “primary” and “secondary,” such that the primary is the only one writing, and the secondary monitors the primary and only writes when it detects that the primary “writer” is no longer writing.

Both cases above use the OWNERSHIP policy kind EXCLUSIVE and arbitrate themselves by means of the OWNERSHIP_STRENGTH. Regardless of the scheme, the desired behavior from the *DataReader* point of view is that reader normally receives data from the primary unless the “primary” writer stops writing in which case the reader starts to receive data from the secondary *DataWriter*.

This approach requires some mechanism to detect that a *DataWriter* (the primary) is no longer “writing” the data as it should. There are several reasons why this may be happening and all must be detected but not necessarily distinguished:

1. [crash] The writing process is no longer running (e.g., the whole application has crashed).
2. [connectivity loss] Connectivity to the writing application has been lost (e.g., network got disconnected).

3. [application fault] The application logic that was writing the data is faulty and has stopped calling the “write” operation on the *DataWriter*.

Arbitrating from a *DataWriter* to one of a higher strength is simple and the decision can be taken autonomously by the *DataReader*. Switching ownership from a higher strength *DataWriter* to one of a lower strength *DataWriter* requires that the *DataReader* can make a determination that the stronger *DataWriter* is “no longer writing the instance.”

2.1.3.22.1.1 Case where the data is periodically updated

This determination is reasonably simple when the data is being written periodically at some rate. The *DataWriter* simply states its offered DEADLINE (maximum interval between updates) and the *DataReader* automatically monitors that the *DataWriter* indeed updates the instance at least once per deadline *period*. If the deadline is missed, the *DataReader* considers the *DataWriter* “not alive” and automatically gives ownership to the next highest-strength *DataWriter* that is alive.

2.1.3.22.1.2 Case where data is not periodically updated

The case where the *DataWriter* is not writing data periodically is also a very important use-case. Since the instance is not being updated at any fixed period, the “deadline” mechanism cannot be used to determine ownership. The liveliness solves this situation. Ownership is maintained while the *DataWriter* is “alive” and for the *DataWriter* to be alive it must fulfill its “LIVELINESS” QoS contract. The different means to renew liveliness (automatic, manual) combined by the implied renewal each time data is written handle the three conditions above [crash], [connectivity loss], and [application fault]. Note that to handle [application fault] LIVELINESS must be MANUAL_BY_TOPIC. The *DataWriter* can retain ownership by periodically writing data or else calling *assert_liveliness* if it has no data to write. Alternatively if only protection against [crash] or [connectivity loss] is desired, it is sufficient that some task on the writer process periodically writes data or calls *assert_liveliness* on the *DomainParticipant*.

However, this scenario requires that the *DataReader* knows what instances are being “written” by the *DataWriter*. That is the only way that the *DataReader* deduces the ownership of specific instances from the fact that the *DataWriter* is still “alive.” Hence the need for the writer to “register” and “unregister” instances. Note that while “registration” can be done lazily the first time the *DataWriter* writes the instance, “unregistration” in general cannot. Similar reasoning will lead to the fact that unregistration will also require a message to be sent to the readers.

2.1.3.22.2 Detection of loss in topological connectivity

There are applications that are designed in such a way that their correct operation requires some minimal topological connectivity, that is, the writer needs to have a minimum number of readers or alternatively the reader must have a minimum number of writers.

A common scenario is that the application does not start doing its logic until it knows that some specific writers have the minimum configured readers (e.g., the alarm monitor is up).

A more common scenario is that the application logic will wait until some writers appear that can provide some needed source of information (e.g., the raw sensor data that must be processed).

Furthermore once the application is running it is a requirement that this minimal connectivity (from the source of the data) is monitored and the application informed if it is ever lost. For the case where data is being written periodically, the DEADLINE QoS and the *on_deadline_missed* listener provides the notification. The case where data is not periodically updated requires the use of the LIVELINESS in combination with register/unregister instance to detect whether the “connectivity” has been lost, and the notification is provided by means of the “NO_WRITERS” view state.

In terms of the required mechanisms the scenario is very similar to the case of maintaining ownership. In both cases the reader needs to know whether a writer is still “managing the current value of an instance” even though it is not continually writing it and this knowledge requires the writer to keep its liveliness plus some means to know which instances the writer is currently “managing” (i.e., the registered instances).

2.1.3.22.3 Semantic difference between unregister and dispose

The *DataWriter* operation *dispose* is semantically different from *unregister*. The *dispose* operation indicates that the data-instance no longer exists (e.g., a track that has disappeared, a simulation entity that has been destroyed, a record entry that has been deleted, etc.) whereas the *unregister* operation indicates that the writer is no longer taking responsibility for updating the value of the instance.

Deleting a *DataWriter* is equivalent to unregistering all the instances it was writing, but is not the same as “disposing” all the instances.

For a *Topic* with EXCLUSIVE OWNERSHIP if the current owner of an instance disposes it, the readers accessing the instance will see the *instance_state* as being “DISPOSED” and not see the values being written by the weaker writer (even after the stronger one has disposed the instance). This is because the *DataWriter* that owns the instance is saying that the instance no longer exists (e.g., the master of the database is saying that a record has been deleted) and thus the readers should see it as such.

For a *Topic* with EXCLUSIVE OWNERSHIP if the current owner of an instance unregisters it, then it will relinquish ownership of the instance and thus the readers may see the value updated by another writer (which will then become the owner). This is because the owner said that it no longer will be providing values for the instance and thus another writer can take ownership and provide those values.

2.1.4 Listeners, Conditions and Wait-sets

Listeners and conditions (in conjunction with wait-sets) are two alternative mechanisms that allow the application to be made aware of changes in the DCPS communication status.

2.1.4.1 Communication Status

The communication statuses whose changes can be communicated to the application depend on the *Entity*. The following table shows for each entity the statuses that are relevant.

Entity	Status Name	Meaning
Topic	INCONSISTENT_TOPIC	Another topic exists with the same name but different characteristics.
Subscriber	DATA_ON_READERS	New information is available.
DataReader	SAMPLE_REJECTED	A (received) sample has been rejected.
	LIVELINESS_CHANGED	The liveliness of one or more <i>DataWriter</i> that were writing instances read through the <i>DataReader</i> has changed. Some <i>DataWriter</i> have become “active” or “inactive.”
	REQUESTED_DEADLINE_MISSED	The deadline that the <i>DataReader</i> was expecting through its <i>QoSPolicy</i> DEADLINE was not respected for a specific instance.
	REQUESTED_INCOMPATIBLE_QOS	A <i>QoSPolicy</i> value was incompatible with what is offered.
	DATA_AVAILABLE	New information is available.
	SAMPLE_LOST	A sample has been lost (never received).
	SUBSCRIPTION_MATCH	The <i>DataReader</i> has found a <i>DataWriter</i> that matches the <i>Topic</i> and has compatible QoS.
DataWriter	LIVELINESS_LOST	The liveliness that the <i>DataWriter</i> has committed through its <i>QoSPolicy</i> LIVELINESS was not respected; thus <i>DataReader</i> entities will consider the <i>DataWriter</i> as no longer “active.”
	OFFERED_DEADLINE_MISSED	The deadline that the <i>DataWriter</i> has committed through its <i>QoSPolicy</i> DEADLINE was not respected for a specific instance.
	OFFERED_INCOMPATIBLE_QOS	A <i>QoSPolicy</i> value was incompatible with what was requested.
	PUBLICATION_MATCH	The <i>DataWriter</i> has found <i>DataReader</i> that matches the <i>Topic</i> and has compatible QoS.

Those statuses may be classified in:

- read communication statuses: i.e., those that are related to arrival of data, namely DATA_ON_READERS and DATA_AVAILABLE;
- plain communication statuses: i.e., all the others.

Read communication statuses are treated slightly differently than the others for they don't change independently. In other words, at least two changes will appear at the same time (DATA_ON_READERS + DATA_AVAILABLE) and even several of the last kind may be part of the set. This ‘grouping’ has to be communicated to the application. How this is done is discussed in each of the two following sections.

For each plain communication status, there is a corresponding structure to hold the status value. These values contain the information related to the change of status, as well as information related to the statuses themselves (e.g., contains cumulative counts). They are used with the two different mechanisms explained in the following sections.

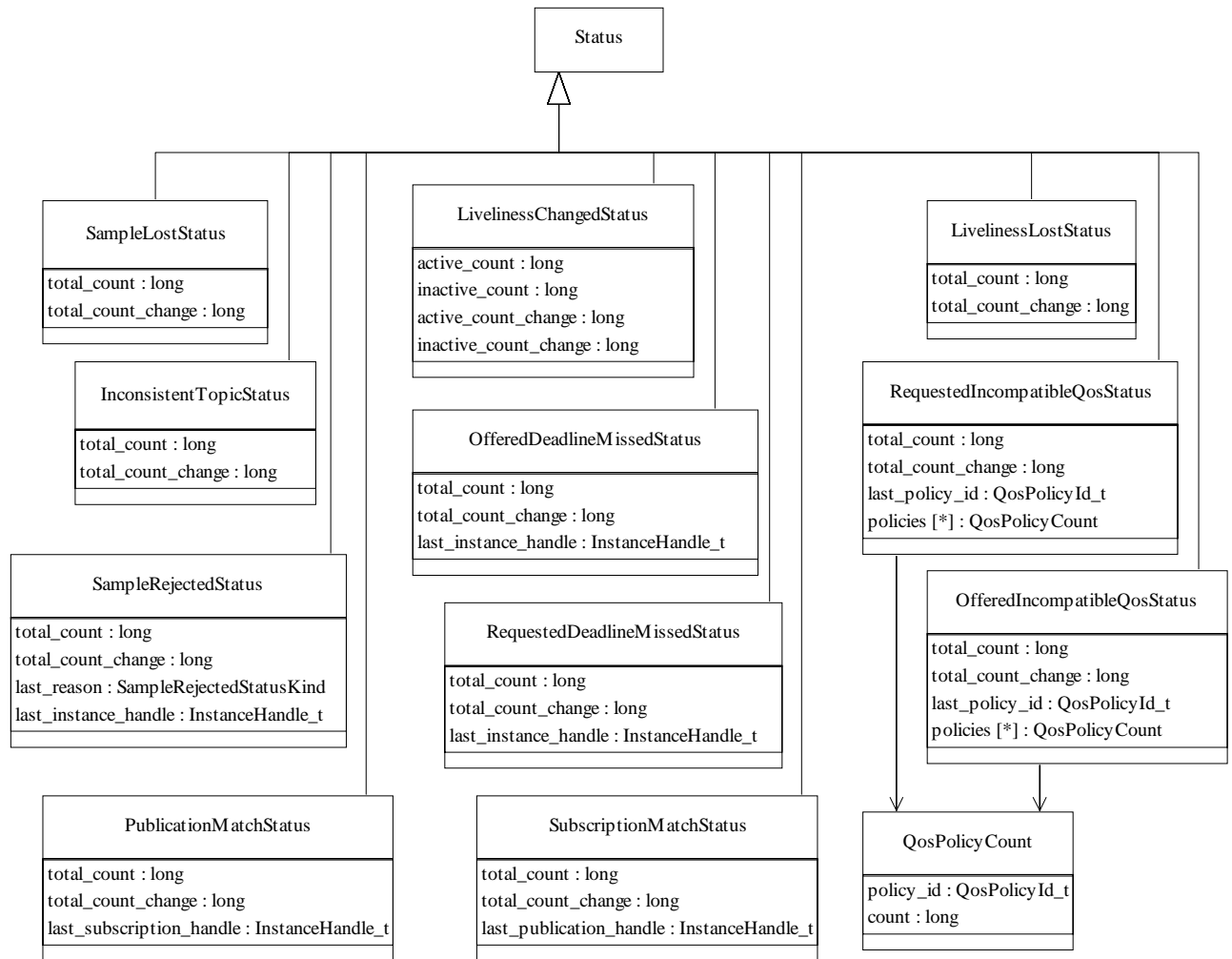


Figure 2-13 Status Values

The interpretation of the attributes for each status value is provided in the following table.

SampleLostStatus	Attribute meaning
total_count	Total cumulative count of all samples lost across of instances of data published under the <i>Topic</i> .
total_count_change	The incremental number of samples lost since the last time the listener was called or the status was read
SampleRejectedStatus	Attribute meaning
total_count	Total cumulative count of samples rejected by the DataReader
total_count_change	The incremental number of samples rejected since the last time the listener was called or the status was read
last_reason	Reason for rejecting the last sample rejected.
last_instance_handle	Handle to the instance being updated by the last sample that was rejected.
InconsistentTopicStatus	Attribute meaning
total_count	Total cumulative count of the Topics discovered whose name matches the Topic to which this status is attached and whose type is inconsistent with the Topic.
total_count_change	The incremental number of inconsistent topics discovered since the last time the listener was called or the status was read.
LivelinessChangedStatus	Attribute meaning
active_count	The total count of currently active DataWriters that write the Topic the DataReader reads.
inactive_count	The total count of currently inactive DataWriters that write the Topic the DataReader reads.
active_count_change	The change in the active_count since the last time the listener was called or the status was read.
inactive_count_change	The change in the inactive_count since the last time the listener was called or the status was read.
RequestedDeadlineMissedStatus	Attribute meaning
total_count	Total cumulative count of the missed deadlines detected for any instance read by the DataReader. Missed deadlines accumulate, that is, each deadline period the <i>total_count</i> will be incremented by one for each instance for which data was not received.
total_count_change	The incremental number of deadlines detected since the last time the listener was called or the status was read.
last_instance_handle	Handle to the last instance in the DataReader for which a deadline was detected.
RequestedIncompatibleQosStatus	Attribute meaning
total_count	Total cumulative count the concerned DataReader discovered a DataWriter for the same Topic with an offered QoS that was incompatible with that requested by the DataReader.
total_count_change	The change in total_count since the last time the listener was called or the status was read.
last_policy_id	The QosPolicyId_t of one of the policies that was found to be incompatible the last time an incompatibility was detected.

polices	A list containing for each policy the total number of times that the concerned DataReader discovered a DataWriter for the same Topic with an offered QoS that is incompatible with that requested by the DataReader.
LivelinessLostStatus	Attribute meaning
total_count	Total cumulative count of the number of times the DataWriter failed to actively signal its liveliness within the offered liveliness period.
total_count_change	The change in total_count since the last time the listener was called or the status was read.
OfferedDeadlineMissedStatus	Attribute meaning
total_count	Total cumulative number of times the DataWriter failed to write within its offered deadline.
total_count_change	The change in total_count since the last time the listener was called or the status was read.
last_instance_handle	Handle to the last instance in the DataWriter for which an offered deadline was missed.
OfferedIncompatibleQosStatus	Attribute meaning
total_count	Total cumulative number of times the concerned DataWriter discovered a DataReader for the same Topic with a requested QoS that is incompatible with that offered by the DataWriter.
total_count_change	The change in total_count since the last time the listener was called or the status was read.
last_policy_id	The PolicyId_t of one of the policies that was found to be incompatible the last time an incompatibility was detected.
polices	A list containing for each policy the total number of times that the concerned DataWriter discovered a DataReader for the same Topic with a requested QoS that is incompatible with that offered by the DataWriter.
PublicationMatchStatus	Attribute meaning
total_count	Total cumulative count the concerned DataWriter discovered a “match” with a DataReader. That is, it found a DataReader for the same Topic with a requested QoS that is compatible with that offered by the DataWriter.
total_count_change	The change in total_count since the last time the listener was called or the status was read.
last_subscription_handle	Handle to the last DataReader that matched the DataWriter causing the status to change.
SubscriptionMatchStatus	Attribute meaning
total_count	Total cumulative count the concerned DataReader discovered a “match” with a DataWriter. That is, it found a DataWriter for the same Topic with a requested QoS that is compatible with that offered by the DataReader.
total_count_change	The change in total_count since the last time the listener was called or the status was read.
last_publication_handle	Handle to the last DataWriter that matched the DataReader causing the status to change.

2.1.4.2 Changes in Status

Associated with each one of an *Entity*'s communication status is a logical *StatusChangedFlag*. This flag indicates whether that particular communication status has changed since the last time the status was 'read' by the application. The way the status changes is slightly different for the Plain Communication Status and the Read Communication status.

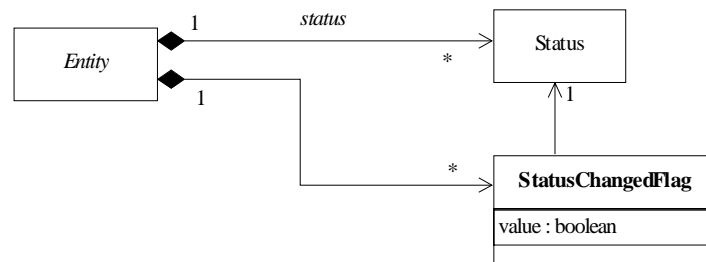


Figure 2-14 StatusChangedFlag indicates if status has changed

Note that Figure 2-14 is only conceptual it simply represents that the *Entity* knows which specific statuses have changed. It does not imply any particular implementation of the *StatusChangedFlag* in terms of boolean values.

2.1.4.2.1 Changes in Plain Communication Status

For the plain communication status, the *StatusChangedFlag* flag is initially set to FALSE. It becomes TRUE whenever the plain communication status changes and it is reset to FALSE each time the application accesses the plain communication status via the proper *get_<plain communication status>* operation on the *Entity*.

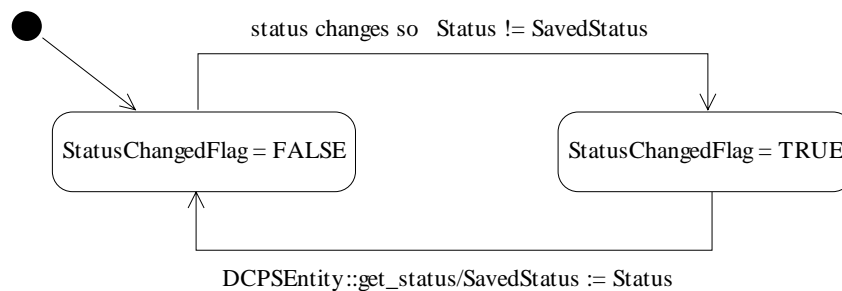


Figure 2-15 Changes in StatusChangedFlag for plain communication status

For example, the value of the *StatusChangedFlag* associated with the REQUESTED_DEADLINE_MISSED status will become TRUE each time new deadline occurs (which increases the *total_count* field within *RequestedDeadlineMissedStatus*). The value changes to FALSE when the application accesses the status via the corresponding *get_requested_deadline_missed_status* method on the proper *Entity*.

2.1.4.2.2 Changes in Read Communication Statuses

For the read communication status, the *StatusChangedFlag* flag is initially set to FALSE. It becomes TRUE when data arrives and it is reset to FALSE when all the data is removed from the responsibility of the middleware via the *take* operation on the proper *DataReader* entities.

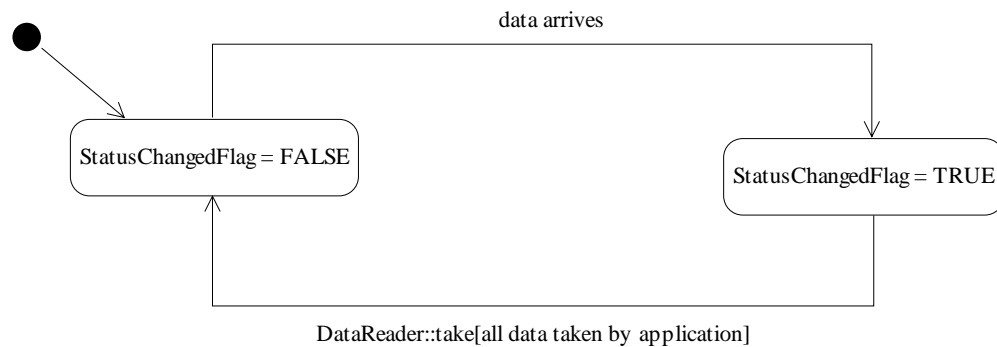


Figure 2-16 Changes in StatusChangedFlag for read communication status

2.1.4.3 Access through Listeners

Listeners provide a mechanism for the middleware to asynchronously alert the application of the occurrence of relevant status changes.

All *Entity* support a listener, which type of which is specialized to the specific type of the related *Entity* (e.g., *DataReaderListener* for the *DataReader*). Listeners are interfaces that the application must implement. Each dedicated listener presents a list of operations that correspond to the relevant communication status changes (i.e., that the application may react to).

All listeners are listed in Figure 2-17, associated with the DCPS constructs that participate in this mechanism (note that only the related operations are displayed).

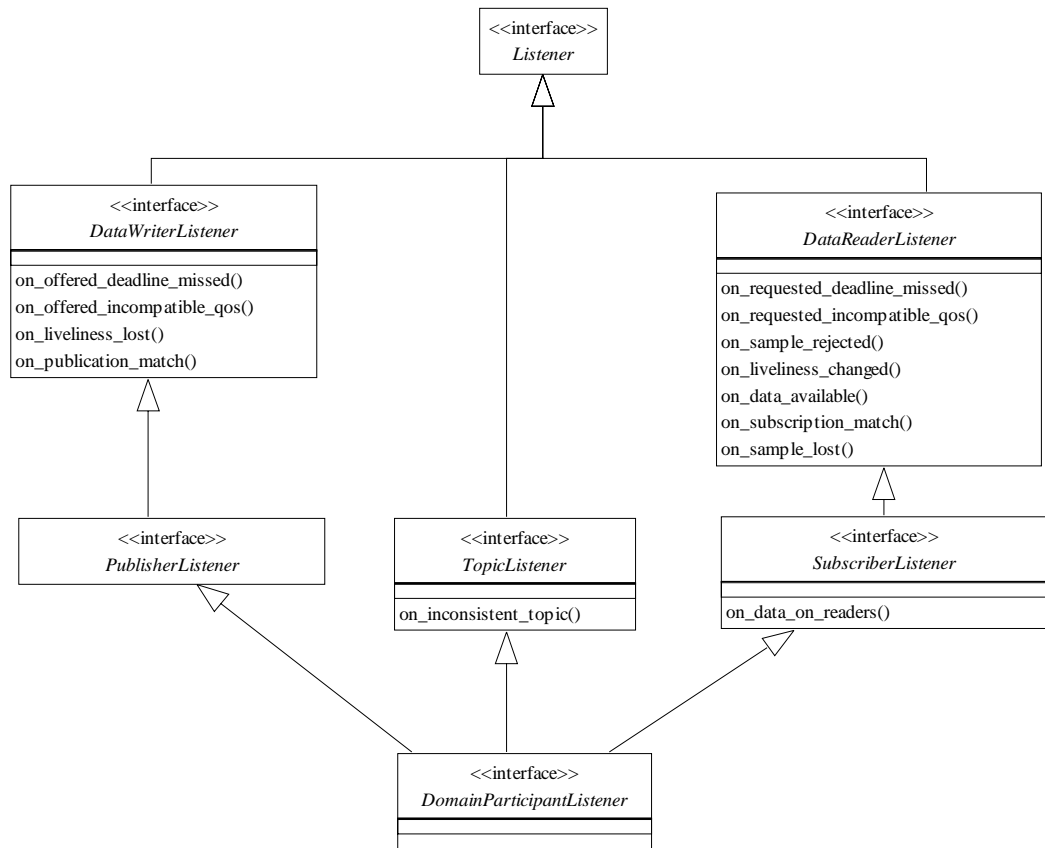


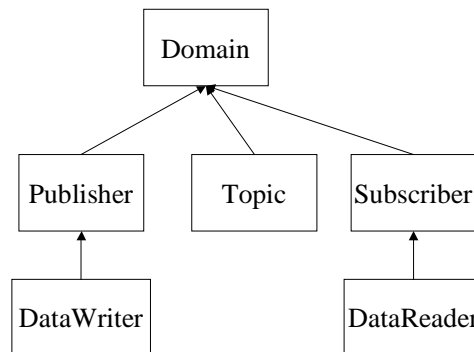
Figure 2-17 Supported DCPS Listeners

Listeners are stateless. It is thus possible to share the same *DataReaderListener* instance among all the *DataReader* objects (assuming that they will react similarly on similar status changes). Consequently, the provided parameter contains a reference to the actual concerned *Entity*.

2.1.4.3.1 Listener Access to Plain Communication Status

The general mapping between the plain communication statuses as explained in Section 2.1.4.1, “Communication Status,” on page 2-116 and the listeners’ operations is as follows:

- For each communication status, there is a corresponding operation whose name is *on_<communication_status>*, which takes a parameter of type *<communication_status>* as listed in Section 2.1.4.1, “Communication Status,” on page 2-116.
- *on_<communication_status>* is available on the relevant *Entity* as well as those that embed it, as expressed on the following figure:



- When the application attaches a listener on an entity, it must set a mask that indicates to the middleware which operations are enabled within this listener (see operation *Entity::set_listener*).
- When a plain communication status changes²⁹, the middleware triggers the most ‘specific’ relevant listener operation that is enabled³⁰.

This behavior allows the application to set a default behavior (e.g., in the listener associated with the *DomainParticipant*) and setting dedicated behaviors only where needed.

2.1.4.3.2 Listener access to Read Communication Status

The two statuses related to data arrival are treated slightly differently. Since they constitute the real purpose of the Data Distribution Service, there is not really a need to provide a default mechanism as for the plain communication statuses, and more importantly, several of them may need to be treated as a whole as explained in Section 2.1.4.1, “Communication Status,” on page 2-116.

The rule is as follows. Each time the read communication status changes³¹:

- First, the middleware tries to trigger the *SubscriberListener* operation *on_data_on_readers* with a parameter of the related *Subscriber*.

29.To be more precise, when the corresponding *StatusChangedFlag* described in “Changes in Plain Communication Status” becomes TRUE.

30.For example, in case of ON_OFFERED_DEADLINE_MISSED for a given *DataWriter*: The *DataWriter*’s listener operation *on_offered_deadline_missed*, or by default (i.e., if there was no listener attached to that *DataWriter*, or if the operation was not enabled), the *Publisher*’s listener or else (no listener attached to the *Publisher* or operation not enabled) the *DomainParticipant*’s listener.

31.To be more precise, when the corresponding *StatusChangedFlag* described in “Changes in Read Communication Statuses” becomes TRUE

- If this does not succeed (no listener or operation non-enabled), it tries to trigger *on_data_available* on all the related *DataReaderListener* objects with as parameter the related *DataReader*.

The rationale is that either the application is interested in relations among data arrivals and it must use the first option (and then get the corresponding *DataReader* objects by calling *get_datareaders* on the related *Subscriber* and then get the data by calling *read/take* on the returned *DataReader* objects³²), or it wants to treat each *DataReader* fully independently and it may choose the second option (and then get the data by calling *read/take* on the related *DataReader*).

Note that if *on_data_on_readers* is called, then the middleware will not try to call *on_data_available*, however, the application can force a call to the *DataReader* objects that have data by means of the *notify_datareaders* operation.

There is no implied “event queuing” in the invocation of the listeners in the sense that, if several changes of status of the same kind occur in sequence, it is not necessary that the DCPS implementation delivers one listener callback per “unit” change. For example, it may occur that the DCPS implementation discovers that the liveliness of a *DataReader* has changed in that several matching *DataWriter* entities have appeared; in that case the DCPS implementation may choose to invoke the *on_liveliness_changed* operation on the *DataReaderListener* just once, as long as the *LivelinessChangedStatus* provided to the listener corresponds to the most current one.

2.1.4.4 Conditions and Wait-sets

As previously mentioned, conditions (in conjunction with wait-sets) provide an alternative mechanism to allow the middleware to communicate communication status changes (including arrival of data) to the application.

Figure 2-18: Wait-sets and Conditions shows all the DCPS constructs that are involved in that mechanism (note that only the related operations are displayed).

32.As detailed in Section 2.1.2.5, “Subscription Module,” on page 2-55.

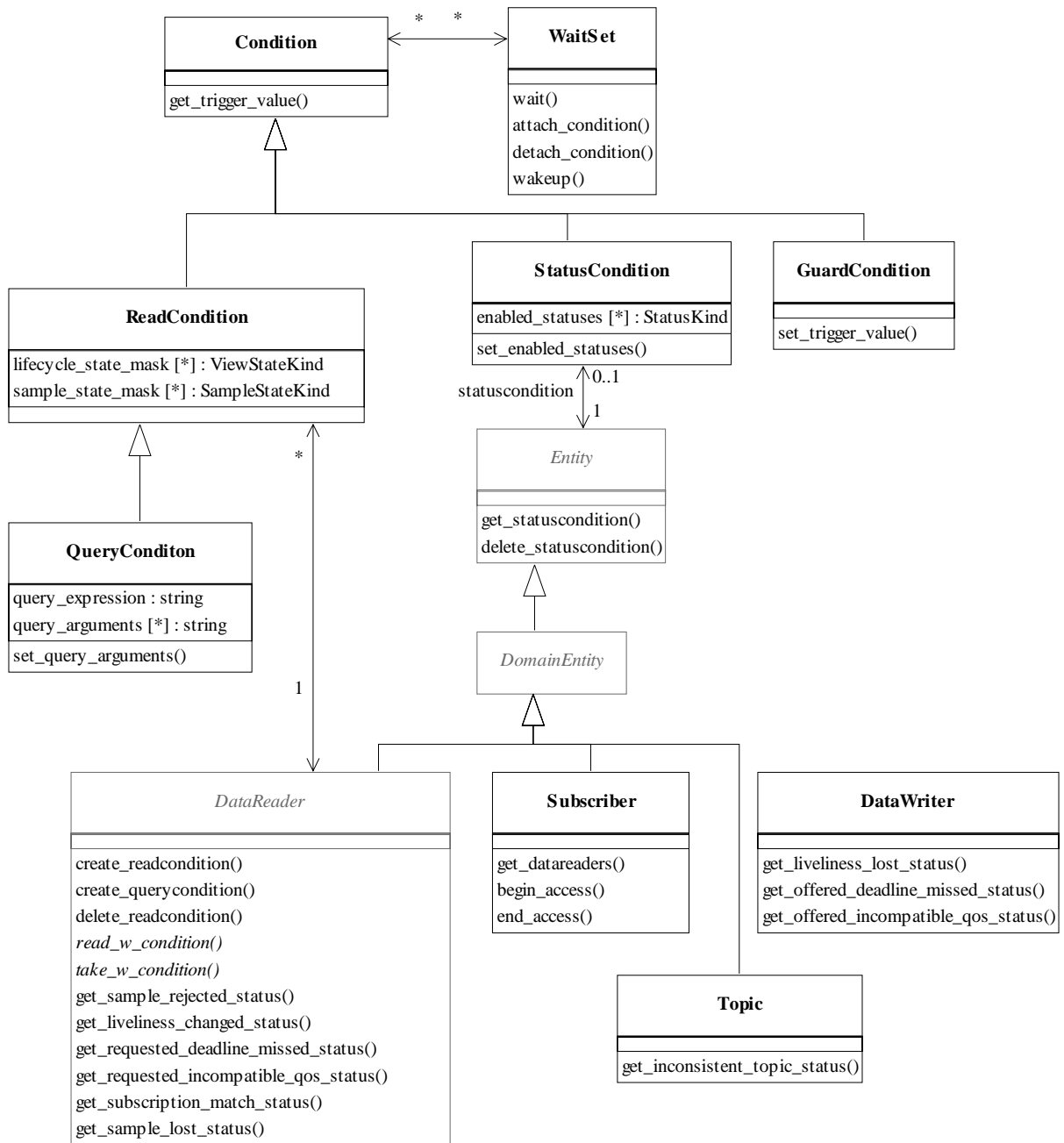


Figure 2-18 Wait-sets and Conditions

This mechanism is wait-based. Its general use pattern is as follows:

- The application indicates which relevant information it wants to get, by creating **Condition** objects (*StatusCondition*, *ReadCondition* or *QueryCondition*³³) and attaching them to a *WaitSet*.

- It then waits on that *WaitSet* until the *trigger_value* of one or several *Condition* objects becomes TRUE.
- It then uses the result of the *wait* (i.e., the list of *Condition* objects with *trigger_value*==TRUE) to actually get the information by calling:
 - *get_status_changes* and then *get_<communication_status>* on the relevant *Entity*, if the condition is a *StatusCondition* and the status changes refer to plain communication status;
 - *get_status_changes* and then *get_datareaders* on the relevant *Subscriber* if the condition is a *StatusCondition* and the status changes refers to DATA_ON_READERS³⁴;
 - *get_status_changes* and then *read/take* on the relevant *DataReader* if the condition is a *StatusCondition* and the status changes refers to DATA_AVAILABLE;
 - directly *read_w_condition/take_w_condition* on the *DataReader* with the *Condition* as a parameter if it is a *ReadCondition* or a *QueryCondition*.

Usually the first step is done in an initialization phase, while the others are put in the application main loop.

As there is no extra information passed from the middleware to the application when a wait returns (only the list of triggered *Condition* objects), *Condition* objects are meant to embed all that is needed to react properly when enabled. In particular, *Entity*-related conditions³⁵ are related to exactly one *Entity* and cannot be shared.

The blocking behavior of the *WaitSet* is illustrated in Figure 2-18. The result of a *wait* operation depends on the state of the *WaitSet*, which in turn depends on whether at least one attached *Condition* has a *trigger_value* of TRUE. If the *wait* operation is called on *WaitSet* with state BLOCKED, it will block the calling thread. If *wait* is called on a *WaitSet* with state UNBLOCKED, it will return immediately. In addition, when the *WaitSet* transitions from BLOCKED to UNBLOCKED it wakes up any threads that had called *wait* on it.

33. See Section 2.1.2.1, "Infrastructure Module," on page 2-10 for general definition of conditions; Section 2.1.2.5, "Subscription Module," on page 2-55 for *ReadCondition* and *QueryCondition*.

34. And then read/take on the returned *DataReader* objects.

35. I.e. *StatusCondition*, *ReadCondition* and *QueryCondition*. See Section 2.1.2.1, "Infrastructure Module," on page 2-10 on the use of basic Condition.

Similar to the invocation of listeners, there is no implied “event queuing” in the awakening of a `WaitSet` in the sense that, if several `Condition`s attached to the `WaitSet` have their `trigger_value` transition to `TRUE` in sequence the DCPS implementation needs to only unblock the `WaitSet` once.

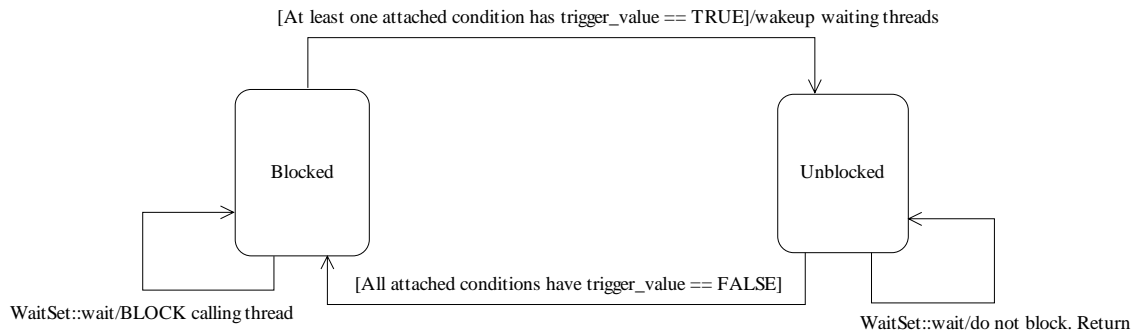


Figure 2-19 Blocking behavior of `WaitSet`

A key aspect of the *Condition/WaitSet* mechanism is the setting of the *trigger_value* of each *Condition*.

2.1.4.4.1 Trigger State of the *StatusCondition*

The *trigger_value* of a *StatusCondition* is the Boolean OR of the *ChangedStatusFlag* of all the communication statuses to which it is sensitive. That is, *trigger_value*==`FALSE` only if all the values of the *ChangedStatusFlags* are `FALSE`.

The sensitivity of the *StatusCondition* to a particular communication status is controlled by the list of *enabled_statuses* set on the condition by means of the *set_enabled_statuses* operation.

2.1.4.4.2 Trigger State of the *ReadCondition*

Similar to the *StatusCondition*, a *ReadCondition* also has a *trigger_value* that determines whether the attached *WaitSet* is `BLOCKED` or `UNBLOCKED`. However, unlike the *StatusCondition*, the *trigger_value* of the *ReadCondition* is tied to the presence of at least a sample managed by the Service with *SampleState*, *ViewState*, and *InstanceState* matching those of the *ReadCondition*. Furthermore, for the *QueryCondition* to have a *trigger_value*==`TRUE`, the data associated with the sample must be such that the *query_expression* evaluates to `TRUE`.

The fact that the *trigger_value* of a *ReadCondition* is dependent on the presence of samples on the associated *DataReader* implies that a single take operation can potentially change the *trigger_value* of several *ReadCondition* or *QueryCondition* conditions. For example, if all samples are taken, any *ReadCondition* and *QueryCondition* conditions associated with the *DataReader* that had their *trigger_value*==`TRUE` before will see the *trigger_value* change to `FALSE`. Note that this does not guarantee that *WaitSet* objects that were separately attached to those conditions will not be woken up. Once we have *trigger_value*==`TRUE` on a condition it may wake

up the attached *WaitSet*, the condition transitioning to *trigger_value*==FALSE does not necessarily ‘unwakeup’ the *WaitSet* as ‘unwakening’ may not be possible in general. The consequence is that an application blocked on a *WaitSet* may return from the wait with a list of conditions some of which are no longer “active.” This is unavoidable if multiple threads are concurrently waiting on separate *WaitSet* objects and taking data associated with the same *DataReader* entity.

To elaborate further, consider the following example: A *ReadCondition* that has a *sample_state_mask* = {NOT_READ}, *view_state_mask* = {NEW} will have *trigger_value* of TRUE whenever a new sample arrives and will transition to FALSE as soon as all the NEW samples are either read (so their status changes to READ) or taken (so they are no longer managed by the Service). However if the same *ReadCondition* had a *sample_state_mask* = {READ, NOT_READ}, then the *trigger_value* would only become FALSE once all the new samples are taken (it is not sufficient to read them as that would only change the *SampleState* to READ but the sample would still have (*SampleState*, *ViewState*) = (READ, NEW), which overlaps the mask on the *ReadCondition*.

2.1.4.4.3 Trigger State of the GuardCondition

The *trigger_value* of a *GuardCondition* is completely controlled by the application via operation *set_trigger_value*.

2.1.4.5 Combination

Those two mechanisms may be combined in the application (e.g., using wait-sets and conditions to access the data and listeners to be warned asynchronously of erroneous communication statuses).

It is likely that the application will choose one or the other mechanism for each particular communication status (not both). However, if both mechanisms are enabled, then the listener mechanism is used first and then the *WaitSet* objects are signalled.

2.1.5 Built-in Topics

As part of its operation, the middleware must discover and possibly keep track of the presence of remote entities such as a new participant in the domain. This information may also be important to the application, which may want to react to this discovery, or else access it on demand.

To make this information accessible to the application, the DCPS specification introduces a set of built-in topics and corresponding *DataReader* objects that can then be used by the application. The information is then accessed as if it was normal application data. This approach avoids introducing a new API to access this information and allows the application to become aware of any changes in those values by means of any of the mechanisms presented in Section 2.1.4, “Listeners, Conditions and Wait-sets,” on page 2-115.

The built-in data-readers all belong to a built-in *Subscriber*. This subscriber can be retrieved by using the method *get_builtin_subscriber* provided by the *DomainParticipant*. The built-in *DataReader* objects can be retrieved by using the operation *get_datareader*, with the Subscriber and the topic name as parameters.

The QoS of the built-in *Subscriber* and *DataReader* objects is listed in the following table:

USER_DATA	<unspecified>
TOPIC_DATA	<unspecified>
GROUP_DATA	<unspecified>
DURABILITY	TRANSIENT
PRESENTATION	access_scope = TOPIC coherent_access = FALSE ordered_access = FALSE
DEADLINE	Period = infinite
LATENCY_BUDGET	duration = <unspecified>
OWNERSHIP	SHARED
OWNERSHIP_STRENGTH	<unspecified>
LIVELINESS	kind = AUTOMATIC lease_duration = <unspecified>
TIME_BASED_FILTER	minimum_separation = 0
PARTITION	<unspecified>
RELIABILITY	kind = RELIABLE
TRANSPORT_PRIORITY	value=0
LIFESPAN	duration = infinite
DESTINATION_ORDER	BY_RECEPTION_TIMESTAMP
HISTORY	kind = KEEP_LAST depth = 1
RESOURCE_LIMITS	All unlimited.

The information that is accessible about the remote entities by means of the built-in topics includes all the QoS policies that apply to the corresponding remote Entity. These QoS policies appear as normal 'data' fields inside the data read by means of the built-in Topic. Additional information is provided to identify the Entity and facilitate the application logic.

The table below lists the built-in topics, their names, and the additional information--beyond the QoS policies that apply to the remote entity--that appears in the data associated with the built-in topic.

Topic name	Field Name	Type	Meaning
DCPSParticipant (entry created when a <i>DomainParticipant</i> object is created)	key	BuiltinTopicKey_t	DCPS key to distinguish entries
	user_data	UserDataQosPolicy	Policy of the corresponding <i>DomainParticipant</i>
DCPSTopic (entry created when a <i>Topic</i> object is created)	key	BuiltinTopicKey_t	DCPS key to distinguish entries
	name	string	Name of the <i>Topic</i>
	type_name	string	Name of the type attached to the <i>Topic</i>
	durability	DurabilityQosPolicy	Policy of the corresponding <i>Topic</i>
	deadline	DeadlineQosPolicy	Policy of the corresponding <i>Topic</i>
	latency_budget	LatencyBudgetQosPolicy	Policy of the corresponding <i>Topic</i>
	liveliness	LivelinessQosPolicy	Policy of the corresponding <i>Topic</i>
	reliability	ReliabilityQosPolicy	Policy of the corresponding <i>Topic</i>
	transport_priority	TransportPriorityQosPolicy	Policy of the corresponding <i>Topic</i>
	lifespan	LifespanQosPolicy	Policy of the corresponding <i>Topic</i>
	destination_order	DestinationOrderQosPolicy	Policy of the corresponding <i>Topic</i>
	history	HistoryQosPolicy	Policy of the corresponding <i>Topic</i>
	resource_limits	ResourceLimitsQosPolicy	Policy of the corresponding <i>Topic</i>
ownership	OwnershipQosPolicy	Policy of the corresponding <i>Topic</i>	
topic_data	TopicDataQosPolicy	Policy of the corresponding <i>Topic</i>	

Topic name	Field Name	Type	Meaning
DCPSPublication (entry created when a <i>DataWriter</i> is created in association with its <i>Publisher</i>)	key	BuiltinTopicKey_t	DCPS key to distinguish entries.
	participant_key	BuiltinTopicKey_t	DCPS key of the participant to which the <i>DataWriter</i> belongs.
	topic_name	string	Name of the related <i>Topic</i> .
	type_name	string	Name of the type attached to the related <i>Topic</i> .
	durability	DurabilityQosPolicy	Policy of the corresponding <i>DataWriter</i>
	deadline	DeadlineQosPolicy	Policy of the corresponding <i>DataWriter</i>
	latency_budget	LatencyBudgetQosPolicy	Policy of the corresponding <i>DataWriter</i>
	liveliness	LivelinessQosPolicy	Policy of the corresponding <i>DataWriter</i>
	reliability	ReliabilityQosPolicy	Policy of the corresponding <i>DataWriter</i>
	lifespan	LifespanQosPolicy	Policy of the corresponding <i>DataWriter</i>
	user_data	UserDataQosPolicy	Policy of the corresponding <i>DataWriter</i>
	ownership_strength	OwnershipStrengthQosPolicy	Policy of the corresponding <i>DataWriter</i>
	presentation	PresentationQosPolicy	Policy of the <i>Publisher</i> to which the <i>DataWriter</i> belongs.
	partition	PartitionQosPolicy	Policy of the <i>Publisher</i> to which the <i>DataWriter</i> belongs.
topic_data	TopicDataQosPolicy	Policy of the related <i>Topic</i> .	
group_data	GroupDataQosPolicy	Policy of the <i>Publisher</i> to which the <i>DataWriter</i> belongs.	
DCPSSubscription (entry created when a <i>DataReader</i> is created in association with its <i>Subscriber</i>)	key	BuiltinTopicKey_t	DCPS key to distinguish entries.
	participant_key	BuiltinTopicKey_t	DCPS key of the participant to which the <i>DataReader</i> belongs.
	topic_name	string	Name of the related <i>Topic</i> .
	type_name	string	Name of the type attached to the related <i>Topic</i> .
	durability	DurabilityQosPolicy	Policy of the corresponding <i>DataReader</i> .
	deadline	DeadlineQosPolicy	Policy of the corresponding <i>DataReader</i> .
	latency_budget	LatencyBudgetQosPolicy	Policy of the corresponding <i>DataReader</i> .
	liveliness	LivelinessQosPolicy	Policy of the corresponding <i>DataReader</i> .
	reliability	ReliabilityQosPolicy	Policy of the corresponding <i>DataReader</i> .
	destination_order	DestinationOrderQosPolicy	Policy of the corresponding <i>DataReader</i> .
	user_data	UserDataQosPolicy	Policy of the corresponding <i>DataReader</i> .
	time_based_filter	TimeBasedFilterQosPolicy	Policy of the corresponding <i>DataReader</i> .
	presentation	PresentationQosPolicy	Policy of the <i>Subscriber</i> to which the <i>DataReader</i> belongs.
	partition	PartitionQosPolicy	Policy of the <i>Subscriber</i> to which the <i>DataReader</i> belongs.
topic_data	TopicDataQosPolicy	Policy of the related <i>Topic</i> .	
group_data	GroupDataQosPolicy	Policy of the <i>Subscriber</i> to which the <i>DataReader</i> belongs.	

2.1.6 *Interaction Model*

Two interaction models are shown here to illustrate the behavior of the DCPS. The first one concerns publication, the second one subscription.

It should be noted that these models are not intended to explain how the Service is implemented. In particular, what happens on the right side of the picture (e.g., which components actually send the notifications) should be understood as how it *may* work rather than how it *actually does* work (as written inside quotes on the diagrams).

2.1.6.1 Publication View

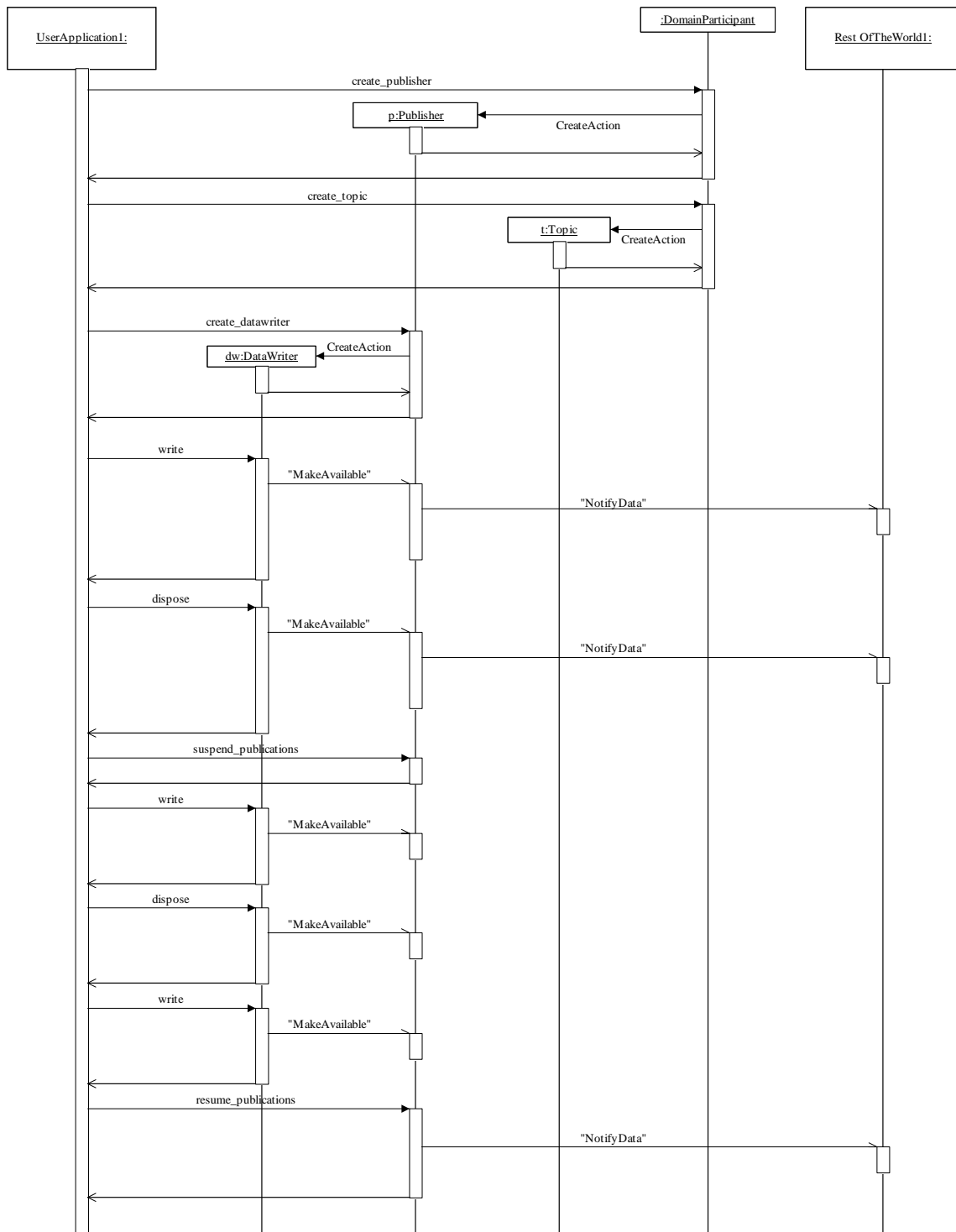


Figure 2-20 DCPS Interaction Model (Publication)

The first part of Figure 2-20 shows the *Publisher*'s creation. The second part shows that topics must be created before they are referred to by a *DataWriter*. It should be noted that the topic creation can be requested by a different actor than the one that will use it afterward (in that case, it has to be searched by *TopicFactory::get_topic*).

The third part of Figure 2-21 shows the *DataWriter*'s creation. Then, a *write* and a *dispose* operation are issued on the *DataWriter*, which immediately informs the *Publisher*. Since the application has not invoked the *suspend_publications* operation on the *Publisher*, the corresponding notifications are propagated according to the current *Publisher*'s policy regarding sending.³⁶

The last part of Figure 2-21 shows the same kind of interactions embedded into a pair of *suspend_publications/resume_publications*. It is important to take into account that the corresponding notifications are now delayed until the last *resume_publications*. It should also be noted that even if the diagram shows only one *DataWriter*, several of them could be bracketed within a suspend/resume pair.

2.1.6.2 Subscription View

On the subscription side, two diagrams are given. The first one (see Figure 2-21) shows how it works when listeners are used, while the second (see Figure 2-22) shows the use of conditions and wait-sets.

2.1.6.2.1 Notification via Listeners

The first part of Figure 2-21 shows the *Subscriber*'s and the *DataReader*'s creation by means of the *DomainParticipant*.

The second part shows the use of a *SubscriberListener*: It must first be created and attached to the *Subscriber* (*set_listener*). Then when data arrives, it is made available to each related *DataReader*. Then the *SubscriberListener* is triggered (*on_data_on_readers*). The application must then get the list of affected *DataReader* objects (*get_datareaders*); then it can *read/take* the data directly on these objects.

Alternatively, the third part of the diagram shows the use of *DataReaderListener* objects that are first created and attached to the readers. When data is made available on a *DataReader*, the related listener is triggered and data can be read (*read/take*). It should be noted that, in this case, no link between readers can be retrieved.

Note – When the two kinds of listeners are set, the *SubscriberListener* supersedes the *DataReaderListener* ones.

³⁶Usually, this means that the notifications are sent immediately.

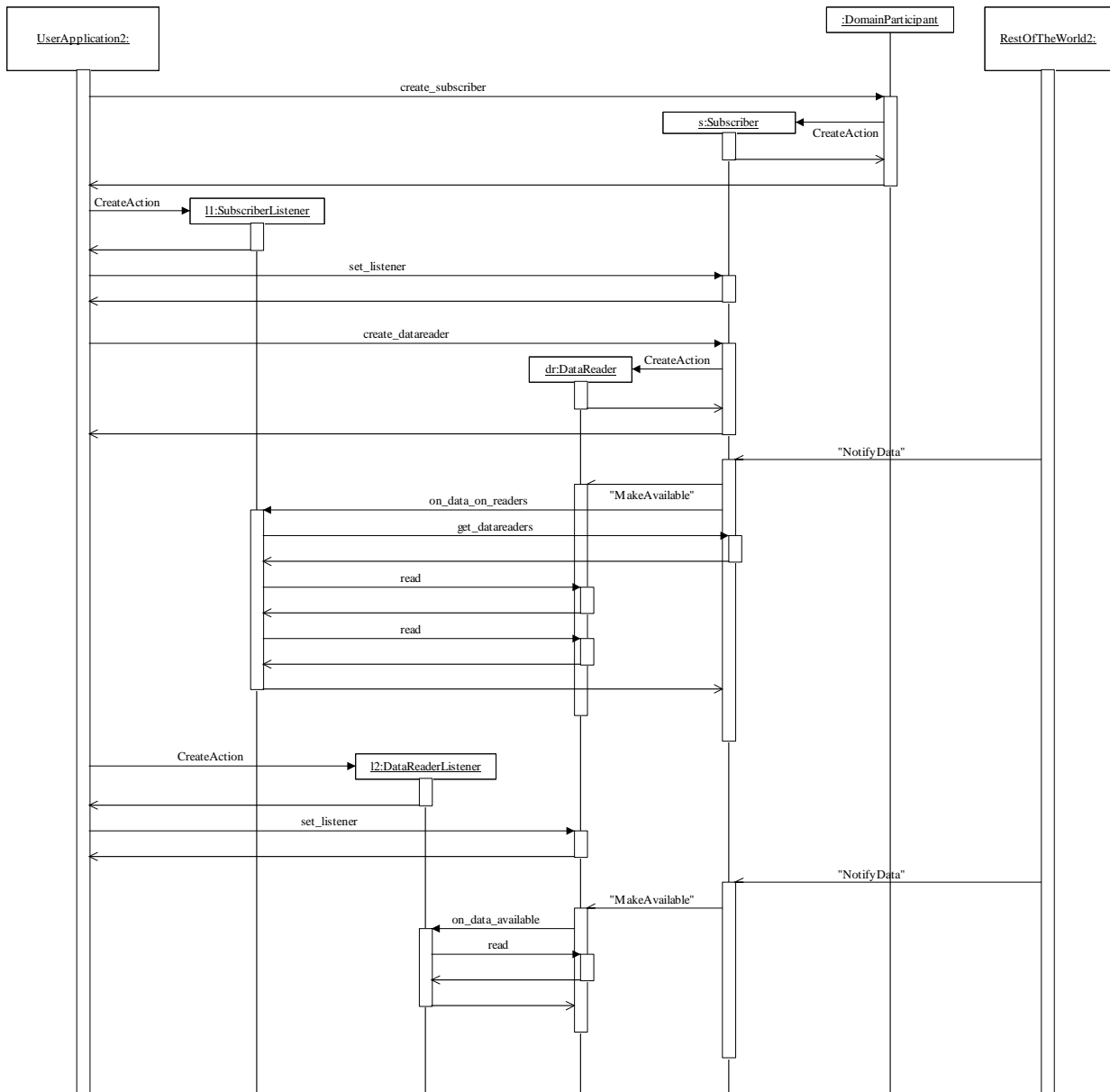


Figure 2-21 DCPS Interaction Model (Subscription with Listeners)

2.1.6.2.2 Notifications via Conditions and Wait-Sets

The first part of Figure 2-21 shows the *Subscriber*'s and the *DataReader*'s creation by means of the *DomainParticipant*.

The second part shows the creation of a *WaitSet* and a *ReadCondition*, the attachment of the latter to the former, and the call to the *WaitSet::wait* operation. Note that it is likely that several conditions (*ReadCondition*, but also *StatusCondition*) will be created and attached to the same *WaitSet*.

The third part of the diagram shows the information flow when data is received. Note that the *wait* returns the list of all the enabled conditions, in an arrival cycle: in case several *DataReader* objects receive available data, several conditions will be set enabled at the same time and the application will perform several *read* accordingly.

Note – With conditions and wait-sets, read operations are executed naturally in the user context.

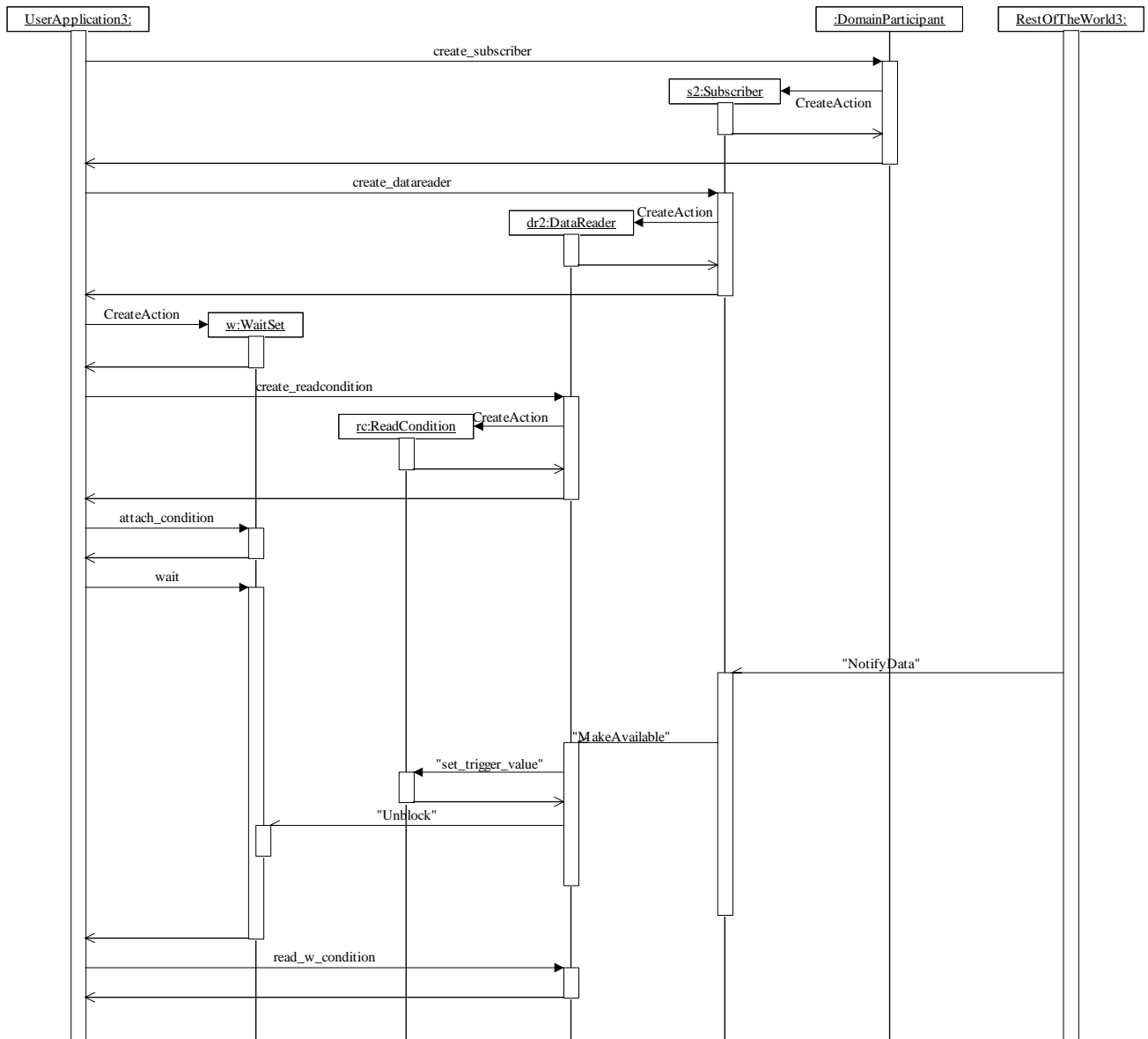


Figure 2-22 DCPS Interaction Model (Subscriptions with Conditions)

2.2 OMG IDL Platform Specific Model (PSM)

2.2.1 Introduction

The OMG IDL PSM is provided by means of the IDL that defines the interface an application can use to interact with the Service.

2.2.2 PIM to PSM Mapping Rules

A key concern in the development of the interface is performance. This is a consequence of the application space targeted by the Data Distribution Service (DDS).

The PIM to PSM mapping maps the UML interfaces and classes interfaces into IDL interfaces. Plain data types are mapped into structures.

IDL interfaces do not support overloading. The cases where a base class or interface has an abstract operation that must be redefined by a specialized class or interface has been mapped into a base IDL interface where the abstract operation appears inside comments. This serves simply as a reminder of the fact that all specializations must implement the operation.

Enumerations have been mapped into either IDL 'enum' or hand-picked IDL 'long' values that correspond to increasing powers of 2 (that is 0x01, 0x02, 0x04, etc.). The latter choice has been made when it was required to refer to multiple values as part of a function parameter. This allowed the use of a 'long' as a mask to indicate a set of enumerated values. This selection affected only the PIM 'status kind' values, namely: *StatusKind*, *SampleStateKind*, *ViewStateKind*, and *InstanceStateKind*.

Collection parameters have been mapped into IDL sequences. The only exception applies to the case where the collection elements are hand-picked IDL 'long.' In this case the collection is mapped into an IDL 'long' interpreted as a mask.

Each *QosPolicy* has been mapped as an IDL struct. The collection of policies suitable for each *Entity* has been modeled as another IDL struct that contains attributes corresponding to the policies that apply to this *Entity*. This approach has several advantages. First, it provides compile-time checking of the suitability of setting a specific *QosPolicy* on a particular *Entity*. A second advantage is that it does not require the use of the type "any" which increases code size and is not natural to use in "C." Other approaches were less attractive. IDL interfaces are not suitable because a collection of *QosPolicy* appears as an argument to several operations and needs to be passed "by value." IDL 'valuetype' was considered but rejected because it is not universally supported and also forces each attribute to be accessed via an operation.

Error-return values have been mapped to plain return codes of the corresponding functions. The reason is that DCPS targets "C" as one of the key deployment languages and return codes are more natural to use in "C."

The *DataSample* class that associates the *SampleInfo* and *Data* collections returned from the data-accessing operations (*read* and *take*) have not been explicitly mapped into IDL. The collections themselves have been mapped into sequences. The correspondence between each *Data* and *SampleInfo* is represented by the use of the same index to access the corresponding elements on each of the collections. It is anticipated that additional data-accessing APIs may be provided on each target language to make this operation as natural and efficient as it can be. The reason is that accessing data is the main purpose of the Data-Distribution service, and, the IDL mapping provides a programming-language neutral representation that cannot take advantage of the strengths of each particular language.

The classes that do not have factory operations, namely *WaitSet* and *GuardCondition* are mapped to IDL interfaces. The intent is that they will be implemented as native classes on each of the implementation languages and they will be constructed using the “new” operator natural for that language. Furthermore, the implementation language mapping should offer at least a constructor that takes no arguments such that applications can be portable across different vendor implementations of this mapping.

The two types used to represent time: *Duration_t* and *Time_t* are mapped into structures that contain fields for the second and the nanosecond parts. These types are further constrained to always use a ‘normalized’ representation for the time, that is, the *nanosec* field must verify $0 \leq \text{nanosec} < 1000000000$.

2.2.3 DCPS PSM : IDL

```

#define DOMAINID_TYPE_NATIVE          long
#define HANDLE_TYPE_NATIVE            long
#define HANDLE_NIL_NATIVE             0
#define BUILTIN_TOPIC_KEY_TYPE_NATIVE long

#define TheParticipantFactory
#define PARTICIPANT_QOS_DEFAULT
#define TOPIC_QOS_DEFAULT
#define PUBLISHER_QOS_DEFAULT
#define SUBSCRIBER_QOS_DEFAULT
#define DATAWRITER_QOS_DEFAULT
#define DATAREADER_QOS_DEFAULT
#define DATAWRITER_QOS_USE_TOPIC_QOS
#define DATAREADER_QOS_USE_TOPIC_QOS

module DDS {
    typedef DOMAINID_TYPE_NATIVE          DomainId_t;
    typedef HANDLE_TYPE_NATIVE            InstanceHandle_t;
    typedef BUILTIN_TOPIC_KEY_TYPE_NATIVE BuiltinTopicKey_t[3];

    typedef sequence<InstanceHandle_t> InstanceHandleSeq;

    typedef long ReturnCode_t;
    typedef long QosPolicyId_t;
    typedef sequence<string> StringSeq;

    struct Duration_t {
        long sec;
        unsigned long nanosec;
    };

    struct Time_t {
        long sec;
        unsigned long nanosec;
    };

    // -----
    // Pre-defined values
    // -----

```

```

const InstanceHandle_t HANDLE_NIL = HANDLE_NIL_NATIVE;

const long LENGTH_UNLIMITED = -1;

const long          DURATION_INFINITY_SEC = 0x7fffffff;
const unsigned long DURATION_INFINITY_NSEC = 0x7fffffff;

const long          DURATION_ZERO_SEC = 0;
const unsigned long DURATION_ZERO_NSEC = 0;

const long          TIMESTAMP_INVALID_SEC = -1;
const unsigned long TIMESTAMP_INVALID_NSEC = 0xffffffff;

// -----
// Return codes
// -----
const ReturnCode_t RETCODE_OK                = 0;
const ReturnCode_t RETCODE_ERROR             = 1;
const ReturnCode_t RETCODE_UNSUPPORTED      = 2;
const ReturnCode_t RETCODE_BAD_PARAMETER    = 3;
const ReturnCode_t RETCODE_PRECONDITION_NOT_MET = 4;
const ReturnCode_t RETCODE_OUT_OF_RESOURCES = 5;
const ReturnCode_t RETCODE_NOT_ENABLED     = 6;
const ReturnCode_t RETCODE_IMMUTABLE_POLICY = 7;
const ReturnCode_t RETCODE_INCONSISTENT_POLICY = 8;
const ReturnCode_t RETCODE_ALREADY_DELETED  = 9;
const ReturnCode_t RETCODE_TIMEOUT         = 10;
const ReturnCode_t RETCODE_NO_DATA        = 11;

// -----
// Status to support listeners and conditions
// -----

typedef unsigned long StatusKind;
typedef unsigned long StatusKindMask; // bit-mask StatusKind

const StatusKind INCONSISTENT_TOPIC_STATUS      = 0x0001 << 0;
const StatusKind OFFERED_DEADLINE_MISSED_STATUS = 0x0001 << 1;
const StatusKind REQUESTED_DEADLINE_MISSED_STATUS = 0x0001 << 2;
const StatusKind OFFERED_INCOMPATIBLE_QOS_STATUS = 0x0001 << 5;
const StatusKind REQUESTED_INCOMPATIBLE_QOS_STATUS = 0x0001 << 6;
const StatusKind SAMPLE_LOST_STATUS            = 0x0001 << 7;
const StatusKind SAMPLE_REJECTED_STATUS        = 0x0001 << 8;
const StatusKind DATA_ON_READERS_STATUS       = 0x0001 << 9;
const StatusKind DATA_AVAILABLE_STATUS        = 0x0001 << 10;
const StatusKind LIVELINESS_LOST_STATUS        = 0x0001 << 11;
const StatusKind LIVELINESS_CHANGED_STATUS     = 0x0001 << 12;

const StatusKind PUBLICATION_MATCH_STATUS      = 0x0001 << 13;
const StatusKind SUBSCRIPTION_MATCH_STATUS     = 0x0001 << 14;

struct InconsistentTopicStatus {

```

```
        long total_count;
        long total_count_change;
};

struct SampleLostStatus {
    long total_count;
    long total_count_change;
};

enum SampleRejectedStatusKind {
    REJECTED_BY_INSTANCE_LIMIT,
    REJECTED_BY_TOPIC_LIMIT
};

struct SampleRejectedStatus {
    long total_count;
    long total_count_change;
    SampleRejectedStatusKind last_reason;
    InstanceHandle_t last_instance_handle;
};

struct LivelinessLostStatus {
    long total_count;
    long total_count_change;
};

struct LivelinessChangedStatus {
    long active_count;
    long inactive_count;
    long active_count_change;
    long inactive_count_change;
};

struct OfferedDeadlineMissedStatus {
    long total_count;
    long total_count_change;
    InstanceHandle_t last_instance_handle;
};

struct RequestedDeadlineMissedStatus {
    long total_count;
    long total_count_change;
    InstanceHandle_t last_instance_handle;
};

struct QosPolicyCount {
    QosPolicyId_t policy_id;
    long count;
};

typedef sequence<QosPolicyCount> QosPolicyCountSeq;

struct OfferedIncompatibleQosStatus {
    long total_count;
    long total_count_change;
};
```

```

        QosPolicyId_t last_policy_id;
        QosPolicyCountSeq policies;
};

struct RequestedIncompatibleQosStatus {
    long total_count;
    long total_count_change;
    QosPolicyId_t last_policy_id;
    QosPolicyCountSeq policies;
};

struct PublicationMatchStatus {
    long total_count;
    long total_count_change;
    InstanceHandle_t last_subscription_handle;
};

struct SubscriptionMatchStatus {
    long total_count;
    long total_count_change;
    InstanceHandle_t last_publication_handle;
};

// -----
// Listeners
// -----

interface Listener;
interface Entity;
interface TopicDescription;
interface Topic;
interface ContentFilteredTopic;
interface MultiTopic;
interface DataWriter;
interface DataReader;
interface Subscriber;
interface Publisher;

typedef sequence<Topic> TopicSeq;
typedef sequence<DataReader> DataReaderSeq;

interface Listener {};

interface TopicListener : Listener {
    void on_inconsistent_topic(in Topic the_topic,
                              in InconsistentTopicStatus status);
};

interface DataWriterListener : Listener {
    void on_offered_deadline_missed(in DataWriter writer,
                                    in OfferedDeadlineMissedStatus status);
    void on_offered_incompatible_qos(in DataWriter writer,
                                    in OfferedIncompatibleQosStatus status);
};

```

```

        void on_liveliness_lost(in DataWriter writer,
                               in LivelinessLostStatus status);
        void on_publication_match(in DataWriter writer,
                                  in PublicationMatchStatus status);
};

interface PublisherListener : DataWriterListener {
};

interface DataReaderListener : Listener {
    void on_requested_deadline_missed(in DataReader reader,
                                       in RequestedDeadlineMissedStatus status);
    void on_requested_incompatible_qos(in DataReader reader,
                                       in RequestedIncompatibleQosStatus status);
    void on_sample_rejected(in DataReader reader,
                            in SampleRejectedStatus status);
    void on_liveliness_changed(in DataReader reader,
                               in LivelinessChangedStatus status);
    void on_data_available(in DataReader reader);
    void on_subscription_match(in DataReader reader,
                               in SubscriptionMatchStatus status);
    void on_sample_lost(in DataReader reader,
                       in SampleLostStatus status);
};

interface SubscriberListener : DataReaderListener {
    void on_data_on_readers(in Subscriber subs);
};

interface DomainParticipantListener : TopicListener,
                                     PublisherListener,
                                     SubscriberListener {
};

// -----
// Conditions
// -----

interface Condition {
    boolean get_trigger_value();
};

typedef sequence<Condition> ConditionSeq;

interface WaitSet {
    ReturnCode_t wait(out ConditionSeq active_conditions,
                    in Duration_t timeout);
    ReturnCode_t attach_condition(in Condition cond);
    ReturnCode_t detach_condition(in Condition cond);
    ReturnCode_t get_conditions(out ConditionSeq attached_conditions);
};

interface GuardCondition : Condition {

```

```

        void set_trigger_value(in boolean value);
};

interface StatusCondition : Condition {
    StatusKindMask get_enabled_statuses();
    ReturnCode_t set_enabled_statuses(in StatusKindMask mask);
    Entity get_entity();
};

// Sample states to support reads
typedef unsigned long SampleStateKind;
typedef sequence <SampleStateKind> SampleStateSeq;
const SampleStateKind READ_SAMPLE_STATE          = 0x0001 << 0;
const SampleStateKind NOT_READ_SAMPLE_STATE      = 0x0001 << 1;

// This is a bit-mask SampleStateKind
typedef unsigned long SampleStateMask;
const SampleStateMask ANY_SAMPLE_STATE          = 0xffff;

// View states to support reads
typedef unsigned long ViewStateKind;
typedef sequence<ViewStateKind> ViewStateSeq;
const ViewStateKind NEW_VIEW_STATE              = 0x0001 << 0;
const ViewStateKind NOT_NEW_VIEW_STATE         = 0x0001 << 1;

// This is a bit-mask ViewStateKind
typedef unsigned long ViewStateMask;
const ViewStateMask ANY_VIEW_STATE             = 0xffff;

// Instance states to support reads
typedef unsigned long InstanceStateKind;
typedef sequence<InstanceStateKind> InstanceStateSeq;
const InstanceStateKind ALIVE_INSTANCE_STATE    = 0x0001 << 0;
const InstanceStateKind NOT_ALIVE_DISPOSED_INSTANCE_STATE = 0x0001 << 1;
const InstanceStateKind NOT_ALIVE_NO_WRITERS_INSTANCE_STATE = 0x0001 << 2;

// This is a bit-mask InstanceStateKind
typedef unsigned long InstanceStateMask;
const InstanceStateMask ANY_INSTANCE_STATE     = 0xffff;
const InstanceStateMask NOT_ALIVE_INSTANCE_STATE= 0x0006;

interface ReadCondition : Condition {
    SampleStateMask get_sample_state_mask();
    ViewStateMask get_view_state_mask();
    InstanceStateMask get_instance_state_mask();
    DataReader get_datareader();
};

interface QueryCondition : ReadCondition {
    string get_query_expression();
    StringSeq get_query_arguments();
    ReturnCode_t set_query_arguments(in StringSeq query_arguments);
};

```

```

// -----
// Qos
// -----
const string USERDATA_QOS_POLICY_NAME           = "UserData";
const string DURABILITY_QOS_POLICY_NAME         = "Durability";
const string PRESENTATION_QOS_POLICY_NAME       = "Presentation";
const string DEADLINE_QOS_POLICY_NAME          = "Deadline";
const string LATENCYBUDGET_QOS_POLICY_NAME     = "LatencyBudget";
const string OWNERSHIP_QOS_POLICY_NAME         = "Ownership";
const string OWNERSHIPSTRENGTH_QOS_POLICY_NAME = "OwnershipStrength";
const string LIVELINESS_QOS_POLICY_NAME        = "Liveliness";
const string TIMEBASEDFILTER_QOS_POLICY_NAME   = "TimeBasedFilter";
const string PARTITION_QOS_POLICY_NAME         = "Partition";
const string RELIABILITY_QOS_POLICY_NAME       = "Reliability";
const string DESTINATIONORDER_QOS_POLICY_NAME  = "DestinationOrder";
const string HISTORY_QOS_POLICY_NAME           = "History";
const string RESOURCELIMITS_QOS_POLICY_NAME    = "ResourceLimits";
const string ENTITYFACTORY_QOS_POLICY_NAME     = "EntityFactory";
const string WRITERDATALIFECYCLE_QOS_POLICY_NAME = "WriterDataLifecycle";
const string READERDATALIFECYCLE_QOS_POLICY_NAME = "ReaderDataLifecycle";
const string TOPICDATA_QOS_POLICY_NAME        = "TopicData";
const string GROUPDATA_QOS_POLICY_NAME        = "GroupData";
const string TRANSPORTPRIORITY_QOS_POLICY_NAME = "TransportPriority";
const string LIFESPAN_QOS_POLICY_NAME         = "Lifespan";

const QosPolicyId_t USERDATA_QOS_POLICY_ID     = 1;
const QosPolicyId_t DURABILITY_QOS_POLICY_ID   = 2;
const QosPolicyId_t PRESENTATION_QOS_POLICY_ID = 3;
const QosPolicyId_t DEADLINE_QOS_POLICY_ID     = 4;
const QosPolicyId_t LATENCYBUDGET_QOS_POLICY_ID = 5;
const QosPolicyId_t OWNERSHIP_QOS_POLICY_ID    = 6;
const QosPolicyId_t OWNERSHIPSTRENGTH_QOS_POLICY_ID = 7;
const QosPolicyId_t LIVELINESS_QOS_POLICY_ID   = 8;
const QosPolicyId_t TIMEBASEDFILTER_QOS_POLICY_ID = 9;
const QosPolicyId_t PARTITION_QOS_POLICY_ID    = 10;
const QosPolicyId_t RELIABILITY_QOS_POLICY_ID  = 11;
const QosPolicyId_t DESTINATIONORDER_QOS_POLICY_ID = 12;
const QosPolicyId_t HISTORY_QOS_POLICY_ID     = 13;
const QosPolicyId_t RESOURCELIMITS_QOS_POLICY_ID = 14;
const QosPolicyId_t ENTITYFACTORY_QOS_POLICY_ID = 15;
const QosPolicyId_t WRITERDATALIFECYCLE_QOS_POLICY_ID = 16;
const QosPolicyId_t READERDATALIFECYCLE_QOS_POLICY_ID = 17;
const QosPolicyId_t TOPICDATA_QOS_POLICY_ID   = 18;
const QosPolicyId_t GROUPDATA_QOS_POLICY_ID   = 19;
const QosPolicyId_t TRANSPORTPRIORITY_QOS_POLICY_ID = 20;
const QosPolicyId_t LIFESPAN_QOS_POLICY_ID    = 21;

struct UserDataQosPolicy {
    sequence<octet> value;
};

struct TopicDataQosPolicy {
    sequence<octet> value;
};

```



```
};

struct GroupDataQosPolicy {
    sequence<octet> value;
};

struct TransportPriorityQosPolicy {
    long value;
};

struct LifespanQosPolicy {
    Duration_t duration;
};

enum DurabilityQosPolicyKind {
    VOLATILE_DURABILITY_QOS,
    TRANSIENT_LOCAL_DURABILITY_QOS,
    TRANSIENT_DURABILITY_QOS,
    PERSISTENT_DURABILITY_QOS
};
struct DurabilityQosPolicy {
    DurabilityQosPolicyKind kind;
    Duration_t service_cleanup_delay;
};

enum PresentationQosPolicyAccessScopeKind {
    INSTANCE_PRESENTATION_QOS,
    TOPIC_PRESENTATION_QOS,
    GROUP_PRESENTATION_QOS
};
struct PresentationQosPolicy {
    PresentationQosPolicyAccessScopeKind access_scope;
    boolean coherent_access;
    boolean ordered_access;
};

struct DeadlineQosPolicy {
    Duration_t period;
};

struct LatencyBudgetQosPolicy {
    Duration_t duration;
};

enum OwnershipQosPolicyKind {
    SHARED_OWNERSHIP_QOS,
    EXCLUSIVE_OWNERSHIP_QOS
};
struct OwnershipQosPolicy {
    OwnershipQosPolicyKind kind;
};

struct OwnershipStrengthQosPolicy {
    long value;
};
```

```
enum LivelinessQosPolicyKind {
    AUTOMATIC_LIVELINESS_QOS,
    MANUAL_BY_PARTICIPANT_LIVELINESS_QOS,
    MANUAL_BY_TOPIC_LIVELINESS_QOS
};

struct LivelinessQosPolicy {
    LivelinessQosPolicyKind kind;
    Duration_t lease_duration;
};

struct TimeBasedFilterQosPolicy {
    Duration_t minimum_separation;
};

struct PartitionQosPolicy {
    StringSeq name;
};

enum ReliabilityQosPolicyKind {
    BEST_EFFORT_RELIABILITY_QOS,
    RELIABLE_RELIABILITY_QOS
};

struct ReliabilityQosPolicy {
    ReliabilityQosPolicyKind kind;
    Duration_t max_blocking_time;
};

enum DestinationOrderQosPolicyKind {
    BY_RECEPTION_TIMESTAMP_DESTINATIONORDER_QOS,
    BY_SOURCE_TIMESTAMP_DESTINATIONORDER_QOS
};

struct DestinationOrderQosPolicy {
    DestinationOrderQosPolicyKind kind;
};

enum HistoryQosPolicyKind {
    KEEP_LAST_HISTORY_QOS,
    KEEP_ALL_HISTORY_QOS
};

struct HistoryQosPolicy {
    HistoryQosPolicyKind kind;
    long depth;
};

struct ResourceLimitsQosPolicy {
    long max_samples;
    long max_instances;
    long max_samples_per_instance;
};

struct EntityFactoryQosPolicy {
    boolean autoenable_created_entities;
};
```

```
};

struct WriterDataLifecycleQosPolicy {
    boolean autodispose_unregistered_instances;
};

struct ReaderDataLifecycleQosPolicy {
    Duration_t autopurge_nowriter_samples_delay;
};

struct DomainParticipantQos {
    UserDataQosPolicy user_data;
    EntityFactoryQosPolicy entity_factory;
};

struct TopicQos {
    TopicDataQosPolicy           topic_data;
    DurabilityQosPolicy         durability;
    DeadlineQosPolicy           deadline;
    LatencyBudgetQosPolicy      latency_budget;
    LivelinessQosPolicy         liveliness;
    ReliabilityQosPolicy        reliability;
    DestinationOrderQosPolicy   destination_order;
    HistoryQosPolicy            history;
    ResourceLimitsQosPolicy     resource_limits;
    TransportPriorityQosPolicy   transport_priority;
    LifespanQosPolicy           lifespan;

    OwnershipQosPolicy         ownership;
};

struct DataWriterQos {
    DurabilityQosPolicy         durability;
    DeadlineQosPolicy           deadline;
    LatencyBudgetQosPolicy      latency_budget;
    LivelinessQosPolicy         liveliness;
    ReliabilityQosPolicy        reliability;
    DestinationOrderQosPolicy   destination_order;
    HistoryQosPolicy            history;
    ResourceLimitsQosPolicy     resource_limits;
    TransportPriorityQosPolicy   transport_priority;
    LifespanQosPolicy           lifespan;

    UserDataQosPolicy           user_data;
    OwnershipStrengthQosPolicy  ownership_strength;
    WriterDataLifecycleQosPolicy writer_data_lifecycle;
};

struct PublisherQos {
    PresentationQosPolicy       presentation;
    PartitionQosPolicy          partition;
    GroupDataQosPolicy          group_data;
    EntityFactoryQosPolicy      entity_factory;
};
```

```

struct DataReaderQos {
    DurabilityQosPolicy          durability;
    DeadlineQosPolicy           deadline;
    LatencyBudgetQosPolicy      latency_budget;
    LivelinessQosPolicy         liveliness;
    ReliabilityQosPolicy         reliability;
    DestinationOrderQosPolicy   destination_order;
    HistoryQosPolicy             history;
    ResourceLimitsQosPolicy      resource_limits;

    UserDataQosPolicy           user_data;
    TimeBasedFilterQosPolicy    time_based_filter;
    ReaderDataLifecycleQosPolicy reader_data_lifecycle;
};

struct SubscriberQos {
    PresentationQosPolicy        presentation;
    PartitionQosPolicy           partition;
    GroupDataQosPolicy           group_data;
    EntityFactoryQosPolicy       entity_factory;
};

// -----

struct ParticipantBuiltinTopicData {
    BuiltinTopicKey_t           key;
    UserDataQosPolicy           user_data;
};

struct TopicBuiltinTopicData {
    BuiltinTopicKey_t           key;
    string                       name;
    string                       type_name;
    DurabilityQosPolicy          durability;
    DeadlineQosPolicy            deadline;
    LatencyBudgetQosPolicy       latency_budget;
    LivelinessQosPolicy          liveliness;
    ReliabilityQosPolicy          reliability;
    TransportPriorityQosPolicy    transport_priority;
    LifespanQosPolicy            lifespan;
    DestinationOrderQosPolicy    destination_order;
    HistoryQosPolicy             history;
    ResourceLimitsQosPolicy       resource_limits;
    OwnershipQosPolicy           ownership;
    TopicDataQosPolicy           topic_data;
};

struct PublicationBuiltinTopicData {
    BuiltinTopicKey_t           key;
    BuiltinTopicKey_t           participant_key;
    string                       topic_name;
    string                       type_name;

    DurabilityQosPolicy          durability;
    DeadlineQosPolicy            deadline;
};

```

```

        LatencyBudgetQosPolicy      latency_budget;
        LivelinessQosPolicy         liveliness;
        ReliabilityQosPolicy        reliability;
        LifespanQosPolicy           lifespan;
        UserDataQosPolicy           user_data;
        OwnershipStrengthQosPolicy  ownership_strength;

        PresentationQosPolicy       presentation;
        PartitionQosPolicy          partition;
        TopicDataQosPolicy         topic_data;
        GroupDataQosPolicy         group_data;
};

struct SubscriptionBuiltinTopicData {
    BuiltinTopicKey_t             key;
    BuiltinTopicKey_t             participant_key;
    string                        topic_name;
    string                        type_name;

    DurabilityQosPolicy           durability;
    DeadlineQosPolicy             deadline;
    LatencyBudgetQosPolicy        latency_budget;
    LivelinessQosPolicy           liveliness;
    ReliabilityQosPolicy          reliability;
    DestinationOrderQosPolicy     destination_order;
    UserDataQosPolicy             user_data;
    TimeBasedFilterQosPolicy      time_based_filter;

    PresentationQosPolicy         presentation;
    PartitionQosPolicy            partition;
    TopicDataQosPolicy            topic_data;
    GroupDataQosPolicy            group_data;
};

// -----
interface Entity {
//     ReturnCode_t set_qos(in EntityQos qos);
//     void get_qos(inout EntityQos qos);
//     ReturnCode_t set_listener(in Listener l, in StatusKindMask mask);
//     Listener get_listener();

    ReturnCode_t enable();

    StatusCondition get_statuscondition();

    StatusKindMask get_status_changes();
};

// -----
interface DomainParticipant : Entity {
    // Factory interfaces
    Publisher create_publisher(in PublisherQos qos,
                              in PublisherListener a_listener);
    ReturnCode_t delete_publisher(in Publisher p);
};

```

```

Subscriber create_subscriber(in SubscriberQos qos,
                             in SubscriberListener a_listener);
ReturnCode_t delete_subscriber(in Subscriber s);
Subscriber get_builtin_subscriber();

Topic create_topic(in string topic_name, in string type_name,
                  in TopicQos qos,
                  in TopicListener a_listener);

ReturnCode_t delete_topic(in Topic a_topic);

Topic find_topic(in string topic_name, in Duration_t timeout);
TopicDescription lookup_topicdescription(in string name);

ContentFilteredTopic create_contentfilteredtopic(in string name,
                                                in Topic related_topic,
                                                in string filter_expression,
                                                in StringSeq filter_parameters);

ReturnCode_t delete_contentfilteredtopic(
    in ContentFilteredTopic a_contentfilteredtopic);

MultiTopic create_multitopic(in string name,
                             in string type_name,
                             in string subscription_expression,
                             in StringSeq expression_parameters);

ReturnCode_t delete_multitopic(in MultiTopic a_multitopic);

ReturnCode_t delete_contained_entities();

ReturnCode_t set_qos(in DomainParticipantQos qos);
void get_qos(inout DomainParticipantQos qos);

ReturnCode_t set_listener(in DomainParticipantListener a_listener,
                          in StatusKindMask mask);
DomainParticipantListener get_listener();

ReturnCode_t ignore_participant(in InstanceHandle_t handle);
ReturnCode_t ignore_topic(in InstanceHandle_t handle);
ReturnCode_t ignore_publication(in InstanceHandle_t handle);
ReturnCode_t ignore_subscription(in InstanceHandle_t handle);

DomainId_t get_domain_id();
void assert_liveliness();

ReturnCode_t set_default_publisher_qos(in PublisherQos qos);
void get_default_publisher_qos(inout PublisherQos qos);

ReturnCode_t set_default_subscriber_qos(in SubscriberQos qos);
void get_default_subscriber_qos(inout SubscriberQos qos);

ReturnCode_t set_default_topic_qos(in TopicQos qos);
void get_default_topic_qos(inout TopicQos qos);
};

```

```
interface DomainParticipantFactory {
    DomainParticipant create_participant(in DomainId_t domainId,
        in DomainParticipantQos qos,
        in DomainParticipantListener a_listener);
    ReturnCode_t delete_participant(in DomainParticipant a_participant);

    DomainParticipant lookup_participant(in DomainId_t domainId);

    ReturnCode_t set_default_participant_qos(in DomainParticipantQos qos);
    void get_default_participant_qos(inout DomainParticipantQos qos);
};

interface TypeSupport {
    // ReturnCode_t register_type(in DomainParticipant domain, in string type_name);
};

// -----
interface TopicDescription {
    string get_type_name();
    string get_name();

    DomainParticipant get_participant();
};

interface Topic : Entity, TopicDescription {
    // Access the status
    InconsistentTopicStatus get_inconsistent_topic_status();
};

interface ContentFilteredTopic : TopicDescription {
    string get_filter_expression();
    StringSeq get_expression_parameters();
    ReturnCode_t set_expression_parameters(in StringSeq expression_parameters);
    Topic get_related_topic();
};

interface MultiTopic : TopicDescription {
    string get_subscription_expression();
    StringSeq get_expression_parameters();
    ReturnCode_t set_expression_parameters(in StringSeq expression_parameters);
};

// -----
interface Publisher : Entity {
    DataWriter create_datawriter(in Topic a_topic, in DataWriterQos qos,
        in DataWriterListener a_listener);
    ReturnCode_t delete_datawriter(in DataWriter a_datawriter);
    DataWriter lookup_datawriter(in string topic_name);

    ReturnCode_t delete_contained_entities();

    ReturnCode_t set_qos(in PublisherQos qos);
    void get_qos(inout PublisherQos qos);
};
```

```

    ReturnCode_t set_listener(in PublisherListener a_listener, in StatusKindMask mask);
    PublisherListener get_listener();

    ReturnCode_t suspend_publications();
    ReturnCode_t resume_publications();

    ReturnCode_t begin_coherent_changes();
    ReturnCode_t end_coherent_changes();

    DomainParticipant get_participant();

    ReturnCode_t set_default_datawriter_qos(in DataWriterQos qos);
    void get_default_datawriter_qos(inout DataWriterQos qos);

    ReturnCode_t copy_from_topic_qos(inout DataWriterQos a_datawriter_qos,
                                     in TopicQos a_topic_qos);
};

interface DataWriter : Entity {
// InstanceHandle_t register(in Data instance_data);
// InstanceHandle_t register_w_timestamp(in Data instance_data,
//                                       in Time_t source_timestamp);
// ReturnCode_t unregister(in Data instance_data,
//                          in InstanceHandle_t handle);
// ReturnCode_t unregister_w_timestamp(in Data instance_data,
//                                     in InstanceHandle_t handle,
//                                     in Time_t source_timestamp);
// ReturnCode_t write(in Data instance_data, in InstanceHandle_t handle);
// ReturnCode_t write_w_timestamp(in Data instance_data,
//                                in InstanceHandle_t handle,
//                                in Time_t source_timestamp);
// ReturnCode_t dispose(in Data instance_data,
//                      in InstanceHandle_t instance_handle);
// ReturnCode_t dispose_w_timestamp(in Data instance_data,
//                                  in InstanceHandle_t instance_handle,
//                                  in Time_t source_timestamp);
// ReturnCode_t get_key_value(inout Data key_holder, in InstanceHandle_t handle);

    ReturnCode_t set_qos(in DataWriterQos qos);
    void get_qos(inout DataWriterQos qos);

    ReturnCode_t set_listener(in DataWriterListener a_listener, in StatusKindMask mask);
    DataWriterListener get_listener();

    Topic get_topic();
    Publisher get_publisher();

    // Access the status
    LivelinessLostStatus get_liveliness_lost_status();
    OfferedDeadlineMissedStatus get_offered_deadline_missed_status();
    OfferedIncompatibleQosStatus get_offered_incompatible_qos_status();
    PublicationMatchStatus get_publication_match_status();

    void assert_liveliness();

```



```

        ReturnCode_t get_matched_subscriptions(
            inout InstanceHandleSeq subscription_handles);
        ReturnCode_t get_matched_subscription_data(
            inout SubscriptionBuiltinTopicData subscription_data,
            in InstanceHandle_t subscription_handle);
};

// -----
interface Subscriber : Entity {
    DataReader create_datareader(in TopicDescription a_topic,
        in DataReaderQos qos,
        in DataReaderListener a_listener);
    ReturnCode_t delete_datareader(in DataReader a_datareader);
    ReturnCode_t delete_contained_entities();
    DataReader lookup_datareader(in string topic_name);
    ReturnCode_t get_datareaders(out DataReaderSeq readers,
        in SampleStateMask sample_states,
        in ViewStateMask view_states,
        in InstanceStateMask instance_states);
    void notify_datareaders();

    ReturnCode_t set_qos(in SubscriberQos qos);
    void get_qos(inout SubscriberQos qos);

    ReturnCode_t set_listener(in SubscriberListener a_listener, in StatusKindMask mask);
    SubscriberListener get_listener();

    ReturnCode_t begin_access();
    ReturnCode_t end_access();

    DomainParticipant get_participant();

    ReturnCode_t set_default_datareader_qos(in DataReaderQos qos);
    void get_default_datareader_qos(inout DataReaderQos qos);

    ReturnCode_t copy_from_topic_qos(inout DataReaderQos a_datareader_qos,
        in TopicQos a_topic_qos);
};

interface DataReader : Entity {
//    ReturnCode_t read(inout DataSeq received_data,
//        inout SampleInfoSeq info_seq,
//        in long max_samples,
//        in SampleStateMask sample_states,
//        in ViewStateMask view_states,
//        in InstanceStateMask instance_states);

//    ReturnCode_t take(inout DataSeq received_data,
//        inout SampleInfoSeq info_seq,
//        in long max_samples,
//        in SampleStateMask sample_states,
//        in ViewStateMask view_states,
//        in InstanceStateMask instance_states);

//    ReturnCode_t read_w_condition(inout DataSeq received_data,

```

```

//          inout SampleInfoSeq info_seq,
//          in long max_samples,
//          in ReadCondition a_condition);

//      ReturnCode_t take_w_condition(inout DataSeq received_data,
//          inout SampleInfoSeq info_seq,
//          in long max_samples,
//          in ReadCondition a_condition);

//      ReturnCode_t read_next_sample(inout Data received_data,
//          inout SampleInfo sample_info);

//      ReturnCode_t take_next_sample(inout Data received_data,
//          inout SampleInfo sample_info);

//      ReturnCode_t read_instance(inout DataSeq received_data,
//          inout SampleInfoSeq info_seq,
//          in long max_samples,
//          in InstanceHandle_t a_handle,
//          in SampleStateMask sample_states,
//          in ViewStateMask view_states,
//          in InstanceStateMask instance_states);

//      ReturnCode_t take_instance(inout DataSeq received_data,
//          inout SampleInfoSeq info_seq,
//          in long max_samples,
//          in InstanceHandle_t a_handle,
//          in SampleStateMask sample_states,
//          in ViewStateMask view_states,
//          in InstanceStateMask instance_states);

//      ReturnCode_t read_next_instance(inout DataSeq received_data,
//          inout SampleInfoSeq info_seq,
//          in long max_samples,
//          in InstanceHandle_t a_handle,
//          in SampleStateMask sample_states,
//          in ViewStateMask view_states,
//          in InstanceStateMask instance_states);

//      ReturnCode_t take_next_instance(inout DataSeq received_data,
//          inout SampleInfoSeq info_seq,
//          in long max_samples,
//          in InstanceHandle_t a_handle,
//          in SampleStateMask sample_states,
//          in ViewStateMask view_states,
//          in InstanceStateMask instance_states);

//      ReturnCode_t read_next_instance_w_condition(inout DataSeq received_data,
//          inout SampleInfoSeq info_seq,
//          in long max_samples,
//          in InstanceHandle_t a_handle,
//          in ReadCondition a_condition);

//      ReturnCode_t take_next_instance_w_condition(inout DataSeq received_data,
//          inout SampleInfoSeq info_seq,

```

```

//          in long max_samples,
//          in InstanceHandle_t a_handle,
//          in ReadCondition a_condition);

//      ReturnCode_t return_loan( inout DataSeq received_data,
//                                inout SampleInfoSeq info_seq);

//      ReturnCode_t get_key_value(inout Data key_holder, in InstanceHandle_t handle);

      ReadCondition create_readcondition(in SampleStateMask sample_states,
                                         in ViewStateMask view_states,
                                         in InstanceStateMask instance_states);

      QueryCondition
      create_querycondition(in SampleStateMask sample_states,
                           in ViewStateMask view_states,
                           in InstanceStateMask instance_states,
                           in string query_expression,
                           in StringSeq query_parameters);

      ReturnCode_t delete_readcondition(in ReadCondition a_condition);

      ReturnCode_t delete_contained_entities();

      ReturnCode_t set_qos(in DataReaderQos qos);
      void get_qos(inout DataReaderQos qos);

      ReturnCode_t set_listener(in DataReaderListener a_listener, in StatusKindMask mask);
      DataReaderListener get_listener();

      TopicDescription get_topicdescription();
      Subscriber get_subscriber();

      SampleRejectedStatus get_sample_rejected_status();
      LivelinessChangedStatus get_liveliness_changed_status();
      RequestedDeadlineMissedStatus get_requested_deadline_missed_status();
      RequestedIncompatibleQosStatus get_requested_incompatible_qos_status();
      SubscriptionMatchStatus get_subscription_match_status();
      SampleLostStatus get_sample_lost_status();

      ReturnCode_t wait_for_historical_data(in Duration_t max_wait);

      ReturnCode_t get_matched_publications(
          inout InstanceHandleSeq publication_handles);
      ReturnCode_t get_matched_publication_data(
          inout PublicationBuiltinTopicData publication_data,
          in InstanceHandle_t publication_handle);
};

struct SampleInfo {
    SampleStateKind sample_state;
    ViewStateKind view_state;
    InstanceStateKind instance_state;
    Time_t source_timestamp;
};

```

```

        InstanceHandle_t instance_handle;
        long disposed_generation_count;
        long no_writers_generation_count;
        long sample_rank;
        long generation_rank;
        long absolute_generation_rank;
};

typedef sequence<SampleInfo> SampleInfoSeq;
};

// Implied IDL for type "Foo"
// Example user defined structure
struct Foo {
    long dummy;
};

typedef sequence<Foo> FooSeq;

#include "dds_dcps.idl"

interface FooTypeSupport : DDS::TypeSupport {
    DDS::ReturnCode_t register_type(in DDS::DomainParticipant participant,
        in string type_name);
};

interface FooDataWriter : DDS::DataWriter {

    DDS::InstanceHandle_t register(in Foo instance_data);
    DDS::InstanceHandle_t register_w_timestamp(in Foo instance_data,
        in DDS::InstanceHandle_t handle,
        in DDS::Time_t source_timestamp);

    DDS::ReturnCode_t unregister(in Foo instance_data,
        in DDS::InstanceHandle_t handle);
    DDS::ReturnCode_t unregister_w_timestamp(in Foo instance_data,
        in DDS::InstanceHandle_t handle,
        in DDS::Time_t source_timestamp);

    DDS::ReturnCode_t write(in Foo instance_data,
        in DDS::InstanceHandle_t handle);

    DDS::ReturnCode_t write_w_timestamp(in Foo instance_data,
        in DDS::InstanceHandle_t handle,
        in DDS::Time_t source_timestamp);

    DDS::ReturnCode_t dispose(in Foo instance_data,
        in DDS::InstanceHandle_t instance_handle);

    DDS::ReturnCode_t dispose_w_timestamp(in Foo instance_data,
        in DDS::InstanceHandle_t instance_handle,
        in DDS::Time_t source_timestamp);

    DDS::ReturnCode_t get_key_value(inout Foo key_holder,

```

```
        in DDS::InstanceHandle_t handle);
};

interface FooDataReader : DDS::DataReader {
    DDS::ReturnCode_t read(inout FooSeq received_data,
        inout DDS::SampleInfoSeq info_seq,
        in long max_samples,
        in DDS::SampleStateMask sample_states,
        in DDS::ViewStateMask view_states,
        in DDS::InstanceStateMask instance_states);

    DDS::ReturnCode_t take(inout FooSeq received_data,
        inout DDS::SampleInfoSeq info_seq,
        in long max_samples,
        in DDS::SampleStateMask sample_states,
        in DDS::ViewStateMask view_states,
        in DDS::InstanceStateMask instance_states);

    DDS::ReturnCode_t read_w_condition(inout FooSeq received_data,
        inout DDS::SampleInfoSeq info_seq,
        in long max_samples,
        in DDS::ReadCondition a_condition);

    DDS::ReturnCode_t take_w_condition(inout FooSeq received_data,
        inout DDS::SampleInfoSeq info_seq,
        in long max_samples,
        in DDS::ReadCondition a_condition);

    DDS::ReturnCode_t read_next_sample(inout Foo received_data,
        inout DDS::SampleInfo sample_info);

    DDS::ReturnCode_t take_next_sample(inout Foo received_data,
        inout DDS::SampleInfo sample_info);

    DDS::ReturnCode_t read_instance(inout FooSeq received_data,
        inout DDS::SampleInfoSeq info_seq,
        in long max_samples,
        in DDS::InstanceHandle_t a_handle,
        in DDS::SampleStateMask sample_states,
        in DDS::ViewStateMask view_states,
        in DDS::InstanceStateMask instance_states);

    DDS::ReturnCode_t take_instance(inout FooSeq received_data,
        inout DDS::SampleInfoSeq info_seq,
        in long max_samples,
        in DDS::InstanceHandle_t a_handle,
        in DDS::SampleStateMask sample_states,
        in DDS::ViewStateMask view_states,
        in DDS::InstanceStateMask instance_states);

    DDS::ReturnCode_t read_next_instance(inout FooSeq received_data,
        inout DDS::SampleInfoSeq info_seq,
        in long max_samples,
        in DDS::InstanceHandle_t a_handle,
```

```
        in DDS::SampleStateMask sample_states,
        in DDS::ViewStateMask view_states,
        in DDS::InstanceStateMask instance_states);

DDS::ReturnCode_t take_next_instance(inout FooSeq received_data,
    inout DDS::SampleInfoSeq info_seq,
    in long max_samples,
    in DDS::InstanceHandle_t a_handle,
    in DDS::SampleStateMask sample_states,
    in DDS::ViewStateMask view_states,
    in DDS::InstanceStateMask instance_states);

DDS::ReturnCode_t read_next_instance_w_condition(inout FooSeq received_data,
    inout DDS::SampleInfoSeq info_seq,
    in long max_samples,
    in DDS::InstanceHandle_t a_handle,
    in DDS::ReadCondition a_condition);

DDS::ReturnCode_t take_next_instance_w_condition(inout FooSeq received_data,
    inout DDS::SampleInfoSeq info_seq,
    in long max_samples,
    in DDS::InstanceHandle_t a_handle,
    in DDS::ReadCondition a_condition);

DDS::ReturnCode_t return_loan( inout FooSeq received_data,
    inout DDS::SampleInfoSeq info_seq);

DDS::ReturnCode_t get_key_value(inout Foo key_holder,
    in DDS::InstanceHandle_t handle);
};
```


Data Local Reconstruction Layer (DLRL)

3

Contents

This chapter contains the following sections.

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3.1 Platform Independent Model (PIM)

DLRL stands for Data Local Reconstruction Layer. It is an optional layer that may be built on top of the Data-Centric Publish-Subscribe (DCPS) layer.

3.1.1 Overview and Design Rationale

The purpose of this layer is to provide more direct access to the exchanged data, seamlessly integrated with the native-language constructs. Object orientation has been selected for all the benefits it provides in software engineering.

As for DCPS, typed interfaces¹ have been selected, for the same reasons of ease of use and potential performance.

¹.In the sense, interfaces whose type depend on application-defined types.

As far as possible, DLRL is designed to allow the application developer to use the underlying DCPS features. However, this may conflict with the main purpose of this layer, which is ease of use and seamless integration into the application. Therefore, some DCPS features may only be used through DCPS and are not accessible from the DLRL.

3.1.2 DLRL Description

With DLRL, the application developer will be able to:

- describe classes of objects with their methods, data fields, and relations;
- attach some of those data fields to DCPS entities;
- manipulate those objects (i.e., create, read, write, delete) using the native language constructs that will, behind the scenes, activate the attached DCPS entities in the appropriate way;
- have those objects managed in a cache of objects, ensuring that all the references that point to a given object actually point to the same language cell.

This specification explains the following:

- which object-oriented constructs can be used to define DLRL objects;
- which functions are applicable to those objects (e.g., create, delete, etc.);
- the different levels of mapping between the two layers:
 - structural mapping
i.e., relations between DLRL objects and DCPS data;
 - operational mapping
i.e., mapping of the DLRL objects to the DCPS entities (*Publisher*, *DataWriter*, etc.) including QoS settings, combined subscriptions, etc.;
 - functional mapping
i.e., relations between the DLRL functions (mainly access to the DLRL objects) and the DCPS functions (write/publish/etc.).

3.1.3 What Can Be Modeled with DLRL

3.1.3.1 DLRL objects

DLRL allows an application to describe objects with:

- methods;
- attributes that can be:
 - local (i.e., that do not participate in the data distribution) or
 - shared (i.e., that participate in the data distribution process and are thus attached to DCPS entities).

Only shared attributes are of concern to the Data Distribution Service; therefore, the remaining part of this document will only deal with these properties.

A DLRL object has at least one shared attribute. Shared attributes are typed² and can be either mono-valued or multi-valued:

- Mono-valued:
 - of a simple type:
 - basic-type (long, short, char, string, etc.);
 - enumeration-type;
 - simple structure³
 - reference to a DLRL object.

For these mono-valued attributes, type enforcement is as follows:

- strict type equality for simple types;
- equality based on inclusion for reference to a DLRL object (i.e., a reference to a derived object can be placed in a reference to a base object).
- Multi-valued (collection-based):
 - two collection basis of homogeneously-typed items:
 - a list (ordered with index);
 - a map (access by key).

Type enforcement for collection elements is as follows:

- strict type equality for simple types;
- equality based on type inclusion for references to DLRL objects (i.e., a reference to a derived object can be placed in a collection typed for base objects).

DLRL will manage DLRL objects in a cache (i.e., two different references to the same object – an object with the same identity – will actually point to the same memory location).

Object identity is given by an *oid* (object ID) part of any DLRL object.

3.1.3.2 *Relations among DLRL objects*

Relations between DLRL objects are of two kinds:

- inheritance that organize the DLRL classes
- associations that organize the DLRL instances.

3.1.3.2.1 *Inheritance*

Single inheritance is allowed between DLRL objects.

Any object inheriting from a DLRL object is itself a DLRL object.

-
2. At the PIM level, we describe the minimum set that is required to describe shared attributes. This does not prevent a specific PSM from extending this minimum set, in case this make sense and does not affect the ability of this layer to be implemented on top of DCPS.
 3. I.e. structures that can be mapped inside one DCPS data.

ObjectRoot is the ultimate root for all DLRL objects.

DLRL objects can, in addition, inherit from any number of native language objects.

3.1.3.2.2 Associations

Supported association ends are either *to-1* or *to-many*. In the following, an association end is named a *relation*.

- to-1 relation is featured by a mono-valued attribute (reference to the target object).
- to-many relation is featured by a multi-valued attribute (collection of references to the target objects).

Supported relations are:

- plain use-relations (no impact on the object life-cycle).
- compositions (constituent object lifecycle follows the compound object's one).

Couples of relations can be managed consistently (one being the *inverse* of the other) to make a real association (in the UML sense):

- one plain relation can inverse another plain relation, providing that the types match: can make 1-1, 1-n, n-m.
- one composition relation can only inverse a to-1 relation to the compound object: can make 1-1 or 1-n.

Note – Embedded structures are restricted to the ones that can be mapped simply at the DCPS level. For more complex ones, component objects (i.e., objects linked by a composition relation) may be used.

3.1.3.3 Metamodel

The following figure represents the DLRL metamodel, i.e., all the constructs that can be used to describe the 'shared' part of a DLRL model. This metamodel is given for explanation purposes. This specification does not require that it is implemented as such.

Note that two objects that will be part of a DLRL model (namely **ObjectRoot** that is the root for all the DLRL classes as well as **ObjectHome** that is the class responsible for creating and managing all DLRL objects of a given class) are featured to show the conceptual relations between the metamodel and the model. They appear in grey on the schema.

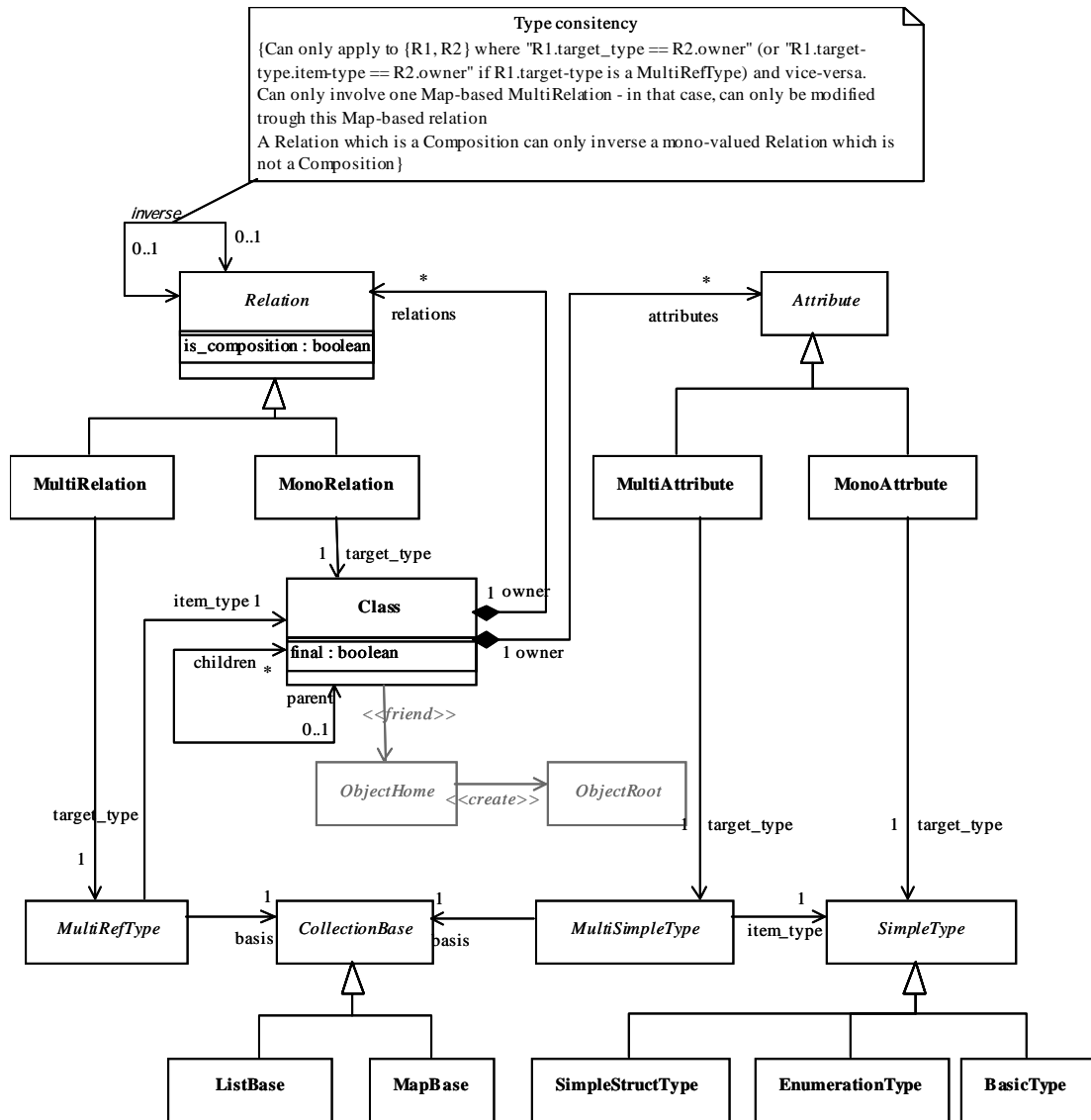


Figure 3-1 DLRL Metamodel

Instances of **BasicType** are:

- long
- short
- char
- octet
- real

- double
- string
- sequence of octet

Instances of *EnumerationType* are all the enumerations.

Instances of *SimpleStructType* are all the structures that can be mapped in a single DCPS data.

3.1.4 Structural Mapping

3.1.4.1 Design Principles

The mapping should not impose unnecessary duplication of data items.

The mapping should not prevent an implementation from being efficient. Therefore, adding information in DCPS data to help DLRL internal management is allowed.

The mapping should be as flexible as possible. It is therefore specified on an attribute basis (that means that *any* attribute, even a simple one, can be located in a DCPS data structure that is separate from the main one; i.e., the DCPS data structure associated with the DLRL class)⁴.

This flexibility is highly desirable to meet specific requirements (e.g., to reuse an existing DCPS description). However, there are cases when this type of flexibility is not needed and leads to extra descriptions that could (and should) be avoided. For these cases, a default mapping is also defined.

3.1.4.2 Mapping rules

Recall that DCPS data can be seen as tables (*Topic*) whose rows correspond to instances identified by their key value and whose columns (fields) correspond to data fields. Each cell contains the value of a given field for a given instance and the key value is the concatenation of the values of all the fields that make the key definition (itself attached to the *Topic*).

Structural mapping is thus very close to Object to Relational mapping in database management.

Generally speaking, there is some flexibility in designing the DCPS model that can be used to map a DLRL model. Nevertheless, there are cases where the underlying DCPS model exists with no provision for storing the object references and no way to modify them. In that case however, the DCPS topics contain fields (the keys) that allow the

4. This is needed to efficiently manage inheritance. Therefore extending it to any attribute is not costly.

unique identification of instances. With some restrictions concerning inheritance, these models can also be mapped back into DLRL models. Section 3.1.4.5 is specifically dedicated to that issue.

The mapping rules when some flexibility is allowed in DCPS model are as follows.

3.1.4.2.1 Mapping of Classes

Each DLRL class is associated with at least one DCPS table, which is considered as the 'main' table. A DLRL object is considered to exist if it has a corresponding row in this table. This table contains at least the fields needed to store a reference to that object (see below).

To facilitate DLRL management and save memory space, it is generally desirable that a derived class has the same main table as its parent concrete class (if any)⁵, with the attributes that are specific to the derived class in an extension table. For example, this allows the application to load all the instances of a given class (including its derivations) in a single operation.

3.1.4.2.2 Mapping of an Object Reference

To reference an object, there must be a way to designate it unambiguously and a way to retrieve the exact class of that object (this last point is needed when the object has to be locally created based on received information).

Therefore, to reference an object, the following must be stored:

- a string that allows retrieval of the exact class (e.g., name class, or more precisely a public name that identifies the class unambiguously).
- a number that identifies the object inside this class⁶ (*oid*).

The combination of these two pieces of information is called *full oid*.

There are cases where the indication of the class is not needed, for it can be deduced from the knowledge embedded in the mapping. A class name is needed when:

- several classes share the same main table;
- several classes are targets for the same relation (in other words, when the target type of a relation is a class that has derived classes).

5. Excluding, of course, the abstract ObjectRoot (otherwise all the objects will be located in a single table).

6. Note that, in case several parts are creating objects at the same time, there should be a means to guarantee that there is no confusion (e.g., by means of two sub-fields, one to designate the author and one for a sequence number). This is left to the implementation.

3.1.4.2.3 Mapping of Attributes and Relations

Mono-valued attributes and relations are mapped to one (or several) cell(s)⁷ in a single row whose key is the means to unambiguously reference the DLRL object (i.e., its *oid* or its full *oid*, depending on the *owner* class characteristics as indicated in the previous section):

- simple basic attributes -> one cell of corresponding DCPS type;
- enumeration -> one cell of type integer⁸ (default behavior) or string;
- simple structures -> as many cells as needed to hold the structure;
- reference to another DLRL object (i.e., relation) -> as many cells as needed to reference unambiguously the referenced object (i.e., its *oid*, or its full *oid* as indicated in the previous section).

Multi-valued attributes are mapped to one (or several) cell(s) in a set of rows (as many as there are items in the collection), whose key is the means to unambiguously designate the DLRL object (i.e., *oid* or full *oid*) plus an index in the collection.

- For each item, there is one row that contains the following, based on the type of attribute:
 - simple basic type -> one cell of the corresponding DCPS type;
 - enumeration -> one cell of type integer or string;
 - simple structures -> as many cells as needed to hold the structure;
 - reference to another DLRL object -> as many cells as needed to reference unambiguously the referenced object (i.e., its *oid*, or its full *oid* as indicated in the previous section).
- The key for that row is the means to designate the owner's object (i.e., its *oid* or full *oid*) + an index, which is:
 - an integer if the collection basis is a list (to hold the rank of the item in the list);
 - a string or an integer⁹ if the collection basis is a map (to hold the access key of the item in the map).

3.1.4.3 Default Mapping

The following mapping rules will be applied by default. This default mapping is overwritten by any mapping information provided by the application developer.

- Main table
 - name of the DCPS Topic is the DLRL class name;

7. Depending of the type of the value.

8. In the PIM, the type 'integer' has been chosen each time a whole number is needed. In the PSM, however, a more suitable representation for such numbers (long, short...) will be chosen.

9. String-keyed maps are desired for their openness; however, integer-keyed maps are more suitable when access performance is desired.

- name of the *oid* fields are:
 - “class”
 - “oid”
- All the mono-valued attributes of an object are located in that main table:
 - name of the DCPS Topic is thus DLRL class name;
 - name of the DCPS fields:
 - name of the DLRL attribute, if only one field is required;
 - name of the DLRL attribute, concatenated with the name of each sub-field, with '.' as separator, otherwise.
- For each multi-valued attribute, a specific DCPS table is allocated:
 - name of the DCPS Topic is the DLRL class name concatenated with the DLRL attribute name, with '.' as separator;
 - name of the DCPS fields
 - same as above for the value part and the OID part
 - “index” for the extra key field
- Inheritance support by means of extension tables gathering all the mono-valued added attributes:
 - this choice is the better as far as memory is concerned;
 - it is made possible once it is admitted that all the attributes of a given class are not located in a single table.

3.1.4.4 *Metamodel with Mapping Information*

Figure 3-2 represents the DLRL metamodel with the information that is needed to indicate the structural mapping.

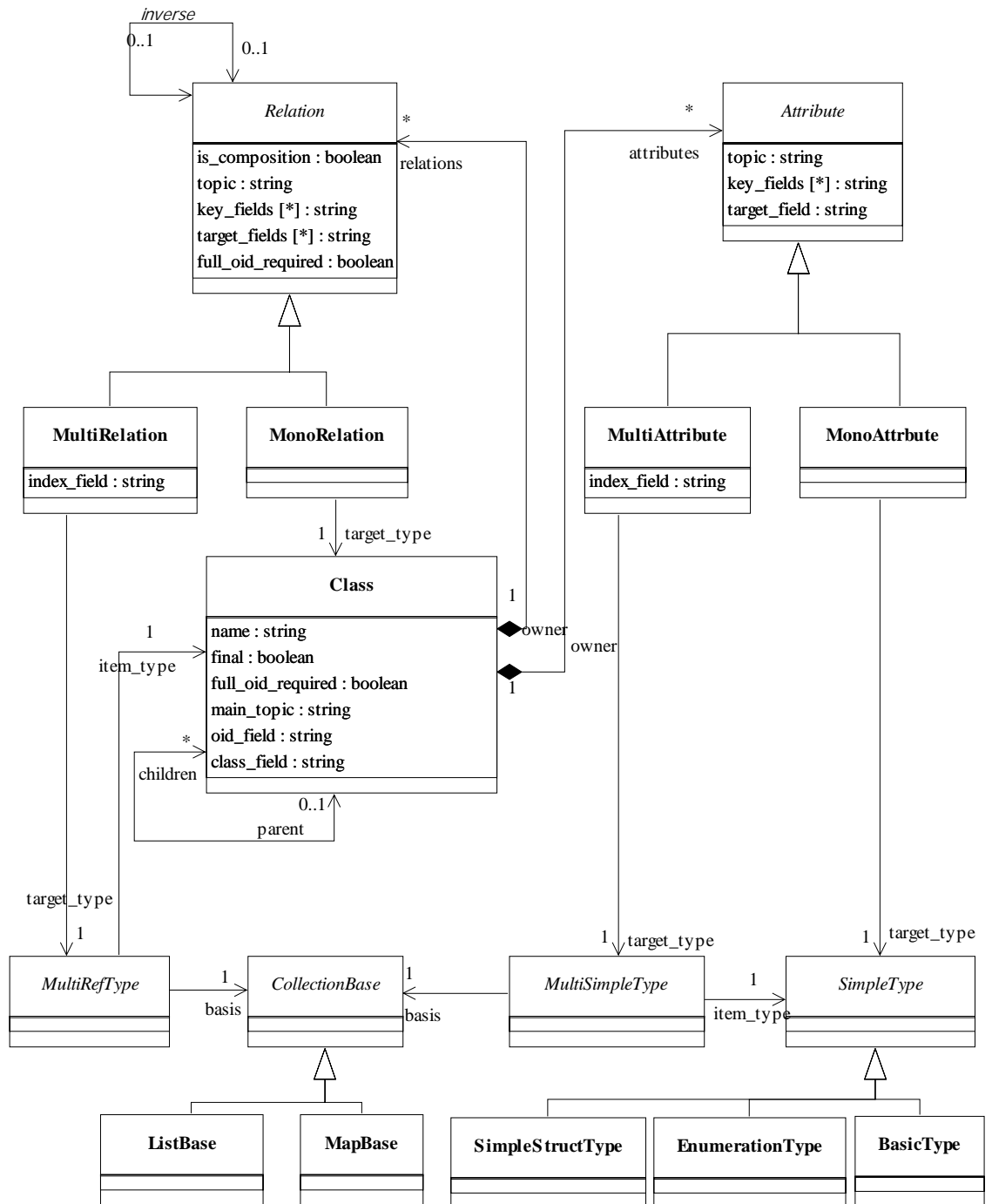


Figure 3-2 DLRL Model with Structural Mapping Information

The three constructs that need added information related to the structural mapping are **Class**, **Attribute** and **Relation**.

3.1.4.4.1 Class

The related fields have the following meaning:

- *main_topic* is the name of the main topic for this class. Any DLRL instance of this *Class* is represented by a row in this *topic*¹⁰;
- *oid_field* is the name of the field meant to store the *oid* of the DLRL object;
- *class_field* is the name of the field meant to store the *name* of the *Class*.
- *full_oid_required* indicates whether the class *name* should be the first part of the actual key; the actual key will be made of:
 - (*class_field*, *oid_field*) if it is true;
 - (*oid_field*) if it is false;
- *final* indicates whether or not the class can be extended.

3.1.4.4.2 MonoAttribute

The related fields have the following meaning:

- *topic* is the name of the table where the related value is located. It may be the same as the *owner Class::main_topic*.
- *target_field* is the field that contains the actual value for the attribute.
- *key_fields* is the name of the fields that make the key in this topic (1 or 2 depending on the *Class* definition).

3.1.4.4.3 MultiAttribute

The related fields have the following meaning:

- *topic* is the name of the table where the related value is located. It cannot be the same as the *owner Class::topic*;
- *target_field* is the field that contains the actual values for the attribute;
- *key_fields* is the name of the fields that make the object part of the key in this topic (1 or 2 depending on the *owner Class* definition);
- *index_field* is the name of the item part of the key in this *topic* (string or integer depending on the collection type)¹¹.

3.1.4.4.4 MonoRelation

The related fields have the following meaning:

10. It may have attributes in other topics as well.

11. In other words, all the rows that have the same value for the *key_fields* constitute the contents of the collection; each individual item in the collection is pointed by (*key_fields*, *index_field*).

- **topic** is the name of the table where the related value is located. It may be the same as the *owner Class::topic*.
- **target_fields** are the fields that contain the actual value for the attribute (i.e., what identifies the target object); it is made of 1 or 2 fields according to the *full_oid_required* value).
- **key_fields** is the name of the fields that make the key in this topic (1 or 2 depending on the *owner Class* definition).
- **full_oid_required** indicates whether that relation needs the full *oid* to designate target objects.
- **is_composition** indicates if it is a mono- or multi-relation.

3.1.4.4.5 MultiRelation

The related fields have the following meaning:

- **topic** is the name of the table where the related value is located. It cannot be the same as the *owner Class::topic*.
- **target_fields** are the fields that contain the actual values for the attribute (i.e., what identify the target objects); it is made of 1 or 2 fields according to the *full_oid_required* value).
- **key_fields** is the name of the fields that make the object part of the key in this *topic* (1 or 2 depending on the *owner Class* definition).
- **index_field** is the name of the item part of the key in this topic (string or integer depending on the collection type).
- **full_oid_required** indicates whether that relation needs the full *oid* to designate target objects.
- **is_composition** indicates if it is a mono- or multi-relation.

3.1.4.5 Mapping when DCPS Model is Fixed

In some occasions, it is desirable to map an existing DCPS model to the DLRL. It is even desirable to mix, in the same system, participants that act at DCPS level with others that act at the DLRL level. The DLRL, by not imposing the same object model to be shared among all participants, is even designed to allow this last feature.

In this case, it is possible to use the topic keys to identify the objects, but not to store the object references directly. Therefore, the DLRL implementation must indicate the topic fields that are used to store the keys so that, behind the scenes, it can manage the association keys to/from oid and perform the needed indirection.

Because the object model remains local, this is feasible even if supporting inheritance between the applicative classes (beyond the primary inheritance between an applicative class and *ObjectRoot*) may be tricky. However an exiting DCPS model by construction is unlikely to rely heavily on inheritance between its 'classes.' Therefore such a mapping is supported.

3.1.4.6 How is this Mapping Indicated?

There should be two orthogonal descriptions:

- the object model itself, i.e.,
 - the full object model,
 - indications of the part that is to be made shared.
- the mapping itself.

In case we were targeting only languages where metaclasses are fully supported, this information could be provided by the application developer by instantiating the above mentioned constructs. As this is not the case, we propose the following approach, as described on Figure 3-3.

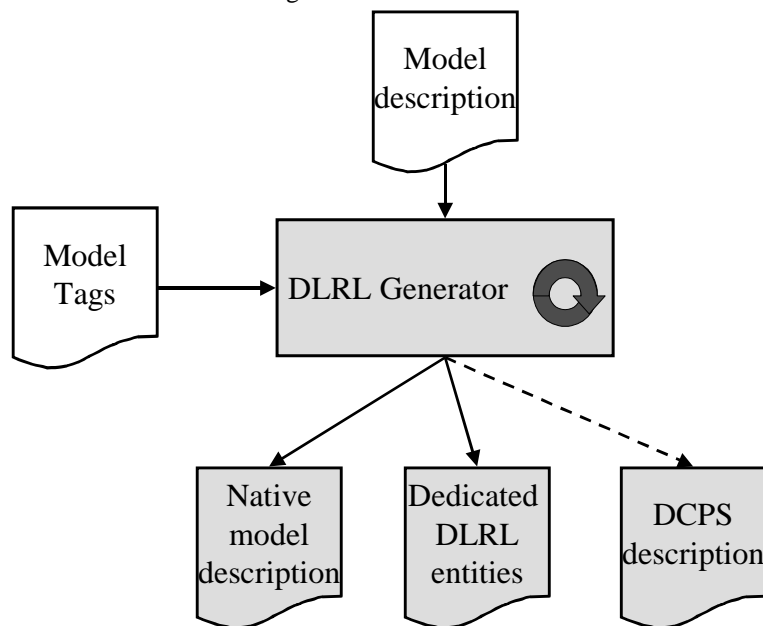


Figure 3-3 DLRL Generation Process

Based on the model description and tags that enhance the description, the tool will generate:

- the native model definition (i.e., the application classes as they will be usable by the application developer);
- the dedicated DLRL entities (i.e., the helper classes to consistently use the former ones and form the DLRL run-time);
- on demand, the corresponding DCPS description.

The syntax of those descriptions is dependant on the underlying platform. One syntax is proposed with the OMG IDL PSM in “OMG IDL Platform Specific Model (PSM)” on page 3-44.

3.1.5 Operational Mapping

3.1.5.1 Attachment to DCPS entities

A DLRL class is associated with several DCPS *Topic*, each of which is accessible via a DCPS *DataWriter* (write access) and/or a DCPS *DataReader* (read access). All the *DataWriter/DataReader* objects that are used by a DLRL object are to be attached to a single *Publisher/Subscriber* in order to consistently manage the object contents.

DLRL classes are linked to other DLRL classes by means of *Relation* objects. In order for these relations to be managed consistently (e.g., when a relation is set to a newly created object, set up of the relation and the object creation are simultaneously performed), the whole graph has to be attached to the same *Publisher/Subscriber*.

Therefore, DLRL has attached a *Publisher* and/or a *Subscriber* to the notion of a *Cache* object, which manages all the objects, thereby making a consistent set of related objects. The use of those DCPS entities is thus totally transparent to the application developer.

3.1.5.2 Creation of DCPS Entities

Operations are provided at the DLRL level to create and activate all the DCPS entities that are needed for managing all the instances of DLRL classes attached to a *Cache*, for publication and/or for subscription.

Note – Activating the related DCPS entities for subscription (namely the *Subscriber* and its attached *DataReader* objects) corresponds to actually performing the subscriptions.

3.1.5.3 Setting of QoS

QoS must be attached to each DCPS entity (*Publisher/Subscriber*, *Topic/DataWriter/DataReader*). This can be done between the creation and activation of these entities.

Putting the same QoS on all the DCPS entities that are used for a graph of objects (or even for a single object) is not very sensible. In return, it is likely that one object will present different attributes with different QoS requirements (i.e., some parts of the object need to be PERSISTENT, others are VOLATILE, etc.). Therefore, DLRL does not offer a specific means to set QoS, but it does offer a means to retrieve the DCPS entities that are attached to the DLRL entities, so that the application developer can set QoS if needed.

3.1.6 Functional Mapping

Functional mapping is the translation of the DLRL functions to DCPS functions. It obviously depends firstly on the DLRL operation modes (i.e., the way the applications may use the DLRL entities).

3.1.6.1 DLRL Requested Functions

3.1.6.1.1 Publishing Application

Once the publishing DCPS infrastructure is set, publishing applications need to repeatedly:

- create objects,
- modify them,
- possibly destroy them,
- request publication of the performed changes (creations, modifications, destructions).

Even if an object is not changeable by several threads at the same time, there is a need to manage concurrent threads of modifications in a consistent manner.

3.1.6.1.2 Subscribing Application

Once the subscribing DCPS infrastructure is set, subscribing applications need to:

- load objects (i.e., make subscribed DCPS data, DLRL objects),
- read their attributes and/or relations,
- possibly use the relations to navigate among the objects,
- be made aware of changes to the objects that are there, or the arrival of new objects.

The application needs to be presented with a consistent view of a set of objects.

3.1.6.1.2.1 Implicit versus Explicit Subscriptions

The first important question is whether the loading of objects happens in the scope of the known subscriptions (explicit subscriptions) or whether it may extend them, especially when navigating to another object by means of a relation (implicit subscriptions). The choice has been to keep the DLRL set of objects inside the boundary of the known subscriptions¹², for the following reasons:

- In the use cases we have, implicit subscriptions are not needed.
- Implicit subscriptions would cause the following issues, which are almost impossible to solve while maintaining a high level of decoupling between DCPS and DLRL:
 - structural mapping - to which DCPS data does the new object definition correspond?
 - operational mapping - in particular, which QoS has to be associated to the related DCPS entities?

12. That means that no subscription will be made 'on the fly' to reach an object that is an instance of a class for which no subscription has been made.

- Implicit subscriptions would make it difficult for the application to master its set of objects.

If a relation points towards an object for which no subscription exists, navigating through that relation will raise an error (NotFound).

3.1.6.1.2.2 Cache Management

The second important question is how the cache of objects is updated with incoming information. This can be done:

- upon application requests,
- fully transparently.

DLRL general principle is to update the cache of objects transparently with incoming updates. However, means are given to the application to turn on/off this feature when needed. In addition, copies of objects can be requested in order to navigate into a consistent set of object values when updates continue to be applied on the originals (see *CacheAccess* objects for more details).

3.1.6.1.2.3 User Interaction

Another important question is how the application is made aware of changes on the objects it has. A listener is a convenient pattern for that purpose. The question is, however, the granularity it gets:

- it is useful to reflect several incoming updates ‘as a whole;’
- for an object modification, it is useful to indicate which are the modified attributes.

3.1.6.1.3 Publishing and Subscribing Applications

Most of DLRL publishing applications will also be subscribing ones. There is thus a strong need to support this nicely. In particular, it means that the application should be able to control the mix of incoming updates and of modifications it performs.

3.1.6.2 DLRL Entities

Figure 3-4 describes all the DLRL entities that support the DLRL operations at run-time. Note that most of them are actually roots for generated classes depending on the DLRL classes (they are indicated in *italics*); the list of classes that are generated for an application-defined class named *Foo* is given in “Generated Classes” on page 3-44.

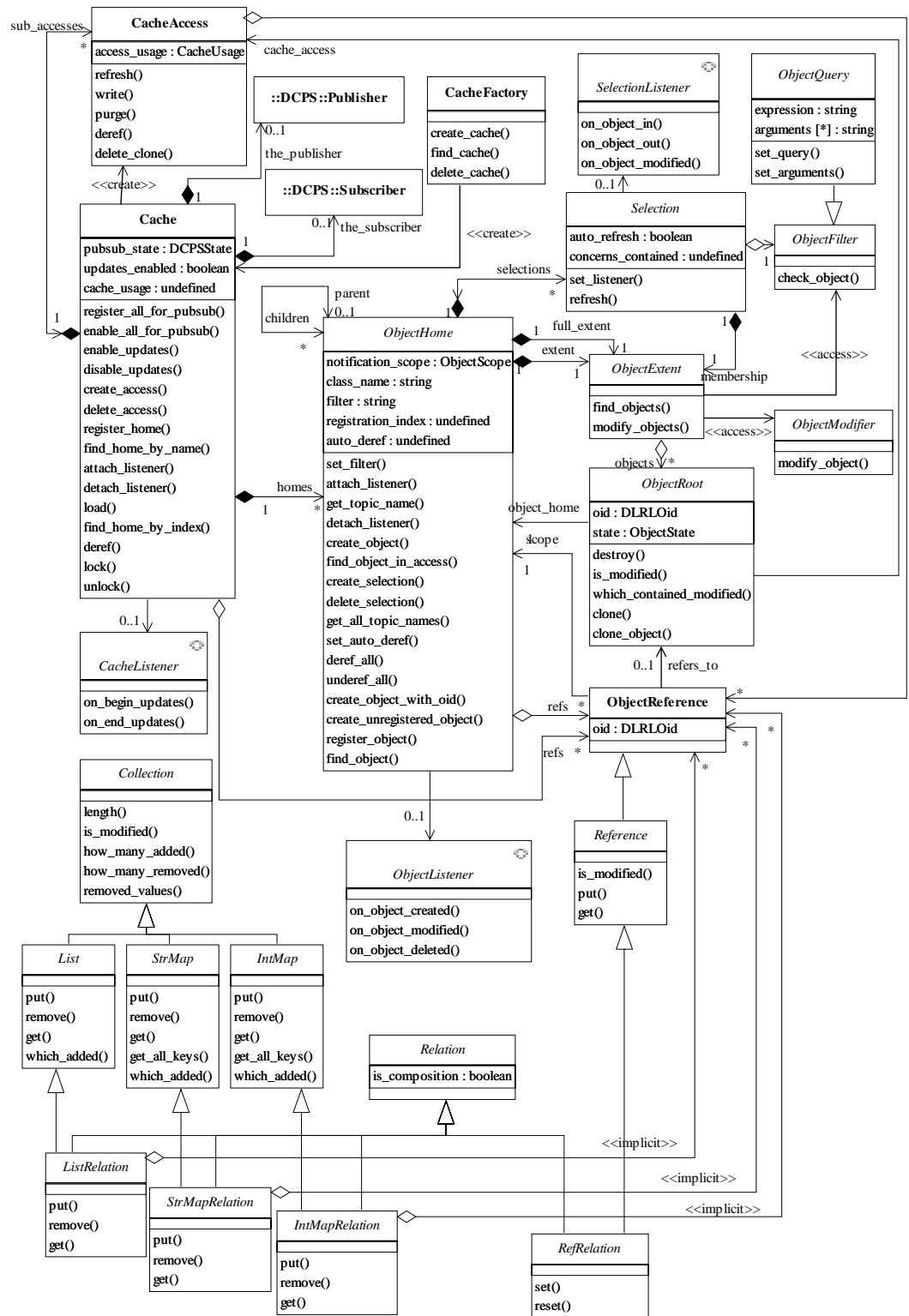


Figure 3-4 DLRL entities

The DLRL entities are:

CacheFactory	Class whose unique instance allows the creation of Cache objects.
Cache	Class whose instance represents a set of objects that are locally available. Objects within a Cache can be read directly; however to be modified, they need to be attached first to a CacheAccess . Several Cache objects may be created but in this case, they must be fully isolated: <ul style="list-style-type: none"> • A Publisher can only be attached to one Cache. • A Subscriber can only be attached to one Cache. • Only DLRL objects belonging to one Cache can be put in relation.
CacheAccess	Class that encapsulates the access to a set of objects. It offers methods to refresh and write objects attached to it; CacheAccess objects can be created in read mode, in order to provide a consistent access to a subset of the Cache without blocking the incoming updates or in write mode in order to provide support for concurrent modifications/updates threads.
CacheListener	Interface to be implemented by the application to be made aware of the arrival of incoming updates on the cache of objects.
ObjectHome	Class whose instances act as representative for all the local instances of a given application-defined class.
ObjectListener	Interface to be implemented by the application to be made aware of incoming updates on the objects belonging to one peculiar ObjectHome .
Selection	Class whose instances act as representatives of a given subset of objects. The subset is defined by an expression attached to the selection.
ObjectFilter	Class whose instances act as filter for Selection objects. When a Selection is created, it must be given an ObjectFilter .
ObjectQuery	Specialization of the above that perform a filter based on a query expression.
SelectionListener	Interface to be implemented by the application to be made aware on updates made on objects belonging to that selection.
ObjectModifier	Class whose instances represent modifiers to be applied to a set of objects.
ObjectExtent	Class to manage a set of instances. ObjectExtent objects are used to represent all the instances managed by an ObjectHome as well as all the members of a Selection . They can also be used in conjunction with ObjectFilter and/or ObjectModifier to allow collective operations on sets of objects.
ObjectRoot	Abstract root class for all the application-defined classes.
ObjectReference	Class to represent a raw reference (untyped) to an object ¹ .
Reference	Class to represent a typed reference to an object.
Collection	Abstract root for all the collections of objects as well as of values.
List	Abstract root for all the lists of objects as well as of values.
StrMap	Abstract root for all the maps of objects as well as of values, with string key management.

<i>IntMap</i>	Abstract root for all the maps of objects as well as of values, with integer key management.
<i>Relation</i>	Abstract root for all the relations between objects.
<i>RefRelation</i>	Abstract root for all the classes to represent a to-1 relation.
<i>ListRelation</i>	Abstract root for all the classes to represent a to-n relation based on a list.
<i>StrMapRelation</i>	Abstract root for all the classes to represent a to-n relation based on a map with string key management.
<i>IntMapRelation</i>	Abstract root for all the classes to represent a to-n relation based on a map with integer key management.

1. The specification does not impose that all existing objects be instantiated by means of ***ObjectRoot***; objects can be kept by means of ***ObjectReference***, provided that they are instantiated when needed (lazy instantiation).

3.1.6.3 Details on DLRL Entities

The following sections describe each DLRL entity one by one. For each entity a table summarizes the public attributes and/or methods provided.

It should be noted that, as far as the return value of a method is concerned, only the functional values are indicated. Errors are not considered here. At PSM level, a consistent scheme for error returning will be added.

When a parameter or a return value is stated as ‘undefined,’ that means that the operation is actually part of an abstract class, which will be derived to give concrete classes with typed operations.

3.1.6.3.1 CacheFactory

The unique instance of this class allows the creation of Cache objects.

<i>CacheFactory</i>		
no attributes		
operations		
create_cache		Cache
	cache_usage	CacheUsage
	description	CacheDescription
find_cache_by_name		Cache
	name	CacheName
delete_cache		void
	a_cache	Cache

This class offers methods:

- To create a Cache (***create_cache***)
This method takes as a parameter ***cache_usage***, which indicates the future usage of the ***Cache*** (namely WRITE_ONLY—no subscription, READ_ONLY—no

publication, or READ_WRITE—both modes) and a description of the *Cache* (at a minimum, this *CacheDescription* gathers the concerned *DomainParticipant* as well as a *name* allocated to the *Cache*); depending on the *cache_usage*, a *Publisher*, a *Subscriber*, or both will be created for the unique usage of the *Cache*; these two objects will be attached to the passed *DomainParticipant*.

- To retrieve a *Cache* based on the name given in the *CacheDescription* (*find_cache_by_name*).
- To delete a *Cache* (*delete_cache*); this operation releases all the resources allocated to the *Cache*.

3.1.6.3.2 CacheAccess

CacheAccess is a class that represents a way to globally manipulate DLRL objects in isolation.

<i>CacheAccess</i>		
attributes		
access_usage		CacheUsage
owner		Cache
refs		ObjectReference []
operations		
refresh		void
write		void
purge		void
delete_clone		void
	ref	ObjectReference
deref		ObjectRoot
	ref	ObjectReference

A *CacheAccess* only belongs to one *Cache* (*owner*)—the one that creates it.

The attribute *access_usage* indicates whether the cache is intended to support write operations (WRITE_ONLY or READ_WRITE) or not (READ_ONLY). This attribute is given at creation time and must be compatible with the value of the owning *Cache* (see *Cache::create_access*).

Once the *CacheAccess* is created for a given purpose, copies of DLRL objects can be attached to it (see *ObjectRoot::clone* method), by means of references (*refs*) and then:

- the attached objects can be refreshed (*refresh*). This operation takes new values from the Cache for all attached objects, following the former clone directives. This can lead to discard changes on the cloned objects if they haven't been saved by writing the *CacheAccess*.

- the copies can be consulted; navigation is performed only into the set of objects attached to the *CacheAccess*. In other words, if a relation points to an object that has not been attached to the *CacheAccess*, navigating through that relation will raise an error – *NotFound*.
- if the *cache_usage* allows write operation, those objects can be modified and/or new objects created for that access and eventually all the performed modifications written for publications (*write*).
- the copies can be detached from the *CacheAccess* (*purge*).
- alternatively, the copy of one object and all its attached contained objects can be detached from the *CacheAccess* (*delete_clone*).
- a method allows transformation of an *ObjectReference* in the *ObjectRoot*, which is valid for this *CacheAccess* (*deref*).

See “ObjectHome” on page 3-24 for a description of typical uses of cache accesses.

3.1.6.3.3 Cache

An instance of this class gathers a set of objects that are managed, published, and/or subscribed consistently.

Cache		
attributes		
cache_usage		CacheUsage
pubsub_state		DCPSState
updates_enabled		boolean
sub_accesses		CacheAccess []
homes		ObjectHome []
listeners		CacheListener []
the_publisher		DDS::Publisher
the_subscriber		DDS::Subscriber
refs		ObjectReference []
operations		
register_home		integer
	a_home	ObjectHome
find_home_by_name		ObjectHome
	class_name	string
find_home_by_index		ObjectHome
	registration_index	integer
register_all_for_pubsub		void
enable_all_for_pubsub		void
attach_listener		void
	listener	CacheListener
detach_listener		void
	listener	CacheListener

enable_updates		void
disable_updates		void
load		void
create_access		CacheAccess
	purpose	CacheUsage
delete_access		void
	access	CacheAccess
deref		ObjectRoot
	ref	ObjectReference
lock		void
	to_in_milliseconds	integer
unlock		void

The public attributes give:

- the usage mode of the cache (WRITE_ONLY—no subscription, READ_ONLY—no publication, or READ_WRITE—both modes). This mode applies to all objects in the cache and has to be given at creation time (*cache_usage*).
- the state of the cache with respect to the underlying Pub/Sub infrastructure (*pubsub_state*), as well as the related *Publisher* (*the_publisher*) and *Subscriber* (*the_subscriber*).
- the state of the cache with respect to incoming updates (*updates_enabled*); this state is modifiable by the applications (see *enable_updates*, *disable_updates*) in order to support applications that are both publishing and subscribing.
- the attached *CacheAccess* (*sub_accesses*).
- the attached *ObjectHome* (*homes*).
- the attached *CacheListener* (*listeners*).
- the attached *ObjectReference* (*refs*).

It offers methods to:

- register an *ObjectHome* (*register_home*); this method returns the index under which the *ObjectHome* is registered by the *Cache*.
- retrieve an already registered *ObjectHome* based on its name (*find_home_by_name*) or based on its index of registration (*find_home_by_index*).
- register all known *ObjectHome* to the Pub/Sub level (*register_all_for_pubsub*), i.e., create all the needed DCPS entities. Registration is performed for publication, for subscription, or for both according to the *cache_usage*. At this stage, it is the responsibility of the service to ensure that all the object homes are properly linked and set up: that means in particular that all must have been registered before.
- enable the derived Pub/Sub infrastructure (*enable_all_for_pubsub*); QoS setting can be performed between those two operations.
- attach/detach a *CacheListener* (*attach_listener*, *detach_listener*).
- enable/disable incoming updates (*enable_updates*, *disable_updates*):

- ***disable_updates*** causes incoming, but not yet applied, updates to be registered for further application. If it is called in the middle of a set of updates (see ***Listener*** operations), the ***Listener*** will receive ***end_updates*** with a parameter that indicates that the updates have been interrupted.
- ***enable_updates*** causes the registered (and thus not applied) updates to be taken into account, and thus to trigger the attached ***Listener***, if any.
- explicitly request taking into account the waiting incoming updates (***load***). In case ***updates_enabled*** is TRUE, the load operation does nothing because the updates are taken into account on the fly. In case ***updates_enabled*** is FALSE, the ***load*** operation ‘takes’ all the waiting incoming updates and applies them in the ***Cache***; the ***load*** operation does not trigger any listener (while automatic taking into account of the updates does - see “Listeners Activation” on page 3-41 for more details on listener activation) and may therefore be useful in particular for global initialization of the ***Cache***.
- create new ***CacheAccess*** objects dedicated to a given purpose (***create_access***). This method allows the application to create sub-accesses and takes as a parameter the purpose of that sub-access, namely:
 - write allowed (WRITE_ONLY or READ_WRITE¹³) – to isolate a thread of modifications.
 - write forbidden (READ_ONLY) – to take a consistent view of a set of objects and isolate it from incoming updates.

The purpose of the ***CacheAccess*** must be compatible with the usage mode of the ***Cache***: only a ***Cache*** that is write-enabled can create sub-accesses that allow writing:

- delete sub-accesses (***delete_access***).
- transform an ***ObjectReference*** to the corresponding ***ObjectRoot***. This operation can return the already instantiated ***ObjectRoot*** or create one if not already done. These ***ObjectRoots*** are not modifiable (modifications are only allowed on cloned objects attached to a ***CacheAccess*** in write mode).
- ***lock*** the ***Cache*** with respect to all other modifications, either from the infrastructure or from other application threads. This operation ensures that several operations can be performed on the same ***Cache*** state (i.e., cloning of several objects in a ***CacheAccess***). This operation blocks until the ***Cache*** can be allocated to the calling thread and the waiting time is limited by a time-out (***to_in_milliseconds***); in case the time-out expired before the lock can be granted, an exception (***ExpiredTimeOut***) is raised.
- ***unlock*** the ***Cache***.

Objects attached to the cache are supposed to be garbage-collected when appropriate. There is therefore no specific operation for doing this.

13. That for a sub-access are equivalent.

3.1.6.3.4 CacheListener

CacheListener is an interface that must be implemented by the application in order to be made aware of the arrival of updates on the cache.

<i>CacheListener</i>		
operations		
on_begin_updates		void
	related_cache	Cache
	update_round	integer
on_end_updates		void
	related_cache	Cache
	update_round	integer
	interrupted	boolean

It provides the following methods:

- *on_begin_updates* to indicates that updates are following. Actual modifications in the cache will be performed only when exiting this method (assuming that *updates_enabled* is true).
- *on_end_updates* that indicates that no more update is foreseen (either because no more update has been received – *interrupted* = FALSE, or because the updates have been disabled for that *Cache* – *interrupted* = TRUE).

In between, the updates are reported on home or selection listeners “Listeners Activation” on page 3-41 describes which notifications are performed and in what order.

3.1.6.3.5 ObjectHome

For each application-defined class, there is an *ObjectHome* instance, which exists to globally represent the related set of instances and to perform actions on it. Actually, *ObjectHome* is the root class for generated classes (each one being dedicated to one application-defined class, so that it embeds the related specificity). The name for such a derived class is *FooHome*, assuming it corresponds to the application-defined class *Foo*.

<i>ObjectHome</i>	
attributes	
class_name	string
filter	string
registration_index	integer
refs	ObjectReference []
auto_deref	boolean
extent	ObjectExtent
full_extent	ObjectExtent
selections	Selection []
listener	ObjectListener []

operations		
get_topic_name		string
	attribute_name	string
get_all_topic_names		string []
set_filter		void
	expression	string
set_auto_deref		void
	value	boolean
deref_all		void
underef_all		void
attach_listener		void
	listener	ObjectListener
	concerns_contained_objects	boolean
detach_listener		void
	listener	ObjectListener
create_selection		Selection
	filter	ObjectFilter
	auto_refresh	boolean
	concerns_contained_objects	boolean
delete_selection		void
	a_selection	Selection
create_object		ObjectRoot
	access	CacheAccess
create_object_with_oid		ObjectRoot
	access	CacheAccess
	oid	DLRLOid
create_unregistered_object		ObjectRoot
	access	CacheAccess
register_object		void
	unregistered_object	ObjectRoot
find_object_in_access		ObjectRoot
	oid	DLRLOid
	access	CacheAccess
find_object		ObjectRoot
	oid	DLRLOid

The public attributes give:

- The public name of the application-defined class (*class_name*).
- A *filter* that is used to filter incoming objects; it only concerns subscribing applications; only the incoming objects that pass the filter will be created in the *Cache* and by that *ObjectHome*. This filter is given by means of a string and is intended to be mapped on the underlying DCPS infrastructure to provide content-based subscription at DLRL level; see Appendix C for its syntax.

- The *index* under which the *ObjectHome* has been registered by the *Cache* (see *Cache::register_home* operation).
- The list of *ObjectReference* that correspond to objects of that class (*refs*).
- A boolean that indicates if *ObjectReference* corresponding to that type should be implicitly instantiated (TRUE) or if this action should be explicitly done by the application when needed by calling a *deref* operation (*auto_deref*); as selections act on instantiated objects (see section 3.1.6.3.7 for details on selections), TRUE is a sensible setting when selections are attached to that home.
- The manager for the list of all the instantiated objects of that class (*extent*).
- The manager for the list of all the instantiated objects of that class and all its derived classes (*full_extent*).
- The list of attached *Selection* (*selections*).
- The list of attached *ObjectListener* (*listeners*).

Those last four attributes will be generated properly typed in the derived specific home. It offers methods to:

- Set the *filter* for that *ObjectHome* (*set_filter*); as a filter is intended to be mapped on the underlying infrastructure it can be set only before the *ObjectHome* is registered (see *Cache::register_home*).
- Set the *auto_deref* boolean (*set_auto_deref*).
- Ask for the instantiation of all the *ObjectReference* that are attached to that home, in the *Cache* (*deref_all*).
- Ask for the removal of non-used *ObjectRoot* that are attached to this home (*underef_all*).
- Attach/detach a *ObjectListener* (*attach_listener*, *detach_listener*). When a listener is attached, a boolean parameter specifies, when set to TRUE, that the listener should listen also for the modification of the contained objects (*concerns_contained_objects*).
- Create a *Selection* (*create_selection*); the *filter* parameter specifies the *ObjectFilter* to be attached to the *Selection*, the *auto_refresh* parameter specifies if the *Selection* has to be refreshed automatically or only on demand (see *Selection*) and a boolean parameter specifies, when set to TRUE, that the *Selection* is concerned not only by its member objects but also by their contained ones (*concerns_contained_objects*); attached *ObjectFilter* belongs to the *Selection* that itself belongs to its creating *ObjectHome*.
- Delete a *Selection* (*delete_selection*); this operation deletes the *Selection* and its attached *ObjectFilter*.
- Create a new DLRL object (*create_object*); this operation takes as parameter the *CacheAccess* concerned by the creation; it raises an exception (*ReadOnlyMode*) if the *CacheAccess* is in READ_ONLY mode.

- Create a new DLRL object with a user-provided *oid* (*create_object_with_oid*). This operation takes as parameter the *CacheAccess* concerned by the creation as well as the allocated oid. It raises an exception (*ReadOnlyMode*) if the *CacheAccess* is in READ_ONLY mode and another exception (*AlreadyExisting*) in that oid has already been given.
- Pre-create a new DLRL object in order to fill its content before the allocation of the *oid* (*create_unregistered_object*); this method takes as parameter the *CacheAccess* concerned with this operation; it raises an exception (*ReadOnlyMode*) if the *CacheAccess* is in READ_ONLY mode.
- Register an object resulting from such a pre-creation (*register_created_object*). This operation embeds a logic to derive from the object content a suitable *oid*; only objects created by *create_unregistered_object* can be passed as parameter. The method raises an exception (*BadParameter*) if an attempt is made to pass another kind of object, or if the object content is not suitable and another exception (*AlreadyExisting*) if the result of the computation leads to an existing *oid*.
- Retrieve a DLRL object based on its *oid* in a given *CacheAccess* (*find_object_in_access*).
- Retrieve a DLRL object based on its *oid* in the main *Cache* (*find_object*).
- Retrieve the name of the topic that contains the value for one attribute (*get_topic_name*).
- Retrieve the name of all the topics that contain values for all attributes of the class (*get_all_topic_names*).

3.1.6.3.6 ObjectListener

This interface is an abstract root, from which a typed interface will be derived for each application type. This typed interface (named *FooObjectListener*, if the application class is named *Foo*) then has to be implemented by the application, so that the application will be made aware of the incoming changes on objects belonging to the *FooHome*.

<i>ObjectListener</i>		
operations		
on_object_created		boolean
	ref	ObjectReference
on_object_modified		boolean
	ref	ObjectReference
	old_value	ObjectRoot
on_object_deleted		boolean
	ref	ObjectReference

It is defined with four methods:

- *on_object_created*, which is called when a new object appears in the *Cache*; this operation is called with the *ObjectReference* of the newly created object (*ref*).

- *on_object_deleted*, which is called when an object has been deleted by another participant; this operation is called with the *ObjectReference* of the newly deleted object (*ref*).
- *on_object_modified*, which is called when the contents of an object changes; this operation is called with the *ObjectReference* of the modified object (*ref*) and its old value (*old_value*); the old value may be NULL.

Each of these methods must return a boolean. TRUE means that the event has been fully taken into account and therefore does not need to be propagated to other *ObjectListener* objects (of parent classes).

See Section 3.1.6.4, “Listeners Activation,” on page 3-41 for a detailed description of how cache, home, and selection listeners are called.

3.1.6.3.7 Selection

A *Selection* is a means to designate a subset of the instances of a given *ObjectHome*, fulfilling a given criterion. This criterion is given by means of the attached *ObjectFilter*.

<i>Selection</i>		
attributes		
filter	ObjectFilter	
auto_refresh	boolean	
concerns_contained	boolean	
membership	ObjectExtent	
listener	SelectionListener	
operations		
set_listener		SelectionListener
	listener	SelectionListener
refresh		void

Actually, the *Selection* class is a root from which are derived classes dedicated to application classes (for an application class named *Foo*, *FooSelection* will be derived).

It has the following attributes:

- the corresponding *ObjectFilter* (*filter*); it is given at *Selection* creation time (see *ObjectHome::create_selection*);
- a boolean *auto_refresh* that indicates if the *Selection* has to be refreshed at each incoming modification (TRUE) or only on demand (FALSE); it is given at *Selection* creation time (see *ObjectHome::create_selection*);
- a boolean *concerns_contained* that indicates whether the *Selection* considers the modification of one of its members based on its content only (FALSE) or based on its content or the content of its contained objects (TRUE); it is given at *Selection* creation time (see *ObjectHome::create_selection*);
- the manager of the list of the objects that are part of the selection (*membership*);

- attached *listener*.

It offers the methods to:

- set the *SelectionListener* (*set_listener*), that will be triggered when the composition of the selection changes, as well as if the members are modified; *set_listener* returns the previously set listener if any; *set_listener* called with a NULL parameter discards the current listener.
- request that the *Selection* updates its members (*refresh*).

The *SelectionListener* is activated when the composition of the *Selection* is modified as well as when one of its members is modified. A member can be considered as modified, either when the member is modified or when that member or one of its contained objects is modified (depending on the value of *concerns_contained*). Modifications in the *Selection* are considered with respect to the state of the *Selection* last time it was examined, i.e.,:

- at each incoming updates processing, if *auto_refresh* is TRUE.
- at each explicit call to *refresh*, if *auto_refresh* is FALSE.

3.1.6.3.8 ObjectFilter

An *ObjectFilter* is an object (attached to a *Selection*) that gives the criterion to be applied to make the *Selection*.

<i>ObjectFilter</i>		
no attributes		
operations		
check_object		boolean
	an_object	ObjectRoot
	membership_state	enum MembershipState

It offers a method to:

- check if an object passes the filter – return value is TRUE – or not – return value is FALSE (*check_object*); this method is called with the first parameter set to the object to be checked and the second parameter set to indicate whether the object previously passed the filter (*membership_state*); the second parameter (which is actually an enumeration with three possible values - UNDEFINED_MEMBERSHIP, ALREADY_MEMBER and NOT_MEMBER) is useful when the *ObjectFilter* is attached to a *Selection* to allow the writing of optimized filters.

The *ObjectFilter* class is a root from which are derived classes dedicated to application classes (for an application class named *Foo*, *FooFilter* will be derived).

FooFilter is itself a base class that may be derived by the application in order to provide its own *check_object* algorithm. The default provided behavior is that *check_object* always returns TRUE.

3.1.6.3.9 ObjectQuery

ObjectQuery is a specialization of *ObjectFilter* that perform the object check based on a query expression.

<i>ObjectQuery</i>		
attributes		
expression		string
parameters		string []
operations		
set_query		boolean
	expression	string
	arguments	string []
set_parameters		boolean
	arguments	string []

The query is made of an *expression* and of *parameters* that may parameterize the *expression* (the number of *parameters* must fit with the values required by the *expression*). See Appendix C for the syntax of an *expression* and its *parameters*.

It offers methods to set the values of the:

- *expression* and its *parameters* (*set_query*); a TRUE return value indicates that they have been successfully changed.
- (*set_parameters*); the number of *parameters* must fit with the values required by the *expression*; a TRUE return value indicates that they have been successfully changed.

After a successful call to one of those methods the owning *Selection* is refreshed if its *auto_refresh* is TRUE.

3.1.6.3.10 SelectionListener

This interface is an abstract root, from which a typed interface will be derived for each application type. This typed interface (named *FooSelectionListener*, if the application class is named *Foo*), then has to be implemented by the application in order to be made aware of the incoming changes on objects belonging to a *FooSelection*.

<i>SelectionListener</i>		
operations		
on_object_in		void
	object	ObjectRoot
on_object_out		void
	ref	ObjectReference
on_object_modified		void
	object	ObjectRoot

It is defined with three methods:

- *on_object_in*, which is called when an object enters the *Selection*.
- *on_object_out*, which is called when an object exits the *Selection*.
- *on_object_modified*, which is called when the contents of an object belonging to the *Selection* changes.

Section 3.1.6.4, “Listeners Activation,” on page 3-41 includes a detailed description of how cache, home, and selection listeners are called.

3.1.6.3.11 ObjectModifier

An *ObjectModifier* is an object that allows the application developer to express an operation that will be applied to a set of objects, by means of an *ObjectExtent*.

<i>ObjectModifier</i>		
no attributes		
operations		
modify_object		void
	an_object	ObjectRoot

It offers a method to modify an object, which is passed as parameter (*modify_object*).

The *ObjectModifier* class is a root from which classes dedicated to application classes are derived (for an application class named *Foo*, *FooModifier* will be derived).

FooModifier is itself a base class that may be derived by the application in order to provide its own *modify_object* algorithm. The default provided behavior is that *modify_object* does nothing.

3.1.6.3.12 ObjectExtent

This class is just a manager for a set of objects of a given class. It is useful for representing all the instances of a given class, or all members of a *Selection*. Other instances may be created by the application to build a new subset of objects or to apply on a subset the same modifying operation..

<i>ObjectExtent</i>		
attributes		
objects	ObjectRoot []	
operations		
find_objects		ObjectExtent
	a_filter	ObjectFilter
modify_objects		void
	a_filter	ObjectFilter
	a_modifier	ObjectModifier

It has one public attribute:

- *objects*, which is the list of all the objects that belong to the *ObjectExtent*.

It offers methods to:

- retrieve a subset of the objects, based on a provided *ObjectFilter* (*find_objects*). The result of this method is itself an *ObjectExtent* to allow the application of filtering on a result of another filtering (composition of filters).
- apply to a subset of the objects a provided *ObjectModifier* (*modify_objects*). In case the provided *a_filter* is NULL, the provided *a_modifier* is called on all the objects.

3.1.6.3.13 ObjectRoot

ObjectRoot is the abstract root for any DLRL class. It brings all the properties that are needed for DLRL management. *ObjectRoots* are used to represent either objects that are in the *Cache* (also called primary objects) or clones that are attached to a *CacheAccess* (also called secondary objects). Secondary objects refer to a primary one with which they share the *ObjectReference*..

<i>ObjectRoot</i>		
attributes		
oid		DLRLOid
state		ObjectState
object_home		ObjectHome
cache_access		CacheAccess
ref		ObjectReference
operations		
destroy		void
is_modified		boolean
	scope	ObjectScope
which_contained_modified		RelationDescription[]
clone		ObjectReference
	access	CacheAccess
	scope	ObjectScope
	depth	integer
clone_object		ObjectRoot
	access	CacheAccess
	scope	ObjectScope
	depth	integer

Its public attributes¹⁴ give:

14.It is likely that other attributes are needed to manage the objects (i.e., a content version, a reference count...); however these are implementation details not part of the specification.

- The identity of the object (*oid*).
- Its lifecycle state (*state*).
- Its related home (*object_home*).
- The *CacheAccess* it belongs to (*cache_access*); when the *ObjectRoot* is a primary object directly attached to the *Cache*, *cache_access* is set to NULL.
- The full *ObjectReference* that corresponds to it (*ref*).

It offers methods to:

- Create a copy¹⁵ of the object and attach it to a *CacheAccess* (*clone*); an object can be cloned to only one *CacheAccess* allowing write operations; the operation takes as parameters the *CacheAccess*, the scope of the request (i.e., the object itself or the object and its components or the object and all the objects that are related) and an integer (depth).
- Clone and instantiate the object in the same operation (*clone_object*); this operation takes the same parameters as the previous one, but returns an *ObjectRoot* instead only an *ObjectReference*; it corresponds exactly to the sequence of clone followed by *CacheAccess::deref* on the reference returned by the clone operation.
- *Destroy* itself.
- See if the object has been modified by incoming modifications (*is_modified*); *is_modified* takes as parameter the scope of the request (i.e., only the object contents, the object and its component objects, the object and all its related objects; in case the object is newly created, this operation returns FALSE; ‘incoming modifications’ should be understood differently for a primary object and for a clone object
 - for a primary object, they refer to incoming updates (i.e., coming from the infrastructure);
 - for a secondary object (cloned), they refer to the modifications applied to the object by the last *CacheAccess::refresh* operation.
- Get which contained objects have been modified (*which_contained_modified*); this method returns a list of descriptions for the relations that point to the modified objects (each description includes the name of the relation and if appropriate the index or key that corresponds to the modified contained object).

In addition, application classes (i.e., inheriting from *ObjectRoot*) will be generated with a set of methods dedicated to each shared attribute:

- *get_<attribute>*, read accessor to the attribute. This accessor will embed whatever is needed to properly get the data.

15. The specification does not impose that the copy is performed at that moment: it just requires that it behaves ‘as if’. In particular, implementations may choose to actually copy the object only if needed (e.g., if incoming updates are coming for that object).

- *set_<attribute>*, write accessor for the attribute. This accessor will embed whatever is needed to further properly *write* the data to the publishing infrastructure (in particular, it will take note of the modification).
- *is_<attribute>_modified*, to get if this attribute has been modified by means of incoming modifications (see method *is_modified*).

The object *state* is actually made of two parts:

- the *primary_state* that refers to incoming modifications (i.e., incoming updates for a primary object or modifications resulting from *CacheAccess::refresh* operations for a secondary object); even if the events that trigger the state change are different for both kinds of objects, the state values are the same;

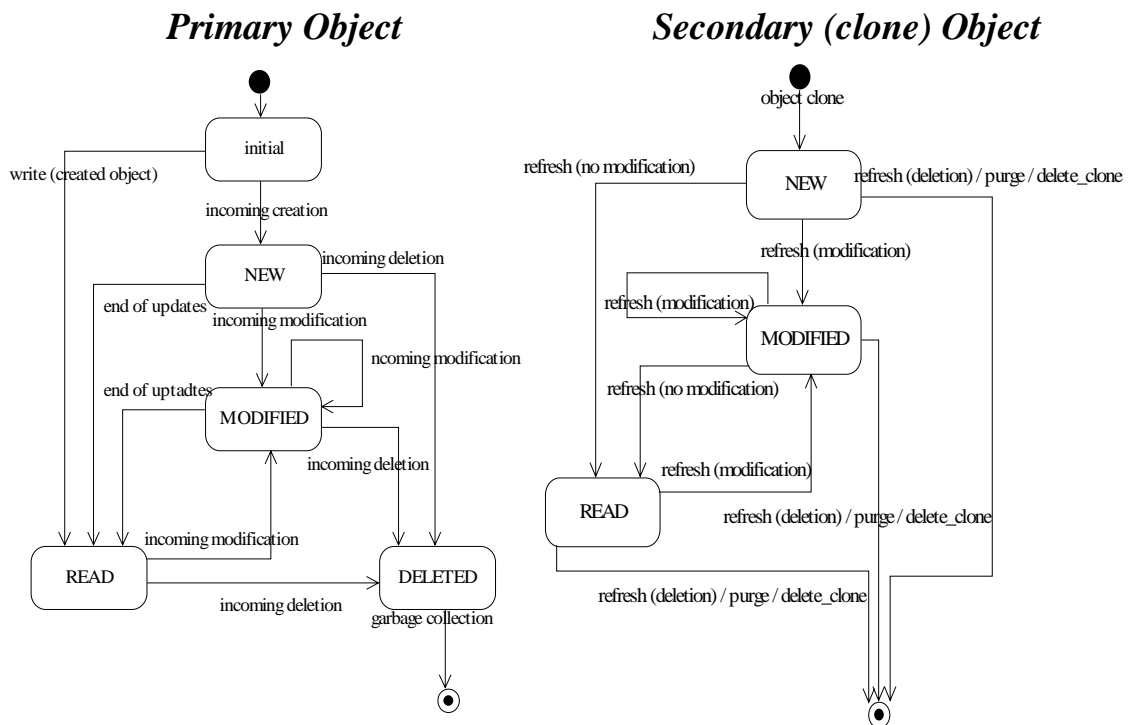


Figure 3-5 Primary State of an Object

- the *secondary_state* that refers to modifications performed by the application; for a secondary object, the state describes the taking into account of the changes asked by the application (*set_xxx* or *destroy* and then *write* of the *CacheAccess*); for a primary object, it tracks if the object has been cloned for modification purpose.

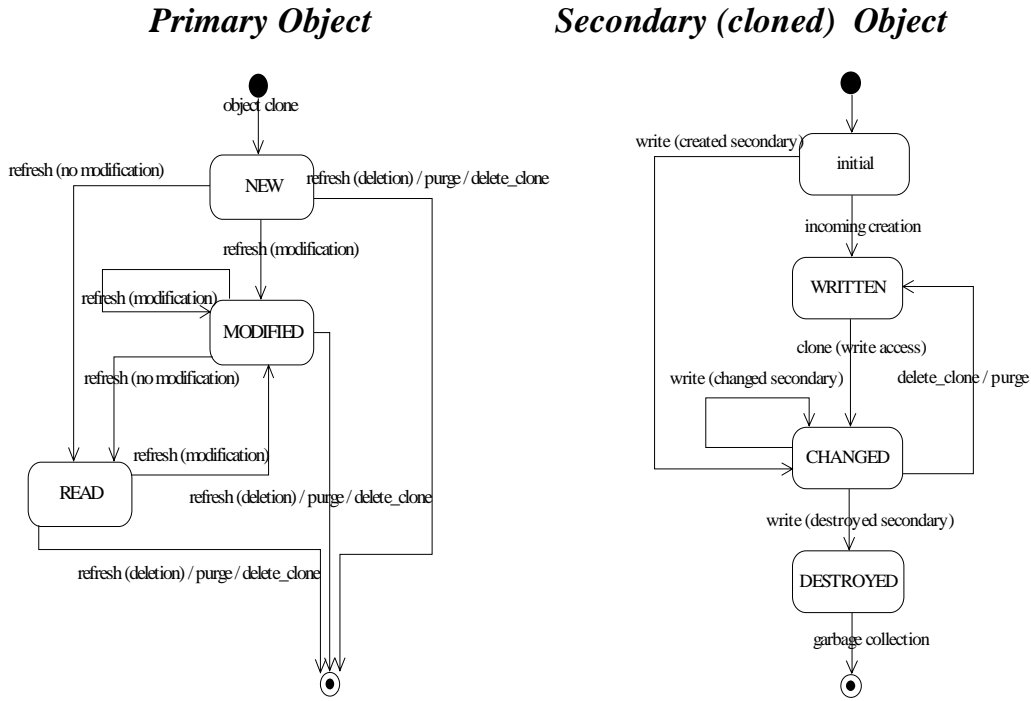


Figure 3-6 Secondary State of an Object

3.1.6.3.14 ObjectReference

Instances of *ObjectReference* classes are used to reference DLRL objects; they comprise the related *oid* and a link to the corresponding *ObjectHome*.

<i>ObjectReference</i>	
attributes	
oid	DLRLOid
scope	ObjectHome
no operations	

3.1.6.3.15 Reference

Reference is a root class for typed references to objects.

Reference : ObjectReference		
no attributes		
operations		
put		void
	object	ObjectRoot
get		ObjectRoot
is_modified		boolean
	scope	ReferenceScope

It offers methods to:

- Modify the contents of the reference (*put*) end to retrieve the pointed object (*get*); these methods are generated for each concrete reference, to take into account the type of the value.
- See if the reference has been modified with incoming updates (*is_modified*); *is_modified* takes as parameter the scope of the request (i.e., the reference itself, or the reference and its referenced content).

3.1.6.3.16 Collection

This class is the abstract root for all collections (lists and maps).

Collection		
no attributes		
operations		
length		integer
is_modified		boolean
	scope	ReferenceScope
how_many_added		integer
how_many_removed		integer
removed_values		boolean
	out: values	undefined

It provides the following methods:

- *length* to return the actual length of the collection.
- *is_modified* to return if the collection has been modified by incoming updates; *is_modified* takes as parameter the scope of the request (i.e., the collection itself, or the collection and its referenced content – note that this parameter makes a difference only if the collection contains objects).
- *how_many_added* to return the number of added items.

- *how_many_removed* to return the number of removed items.
- *removed_values* to return the list of removed values, if manageable (a FALSE return value means that the collection is to be considered as fully modified).

3.1.6.3.17 List

This class is the abstract root for all the lists. Concrete list classes will be derived, in order to provide typed lists (those classes will be named *FooList*, assuming that *Foo* is the type of one item)

List : Collection		
no attributes		
operations		
put		void
	index	integer
	value	undefined
remove		void
get		undefined
	index	integer
which_added		boolean
	out: indexes	integer []

It provides the following methods:

- *put* - to put an item in the collection.
- *remove* - to remove an item from the collection.
- *get* - to retrieve an item in the collection (based on its index).
- *which_added* - to return the indexes of the added objects, if manageable (a FALSE return value means that the collection is to be considered as fully modified).

3.1.6.3.18 StrMap

This class is the abstract root for all the maps with string keys. Concrete map classes will be derived, in order to provide typed maps (those classes will be named *FooStrMap*, assuming that *Foo* is the type of one item).

StrMap : Collection		
no attributes		
operations		
put		void
	key	string

	value	undefined
remove		void
	key	string
get		undefined
	key	string
get_all_keys		string []
which_added		boolean
	out: keys	string []

It provides the following methods:

- **put** - to put an item in the collection.
- **remove** - to remove an item from the collection.
- **get** - to retrieve an item in the collection (based on its key).
- **get_all_keys** - to retrieve all the keys of the items belonging to the map.
- **which_added** - to return the keys of the added objects, if manageable (a specific return value means that the collection is to be considered as fully modified).

3.1.6.3.19 *IntMap*

This class is the abstract root for all the maps with integer keys. Concrete map classes will be derived, in order to provide typed maps (those classes will be named **FooIntMap**, assuming that **Foo** is the type of one item).

<i>IntMap : Collection</i>		
no attributes		
operations		
put		void
	key	integer
	value	undefined
remove		void
	key	integer
get		undefined
	key	integer
get_all_keys		integer []
which_added		boolean
	out: keys	integer []

It provides the following methods:

- **put** - to put an item in the collection.
- **remove** - to remove an item from the collection.
- **get** - to retrieve an item in the collection (based on its key).

- *get_all_keys* - to retrieve all the keys of the items belonging to the map.
- *which_added* - to return the keys of the added objects, if manageable (a specific return value means that the collection is to be considered as fully modified).

3.1.6.3.20 Relation

Relation is the abstract root for all relations. It comprises an attribute that indicates whether the relation is a composition or not (*is_composition*)

Relation	
attributes	
is_composition	boolean
no operations	

3.1.6.3.21 RefRelation

RefRelation is the root for all generated classes that implement to-1 relations.

RefRelation : Relation, Reference		
no attributes		
operations		
set		void
	object	ObjectRoot
reset		void

It offers methods to modify the contents of the relation (set, reset); these methods are generated for each concrete relation, to take into account the type of the value as well as the inverse management if needed (in particular, they raise an exception (NotAllowed) if the inverse relation is a *MapRelation*).

3.1.6.3.22 ListRelation

ListRelation is the root class for all generated classes that implement to-n relations on a list basis.

ListRelation	
attributes	

values	ObjectReference []	
operations		
put		void
	index	integer
	object	ObjectRoot
remove		void
get		ObjectRoot
	index	integer

The methods to modify the contents of the *ListRelation* (*put*, *remove*) are generated to take into account the type of the value as well as the inverse management if needed. In particular, they raise an exception (NotAllowed) if the inverse relation is a *MapRelation*.

The method to retrieve one item (*get*) is generated to take into account the type of the value.

The *is_modified* definition that is applicable to a *ListRelation* is *Relation::is_modified*.

3.1.6.3.23 StrMapRelation

StrMapRelation is the root class for all generated classes that implement to-n relations on a map with string key basis.

<i>StrMapRelation</i>		
attributes		
values	ObjectReference []	
operations		
put		void
	key	string
	object	ObjectRoot
remove		void
get		ObjectRoot
	key	string

The methods to modify the contents of the *StrMapRelation* (*put*, *remove*) are generated to take into account the type of the value as well as the inverse management if needed.

The method to retrieve one item (*get*) is generated to take into account the type of the value.

The *is_modified* definition that is applicable to a *StrMapRelation* is the one of *Relation::is_modified*.

3.1.6.3.24 *IntMapRelation*

IntMapRelation is the root class for all generated classes that implement to-n relations on a map with integer key basis.

<i>IntMapRelation</i>		
attributes		
	values	ObjectReference []
operations		
	put	void
	key	integer
	object	ObjectRoot
	remove	void
	get	ObjectRoot
	key	integer

The methods to modify the contents of the *IntMapRelation* (*put*, *remove*) are generated to take into account the type of the value as well as the inverse management if needed.

The method to retrieve one item (*get*) is generated to take into account the type of the value.

The *is_modified* definition that is applicable to an *IntMapRelation* is the one of *Relation::is_modified*.

3.1.6.4 *Listeners Activation*

As described in Section 3.1.6.2, there are three kinds of listeners that the application developer may implement and attach to DLRL entities: *CacheListener*, *ObjectListener*, and *SelectionListener*. All these listeners are a means for the application to attach specific application code to the arrival of some events. They are therefore only concerned with incoming information.

This section presents how these listeners are triggered (i.e., which ones, on which events, and in which order).

3.1.6.4.1 *General Scenario*

Incoming updates¹⁶ are usually a set of coherent individual updates that may be object creations, object deletions, and object modifications.

This set of updates is managed as follows:

16. Whether those incoming updates are transmitted to the DLRL layer by means of DCPS listeners or by means of wait sets and conditions is not discussed here: this is an implementation detail

- First, all the *CacheListener::start_updates* operations are triggered; the order in which these listeners are triggered is not specified.
- Then all the updates are actually applied in the cache¹⁷. When an object is modified, several operations allow to get more precisely which parts of the object are concerned (see *ObjectRoot::is_modified* operations as well as the operations for *Collection*, namely, *is_modified*, *how_many_added*, *how_many_removed*, *removed_values*, and *which_added*); these operations can be called in the listeners.
- Then, the suitable object and selection listeners are triggered, depending on each individual update (see the following sections).
- Finally all the *CacheListener::end_updates* operations are triggered and the modification states of the updated objects is cleaned; the order in which these listeners are triggered is not specified.

3.1.6.4.2 Object Creation

When an individual update reports an object creation, the following listeners are activated:

- First, the *ObjectListener* listeners suitable to that object are searched and their *on_object_created* operations triggered. The search follows the inheritance structure starting with the more specific *ObjectHome* (e.g., *FooHome*, if the object is typed *Foo*) to *ObjectRoot*. The search is stopped when all *on_object_created* operations return true at one level; inside one level, the triggering order is not specified.
- Then, all the *Selection* objects that are concerned with that kind of objects (e.g., the *FooSelection* and above in the inheritance hierarchy) are checked to see if that new object is becoming a member of the selection. In case it is true, the attached *SelectionListener::on_object_in* is triggered.

3.1.6.4.3 Object Modification

When an individual update reports an object modification, the following listeners are activated:

- First, all the *Selection* objects that are concerned with that kind of object (e.g., the *FooSelection* and above in the inheritance hierarchy, assuming that the object is of type *Foo*) are checked to see if that new object is:
 - becoming a member of the selection; if so, the attached *SelectionListener::on_object_in* is triggered.
 - already and still part of the selection; if so, the attached *SelectionListener::on_object_modified* is triggered.
 - leaving the selection; if so, the attached *SelectionListener::on_object_out* is triggered.

¹⁷If an object is deleted, its state is set as DELETED; it will be actually removed when there are no more references to it.

- Then, the *ObjectListener* listeners suitable to that object are searched and their *on_object_modified* operations triggered. The search follows the inheritance structure starting with the more specific *ObjectHome* (e.g., *FooHome*, if the object is typed *Foo*) to *ObjectRoot*; the search is stopped when all *on_object_modified* operations return true at one level; inside one level, the triggering order is not specified.

3.1.6.4.4 Object Deletion

When an individual update reports an object deletion, the following listeners are activated:

- First, all the *Selection* objects that are concerned with that kind of object (e.g., the *FooSelection* and above in the inheritance hierarchy, assuming that the object is of type *Foo*) are checked to see if that new object was part of the selection; if so, the attached *SelectionListener::on_object_out* is triggered.
- Then, the *ObjectListener* listeners suitable to that object are searched and their *on_object_deleted* operations triggered. The search follows the inheritance structure starting with the more specific *ObjectHome* (e.g., *FooHome*, if the object is typed *Foo*) to *ObjectRoot*; the search is stopped when all *on_object_deleted* operations return true at one level; inside one level, the triggering order is not specified.

3.1.6.5 Cache Accesses Management

Cache accesses are a means to perform read or write operations in isolation from other object modifications. The two following subsections present typical use scenarios.

It should be noted that, even though a sensible design is to create a *CacheUsage* per thread, DLRL does not enforce this rule by any means.

3.1.6.5.1 Read Mode

The typical scenario for read mode is as follows:

1. Create the *CacheAccess* for read purpose (*Cache::create_access*).
2. Clone some objects in it (*ObjectRoot::clone* or *clone_object*).
3. Refresh them (*CacheAccess::refresh*).
4. Consult the clone objects and navigate amongst them (plain access to the objects); these objects are not subject to any incoming notifications.
5. Purge the cache (*CacheAccess::purge*); step 2 can be started again.
6. Eventually, delete the *CacheAccess* (*Cache::delete_access*).

3.1.6.5.2 Write Mode

The typical scenario for write mode is as follows

1. Create the *CacheAccess* for write purpose (*Cache::create_access*).

2. Clone some objects in it (*ObjectRoot::clone* or *clone_object*).
3. Refresh them (*CacheAccess::refresh*).
4. If needed create new ones for that *CacheAccess* (*ObjectHome:: create_object*).
5. Modify the attached (plain access to the objects).
6. Write the modifications into the underlying infrastructure (*CacheAccess::write*).
7. Purge the cache (*CacheAccess::purge*); step 2 can be started again.
8. Eventually, delete the *CacheAccess* (*Cache::delete_access*).

3.1.6.6 Generated Classes

Assuming that there is an application class named *Foo* (that will extend *ObjectRoot*), the following classes will be generated:

- *FooHome* : *ObjectHome*
- *FooListener* : *ObjectListener*
- *FooSelection* : *Selection*
- *FooSelectionListener* : *SelectionListener*
- *FooFilter* : *ObjectFilter*
- *FooQuery* : *FooFilter*, *ObjectQuery*
- And for relations to *Foo* objects (assuming that these relations are described in the applicative mode – note also that the actual name of these classes will be indicated by the application):
 - “*FooRelation*” : *RefRelation*
 - “*FooListRelation*” : *ListRelation*
 - “*FooStrMapRelation*” : *StrMapRelation*
 - “*FooIntMapRelation*” : *IntMapRelation*

3.2 OMG IDL Platform Specific Model (PSM)

This section provides a mapping suitable for CORBA platforms. It is described by means of IDL constructs that can be used by an application in order to interact with the services; this is described in section 3.2.1.

This section also specifies the generation process (specializing the abstract one presented on Figure 3-3 : DLRL Generation Process); in particular, the following are described:

- How the application introduces its application classes (“Model Description” on Figure 3-3).
- How the application adds indication to properly generate the DLRL entities as well as the resulting enhanced application constructs (“Model Tags” on Figure 3-3).

This process is described in section 3.2.2.

3.2.1 Run-time Entities

3.2.1.1 Mapping Rules

Rationale to define DLRL entities mapping is slightly different from what ruled the DCPS mapping, mainly because this layer does not target C language. Therefore, valuetypes or exceptions have been considered as suitable at the DLRL level, while they have been rejected for DCPS.

In summary, there are two kinds of DLRL entities:

1. Entities that are access points to servicing objects (e.g., *Cache*).
2. Entities that are application objects (i.e., whose aim is to be distributed), or parts of them.

Entities belonging to the first category are modeled as IDL local interfaces; entities belonging to the second one are modeled as IDL valuetypes (with the exception of *ObjectReference*, which is a fixed-size structure, so that it can be embedded).

The choice for valuetypes has been driven by two main reasons:

- It is the IDL construct that fits the best with the concept of DLRL objects.
- It offers a means to differentiate private from public attributes.

Error reporting has been modeled by use of exceptions, with the following rule:

- When a real error that will affect the future behavior is reported (e.g., passing of a wrong parameter), an exception is raised.
- When this ‘error’ is actually a warning in the sense that behavior will not be affected (e.g., an attempt to remove something from a list where it is not, or no more), a return value is used instead.

3.2.1.2 IDL Description

This IDL is split in two sections:

- IDL for the generic DLRL entities.
- Implied IDL.

3.2.1.2.1 Generic DLRL Entities

```
#include "dds_dcps.idl"
```

```
// =====  
// DLRL Entities  
// =====
```

```
module DDS {
```

```
// Type definitions
// =====

// Scope of action
// -----

enum ReferenceScope {
SIMPLE_CONTENT_SCOPE,      // only the reference content
REFERENCED_CONTENTS_SCOPE // + referenced contents
};

enum ObjectScope {
SIMPLE_OBJECT_SCOPE,      // only the object
CONTAINED_OBJECTS_SCOPE, // + contained objects
RELATED_OBJECTS_SCOPE    // + all related objects
};

// State of the underlying infrastructure
// -----

enum DCPState {
    INITIAL,
    REGISTERED,
    ENABLED
};

// Usage of the Cache
// -----

enum CacheUsage {
    READ_ONLY,
    WRITE_ONLY,
    READ_WRITE
};

// States of an object
// -----

typedef unsigned short ObjectSubState;

// Primary object state
const ObjectSubState OBJECT_NEW      = 0x0001 << 0;
const ObjectSubState OBJECT_MODIFIED = 0x0001 << 1;
const ObjectSubState OBJECT_READ    = 0x0001 << 2;
const ObjectSubState OBJECT_DELETED = 0x0001 << 3;

// Secondary object state
const ObjectSubState OBJECT_CREATED = 0x0001 << 8;
const ObjectSubState OBJECT_CHANGED = 0x0001 << 9;
const ObjectSubState OBJECT_WRITTEN = 0x0001 << 10;
```

```

const ObjectSubState OBJECT_DESTROYED = 0x0001 << 11;

// OID
// ---

struct DLRLoid {
    unsigned long creator_id;
    unsigned long local_id;
};

// Time-out
// -----

typedef long TimeOutDuration;
const TimeOutDuration INFINITE_TIME_OUT = -1;

// Miscellaneous
// -----

typedef sequence<long>    LongSeq;

typedef string    ClassName;
typedef string    CacheName;
typedef string    RelationName;

// Exceptions
// =====

exception DCPSError {};
exception BadHomeDefinition {};
exception BadParameter {};
exception NotFound {};
exception ReadOnlyMode {};
exception WriteOnlyMode {};
exception AlreadyExisting {};
exception AlreadyClonedInWriteMode {};
exception ExpiredTimeOut {};

// DLRL Entities
// =====

/*****
 * Forward References
 *****/

valuetype ObjectRoot;
typedef sequence<ObjectRoot> ObjectRootSeq;

```

```

local interface ObjectHome;
typedef sequence<ObjectHome> ObjectHomeSeq;

local interface ObjectListener;
typedef sequence<ObjectListener> ObjectListenerSeq;

local interface Selection;
typedef sequence<Selection> SelectionSeq;

local interface CacheAccess;
typedef sequence<CacheAccess> CacheAccessSeq;

local interface CacheListener;
typedef sequence<CacheListener> CacheListenerSeq;

local interface Cache;

/*****
 * ObjectReference
 *****/

struct ObjectReference {
    DLRLoid    oid;
    unsigned long  home_index;
};
typedef sequence<ObjectReference> ObjectReferenceSeq;

/*****
 * ObjectListener : Root for Listeners to be attached to
 * Home objects
 *****/

local interface ObjectListener {
    boolean on_object_created (
        in ObjectReference ref);
    boolean on_object_modified (
        in ObjectReference ref,
        in ObjectRoot    old_value);
    boolean on_object_deleted (
        in ObjectReference ref);
};

/*****
 * SelectionListener : Root for Listeners to be attached to
 * Selection objects
 *****/

local interface SelectionListener {

```

```

/**
 * will be generated with the proper Foo type
 * in the derived FooSelectionListener
 *
void on_object_in (
    in ObjectRoot the_object);
void on_object_modified (
    in ObjectRoot the_object);
 *
*/
void on_object_out (
    in ObjectReference the_ref);
};

/******
 * CacheListener : Listener to be associated with a Cache
******/

local interface CacheListener {
    void begin_updates (
        in long update_round);
    void end_updates (
        in long update_round);
};

/******
 * ObjectRoot : Root for the shared objects
******/

enum RelationKind {
    REF_RELATION,
    LIST_RELATION,
    INT_MAP_RELATION,
    STR_MAP_RELATION};

valuetype RelationDescription {
    public RelationKind  kind;
    public RelationName  name;
};
valuetype ListRelationDescription : RelationDescription {
    public long index;
};
valuetype IntMapRelationDescription : RelationDescription {
    public long key;
};
valuetype StrMapRelationDescription : RelationDescription {
    public string key;
};
typedef sequence<RelationDescription> RelationDescriptionSeq;

```



```

typedef short RelatedObjectDepth;
const RelatedObjectDepth UNLIMITED_RELATED_OBJECTS = -1;

valuetype ObjectRoot {

    // State
    // ----
    private DLROid    m_oid;
    private ClassName m_class_name;

    // Attributes
    // -----
    readonly attribute DLROid        oid;
    readonly attribute ObjectSubState primary_state;
    readonly attribute ObjectSubState secondary_state;
    readonly attribute ObjectHome    object_home;
    readonly attribute ClassName     class_name;
    readonly attribute CacheAccess    cache_access;
    readonly attribute ObjectReference ref;

    // Operations
    // -----
    void destroy ()
        raises (
            DCPSError,
            ReadOnlyMode);
    boolean is_modified (
        in ObjectScope scope);
    RelationDescriptionSeq which_contained_modified ();

    ObjectReference clone (
        in CacheAccess    access,
        in ObjectScope    scope,
        in RelatedObjectDepth depth)
        raises (
            ReadOnlyMode,
            AlreadyClonedInWriteMode);
    ObjectRoot clone_object (
        in CacheAccess    access,
        in ObjectScope    scope,
        in RelatedObjectDepth depth)
        raises (
            ReadOnlyMode,
            AlreadyClonedInWriteMode);
};

/*****
 * ObjectFilter: Root of all the objects filters
 *****/
enum MembershipState {

```

```

    UNDEFINED_MEMBERSHIP,
    ALREADY_MEMBER,
    NOT_MEMBER
};

local interface ObjectFilter {
    /**
     * Following method will be generated properly typed
     * in the generated derived classes
     *
     boolean check_object (
         in ObjectRoot an_object,
         in MembershipState membership_state);
     *
     ***/
};

/*****
 * ObjectQuery : Specialisation of the above to make a Query
 *****/

local interface ObjectQuery {

    // Atributes
    // -----
    readonly attribute string      expression;
    readonly attribute StringSeq   parameters;

    //-- Methods
    boolean set_query (
        in string expression,
        in StringSeq parameters);
    boolean set_parameters (
        in StringSeq parameters);
};

/*****
 * ObjectModifier: Root of all the objects modifiers
 *****/

local interface ObjectModifier {
    /**
     * Following method will be generated properly typed
     * in the generated derived classes
     *
     void modify_object (
         in ObjectRoot an_object);
     *
     ***/
};

```

```

/*****
* ObjectExtent : Root of all the extent (lists of objects)
*****/

local interface ObjectExtent {
    /***
    * Following method will be generated properly typed
    * in the generated derived classes
    *
    *
    * readonly attribute ObjectRootSeq objects;

    ObjectExtent find_objects (
        in ObjectFilter filter
    );
    void modify_objects (
        in ObjectFilter filter,
        in ObjectModifier modifier
    );
    *
    ***/
};

/*****
* Selection : Root of all the selections (dynamic subsets)
*****/

local interface Selection {

    // Attributes
    // -----
    readonly attribute boolean auto_refresh;
    readonly attribute boolean concerns_contained;

    /***
    * Following attributes will be generated properly typed
    * in the generated derived classes
    *
    *
    * readonly attribute ObjectFilter filter;
    * readonly attribute ObjectExtent membership;
    * readonly attribute SelectionListener listener;
    *
    */

    // Operations
    // -----
    /***
    * Following method will be generated properly typed
    * in the generated derived classes
    *
    *

```

```

SelectionListener set_listener (
    in SelectionListener listener);
*
***/
void refresh ();
};

/*****
* ObjectHome : Root of all the representatives of applicative classes
*****/

local interface ObjectHome {

    // Attributes
    // -----
    readonly attribute string      name; // Shared name of the class
    readonly attribute string      filter;
    readonly attribute ObjectHome  parent;
    readonly attribute ObjectHomeSeq children;
    readonly attribute unsigned long registration_index;
    readonly attribute ObjectReferenceSeq refs;
    readonly attribute boolean     auto_deref;

    /***
    * Following attributes will be generated properly typed
    * in the generated derived classes
    *
    readonly attribute ObjectExtent  extent;
    readonly attribute ObjectExtent  full_extent;
    readonly attribute SelectionSeq  selections;
    readonly attribute ObjectListenerSeq listeners;
    *
    ***/

    // Operations
    // -----

    void set_filter (
        in string filter)
        raises (
            BadParameter);

    void set_auto_deref (
        in boolean value);
    void deref_all();
    void underef_all ();

    /**-- Relations to topics

    string get_topic_name (

```

```
        in string attribute_name)
        raises (
            BadParameter);
StringSeq get_all_topic_names ();

// --- Listener management

void attach_listener (
    in ObjectListener listener,
    in boolean concerns_contained_objects);
void detach_listener (
    in ObjectListener listener);

// --- Selection management

/**
 * Following methods will be generated properly typed
 * in the generated derived classes
 */
Selection create_selection (
    in ObjectFilter filter,
    in boolean auto_refresh)
    raises (
        BadParameter);
void delete_selection (
    in Selection a_selection)
    raises (
        BadParameter);
*
***/

// --- Object management

/**
 * Following methods will be generated properly typed
 * in the generated derived classes
 */
ObjectRoot create_object(
    in CacheAccess access)
    raises (
        ReadOnlyMode);
ObjectRoot create_object_with_oid(
    in CacheAccess access,
    in DLRLoid oid)
    raises (
        ReadOnlyMode,
        AlreadyExisting);
ObjectRoot create_unregistered_object (
    in CacheAccess access)
    raises (
        ReadOnlyMode);
```

```

void register_created_object (
    in ObjectRoot  unregistered_object)
    raises (
        AlreadyExisting,
        BadParameter);

ObjectRoot find_object_in_access (
    in DLRLoid oid,
    in CacheAccess access)
    raises (
        NotFound);
ObjectRoot find_object (
    in DLRLoid oid);
*
***/
};

/*****
* Collection operations
*****/

abstract valuetype CollectionBase {
    long length();
    boolean is_modified (
        in ReferenceScope scope);
    long how_many_added ();
    long how_many_removed ();
};

abstract valuetype ListBase : CollectionBase {
    boolean which_added (out LongSeq indexes);
    void remove ();
};

abstract valuetype StrMapBase : CollectionBase {
    boolean which_added (out StringSeq keys);
    StringSeq get_all_keys ();
};

abstract valuetype IntMapBase : CollectionBase {
    boolean which_added (out LongSeq keys);
    LongSeq get_all_keys ();
};

/*****
* Value Bases for Relations
*****/

valuetype RefRelation {
    private ObjectReference  m_ref;

```

```

        boolean is_composition();
        void reset();
        boolean is_modified (
            in ReferenceScope scope);
    };

    valuetype ListRelation : ListBase {
        private ObjectReferenceSeq m_refs;

        boolean is_composition();
    };

    valuetype StrMapRelation : StrMapBase {
        struct Item {
            string      key;
            ObjectReference ref;
        };
        typedef sequence <Item> ItemSeq;

        private ItemSeq  m_refs;

        boolean is_composition();
    };

    valuetype IntMapRelation : IntMapBase {
        struct Item {
            long      key;
            ObjectReference ref;
        };
        typedef sequence <Item> ItemSeq;

        private ItemSeq  m_refs;

        boolean is_composition();
    };

    /*****
    * CacheAccess : Manager of the access of a subset of objects
    * (cloned) from a Cache
    *****/

    local interface CacheAccess {

        // Attributes
        // =====
        readonly attribute CacheUsage      access_usage;
        readonly attribute Cache           owner;
        readonly attribute ObjectReferenceSeq refs;
    };

```

```

// Operations
// =====
void refresh ()
    raises (
        DCPSError);
void write ()
    raises (
        ReadOnlyMode,
        DCPSError);
void purge ();
ObjectRoot deref (
    in ObjectReference ref)
    raises (
        NotFound);
};

/*****
* Cache : Manager of a set of related objects
* is associated to one DDS::Publisher and/or one DDS::Subscriber
*****/

local interface Cache {

// Attributes
// -----
readonly attribute CacheUsage      cache_usage;
readonly attribute DCPSSState      pubsub_state;
readonly attribute DDS::Publisher  the_publisher;
readonly attribute DDS::Subscriber the_subscriber;
readonly attribute boolean         updates_enabled;
readonly attribute ObjectHomeSeq   homes;
readonly attribute CacheAccessSeq  sub_accesses;
readonly attribute CacheListenerSeq listeners;
readonly attribute ObjectReferenceSeq refs;

// Operations
// -----

/-- Infrastructure management
void register_all_for_pubsub()
    raises (
        BadHomeDefinition,
        DCPSError);
void enable_all_for_pubsub()
    raises (
        DCPSError);

// -- Home management;
unsigned long register_home (
    in ObjectHome a_home)

```



```
        raises (
            BadHomeDefinition);
ObjectHome find_home_by_name (
    in ClassName class_name)
    raises (
        BadParameter);
ObjectHome find_home_by_index (
    in unsigned long index)
    raises (
        BadParameter);

// -- Listener Management
void attach_listener (
    in CacheListener listener);
void detach_listener (
    in CacheListener listener);

// --- Updates management
void enable_updates ();
void disable_updates ();

// --- CacheAccess Management
CacheAccess create_access (
    in CacheUsage purpose)
    raises (
        ReadOnlyMode);
void delete_access (
    in CacheAccess access)
    raises (
        BadParameter);

// --- Object management
ObjectRoot deref (
    in ObjectReference ref);
void load ()
    raises (
        DCPSError);

// --- Protection against concurrent access
void lock (
    in TimeoutDuration to_in_milliseconds)
    raises (ExpiredTimeOut);
void unlock ();
};

/*****
* CacheFactory : Factory to create Cache objects
*****/

valuetype CacheDescription {
    public CacheName    name;
```

```

    public DDS::DomainParticipant domain;
};

local interface CacheFactory {
    Cache create_cache (
        in CacheUsage    cache_usage,
        in CacheDescription cache_description)
    raises (
        DCPSError,
        AlreadyExisting);
    Cache find_cache_by_name(
        in CacheName    name)
    raises (
        BadParameter);
    void delete_cache (
        in Cache    a_cache);

};
};

```

3.2.1.2.2 Implied IDL

This section contains the implied IDL constructs for an application-defined class named *Foo*.

```

#include "dds_dlr1.idl"

valuetype Foo: DDS::ObjectRoot {
    // some attributes and methods
    //...implied
    Foo clone_foo (
        in DDS::CacheAccess    access,
        in DDS::ObjectScope    scope,
        in DDS::RelatedObjectDepth depth)
    raises (
        DDS::ReadOnlyMode,
        DDS::AlreadyClonedInWriteMode);
};

/*****
 * DERIVED CLASSES FOR Foo
 *****/

typedef sequence<Foo> FooSeq;

local interface FooListener: DDS::SelectionListener {
    void on_object_in (
        in Foo the_object);

```

```
void on_object_modified (
    in Foo the_object);
};
typedef sequence <FooListener> FooListenerSeq;

local interface FooSelectionListener : DDS::SelectionListener {
    void on_object_in (
        in Foo the_object);
    void on_object_modified (
        in Foo the_object);
};

local interface FooFilter: DDS::ObjectFilter {
    boolean check_object (
        in Foo an_object,
        in DDS::MembershipState membership_state);
};

local interface FooQuery : DDS::ObjectQuery, FooFilter {
};

local interface FooModifier: DDS::ObjectModifier {
    void modify_object (
        in Foo an_object);
};

local interface FooExtent: DDS::ObjectExtent {
    readonly attribute FooSeq objects;

    FooExtent find_objects (
        in FooFilter filter
    );
    void modify_objects (
        in FooFilter filter,
        in FooModifier modifier
    );
};

local interface FooSelection : DDS::Selection {
    readonly attribute FooFilter filter;
    readonly attribute FooExtent membership;
    readonly attribute FooSelectionListener listener;

    FooSelectionListener set_listener (
        in FooSelectionListener listener);
};
typedef sequence <FooSelection> FooSelectionSeq;

local interface FooHome : DDS::ObjectHome {
    readonly attribute FooExtent extent;
    readonly attribute FooExtent full_extent;
```

```

readonly attribute FooSelectionSeq selections;
readonly attribute FooListenerSeq listeners;

FooSelection create_selection (
    in FooFilter filter,
    in boolean auto_refresh)
    raises (
        DDS::BadParameter);
void delete_selection (
    in FooSelection a_selection)
    raises (
        DDS::BadParameter);
Foo create_object(
    in DDS::CacheAccess access)
    raises (
        DDS::ReadOnlyMode);
Foo create_object_with_oid(
    in DDS::CacheAccess access,
    in DDS::DirIOid oid)
    raises (
        DDS::ReadOnlyMode,
        DDS::AlreadyExisting);
Foo create_unregistered_object (
    in DDS::CacheAccess access)
    raises (
        DDS::ReadOnlyMode);
void register_created_object (
    in Foo unregistered_object)
    raises (
        DDS::AlreadyExisting,
        DDS::BadParameter);
Foo find_object_in_access (
    in DDS::DirIOid oid,
    in DDS::CacheAccess access)
    raises (
        DDS::NotFound);
Foo find_object (
    in DDS::DirIOid oid);
};

/*****
* Derived class for relations to Foo
*****/

valuetype FooRef : DDS::RefRelation { // Ref<Foo>
    void set(
        in Foo object);
};

valuetype FooList : DDS::ListRelation { // List<Foo>

```

```
void put (  
    in long index,  
    in Foo a_foo);  
Foo get (  
    in long index)  
    raises (  
        DDS::NotFound);  
};  
  
valuetype FooStrMap : DDS::StrMapRelation { // StrMap<Foo>  
    void put (  
        in string key,  
        in Foo a_foo);  
    Foo get (  
        in string Key)  
        raises (  
            DDS::NotFound);  
    void remove (  
        in string Key);  
};  
  
valuetype FooIntMap : DDS::IntMapRelation { // IntMap<Foo>  
    void put (  
        in long key,  
        in Foo a_foo);  
    Foo get (  
        in long Key)  
        raises (  
            DDS::NotFound);  
    void remove (  
        in long Key);  
};
```

3.2.2 Generation Process

3.2.2.1 Principles

The generic generation process explained in Section 3.1.4.6, “How is this Mapping Indicated?,” on page 3-13, is instantiated as follows:

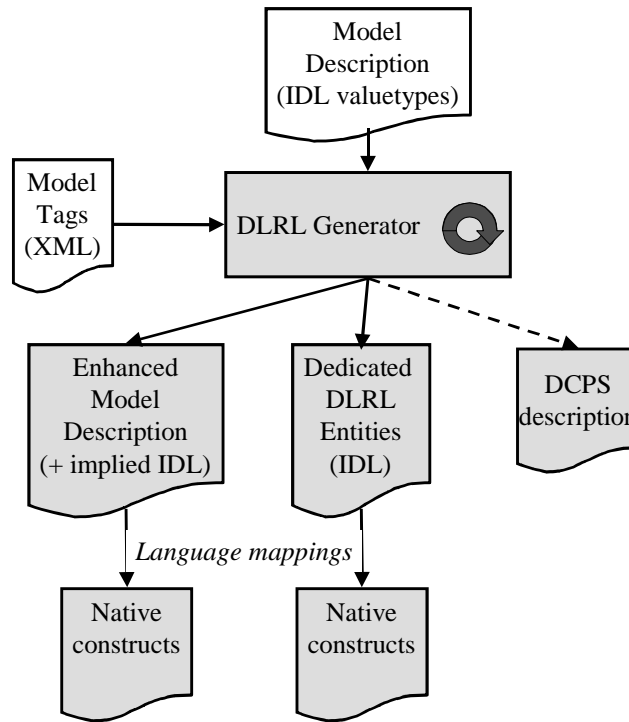


Figure 3-7 DLRL Generation Process (OMG IDL)

3.2.2.2 Model Description

As stated in section 3.2.1, application classes are modeled by means of IDL value-types.

Support for specific typed collections is introduced by means of a void value declaration, which will be transformed in the generation process by means of special model tags that are explained in the following section.

3.2.2.3 Model Tags

Model tags are specified by means of XML declarations that must be compliant with the DTD listed in the following section; subsequent sections give details on the constructs.

3.2.2.3.1 Model Tags DTD

The following is the DTD for expressing the Model Tags in XML:

```
<?xml version="1.0" encoding="ISO-8859-1"?>
```

```

<!ELEMENT Dirl
  (enumDef | templateDef | associationDef | compoRelationDef| classMapping)*>
<!ATTLIST Dirl name CDATA #IMPLIED>

<!ELEMENT enumDef (value)*>
<!ATTLIST enumDef name CDATA #REQUIRED>
<!ELEMENT value (#PCDATA)>

<!ELEMENT templateDef EMPTY>
<!ATTLIST templateDef name CDATA #REQUIRED
  pattern (List | StrMap | IntMap | Ref) #REQUIRED
  itemType CDATA #REQUIRED>

<!ELEMENT associationDef (relation,relation)>
<!ELEMENT relation EMPTY>
<!ATTLIST relation class CDATA #REQUIRED
  attribute CDATA #REQUIRED>

<!ELEMENT compoRelationDef EMPTY>
<!ATTLIST compoRelationDef class CDATA #REQUIRED
  attribute CDATA #REQUIRED>

<!ELEMENT classMapping (mainTopic,extensionTopic?,
  (monoAttribute | multiAttribute | monoRelation | multiRelation | local)*>
<!ATTLIST classMapping name CDATA #REQUIRED>

<!ELEMENT mainTopic (keyDescription)>
<!ATTLIST mainTopic name CDATA #REQUIRED>

<!ELEMENT extensionTopic (keyDescription)>
<!ATTLIST extensionTopic name CDATA #REQUIRED>

<!ELEMENT monoAttribute (placeTopic?,valueField+)>
<!ATTLIST monoAttribute name CDATA #REQUIRED>

<!ELEMENT multiAttribute (multiPlaceTopic,valueField+)>
<!ATTLIST multiAttribute name CDATA #REQUIRED>

<!ELEMENT monoRelation (placeTopic?,keyDescription)>
<!ATTLIST monoRelation name CDATA #REQUIRED>

<!ELEMENT multiRelation (multiPlaceTopic,keyDescription)>
<!ATTLIST multiRelation name CDATA #REQUIRED>

<!ELEMENT local EMPTY>
<!ATTLIST local name CDATA #REQUIRED>

<!ELEMENT placeTopic (keyDescription)>
<!ATTLIST placeTopic name CDATA #REQUIRED>

<!ELEMENT multiPlaceTopic (keyDescription)>
<!ATTLIST multiPlaceTopic name CDATA #REQUIRED
  indexField CDATA #REQUIRED>

<!ELEMENT keyDescription (keyField*)>

```

```
<!ATTLIST keyDescription content (FullOid | SimpleOid | NoOid) #REQUIRED>
```

```
<!ELEMENT keyField (#PCDATA)>
```

```
<!ELEMENT valueField (#PCDATA)>
```

3.2.2.3.2 Details on the XML constructs

To allow a better understanding, in the following examples, the DCPS information (topics, fields) is in capital letters, while the DLRL one is not.

3.2.2.3.2.1 Root

A DLRL Model Tags XML document, is a list of following XML tags:

- **enumDef** - to give explicit names to enumeration items, in case the default behavior (coding them by means of long values) is not suitable.
- **templateDef** - to define a typed collection or a reference (giving its pattern as well as the type of its elements; it comes in place of a statement such as List<Foo> which is not allowed in IDL).
- **compoRelationDef** - to state that a given relation is actually a composition.
- **associationDef** - to associate two relations, so that they make a full association (in the UML sense).
- **classMapping** - to define the mapping of a DLRL class to DCPS topics; it comprises a list of:
 - **monoAttribute** for mono-valued attributes.
 - **multiAttribute** for multi-valued attributes.
 - **monoRelation** for mono-valued relations.
 - **multiRelation** for multi-valued relations.
 - **local**, to state that an attribute is not a DLRL attribute (and thus will not be considered by this generation process).

3.2.2.3.2.2 EnumDef

This tag contains an attribute **name** (scoped name of the IDL enumeration) and as many **value** sub-tags that needed to give values.

Example:

```
<enumDef name="WeekDays">
  <value>Monday</value>
  <value>Tuesday</value>
  <value>Wednesday</value>
  <value>Thursday</value>
  <value>Friday</value>
  <value>Saturday</value>
  <value>Sunday</value>
</enumDef>
```


3.2.2.3.2.3 *TemplateDef*

This tag contains three attributes

- **name**, that gives the scoped name of the type
- **pattern**, that gives the collection pattern (are supported **List**, **StrMap** and **IntMap**);
- **itemType**, that gives the type of each element in the collection.

Example:

```
<templateDef name="BarStrMap" basis="StrMap" itemType="Bar"/>
```

This corresponds to a hypothetical `typedef StrMap<Foo> FooStrMap;`

3.2.2.3.2.4 *AssociationDef*

This tag puts in association two relations (that represent then the association ends of that association). It embeds two mandatory **relation** sub-tags to designate the concerned relations. Each of these sub-tags has two mandatory attributes:

- **class**, that contains the scoped name of the class.
- **attribute**, that contains the name of the attribute that supports the relation inside the class.

Example:

```
<associationDef>
  <relation class="Track" attribute="a_radar"/>
  <relation class="Radar" attribute="tracks"/>
</associationDef>
```

3.2.2.3.2.5 *compoRelationDef*

This tag states that the relation is actually a composition. It has two mandatory attributes:

- **class**, that contains the scoped name of the class.
- **attribute**, that contains the name of the attribute that supports the relation inside the class.

Example:

```
<compoRelationDef class="Radar" attribute="tracks"/>
```

3.2.2.3.2.6 *ClassMapping*

This tag contains one attribute **name** that gives the scoped name of the class and:

- a mandatory sub-tag **mainTopic**
- an optional sub-tag **extensionTopic**
- a list of attribute and/or relation descriptions.

Example:

```
<classMapping name="Track">
  ...
</classMapping>
```

3.2.2.3.2.7 *MainTopic*

This tag gives the main DCPS *Topic*, to which that class refer. The main *Topic* is the topic that gives the existence of a object (an object is declared as existing if and only if there is an instance in that *Topic* matching its *key* value.

It comprises one attribute *name* that gives the name of the *Topic* and:

- a mandatory sub-tag *keyDescription*.

Example:

```
<mainTopic name="TRACK-TOPIC">
  <keyDescription
    ...
  </keyDescription>
</mainTopic>
```

3.2.2.3.2.8 *KeyDescription*

This tag describes the key to be associated to several elements (*mainTopic*, *extensionTopic*, *placeTopic*, and *multiPlaceTopic*).

It comprises an attribute that describes the content of the *keyDescription*, that can be:

- *FullOid*, in that case, the key description should contain as first *keyField* the name of the *Topic* field used to store the class name and as second *keyField* the name of the *Topic* field used to store the OID itself.
- *SimpleOid*, in that case the key description should only contain one *keyField* to contain the OID itself.
- *NoOid*, in that case the case description should contain as many *keyFields* that are needed to identify uniquely one row in the related *Topic*, and it is the responsibility of the DLRL implementation to manage the association between those fields and the *DLRLOid* as perceived by the application developer.

It contains also as many elements *keyField* as needed.

Example:

```
<keyDescription content="SimpleOid">
  <keyField>OID</keyField>
</keyDescription>
```

3.2.2.3.2.9 *ExtensionTable*

This tag gives the DCPS *Topic* that is used as an extension table for the attributes. It comprises the same attributes than *mainTopic*.

3.2.2.3.2.10 *MonoAttribute*

This tag gives the mapping for a mono-valued attribute. It has:

- A mandatory attribute to give the *name* of the attribute.

- An optional sub-tag to give the DCPS *Topic* where it is placed (*placeTopic*). This sub-tag follows the same pattern as *mainTopic*. In case it is not given, the *extensionTopic*, or if there is no *extensionTopic*, the *mainTopic* is used in place of *placeTopic*;
- One or more *valueField* sub-tag(s) to give the name of the field(s) that will contain the value of that attribute.

Example:

```
<monoAttribute name="y">
  <placeTopic name="Y_TOPIC">
    <keyDescription content="SimpleOID">
      <keyField>OID</keyField>
    </keyDescription>
  </placeTopic>
  <valueField>Y</valueField>
</monoAttribute>
```

3.2.2.3.2.11 MultiAttribute

This tag gives the mapping for a multi-valued attribute. It has:

- A mandatory attribute to give the *name* of the attribute.
- A mandatory sub-tag to give the DCPS *Topic* where it is placed (*multiPlaceTopic*). This sub-tag follows the same pattern as *placeTopic*, except it has a mandatory attribute in addition to state the field needed for storing the collection index.
- One or more *valueField* sub-tag(s) to give the name of the field(s) that will contain the value of that attribute.

Example:

```
<multiAttribute name="comments">
  <multiPlaceTopic name="COMMENTS-TOPIC">
    <keyDescription content="FullOID">
      <keyField>CLASS</keyField>
      <keyField>OID</keyField>
    </keyDescription>
  </multiPlaceTopic>
  <valueField>COMMENT</valueField>
</multiAttribute>
```

3.2.2.3.2.12 MonoRelation

This tag gives the mapping for a mono-valued attribute. It has:

- A mandatory attribute to give the *name* of the attribute.
- An optional sub-tag to give the *Topic* where it is placed (*placeTopic* – see Section 3.2.2.3.2.10).
- One *keyDescription* sub-tag to give the name of the field(s) that will contain the value of that relation (i.e., a place holder to a reference to the pointed object).

Example:

```
<monoRelation name="a_radar">
```

```

    <keyDescription content="SimpleOID">
      <keyField>RADAR_OID</keyField>
    </keyDescription>
  </monoRelation>

```

3.2.2.3.2.13 MultiRelation

This tag gives the mapping for a multi-valued relation. It has:

- A mandatory attribute to give the *name* of the relation.
- A mandatory sub-tag to give the DCPS *Topic* where it is placed (*multiPlaceTopic* – see Section 3.2.2.3.2.11).
- One *valueKey* sub-tag (see Section 3.2.2.3.2.12).

Example:

```

<multiRelation name="tracks">
  <multiPlaceTopic name="RADARTRACKS-TOPIC"
    <keyDescription content="SimpleOID">
      <keyField>RADAR-OID</keyField>
    </keyDescription>
  </multiPlaceTopic>
  <keyDescription content="FullSimpleOID">
    <keyField>TRACK-CLASS</keyField>
    <keyField>TRACK-OID</keyField>
  </keyDescription>
</multiRelation>

```

3.2.2.3.2.14 Local

This tag just indicates that the corresponding attribute (designated by its name) has to be ignored by the service.

Example:

```

<local name="w"/>

```

3.2.3 Example

This section contains a very simple example to illustrate DLRL.

3.2.3.1 UML Model

The following UML diagram describes a very simple application model with three classes:

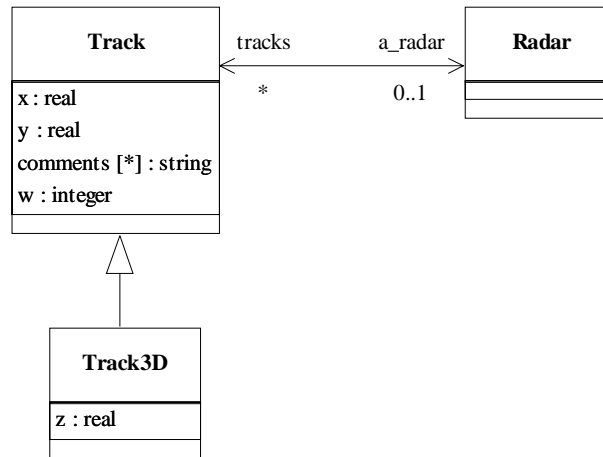


Figure 3-8 UML Class Diagram of the Example

3.2.3.2 IDL Model Description

Based on this model, the model description (IDL provided by the application developer) could be:

```

#include "dlrl.idl"

valuetype stringStrMap; // StrMap<string>
valuetype TrackList; // List<Track>
valuetype RadarRef; // Ref<Radar>

valuetype Track : DLRL::ObjectRoot {
    public double x;
    public double y;
    public stringStrMap comments;
    public long w;
    public RadarRef a_radar;
};

valuetype Track3D : Track {
    public double z;
};

valuetype Radar : DLRL::ObjectRoot {
    public TrackList tracks;
};
  
```

3.2.3.3 XML Model Tags

The following UML tags, to drive the generation process could then be:

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<!DOCTYPE DlrI SYSTEM "dlrI.dtd">
<DlrI name="example">
  <templateDef name="StringStrMap" pattern="StrMap" itemType="string"/>
  <templateDef name="RadarRef" pattern="Ref" itemType="Radar"/>
  <templateDef name="TrackList" pattern="List" itemType="Track"/>
  <classMapping name="Track">
    <mainTopic name="TRACK-TOPIC">
      <keyDescription content="FullOid">
        <keyField>CLASS</keyField>
        <keyField>OID</keyField>
      </keyDescription>
    </mainTopic>
    <monoAttribute name="x">
      <valueField>X</valueField>
    </monoAttribute>
    <monoAttribute name="y">
      <placeTopic name="Y_TOPIC">
        <keyDescription content="FullOid">
          <keyField>CLASS</keyField>
          <keyField>OID</keyField>
        </keyDescription>
      </placeTopic>
      <valueField>Y</valueField>
    </monoAttribute>
    <multiAttribute name="comments">
      <multiPlaceTopic name="COMMENTS-TOPIC" indexField="INDEX">
        <keyDescription content="FullOid">
          <keyField>CLASS</keyField>
          <keyField>OID</keyField>
        </keyDescription>
      </multiPlaceTopic>
      <valueField>COMMENT</valueField>
    </multiAttribute>
    <monoRelation name="a_radar">
      <keyDescription content="SimpleOid">
        <keyField>RADAR_OID</keyField>
      </keyDescription>
    </monoRelation>
    <local name="w"/>
  </classMapping>
  <classMapping name="Track3D">
    <mainTopic name="TRACK-TOPIC">
      <keyDescription content="FullOid">
        <keyField>CLASS</keyField>
        <keyField>OID</keyField>
      </keyDescription>
    </mainTopic>
    <extensionTopic name="TRACK3D-TOPIC">
      <keyDescription content="FullOid">
        <keyField>CLASS</keyField>

```

```
        <keyField>OID</keyField>
    </keyDescription>
</extensionTopic>
<monoAttribute name="z">
    <valueField>Z</valueField>
</monoAttribute>
</classMapping>
<classMapping name="Radar">
    <mainTopic name="RADAR-TOPIC">
        <keyDescription content="SimpleOid">
            <keyField>OID</keyField>
        </keyDescription>
    </mainTopic>
    <multiRelation name="tracks">
        <multiPlaceTopic name="RADARTRACKS-TOPIC" indexField="INDEX">
            <keyDescription content="SimpleOid">
                <keyField>RADAR-OID</keyField>
            </keyDescription>
        </multiPlaceTopic>
        <keyDescription content="FullOid">
            <keyField>TRACK-CLASS</keyField>
            <keyField>TRACK-OID</keyField>
        </keyDescription>
    </multiRelation>
</classMapping>
<associationDef>
    <relation class="Track" attribute="a_radar"/>
    <relation class="Radar" attribute="tracks"/>
</associationDef>
</DirI>
```

It should be noted that XML is not suitable for manual editing, therefore the file seems much more complicated than it actually is; it seems much simpler when viewed through an XML editor, as on the following picture illustrates.

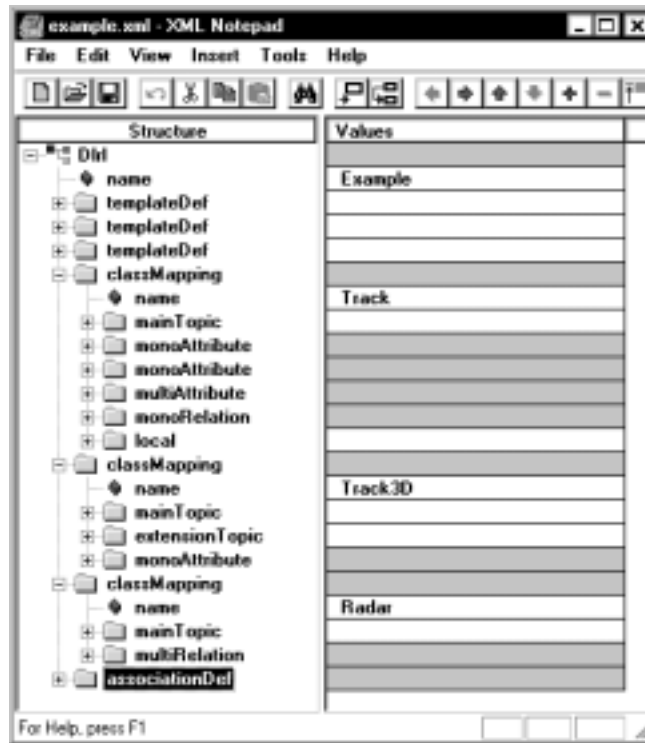


Figure 3-9 XML Editor Illustration

Also note that only the three *templateDef*, the *associationDef*, and the *local*¹⁸ tags are mandatory in all cases. The *ClassMapping* tags are only required if a deviation is wanted from the default mapping described in Section 3.1.4.3. In case no deviation is wanted from the default mapping, the XML description can be restricted to the following minimum:

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<!DOCTYPE Dlrl SYSTEM "dlrl.dtd">
<Dlrl name="Example">
  <templateDef name="stringStrMap" pattern="StrMap" itemType="string"/>
  <templateDef name="RadarRef" pattern="Ref" itemType="Radar"/>
  <templateDef name="TrackList" pattern="List" itemType="Track"/>
  <classMapping name="Track">
<local name="w"/>
  </classMapping>
  <associationDef>
    <relation class="Track" attribute="a_radar"/>
    <relation class="Radar" attribute="tracks"/>
  </associationDef>
</Dlrl>
```

18. To state that Track::w is not a DLRL attribute.

A following step could be to define UML 'tags'¹⁹ and to generate those files based on the UML model. However, this is far beyond the scope of this specification.

3.2.3.4 Underlying DCPS Data Model

This mapping description assumes that the underlying DCPS data model is made of five topics with their fields as described in the following tables:

TRACK-TOPIC	Topic to store all <i>Track</i> objects (including the derived classes) – as well as the embedded attributes/relations defined on <i>Track</i>
CLASS	Field to store the <i>class</i> part of the object reference
OID	Field to store the <i>oid</i> part of the object reference
X	Field to store the value of the attribute <i>x</i>
RADAR-OID	Field to store the relation <i>a_radar</i>

Y-TOPIC	Topic to store <i>Track::y</i> , outside <i>Track</i> 's main topic.
CLASS	Field to store the <i>class</i> part of the object reference
OID	Field to store the <i>oid</i> part of the object reference
Y	Field to store the value of the attribute <i>y</i>

COMMENTS-TOPIC	Topic to store <i>Track::comments</i> (required as it is a collection)
CLASS	Field to store the <i>class</i> part of the owning object reference (here a <i>Track</i>)
OID	Field to store the <i>oid</i> part of the owning object reference (here a <i>Track</i>)
INDEX	Field to store the <i>index</i> part in the collection
COMMENT	Field to store one element of the attribute <i>comments</i>

19. This specification does not address this point and therefore does not say anything about how this should/could be represented in UML. The interface between the modeling phase and the coding phase has just been designed as simple as possible, so that it would be very easy to fill the gap.

TRACK3D-TOPIC	Topic to store the embedded attributes/relations added on <i>Track3D</i> (here only <i>z</i>)
CLASS	Field to store the <i>class</i> part of the object reference
OID	Field to store the <i>oid</i> part of the object reference
z	Field to store the value of the attribute <i>z</i>

RADARTRACKS-TOPIC	Topic to store <i>Radar::tracks</i> (required as it is a collection)
RADAR-OID	Field to store the reference to the owning object (here a <i>Radar</i>)
INDEX	Field to store <i>index</i> in the collection
TRACK-CLASS	Field to store the <i>class</i> part of a reference to an item in the collection (here a <i>Track</i>)
TRACK-OID	Field to store the <i>oid</i> part of a reference to an item in the collection (here a <i>Track</i>)

Note that references to *Track* objects (including derived *Track3D*) must provision a field for the class indication, while references to *Radar* objects do not, for the *Radar* class has no subclasses and does not share its main Topic.

3.2.3.5 Code Example

The following text is a very simple, non fully running, C++ example just to give the flavour of how objects can be created, modified and then published.

```

DDS::DomainParticipant_var dp;
DLRL::CacheFactory_var cf;

/*
 * Init phase
 */
DLRL::Cache_var c = cf->create_cache (WRITE_ONLY, dp);
RadarHome_var rh;
TrackHome_var th;
Track3DHome_var t3dh;

c->register_home (rh);
c->register_home (th);
c->register_home (t3dh);
c->register_all_for_pubsub();
// some QoS settings if needed
c->enable_all_for_pubsub();

```

```
/*
 * Creation, modifications and publication
 */
Radar_var r1 = rh->create_object(c);
Track_var t1 = th->create-object (c);
Track3D_var t2 = t3dh->create-object (c);
t1->w(12); // setting of a pure local attribute
t1->x(1000.0); // some DLRL attributes settings
t1->y(2000.0);
t2->a_radar->put(r1); // modifies r1->tracks accordingly
t2->x(1000.0);
t2->y(2000.0);
t2->z(3000.0);
t2->a_radar->put(r1); // modifies r1->tracks accordingly
c->write(); // all modifications are published
};
```

Compliance Points

A

This specification includes the following compliance profiles.

- *Minimum profile*: This profile contains just the mandatory features of the DCPS layer. None of the optional features are included.
- *Content-subscription profile*: This profile adds the optional classes: **ContentFilteredTopic**, **QueryCondition**, **MultiTopic**. This profile enables subscriptions by content. See section 2.1.2.3.
- *Persistence profile*: This profile adds the optional settings ‘TRANSIENT’ and ‘PERSISTENT’ of the DURABILITY QoS policy **kind**. This profile enables saving data into either TRANSIENT memory, or permanent storage so that it can survive the lifecycle of the **DataWriter** and system outings. See section 2.1.3.4.
- *Ownership profile*: This profile adds two things First the optional setting ‘EXCLUSIVE’ of the OWNERSHIP **kind**. Second support for the optional OWNERSHIP_STRENGTH policy. Third the ability to set a **depth** > 1 for the HISTORY QoS policy.
- *Object model profile*: This profile includes the DLRL and also includes support for the PRESENTATION **access_scope** setting of ‘GROUP’ (section 2.1.3.5).

Syntax for DCPS Queries and Filters B

A subset of SQL syntax is used in several parts of the specification:

- the *filter_expression* in the *ContentFilteredTopic* (see “ContentFilteredTopicClass” on page 2-29).
- the *topic_expression* in the *MultiTopic* (see “MultiTopic Class [optional]” on page 2-29).
- the *query_expression* in the *QueryReadCondition* (see “QueryCondition Class” on page 2-60).

Those expressions may use a subset of SQL, extended with the possibility to use program variables in the SQL expression. The allowed SQL expressions are defined with the BNF-grammar below.

The following notational conventions are made:

- the *NonTerminals* are typeset in italics;
- the ``Terminals`` are quoted and typeset in a fixed width font;
- the `TOKENS` are typeset in small caps;
- the notation (*element // ‘,’*) represents a non-empty comma-separated list of *elements*.

SQL grammar in BNF

```
Expression ::= FilterExpression
            | TopicExpression
            | QueryExpression
            .
FilterExpression ::= Condition
TopicExpression ::= SelectFrom {Where } `;'
QueryExpression ::= {Condition}{`ORDER BY' (FIELDNAME // `,') }
            .
SelectFrom ::= `SELECT' Aggregation `FROM' Selection
            .
```

```

Aggregation      ::= '*'
                  | (SubjectFieldSpec // ',')
                  .
SubjectFieldSpec ::= FIELDNAME
                  | FIELDNAME 'AS' FIELDNAME
                  | FIELDNAME FIELDNAME
                  .
Selection        ::= TOPICNAME
                  | TOPICNAME NaturalJoin JoinItem
                  .
JoinItem         ::= TOPICNAME
                  | TOPICNAME NaturalJoin JoinItem
                  | '(' TOPICNAME NaturalJoin JoinItem ')'
                  .
NaturalJoin      ::= 'INNER NATURAL JOIN'
                  | 'NATURAL JOIN'
                  | 'NATURAL INNER JOIN'
                  .
Where            ::= 'WHERE' Condition
                  .
Condition        ::= Predicate
                  | Condition 'AND' Condition
                  | Condition 'OR' Condition
                  | 'NOT' Condition
                  | '(' Condition ')'
                  .
Predicate        ::= ComparisonPredicate
                  | BetweenPredicate
                  .
ComparisonPredicate ::= FIELDNAME RelOp Parameter
                  | Parameter RelOp FIELDNAME
                  | FIELDNAME RelOp FIELDNAME
                  .
BetweenPredicate ::= FIELDNAME 'BETWEEN' Range
                  | FIELDNAME 'NOT BETWEEN' Range
                  .
RelOp            ::= '=' | '>' | '>=' | '<' | '<=' | '<>' | like
                  .
Range            ::= Parameter 'AND' Parameter
                  .
Parameter        ::= INTEGERVALUE
                  | FLOATVALUE
                  | STRING
                  | ENUMERATEDVALUE
                  | PARAMETER
                  .

```

Note – INNER NATURAL JOIN, NATURAL JOIN, and NATURAL INNER JOIN are all aliases, in the sense that they have the same semantics. They are all supported because they all are part of the SQL standard.

Token expression

The syntax and meaning of the tokens used in the SQL grammar is described as follows:

- **FIELDNAME** - A fieldname is a reference to a field in the data-structure. The dot `'.'` is used to navigate through nested structures. The number of dots that may be used in a FIELD-NAME is unlimited. The FIELDNAME can refer to fields at any depth in the data structure. The names of the field are those specified in the IDL definition of the corresponding structure, which may or may not match the field-names that appear on the language-specific (e.g. C/C++, Java) mapping of the structure.
- **TOPICNAME** - A topic name is an identifier for a topic, and is defined as any series of characters `'a', ..., 'z', 'A', ..., 'Z', '0', ..., '9', '-'` but may not start with a digit.
- **INTEGERVALUE** - Any series of digits, optionally preceded by a plus or minus sign, representing a decimal integer value within the range of the system. A hexadecimal number is preceded by `0x` and must be a valid hexadecimal expression.
- **FLOATVALUE** - Any series of digits, optionally preceded by a plus or minus sign and optionally including a floating point (`'.'`). A power-of-ten expression may be postfixed, which has the syntax `en`, where `n` is a number, optionally preceded by a plus or minus sign.
- **STRING** - Any series of characters encapsulated in single quotes, except a new-line character or a right quote. A string starts with a left or right quote, but ends with a right quote.
- **ENUMERATEDVALUE** - An enumerated value is a reference to a value declared within an enumeration. A double colon `::` is used to separate the name of the enumeration from that of the field. Both the name of the enumeration and the name of the value correspond to the names specified in the IDL definition of the enumeration.
- **PARAMETER** - A parameter is of the form `%n`, where `n` represents a natural number (zero included) smaller than 100. It refers to the `n + 1th` argument in the given context.

Examples

Assuming Topic “Location” has as an associated type a structure with fields “flight_name, x, y, z”, and Topic “FlightPlan” has fields “flight_id, source, destination”. The following are examples of using these expressions.

Example of a *topic_expression*:

- “SELECT flight_name, x, y, z AS height FROM ‘Location’ NATURAL JOIN ‘FlightPlan’ WHERE height < 1000 AND x <23”

Example of a *query_expression* or a *filter_expression* :

- “height < 1000 AND x <23”

Syntax for DLRL Queries and Filters C

The syntax, defined with the BNF-grammar below, is used to express a filter or a query expression in the DLRL constructs:

- the *filter* in the *ObjectHome* (see. “ObjectHome” on page 4-23)
- the *query* in the *ObjectQuery* (see “ObjectQuery” on page 4-27)

The following notational conventions are made:

- the *NonTerminals* are typeset in italics;
- the ‘Terminals’ are quoted and typeset in a fixed width font;
- the TOKENS are typeset in small caps;
- the notation (*element // ‘,’*) represents a non-empty comma-separated list of *elements*.

Query grammar in BNF

```
Condition ::= Predicate
           | Condition 'AND' Condition
           | Condition 'OR' Condition
           | 'NOT' Condition
           | '(' Condition ')'

Predicate ::= ComparisonPredicate
           | BetweenPredicate

ComparisonPredicate ::= FIELDNAME RelOp Parameter
                    | Parameter RelOp FIELDNAME
                    | FIELDNAME RelOp FIELDNAME

BetweenPredicate ::= FIELDNAME 'BETWEEN' Range
                  | FIELDNAME 'NOT BETWEEN' Range

RelOp ::= '=' | '>' | '>=' | '<' | '<=' | '<>'

Range ::= Parameter 'AND' Parameter
```

```
Parameter ::= INTEGERVALUE  
           | FLOATVALUE  
           | STRING  
           | ENUMERATEDVALUE  
           | PARAMETER
```

Token expression

The syntax and meaning of the tokens used in the SQL grammar is described as follows:

- **FIELDNAME** - A fieldname is a reference to a field in the data-structure. The dot `'.'` is used to navigate through nested structures. The number of dots that may be used in a FIELD-NAME is unlimited. The `'[INTEGERVALUE | STRING]'` construct is used to navigate in a collection. The FIELDNAME can refer to fields at any depth in the data structure. The names of the field are those specified in the IDL definition of the corresponding structure, which may or may not match the field-names that appear on the language-specific (e.g. C/C++, Java) mapping of the structure.
- **INTEGERVALUE** - Any series of digits, optionally preceded by a plus or minus sign, representing a decimal integer value within the range of the system. A hexadecimal number is preceded by `0x` and must be a valid hexadecimal expression.
- **FLOATVALUE** - Any series of digits, optionally preceded by a plus or minus sign and optionally including a floating point (`'.'`). A power-of-ten expression may be postfix, which has the syntax `en`, where `n` is a number, optionally preceded by a plus or minus sign.
- **STRING** - Any series of characters encapsulated in single quotes, except a new-line character or a right quote. A string starts with a left or right quote, but ends with a right quote.
- **ENUMERATEDVALUE** - An enumerated value is a reference to a value declared within an enumeration. A double colon `::` is used to separate the name of the enumeration from that of the field. Both the name of the enumeration and the name of the value correspond to the names specified in the IDL definition of the enumeration.
- **PARAMETER** - A parameter is of the form `%n`, where `n` represents a natural number (zero included) smaller than 100. It refers to the $n + 1^{\text{th}}$ argument in the given context.

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