OpenSplice DDS

Version 4.x

C Tutorial Guide

PrismTech

OpenSplice DDS

C Tutorial Guide

PrismTech

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Preface

About the C Tutorial Guide

The *C Tutorial Guide* introduces OpenSplice's main concepts, aided by code examples which use the OpenSplice API to create a *chat room* using OpenSplice's publish and subscribe features in order to enable users to efficiently communicate with each other.

The tutorial examples progress from introducing basic concepts, gradually developing them through to a complete application. The complete source code for the example are listed in the *Appendices*[1].

i Please note that the *C Tutorial Guide* is not intended to covers all aspects of OpenSplice, but simply to introduce essential concepts and enable users to begin using OpenSplice as quickly as possible.

The OpenSplice DDS API is embedded in different programming languages. The *C Tutorial Guide* covers the C version of OpenSplice: refer to the appropriate tutorial version for the other supported languages. Example code for all supported languages are listed in the *C Tutorial Guide's Appendices*.

Intended Audience

The *C Tutorial Guide* is intended to be used by C programmers who are using OpenSplice to develop applications.

Organisation

Chapter 1, *Introduction to OpenSplice DDS*, provides an introduction about OpenSplice DDS product and the OMG DDS standard which OpenSplice DDS is based on. This chapter explains the various DDS profiles and the extent that OpenSplice supports them. Also, the tools which are included with OpenSplice are briefly described. *Introduction to OpenSplice DDS* can be skipped if you are already familiar with OpenSplice.

Chapter 2, *A DDS-based Chatroom*, describes the high-level architecture of an example chatroom application, called *Chat*, which the *C Tutorial Guide* uses to explain how to develop applications using OpenSplice. The chapter also analyses the example application is constructed from autonomous components.

Chapter 3, *Data Modelling*, explains how to define data models in IDL and how to translate this IDL model into your chosen language, including how to represent the IDL in the C language.

1. Please note that the examples provided in this guide are intended for instructional purposes only and have not been optimised for resource usage.

Chapter 4, *Managing Domains and Topics* describes the initial steps that are needed to connect an application to a DDS Domain as well as how to define the topics the application will use in the Domain. This chapter explains concepts and skills that are needed for subsequent steps in developing an application, such as creating and deleting Entities by means of a factory, error handling and tailoring QoS settings.

Chapter 5, *Publishing the Data*, and Chapter 6, *Subscribing to Data*, describes how to publish data and make subscriptions for accessing information, respectively. A primitive version of a message board, called *MessageBoard*, that sends all incoming chat messages to your screen is introduced.

Chapter 7, *Content-Subscription Profile and Listeners* further develops the message board application by adding *content awareness* through the use of filters, queries and event-based data notification.

Chapter 8, *Waiting for Conditions*, describes how to display user activity and how to keep track of usage history in the chat room through the use of *Conditions*, *WaitSets*, and Quality of Service policies (QosPolicy) which are employed in a *UserLoad* application.

The *Appendices* contain listings of all example source code used in the *C Tutorial Guide*, plus the code listings for the other languages supported by *OpenSplice*.

The *Bibliography* contains a list of references used by the guide and which also may provide useful or essential information.

Conventions

The conventions listed below are used to guide and assist the reader in understanding the C Tutorial Guide.

⚠	Item of special significance or where caution needs to be taken.
i	Item contains helpful hint or special information.
WIN	Information applies to Windows (e.g. NT, 2000, XP) only.
UNIX	Information applies to Unix based systems (e.g. Solaris) only.
C	C language specific
C++	C++ language specific
Java	Java language specific

Hypertext links are shown as *blue italic underlined.*

On-Line (PDF) versions of this document: Items shown as cross references, e.g. *Contacts* on page xi, are as hypertext links: click on the reference to go to the item.

```
%  Commands or input which the user enters on the
   command line of their computer terminal
```

`Courier` fonts indicate programming code and file names.

Extended code fragments are shown in shaded boxes:

```
NameComponent newName[] = new NameComponent[1];

// set id field to "example" and kind field to an empty string
newName[0] = new NameComponent ("example", "");
```

Italics and ***Italic Bold*** are used to indicate new terms, or emphasise an item.

Arial Bold is used to indicate user related actions, e.g. **File | Save** from a menu.

Step 1: One of several steps required to complete a task.

Contacts

PrismTech can be reached at the following contact points for information and technical support.

Corporate Headquarters	European Head Office
PrismTech Corporation 6 Lincoln Knoll Lane Suite 100 Burlington, MA 01803 USA	PrismTech Limited PrismTech House 5th Avenue Business Park Gateshead NE11 0NG UK
Tel: +1 781 270 1177 Fax: +1 781 238 1700	Tel: +44 (0)191 497 9900 Fax: +44 (0)191 497 9901

Web:	*http://www.prismtech.com*
General Enquiries:	*info@prismtech.com*

OpenSplice DDS C Tutorial

CHAPTER

1 Introduction to OpenSplice DDS

This section starts by introducing the concepts and philosophies behind the Object Management Groups Data Distribution System (OMG DDS) standardization process. It will explain the characteristics of the different DDS profiles, and will explain how these profiles are incorporated in the OpenSplice DDS product. Then it will provide a short impression of the basic architecture of OpenSplice DDS and how this influences issues like scalability and configuration, followed by a detailed overview of all the benefits that the OpenSplice DDS product will offer you. Finally the OpenSplice DDS Productivity Tools are introduced and it is explained how these might dramatically decrease the costs of your development and maintenance efforts.

1.1 Overview

Real-time availability of information is of utmost importance in the large class of network-centric systems. Information generated from multiple sources must be distributed and made available to 'interested parties' taking into account Quality of Service (QoS) offerings by information-producers and requests by information-consumers. Especially in real-time and mission-critical systems, getting 'the right data at the right time at the right place' is not a trivial task at all and up until recently, there were no standards nor COTS products that addressed this challenge in an integrated solution. The OMG recognized this need for a Data Distribution Service (DDS) and organized members with vast experience in both the 'underlying' technologies (networking and information-management) as well as 'user-level' requirements (distributed, real-time and mission-critical system characteristics), including Thales Naval Netherlands, to join forces and these members defined the 'OMG-DDS' service. The OMG-DDS service specifies a coherent set of profiles that target real-time information-availability for domains ranging from small-scale embedded control systems up to large-scale enterprise information management systems. Each DDS-profile adds distinct capabilities that define the service-levels offered by DDS in order to realize this '*right data at the right time at the right place*' paradigm:

- ***Minimum Profile*** - this *basic* profile utilizes the well known publish/subscribe paradigm to implement highly efficient information dissemination between multiple publishers and subscribers that share interest in so called 'topics'. Topics are the basic data structures expressed in the OMG's IDL language (allowing for automatic generation of typed 'Readers' and 'Writers' of those 'topics' for any mix of languages desired). This profile also includes the QoS framework that allows the middleware to 'match' requested and offered Quality of Service parameters (the minimum profile offering basic QoS attributes such as 'reliability', 'ordering' or 'urgency').

- ***Ownership Profile*** **-** this 'replication' profile offers support for replicated publishers of the same information by allowing a '*strength*' to be expressed by each publisher so that only the 'highest strength' information will be made available to interested parties.
- ***Content Subscription Profile*** **-** this 'content awareness' profile offers powerful features to express fine grained interest in specific information content (content filters). This profile also allows applications to specify *projection views* and *aggregation* of data as well as dynamic *queries* for subscribed 'topics' by utilizing a subset of the well known SQL language whilst preserving the real-time requirements for the information access.
- ***Persistence Profile*** **-** this 'durability' profile offers transparent and fault tolerant availability of 'non volatile' data that may either represent persistent 'settings' (to be stored on mass media throughout the distributed system) or 'state' preserved in a fault tolerant manner outside the scope of transient publishers (allowing late joining applications and dynamic reallocation).
- ***DLRL Profile*** **-** this 'object model' (Data Local Reconstruction Layer) extends the previous four data centric *DCPS* profiles with an *object-oriented view* on a set of related topics thus providing typical OO features such as navigation, inheritance and use of value types.

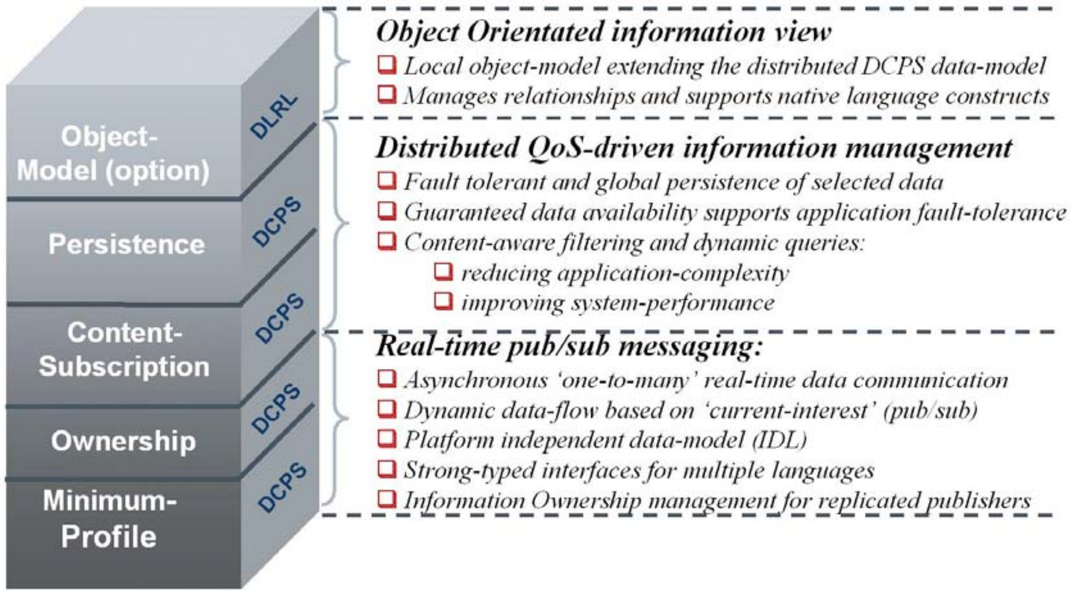

Object-Model (option)
Persistence
Content-Subscription
Ownership
Minimum-Profile
DLRL
DCPS
DCPS
DCPS
DCPS
Object Orientated information view
Local object-model extending the distributed DCPS data-model
Manages relationships and supports native language constructs
Distributed QoS-driven information management
Fault tolerant and global persistence of selected data
Guaranteed data availability supports application fault-tolerance
Content-aware filtering and dynamic queries:
reducing application-complexity
improving system-performance
Real-time pub/sub messaging:
Asynchronous 'one-to-many' real-time data communication
Dynamic data-flow based on 'current-interest' (pub/sub)
Platform independent data-model (IDL)
Strong-typed interfaces for multiple languages
Information Ownership management for replicated publishers

Figure 1 OMG DDS Layers

1.2 OpenSplice DDS Summary

PrismTech's OpenSplice DDS, is a second generation, fully compliant OMG DDS implementation, offering support for all the DCPS profiles (minimum profile, ownership profile, content subscription profile and persistence profile) as well as the DLRL object profile. OpenSplice DDS was initially developed as SPLICE-DDS by Thales Naval Netherlands (TNL), one of the co-authors of the DDS specification and is the result of TNL's over 15 year experience in developing distributed information systems for naval Combat Management Systems (CMS). This field proven middleware is used as the 'information backbone' of TNL's TACTICOS CMS currently deployed in 15 navies around the world. OpenSplice DDS is the 2nd generation COTS evolution of this successful product and consists of several modules that cover the full OMG specification as well as provision of total lifecycle support by an integrated productivity tool suite:

- **OpenSplice DDS core modules** cover the "Minimum" and "Ownership" profiles that provide the basic publish-subscribe messaging functions. The minimum profile is meant to address real time messaging requirements, where performance and low footprint are essential. The ownership profile provides basic support for replicated publishers where 'ownership' of published data is governed by 'strength' indicating the quality of published information.

- **OpenSplice DDS *content subscription* and *persistence* profiles** provide the additional information management features, key for assuring high information availability (fault tolerant persistence of non-volatile information) as well as powerful 'content aware' features (filters and queries), thus enabling unmatched performance for the full range of small scale embedded up to large scale fault tolerant systems.

Free evaluation licenses of OpenSplice DDS are available by e-mailing *sales@prismtech.com*. Currently supported platforms include Solaris Sparc, Linux x86, x86 and VxWorks PowerPC, whereas supported languages are C, C++ (standalone or in seamless cohabitation with any ORB and related C++ compiler) and Java.

1.3 OpenSplice DDS Architecture

1.3.1 Overall

To ensure scalability, flexibility and extensibility, OpenSplice DDS has an internal architecture that utilizes shared memory to 'interconnect' not only all applications that reside within one computing node, but also 'hosts' a configurable and extensible set of services. These services provide 'pluggable' functionality such as networking (providing QoS driven real-time networking based on multiple reliable multicast 'channels'), durability (providing fault tolerant storage for both real-time 'state' data as well as persistent 'settings'), and remote control & monitoring 'soap service' (providing remote web based access using the SOAP protocol from the OpenSplice DDS Tuner tools).

1.3.2 Scalability

OpenSplice DDS utilizes a shared-memory architecture where data is physically present only once on any machine, and where smart ad-ministration still provides each subscriber with his own private 'view' on this data. This allows a subscriber's data cache to be perceived as an individual 'database' that can be content-filtered, queried, etc. (using the content-subscription profile as supported by OpenSplice DDS). This shared-memory architecture results in an extremely low foot-print, excellent scalability and optimal performance when compared to implementations where each reader/writer are 'communication-endpoints' each with its own storage (in other words, historical data both at reader and writer) and where the data itself still has to be moved, even within the same physical node.

1.3.3 Configuration

The OpenSplice DDS middleware can be easily configured 'on the fly' by specifying (only the needed) services to be used as well as configuring those service for optimal matching with the application domain (networking parameters, durability levels, etc). Easily maintainable XML files are utilized to configure all OpenSplice services. OpenSplice DDS configuration is also supported by means of the MDA tool set allowing system/network modelling and automatic generation of the appropriate XML configuration files.

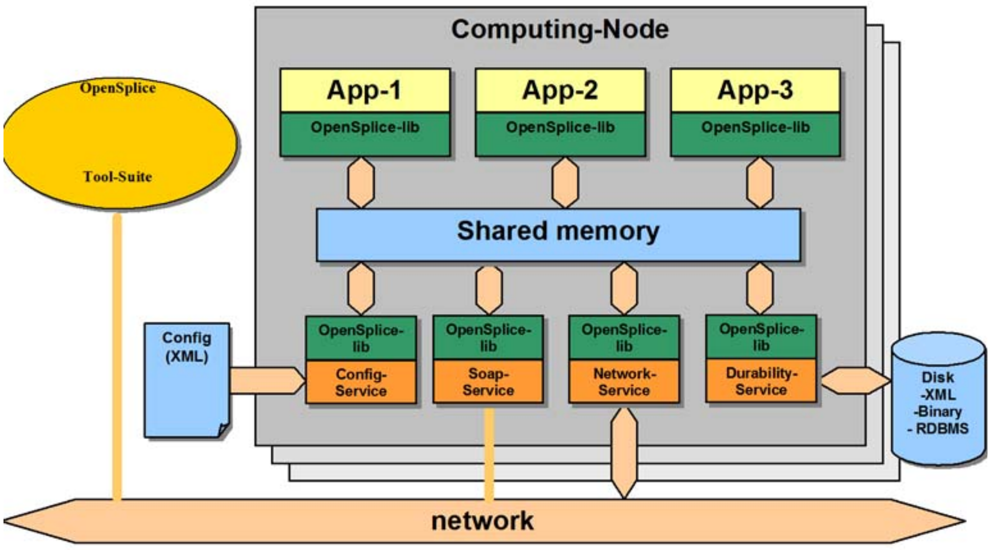


Figure 2 OpenSplice DDS Pluggable Service Architecture

i *Figure 2* only shows one node whereas there are typically many nodes within a system.

1.4 OpenSplice DDS Implementation Benefits

Table 1 below shows the following aspects of OpenSplice DDS, where:

Features significant characteristics of OpenSplice
Advantages shows why a feature is important
Benefits describes how users of OpenSplice can exploit the advantages

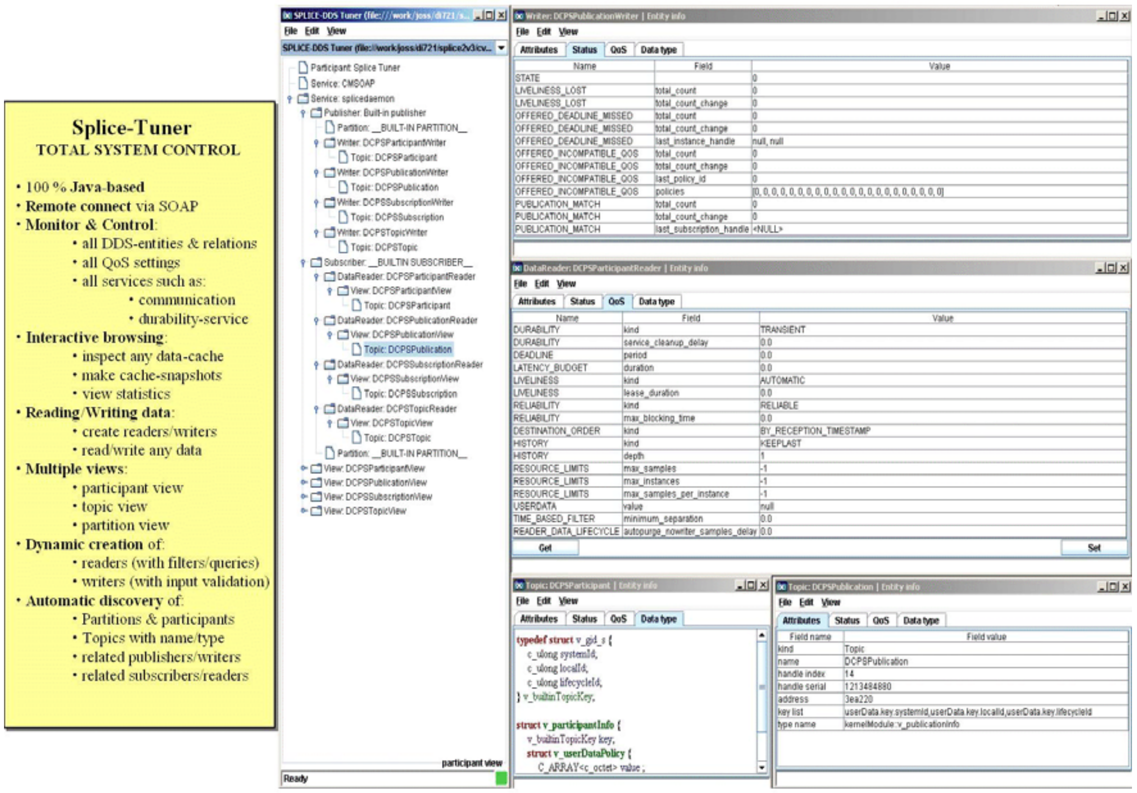
Table 1 OpenSplice DDS Features and Benefits

	Features	**Advantages**	**Benefits**
General	Information-centric	Enable dynamic, loosely coupled system.	Simplified & better scalable architectures
	Open standard	'Off the shelf' solutions	Lower cost, no vendor lock in
	Built on proven technology	Intended for most the demanding situations.	Assured quality and applicability
	TNN/PT ‘inheritance’	Decade long of ‘DDS’ experience	Proven suitability in mission critical domain
Functional	Real-time pub/sub	Dynamic/asynchronous data communication	Autonomous decoupled applications
	Persistence profile	Fault tolerant data persistence	Application fault tolerance and data high availability
	Content-sub. Profile	Reduced complexity & higher performance.	Easier application design & scalable systems
Performance	Shared memory	low footprint, instant data availability	Processor Scalability
	Smart networking	Efficient data transport	Network Scalability
	Extensive IDL sup.	Includes unbounded strings, sequences	Data Scalability
Usability	Multiple language	Any (mix) of C, C++, Java, Ada	Supports (legacy) code, allows hybrid systems
	Multiple platforms	Any (mix) of Enterprise & RTE Oss	Intercons, enterprise and embedded systems
Tooling and Ease of use	All metadata at runtime	Dynamic discovery of all 'entity info'	Guaranteed data integrity
	Powerful tooling	Support for complete system lifecycle	Enhanced productivity and System Integration
	Remote connect	Web based remote access & control	Remote diagnostics using standard protocols
Legend:	**Equal** to competition	**Better** than competition	**Far surpassing** competition

1.4.1 OpenSplice DDS Tuner

The 100% Java based OpenSplice DDS Tuner tool greatly aids the design, implementation, test and maintenance of OpenSplice-based distributed systems:

- ***Design*** **-** During the design phase, once the information model is established (in other words, topics are defined and 'registered' in a runtime environment, which can be both a host environment as well as a target environment), the OpenSplice DDS Tuner allows creation of publishers/writers and subscribers/readers on the fly to experiment and validate how this data should be treated by the middleware regarding persistence, durability, latency, etc.
- ***Implementation*** **-** During the implementation phase, where actual application level processing and distribution of this information is developed, the OpenSplice DDS Tuner allows injection of test input data by creating publishers and writers 'on the fly' as well as validating the responses by creating subscribers and readers for any produced topics.
- ***Test*** **-** During the test phase, the total system can be monitored by inspection of data (by making 'snapshots' of writer and reader history caches) and behaviour of readers & writers (statistics, like how long data has resided in the reader's cache before it was read).
- ***Maintenance*** **-** Maximum flexibility for planned and 'ad hoc' maintenance is offered by allowing the 100% JAVA based OpenSplice DDS Tuner tool suite (which can be executed on any JAVA enabled platform without the need of OpenSplice DDS to be installed) to remotely connect via the web based SOAP protocol to any 'reachable' OpenSplice DDS system around the world (as long a HTTP connection can be established with the OpenSplice DDS computing nodes of that system). Using such a dynamic connection, critical data may be logged and data sets may be 'injected' into the system to be maintained (such as new settings which can be automatically 'persisted' using the QoS features as offered by the 'persistence profile supported by OpenSplice DDS).



Splice-Tuner
TOTAL SYSTEM CONTROL

- 100 % Java-based
- Remote connect via SOAP
- Monitor & Control:
  - all DDS-entities & relations
  - all QoS settings
  - all services such as:
    - communication
    - durability-service
- Interactive browsing:
  - inspect any data-cache
  - make cache-snapshots
  - view statistics
- Reading/Writing data:
  - create readers/writers
  - read/write any data
- Multiple views:
  - participant view
  - topic view
  - partition view
- Dynamic creation of:
  - readers (with filters/queries)
  - writers (with input validation)
- Automatic discovery of:
  - Partitions & participants
  - Topics with name/type
  - related publishers/writers
  - related subscribers/readers

SPLICE-DDS Tuner (file:///work/joss/di721/s...
File Edit View
SPLICE-DDS Tuner (file://work/joss/di721/splice2v3/cv...
participant view
Ready

```
Participant: Splice Tuner
Service: CMSOAP
Service: splicedaemon
  Publisher: Built-in publisher
    Partition: __BUILT-IN PARTITION__
    Writer: DCPSParticipantWriter
      Topic: DCPSParticipant
    Writer: DCPSPublicationWriter
      Topic: DCPSPublication
    Writer: DCPSSubscriptionWriter
      Topic: DCPSSubscription
    Writer: DCPSTopicWriter
      Topic: DCPSTopic
  Subscriber: __BUILTIN SUBSCRIBER__
    DataReader: DCPSParticipantReader
      View: DCPSParticipantView
        Topic: DCPSParticipant
    DataReader: DCPSPublicationReader
      View: DCPSPublicationView
        Topic: DCPSPublication
    DataReader: DCPSSubscriptionReader
      View: DCPSSubscriptionView
        Topic: DCPSSubscription
    DataReader: DCPSTopicReader
      View: DCPSTopicView
        Topic: DCPSTopic
    Partition: __BUILT-IN PARTITION__
  View: DCPSParticipantView
  View: DCPSPublicationView
  View: DCPSSubscriptionView
  View: DCPSTopicView
```

Name	Field	Value
STATE		0
LIVELINESS_LOST	total_count	0
LIVELINESS_LOST	total_count_change	0
OFFERED_DEADLINE_MISSED	total_count	0
OFFERED_DEADLINE_MISSED	total_count_change	0
OFFERED_DEADLINE_MISSED	last_instance_handle	null, null
OFFERED_INCOMPATIBLE_QOS	total_count	0
OFFERED_INCOMPATIBLE_QOS	total_count_change	0
OFFERED_INCOMPATIBLE_QOS	last_policy_id	0
OFFERED_INCOMPATIBLE_QOS	policies	[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0]
PUBLICATION_MATCH	total_count	0
PUBLICATION_MATCH	total_count_change	0
PUBLICATION_MATCH	last_subscription_handle	<NULL>

Name	Field	Value
DURABILITY	kind	TRANSIENT
DURABILITY	service_cleanup_delay	0.0
DEADLINE	period	0.0
LATENCY_BUDGET	duration	0.0
LIVELINESS	kind	AUTOMATIC
LIVELINESS	lease_duration	0.0
RELIABILITY	kind	RELIABLE
RELIABILITY	max_blocking_time	0.0
DESTINATION_ORDER	kind	BY_RECEPTION_TIMESTAMP
HISTORY	kind	KEEPLAST
HISTORY	depth	1
RESOURCE_LIMITS	max_samples	-1
RESOURCE_LIMITS	max_instances	-1
RESOURCE_LIMITS	max_samples_per_instance	-1
USERDATA	value	null
TIME_BASED_FILTER	minimum_separation	0.0
READER_DATA_LIFECYCLE	autopurge_nowriter_samples_delay	0.0

```
typedef struct v_gid_s {
   c_ulong systemId;
   c_ulong localId;
   c_ulong lifecycleId;
} v_builtinTopicKey;

struct v_participantInfo {
   v_builtinTopicKey key;
   struct v_userDataPolicy {
      C_ARRAY<c_octet> value ;
```

Field name	Field value
kind	Topic
name	DCPSPublication
handle index	14
handle serial	1213484880
address	3ea220
key list	userData.key.systemId,userData.key.localId,userData.key.lifecycleId
type name	kernelModule::v_publicationInfo

Figure 3 OpenSplice DDS Tuner

1.5 Conclusion

PrismTech's OpenSplice DDS product complemented by its tool sup-port together encompass the industry's most profound expertise on the OMG's DDS standard and products.

The result is unrivalled functional DDS-coverage and performance in large-scale mission-systems, fault-tolerance in information availability, and total lifecycle support including round-trip engineering. A complete DDS solution to ensure a customer's successful adoption of this exciting new technology and to support delivery of the highest-quality applications with shortest time to market in the demanding real-time world.

CHAPTER

2 A DDS-based Chatroom

This section introduces the basic architecture of a Chatroom that is based on OpenSplice DDS. Each subsequent section will elaborate on this basic architecture: a data model will be defined first, then the publishing side will be created, followed by the subscribing side, which will be developed in a number of iterations, increasing its functionality step by step. Finally a monitor will be added that keeps track of the number of Chatters that are currently logged on to the Chatroom.

2.1 Client-Server vs Peer-to-Peer

In this tutorial we want to build an application that uses OpenSplice DDS to distribute chat messages. Traditionally, chatrooms are examples of common client-server architectures, where clients (the chatters) connect to a server (the chatroom) and identify themselves by giving their user name. (In most cases they will have to confirm their identity by providing a password as well.). After the server has recorded their identity, the clients can send as many chat messages as they like. The chatroom collects the chat messages of each client and will forward them to all other participating clients. New clients can request to join a chatroom at any moment in time: they will then have to identify themselves to the server, and the server will make sure that all chat messages received from that moment on will also be forwarded to the newly added client. An example of such a typical client-server approach is presented in *Figure 4*.

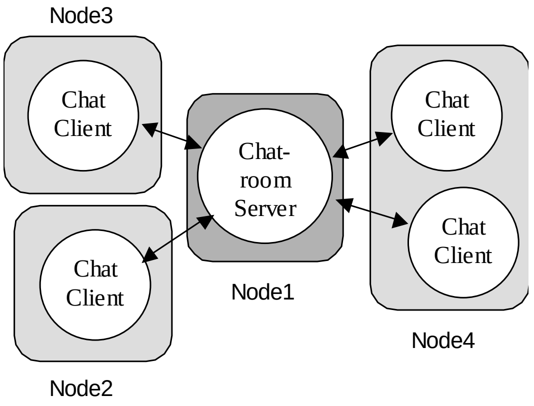


Figure 4 Client-Server Based Approach for a Chatroom

As can be seen from this example, the server is the single point of failure. If it fails, all chatter applications get disconnected. On top of that, every connection is point-to-point, meaning that every chat message is forwarded to each client individually. If the number of connected clients is doubled, the number of messages transmitted from the server is doubled as well. (Provided that the newly added clients do not transmit any chat messages of their own, which would increase the network load even further and could even quadruple it.)

To provide for a more efficient chatter approach, we will employ the DDS-DCPS. The idea is to remove the Chatroom server altogether and let the chat applications (which can now no longer be called clients) directly communicate with each other. The architecture will then become less centralized and will look more like the picture presented in *Figure 5*.

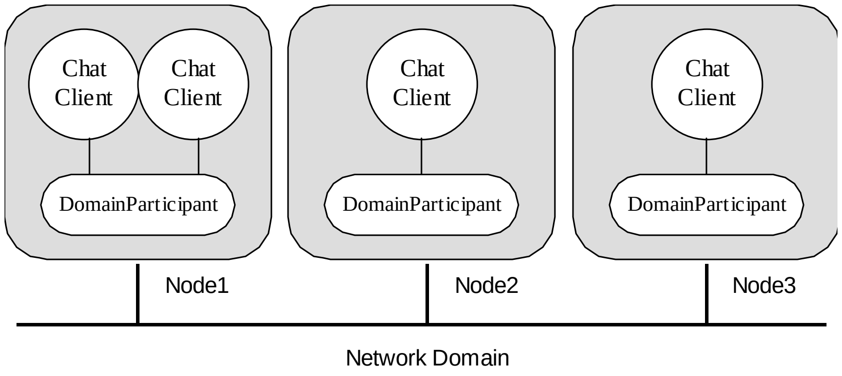


Figure 5 DDS-based Approach

As can be seen from this picture, all applications are equal; there is no centralized point of failure. If a node crashes, all Chatters on that node die, but all the others can keep communicating with each other. What's more, every chat message only has to be transmitted over the network once (using either multicast or broadcast) to deliver it to all the other interested Chatters. Scaling up the number of Chatter applications does not use up any more bandwidth, except of course for the messages sent by these newly added Chatters.

2.2 Analysing the Chatroom Example

In order to focus on the DDS aspect of our Chatroom example, and not on things such as its graphical representation, we will have to break down the problem into several autonomous applications. The following separate applications are distinguished:

- ***Chatter*** **-** This part is responsible for publishing the identity of the user, followed by all chat messages he or she wishes to transmit. (This application is write only.)
- ***MessageBoard*** **-** This part is responsible for subscribing itself to all chat messages and for displaying them in the order in which they are received. (This application is read-only).
- ***UserLoad*** **-** This part is responsible for continuously keeping track of users that join and leave the Chatroom. (This application is read only).

Each of these functional parts will be modelled as a separate process, each one using the standard output to print its messages. Although this constitutes a very primitive User Interface, it completely separates user input from user output thus completely removing the need for any layout related function calls. This helps us to focus our applications almost entirely on efficient utilization of the DCPS, which is the main purpose of this tutorial.

CHAPTER 3 Data Modelling

OpenSplice DDS distributes its data in structured data types, which are transported by means of topics. The first step when using OpenSplice DDS consists of defining these data types. Since OpenSplice can be used on several different platforms with several different programming languages, OMG IDL is used as a language and platform independent modelling language.

This section starts by introducing some basic DDS terminology, which is required to understand the conceptual differences between topics, data types, samples and instances. After that, it will explain which subset of IDL you may use to model your data types, and how to annotate this model with your key field definitions. Finally it will explain how to use the OpenSplice preprocessor to compile the IDL model into your language of choice.

3.1 Data Types, Samples and Instances

All data you want to distribute using OpenSplice DDS has to be defined as a topic. A topic is an aggregation of a structured data type, a keylist, and a specific Quality of Service (QoS) annotation. The keylist is specified as part of the data-type, and identifies the keyfields for that data type. These keyfields can be used to uniquely identify instances of the data type in question, which is a very common approach in relational modelling.

A topic is identified by a topic name that is unique in the context of the Domain where it is used. Note that a topic name and a type name represent two different things: the type name represents the name of the structured data type, the topic name represents the aggregation of this data type with a specific QoS annotation. One data type can be used in several different topic definitions (using different or even the same QoS annotations).

To clarify the efficient usage of topics and to avoid confusion, some basic DDS terms will have to be defined in more detail first:

- ***Data type*** - A DCPS data type represents the definition of a piece of information and is normally declared in IDL as a structured datatype. A data type may embed any number of other data types, but cyclic nesting data types is not possible. Datatypes that are to be distrubuted using topics must be annotated by a declaration of the key fields for that data type.
- ***Sample*** - A DCPS sample represents an allocated data type: in other words, a set of attribute values that is to be distrubuted using a topic.

- ***Keyfield*** - Some fields of a structured datatype can be annotated as being keyfields. The combined values of all keyfields in a sample make up the identity of the item whose state the sample describes.
- ***Instance*** - A DCPS instance represents the notion of a specific observable item, whose state at a certain moment in time can be represented by a sample of a specific data type. The observable item is uniquely identified by the values of its key fields: two samples with different key values represent the states of different instances; two samples with the same key values represent the state of the same instance (but probably these samples represent the state of the instance at different moments in time).

3.2 Modelling Data Types in IDL

A data type represents a structured data type, like an IDL `struct` with several members and a keylist. Whenever you want to read or write topics, you will actually be reading or writing samples of a specific data type. The definition of each data type you will be using has to be written in (a subset of) OMG IDL. The keylist cannot be expressed in IDL, so OpenSplice DDS introduced a special `#pragma` statement for that purpose. [1]

For our chatter application, we will have to define the data types that need to be used to exchange messages between several chatters. We will need at least one topic to transmit the chat messages, and these messages must be accompanied by the user ID of its sender. We can of course use the sender's username as the user ID, but this will mean that the topic's key field will be represented by a string, which may be expensive to process. For this reason, and also for some illustrational purposes, we will decide to make the user ID a 32 bit integer (in other words, an IDL `long`), and to introduce a second topic that maps this user ID to the user's name.

When a Chatter application starts, it will make its existence known to the world by publishing a `NameService` instance, containing a unique `userID` value and the name of the user (which can not be longer than 32 bytes, excluding the '`\0`' terminator according to the IDL). The `userID` field will act as a key to find the corresponding username. After the application has published his `userID` and username, it can start sending chat messages into the world. Each chat message is represented by a `ChatMessage` instance, containing the `userID` of its sender (which acts as its key field), a sequence number expressing the number of chat messages already transmitted, and the message itself, which is an unbounded `string`. Unbounded strings can be of arbitrary length. The resulting topic model is presented below:

1. The use of customized pragma statements is compliant with the IDL standard.

```
1    module Chat {
2      const long MAX_NAME = 32;
3      typedef string<MAX_NAME> nameType;
4
5      struct ChatMessage {
6        long      userID;           // owner of message
7        long      index;            // message number
8        string    content;          // message body
9      };
10  #pragma keylist ChatMessage userID
11
12    struct NameService {
13      long     userID;            // unique user identification
14      nameType name;              // name of the user
15    };
16  #pragma keylist NameService userID
17  };
```

In line *1* a `module` called *`Chat`* is opened, that acts as a scope for all the following declarations. Line *5* introduces the structured data type called *`ChatMessage`*, that contains all the information that is required to identify a specific chat message. Line *10* defines the keylist for this data type (using the `#pragma keylist` statement): it first identifies the data type to which it applies by name, followed by a list of the names of all attributes that represent its key fields (use spaces in case of multiple key fields).

Although the definition of `ChatMessage` is fully OMG IDL compliant, the keylist definition is specific to OpenSplice and mandatory for all data types that are to be used as a topic. The OpenSplice preprocessor will not generate appropriate DataReaders and DataWriters for data types that do not have a corresponding keylist definition. A keylist definition should always be located in the same module as the data type it applies to. Apart from that requirement, the exact location of the keylist statement is irrelevant (it may be located before or after the actual definition of the data type).

Data Types without a keylist definition can still be used as embedded structures for data types that do have a keylist definition. Data Types that are to be used as topics but that do not require any keyfields (so called singleton instances) still require a keylist definition, but with an empty keylist. In case of the example above, if we did not require any keys, line *10* could be replaced by the following statement:

```
   #pragma keylist ChatMessage
```

In the example above, only a very limited subset of IDL is being used. Apart from the trivial primitives (e.g. structures consisting of (unsigned) short, (unsigned) long, (unsigned) long long, float, double, boolean, octet and char), OpenSplice is also capable of handling fixed length arrays, bounded and unbounded sequences, bounded and unbounded strings, union types and enumerations. Types can be nested, which means that a struct can contain a struct field or an array of structs, or a sequence of strings or an array of sequences containing structs or... many more complex examples you can think of. Any definition following the OpenSplice IDL subset is allowed (refer to the *OpenSplice DDS IDL Preprocessor Guide*). It is important to know that the preprocessor used by the DCPS accepts struct definitions only, not interfaces or value types (occurrences of both types will be ignored by this preprocessor[1]).

You have to remember, however, that in the case of `sequences` and `strings`, you as a programmer are responsible for claiming and releasing memory resources and initializing the data type. For example, the string field `content` of the `ChatMessage` can be used only after the programmer has allocated the necessary memory. For more information on using the generated C structs see the OMG's *C Language Mapping Specification*.

3.3 Language Specific Representation

Even though the data type is defined using IDL, your application (when written in C) will be using an equivalent C struct. This is achieved by invoking the OpenSplice DDS IDL preprocessor, an application that translates your IDL data type definition into a matching C definition. The exact translation is defined by the OMG IDL to C mapping. The ChatMessage definition will result in the following C code:

```
 #include <dds_dcps.h>

 #ifndef _Chat_ChatMessage_defined
 #define _Chat_ChatMessage_defined
 #ifdef __cplusplus
 struct Chat_ChatMessage;
 #else /* __cplusplus */
 typedef struct Chat_ChatMessage Chat_ChatMessage;
 #endif /* __cplusplus */
#endif /* _Chat_ChatMessage_defined */
Chat_ChatMessage *Chat_ChatMessage__alloc (void);

struct Chat_ChatMessage {
   DDS_long userID;
   DDS_long index;
   DDS_string content;
};
```

As can be seen, the preprocessor alters the IDL typename by adding the prefix `Chat_` (generated from the IDL module name), to allow for the scoping required by the IDL module. It also provides a typedef named `Chat_ChatMessage`, which simplifies the declaration of a chatmessage variable because of its implicit struct declaration, as can be seen from the following example application:

1. In contrast, the DLRL preprocessor is able to handle value types. If your application needs to distribute information using valuetypes, consider using the DLRL for that purpose.

```
35    // explicit struct declaration.
36    struct Chat_ChatMessage message1;
37
38    // implicit struct declaration.
39    Chat_ChatMessage message2;
```

For C++, this way of declaring variables is already supported (so the typedef is not applied when a C++ compiler is being used), but for convenience we added it to the C API as well. The preprocessor also generates an allocation function, as mandated by the IDL to C language mapping, which can be used to allocate samples of a data type on heap. For our current example this allocation function is named `Chat_ChatMessage__alloc()` (see line *28*). Additional information is provided in the *OpenSplice DDS C Reference Guide*.

The type of each of the fields in the struct is based on the IDL to C mapping, with the difference that the `CORBA_` prefix of each primitive type is replaced by a `DDS_` prefix. (The semantics for each of the types have not been changed with respect to the language mapping). This deviation represents the fact that we are dealing with a standalone C API, that has no dependencies on CORBA whatsoever. API's that cohabitate with CORBA use the pre-processor that comes with the ORB to do the IDL translation. In that case there will be plenty of CORBA dependencies in the generated code.

3.4 Invoking the IDL Pre-processor

If you want to reproduce the example, create a file named Chat.idl. Insert the IDL definition given in the previous example into this file. Run the IDL pre-processor from the command line using:

```
%  idlpp -S -l c Chat.idl
```

If it successfully completes, examine the resulting file called *`ChatDcps.h`*, which contains the C structs. Do not include this file directly into your application though, but use the `Chat.h` file instead. That file is a collection of all relevant information for your application. For now, ignore all other files that are also generated by the preprocessor, we will get back on some of those in a later section.

The ***`-S`*** option specifies that the IDL pre-processor should run in *StandAlone* mode, meaning that it does not have any dependency on CORBA and so can be used without any ORB being installed.

The ***`-l`*** option indicates the target language, which in this case represents C code. Other supported languages are Java (*`-l java`*) and C++ (*`-l cpp`*). See the *IDL Pre-processor Guide* for a summary of all other possible options.

CHAPTER

4 Managing Domains and Topics

In this section you will write your first OpenSplice DDS application. Before you are ready to start writing the first lines of code, we need to explain a little about some basic DDS building blocks and the way data is handled in OpenSplice DDS. The first example of an OpenSplice application is small and is just a declaration of the Domain to use, the topics to use inside it and the QoS settings that need to be applied to both.

The first section will introduce the generic API building blocks and explain their purpose. The second section will introduce you to the concept of QoS policies and will show the policies which are most relevant to our Chatter application. The third section will show you how to connect your application to a specific DDS Domain. The fourth section will demonstrate the steps that are necessary to introduce the required topics into that Domain.

4.1 Entities, Policies, Listeners and Conditions

The DDS can be seen as a large toolbox full of different building blocks. To understand the granularity of these DDS building blocks and the way in which they interact, we will first explain some higher level DDS concepts in more detail:

- ***Entity*** **-** An Entity is a basic DCPS building block. It represents either a producer of information (Publisher or DataWriter), a consumer of information (Subscriber or DataReader), a connection to information (DomainParticipant) or the information that is being communicated (Topic). The behaviour of each Entity can be influenced by means of QoS Policies that must be associated to it at creation time. To keep track of the communication status of an Entity, a StatusCondition object can be obtained from it, or a Listener object can be attached to it. An Entity can only be created or deleted using its corresponding factory. Some Entities may act as a factory for other Entities.
- ***QoS Policy*** **-** QoS Policies provide a generic mechanism for the application to control the behaviour of an Entity: each policy controls one aspect of the Entity and is represented by a structured type containing attributes for all relevant parameters. Entities have a varying set of supported policies: some of them are applicable to only one Entity, some others to more. To make sure neither more nor less than the supported policies are attached to each specific Entity, each Entity provides a specialized QoS structure that aggregates all applicable policies.

- ***StatusCondition*** **-** A StatusCondition object provides a generic mechanism for the application to be informed about relevant status changes in Entities, such as the availability of data corresponding to a subscription, conflicting QosPolicy settings between related Entities, contracts that are being violated, etc. Each of these individual statuses can be either TRUE or FALSE, and may change independently from all the others. The application can make a selection of the statuses it is interested in by setting a bit mask in the StatusCondition object, and when one or more of the selected statuses is TRUE, the overall status flag in the StatusCondition object itself becomes TRUE as well. This flag remains TRUE, until each and every of the selected statuses has been reset to FALSE again. Resetting these individual statuses can be done by invoking their corresponding status accessor method in the related Entity object. To find out which individual statuses are responsible for raising the StatusCondition flag, the Entity object offers a helpful operation that returns a mask that specifies the statuses that are currently set to TRUE.
- ***WaitSet*** **-** An application can use a WaitSet to block the current thread until one or more of the (Status) Conditions attached to that WaitSet will have a trigger value of TRUE, or until a specified timeout expires.
- ***Listener*** **-** A Listener provides a generic mechanism for the middleware to notify the application of changes in StatusConditions. Each Entity supports its own specialized kind of Listener interfaces, which offer specialized callback methods for every individual status change. The application can make a selection of the status changes it is interested in by setting a bit mask that can be supplied at creation time, or in the `set_listener` operation.

Although `DDS_Listeners` and `DDS_WaitSets` both allow the middleware to notify the application of the occurrence of certain events (so that it does not need to poll for this) there are two differences in their intended usage:

1. Listeners are event based and trigger only when a selected status flag changes from `FALSE` to `TRUE`. WaitSets are state based and will trigger as long as a selected status flag remains `TRUE`.
2. Listeners offer callback methods that are invoked by a middleware thread. This means that using Listeners always result in multi-threaded applications. WaitSets can be used to block the current application thread temporarily, and do not necessarily require your application to be multi-threaded.

If an application chooses to use both Listeners and WaitSets to be notified of status conditions in the same `DDS_Entities`, then OpenSplice will first trigger the `DDS_Listeners`, and after that (if the `DDS_StatusConditions` have not yet been reset by the listener operations) it will trigger the `DDS_WaitSets`.

4.2 QoS Policies

The way OpenSplice DDS communicates and stores samples, either in main memory or on disk, is defined by the key fields of their corresponding data type and the Quality of Service (QoS) Policies of their corresponding topic. Every topic must be created before it can be distributed by specifying its data type and associating a QoS Policy.

The QoS Policies that need to be associated with a specific topic describe several aspects of data management for that specific topic. In this tutorial we will not discuss each individual policy, but simply focus on the two most important ones, that define to a large extent the delivery characteristics of each participating Entity.

The Topic related QoS Policies that will be discussed in this tutorial are:

- ***DURABILITY* -** OpenSplice DDS supports four types of durability. DURABILITY defines the lifespan of the data, categorized into VOLATILE, TRANSIENT_LOCAL, TRANSIENT and PERSISTENT data. OpenSplice realizes no backup storage for volatile data. When volatile data is delivered, no guarantee is given that this data can be obtained again. Transient data is recorded by OpenSplice for late joining readers, but only during the up time of the OpenSplice infrastructure. As long as the OpenSplice infrastructure is up-and-running, a copy of all transient data is preserved. Persistent data outlives the lifetime of the OpenSplice infrastructure because it is saved on a number of redundant disks (depending on your configuration). Therefore a copy of persistent data is always available, even when the OpenSplice infrastructure is restarted. Typically, your system configuration data will be persistent. It is not wise to mark frequently updated information as PERSISTENT, since the benefits will probably not outweigh the overhead.
- ***RELIABILITY* -** Two types of RELIABILITY can be used in OpenSplice, which are BEST_EFFORT and RELIABLE delivery. Data that is annotated for a reliable delivery is guaranteed to arrive ultimately because of automatic re-transmission of lost samples. Data that is marked for a best effort delivery gives no more guarantees than the network does: it remains unnoticed when the data gets lost on its way. Choosing not to re-transmit lost samples may be useful when data loses its accuracy quickly; second tries may unnecessarily use the infrastructure when more recent updates have already been sent.

All QoS policies have pre-defined (factory) settings. For the policies presented above, the default settings are depicted in *Table 2*.Refer to the *C Reference Guide* for all other policies and default settings.

Table 2 Default QosPolicy Settings

QoS Policy	Attribute	Value
DURABILITY	kind	DDS_VOLATILE_DURABILITY_QOS
RELIABILITY	kind	DDS_BEST_EFFORT_RELIABILITY_QOS
	max_ blocking_time	100 ms.

4.3 Connecting to a Domain

With the following steps you will be guided to write a small OpenSplice application. The goal of this application is to publish messages, but you start with opening a connection to an OpenSplice Domain and will later add the creation of the required topics.

```
   /* CreateTopics.c */

   #include "dds_dcps.h"
   #include "Chat.h"

   int
   main (
     int argc,
     char *argv[])
 {

    DDS_DomainParticipantFactory    dpf;
    DDS_DomainParticipant           dp;
    DDS_DomainId_t                  domain = NULL;
    DDS_ReturnCode_t                status;

   /* Create a DomainParticipantFactory and a DomainParticipant */
    /* (using Default QoS settings).                             */

    dpf = DDS_DomainParticipantFactory_get_instance();
    if (!dpf) {
      printf("Creating ParticipantFactory failed!!\n");
      exit(-1);
    }
    dp = DDS_DomainParticipantFactory_create_participant (
      dpf,
      domain,
      DDS_PARTICIPANT_QOS_DEFAULT,
      NULL,
      DDS_ANY_STATUS);
    if (!dp) {
      printf("Creating Participant failed!!\n);
      exit(-1);
    }

    /* Deleting the DomainParticipant */
    status = DDS_DomainParticipantFactory_delete_participant(
                    dpf, dp);
```

```
39     if (status != DDS_RETCODE_OK) {
40      printf("Deleting participant failed. Status = %d\n", status);
41      exit(-1);
42     };
43
44     /* Everything is fine, return normally. */
45     return 0;
46   };
```

This application is complete, and can be compiled and run. To do so, you need to add the location of the OpenSplice header files to your compiler's include path and link the result to the OpenSplice shared libraries. The location of the header files can be found (relative to the OpenSplice DDS installation directory) in the *include/dcps/C/SAC* subdirectory. The installation directory is specified in the OSPL_HOME environment variable, which should have been initialized when you executed the release.com script. The shared library files can be found in the subdirectory lib, and in this case you will need to link your application to the dcpssac library[1].

When the application has been successfully compiled and linked, you will need to start the OpenSplice infrastructure before executing your application. This is necessary because your application will try to setup a connection to a DDS Domain, which does not exist if the OpenSplice infrastructure is not up and running. The infrastructure can be started by issuing the following command:

```
%  ospl start
```

This command will launch all services specified in the configuration file that is identified by the OSPL_URI environment variable. The default configuration file that comes with OpenSplice is good enough for the examples in this tutorial.

To see whether the OpenSplice infrastructure is already up and running, issue the ospl list command, it will give you an overview of all instances of OpenSplice that are running on your node. To stop a specific instance of OpenSplice, issue the ospl stop command. It will detach all applications, stop the services and release all memory on your node.

Now start your newly created application. If it is correct, you will not get any error messages, but you will not notice anything else happening as well. Let's have a look at what happens at each code line that was presented above.

In line *3*, the file `dds_dcps.h` is included. This file contains all generic API calls of OpenSplice that are available. When dealing with reading or writing specific data types, typed reader/writer calls are also required to handle these data types. These

1. On a UNIX like platform this file is named libdcpssac.so, on the Windows platform it is named dcpssac.dll.

typed interfaces must be generated by the OpenSplice pre-processor, and the resulting output file must be included as well. This is already done in line *4*, although no typed interfaces are yet presented in this stage.[1]

In line *20* the `DDS_DomainParticipantFactory` instance is obtained. The `DDS_DomainParticipantFactory` is a singleton, meaning that there can only be one participant factory in each process. Obtaining the factory for the first time with the `DomainParticipantFactory_get_instance()` call implicitly instantiates it. Making this call at a later moment in time returns the already existing participant factory.

i Note that the `DomainParticipantFactory_get_instance()` function is not re-entrant, so it may only be called by one thread at a time. (See also Section 8.8, *Cleaning Up*, on page 96.)

In lines *21-24* it is checked whether the factory handle obtained above is actually a valid handle (i.e. does not represent a `NULL` pointer). ALWAYS CHECK THE VALIDITY OF HANDLES RETURNED BY FUNCTION CALLS! Not doing so may result in failing function calls later on in your application, which are not easy to trace back to their root cause.

In lines *25-30* `DDS_DomainParticipantFactory_create_participant()` is invoked to create a `DDS_DomainParticipant`, which represents our connection to a specific DDS Domain. The first parameter for this operation (as for any DDS operation) represents the entity that actually needs to execute the function call, which in this case is our participant factory. The second parameter is the domain ID (represented by a URI - a Universal Resource Indicator), which should point to the OpenSplice configuration file containing the Domain related properties for this node. See the *OpenSplice DDS Deployment Guide* for additional information.

Not assigning a value to this URI, like we do in our example, means that OpenSplice will look for the configuration file in the location specified by the environment variable called `OSPL_URI`. (For Linux/Unix based platforms, this variable is initialized by sourcing the `release.com` script that is created by the OpenSplice installer. On Windows platforms, this variable is already initialized in your environment by your Windows installer. The variable will point to a default configuration file that comes with OpenSplice.). For our tutorial example that is okay for now.

The third parameter specifies the QoS settings that will be used for the `DDS_DomainParticipant`. Since we are satisfied with the pre-defined (factory) settings for the participant QoS, we indicate that we want to copy these factory settings (as is) to our `DDS_DomainParticipant` by using a so called convenience

1. In fact, the IDL preprocessor creates more files than just this one, but the file presented here is the one that includes all the other files that are relevant for the application.

macro. The DDS provides for each DDS_Entity a corresponding convenience macro that represents the default QoS for that DDS_Entity[1]. The name of that macro always consists of the prefix DDS_ followed by the name of the DDS_Entity (in the case of a DDS_DomainParticipant this name is shortened to PARTICIPANT), followed by the postfix _QOS_DEFAULT. This macro can be used at any location where a QoS for the corresponding Entity needs to be supplied by the application.

The last two parameters specify a DDS_DomainParticipantListener object that can be attached to the DDS_DomainParticipant and a bit mask identifying the status events on which it should trigger. In this example we are not interested in handling any status changes on the DDS_DomainParticipant, so we choose not to attach a listener object here. We do that by providing a NULL pointer for this parameter[2]. The bit mask specifies which status events should be handled by the supplied DDS_DomainParticipantListener object: each status is represented by a special constant that represents its bit position in the bit mask. See *Table 3* for an overview of the names and meaning of all these status events and the DDS_Entities to which they are applicable.

For all classes that inherit from DDS_Entity all events not handled by their attached listener objects will be propagated to the listener objects attached to their factories. Since we are not interested in propagating our events anywhere (we just want to ignore them) we select a bit mask that handles all appropriate events by our NULL listener[3]. There is a special constant called DDS_ANY_STATUS that selects all appropriate status bits for the DDS_Entity to which it is applied.

Table 3 Status Events Overview

DDS_Entity	Status Name	Meaning
DDS_Topic	DDS_INCONSISTENT_TOPIC_STATUS	Another DDS_Topic exists with the same name but with different characteristics.
DDS_Subscriber	DDS_DATA_ON_READERS_STATUS	New information is available.

1. There are convenience macros for other purposes as well.
2. A NULL listener behaves like a listener that handles all events it receives as a no-op.
3. A DDS_DomainParticipant has no factory to which it can propagate its events, so technically speaking it doesn't matter what bit-mask you select in this case. For all other DDS_Entities however it is an important consideration to make.

Table 3 Status Events Overview (Continued)

DDS_Entity	Status Name	Meaning
DDS_DataReader	DDS_SAMPLE_REJECTED_STATUS	A (received) sample has been rejected.
	DDS_LIVELINESS_CHANGED_STATUS	The liveliness of one or more DDS_DataWriter objects that were writing instances read through the DDS_DataReader has changed. Some DDS_DataWriter have become "active" or "inactive".
	DDS_REQUESTED_DEADLINE_ MISSED_STATUS	The deadline that the DDS_DataReader was expecting through its DDS_DeadlineQosPolicy was not respected for a specific instance.
	DDS_REQUESTED_ INCOMPATIBLE_QOS_STATUS	A QosPolicy setting was incompatible with what is offered.
	DDS_DATA_AVAILABLE_STATUS	New information is available.
	DDS_SAMPLE_LOST_STATUS	A sample has been lost (never received).
	DDS_SUBSCRIPTION_MATCHED_STATUS	The DDS_DataReader has found a DDS_DataWriter that matches the DDS_Topic and has compatible QoS.
DDS_DataWriter	DDS_LIVELINESS_LOST_STATUS	The liveliness that the DDS_DataWriter has committed through its DDS_LivelinessQosPolicy was not respected; thus DDS_DataReader objects will consider the DDS_DataWriter as no longer "active".
	DDS_OFFERED_DEADLINE_ MISSED_STATUS	The deadline that the DDS_DataWriter has committed through its DDS_DeadlineQosPolicy was not respected for a specific instance.
	DDS_OFFERED_INCOMPATIBLE_ QOS_STATUS	A QosPolicy setting was incompatible with what was requested.
	DDS_PUBLICATION_MATCHED_STATUS	The DDS_DataWriter has found DDS_DataReader that matches the DDS_Topic and has compatible QoS.

Table 3 Status Events Overview (Continued)

DDS_Entity	Status Name	Meaning
All `DDS_Entity` objects.	`DDS_ANY_STATUS`	All status events applicable to the `DDS_Entity` in question.

When the `DDS_DomainParticipantFactory_create_participant` operation completed successfully, it returns the handle to the created `DDS_DomainParticipant`. Again, check whether the resulting handle is valid before using it in other operations.

After the `DDS_DomainParticipant` has been created, the application is ready to use the OpenSplice infrastructure. The application could now create topics, publishers and subscribers, but we will do that in a later stage. For now, we will release the resources used by OpenSplice by deleting the participant again. We do this in the `DDS_DomainParticipantFactory` by invoking the `DDS_DomainParticipantFactory_delete_participant()` call. This operation deletes all resources used by this participant and returns a status code of type `DDS_ReturnCode_t`. Since we didn't do anything with our participant yet, the status code should indicate a successful result, represented by `DDS_RETCODE_OK`. However, never assume everything will go according to plan: always check your assumptions! In line *39* we check whether the result is what we expect. In a later stage, when our application has expanded a little bit, the result could indicate that we are not yet allowed to delete this participant. The possible return statuses of type `DDS_ReturnCode_t` are depicted in *Table 4*, together with their value and their meaning.

This concludes our first example. When you monitor all OpenSplice activity with the OpenSplice DDS Tuner, nothing seems to have happened. This is because the participant was created and deleted so fast, that OpenSplice DDS Tuner did not have the time to depict it. If you run the application in a debugger, and stop the execution before the `DomainParticipantFactory_delete_participant()` operation, then you will see that the OpenSplice DDS Tuner actually detects the DomainParticipant and shows it in its participant list. You can even check its QoS settings to see if they match the defaults that you specified. In a later example we will show you how you can provide your own QoS settings.

Table 4 Return Code Definitions

Return Code	Value	Meaning
`DDS_RETCODE_OK`	0	Successful return.
`DDS_RETCODE_ERROR`	1	Generic, unspecified error.
`DDS_RETCODE_UNSUPPORTED`	2	Unsupported operation. Can only be returned by operations that are optional.
`DDS_RETCODE_BAD_PARAMETER`	3	Illegal parameter value.
`DDS_RETCODE_PRECONDITION_NOT_MET`	4	A precondition for the operation was not met.
`DDS_RETCODE_OUT_OF_RESOURCES`	5	Service ran out of the resources needed to complete the operation.
`DDS_RETCODE_NOT_ENABLED`	6	Operation invoked on an Entity that is not yet enabled.
`DDS_RETCODE_IMMUTABLE_POLICY`	7	Application attempted to modify an immutable QosPolicy.
`DDS_RETCODE_INCONSISTENT_POLICY`	8	Application specified a set of policies that are not consistent with each other.
`DDS_RETCODE_ALREADY_DELETED`	9	The object target of this operation has already been deleted.
`DDS_RETCODE_TIMEOUT`	10	The operation timed out.
`DDS_RETCODE_NO_DATA`	11	Indicates a transient situation where the operation did not return any data but there is no inherent error.
`DDS_RETCODE_ILLEGAL_OPERATION`	12	An operation was invoked on an inappropriate object or at an inappropriate time (as determined by policies set by the specification or the Service implementation). There is no precondition that could be changed to make the operation succeed.

4.4 Registering Data Types and Creating Topics

We can now start using the `DDS_DomainParticipant` created in the previous example to actually create a `DDS_Topic`. Reiterating from the previous sections, a topic was an aggregation between a data type (including its key list) and a QosPolicy setting. So before being able to create a topic, first the corresponding data type will need to be registered in the middleware. To register a data type, we require a some source code that announces the type specific meta data to OpenSplice. This code is embedded in a so called `DDS_TypeSupport` class, which is generated by the OpenSplice DDS Preprocessor.

The OpenSplice preprocessor generates a number of files out of each IDL input file. We already introduced two of these files:

- The file `Chat.h` is the overall include file. It includes all other files relevant for the application. Its name is based on the name of the corresponding IDL file, where the `.idl` extension is replaced by the `.h` extension.
- The file `ChatDcps.h` contains the C representations of the data structures defined in your IDL file. Its name is based on the base name of the corresponding IDL file, but it is appended by the postfix `Dcps.h`.

We will now explain a third file generated by the pre-processor, called `ChatSacDcps.h`. This file name is also based on the basename of the IDL file, but it is appended by the postfix `SacDcps.h` (Sac stands for Standalone C API, which is the OpenSplice DDS API that you are now using). It contains the specialized API interface definitions for the `DDS_TypeSupport`, `DDS_DataReader` and `DDS_DataWriter` classes parameterized for all data types mentioned in the IDL file[1]. It is a very big file, so we will not show it here entirely. Instead, we will focus on the parts that define the `DDS_TypeSupport` interface for our `ChatMessage` data type.

```
47    #include "ChatDcps.h"
48
49    #define Chat_ChatMessageTypeSupport DDS_TypeSupport
50
51    Chat_ChatMessageTypeSupport
52    Chat_ChatMessageTypeSupport__alloc (
53      void
54    );
55
56   DDS_ReturnCode_t
57   Chat_ChatMessageTypeSupport_register_type (
58     Chat_ChatMessageTypeSupport _this,
59     DDS_DomainParticipant domain,
60     DDS_string name
61   );
```

In line *47* we see that this file includes the C representations of the data types, which is necessary because the corresponding DataReaders and DataWriters will be accessing this data. Line *49* introduces the definition of our specialized `Chat_ChatMessageTypeSupport` class. Its name is based on the name of our

1. The corresponding ChatSacDcps.c file contains the implementation code for these interfaces.

data type (prepended by the `module` name in which it is located), and it is followed by the `TypeSupport` postfix. As can be seen from this declaration, the specialized TypeSupport handle is just an alias for the handle of its parent class.

Lines *51-54* present an allocation function that is needed to actually instantiate a TypeSupport object on heap. Its name is based on the specialized TypeSupport class, followed by the `__alloc()` postfix. Every DDS object allocated by an `__alloc()` operation must be released by using the `DDS_free()` operation, which is included from the `dds_dcps.h` file. Never try to de-allocate a DDS object any other way, since it will almost definitely corrupt your memory and crash your application.

Lines *56-61* finally present the operation required to register the data type in a `DDS_DomainParticipant`. This operation can only be performed on an allocated TypeSupport: forgetting to allocate the TypeSupport will probably result in a `DDS_RETCODE_BAD_PARAMETER`. A TypeSupport object may be registered in different `DDS_DomainParticipants`, but has no more purpose after the registering is completed, so it may be released afterwards. There is no way to un-register a data type, so after the `DDS_TypeSupport` has been released its registered data types can still be used in the `DDS_DomainParticipant`.

The `Chat_ChatMessageTypeSupport_register_type` method requires three parameters:

- the pointer to the allocated `Chat_ChatMessageTypeSupport` object
- the handle to the `DDS_DomainParticipant` in which it is to be registered
- the name by which this data type can be identified within the specified `DDS_DomainParticipant`

This name parameter is a little bit tricky, since it identifies the data type only in the scope of the specified `DDS_DomainParticipant`. Other participants could choose to register the same data type using a different name. This makes setting up communications between different DomainParticipants a hazardous task: what if two DomainParticipants have registered the same data type using different names?

To avoid such configuration problems, we advise you to always register a data type using its IDL type name. The `DDS_TypeSupport` offers helpful features for this:

- If you pass a `NULL` value to the name, the `DDS_TypeSupport` will register the data type using its IDL type name, including its scope, in other words. the names of the modules that the IDL data type is embedded in, separated by the IDL scoping operator, `::`. In this example the resulting name will be: `Chat::ChatMessage`.
- Alternatively, you can obtain the fully qualified IDL type name directly from a `DDS_TypeSupport` itself using the `Chat_ChatMessageTypeSupport_get_type_name()` operation in this example. The resulting name can then be used for both the registration of the type and the creation of the topic.

Using these tricks ensures you will always be using the same type name for a given data type in every `DDS_DomainParticipant`. We strongly advise you to always register the data types this way: only use different names when you have very compelling reasons to do so.

The data types registered this way can be used to create topics: the basic DDS communication entities. Creating a `DDS_Topic` is very similar to creating a `DDS_DomainParticipant` (remember that there are lots of similarities since both interfaces are specialiations of the `DDS_Entity` interface):

- A `DDS_Entity` can only be created and deleted by using its factory. The `DDS_DomainParticipant` acts as a factory for `DDS_Topics`.
- At creation time, a `DDS_Entity` needs to be associated with a set of QoS Policies.
- At creation time, a `DDS_Listener` can be attached to the entity, accompanied by a bit mask that indicates which status events need to be handled by the provided listener.

Below, we have expanded the example presented in Section 4.3, *Connecting to a Domain*, with the code that actually creates the `ChatMessage` topic:

```
/* CreateTopics.c */

#include "dds_dcps.h"
#include "Chat.h"

int
main (
  int argc,
  char *argv[])
{

  DDS_DomainParticipantFactory    dpf;
  DDS_DomainParticipant           dp;
  DDS_DomainId_t                  domain = NULL;
  DDS_ReturnCode_t                status;
  Chat_ChatMessageTypeSupport     chatMessageTS;
  DDS_Topic                       chatMessageTopic;
  char                            *chatMessageTypeName;

  /* Create a DomainParticipantFactory and a DomainParticipant */
  /* (using Default QoS settings).                              */

  dpf = DDS_DomainParticipantFactory_get_instance();
  if (!dpf) {
    printf("Creating ParticipantFactory failed!!\n");
    exit(-1);
  };
  dp = DDS_DomainParticipantFactory_create_participant(
    dpf,
    domain,
    DDS_PARTICIPANT_QOS_DEFAULT,
    NULL,
    DDS_ANY_STATUS);
95    if (!dp) {
96      printf("Creating Participant failed!!\n);
97      exit(-1);
98    };
99
100   /* Register the required data type for ChatMessage. */
101   chatMessageTS = Chat_ChatMessageTypeSupport__alloc();
102   if (!chatMessageTS) {
103     printf ("Allocating TypeSupport failed!!\n");
104     exit(-1);
105   };
106   chatMessageTypeName =
107     Chat_ChatMessageTypeSupport_get_type_name(chatMessageTS);
108   status = Chat_ChatMessageTypeSupport_register_type(
109     chatMessageTS, dp, chatMessageTypeName);
110   if (status != DDS_RETCODE_OK) {
111     printf (
112         "Registering data type failed. Status = %d\n", status);
113     exit(-1);
114   };
115
116   /*Create the ChatMessage topic */
117   chatMessageTopic = DDS_DomainParticipant_create_topic(
118     dp,
119     "Chat_ChatMessage",
120     chatMessageTypeName,
121     DDS_TOPIC_QOS_DEFAULT,
122     NULL,
123     DDS_ANY_STATUS);
124   if (!chatMessageTopic) {
125     printf("Creating ChatMessage topic failed!!\n");
126     exit(-1);
127   };
128
129   /* Deleting the Topic. */
130   status = DDS_DomainParticipant_delete_topic(
131     dp, chatMessageTopic);
132   if (status != DDS_RETCODE_OK) {
133     printf("Deleting topic failed. Status = %d\n", status);
134     exit(-1);
135   };
136
137   /* Deleting the DomainParticipant */
138   status = DDS_DomainParticipantFactory_delete_participant(
139     dpf, dp);
140   if (status != DDS_RETCODE_OK) {
141     printf("Deleting participant failed. Status = %d\n", status);
142     exit(-1);
143   };
144
145   /* Everything is fine, return normally. */
146   return 0;
147 };
```

As can be seen from this code example in lines *101-114*, a `Chat_ChatMessageTypeSupport` is allocated and its data type is registered in our `DDS_DomainParticipant` using its default name. Again, the result of every operation is checked against our assumptions.

In lines *117-127*, we create our first topic using the `DDS_DomainParticipant_create_topic()` operation. As always, the first parameter is the handle to the object that actually needs to perform the operation (our `DDS_DomainParticipant`). The second parameter provides the name that will be used to identify the topic. This is also the name that we will see when we display our topic list in the OpenSplice DDS Tuner. The third parameter is the name of the data type that we wish to associate with our topic. In our case, this is the default name provided by our `Chat_ChatMessageTypeSupport` class. The fourth, fifth and sixth parameters are the set of QoS Policies we wish to associate with the topic, the `DDS_TopicListener` we wish to attach to it and the bit mask which applies to that listener respectively. In this case we again used a convenience macro to select the default set of QoS Policies for this topic, and we also specified that we do not want to attach a Listener.

In this example, we don't use our topic for any purpose yet: we delete it just before we delete our `DDS_DomainParticipant`. This is necessary, since in the DDS it is not possible to delete any type of factory that still contains elements that are created by it. In our case, the `DDS_DomainParticipant` acted as a factory for our `DDS_Topic`, and can therefore not be deleted while our topic object still exists. Trying to delete the participant in this stage will definitely result in a `DDS_RETCODE_PRECONDITION_NOT_MET` being returned.

That is why we need to delete the topic first. This is done in line *130*, by means of the `DDS_DomainParticipant_delete_topic()` operation, whose parameter signature is very obvious and needs no further explanation. After the topic has been deleted, the `DDS_DomainParticipant` can be deleted without any problems as well. That ends our little application for now.

4.5 Topics as Global Concepts

When we look in the OpenSplice DDS Tuner at the results of the application presented in the previous section, we will see that although our DomainParticipant has disappeared, our topic is still available in the list of topics. This is not a bug! To understand what is happening here, we need to elaborate a little bit more on the global concept of a topic. A topic represents the smallest undividable part of an information model that can be communicated within a domain. In order for the communication to be successful, all parties within the domain must agree upon how the information is distributed and what it represents. That means that the topic definition is not just something local: all participants in our domain must agree upon it.

That means that if I create a topic in my DomainParticipant, this topic will automatically be forwarded to all other participants in my domain. They will then compare it to the topic definitions they already know. If my topic definition matches with already existing definitions or does not yet exist, my topic definition is accepted and my call returns successfully. If my definition conflicts with an already existing topic definition, my creation will fail and my call will return a `NULL` pointer.

So the `DDS_Topic` I create is not just a local object; it represents a global concept of a part of an information model, agreed upon by all parties within my domain. The Topic object I create is just a 'proxy' that represents this global concept. Deleting my local `DDS_Topic` object will not destroy it globally: it will merely destroy my local proxy that represents it. This seems natural: one party joining a system that already agreed upon its topic model, cannot by itself decide to destroy this global topic model when it decides to leave the system. It can only decide for itself that it is no longer interested in the existence of certain topics, without interfering with the parts of the system that still do want to know about them.

This is why a topic as a global concept cannot be deleted: you never know which parts of the system may still have a need for it. When you really want to completely remove a topic definition from a running system, you will need to bring down all applications joining in your domain, stop their daemons and restart everything. This is why you should be careful when introducing new topics into a running system: you cannot easily undo any mistakes you make. Creating new topics is therefore not something that everybody should be allowed to do: a system architect should be made responsible for defining an overall information model that all participants need to agree upon[1].

4.6 Tailoring QosPolicy Settings

In the previous examples we defined a complete information model for our Chatroom application in IDL, but we only created topics using default QoS settings. In this section we will elaborate on the requirements for our `Chatter` application, and decide which QosPolicy settings are best suitable for our application.

Since we do not want to lose any chat message or username, both topics will have to be transmitted reliably. A late joining chatter application is probably not interested in receiving the chat messages that were transmitted before he decided to join in, but it will definitely want to be able to figure out which `userID` represents which username once it starts to receive chat messages. That means that the `ChatMessage` topic can be transmitted with volatile durability, but the `NameService` topic will require either transient or persistent storage. Since chatter application will always publish its username before writing its chat messages, the storage of these names will not need to be persistent, and a transient store will be sufficient.

1. An individual application is however allowed to create its own local view of existing topics by using a MultiTopic. This can only be used for reading information, not for writing it.

For a late joining application this means that once it subscribes itself to the `NameService` topic, it will receive from the transient store the usernames and `userID`'s of all other Chatters that have already connected to the same Domain before. In contrast, it will only receive those chat messages that have been transmitted after its own subscription to the `ChatMessage` topic.

To make our Chatroom application work this way, we need to deviate from the default QoS settings. These default QoS Policies have been chosen in such a way that they form an internally consistent set that is most suitable to 'first time users' and that gives a good 'out of the box' experience. When dedicated requirements call for alternative QoS settings on your Entities, you can tailor these settings in the following ways:

1. You can create Entities using a QoS in which each policy is set explicitly.
2. You can obtain the default QoS, modify some of its policies to match your own preference, and use the result to create your Entities.
3. You can permanently make changes to the default QoS of each factory.

All these approaches have their benefits in certain conditions. You can explicitly set each policy when you need very dedicated settings that do totally not comply with the factory defaults. However, if you reuse the same settings in most of your Entities, it makes sense to use the default settings from your factories, even when you need to modify these factory defaults first. When you are satisfied with the default policies, but need little deviations from them every now and then, it makes sense to obtain the default QoS, modify some of the policies to fit a specific Entity, and create that Entity with it.

The following code again expands our example application, but this time we will create both topics using different QoS settings. The explicit checks on the validity of return statuses and handles have all been replaced with specialized functions, which are included from the `CheckStatus.h` file, and implemented in the `CheckStatus.c` file. The code listings for both files can be found under *CheckStatus.h* and *CheckStatus.c* in Appendix A, *C Language Examples’ Code*:

```
 /* CreateTopics.c */

 #include "dds_dcps.h"
 #include "Chat.h"
 #include "CheckStatus.h"

 int
 main (
   int argc,
  char *argv[])
{
  DDS_DomainParticipantFactory    dpf;
  DDS_DomainParticipant           dp;
  DDS_DomainId_t                  domain = NULL;
  DDS_ReturnCode_t                status;
```

```
Chat_ChatMessageTypeSupport     chatMessageTS;
Chat_NameServiceTypeSupport     nameServiceTS;
char                            *chatMessageTypeName;
char                            *nameServiceTypeName;
DDS_TopicQos                    *reliable_topic_qos;
DDS_TopicQos                    *setting_topic_qos;
DDS_Topic                       chatMessageTopic;
DDS_Topic                       nameServiceTopic;

/* Create DomainParticipantFactory and a DomainParticipant */
/* (using Default QoS settings).                           */

dpf = DDS_DomainParticipantFactory_get_instance();
checkHandle(dpf, "DDS_DomainParticipantFactory_get_instance");
dp = DDS_DomainParticipantFactory_create_participant (
  dpf,
  domain,
  DDS_PARTICIPANT_QOS_DEFAULT,
  NULL,
  DDS_ANY_STATUS);
checkHandle(
  dp, "DDS_DomainParticipantFactory_create_participant");

/* Register the required data type for ChatMessage. */
chatMessageTS = Chat_ChatMessageTypeSupport__alloc();
checkHandle(
  chatMessageTS, "Chat_ChatMessageTypeSupport__alloc");
chatMessageTypeName =
  Chat_ChatMessageTypeSupport_get_type_name(chatMessageTS);
status = Chat_ChatMessageTypeSupport_register_type(
  chatMessageTS, dp, chatMessageTypeName);
checkStatus(
  status, "Chat_ChatMessageTypeSupport_register_type");

/* Register the required data type for NameService. */
nameServiceTS = Chat_NameServiceTypeSupport__alloc();
checkHandle(
  nameServiceTS, "Chat_NameServiceTypeSupport__alloc");
nameServiceTypeName =
    Chat_NameServiceTypeSupport_get_type_name(nameServiceTS);
Chat_NameServiceTypeSupport_register_type(
  nameServiceTS, dp, nameServiceTypeName);
checkStatus(
  status, "Chat_NameServiceTypeSupport_register_type");

/* Change the default TopicQos to Reliable reliability. */
reliable_topic_qos = DDS_TopicQos__alloc();
checkHandle(reliable_topic_qos, "DDS_TopicQos__alloc");
status = DDS_DomainParticipant_get_default_topic_qos(
  dp, reliable_topic_qos);
checkStatus(
  status, "DDS_DomainParticipant_get_default_topic_qos");
reliable_topic_qos->reliability.kind =
                                DDS_RELIABLE_RELIABILITY_QOS;

/* Make the tailored QoS the new default. */
status = DDS_DomainParticipant_set_default_topic_qos(
  dp, reliable_topic_qos);
checkStatus(
  status, "DDS_DomainParticipant_set_default_topic_qos");

  /*Create the ChatMessage topic */
  chatMessageTopic = DDS_DomainParticipant_create_topic(
    dp,
    "Chat_ChatMessage",
    chatMessageTypeName,
    DDS_TOPIC_QOS_DEFAULT,
    NULL,
    DDS_ANY_STATUS);
  checkHandle(
    chatMessageTopic,
    "DDS_DomainParticipant_create_topic (ChatMessage)");

  /* Obtain a private copy of the default QoS to tailor it. */
  setting_topic_qos = DDS_TopicQos__alloc();
  checkHandle(setting_topic_qos, "DDS_TopicQos__alloc");
  status = DDS_DomainParticipant_get_default_topic_qos(
    dp, setting_topic_qos);
  checkStatus(
    status, "DDS_DomainParticipant_get_default_topic_qos");

  /* Note: changing the copy doesn't change the original
itself!*/
  setting_topic_qos->durability.kind =
    DDS_TRANSIENT_DURABILITY_QOS;

  /* Associate the tailored policy with the NameService topic */
  nameServiceTopic = DDS_DomainParticipant_create_topic(
   dp,
   "Chat_NameService",
   nameServiceTypeName,
   setting_topic_qos,
   NULL,
   DDS_ANY_STATUS);
 checkHandle(
   nameServiceTopic,
   "DDS_DomainParticipant_create_topic (NameService)");

 /* Deleting the Topics to be able to delete my participant. */
 status = DDS_DomainParticipant_delete_topic(
   dp, nameServiceTopic);
 checkStatus(
   status,
   "DDS_DomainParticipant_delete_topic (NameServiceTopic)");

 status = DDS_DomainParticipant_delete_topic(
   dp, chatMessageTopic);
 checkStatus(
   status,
   "DDS_DomainParticipant_delete_topic (chatMessageTopic)");

 /* De-allocate the QoS policies. */
 DDS_free(reliable_topic_qos);
 DDS_free(setting_topic_qos);
 DDS_free(pub_qos);

 /* De-allocate the type-names and TypeSupports. */
 DDS_free(nameServiceTypeName);
 DDS_free(chatMessageTypeName);
 DDS_free(nameServiceTS);
 DDS_free(chatMessageTS);
```

```
283
284   /* Deleting the DomainParticipant */
285   status = DDS_DomainParticipantFactory_delete_participant(
286     dpf, dp);
287   checkStatus(
288     status,
289     "DDS_DomainParticipantFactory_delete_participant");
290
291   /* Everything is fine, return normally. */
292   return 0;
293 };
```

This example starts like the previous ones, but in line *209* we allocate a holder for the `DDS_TopicQos` that we will be using to create our topics. Since the change we want to make to our TopicQos is only minor compared to the default TopicQos, we will not set each policy field explicitly, but instead in line *211* we request the `DDS_DomainParticipant` to fill our holder with the current values of the default Topic Qos. Now we only have to change explicitly those QoS fields in the holder that are not suitable for our application. For our first topic, only the RELIABILITY settings will need to be changed and this is done in line *215*. Since all other topics that we will create in this `DDS_DomainParticipant` also require reliable transportation, it makes sense to make this the new default setting for this participant. (Note: default QoS settings are a property of the factory: different factories can have different default settings!). The participant default is changed according to the settings specified in our holder in line *219*.

The creation of the `ChatMessage` topic now in lines *225-231* is not really different from its creation it in the previous example, but since we changed the default QoS, the resulting topic will be different as well. If you did not restart your OpenSplice daemons after running the previous example, the creation of the current topic will fail since its QoS settings conflict with the settings of the previous example. In the OpenSplice DDS Tuner you will now be able to see that the `ChatMessage` topic indeed has different QoS settings and will be transported reliably.

The `NameService` topic requires another QoS change, so we will use the same trick employed before. This time however, since it is the only topic that requires transient durability, we will not change the default, but just create a custom QoS holder that we adapt to our needs. Again we fill it with the default QoS settings in line *239*, but this time we change the durability field to TRANSIENT durability in line *245*. We can now use our customized QoS holder in the creation of the `NameService` topic in lines *249-255*.

Don't forget to de-allocate your QoS holders, type-names and TypeSupport objects when you no longer need them. In our case, this is performed in lines *274-282*. Remember: the `DDS_free` operation can and must be used on any handle that was obtained by an operation whose name end with `__alloc()`, and on any string that is allocated as a result of a getter-operation on an entity.

This ends our first application now. We have shown you how to define an information model that suits your needs, how to select an efficient QoS that fits this model and how to create topics according to these choices. In the coming sections we will show you how to use these topic definitions to publish information into the system, and how to access this information in other applications by making subscriptions to these topics.

CHAPTER

5 *Publishing the Data*

In this section, you will be guided to create the publishing part of the chatter application. You will use the topic definitions of the previous section to publish your username and userID into the chatter domain, send an arbitrary number of chat messages afterwards, and then indicate that you leave the chatroom by disposing your username and ID.

The first section will give a short explanation of the different DDS entities that play a role in the publishing part of an application. The next section will teach you how to create a Publisher with accompanying DataWriters. That is followed by a section that describes the principles behind RxO QosPolicy matching between Readers and Writers and a section that describes how to delete your Publishers and Subscribers. The last two sections will show you how to use a DataWriters to register instances, write data samples into the system, and how to unregister and dispose these instances afterwards.

5.1 Publishers, DataWriters and their QoS Policies

Publishers and DataWriters are the building blocks required to publish information into your system. Both classes are modelled as `DDS_Entities`, meaning both are controlled by a set of QoS Policies, both have their own `DDS_StatusCondition`, both classes can have their own `DDS_Listener` object attached to them, and both classes can only be created and deleted by means of their corresponding factories. This section will introduce the reasons for separating Publishers from DataWriters in the DDS specification and explain the different objectives of both entities.

- ***Publisher*** - A Publisher is responsible for the dissemination of publications, in other words, the Publisher decides what information is to be published at what time and in which partition. The Publisher's QoS policiescontrol whether samples will be transmitted individually or as coherent sets of information (in order to allow for some primitive form of Transactions), whether the ordering between them will be preserved, and in which Partitions the information will be made available. The DomainParticipant acts as a factory for Publishers.
- ***Partition*** - The Partition QoSPolicy defines in which partitions information will be made available. Partitions are identified by name, and allow you to logically partition your information space: only when a publisher and a subscriber are connected to the same partition, communication will be established[1]. The PartitionQoSPolicy consists of an unbounded sequence of strings: each element

represents the name of a partition to which you will be connected. Elements containing names that have not yet been used before result in the creation of new Partitions. Elements may also contain wildcards, which will then be matched against all existing Partitions.

- ***DataWriter*** **-** A DataWriter is a type specific interface for the Publisher, in other words, it allows an application to offer samples for a specific topic to the Publisher, which will then perform the actual transmission of these samples. A Publisher acts as a factory for its own set of typed DataWriters, and can publish information that spans more than one Topic. In such cases, it employs a separate DataWriter for each individual Topic. The QoS Policies of a DataWriter control how its samples will be transmitted by the Publisher (e.g. their reliability and durability settings).

As you might have noticed from the previous bullet, some of the QoS Policies that you need to specify on the DataWriter are already specified on the Topic as well. That means that you might have conflicting QoS settings for a Topic on one hand, and for the DataWriters that actually provide samples for that specific Topic on the other hand. You might wonder why the DDS specification introduces such QoS Policy overlaps.

The reason is quite simple: the Topic QoS Policies act as some sort of system preference for all DataWriters (and also all DataReaders) of that Topic in your system. Normally, the system architect will select the most appropriate QoS Policiy settings that should be applicable to most DataReader/DataWriter combinations in your system, and he will attach those QosPolicy settings to the Topic. If you, as an application programmer, do not know what policies to use on your DataWriters (or DataReaders), just use the policies specified on the Topic.

However, you as an application programmer may have a very good reason to deviate from this system preference because of some dedicated knowledge you have about the behaviour of your application. In such cases you can tailor the DataWriter QoS Policy settings to your own needs, since it is always the QosPolicy settings on each individual DataWriter that decide how the samples are being transmitted.

1. You can also partition your information space by using different Domains (physical partitioning), which is a very static approach since an application cannot easily change the Domain it is attached to. In contrast, logical partitioning allows you to change your region-of-interest on the fly: you can change the number and type of partitions you are attached to at any moment in time.

5.2 Creating Publishers and DataWriters

In this section we will expand the example presented in Section 4.6, *Tailoring QosPolicy Settings*, with some code that creates our `DDS_Publisher` together with its two `DDS_DataWriters`: one for the `NameService` Topic, and one for the `ChatMessage` Topic.

The following code fragment shows the code fragments that should be inserted (between lines *258* and *260*) in order to create the `DDS_Publisher` with its `DDS_DataWriters` (it does not show the code already provided under *Tailoring QosPolicy Settings*.

```
DDS_PublisherQos                  *pub_qos;
  DDS_DataWriterQos               *dw_qos;
  DDS_Publisher                   chatPublisher;
  Chat_ChatMessageDataWriter      talker;
  Chat_NameServiceDataWriter      nameServer;
  char                            *partitionName = NULL;

  /* Adapt the default PublisherQos to write into the
     "ChatRoom" Partition. */
  partitionName = "ChatRoom";
 pub_qos = DDS_PublisherQos__alloc();
 checkHandle(pub_qos, "DDS_PublisherQos__alloc");
 status = DDS_DomainParticipant_get_default_publisher_qos (
   participant, pub_qos);
 checkStatus(
   status, "DDS_DomainParticipant_get_default_publisher_qos");
 pub_qos->partition.name._length = 1;
 pub_qos->partition.name._maximum = 1;
 pub_qos->partition.name._buffer = DDS_StringSeq_allocbuf (1);
 checkHandle(
   pub_qos->partition.name._buffer, "DDS_StringSeq_allocbuf");
 pub_qos->partition.name._buffer[0] = DDS_string_alloc (
   strlen(partitionName));
 checkHandle(
   pub_qos->partition.name._buffer[0], "DDS_string_alloc");
 strcpy (pub_qos->partition.name._buffer[0], partitionName);

 /* Create a Publisher for the chatter application. */
 chatPublisher = DDS_DomainParticipant_create_publisher(
   participant, pub_qos, NULL, DDS_ANY_STATUS);
 checkHandle(
   chatPublisher, "DDS_DomainParticipant_create_publisher");

 /* Create a DataWriter for the ChatMessage Topic
    (using the appropriate QoS). */
 talker = DDS_Publisher_create_datawriter(
   chatPublisher,
   chatMessageTopic,
   DDS_DATAWRITER_QOS_USE_TOPIC_QOS,
   NULL,
   DDS_ANY_STATUS);
 checkHandle(
   talker, "DDS_Publisher_create_datawriter (chatMessage)");

 /* Create a DataWriter for the NameService Topic
```

```
46       (using the appropriate QoS). */
47    dw_qos = DDS_DataWriterQos__alloc();
48    checkHandle(dw_qos, "DDS_DataWriterQos__alloc");
49    status = DDS_Publisher_get_default_datawriter_qos(
50      chatPublisher, dw_qos);
51    checkStatus(
52      status, "DDS_Publisher_get_default_datawriter_qos");
53    status = DDS_Publisher_copy_from_topic_qos(
54      chatPublisher, dw_qos, setting_topic_qos);
55    checkStatus(status, "DDS_Publisher_copy_from_topic_qos");
56    dw_qos->writer_data_lifecycle.autodispose_unregistered_instances =
57      FALSE;
58    nameServer = DDS_Publisher_create_datawriter(
59      chatPublisher,
60      nameServiceTopic,
61      dw_qos,
62      NULL,
63      DDS_ANY_STATUS);
64    checkHandle(
65      nameServer, "DDS_Publisher_create_datawriter (NameService)");
```

As you can see, in lines *11-14* a holder for the `PublisherQos` is allocated on heap and the default QosPolicy settings are copied into it. In lines *17-26*, the PartitionQosPolicy value is changed from its default value into a user defined Partition called *`ChatRoom`*. It is interesting to elaborate a little bit more on this, since besides demonstrating the Partition mechanism it also shows how to use IDL `sequences` and `strings` in the C language mapping.

As stated before, the PartitionQosPolicy is a sequence of strings. The default policy value is a sequence of zero elements, which is interpreted as a connection to the default Partition[1]. To attach to our own user defined Partition, we first need to allocate elements for the Partition sequence. A sequence in C is mapped onto a structure that contains a number of attributes:

- A field named `_maximum`: indicates the number of allocated elements.
- A field named `_length`: indicates the number of assigned elements.
- A field named `_buffer`: indicates a pointer to the first element.

In order to connect to only one Partition, we will need to allocate and assign at least one element. That means that the `_maximum` and `_length` fields can be set to 1, and that the `_buffer` field should point to a memory location that is able to hold a pointer to a string. The easiest way to allocate sequence elements is to use the convenience function that is generated by the OpenSplice DDS preprocessor specifically for that purpose. It is named after the sequence type (in this case `DDS_StringSeq`), followed by the postfix `_allocbuf`. Its parameter specifies the number of elements that need to be allocated.

1. The name of this default Partition is an empty string (""), so a Partition-sequence of 0 elements is equal to a Partition sequence of 1 element with an empty string.

In line *22* we actually allocate the memory for the `ChatRoom` string itself, using another dedicated function provided by the DDS API: `DDS_string_alloc`, where the parameter specifies the number of bytes to allocate[1]. The functions used to obtain the string length and to copy string contents are included from the standard `string.h` library. The reason why we use our own allocation functions instead of the more common `malloc` and `free` will become clear when we will release the memory later on.

Now that the `PublisherQos` has been tailored to our own needs, we invoke the `DDS_DomainParticipant_create_publisher` function in line *29*, to instruct the `DDS_DomainParticipant` (1st parameter) to create a new `DDS_Publisher` using our tailored QoS (2nd parameter) and no `DDS_PublisherListener` for all status events (3rd and 4th parameter). Again, the result is checked for correctness in line *31*.

In line *36*, we invoke the `DDS_Publisher_create_datawriter` function to instruct the `DDS_Publisher` (1st parameter) to create a typed DataWriter for the `chatMessageTopic` (2nd parameter) with QosPolicy values that are copied directly from the corresponding `DDS_TopicQos` (3rd parameter) and no `DDS_DataWriterListener` for all status events (4th and 5th parameter). The third parameter we used is again an example of a convenience macro: it is a substitute for a number of explicit steps, which would normally be:

- Allocate a `DDS_DataWriterQos` holder (`DDS_DataWriterQos__alloc`)
- Fill it with the default `DDS_DataWriterQos` settings of the DomainParticipant (`DDS_DomainParticipant_get_default_datawriter_qos`)
- Overwrite the policy values that overlap with the corresponding `DDS_TopicQos` by the values of that `DDS_TopicQos` (`DDS_Publisher_copy_from_topic_qos`).

In lines *47*-*55* an example of setting the `DDS_DataWriterQoS` using these explicit steps is shown. In this case, we do not use the convenience macro because we want to make one small modification to the resulting QoS (see lines *56*-*57*): we want to change the `writer_data_lifecycle` QosPolicy so that the `nameServer` does not automatically dispose a username when the user leaves the chatroom, which is its default behaviour. The exact meaning of this QosPolicy setting will be explained in Section 5.6, *Unregistering and Disposing of Instances*.

1. The `DDS_string_alloc` function allocates one more byte to accommodate for the `'\0'` terminator as well.

5.3 Requested/Offered QosPolicy Semantics

If the QosPolicies that are applicable to the DataWriter are closely examined, it will be observed that some of these policies overlap with the policies applicable to the topic. The `DDS_Publisher_copy_from_topic_qos` function is used to match all overlapping QosPolicies between topic and DataWriter.

Why do some of these policies overlap and what happens if they do not match? Before explaining the underlying mechanisms, let's first take a look at *Table 5*, which gives an overview of all QosPolicies that are applicable to Topics, DataWriters and DataReaders:

Table 5 Applicable Topic, DataWriter and DataReader Policies

QoS Policy	Concerns	RxO
DURABILITY	Topic, DataWriter, DataReader	Yes
DEADLINE	Topic, DataWriter, DataReader	Yes
OWNERSHIP	Topic, DataWriter, DataReader	Yes
LIVELINESS	Topic, DataWriter, DataReader	Yes
RELIABILITY	Topic, DataWriter, DataReader	Yes
DESTINATION_ORDER	Topic, DataWriter, DataReader	Yes
HISTORY	Topic, DataWriter, DataReader	No
RESOURCE_LIMITS	Topic, DataWriter, DataReader	No

In some of these cases, the QosPolicy settings are local to an entity and do not affect the behaviour of other (related) entities. Examples of these are `HISTORY` and `RESOURCE_LIMITS`, that specify how much storage space an entity reserves for buffering samples. In those situations, the `DataWriterQos` specifies how much storage space is reserved in the DataWriter and the `DataReaderQos` specifies how much storage space is reserved by the DataReader. DataWriters and DataReaders can make different choices without affecting each other's behaviour.

In the other cases, QosPolicy settings are not local to an entity and the DataReader and DataWriter will need to agree on the QosPolicy settings in order to establish successful communication. If the QosPolicies are considered compatible, then the DataWriter and DataReader will establish a successful connection. If the QosPolicies are considered incompatible, then the DataWriter and DataReader will be disconnected and not be able to communicate.

So when are policy settings considered compatible? That is decided by means of a subscriber-Requested/publisher-Offered (RxO) pattern. In this pattern, the DataReader can specify a *requested* value for a particular QosPolicy, while the DataWriter can specify an *offered* value for that QosPolicy. The Service will then determine whether the value requested by the DataReader is not considered 'higher' than what is offered by the DataWriter. For this purpose, each RxO enabled Qospolicy will specify an ordering between its possible values to be able to make a comparison and determine the higher value. As long as the requested value is considered smaller than or equal to the offered value, the policies are considered compatible. If the requested value is higher than the offered value, the policies are considered incompatible, and the concerned DataWriter will raise an `OFFERED_INCOMPATIBLE_QOS` status, while the concerned DataReader will raise its `REQUESTED_INCOMPATIBLE_QOS` status. The application can detect this status change by means of a `Listener` or a `StatusCondition` (see Section 7.3.2, *Attaching a Listener* and Section 8.3, *Using a StatusCondition*).

Take as an example the `ReliabilityQosPolicy`: `RELIABLE` communication is considered *better* than `BEST_EFFORT` communication and so it has a higher value. A DataWriter that offers `BEST_EFFORT` communication will not attempt to retransmit samples that are lost, and so cannot satisfy the reliability request of a DataReader. In that case the requested value is higher than the offered value so the DataWriter and DataReader will be considered incompatible and can not communicate. However, a DataReader that requests `BEST_EFFORT` communication can be connected to a DataWriters that offers `RELIABLE` data, since the quality of the data that it gets is ‘better’ than what it required. In that case the requested value is lower than the offered value and so the policies are considered compatible.

Likewise for the DurabilityQosPolicy, the ordering of the possible values is `PERSISTENT > TRANSIENT > TRANSIENT_LOCAL > VOLATILE`. All other QosPolicies are outside the scope of this tutorial, so for the ordering of their QosPolicy values please consult the Reference Manuals.

So now it is clear what happens when you set different QosPolicy values on DataReaders and DataWriters, but how exactly do they relate to the QosPolicy values set on the Topic? To answer that question, it is important to realize what the QosPolicy settings on each Entity actually represent:

- The QosPolicy settings on a DataWriter define the amount of quality used to transport each sample written by that DataWriter.
- The QosPolicy settings on a DataReader define the requirements for the minimal amount of quality that each of the received samples should have. Samples that are transmitted with a lower quality will not be received.
- The QosPolicy settings on the Topic focus on global information-availability aspects rather than transmission-aspects of individual applications and represent the intended system behaviour.

Typically the information model is defined by a system architect, whose job is not only to think about the information content, but also about the Quality of Service that is normally required to transmit this information with. So he is responsible for designing an overall Topic model, which is an aggregation of datatypes and `TopicQos` settings.

The applications are typically designed by application developers, who will define all required publications and subscriptions, including the `DataWriterQos` and `DataReaderQos` settings. In normal circumstances, they will just copy the QosPolicy settings from the Topics, since those contain the settings as they are intended by the System Architect. Only in very special circumstances should an Application Developer deviate from `TopicQos` settings, for example when he knows that the samples he will read or write require different treatment than the rest of the samples of the same topic. Be careful with deviating from the TopicQos settings though, there is a good chance you will get disconnected from most of the other DataWriters or DataReaders who do follow the `TopicQos`.

Summarizing: the `TopicQos` specifies the QosPolicy settings the system architect intends the samples to be transmitted with, and so makes a good default setting for your DataWriters and DataReaders. However, deviating from the `TopicQos` settings does not violate any rules, and you will not be notified about it, although it may impact the connectivity of your Entity. RxO matching only takes place between DataWriters and DataReaders, the `TopicQos` settings are irrelevant for determining compatibility.

There is one exception to this: the durability service will only look at the `TopicQos` to see whether it needs to prepare storage facilities for a specific Topic. If the `DurabilityQosPolicy` is not set to `TRANSIENT` or `PERSISTENT` on the topic, then no storage facilities will be prepared for it, regardless of the settings of each individual DataWriter. So when the durability is set to `VOLATILE` on the topic, but a DataWriter specifies `TRANSIENT` durability, then the samples of that DataWriter will not be stored by the durability service. Be careful about that, because you will not be notified about such incompatibilities between Topic and DataWriter. The other way around is not a problem: if the topic specifies a `TRANSIENT` durability, but a DataWriter does not want its samples to be stored by the durability service, then it can specify a `VOLATILE` durability. That is not considered a conflict: in that case the service has prepared storage facilities, but the DataWriter intentionally chooses not to use them.

5.4 Deleting Publishers and DataWriters

Of course, at the end of the application we will need to delete the Publisher and DataWriters before we can delete the DomainParticipant itself. We must also not forget to delete the `DDS_PublisherQos` structure that we allocated on heap, which also includes our Partition string sequence. The following code releases all the resources allocated in the previous code fragment:

```
   /* Remove the DataWriters */
   status = DDS_Publisher_delete_datawriter(chatPublisher,
     talker);
   checkStatus(status,
     "DDS_Publisher_delete_datawriter (talker)");

   status = DDS_Publisher_delete_datawriter(
     chatPublisher, nameServer);
   checkStatus(
     status, "DDS_Publisher_delete_datawriter (nameServer)");

  /* Remove the Publisher. */
  status = DDS_DomainParticipant_delete_publisher(
    participant, chatPublisher);
  checkStatus(status, "DDS_DomainParticipant_delete_publisher");

  /* De-allocate the PublisherQoS holder. */
  DDS_free(pub_qos);  // Note that DDS_free recursively
                      // de-allocates all indirections!!
```

This code seems very straightforward, each entity is deleted by the same factory that created it, and the result status is always checked for correctness. Now also take a look at the part where we release the `DDS_PublisherQos`. As you can probably remember, the `DDS_PublisherQos` is a structure that embeds all QoS Policies relevant to the `DDS_Publisher`. One of these policies is the PartitionQosPolicy, that embeds a sequence containing a number of string elements. The normal way to release all these indirections is to de-allocate all elements in the reverse order in which they were allocated, in other words,:

- Release the *ChatRoom* string of the Partition sequence.
- Release the sequence buffer itself.
- Release the `DDS_PublisherQos`.

All these steps are automatically performed by the `DDS_free` function, which is very powerful: its function parameter is un-typed, so it can be used to release any type of memory (including all its indirections) that has been allocated using the specialized DDS allocation functions. In this case it will recursively traverse through all attributes of the `DDS_PublisherQos`, release all encountered indirections in there (provided these have also been allocated by the specialized DDS allocation routines), and then release the `DDS_PublisherQos` itself. So the specialized DDS allocation and de-allocation routines should always be used in pairs: mixing them up with other allocation algorithms will most definitely result in corruption of your memory.

5.5 Registering Instances and Writing Samples

In this section we will actually write our first samples into the system. The first sample will be of type `Chat_NameService` and will contain our user name and user id. The samples following after that will be our actual chat messages. When we are done and want to leave the Chatroom, we will dispose our user information. For that purpose, the example presented in Section 5.2, *Creating Publishers and DataWriters*, is extended with the following lines of code:

```
 /* Initialize a data sample for the ChatMessage on heap.
 Chat_ChatMessage *msg;            // Example on Heap.

 /* Initialize a data sample for the NameServer on stack.
 Chat_NameService ns;              // Example on Stack.
 ns.userID = ownID;
 ns.name = DDS_string_alloc(Chat_MAX_NAME+1);
 checkHandle(ns.name, "DDS_string_alloc");
 if (chatterName) {
   strncpy (ns.name, chatterName, Chat_MAX_NAME + 1);
} else {
   snprintf(ns.name, Chat_MAX_NAME+1, "Chatter %d", ownID);
}

/* Write the user-information into the system
   (registering the instance implicitly). */
status = Chat_NameServiceDataWriter_write(
  nameServer, &ns, DDS_HANDLE_NIL);
checkStatus(status, "Chat_ChatMessageDataWriter_write");

/* Initialize the chat messages that will be written into
   the ChatRoom on Heap. */
msg = Chat_ChatMessage__alloc();
checkHandle(msg, "Chat_ChatMessage__alloc");
msg->userID = ownID;
msg->index = 0;
msg->content = DDS_string_alloc(MAX_MSG_LEN);
checkHandle(msg->content, "DDS_string_alloc");
if (ownID == TERMINATION_MESSAGE) {
  snprintf (msg->content, MAX_MSG_LEN, "Termination message.");
} else {
  snprintf(msg->content, MAX_MSG_LEN,
        "Hi there, I will send you %d more messages.", NUM_MSG);
}

/* Register a chat message for this user
   (pre-allocating resources for it!!) */
DDS_InstanceHandle_t userHandle;
userHandle = Chat_ChatMessageDataWriter_register_instance(
  talker, msg);

/* Write a message using the pre-generated instance handle. */
status = Chat_ChatMessageDataWriter_write(
128   talker, msg, userHandle);
129 checkStatus(status, "Chat_ChatMessageDataWriter_write");
130
131 sleep (1); /* do not run so fast! */
132
133 /* Write any number of messages, re-using the existing
134    string-buffer: no leak!!. */
135 for (i = 1; i <= NUM_MSG && ownID != TERMINATION_MESSAGE; i++) {
136   msg->index = i;
137   snprintf (msg->content, MAX_MSG_LEN,
138             "Message no. %d", msg->index);
139   status = Chat_ChatMessageDataWriter_write(
140     talker, msg, userHandle);
141   checkStatus(status, "Chat_ChatMessageDataWriter_write");
142   sleep (1); /* do not run so fast! */
143 }
```

We first start with the allocation of two samples for the data types that we will be writing. For demonstrational purposes, one of them will be allocated on heap (the `Chat_ChatMessage`) and one will be allocated on stack (the `Chat_NameService`). The advantage of allocating samples on stack is that when they run out of scope, the memory they occupy is automatically reclaimed. However, when such a sample contains indirections, these will have to be released manually in order to avoid a memory leak (see lines *89-91* for the allocation of the NameService sample and its indirection, and line *160* for the de-allocation of this indirection).

In contrast, the `Chat_ChatMessage` sample that is allocated on heap (together with its indirections in lines *107-111*) must be manually de-allocated before it runs out of scope, but by using the `DDS_free` function for that purpose (as demonstrated in line *162* of Section 5.6, *Unregistering and Disposing of Instances*) all indirections will recursively be released as well.

Every sample we write into the system belongs to a specific instance, which is identified by the values of its keyfields. The identity of the `Chat_NameService` sample is determined by its userID field. The `Chat_NameService` sample we intend to write will effectively introduce a new instance into the system. Normally it is a good habit to announce the creation of a new instance, so that the system can pre-allocate and reserve resources for the samples that are to come. This means that the time it takes to write samples describing the state of that instance (which is often the main loop of your applications) can be minimized, since the administrative overhead has already been incurred outside the main loop. In this specific situation, where we only write one sample in the entire lifetime of the instance, it doesn't really profit to announce the existence of the instance explicitly.

Therefore in line *101* we will just write the sample immediately, using the typed DataWriter function `Chat_NameServiceDataWriter_write`, as it is generated by the OpenSplice preprocessor. Again, the first parameter represents the DataWriter that actually performs the operation, the second parameter must be a pointer to the sample we intend to write (since it was allocated on stack, we need to use the '&' operator here), and the last parameter is the handle to the instance that corresponds to this sample. Since we did not announce the existence of our instance yet, we have no handle to it and therefore use the special constant `DDS_HANDLE_NIL` instead. This forces the DataWriter to deduce the identity of the sample from its key fields, registering the existence of the instance implicitly during the process.

We are then ready to send our chat messages into the world. Since we intend to write more than one chat message, and each message is only identified by the userID of its sender (which is the same for each message we send), it makes sense to announce our new `Chat_ChatMessage` instance first, so that the Publisher can pre-allocate resources for it and we can get its handle immediately. In line *123* we register the existence of our new instance using the typed DataWriter function `Chat_ChatMessageDataWriter_register_instance`, as it is generated by the OpenSplice preprocessor. Again, the first parameter represents the DataWriter that actually performs the operation and the second parameter must be a pointer to a sample that uniquely identifies the new instance by the values of its keyfields. (Since this time the sample is allocated on heap, we do not need to use the '&' operator here). The result of this operation is a handle that uniquely identifies our instance. We will use it in the subsequent write operations.

Before we start writing the chat messages we will first examine their content to see if one of them resembles a termination message. For our simple chatroom application we need a way to tell the `MessageBoard` that it is allowed to terminate, and we do that by sending a special termination message using our Chatter application. A termination messages is a chat message that has a user ID that resembles the special macro `TERMINATION_MESSAGE`, which is an alias for *-1*. When our Chatter encounters such a message it will write this message to the system and print a special message on the screen stating that it just transmitted a termination message, see lines *113-118*.

When the user ID does not resemble a termination request, we enter a loop in lines *135-143* where we write a number of Chat messages into the system, reusing the same sample over and over again by overwriting its string content. In these consecutive write operations we can now pass the instance handle we obtained as a result of the `register_instance` call, so that the DataWriter does not longer need to process the keyfields of the sample in order to deduce the identity of its corresponding instance.

Be careful with this however: if the identity of the instance, as described by the keyfields of the sample, does not match the handle you supply, you will get undefined behaviour: the DataWriter will not give an error message in such a case[1].

5.6 Unregistering and Disposing of Instances

When an instance is no longer relevant for the system it must be unregistered to be able to release the resources it claimed. An instance not only claims resources on the writer side (for example to accommodate for the re-send buffer in case of reliable transmission) but ultimately also on the reader side (to accommodate for the samples it has received so far). As long as a DataWriter has registered an instance, it indicates to the system that it reserves the right to send future updates of that instance. That means that even the readers will need reserve resources to accommodate for these potential updates. So when a writer drops the intention to update a specific instance any longer, it makes sense to announce this decision to the rest of the system. That way not only the writer itself but also all readers communicating with it may reclaim resources they reserved especially for those potential updates.

Be very vigilant about this: writers that keep adding new instances to the system but that fail to unregister the instances they no longer intend to update will not only drain resources on the writer side but also on all readers connected to this writer. A reader is simply not allowed to cleanup resources for instances that are still registered to a datawriter. Don’t be afraid that unregistering an instance on the writer side will immediately clean up its resources on the reader side as well, potentially losing information that the reading application didn’t have a chance to consume yet: that is not the case. A reader will only reclaim resources of an instance once the writer has unregistered that instance ***and*** once the reading application has consumed all samples for that instance.

So ultimately each instance introduced by a writer must on some moment in time be unregistered by that writer: it is not relevant whether that instance was registered implicitly or explicitly. Unregistering can be done explicitly by invoking the unregister_instance operation on the appropriate datawriter or implicitly by deleting the datawriter. When the system detects that a datawriter has crashed or has simply been deleted, it will automatically unregister all its instances throughout the system.

Besides unregistering an instance, it is also possible to dispose it. The difference between them is predominantly semantical: an instance that is no longer registered to a DataWriter implies that the system does no longer expect any updates for that instance by that DataWriter. That does not imply anything about the lifecycle of the instance: it could be that the DataWriter crashed or that the DataWriter is no longer able to observe the item whose state it was publishing before. Maybe another

1. Caching the instance handle and passing it to the DataWriter with each sample that you write for that instance saves you some performance, since the DataWriter does not need to extract the identity of the instance from the sample. If the DataWriter was forced to check whether sample and instance handle actually match, you would loose this performance gain.

(backup) DataWriter has also registered the instance and is still able to publish updates for it. In that case a DataReader won’t even need to deallocate any resources since it can still expect updates from that other DataWriter for the same instance.

By disposing an instance you explicitly tell the system that the instance is no longer alive, for example because the item whose state you were publishing does no longer exist. Normally that means you no longer expect any updates, so a typical response would be to try to reclaim the resources used by that instance. However, since the dispose does not implicitly release any resources by itself, it is typically followed by an explicit unregister operation. Again, on the DataReader side the resources claimed by a disposed and unregistered instance will only be released **after** the application has consumed all samples for that instance.

```
144 /* Leave room by disposing & unregistering message instance.*/
145 status = Chat_ChatMessageDataWriter_dispose(
146   talker, msg, userHandle);
147 checkStatus(status, "Chat_ChatMessageDataWriter_dispose");
148 status = Chat_ChatMessageDataWriter_unregister_instance(
149   talker, msg, userHandle);
150 checkStatus(
151   status, "Chat_ChatMessageDataWriter_unregister_instance");
152
153 /* Also unregister our name. */
154 status = Chat_NameServiceDataWriter_unregister_instance(
155   nameServer, &ns, DDS_HANDLE_NIL);
156 checkStatus(
157   status, "Chat_NameServiceDataWriter_unregister_instance");
158
159 /* Release the data-samples. */
160 DDS_free(ns.name); // ns allocated on stack:
161                    // explicit de-allocation of indirections!!
162 DDS_free(msg);     // msg allocated on heap:
163                    // implicit de-allocation of indirections!!
```

When we are done writing chat messages in our chatter application, we will dispose and un-register the ChatMessage instance, thus announcing the end of our chat session and freeing the resources that it claimed. For this purpose we will use the typed DataWriter functions `Chat_ChatMessageDataWriter_dispose` and `Chat_ChatMessage DataWriter_unregister_instance`, since they are generated by the OpenSplice preprocessor, in lines *145-149*. Their parameter signature is exactly identical to that of the `Chat_ChatMessageDataWriter_write` operation.

It seems logical to also dispose and unregister our user name from the nameservice after we leave the chatroom, but in this case we want to keep track of our user name for future reference. (For example to prevent others from claiming our unique user ID, or to be able to keep track of a list of favorite chat friends[1].) If we would dispose our user name here, it would be marked for destruction not only in the subscribing chatroom but also in the NameService’s transient store, so that late joining subscribers will not be aware of our former existence.

So instead of disposing and unregistering our user name, we only want to unregister it so that it remains available in the transient store. This is more tricky then it looks however, because according to the default QoS settings of a DataWriter, an instance is automatically disposed when it is unregistered. Only ommitting the explicit dispose of a user name will merely result in an implicit dispose upon unregistering of that sane user name. That's why we needed to change the DataWriter's `WriterDataLifecycleQosPolicy` to an `autodispose_unregistered_instances` setting of `FALSE` in lines *47-57* of Section 5.2, *Creating Publishers and DataWriters*.

i Note that in most cases transient data will need to outlive the lifetime of the DataWriter that published it (for example for reasons of fault tolerance), so in general it makes sense to set the `autodispose_unregistered_instances` policy of your transient DataWriters to `FALSE`.

In this particular case, it was not necessary to explicitly unregister the message and the user name instances since both instances will implicitly be unregistered when we delete their datawriters This happens very soon afterwards (see lines *67-73* in the last code example in Section 5.2, *Creating Publishers and DataWriters*). However, in a typical application, the lifetime of an instance is shorter than the lifetime of the DataWriter that publishes it, so it is a good habit to explicitly unregister the instances you no longer need.

This ends the publishing side of our Chatter application. The full code listing of this application is under *Chatter.c* in Appendix A, *C Language Examples' Code*.

1. In fact, the DLRL Tutorial introduces a WhiteList object that contains references to some of the users stored in the NameService's transient store, so that only messages originating from those users will be visible on its WhiteListedMessageBoard. See the DLRL Tutorial for more information on that subject.

CHAPTER

6 Subscribing to Data

In this section, you will be guided to create the first (basic) subscribing part of the chatter application, which is the MessageBoard. You will reuse the ChatMessage topic definition of the previous sections to subscribe to all chat messages and to print each of these messages on the message board, together with the userID of its sender. In a later section we will try to substitute this UserID by the appropriate user name of its sender.

The first section will give a short explanation of the different DDS entities that play a role in the subscribing part of an application and the way in which they interact with the publishing side. The next section will teach you how to create a Subscriber with accompanying DataReaders, and how to delete them afterwards. The last section will show you how to use these DataReaders to access samples, how to obtain information about their life cycles and how to manage the memory that holds these samples.

6.1 Subscribers, DataReaders and their QoS Policies

Subscribers and DataReaders are the building blocks required to retrieve information from your system. Both classes are modelled as Entities, meaning both are controlled by a set of QoS Policies, both have their own StatusCondition, both classes can have their own Listener object attached to them, and both classes can only be created and deleted by means of their corresponding factories. This section will introduce the reasons for separating Subscribers from DataReaders in the DDS specification, present the different objectives of both entities, and explain the way in which they interact with their publishing counterparts.

- ***Subscriber*** - A Subscriber is responsible for collecting information coming from various publications, in other words, the Subscriber decides what information is to be retrieved at what time and in which partition. The QoS Policies of the Subscriber control whether samples will be expected to arrive as coherent sets of information, whether the ordering between them will be preserved, and from which Partitions the information will be retrieved. The DomainParticipant acts as a factory for Subscribers.
- ***DataReader*** - A DataReader is a type specific interface for the Subscriber, in other words, it allows an application to access samples of a specific topic from the Subscriber, which actually collects all incoming samples. A Subscriber acts as a factory for its own set of typed DataReaders, and can subscribe to information that

spans more than one Topic. In such cases, it employs a separate DataReader for each individual Topic. The QoS Policies on each DataReader control for the corresponding data type which of the transmitted samples will be accepted into the Subscriber. This acceptance is allocated on the basis of a Request/Offered (RxO) protocol.

- ***Request/Offered Protocol*** - Some policies are applicable to Topics as well as DataWriters and DataReaders (like durability and reliability for example). We already saw in Section 5.1, *Publishers, DataWriters and their QoS Policies*, that in the cases where there is an overlapping QosPolicy between a Topic and a DataWriter, the DataWriter actually decides how the samples are to be transmitted. The TopicQos is only there to provide the DataWriter with a sensible suggestion, and it is free to make another choice. The DataReader has a similar philosophy: for its QoS Policies that overlap with Topics and DataWriters, the TopicQos only serves as a sensible suggestion and the DataReader is free to make another choice. Although the DataReader cannot control with what policy settings the samples are to be offered by the DataWriters, it can control to which DataWriters it will connect. The Request/Offered protocol specifies that a DataReader will only connect to DataWriters with compatible settings: in other words, when DataReaders do not request "more" than what is offered by the DataWriters[1]. DataWriters will not be able to deliver their samples to DataReaders with incompatible QosPolicy settings[2].
- ***SampleInfo*** - Each sample describes the state of a specific instance and may change the lifecycle of that instance. This lifecycle related information might be of interest to the application and is made available through SampleInfo. Each data sample comes with a corresponding SampleInfo structure that contains, among other things, the following fields:
  - ***SampleState*** - Whether the sample has been read before (`DDS_READ_SAMPLE_STATE`) or not (`DDS_NOT_READ_SAMPLE_STATE`).
  - ***ViewState*** - Whether the corresponding instance has already been observed by the application before (`DDS_NEW_VIEW_STATE`) or not (`DDS_NOT_NEW_VIEW_STATE`).

1. The DDS specification explicitly formulates an ordering between the different policy values of each QosPolicy to which the Request/Offered (RxO) protocol applies. For our particular example: the ReliabilityQosPolicy value `RELIABLE` > `BEST_EFFORT` and the DurabilityQosPolicy value `PERSISTENT` > `TRANSIENT` > `TRANSIENT_LOCAL` > `VOLATILE`. Refer to the *OpenSplice DDS C Reference Guide*.
2. If a DataReader and a DataWriter have incompatible QosPolicy settings, then both Entities can be notified of this event by their StatusConditions or by their Listeners: the DataWriter will get an OfferedIncompatibleQosStatus event and the DataReader will get an `RequestedIncompatibleQosStatus` event.

- ***InstanceState*** - Whether the instance is still considered alive (`DDS_ALIVE_INSTANCE_STATE`), has already been disposed (`DDS_NOT_ALIVE_DISPOSED_INSTANCE_STATE`), or is no longer registered in any of the DataWriters that are associated to this DataReader (`DDS_NOT_ALIVE_NO_WRITERS_INSTANCE_STATE`).
- ***SourceTimestamp*** - The time at which the sample was written by the DataWriter.[1]

With these building blocks we should be able to build the first elements of our MessageBoard: an application that collects all chat messages and prints them onto the screen.

6.2 Creating Subscribers and DataReaders

In this section we will start to build our entirely new MessagBoard application. The first steps however, are very similar to the ones we took in our Chatter application and are in fact very common for any type of DDS application:

1. Connect to a Domain.
2. Register the required data types to your DomainParticipant
3. Specify the Topics that you want to use

In the previous section, we implemented the last step by creating two new Topics. Creating a Topic is required when you can not be sure that your Topic definition is already available within your Domain. If it was not, creating the Topic will make its definition available to the Domain. If it already was, then creating the Topic for the second time will have no effect on the Domain: your definition is checked against the already available definition and if it conflicts, your Topic creation fails. If it does not conflict, you just get another proxy to the already existing Topic definition (see also Section 4.5, *Topics as Global Concepts*).

If we already know in advance that the Topic definition that we want to use is already available within our Domain, we can also try to obtain a proxy to it without having to actually recreate the Topic ourselves. We can use the `DDS_DomainParticipant_find_topic` function for that purpose. As always, the first parameter specifies the `DDS_DomainParticipant` object that is to execute our function. The second parameter specifies the name of the Topic for which we want to obtain the proxy, and the third parameter specifies the maximum time we want to wait for the topic definition to become available.[2]

1. For this field is to be interpreted correctly by the DataReader, the time on different nodes within the system should be aligned.
2. It is perfectly possible that the application that actually creates the Topic you are waiting for is started after you have been started. In that case you have to wait until its definition is available.

Be aware that even when you try to find an already existing Topic definition, you still need to register its data type locally within your DomainParticipant to be able to read and write samples of it.

In our particular case, we do not know which application will be started first: the `Chatter` or the `MessageBoard`. In fact, we want to be able to experiment a little bit with this ordering to test the effects of the Durability service. That's why in this case we will just create a similar Topic definition for the `ChatMessage` topic as we did in Section 4.6, *Tailoring QosPolicy Settings*. Since we already know how to do that, we will not repeat all these necessary steps. In the following pieces of code, we will therefore just focus on the parts that have to do with the creation of the subscribing entities.

```
DDS_SubscriberQos                *sub_qos;
DDS_Subscriber                   chatSubscriber;
Chat_ChatMessageDataReader       mbReader;
char                             *partitionName = NULL;

/* Adapt the default SubscriberQos to read from the
   "ChatRoom" Partition. */
partitionName = "ChatRoom";
sub_qos = DDS_SubscriberQos__alloc();
checkHandle(sub_qos, "DDS_SubscriberQos__alloc");
status = DDS_DomainParticipant_get_default_subscriber_qos (
  participant, sub_qos);
checkStatus(
  status, "DDS_DomainParticipant_get_default_subscriber_qos");
sub_qos->partition.name._length = 1;
sub_qos->partition.name._maximum = 1;
sub_qos->partition.name._buffer = DDS_StringSeq_allocbuf (1);
checkHandle(
  sub_qos->partition.name._buffer, "DDS_StringSeq_allocbuf");
sub_qos->partition.name._buffer[0] =
  DDS_string_alloc (strlen(partitionName));
checkHandle(
  sub_qos->partition.name._buffer[0], "DDS_string_alloc");
strcpy (sub_qos->partition.name._buffer[0], partitionName);

/* Create a Subscriber for the MessageBoard application. */
chatSubscriber = DDS_DomainParticipant_create_subscriber(
  participant, sub_qos, NULL, DDS_ANY_STATUS);
checkHandle(
  chatSubscriber, "DDS_DomainParticipant_create_subscriber");

/* Create a DataReader for the ChatMessage Topic
   (using the appropriate QoS). */
mbReader = DDS_Subscriber_create_datareader(
  chatSubscriber,
  chatMessageTopic,
  DDS_DATAREADER_QOS_USE_TOPIC_QOS,
  NULL,
  DDS_ANY_STATUS);
checkHandle(mbReader, "DDS_Subscriber_create_datareader");
```

As you can see, this code is very similar to the code used for creating the publishing part of our Chatter application (see Section 5.2, *Creating Publishers and DataWriters*). Since we want to attach to the same Partition as the Chatter application, we first have to adapt the PartitionQosPolicy of our `DDS_SubscriberQos` holder (which is filled with the default settings in line *11*) in a similar way as we did for the `DDS_PublisherQos` in the Chatter application.

We then instruct the `DDS_DomainParticipant` to create a `DDS_Subscriber` (`DDS_DomainParticipant_create_subscriber`), using this `DDS_SubscriberQos` holder (2nd argument) and no `DDS_SubscriberListener` for all status events (3rd and 4th argument).

In line *34*, we invoke the `DDS_Subscriber_create_datareader` function to instruct the `DDS_Subscriber` (1st parameter) to create a typed DataReader for the `ChatMessage` topic (2nd parameter) with QosPolicy values that are copied directly from the corresponding `DDS_TopicQos` (3rd parameter) and no `DDS_DataReaderListener` for all status events (4th and 5th parameter). For the third parameter we used another convenience macro, which has identical functionality as the one explained in Section 5.2, *Creating Publishers and DataWriters*.

Like we already saw in the Chatter application, at the end of the application we will need to delete all these created Entities before we can delete the `DDS_DomainParticipant`. And we must also not forget to delete the `DDS_SubscriberQos` structure that we allocated on heap, which also includes our Partition string sequence. The following code fragment, which is very similar to the one shown in Section 5.2, *Creating Publishers and DataWriters*, releases all the resources allocated in the previous code.

```
41    /* Remove the DataReader */
42    DDS_Subscriber_delete_datareader(chatSubscriber);
43    checkStatus(status, "DDS_Subscriber_delete_datareader");
44
45    /* Remove the Subscriber. */
46    status = DDS_DomainParticipant_delete_subsciber(
47      participant, chatSubscriber);
48   checkStatus(status, "DDS_DomainParticipant_delete_subscriber");
49
50   /* De-allocate the SubscriberQoS holder. */
51   DDS_free(sub_qos);  // Note that DDS_free recursively
52                       // de-allocates all indirections!!
```

6.3 Managing and Reading Samples

In this section we will actually be reading ChatMessage samples from our DataReader and we will print their contents on the standard output. The MessageBoard will be running in a loop, reading all available samples that correspond to live Chatters. The loop is ended when a termination message is received: that is a chat message whose userID field resembles `TERMINATION_MESSAGE` (a macro for the value `-1`): see line *78*. The code to do all this is presented below.

```
53   DDS_sequence_Chat_ChatMessage *msgSeq =
54     DDS_sequence_Chat_ChatMessage__alloc();
55   checkHandle(msgSeq, "DDS_sequence_Chat_NamedMessage__alloc");
56   DDS_SampleInfoSeq *infoSeq = DDS_SampleInfoSeq__alloc();
57   checkHandle(infoSeq, "DDS_SampleInfoSeq__alloc");
58   DDS_unsigned_long i;
59
60   DDS_boolean terminated = FALSE;
61   while (!terminated) {
62     /* Note: using read does not remove the samples from
63       unregistered instances from the DataReader. This means
64       that the DataRase would use more and more resources.
65       That's why we use take here instead. */
66
67     status = Chat_ChatMessageDataReader_take(
68      mbReader,
69      msgSeq,
70      infoSeq,
71      DDS_LENGTH_UNLIMITED,
72      DDS_ANY_SAMPLE_STATE,
73      DDS_ANY_VIEW_STATE,
74      DDS_ALIVE_INSTANCE_STATE);
75    checkStatus(status, "Chat_NamedMessageDataReader_take");
76    for (i = 0; i < msgSeq->_length; i++) {
77      Chat_ChatMessage *msg = &(msgSeq->_buffer[i]);
78      if (msg->userID == TERMINATION_MESSAGE) {
79        printf("Termination message received: exiting...\n");
80        terminated = TRUE;
81      } else {
82        printf ("%s: %s\n", msg->userName, msg->content);
83      }
84    }
85    status = Chat_ChatMessageDataReader_return_loan(
86      mbReader, msgSeq, infoSeq);
87    checkStatus(
88      status, "Chat_ChatMessageDataReader_return_loan");
89
90    /* Sleep for some amount of time, as not to consume
91       too much CPU cycles. */
92    usleep(100000);
93  }
```

The most important part of this code is located in lines *67-74*, where samples are obtained from the `Chat_ChatMessageDataReader`, using the typed DataReader function `Chat_ChatMessageDataReader_take`, as it is generated by the OpenSplice DDS preprocessor. This function has a number of interesting characteristics:

- It destructively obtains the samples from the DataReader, meaning the samples will no longer be available next time you access the DataReader. There is also an alternative function that is generated by the OpenSplice preprocessor named

`Chat_ChatMessageDataReader_read` that non-destructively obtains the samples, meaning the samples will still be available next time you access the DataReader.

- Both the take and the read functions are non-blocking, meaning they return what is currently available. If nothing is available then no samples are returned and no time is spent waiting for samples to arrive. If you do want to wait until samples are available you will need to use Listeners or WaitSets for that purpose (see also Chapter 7, *Content-Subscription Profile and Listeners* and Chapter 8, *Waiting for Conditions*). To keep this application as simple as possible we will not wait for data to arrive, but will simply take all available samples every 100 milliseconds. In line *92* we use the *`usleep()`* function (imported from unistd.h) to wait between two successive attempts, as not to use to much processing bandwidth.
- Both the take and the read functions have similar signatures in which the following parameters need to be specified:
  - The DataReader whose samples need to be obtained.
  - A sequence that will hold the returned samples.
  - A sequence that will hold the returned SampleInfo.
  - The maximum number of samples that you want to obtain.
  - A SampleState mask for the samples you want to obtain.
  - A ViewState mask for the samples you want to obtain.
  - An InstanceState mask for the samples you want to obtain.

As stated above, both the samples that are to be obtained and their corresponding `DDS_SampleInfo` are returned in sequences that are to be provided by the application as function input parameters. For that reason, both sequences are prepared in advance in lines *53* and *56* using the allocation functions generated by the OpenSplice preprocessor (for each IDL data type `<type>` in module `<module>`, the preprocessor will generate an allocation function called `DDS_sequence_<module>_<type>__alloc`). As you may have noticed in this example, we allocated the sequences on heap, but we did not allocate their internal buffers. That is because the read and take functions are able to perform the allocation of the sequence buffer on account of the application. Both functions have two modes in which they can be operated:

1. The DataReader can *loan* memory to the application (demonstrated above): the sequence buffers are allocated by the DataReader and 'loaned' to the application. If the application does no longer need the samples, it needs to return the 'loan' to the DataReader. Memory that is loaned to the application cannot be used in subsequent read/take function calls.

2. The DataReader can pre-allocate the sequence buffers himself. The DataReader will then just overwrite the allocated memory with the samples that are to be returned. The application itself is responsible for releasing the buffers when no longer required, but the same buffers can be reused in subsequent read/take function calls.

By not pre-allocating the sequence buffers, you indicate the DataReader of the fact that it has to do the allocation on your account. Since we do not know how much samples we may expect, it is hard to give a good estimate for the number of elements that needs to be pre-allocated in your sequence buffer. That's why we make the DataReader responsible for allocating the memory for us: that way it can exactly allocate the number of elements required to return all available samples that match the specified criteria.

The fourth parameter specifies the maximum number of samples you want to obtain as a result of this call. This is very convenient if you pre-allocate your sequence buffer because it can avoid a buffer overflow, or when you can only process a specific number of samples at maximum. In our case neither applies, so we use the special constant `DDS_LENGTH_UNLIMITED` to indicate any number of samples may be returned.

The last three parameters specify the kind of samples that you want to obtain. In Section 6.1, *Subscribers, DataReaders and their QoS Policies*, we saw that every sample had a number of corresponding states (`DDS_SampleState`, `DDS_ViewState` and `DDS_InstanceState`), each of which is represented by a separate bit value. The `read/take` functions allow you to specify in a bit mask exactly which states you are interested in: only samples with a state that satisfies the bit mask will be returned to you. For our MessageBoard, the only requirement is that we obtain samples from live Chatters, in other words, messages that have a `DDS_InstanceState` of `DDS_ALIVE_INSTANCE_STATE`. We don't care about the other states, meaning we can raise all bits in their masks. For this purpose the DDS specification provides a special ANY constant for each mask, which has already raised all the relevant bits. In lines *71-74* both the number and the kind of samples we want to obtain are selected.

When the `read/take` function returns, the samples and corresponding `DDS_SampleInfo` are available in the sequences we provided. The exact number of returned samples can be found in the _length field of each sequence. In lines *76-84* we iterate through all of the returned samples and print both their userID and their message content. When we do not longer need both sequences we return the so called 'loan' using the typed DataReader function `Chat_ChatMessageDataReader_return_loan`, as it is generated by the OpenSplice preprocessor. This allows the DataReader to reclaim the allocated memory.

To make a good distinction between *loaned* buffers and pre-allocated buffers, we will present the same code below, now using pre-allocated buffers with an estimated maximum number of 100 elements.

```
94   DDS_sequence_Chat_ChatMessage *msgSeq =
95     DDS_sequence_Chat_ChatMessage__alloc();
96   checkHandle(msgSeq, "DDS_sequence_Chat_NamedMessage__alloc");
97   DDS_SampleInfoSeq *infoSeq = DDS_SampleInfoSeq__alloc();
98   checkHandle(infoSeq, "DDS_SampleInfoSeq__alloc");
99   DDS_unsigned_long i;
100
101  msgSeq->_buffer = DDS_sequence_Chat_ChatMessage_allocbuf(100);
102  checkHandle(
103   msgSeq->_buffer, "DDS_sequence_Chat_ChatMessage_allocbuf");
104 infoSeq->_buffer = DDS_ SampleInfoSeq_allocbuf(100);
105 checkHandle(infoSeq->_buffer, "SampleInfoSeq_allocbuf");
106 DDS_sequence_set_release(msgSeq, TRUE);
107 DDS_sequence_set_release(infoSeq, TRUE);
108
109 while (!terminated) {
110   /* Note: using read does not remove the samples from
111      unregistered instances from the DataReader. This means
112      that the DataRase would use more and more resources.
113      That's why we use take here instead. */
114   status = Chat_ChatMessageDataReader_take(
115     mbReader,
116     msgSeq,
117     infoSeq,
118     DDS_LENGTH_UNLIMITED,
119     DDS_ANY_SAMPLE_STATE,
120     DDS_ANY_VIEW_STATE,
121     DDS_ALIVE_INSTANCE_STATE);
122   checkStatus(status, "Chat_NamedMessageDataReader_read");
123   for (i = 0; i < msgSeq->_length; i++) {
124     Chat_ChatMessage *msg = &(msgSeq->_buffer[i]);
125     if (msg->userID == TERMINATION_MESSAGE) {
126       printf("Termination message received: exiting...\n");
127       terminated = TRUE;
128     } else {
129       printf ("%s: %s\n", msg->userName, msg->content);
130     }
131   }
132
133   /* Sleep for some amount of time, as not to consume too
134      much CPU cycles. */
135   usleep(100000);
136 }
137
138 /* Delete the sequences and their contents. */
139 DDS_free(msgSeq);
140 DDS_free(infoSeq);
```

The main differences with the previous code can be found in lines *101-107* where we actually pre-allocate our sequence buffer. As you can see, pre-allocating the buffer requires another generated function named `DDS_sequence_<module>_<type>_allocbuf`, where the parameter specifies the number of elements that need to be allocated. Another function you see here for the first time is named `DDS_sequence_set_release` and is responsible for setting the release flag of the sequence. (There is also a corresponding function, `DDS_sequence_get_release()`, that returns the value of the release flag).

This release flag is another property of a sequence in C and describes whether the buffer is actually 'owned' by the sequence or not. If it is owned by the sequence, it means the sequence may release the buffer if it is being de-allocated itself (for example by the `DDS_free()` function). However, if the sequence does not own the memory (for example because it just copied an existing pointer instead of all the contents), it may not release that memory when de-allocated by means of the `DDS_free()` function. Since in this example we explicitly allocate buffer space for the sequence, the sequence may consider itself owner of that memory and that's why we need to set the release flag to `TRUE` as well.

If we look at the release flag of a sequence that has 'loaned' a buffer, we will see that its release flag is set to `FALSE`. That means `DDS_free` will not release the buffer when you de-allocate the sequence. You will explicitly need to return this loan before de-allocating the sequence. The read/take functions will not accept sequences that have a release flag set to `FALSE` and that have allocated more than 0 elements, because it will assume it will then be overwriting 'loaned' buffers.

Another difference is the fact that because we now 'own' the buffers ourselves, we do not longer need to return the loan any more: we simply reuse the same buffers over and over again. Notice that we may still use the special `DDS_LENGTH_UNLIMITED` constant to indicate the number of samples we want to obtain, but in this case it represents 100 samples or less, since that is the maximum number of samples that can be stored in the buffers. It is also possible to specify an exact number instead, but that number may not be bigger then the maximum number of samples that the sequences are able to hold. Specifying a bigger number here will result in a return value of `DDS_PRECONDITION_NOT_MET`.

When we exit our loop now, we still own the sequences and their contents, so we should release them manually by using the `DDS_free()` function for that purpose, see lines *139* and *140*.

That concludes our simple MessageBoard for now. In the next section we will expand the MessageBoard to incorporate some smart algorithms to display the username instead of the userID of the sender of a message.

CHAPTER 7 Content-Subscription Profile and Listeners

In this section we will expand the MessageBoard with some code to display the userName instead of the userID for each chat message and to filter out our own messages. Instead of doing all the necessary processing in our application, we will instruct OpenSplice DDS to substitute the userID with a userName by using the principles of aggregation/selection/projection offered by the MultiTopic.

Unfortunately, the MultiTopic is not supported yet in this version of OpenSplice DDS, so we will be simulating its behaviour using a dedicated data type, a ContentFilteredTopic, a private DataReader and DataWriter, a Listener and a QueryCondition.

The first section will introduce the concepts behind the ContentFilteredTopic, the MultiTopic, the ReadCondition and the QueryCondition. The second section shows us how to employ the MultiTopic in our MessageBoard example. The third section will show us how to simulate this MultiTopic, using the above mentioned building blocks, in dedicated code.

7.1 SQL Controlled Building Blocks

This section explains some of the more advanced API building blocks you can use to access only the data you are interested in. These building blocks allow you to use the SQL selection, aggregation, andprojection facilities to express your interest in a greater detail:

- ***ContentFilteredTopic*** - A `ContentFilteredTopic` allows you to filter out samples based on their state. It allows you to specify the `WHERE` clause of an SQL expression, and each sample that does not match the expression will not be inserted into the attached DataReader.
- ***MultiTopic*** - When information coming from several sources needs to be merged into a single (new) data type, so that it is much easier to handle for the application, the `MultiTopic` is a good candidate. It is more advanced than just a `ContentFilteredTopic` and allows advanced features like:
  - *Projection* - Specifies how each original field is projected into the merged data type (the `AS` clause of the SQL expression).

  - *Aggregation* - Select the fields and their Topics that need to merged (using the SELECT clause of the SQL expression).
  - *Selection* - Specify a filter that the merged data type must pass (using the WHERE clause of the SQL expression).

- ***ReadCondition*** - A ReadCondition allows you to specify your interest (with respect to SampleState, ViewState and InstanceState) by means of bit masks. It will raise a flag when data is available that matches the criteria. When attached to a WaitSet, this will trigger the WaitSet. The ReadCondition can be passed to a specialized accessor function, that only returns samples that match its criteria.
- ***QueryCondition*** - A QueryCondition is more expressive then a ReadCondition and also allows you to specify your interest in more detail by adding an SQL SELECTION clause. When used in combination with specialized accessor functions, only samples that satisfy the criteria will be returned.

Using these building blocks, we should be able to expand our MessageBoard and to simulate MultiTopics. The coming sections will show how.

7.2 Creating and Using a MultiTopic

If we want to print the userName instead of the userID for each ChatMessage, we require the merged information from two different Topics. The merge criterion is the userID, since that is the common keyfield for both Topics. So the easiest thing to do is to create a new data type that aggregates the user name from the NameService Topic with the message and index fields of the ChatMessage Topic. An IDL expression for such a merged data type can be found below.

```
struct NamedMessage {
  long       userID            // user ID
  nameType   userName;         // user name
  long       index;            // message number
  string     content;          // message body
};
#pragma keylist NamedMessage userID
```

As you can see, this is the definition for a data type as the MessageBoard application would like to see it: with userName and content in one structured data type, were the userID acts as the keyfield. The next step the application will have to consider is how to map this 'projection type' onto the existing Topics using an SQL expression. Since we want to filter out our own messages on the MessageBoard, but our MessageBoard doesn’t know by which userID these messages are represented, we will use an SQL parameter for that (that parameter can then later be substituted with the correct value, which will be passed as a command line parameter to the MessageBoard application):

```
SELECT userID, name AS userName, index, content
FROM Chat_NameService NATURAL JOIN Chat_ChatMessage
WHERE userID <> %0
```

In the above SQL expression you can clearly distinguish the three different aspects of Projection, Aggregation and Selection. The first line specifies which fields will be copied into the merged projection type: if there is an `AS` clause, the projected field will be named accordingly, if there is no `AS` clause, the projected field will have the same name as its original. The second line specifies the source Topics of these fields: since there is more than one source, the several source Topics need to be JOINED together[1]. The third line specifies the conditions that the merged Topics need to satisfy.

Now the only thing the MessageBoard will need to change in order to print a name instead of a userID is the fact that it also needs to obtain a proxy to the `NameService` Topic now (the code will not be shown for that), that it needs to register the projection type, and that it needs to create the `DDS_MultiTopic` according to the above mentioned SQL expression. The DataReader for the `ChatMessage` Topic can then simply be replaced by a similar DataReader for the `DDS_MultiTopic`, as can be seen in the following code.

```
Chat_NamedMessageTypeSupport    namedMessageTS;
DDS_StringSeq                   *parameterList;
Chat_NamedMessageDataReader     mbReader;

/* Options: MessageBoard [ownID] */
/* Messages having owner ownID will be ignored */
parameterList = DDS_StringSeq__alloc();
checkHandle(parameterList, "DDS_StringSeq__alloc");
parameterList->_length = 1;
parameterList->_maximum = 1;
parameterList->_buffer = DDS_StringSeq_allocbuf(1);
checkHandle(parameterList->_buffer, "DDS_StringSeq_allocbuf");

if (argc > 1) {
  parameterList->_buffer[0] = DDS_string_alloc(strlen(argv[1]));
   checkHandle(parameterList->_buffer[0], "DDS_string_alloc");
   strcpy (parameterList->_buffer[0], argv[1]);
}
else
{
   parameterList->_buffer[0] = DDS_string_alloc(1);
   checkHandle(parameterList->_buffer[0], "DDS_string_alloc");
   strcpy (parameterList->_buffer[0], "0");
}

/* Register the required data type for NamedMessage. */
namedMessageTS = Chat_NamedMessageTypeSupport__alloc();
checkHandle(
   namedMessageTS, "Chat_NamedMessageTypeSupport__alloc");
```

1. In case of a name-clash between two joined Topics: it is possible to indicate the source Topic explicitly by prefixing the field name by the Topic name, separated by a dot.

```
37  status = Chat_NamedMessageTypeSupport_register_type(
38    namedMessageTS,
39    participant,
40    namedMessageTypeName);
41  checkStatus(
42    status, "Chat_NamedMessageTypeSupport_register_type");
43
44  /* Create a multitopic that substitutes the userID with
45     its corresponding userName. */
46  namedMessageTopic = DDS_DomainParticipant_create_multitopic(
47    participant,
48    "Chat_NamedMessage",
49    namedMessageTypeName,
50    "SELECT userID, name AS userName, index, content "
51      "FROM Chat_NameService NATURAL JOIN Chat_ChatMessage "
52      "WHERE userID <> %0",
53    parameterList);
54  checkHandle(
55   namedMessageTopic, "DDS_DomainParticipant_create_multitopic");
56
57  /* Create a DataReader for the NamedMessage Topic
58     (using the appropriate QoS). */
59  chatAdmin = DDS_Subscriber_create_datareader(
60    chatSubscriber,
61    namedMessageTopic,
62    DDS_DATAREADER_QOS_USE_TOPIC_QOS,
63    NULL,
64    DDS_ANY_STATUS);
65  checkHandle(chatAdmin, "DDS_Subscriber_create_datareader");
```

In lines *14-31* you see that the SQL parameter variable (representing our own `userID`) is obtained from the command line. The projection data type is registered in lines *34-40*, under *`namedMessageTS`*. This name is then used in lines *46-53*, where the `DDS_DomainParticipant_create_multitopic` function is called to instruct the `DDS_DomainParticipant` (1st parameter) to create a `DDS_MultiTopic` with the name that is specified in the 2nd parameter for the type that is registered under the name specified by the 3rd parameter. The SQL expression is specified in the 4th parameter, and a sequence containing all parameter values (if applicable) is specified in the 5th parameter. SQL parameter values are always specified as strings, since they can refer to variables of different types, depending on the preceding SQL expression.

As you can see in line *59*, creating a DataReader for a `DDS_MultiTopic` is identical to creating a DataReader for a normal `DDS_Topic`: the same function is used. That is possible because the parameter that specifies the Topic is of type `DDS_TopicDescription`, which is the common parent for `DDS_Topics`, as well as for `DDS_MultiTopics` and `DDS_ContentFilteredTopics`.

The last change we need to make of course is to change the print statement to actually display the `userName` instead of the `userID`. We will not show the code for that here, but you can find the full code listing for the `MessageBoard` under *MessageBoard.c* in *Appendix A*.

7.3 Simulating a MultiTopic Using Other Building Blocks

The code presented in the previous section should work according to the DDS specification, but the problem is that this release of OpenSplice DDS does not yet support the `DDS_MultiTopic`. For that reason, and for educational reasons of course, we will simulate the behaviour of the `DDS_MultiTopic` using other building blocks. The idea is that we substitute the `DDS_DomainParticipant_create_multitopic` function with our own function called `DDS_DomainParticipant_create_simulated_multitopic`. This function will do the following things:

1. It will subscribe itself to both the `NameService` and the `ChatMessage` Topics.
2. It will attach the specified Content Filter to the `ChatMessage` Topic
3. It will attach a Listener to the `ChatMessage` DataReader.
4. For each incoming `ChatMessage` it will issue a Query based on its `userID`, to find the corresponding userName in the NameService.
5. It will then manually merge the results into the projection data type.
6. Finally, it will publish this manually created projection type.

The nice thing about this approach is that we can completely hide its functionality to the `MessageBoard`: the code to make the subscriptions and attach the Listener (steps 1 to 3) can be encapsulated in the `create_simulated_multitopic` call, and the manual merge activities for each incoming `ChatMessage` (all the other steps) can be encapsulated in the Listener implementation. We have isolated all this code from the `MessageBoard` and introduced a separate file named `multitopic.c` for it. We already showed you how to make subscriptions, so we will not repeat those steps here, but it is interesting to demonstrate how to create a `DDS_ContentFilteredTopic`, how to implement and attach a Listener interface and how to use `DDS_QueryConditions` to search for information. Those steps will be presented in the following sections. The full implementation for the `multitopic.c` file can be found under *`multitopic.c`* in Appendix A, *C Language Examples' Code*.

7.3.1 Using a ContentFilteredTopic

To avoid unnecessary merging of information, it makes sense to assure that the newly arriving samples match the interest of the user first (in other words, the `WHERE` clause of his SQL expression). A `DDS_ContentFilteredTopic` is a very convenient in such cases: it allows you to attach an SQL Filter expression to an existing Topic and to create a normal DataReader for it. This DataReader will then only receive samples that match the filter expression of the `DDS_ContentFilteredTopic`.

To avoid awkward string parsing to extract the `WHERE` clause of our MultiTopic SQL expression, we will cheat a little bit and manually provide a compatible filter expression for our `DDS_ContentFilteredTopic`.

```
66   DDS_Topic                        chatMessageTopic;
67   DDS_ContentFilteredTopic         filteredMessageTopic;
68   Chat_ChatMessageDataReader       chatMessageDR;
69   DDS_Duration_t infiniteTimeOut   = DDS_DURATION_INFINITE;
70
71   /* Lookup the original ChatMessage Topic. */
72   chatMessageTopic = DDS_DomainParticipant_find_topic(
73     participant,
74     "Chat_ChatMessage",
75    &infiniteTimeOut);
76  checkHandle(
77    chatMessageTopic,
78    "DDS_DomainParticipant_find_topic (Chat_ChatMessage)");
79
80  /* Create a ContentFilteredTopic to filter out our
81     own ChatMessages. */
82  filteredMessageTopic =
83    DDS_DomainParticipant_create_contentfilteredtopic(
84      participant,
85      "Chat_FilteredMessage",
86      chatMessageTopic,
87      "userID <> %0",
88      expression_parameters);
89  checkHandle(
90    filteredMessageTopic,
91    "DDS_DomainParticipant_create_contentfilteredtopic");
92
93  /* Create a DataReader for the FilteredMessage Topic
94     (using the appropriate QoS). */
95  chatMessageDR = DDS_Subscriber_create_datareader(
96    multiSub,
97    filteredMessageTopic,
98    DDS_DATAREADER_QOS_USE_TOPIC_QOS,
99    NULL,
100   DDS_ANY_STATUS);
101 checkHandle(
102   chatMessageDR,
103   "DDS_Subscriber_create_datareader (ChatMessage)");
```

Since this code is in a separate file from the `MessageBoard`, it does not have access to all variables it needs, except for the ones that were passed as parameters to our `create_simulated_multitopic` function. One of the first things we need is a proxy to the `ChatMessage` Topic. Of course we can create our own, like we did before, but that would require us to specify the same QoS parameters and stuff. Right now is easier to just look up the Topic by name: we used the `DDS_DomainParticipant_find_topic` call for that in lines *72-75*, which returns a new proxy to an existing `DDS_Topic` that is identified by the name specified in its 2nd parameter. If a Topic identified by that name cannot yet be found in the `DDS_DomainParticipant` specified in the 1st parameter, it will wait for the time specified in its 3rd parameter to become available (in case it is created by another, connected, DomainParticipant). If after the specified time it is still not available, it returns a `NULL` pointer. The time out value we provided here is based on the special constant `DDS_DURATION_INFINITE`, which indicates it should wait indefinitely for the Topic to become available.

An alternative operation we could have used for this purpose was the `DDS_DomainParticipant_lookup_topicdescription`: here you also look for a topic by name, but only in your own DomainParticipant: if it is not yet available, it will immediately return `NULL`. However, this operation also allows you to get proxies to `DDS_ContentFilteredTopics` and `DDS_MultiTopics` that are available in the specified `DDS_DomainParticipant`. Because this means that the result can be of different types, the return type is of type `DDS_TopicDescription`, the common parent for all kinds of Topics.

In lines *83-88* we actually create the ContentFilteredTopic itself: the 2nd parameter specifies the name with which this `DDS_ContentFilteredTopic` can be identified (though only locally in the `DDS_DomainParticipant` specified in the 1st parameter, since ContentFilteredTopic definitions are not communicated to other participants), the 3rd parameter specifies the `DDS_Topic` it should filter on, the 4th parameter specifies the filter expression (in SQL), and the 5th parameter specifies the optional filter parameters. Although we cheated a little bit with the creation of the filter expression, we can reuse the SQL expression parameters from the MultiTopic as is, since they are only applicable to the filter part.

In lines *95-100* you can see that creating a DataReader for a `DDS_ContentFilteredTopic` is similar to creating a DataReader for a normal `DDS_Topic` or a `DDS_MultiTopics`.

7.3.2 Attaching a Listener

One of the problems of the IDL to C language mapping is that it does not state how to map a callback interface to C. OpenSplice DDS has solved that problem (like most well known DDS implementations have done) by mapping the callback interface onto a structure that contains a function pointer for each of the contained callback methods. As an example, the Listener of the `DDS_DataReader` is mapped to a structure named `DDS_DataReaderListener` that contains seven function pointer attributes: one for each of the seven callback methods. Besides that, it also contains one extra pointer called `listener_data`, that can be used to store any type of data that needs to be available during each callback that the Listener will make.

Since we only want to respond to incoming data, we only need to implement the `on_data_available` callback function: the other functions we will leave blank, as is demonstrated in the following code.

```
104  /* Declaration of the DataReaderListener. */
105  static struct DDS_DataReaderListener *msgListener = NULL;
106
107  struct MsgListenerState {
108    /* Type-specific DDS entities */
109    Chat_ChatMessageDataReader       chatMessageDR;
110    Chat_NameServiceDataReader       nameServiceDR;
111    Chat_NamedMessageDataWriter      namedMessageDW;
112
113   /* Query related stuff */
114   DDS_QueryCondition               nameFinder;
115   DDS_StringSeq                    *nameFinderParams;
116 };
117
118 /* Implementation for callback function "on_data_available". */
119 void on_message_available(
120   void *listener_data, DDS_DataReader reader ) {
121     ………
122 };
123
124 /* Allocate the DataReaderListener interface. */
125 msgListener = DDS_DataReaderListener__alloc();
126 checkHandle(msgListener, "DDS_DataReaderListener__alloc");
127
128 /* Fill the listener_data with pointers to all entities
129    needed by the Listener implementation. */
130 struct MsgListenerState *listener_state =
131   malloc(sizeof(struct MsgListenerState));
132 checkHandle(listener_state, "malloc");
133 listener_state->chatMessageDR = chatMessageDR;
134 listener_state->nameServiceDR = nameServiceDR;
135 listener_state->namedMessageDW = namedMessageDW;
136 listener_state->nameFinder = nameFinder;
137 listener_state->nameFinderParams = nameFinderParams;
138 msgListener->listener_data = listener_state;
139
140 /* Assign the function pointer attributes
141    to their implementation functions. */
142 msgListener.on_data_available =
143   (void (*)(void *, DDS_DataReader)) on_message_available;
144 msgListener.on_requested_deadline_missed = NULL;
145 msgListener.on_requested_incompatible_qos = NULL;
146 msgListener.on_sample_rejected = NULL;
147 msgListener.on_liveliness_changed = NULL;
148 msgListener.on_subscription_match = NULL;
149 msgListener.on_sample_lost = NULL;
```

In line *105*, the `DDS_DataReaderListener` struct is allocated on the heap. Each of the function pointer attributes is then assigned to its corresponding function implementation in lines *142-149*, which in this case only concerns the `on_data_available` function that is implemented in lines *119-121*. (The actual implementation for this function will be presented later on). Please note in line *143* that you will need to cast your function implementation into the proper type, to match the attribute definition of the `DDS_DataReaderListener`.

In this case the `on_data_available` callback will need to access the following Entities: it will need to read a sample from the ChatMessage DataReader, Query for a matching `userName` in the NameService DataReader and write a merged sample using the `namedMessageDataWriter`. To be able to access all these Entities during this listener callback, we created a special structure called `MsgListenerState` containing pointers to each of them: see lines *107-116*. To make this information available during each listener callback, we first have to allocate and assign the contents of this struct (see lines *130-137*) and then assign its pointer to the `listener_data` fields of the `DDS_DataReaderListener`, see line *138*.

As you can see, the first parameter of each callback function in each listener type is always named `listener_data`, and is in fact exactly the `listener_data` field you store in the corresponding listener structure. That way you have full control over what type of information should be available for each individual Listener instance. Be aware however that for the Listener itself the `listener_data` is an opaque type, it doesn't know what it represents. The implementation for the callback function will always need to cast the `listener_data` field to its correct type before it will be able to access its contents.

Apart from the `on_data_available` function, all the other function pointer attributes have no corresponding implementation and are assigned to `NULL`. Be careful with this though: if the DataReader tries to invoke a function using a function pointer that is set to `NULL` you will definitely get a Segmentation Violation. That's why we need to make sure that the DataReader never tries to invoke the functions that we didn't implement. We can do that by specifying a Listener bit mask: in other words, a mask that tells the DataReader for which events it may notify the Listener and for which events it may not. Each event is represented by its own bit in the bit mask, and each of these bits has its own identifier. Selecting the events for which you want to receive a callback is thus simply a matter of chaining their identifiers in the bit mask when attaching the Listener. For the data_available event, this identifier is named `DDS_DATA_AVAILABLE_STATUS`, see also Table 3, *Status Events Overview*, on page 27:

```
/* Attach the DataReaderListener to the DataReader,
   only enabling the data_available event. */
status = DDS_DataReader_set_listener(
  cmReader, msgListener, DDS_DATA_AVAILABLE_STATUS);
checkStatus(status, "DDS_DataReader_set_listener");
```

The `DDS_DATA_AVAILABLE_STATUS` is *event-based*, *not state* based: it does not trigger on the availability of data (as its name may imply), but on incoming samples or events that have not yet been viewed by the application.

7.3.3 Using a QueryCondition

As stated in Section 7.3, *Simulating a MultiTopic Using Other Building Blocks*, when a new `ChatMessage` sample triggers the Listener we will have to perform the following steps:

1. Extract its `userID`.
2. Execute a query to look for the corresponding `userName` in the `NameService` DataReader.
3. Manually merge the results into a projection sample.
4. Publish this sample.

You should already be able to write the code for most of the above mentioned steps except for the query part, which will be the focus of this section. Before executing a query, you will first need to describe what you are looking for. In DDS terms it means you will need to create a `DDS_QueryCondition` first, where your interest is expressed in SQL. The next step is then to execute this query in a DataReader and to obtain all samples that satisfy it. Since every query is dedicated to look for a specific `userID`, you might be tempted to create new queries for every incoming `ChatMessage`. However, creating the `DDS_QueryCondition` objects is rather expensive, and since all queries are very similar (they only differ with respect to the value of the `userID` they are looking for), it makes sense to parameterise our `DDS_QueryCondition` and reuse it over and over again, only changing the value of the parameter when required.

Such an approach can save you a lot of performance, especially when the creation of `DDS_QueryConditions` can be done outside the main loop, so that this main loop can limit itself to executing queries and changing their parameters. Following this approach, our example will create the `DDS_QueryCondition` during the `DDS_DomainParticipant_create_simulated_multitopic` call (outside the main loop), and adjust and execute it during the Listener callback (inside the main loop). Let's focus on the creation of the `DDS_QueryCondition` first.

```
 DDS_StringSeq *nameFinderParams;
 const char *nameFinderExpr;

 /* Define the SQL expression (using a parameterized value). */
 nameFinderExpr = "userID = %0";

 /* Allocate and assign the query parameters. */
 nameFinderParams = DDS_StringSeq__alloc();
 checkHandle(nameFinderParams, "DDS_StringSeq__alloc");
nameFinderParams->_length = 1;
nameFinderParams->_maximum = 1;
nameFinderParams->_buffer = DDS_StringSeq_allocbuf (1);
checkHandle(
  nameFinderParams->_buffer, "DDS_StringSeq_allocbuf");
nameFinderParams->_buffer[0] = DDS_string_alloc(
  strlen(expression_parameters->_buffer[0]) );
```

```
171 checkHandle(nameFinderParams->_buffer[0], "DDS_string_alloc");
172 /* Large enough to hold biggest value */
173 strcpy(
174   nameFinderParams->_buffer[0],
175   expression_parameters->_buffer[0] );
176 DDS_sequence_set_release(nameFinderParams, TRUE);
177
178 /* Create a QueryCondition to only read corresponding
179    nameService information by key-value. */
180 nameFinder = DDS_DataReader_create_querycondition(
181   nameServiceDR,
182   DDS_ANY_SAMPLE_STATE,
183   DDS_ANY_VIEW_STATE,
184   DDS_ANY_INSTANCE_STATE,
185   nameFinderExpr,
186   nameFinderParams);
187 checkHandle(
188   nameFinder, "DDS_DataReader_create_querycondition");
```

As you can see, line *159* specifies the SQL expression, which simply states that the `userID` should be equal to the first parameter. (Parameters in SQL are numbered starting with zero, and are prefixed by the *%* character). Lines *162-176* allocate and initialize the sequence that will represent the query parameters (in this case only 1). Here also all parameters, regardless of their type, must be represented as strings. We have allocated enough string space to make sure that it can hold even the biggest value of the `userID`.

The `DDS_QueryCondition` itself is created in lines *180-186*, where the 1st parameter specifies the DataReader that has to execute the query, the 2nd, 3rd and 4th parameters specify the desired lifecycle states, the 5th parameter specifies the SQL expression and the 6th parameter its parameters.

So this query will be used during a Listener callback to look up the name for a given `ChatMessage`. Let's take a look at what happens during that Listener callback, when we have read a `ChatMessage` sample and want to find the corresponding `NameService` entry.

```
189  /* Find the corresponding named message. */
190  struct MsgListenerState *listener_state;
191
192  /* Obtain all entities mentioned in the listener state. */
193  listener_state = (struct MsgListenerState *) listener_data;
194
195   /* Take available samples and process each one individually. */
196  ....
197
198  if (infoSeq1._buffer[i].valid_data)
199  {
200    if (msgSeq._buffer[i].userID != previous)
201    {
202      previous = msgSeq._buffer[i].userID;
203      snprintf(
204        listener_state->nameFinderParams->_buffer[0],
205        15, "%d", previous);
206      status = DDS_QueryCondition_set_query_parameters(
207        listener_state->nameFinder,
208        listener_state->nameFinderParams);
209      checkStatus(
210        status, "DDS_QueryCondition_set_query_parameters");
211      status = Chat_NameServiceDataReader_read_w_condition(
212       listener_state->nameServiceDR,
213       &nameSeq,
214       &infoSeq2,
215       DDS_LENGTH_UNLIMITED,
216       listener_state->nameFinder);
217     checkStatus(
218       status, "Chat_NameServiceDataReader_read_w_condition");
219
220     /* Extract Name (there should only be one result). */
221     DDS_free(userName);
222     if (status == DDS_RETCODE_NO_DATA)
223     {
224       userName = DDS_string_alloc(40);
225       checkHandle(userName, "DDS_string_alloc");
226      snprintf(userName, 40, "Name not found!! id = %d",previous);
227     }
228     else
229     {
230       userName = DDS_string_alloc(
231         strlen(nameSeq._buffer[0].name));
232       checkHandle(userName, "DDS_string_alloc");
233         strcpy(userName, nameSeq._buffer[0].name);
234     }
235
236     /* Release the name sample again. */
237     status = Chat_NameServiceDataReader_return_loan(
238       nameServiceDR, &nameSeq, &infoSeq2);
239     checkStatus(
240       status,"Chat_NameServiceDataReader_return_loan");
241   }
242 }
```

The first thing that happens during our listener callback is that we cast the `listener_data` field to a `listener_state` structure, to be able to obtain all the Entities we need during the rest of the callback: see lines *190-193*.

Then we take all available samples (which are not displayed here) and iterate through them. For each sample, we check its SampleInfo to see whether its contents are valid (see line *198*). This is necessary since in some cases a sample is only a placeholder for an instance of a state change. This is an example: the case when a writer disposes of an instance while on the reader side when all samples for that instance have already been taken. Since the dispose operation only changes the instance state, but does not actually transmit the sample it received as one of its parameters,[1] the reader side has no sample with which it can add a change in the

1. Use the writedispose operation if you want both the instance to be disposed and the sample to be transmitted.

SampleInfo. In such cases, the reader will insert a dummy sample of which only the keyfields have any meaningful data. The other fields are not initialized and should therefore not be accessed.

Since this can have drastic consequences for the application, it is important that the application is made aware of which samples are real and which samples are not, so that is does not try to access uninitialized fields of a dummy sample. The field named `valid_data` in the SampleInfo contains exactly that information: if it is `TRUE`, then the sample is a real sample for which all fields are initialized properly, if it is `FALSE`, then only its keyfields should be accessed.

When we know that we have a valid sample, we check (line *200*) whether the current `userID` that needs to be resolved is not equal to the previous one. If so, we still have the previous name and need not look for it again. If this is not the case, we need to look it up anyway, and therefore change the expression parameter to the current `userID`: first we translate the decimal `userID` into a string and insert it into element 0 of the parameter sequence (lines *203*-*205*), then we use the `DDS_QueryCondition_set_query_parameters` operation to tell the `DDS_QueryCondition` is has to accept this new expression parameter sequence.

We then execute the query on our `Chat_NameServiceDataReader` by invoking the specialized `Chat_NameServiceDataReader_read_w_condition` operation, as it is generated by the OpenSplice preprocessor (lines *211*-*216*). This operation is similar to the normal `read/take` methods, and also has a `take` counterpart. The first 4 parameters are identical to the normal read/take methods, and the last parameter specifies the `DDS_ReadCondition` that the samples need to match. Since a `DDS_QueryCondition` is a specialization of a `DDS_ReadCondition`, it can be used here to make the DataReader only return samples that satisfy our query.

The rest of the code is very straightforward, either one sample is returned (there can be at most one sample that matches the query since `userID` is a key field) or none at all. If there is a sample, we will extract its name, cache it (possibly the next sample that needs to be resolved has the same `userID`) and return the loan. We can then copy the resolved `userName` into the projected data type, together with the content of the `ChatMessage`, and write it into the system. Not all that code is presented here, but see *multitopic.c* in *Appendix A* for the full code listing.

CHAPTER 8 Waiting for Conditions

In this example we will be working on another application called UserLoad, that continuously monitors what is going on in the ChatRoom. It keeps track of all users that come and go, and of all the messages they have sent. It will print a message on the screen when users enter and leave the ChatRoom, and for users that leave the room it will also print the number of messages they have sent while the UserLoad program was monitoring.

For the UserLoad program to detect incoming events, we will use several kinds of Condition objects. A Condition object can be configured to raise a flag when a certain predefined situation occurs. Our application will use different types of Conditions to notify of situations where new users join our ChatRoom, where active users leave it, and when it is time for our application to stop monitoring the ChatRoom. These Conditions are all attached to a WaitSet, that will immediately trigger the main application thread when any of these attached Conditions becomes TRUE.

***Section 8.1,** Conditions and WaitSets, introduces the general rationale behind Conditions and WaitSets and explains the purpose of each Condition type.*

***Section 8.2,** Using a ReadCondition, explains how to use ReadConditions to signal a thread on the arrival of new instances.*

***Section 8.3,** Using a StatusCondition, describes the alternative StatusCondition mechanism to detect when a user leaves the ChatRoom example.*

***Section 8.4,** Using a GuardCondition , describes how a GuardCondition can be used to manually trigger a WaitSet for any user defined reason.*

***Section 8.5,** Using a WaitSet, describes how to attach Conditions to a WaitSet, and how to use this WaitSet to be notified of incoming events.*

***Section 8.6,** Processing Expired Transient Data describes how the transient store treats samples for which the originating writers are no longer alive and the impact it has for an application.*

***Section 8.7,** Using the HistoryQosPolicy, shows how the HistoryQosPolicy can be used to keep track of the history of all messages that are received from the various users.*

*The last section, **Section 8.8,** Cleaning Up, explains how to release resources when an application is terminated.*

8.1 Conditions and WaitSets

There are several different types of Condition objects, each one dedicated to detect a certain type of situation. Each `DDS_Condition` has a flag that becomes `TRUE` when a certain situation occurs, and that remains `TRUE` until that situation has elapsed. The value of this flag can be examined at any time by the application by using the `DDS_Condition_get_trigger_value` operation.

By examining the value of this flag, it is possible for an application to use a polling mechanism to detect the occurrence of a certain event. However, polling might be quite expensive and therefore it may be better to use a mechanism that can block a thread until a certain situation occurs. That is were the `DDS_WaitSet` comes in: a WaitSet allows you to attach any number of `DDS_Condition` objects to it, and to block a thread until one or more of these attached condition objects will have a trigger value that is `TRUE`.

OpenSplice DDS offers the following types of `DDS_Condition` objects:

- ***ReadCondition*** - We already introduced the `DDS_ReadCondition` in Section 7.1, *SQL Controlled Building Blocks*. What we did not mention there is that, since it inherits from the `DDS_Condition` class, it also has a trigger value. This trigger value is `TRUE` as long is data is available that matches the selected lifecycle criteria.
- ***QueryCondition*** - We already introduced the `DDS_QueryCondition` in *SQL Controlled Building Blocks* as well. What we did not mention there is that, since it inherits from the `DDS_ReadCondition`, it also has a trigger value. This trigger value is `TRUE` as long as data is available that matches both the selected lifecycle criteria and the SQL expression.
- ***StatusCondition*** - The `DDS_StatusCondition` was already introduced in *SQL Controlled Building Blocks*. We repeat in here that a `DDS_StatusCondition` may be configured to monitor a user defined set of Entity conditions (being reports of contract violations, reports of conflicting QosPolicy settings with related Entities, reports of the availability of data, etc.), and that the flag of the `DDS_StatusCondition` will be raised as long as at least one of these Entity conditions is `TRUE`.
- ***GuardCondition*** - A `DDS_GuardCondition`'s trigger value is under full control of the application, which can manipulate its state by using the `DDS_StatusCondition_set_trigger_value` operation.

For our `UserLoad` application we will use a `DDS_WaitSet` to block the main thread. The the following `DDS_Conditions` will be attached to this `DDS_WaitSet`:

1. A `DDS_ReadCondition` that is used to trigger on the event of a new user joining the ChatRoom. It will be created by the `NameService` DataReader and will be set to trigger on any `NameService` sample that has a SampleState of `NOT_READ`, a `ViewState` of `NEW` and an `InstanceState` of `ALIVE`.
2. A `DDS_StatusCondition` that is used to trigger on the event of an active user leaving the system. Of course we could do this using another `DDS_ReadCondition` on the `NameService` DataReader that would trigger on an `InstanceState` of `NOT_ALIVE_DISPOSED`, but for educational purposes we will use the `DDS_StatusCondition` of the `ChatMessage` DataReader instead. It will trigger when an associated `ChatMessage` DataWriter leaves the system.
3. A `DDS_GuardCondition` that is used to trigger the WaitSet when a pre-defined amount of time has passed. This prevents the `UserLoad` application from running forever.

When one or more of these Conditions raise their flag, they will trigger the WaitSet, which will then unblock the main application thread. This application thread then receives a list of all the Conditions responsible for the trigger and can handle each one of them individually. The following sections will focus on each of these Conditions.

8.2 Using a ReadCondition

In Section 7.3.3, *Using a QueryCondition*, we already saw an example of how to create a `DDS_QueryCondition`. Creating a `DDS_ReadCondition` is very similar to this, since it is a generalization of the `DDS_QueryCondition`: the only difference is that it doesn't have a corresponding SQL expression.

In our application we want to be informed of new Chatters joining our ChatRoom. Since every Chatter publishes his name and ID in a `NameService` Topic before joining in, and since each `userID` represents a unique instance within our `NameService DataReader`, it seems logical that new instances represent new users joining our ChatRoom. (Note that an instance is marked `NEW` until its first sample has actually been read. That means that a `NEW ViewState` can never be combined with a `READ SampleState`.)

So to detect new users joining our `ChatRoom`, we only need to get triggered on the arrival of new `NameService` instances. That means we need to configure our NameService ReadCondition to trigger on samples that have a ViewState of `NEW` and a SampleState of `NOT_READ`. Since we only want to signal new users that are still logged in (we will ignore the users that have already logged out before we even got the chance to discover their presence), we will configure our `InstanceState` to `ALIVE`. That results in the following code fragment.

```
    /* A ReadCondition that will contain new users only */
    newUser = DDS_DataReader_create_readcondition(
      nameServer,
      DDS_NOT_READ_SAMPLE_STATE,
      DDS_NEW_VIEW_STATE,
      DDS_ALIVE_INSTANCE_STATE);
    checkHandle(
      newUser, "DDS_DataReader_create_readcondition (newUser)");
```

As you can see, its very similar to the code presented in *Using a QueryCondition*. The same approach could also be used to detect users that leave our `ChatRoom`: just select an `InstanceState` that is `NOT_ALIVE_DISPOSED`

In the coming section however, we will use an alternative way of detecting when a user leaves the `ChatRoom`.

8.3 Using a StatusCondition

A `DDS_StatusCondition` is available on every `DDS_Entity` object, just by invoking its `DDS_Entity_get_statuscondition` operation. Since a `DDS_DataReader` inherits from `DDS_Entity`, it also has a `DDS_StatusCondition`. As stated before, `StatusConditions` can be used to notify the Entity of certain situations, like a violation to one of its contracts.

We will not treat each and every possible contract in this tutorial, but we will mention one type of contract here, just to explain the mechanism of the `DDS_StatusCondition`.

When a DataWriter connects to a DataReader, it will establish a contract with it to keep it informed about its Liveliness: in other words, the DataWriter will promise to give a sort of heartbeat to the DataReader, so that the DataReader knows whether it can still expect any updates coming from that DataWriter. If a DataWriter crashes or is deleted, this heartbeat stops, which is a violation of the contract, and so the DataReader must be informed about that. It can then (if applicable[1]) change the `InstanceState` of the concerned instances, in other words, the instances that were being transmitted by that DataWriter, from `ALIVE` to `NOT_ALIVE_NO_WRITERS`. This is important information because it could mean that the resources occupied by these concerned instances may be released after some amount of time[2].

1. Decisions on the liveliness aspects and their consequences are under the control of lots of different QoS Policies, the most important ones being the `LivelinessQosPolicy`, the `OwnershipQosPolicy` and the `DeadlineQosPolicy`. Refer to the *OpenSplice DDS C Reference Guide*.
2. That is controlled by the `ReaderDataLifecycleQosPolicy`.

What is interesting for our application is that we can be notified of the fact that a DataWriter loses its Liveliness, meaning a user effectively leaves the ChatRoom. So besides monitoring the `NameService` for the disposal of a specific `userID`, we can also monitor the Liveliness of each `ChatMessage DataWriter` instead. Let's see how that works.

```
9      /* Obtain a StatusCondition that triggers only when a
10        Writer changes Liveliness */
11     leftUser = DDS_DataReader_get_statuscondition(loadAdmin);
12     checkHandle(leftUser, "DDS_DataReader_get_statuscondition");
13     status = DDS_StatusCondition_set_enabled_statuses(
14       leftUser, DDS_LIVELINESS_CHANGED_STATUS);
   checkStatus(status, "DDS_StatusCondition_set_enabled_statuses");
```

In line *11* you see that we use the `DDS_DataReader_get_statuscondition` operation to obtain the `DDS_StatusCondition` of our `ChatMessage DataReader`. (This operation is inherited from the Entity class and is also available as the `DDS_Entity_get_statuscondition` operation.) By default, the StatusCondition is configured to trigger on all Statuses that are relevant to the corresponding Entity. We only want to respond to the event where a connected `ChatMessage` DataWriter loses its Liveliness, so we will configure the StatusCondition only to trigger on that occasion. The StatusCondition uses a bit mask to select the Statuses it has to monitor, so for that reason we need to set a new bit mask, using the `DDS_StatusCondition_set_enabled_statuses` operation. Each Status is identified by a separate bit and has a unique identifier: the Status we need is named `DDS_LIVELINESS_CHANGED_STATUS, see also Table 3, `*`Status Events Overview`*, on page 27. You can see in lines *13-14* how we use this identifier to set up the new bit mask.

Once the StatusCondition has triggered, it only means that there is a change in Liveliness in one of the connected DataWriters: the `LivelinessStatus` keeps track of the current number of `alive` DataWriters and of the current number of `not_alive` DataWriters. Any change to these numbers will trigger the StatusCondition. So if we get a trigger, we do not know which user is effected by that, and we do not know whether that user just entered (was added to the `alive_count`) or just left (was removed from the `not_alive_count`). There are two special change counters that keep track of the changes to both the `alive_count` and `not_alive_count`, but these treat both additions and removals in the same way: a removal followed by an addition of a DataWriter leads to an `alive_count_change` of 2. Both change counters will be reset each time the `LivelinessStatus` is obtained.

Since we can't distinguish between users entering and leaving the ChatRoom by just studying the `LivelinessStatus`, we will need to keep track of the previous number of `alive` users. That way we can see whether the current number of users is bigger or smaller than the previous number, and so whether a user has actually entered or left the ChatRoom. To access this `LivelinessStatus`, we use the `DDS_DataReader_get_liveliness_changed_status` operation on the DataReader.

So now we know when a user actually leaves the ChatRoom, but we still don't know which user that was. We could use a complicated algorithm to map the effected DataWriter to a specific user, but because we already know that a user also unregisters its `userID` in the `NameService` when leaving the room, we will just take all `NOT_ALIVE_NO_WRITERS` instances from the `NameService` DataReader instead, which is much easier to do. So each time we get a trigger for a change in Liveliness, we execute the following code:

```
  /* Some liveliness has changed (either a DataWriter joined
     or a DataWriter left) */
  status = DDS_DataReader_get_liveliness_changed_status(
    loadAdmin, &livChangStatus);
  if (livChangStatus.active_count < prevCount) {
    ...
    /* A user has left the ChatRoom, since a DataWriter lost
       its liveliness. Take the effected users so they will
       not appear in the list later on. */
   status = Chat_NameServiceDataReader_take(
     nameServer,
     &nsList,
     &infoSeq,
     DDS_LENGTH_UNLIMITED,
     DDS_ANY_SAMPLE_STATE,
     DDS_ANY_VIEW_STATE,
     DDS_NOT_ALIVE_NO_WRITERS_INSTANCE_STATE);
   checkStatus(status, " Chat_NameServiceDataReader_take ");
   ...
   prevCount = livChangStatus.active_count;
 };
```

Much more happens in the real code, but we will get back on that later in Section 8.7, *Using the HistoryQosPolicy*.

8.4 Using a GuardCondition

We want the `UserLoad` application to run only for 60 seconds, so we could check in every loop whether this time has already elapsed, and if so, terminate the application. However, if the `UserLoad`'s main thread is blocked on a WaitSet, and no incoming events unblock it, the application can not check our timing constraint and could theoretically be stuck in that WaitSet forever is no more events would allow it to unblock first.

This is where the `DDS_GuardCondition` comes in. As stated before, a `DDS_GuardCondition` is simply a `DDS_Condition` whose trigger value is under full control of the application. In this specific example we could add a GuardCondition to all the other Conditions already attached to the WaitSet. If the `DDS_GuardCondition` has an initial trigger value of `FALSE`, it will not influence the WaitSet in any way. However, as soon as we change its trigger value into `TRUE`, the WaitSet must trigger and unblock the main thread, regardless of the settings of all other attached Conditions.

What we will do in our application is to spawn a separate thread that sleeps for 60 seconds. As soon as it wakes up, it will set the trigger value of the `DDS_GuardCondition` to `TRUE`. First we will show you how the `DDS_GuardCondition` is created:

```
36   /* Create a bare guard which will be used to close the room */
37   escape = DDS_GuardCondition__alloc();
38   checkHandle(escape, "DDS_GuardCondition__alloc");
39   .........
40   /* Start the sleeper thread. */
41   pthread_t tid;
42   pthread_create (&tid, NULL, delayedEscape, NULL);
```

As you can see, a `DDS_GuardCondition` has no corresponding factory and must be created by a `DDS_GuardCondition__alloc` operation (see line *37*). A new thread is spawned in line *42*, which is instructed to invoke the `delayedEscape` function as soon as it is ready to be executed. The implementation of that function is depicted below:

```
43   void *
44   delayedEscape(
45     void *arg)
46   {
47     DDS_ReturnCode_t status;
48
49     sleep(60);     /* wait for 60 sec. */
50     status = DDS_GuardCondition_set_trigger_value(escape, TRUE);
51     checkStatus(status, "DDS_GuardCondition_set_trigger_value");
52
53    return NULL;
54  }
```

As you can see, the `DDS_GuardCondition` is actually a very simple object that can be very convenient if you manually want to unblock a WaitSet. But let's first focus some more on the WaitSet itself, which is the subject of the next section.

8.5 Using a WaitSet

In the previous sections we create a number of `DDS_Conditions` with the intention of attaching them to a `DDS_WaitSet`, so that the `DDS_WaitSet` could unblock the main thread in case of any necessary activity. Let's first see how a `DDS_WaitSet` is created and how all these `DDS_Conditions` can be attached to it:

```
55   DDS_WaitSet userLoadWS;
56
57   /* Create a waitset and add the ReadConditions */
58   userLoadWS = DDS_WaitSet__alloc();
```

```
59   checkHandle(userLoadWS, "DDS_WaitSet__alloc");
60   status = DDS_WaitSet_attach_condition(userLoadWS, newUser);
61   checkStatus(status, "DDS_WaitSet_attach_condition (newUser)");
62   status = DDS_WaitSet_attach_condition(userLoadWS, leftUser);
63   checkStatus(status, "DDS_WaitSet_attach_condition (leftUser)");
64  status = DDS_WaitSet_attach_condition(userLoadWS, escape);
65  checkStatus(status, "DDS_WaitSet_attach_condition (escape)");
```

As with the DDS_GuardCondition, the DDS_WaitSet has no corresponding factory and needs to be created using a special DDS_WaitSet__alloc operation (see line *58*). Because of this, there is no dependency on any DomainParticipant and so a DDS_WaitSet can be used to combine DDS_Conditions coming from different DomainParticipants. This makes WaitSets extremely useful to build bridges between several Domains, since they allow an application to react on events coming from different origins.

In lines *60-65* you see how each Condition is attached to the WaitSet, simply using the same DDS_WaitSet_attach_condition operation for each type of Condition. For the WaitSet it doesn't matter what type of Condition is attached, it will only monitor its trigger value.

Now that we have set up our DDS_WaitSet, we can block our main application thread until one of the attached Conditions actually raises its flag. In such cases, the WaitSet will unblock and return you the Conditions responsible for that. (Note that more than one Condition could have caused the WaitSet to unblock). Let's look at the following code, where the main thread blocks itself and then handles the triggered Conditions.

```
66   DDS_ConditionSeq *  guardList = NULL;
67   DDS_Duration_t      timeout = DDS_DURATION_INFINITE;
68   int                 closed = 0;
69   DDS_unsigned_long   i, j;
70
71   /* Initialize and pre-allocate the GuardList used to obtain
72      the triggered Conditions. */
73   guardList = DDS_ConditionSeq__alloc();
74   checkHandle(guardList, "DDS_ConditionSeq__alloc");
75  guardList->_maximum = 3;
76  guardList->_length = 0;
77  guardList->_buffer = DDS_ConditionSeq_allocbuf(3);
78  checkHandle(guardList->_buffer, "DDS_ConditionSeq_allocbuf");
79
80   while (!closed) {
81     /* Wait until at least one of the Conditions in
82        the waitset triggers. */
83     status = DDS_WaitSet_wait(userLoadWS, guardList, &timeout);
84    checkStatus(status, "DDS_WaitSet_wait");
85
86    /* Walk over all guards to display information */
87    for (i = 0; i < guardList->_length; i++) {
88      guard = guardList->_buffer[i];
89      if (guard == newUser) {
90        .........
91      } else if (guard == leftUser) {
```

```
92          .........
93        } else if (guard == escape) {
94          printf ("UserLoad has terminated.\n");
95          closed = 1;
96        } else {
97          assert(0);
98        };
99      } /* for */
100  } /* while (!closed) */
```

In line *83* you see how the main thread blocks itself on the WaitSet using the `DDS_WaitSet_wait` operation. The purpose of the `guardList` parameter is to pass back a sequence of all Conditions that were responsible for the trigger: since it is an inout type parameter, we can pre-allocate its contents so that the WaitSet doesn't have to allocate new resources in each and every iteration. Since we already know we attached 3 `Condition`s to the `WaitSet`, the `guardList` can never contain more than 3 elements. That's why we pre-allocate the `guardList` with the worst-case number of elements in lines *73-78*, so that we know we can re-use this buffer in all subsequent iterations without ever having to re-allocate to a bigger buffer. The last parameter specifies how long the `WaitSet` should block at maximum: if the specified time has elapsed but no Condition has triggered, the WaitSet will unblock anyway and return a `DDS_RETCODE_TIMEOUT` and will set the length of the Condition sequence to 0. In this case we have supplied the special constant `DDS_DURATION_INFINITE` to indicate that the WaitSet should wait indefinitely until one of its `Condition`s raises its flag (which is no problem since we use our `GuardCondition` to escape it).

Once the `WaitSet` has triggered, we need to handle all the `Condition`s that were responsible for that. We will do that by just iterating through the `guardList` we obtained (line *87-99*) and comparing each element inside it to the `Condition`s we attached to this `WaitSet`. That way we know which `Condition` represents which purpose, and we can handle each `Condition` in its own special way.

All this said and done, we are almost finished with the `UserLoad` application: the only thing we still need to do is to explain how to keep track of the entire `ChatMessage` history of each `Chatter` that joined our `ChatRoom`. That will be the subject of the next section.

8.6 Processing Expired Transient Data

Since our `UserLoad` application subscribes itself to the `NameService` Topic, which has `TRANSIENT` durability, it will automatically receive all known usernames at startup from the Durability service. Since Chatters leaving the chatroom do not dispose their names from the NameService (see section Section 5.6, *Unregistering and Disposing of Instances*), these names will not be removed from the transient store[1]. That means that a late joining `NamerService DataReader` at its startup will receive usernames of both currently active users and of users that already left the chatroom.

Since the `UserLoad` application is only interested in displaying usernames of currently active users, it must have a way to filter out the ones that are not currently active. Luckily, the durability service does not influence the instance_state of a sample: if an instance has no active DataWriters, it is delivered with an `instance_state` that is set to `DDS_NOT_ALIVE_NO_WRITERS`, while the ones that do have on or more active DataWriters are set to `DDS_ALIVE`.

```
101   /* Remove all known Users that are not currently active. */
102   status = Chat_NameServiceDataReader_take(
103     nameServer,
104     &nsList,
105     &infoSeq,
106     DDS_LENGTH_UNLIMITED,
107     DDS_ANY_SAMPLE_STATE,
108     DDS_ANY_VIEW_STATE,
109     DDS_NOT_ALIVE_INSTANCE_STATE);
110   checkStatus(status, "Chat_NameServiceDataReader_take");
111   status = Chat_NameServiceDataReader_return_loan(
112     nameServer, &nsList, &infoSeq);
113   checkStatus(status, "Chat_NameServiceDataReader_return_loan");
```

In the listing above, we use of this behaviour to filter out the usernames of user that already left the chatroom. In lines *102-110* we take away all instances that have their instance_state set to `NOT_ALIVE`, leaving only the instances that are currenly still alive[2]. We use the loaning mechanism here because it is difficult to anticipate how many instances that are not considered alive will be delivered by the transient store. That means we may not forget to return the loan right after we took away these samples (see lines *111-113*).

8.7 Using the HistoryQosPolicy

Until now, our DataReaders were configured to store at maximum only one sample for each instance. As you know, a new instance is produced on the DataReader side as soon as its first sample has arrived. When the next sample arrives before the first sample was consumed by the application, it will overwrite the previous one: the idea is that the DataReader always stores the sample that represents the most recent state of an instance.

1. A DataWriter that disposes an instance, also removes it from the transient store. Late joining DataReaders will not be aware of that instance's former existence.
2. The `NOT_ALIVE` instance_state mask specifies both the `NOT_ALIVE_DISPOSED` and `NOT_ALIVE_NO_WRITERS` state.

It may be possible however that you are not interested in just the most recent state of an instance, but that you want to keep track of the latest ***n*** samples of an instance, or maybe even of all samples of an instance. The DataReader can be configured in such a way that it provides you exactly the kind of storage you need. The storage spectrum of a DataReader is under the full control of a QosPolicy named HistroyQosPolicy, that has two main settings:

- ***KEEP_LAST*** **-** This setting comes with a second variable named depth. If this depth variable equals n, the DataReader will store the latest n samples of each instance for you. For newly arriving samples it will behave like a FIFO queue, the oldest sample is shifted out when a new sample arrives.
- ***KEEP_ALL*** **-** This setting prevents newer samples from overwriting older ones: samples can only disappear when they are actually consumed by the application. If the application does not 'take' its samples and new samples continue to arrive, the DataReader will allocate more and more space, until it reaches its resource limits[1]. If that is the case, it will reject newly arriving samples until the application releases some resources by consuming the older samples. As you may expect, this behaviour can be dangerous if the data is labelled as RELIABLE, since the DataWriter may not just drop the data and therefore continuously will need to re-transmit it until it is finally accepted by all the connected DataReaders.

The default HistoryQosPolicy settings are configured to be KEEP_LAST with a history depth of ***1***. For our UserLoad application we want to keep track of all messages sent by each of the Chatters. That means we will have to change the HistroyQosPolicy to KEEP_ALL. We do not have a *depth* setting in this case, since the DataReader will just allocate all resources it can claim. This is potentially dangerous if too much users stay online too long, sending out thousands of chat messages while logged in. We will just assume for now that is not the case, so if we take care of the fact that when a user leaves the ChatRoom we will release all the messages it had sent, we should not get into trouble with respect to our resource limits. The following code will show you how to tailor the DataReader QoS settings for this purpose.

```
/* Adapt the DataReaderQos for the ChatMessageDataReader
   to keep track of all messages. */
message_qos = DDS_DataReaderQos__alloc();
checkHandle(message_qos, "DDS_DataReaderQos__alloc");
status = DDS_Subscriber_get_default_datareader_qos(
  chatSubscriber, message_qos);
checkStatus(
  status, "DDS_Subscriber_get_default_datareader_qos");
status = DDS_Subscriber_copy_from_topic_qos(
  chatSubscriber, message_qos, reliable_topic_qos);
```

1. These resource limits are under full control of the ResourceLimitsQosPolicy, and by default are set to unlimited, meaning all the memory available on that specific machine.

```
124  checkStatus(status, "DDS_Subscriber_copy_from_topic_qos");
125  message_qos->history.kind = DDS_KEEP_ALL_HISTORY_QOS;
126
127 /* Create a DataReader for the ChatMessage Topic (using the
128    appropriate QoS). */
129 loadAdmin = DDS_Subscriber_create_datareader(
130   chatSubscriber,
131   chatMessageTopic,
132   message_qos,
133   NULL,
134   DDS_ANY_STATUS);
135 checkHandle(
136   loadAdmin, "DDS_Subscriber_create_datareader (ChatMessage)");
```

As you can see in line *116*, we start with allocating a `DDS_DataReaderQos` holder, which is filled with the default DataReader settings in line *118*. We then overwrite the QoS Policies that overlap with the Topic policies with the QosPolicy settings of our `ChatMessage` topic in line *122*. Finally we change its History to the `KEEP_ALL` setting in line *125*. (The `HistroyQosPolicy` is no Request/Offered policy, it can be configured independently from the DataWriter settings). We then simply create our DataReader with it in lines *129-134*.

Now let's look at how to access the historical data of a user when he leaves our ChatRoom.

```
137  DDS_LivelinessChangedStatus livChangStatus;
138  DDS_long prevCount = 0;
139
140  if (guard == leftUser) {
141    /* Some liveliness has changed (either a DataWriter
142       joined or a DataWriter left). */
143    status = DDS_DataReader_get_liveliness_changed_status(
144      loadAdmin, &livChangStatus);
145    if (livChangStatus.alive_count < prevCount) {
146      /* A user has left the ChatRoom, since a DataWriter lost
147         its liveliness. Take the effected users so they will not
148         appear in the list later on. */
149     status = Chat_NameServiceDataReader_take(
150       nameServer,
151       &nsList,
152       &infoSeq,
153       DDS_LENGTH_UNLIMITED,
154       DDS_ANY_SAMPLE_STATE,
155       DDS_ANY_VIEW_STATE,
156       DDS_NOT_ALIVE_INSTANCE_STATE);
157     checkStatus(status, "Chat_NameServiceDataReader_take");
158
159     for (j = 0; j < nsList._length; j++) {
160       /* re-apply query arguments */
161       sprintf(args._buffer[0], "%d", nsList._buffer[j].userID);
162       status = DDS_QueryCondition_set_query_parameters(
163         singleUser, &args);
164       checkStatus(
165         status, "DDS_QueryCondition_set_query_parameters");
166
167       /* Read this users history */
168       status = Chat_ChatMessageDataReader_take_w_condition(
169         loadAdmin,
170         &msgList,
171         &infoSeq2,
172         DDS_LENGTH_UNLIMITED,
173         singleUser);
174       checkStatus(
175         status, "Chat_ChatMessageDataReader_take_w_condition");
176 
177       /* Display the user and his history */
178       printf (
179         "Departed user %s has sent %d messages\n",
180         nsList._buffer[j].name,
181         msgList._length);
182       status = Chat_ChatMessageDataReader_return_loan(
183         loadAdmin, &msgList, &infoSeq2);
184       checkStatus(
185         status, "Chat_ChatMessageDataReader_return_loan");
186     }
187     status = Chat_NameServiceDataReader_return_loan(
188       nameServer, &nsList, &infoSeq);
189     checkStatus(
190       status, "Chat_NameServiceDataReader_return_loan");
191   }
192   prevCount = livChangStatus.alive_count;
193 }
```

Parts of this code were already presented in Section 8.3, *Using a StatusCondition*, where we explained how to interpret the StatusCondition trigger. After we have obtained all disposed users by using the instance state `DDS_NOT_ALIVE_INSTANCE_STATE` in lines *149-156*, we iterate over each of these users and try to find their corresponding `ChatMessages` by tailoring the SQL expression parameters (lines *161-165*) and executing this `DDS_QueryCondition` on the `ChatMessage` DataReader (lines *168-173*). We take the data to avoid the DataReader from exhausting its resources, and also because we no longer need `ChatMessages` of a user that has already left. The result is a sequence that contains all the `ChatMessages` of a single user (we queried on `userID`, which is unique for every user), so the length of this sequence tells us how many messages were received from that user.

In case the result would contain information from multiple instances, all samples would still be returned in the same, one dimensional sequence. The ordering of the different samples belonging to the different instances is under full control of the `PresentationQosPolicy` of the Subscriber. When using default policy settings the samples will be ordered as a list, where samples belonging to the same instance are consecutive. The `DDS_SampleInfo` that comes with each sample will give you a *`sample_rank`*, that tells you how much more of the following samples belong to the same instance as the current sample. This may be a very convenient feature if you want to collect all samples that belong to the same instance.

8.8 Cleaning Up

When the `GuardCondition` has triggered our `WaitSet`, and the application leaves its main loop, we need to clean up lots of resources. However, since lots of Entities are currently attached to each other, we will first have to break them apart before we can start to delete them. (Otherwise we would create dangling relationships, in which one entity points to another, already deleted, entity). Let's see what happens when our application leaves the main loop.

```
194  /* Remove all Conditions from the WaitSet. */
195  status = DDS_WaitSet_detach_condition(userLoadWS, escape);
196  checkStatus(status, "DDS_WaitSet_detach_condition (escape)");
197  status = DDS_WaitSet_detach_condition(userLoadWS, leftUser);
198  checkStatus(status, "DDS_WaitSet_detach_condition (leftUser)");
199  status = DDS_WaitSet_detach_condition(userLoadWS, newUser);
200  checkStatus(status, "DDS_WaitSet_detach_condition (newUser)");
201
202  /* Free all resources */
203 DDS_free(guardList);
204 DDS_free(args._buffer);
205 DDS_free(userLoadWS);
206 DDS_free(escape);
207 DDS_free(setting_topic_qos);
208 DDS_free(reliable_topic_qos);
209 DDS_free(nameServiceTypeName);
210 DDS_free(chatMessageTypeName);
211 DDS_free(nameServiceTS);
212 DDS_free(chatMessageTS);
213 status = DDS_DomainParticipant_delete_contained_entities(
214   participant);
215 checkStatus(
216   status, "DDS_DomainParticipant_delete_contained_entities");
217 status = DDS_DomainParticipantFactory_delete_participant(
218   DDS_TheParticipantFactory,
219   participant);
220 checkStatus(
221   status, "DDS_DomainParticipantFactory_delete_participant");
```

In lines *195-200* we detach all Conditions from the `DDS_WaitSet`. Now both the `DDS_WaitSet` and the `DDS_GuardCondition` can be released, and since neither of them has a corresponding factory, we will have to use the `DDS_free` operation to do that (see lines *205*, *206*). After deleting all QoS holders and sequence buffers, it is now time to delete all our Entities using their corresponding factories. Normally we would recursively travel from our `DDS_DomainParticipant` to all its embedded factories, delete all embedded Entities in there, then delete these factories and finally delete our `DDS_DomainParticipant`.

There is however a convenience operation on each factory named `DDS_<factory>_delete_contained_entities` that does exactly that: it recursively travels through all embedded entities and deletes them all. That means that if we invoke it on the `DDS_DomainParticipant` (like we do in line *213*), all

Entities underneath it will be deleted. That leaves only the DDS_DomainParticipant itself to be deleted (line *217-219*). Here you see an example of the last convenience macro called DDS_TheParticipantFactory.

This macro represents the singleton DomainParticipantFactory handle, which can be used at any location where the DomainParticipantFactory is required. It allows you to skip the explicit DDS_DomainParticipantFactory_get_instance function call that normally provides you with that handle. So creating a DDS_DomainParticipant can be as easy as this.

```
/* Create a DomainParticipant (using the
   'TheParticipantFactory' convenience macro). */
participant = DDS_DomainParticipantFactory_create_participant(
  DDS_TheParticipantFactory,
  domain,
  DDS_PARTICIPANT_QOS_DEFAULT,
  NULL,
  DDS_ANY_STATUS);
```

We do not need to obtain the DomainParticipantFactory handle first; we can just directly insert its convenience macro in here. Be careful when using this specific convenience macro in multi-threaded applications though! Although all other API calls of OpenSplice are re-entrant, the DDS_DomainParticipantFactory_get_instance call is not.

Invoking it simultaneously by two or more threads may result in the corruption of memory. This restriction no longer applies after a successful return from its first invocation. Since the convenience macro is just an alias for this function call, it should be used carefully in multi-threaded environments as well.

Finally, as you may have noticed, we did not clean up the sequences used to read and take NameService and ChatMessage samples. In this case that was not necessary, since we allocated all these sequences on stack.

```
DDS_sequence_Chat_ChatMessage msgList =
  { 0, 0, DDS_OBJECT_NIL, FALSE };
DDS_sequence_Chat_NameService nsList =
  { 0, 0, DDS_OBJECT_NIL, FALSE };
DDS_SampleInfoSeq infoSeq = { 0, 0, DDS_OBJECT_NIL, FALSE };
DDS_SampleInfoSeq infoSeq2 = { 0, 0, DDS_OBJECT_NIL, FALSE };
```

Allocating a sequence on stack is allowed, but you should not forget to manually release the buffer when the sequence runs out of scope. In this case that was not necessary as well, since we 'loaned' our buffer from the DataReader and we already returned the loan. When allocating sequences on stack though, be sure to initialize them correctly: not only the _length, _maximum and _buffer fields should be initialized correctly, but also the corresponding release flag. According to the IDL C language mapping, this flag can only be set using the appropriate getter and setter functions (see Section 8.3, *Using a StatusCondition*), but when allocating the sequence on stack it is very convenient to know that the release flag is just a fourth attribute, that can be initialized just like its predecessors.

This completes the tutorial. The full code listing for this application can be found under *UserLoad.c* in *Appendix A*. Of course there is a lot more to learn, especially with regard to all the QoS settings and the corresponding Statuses, but all the basic DDS principles have been covered now. The best way to go from here is to start experimenting yourself now: build some small applications and try to get them to work. While mastering the basics, try to familiarize yourself with the Reference Manual: examine the details of the more complicated API calls and try to get a good overview of all the available QoS settings. Don't be afraid to experiment: it's the best way to increase your knowledge.

APPENDICES

Appendix A C Language Examples' Code

This appendix lists the complete C source code for the examples provided in the *C Tutorial Guide.*

Chat.idl

```
/************************************************************************
 *
 * Copyright (c) 2007
 * PrismTech Ltd.
 * All rights Reserved.
 *
 * LOGICAL_NAME:    Chat.idl
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the C programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the data definitions for the tutorial examples.
 *
 ***/

module Chat {

    const long MAX_NAME = 32;
    typedef string<MAX_NAME> nameType;

    struct ChatMessage {
        long      userID;           // owner of message
        long      index;            // message number
        string    content;          // message body
    };
#pragma keylist ChatMessage userID

    struct NameService {
        long     userID;            // unique user identification
        nameType name;              // name of the user
    };
#pragma keylist NameService userID

    struct NamedMessage {
        long     userID;            // unique user identification
        nameType userName;          // user name
        long     index;             // message number
        string   content;           // message body
    };
#pragma keylist NamedMessage userID

};
```

CheckStatus.h

```
/************************************************************************
 *
 * Copyright (c) 2007
 * PrismTech Ltd.
 * All rights Reserved.
 *
 * LOGICAL_NAME:    CheckStatus.h
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the C programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the headers for the error handling operations.
 *
 ***/

#ifndef __CHECKSTATUS_H__
#define __CHECKSTATUS_H__

#include "dds_dcps.h"
#include <stdio.h>
#include <stdlib.h>

/* Array to hold the names for all ReturnCodes. */
char *RetCodeName[13];

/**
 * Returns the name of an error code.
 **/
char *getErrorName(DDS_ReturnCode_t status);

/**
 * Check the return status for errors. If there is an error, then terminate.
 **/
void checkStatus(DDS_ReturnCode_t status, const char *info);

/**
 * Check whether a valid handle has been returned. If not, then terminate.
 **/
void checkHandle(void *handle, char *info);

#endif
```

CheckStatus.c

```
/************************************************************************
 *
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 *
 * LOGICAL_NAME:    CheckStatus.c
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the C programming language.
 * DATE              june 2007.
 *************************************************************************
 *
 * This file contains the implementation for the error handling operations.
 *
 ***/

#include "CheckStatus.h"

/* Array to hold the names for all ReturnCodes. */
char *RetCodeName[13] = {
    "DDS_RETCODE_OK",
    "DDS_RETCODE_ERROR",
    "DDS_RETCODE_UNSUPPORTED",
    "DDS_RETCODE_BAD_PARAMETER",
    "DDS_RETCODE_PRECONDITION_NOT_MET",
    "DDS_RETCODE_OUT_OF_RESOURCES",
    "DDS_RETCODE_NOT_ENABLED",
    "DDS_RETCODE_IMMUTABLE_POLICY",
    "DDS_RETCODE_INCONSISTENT_POLICY",
    "DDS_RETCODE_ALREADY_DELETED",
    "DDS_RETCODE_TIMEOUT",
    "DDS_RETCODE_NO_DATA",
    "DDS_RETCODE_ILLEGAL_OPERATION" };

/**
 * Returns the name of an error code.
 **/
char *getErrorName(DDS_ReturnCode_t status)
{
    return RetCodeName[status];
}

/**
 * Check the return status for errors. If there is an error, then terminate.
 **/
void checkStatus(
    DDS_ReturnCode_t status,
    const char *info ) {


    if (status != DDS_RETCODE_OK && status != DDS_RETCODE_NO_DATA) {
        fprintf(stderr, "Error in %s: %s\n", info, getErrorName(status));
        exit (0);
    }
}

/**
 * Check whether a valid handle has been returned. If not, then terminate.
 **/
void checkHandle(
    void *handle,
    char *info ) {

     if (!handle) {
        fprintf(
            stderr,
            "Error in %s: Creation failed: invalid handle\n",
            info);
        exit (0);
     }
}
```

Chatter.c

```
/************************************************************************
 *
 * Copyright (c) 2007
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 * All rights Reserved.
 *
 * LOGICAL_NAME:    Chatter.c
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the C programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the implementation for the 'Chatter' executable.
 *
 ***/

#include <stdlib.h>
#include <stdio.h>
#include <unistd.h>
#include <string.h>
#include "dds_dcps.h"
#include "CheckStatus.h"
#include "Chat.h"

#define MAX_MSG_LEN 256
#define NUM_MSG 10
#define TERMINATION_MESSAGE -1

int
main (
    int argc,
    char *argv[])
{
    /* Generic DDS entities */
    DDS_DomainParticipantFactory    dpf;
    DDS_DomainParticipant           participant;
    DDS_Topic                       chatMessageTopic;
    DDS_Topic                       nameServiceTopic;
    DDS_Publisher                   chatPublisher;

    /* QosPolicy holders */
    DDS_TopicQos                    *reliable_topic_qos;
    DDS_TopicQos                    *setting_topic_qos;
    DDS_PublisherQos                *pub_qos;
    DDS_DataWriterQos               *dw_qos;

    /* DDS Identifiers */
    DDS_DomainId_t                  domain = NULL;
    DDS_InstanceHandle_t            userHandle;
    DDS_ReturnCode_t                status;

    /* Type-specific DDS entities */
    Chat_ChatMessageTypeSupport     chatMessageTS;
    Chat_NameServiceTypeSupport     nameServiceTS;
    Chat_ChatMessageDataWriter      talker;
    Chat_NameServiceDataWriter      nameServer;

    /* Sample definitions */
    Chat_ChatMessage                *msg;    /* Example on Heap */
    Chat_NameService                ns;      /* Example on Stack */

    /* Others */
    int                             ownID = 1;
    int                             i;
    char                            *chatMessageTypeName = NULL;
    char                            *nameServiceTypeName = NULL;
    char                            *chatterName = NULL;
    char                            *partitionName = NULL;


    /* Options: Chatter [ownID [name]] */
    if (argc > 1) {
        sscanf(argv[1], "%d", &ownID);
        if (argc > 2) {
            chatterName = argv[2];
        }
    }

    /* Create a DomainParticipantFactory and a DomainParticipant
       (using Default QoS settings). */
    dpf = DDS_DomainParticipantFactory_get_instance ();
    checkHandle(dpf, "DDS_DomainParticipantFactory_get_instance");
    participant = DDS_DomainParticipantFactory_create_participant (
        dpf,
        domain,
        DDS_PARTICIPANT_QOS_DEFAULT,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(
        participant, "DDS_DomainParticipantFactory_create_participant");

    /* Register the required datatype for ChatMessage. */
    chatMessageTS = Chat_ChatMessageTypeSupport__alloc();
    checkHandle(chatMessageTS, "Chat_ChatMessageTypeSupport__alloc");
    chatMessageTypeName =
        Chat_ChatMessageTypeSupport_get_type_name(chatMessageTS);
    status = Chat_ChatMessageTypeSupport_register_type(
        chatMessageTS,
        participant,
        chatMessageTypeName);
    checkStatus(status, "Chat_ChatMessageTypeSupport_register_type");

    /* Register the required datatype for NameService. */
    nameServiceTS = Chat_NameServiceTypeSupport__alloc();
    checkHandle(nameServiceTS, "Chat_NameServiceTypeSupport__alloc");
    nameServiceTypeName =
        Chat_NameServiceTypeSupport_get_type_name(nameServiceTS);
    status = Chat_NameServiceTypeSupport_register_type(
        nameServiceTS,
        participant,
        nameServiceTypeName);
    checkStatus(status, "Chat_NameServiceTypeSupport_register_type");

    /* Set the ReliabilityQosPolicy to RELIABLE. */
    reliable_topic_qos = DDS_TopicQos__alloc();
    checkHandle(reliable_topic_qos, "DDS_TopicQos__alloc");
    status = DDS_DomainParticipant_get_default_topic_qos(
        participant, reliable_topic_qos);
    checkStatus(status, "DDS_DomainParticipant_get_default_topic_qos");
    reliable_topic_qos->reliability.kind = DDS_RELIABLE_RELIABILITY_QOS;

    /* Make the tailored QoS the new default. */
    status = DDS_DomainParticipant_set_default_topic_qos(
        participant, reliable_topic_qos);
    checkStatus(status, "DDS_DomainParticipant_set_default_topic_qos");

    /* Use the changed policy when defining the ChatMessage topic */
    chatMessageTopic = DDS_DomainParticipant_create_topic(
        participant,
        "Chat_ChatMessage",
        chatMessageTypeName,
        reliable_topic_qos,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(
        chatMessageTopic, "DDS_DomainParticipant_create_topic (ChatMessage)");

    /* Set the DurabilityQosPolicy to TRANSIENT. */
    setting_topic_qos = DDS_TopicQos__alloc();
    checkHandle(setting_topic_qos, "DDS_TopicQos__alloc");
    status = DDS_DomainParticipant_get_default_topic_qos(
        participant, setting_topic_qos);
    checkStatus(status, "DDS_DomainParticipant_get_default_topic_qos");
    setting_topic_qos->durability.kind = DDS_TRANSIENT_DURABILITY_QOS;

    /* Create the NameService Topic. */
    nameServiceTopic = DDS_DomainParticipant_create_topic(
        participant,
        "Chat_NameService",
        nameServiceTypeName,
        setting_topic_qos,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(nameServiceTopic, "DDS_DomainParticipant_create_topic");

    /* Adapt the default PublisherQos to write into the
       "ChatRoom" Partition. */
    partitionName = "ChatRoom";
    pub_qos = DDS_PublisherQos__alloc();
    checkHandle(pub_qos, "DDS_PublisherQos__alloc");
    status = DDS_DomainParticipant_get_default_publisher_qos(
        participant, pub_qos);
    checkStatus(status, "DDS_DomainParticipant_get_default_publisher_qos");
    pub_qos->partition.name._length = 1;
    pub_qos->partition.name._maximum = 1;
    pub_qos->partition.name._buffer = DDS_StringSeq_allocbuf (1);
    checkHandle(pub_qos->partition.name._buffer, "DDS_StringSeq_allocbuf");
    pub_qos->partition.name._buffer[0] =
        DDS_string_alloc( strlen(partitionName) );
    checkHandle(pub_qos->partition.name._buffer[0], "DDS_string_alloc");
    strcpy (pub_qos->partition.name._buffer[0], partitionName);

    /* Create a Publisher for the chatter application. */
    chatPublisher = DDS_DomainParticipant_create_publisher(
        participant, pub_qos, NULL, DDS_ANY_STATUS);
    checkHandle(chatPublisher, "DDS_DomainParticipant_create_publisher");

    /* Create a DataWriter for the ChatMessage Topic
       (using the appropriate QoS). */
    talker = DDS_Publisher_create_datawriter(
        chatPublisher,
        chatMessageTopic,
        DDS_DATAWRITER_QOS_USE_TOPIC_QOS,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(talker, "DDS_Publisher_create_datawriter (chatMessage)");

    /* Create a DataWriter for the NameService Topic
       (using the appropriate QoS). */
    dw_qos = DDS_DataWriterQos__alloc();
    checkHandle(dw_qos, "DDS_DataWriterQos__alloc");
    status = DDS_Publisher_get_default_datawriter_qos (chatPublisher, dw_qos);
    checkStatus(status, "DDS_Publisher_get_default_datawriter_qos");
    status = DDS_Publisher_copy_from_topic_qos(
        chatPublisher, dw_qos, setting_topic_qos);
    checkStatus(status, "DDS_Publisher_copy_from_topic_qos");
    dw_qos->writer_data_lifecycle.autodispose_unregistered_instances = FALSE;
    nameServer = DDS_Publisher_create_datawriter(
        chatPublisher,
        nameServiceTopic,
        dw_qos,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(nameServer, "DDS_Publisher_create_datawriter (NameService)");

    /* Initialize the NameServer attributes located on stack. */
    ns.userID = ownID;
    ns.name = DDS_string_alloc(Chat_MAX_NAME+1);
    checkHandle(ns.name, "DDS_string_alloc");
    if (chatterName) {
        strncpy (ns.name, chatterName, Chat_MAX_NAME + 1);
    } else {
        snprintf(ns.name, Chat_MAX_NAME+1, "Chatter %d", ownID);
    }

    /* Write the user-information into the system
       (registering the instance implicitly). */
   status = Chat_NameServiceDataWriter_write(nameServer, &ns, DDS_HANDLE_NIL);
    checkStatus(status, "Chat_ChatMessageDataWriter_write");

    /* Initialize the chat messages on Heap. */
    msg = Chat_ChatMessage__alloc();
    checkHandle(msg, "Chat_ChatMessage__alloc");
    msg->userID = ownID;
    msg->index = 0;
    msg->content = DDS_string_alloc(MAX_MSG_LEN);
    checkHandle(msg->content, "DDS_string_alloc");
    if (ownID == TERMINATION_MESSAGE) {
        snprintf (msg->content, MAX_MSG_LEN, "Termination message.");
    } else {
        snprintf (msg->content, MAX_MSG_LEN,
            "Hi there, I will send you %d more messages.", NUM_MSG);
    }
    printf("Writing message: %s\n", msg->content);

    /* Register a chat message for this user
       (pre-allocating resources for it!!) */
    userHandle = Chat_ChatMessageDataWriter_register_instance(talker, msg);

    /* Write a message using the pre-generated instance handle. */
    status = Chat_ChatMessageDataWriter_write(talker, msg, userHandle);
    checkStatus(status, "Chat_ChatMessageDataWriter_write");

    sleep (1); /* do not run so fast! */

    /* Write any number of messages, re-using the existing
       string-buffer: no leak!!. */
    for (i = 1; i <= NUM_MSG && ownID != TERMINATION_MESSAGE; i++) {
        msg->index = i;
        snprintf ( msg->content, MAX_MSG_LEN, "Message no. %d", msg->index);
        printf("Writing message: %s\n", msg->content);
        status = Chat_ChatMessageDataWriter_write(talker, msg, userHandle);
        checkStatus(status, "Chat_ChatMessageDataWriter_write");
        sleep (1); /* do not run so fast! */
    }

    /* Leave the room by disposing and unregistering the message instance. */
    status = Chat_ChatMessageDataWriter_dispose(talker, msg, userHandle);
    checkStatus(status, "Chat_ChatMessageDataWriter_dispose");
    status = Chat_ChatMessageDataWriter_unregister_instance(
        talker, msg, userHandle);
    checkStatus(status, "Chat_ChatMessageDataWriter_unregister_instance");

    /* Also unregister our name. */
    status = Chat_NameServiceDataWriter_unregister_instance(
        nameServer, &ns, DDS_HANDLE_NIL);
    checkStatus(status, "Chat_NameServiceDataWriter_unregister_instance");

    /* Release the data-samples. */
    DDS_free(ns.name); // ns allocated on stack:
                       // explicit de-allocation of indirections!!
    DDS_free(msg);     // msg allocated on heap:
                       // implicit de-allocation of indirections!!

    /* Remove the DataWriters */
    status = DDS_Publisher_delete_datawriter(chatPublisher, talker);
    checkStatus(status, "DDS_Publisher_delete_datawriter (talker)");

    status = DDS_Publisher_delete_datawriter(chatPublisher, nameServer);
    checkStatus(status, "DDS_Publisher_delete_datawriter (nameServer)");

    /* Remove the Publisher. */
    status = DDS_DomainParticipant_delete_publisher(
        participant, chatPublisher);
    checkStatus(status, "DDS_DomainParticipant_delete_publisher");

    /* Remove the Topics. */
    status = DDS_DomainParticipant_delete_topic(
        participant, nameServiceTopic);
    checkStatus(
        status, "DDS_DomainParticipant_delete_topic (nameServiceTopic)");

    status = DDS_DomainParticipant_delete_topic(
        participant, chatMessageTopic);
    checkStatus(
        status, "DDS_DomainParticipant_delete_topic (chatMessageTopic)");

    /* De-allocate the QoS policies. */
    DDS_free(reliable_topic_qos);
    DDS_free(setting_topic_qos);
    DDS_free(pub_qos);  // Note that DDS_free recursively de-allocates
                        // all indirections as well!!

    /* De-allocate the type-names and TypeSupport objects. */
    DDS_free(nameServiceTypeName);
    DDS_free(chatMessageTypeName);
    DDS_free(nameServiceTS);
    DDS_free(chatMessageTS);

    /* Remove the DomainParticipant. */
    status = DDS_DomainParticipantFactory_delete_participant(
        dpf, participant);
    checkStatus(status, "DDS_DomainParticipantFactory_delete_participant");

    return 0;
}
```

MessageBoard.c

```
/************************************************************************
 *
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 *
 * LOGICAL_NAME:    MessageBoard.c
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the C programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the implementation for the 'MessageBoard' executable.
 *
 ***/

#include <stdio.h>
#include <unistd.h>
#include <string.h>

#include "dds_dcps.h"
#include "CheckStatus.h"
#include "Chat.h"
#include "multitopic.h"



#define TERMINATION_MESSAGE -1



int
main (
    int argc,
    char *argv[])
{
    /* Generic DDS entities */
    DDS_DomainParticipantFactory    dpf;
    DDS_DomainParticipant           participant;
    DDS_Topic                       chatMessageTopic;
    DDS_Topic                       nameServiceTopic;
    DDS_MultiTopic                  namedMessageTopic;
    DDS_Subscriber                  chatSubscriber;

    /* Type-specific DDS entities */
    Chat_ChatMessageTypeSupport     chatMessageTS;
    Chat_NameServiceTypeSupport     nameServiceTS;
    Chat_NamedMessageTypeSupport    namedMessageTS;
    Chat_NamedMessageDataReader     chatAdmin;
    DDS_sequence_Chat_NamedMessage  *msgSeq;
    DDS_SampleInfoSeq               *infoSeq;

    /* QosPolicy holders */
    DDS_TopicQos                    *reliable_topic_qos;
    DDS_TopicQos                    *setting_topic_qos;
    DDS_SubscriberQos               *sub_qos;
    DDS_StringSeq                   *parameterList;

    /* DDS Identifiers */
    DDS_DomainId_t                  domain = NULL;
    DDS_ReturnCode_t                status;

    /* Others */
    DDS_unsigned_long               i;
    DDS_boolean                     terminated = FALSE;
    char *                          partitionName;
    char *                          chatMessageTypeName = NULL;
    char *                          nameServiceTypeName = NULL;
    char *                          namedMessageTypeName = NULL;

    /* Options: MessageBoard [ownID] */
    /* Messages having owner ownID will be ignored */
    parameterList = DDS_StringSeq__alloc();
    checkHandle(parameterList, "DDS_StringSeq__alloc");
    parameterList->_length = 1;
    parameterList->_maximum = 1;
    parameterList->_buffer = DDS_StringSeq_allocbuf(1);
    checkHandle(parameterList->_buffer, "DDS_StringSeq_allocbuf");

    if (argc > 1) {
        parameterList->_buffer[0] = DDS_string_alloc ( strlen(argv[1]) );
        checkHandle(parameterList->_buffer[0], "DDS_string_alloc");
        strcpy (parameterList->_buffer[0], argv[1]);
    }
    else
    {
        parameterList->_buffer[0] = DDS_string_alloc(1);
        checkHandle(parameterList->_buffer[0], "DDS_string_alloc");
        strcpy (parameterList->_buffer[0], "0");
    }

    /* Create a DomainParticipantFactory and a DomainParticipant
       (using Default QoS settings. */
    dpf = DDS_DomainParticipantFactory_get_instance ();
    checkHandle(dpf, "DDS_DomainParticipantFactory_get_instance");
    participant = DDS_DomainParticipantFactory_create_participant (
        dpf,
        domain,
        DDS_PARTICIPANT_QOS_DEFAULT,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(
        participant, "DDS_DomainParticipantFactory_create_participant");

    /* Register the required datatype for ChatMessage. */
    chatMessageTS = Chat_ChatMessageTypeSupport__alloc();
    checkHandle(chatMessageTS, "Chat_ChatMessageTypeSupport__alloc");
    chatMessageTypeName =
        Chat_ChatMessageTypeSupport_get_type_name(chatMessageTS);
    status = Chat_ChatMessageTypeSupport_register_type(
        chatMessageTS,
        participant,
        chatMessageTypeName);
    checkStatus(status, "Chat_ChatMessageTypeSupport_register_type");

    /* Register the required datatype for NameService. */
    nameServiceTS = Chat_NameServiceTypeSupport__alloc();
    checkHandle(nameServiceTS, "Chat_NameServiceTypeSupport__alloc");
    nameServiceTypeName =
        Chat_NameServiceTypeSupport_get_type_name(nameServiceTS);
    status = Chat_NameServiceTypeSupport_register_type(
        nameServiceTS,
        participant,
        nameServiceTypeName);
    checkStatus(status, "Chat_NameServiceTypeSupport_register_type");

    /* Register the required datatype for NamedMessage. */
    namedMessageTS = Chat_NamedMessageTypeSupport__alloc();
    checkHandle(namedMessageTS, "Chat_NamedMessageTypeSupport__alloc");
    namedMessageTypeName =
        Chat_NamedMessageTypeSupport_get_type_name(namedMessageTS);
    status = Chat_NamedMessageTypeSupport_register_type(
        namedMessageTS,
        participant,
        namedMessageTypeName);
    checkStatus(status, "Chat_NamedMessageTypeSupport_register_type");

    /* Set the ReliabilityQosPolicy to RELIABLE. */
    reliable_topic_qos = DDS_TopicQos__alloc();
    checkHandle(reliable_topic_qos, "DDS_TopicQos__alloc");
    status = DDS_DomainParticipant_get_default_topic_qos(
        participant, reliable_topic_qos);
    checkStatus(status, "DDS_DomainParticipant_get_default_topic_qos");
    reliable_topic_qos->reliability.kind = DDS_RELIABLE_RELIABILITY_QOS;

    /* Make the tailored QoS the new default. */
    status = DDS_DomainParticipant_set_default_topic_qos(
        participant, reliable_topic_qos);
    checkStatus(status, "DDS_DomainParticipant_set_default_topic_qos");

    /* Use the changed policy when defining the ChatMessage topic */
    chatMessageTopic = DDS_DomainParticipant_create_topic(
        participant,
        "Chat_ChatMessage",
        chatMessageTypeName,
        reliable_topic_qos,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(
        chatMessageTopic, "DDS_DomainParticipant_create_topic (ChatMessage)");

    /* Set the DurabilityQosPolicy to TRANSIENT. */
    setting_topic_qos = DDS_TopicQos__alloc();
    checkHandle(setting_topic_qos, "DDS_TopicQos__alloc");
    status = DDS_DomainParticipant_get_default_topic_qos(participant,
setting_topic_qos);
    checkStatus(status, "DDS_DomainParticipant_get_default_topic_qos");
    setting_topic_qos->durability.kind = DDS_TRANSIENT_DURABILITY_QOS;

    /* Create the NameService Topic. */
    nameServiceTopic = DDS_DomainParticipant_create_topic(
        participant,
        "Chat_NameService",
        nameServiceTypeName,
        setting_topic_qos,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(nameServiceTopic, "DDS_DomainParticipant_create_topic");

    /* Create a multitopic that substitutes the userID with
       its corresponding userName. */
    namedMessageTopic = DDS_DomainParticipant_create_simulated_multitopic(
        participant,
        "Chat_NamedMessage",
        namedMessageTypeName,
        "SELECT userID, name AS userName, index, content "
            "FROM Chat_NameService NATURAL JOIN Chat_ChatMessage "
            "WHERE userID <> %0",
        parameterList);
    checkHandle(
        namedMessageTopic, "DDS_DomainParticipant_simulate_multitopic");

    /* Adapt the default SubscriberQos to read from the
       "ChatRoom" Partition. */
    partitionName = "ChatRoom";
    sub_qos = DDS_SubscriberQos__alloc();
    checkHandle(sub_qos, "DDS_SubscriberQos__alloc");
    status = DDS_DomainParticipant_get_default_subscriber_qos (
        participant, sub_qos);
    checkStatus(status, "DDS_DomainParticipant_get_default_subscriber_qos");
    sub_qos->partition.name._length = 1;
    sub_qos->partition.name._maximum = 1;
    sub_qos->partition.name._buffer = DDS_StringSeq_allocbuf (1);
    checkHandle(sub_qos->partition.name._buffer, "DDS_StringSeq_allocbuf");
    sub_qos->partition.name._buffer[0] =
        DDS_string_alloc( strlen(partitionName) );
    checkHandle(sub_qos->partition.name._buffer[0], "DDS_string_alloc");
    strcpy (sub_qos->partition.name._buffer[0], partitionName);

    /* Create a Subscriber for the MessageBoard application. */
    chatSubscriber = DDS_DomainParticipant_create_subscriber(
        participant, sub_qos, NULL, DDS_ANY_STATUS);
    checkHandle(chatSubscriber, "DDS_DomainParticipant_create_subscriber");

    /* Create a DataReader for the NamedMessage Topic
       (using the appropriate QoS). */
    chatAdmin = DDS_Subscriber_create_datareader(
        chatSubscriber,
        namedMessageTopic,
        DDS_DATAREADER_QOS_USE_TOPIC_QOS,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(chatAdmin, "DDS_Subscriber_create_datareader");

    /* Print a message that the MessageBoard has opened. */
    printf( "MessageBoard has opened: send a ChatMessage with "
                "userID = -1 to close it....\n\n" );

    /* Allocate the sequence holders for the DataReader */
    msgSeq = DDS_sequence_Chat_NamedMessage__alloc();
    checkHandle(msgSeq, "DDS_sequence_Chat_NamedMessage__alloc");
    infoSeq = DDS_SampleInfoSeq__alloc();
    checkHandle(infoSeq, "DDS_SampleInfoSeq__alloc");

    while (!terminated) {
        /* Note: using read does not remove the samples from
           unregistered instances from the DataReader. This means
           that the DataRase would use more and more resources.
           That's why we use take here instead. */

        status = Chat_NamedMessageDataReader_take(
            chatAdmin,
            msgSeq,
            infoSeq,
            DDS_LENGTH_UNLIMITED,
            DDS_ANY_SAMPLE_STATE,
            DDS_ANY_VIEW_STATE,
            DDS_ALIVE_INSTANCE_STATE );
        checkStatus(status, "Chat_NamedMessageDataReader_take");

        for (i = 0; i < msgSeq->_length; i++) {
            Chat_NamedMessage *msg = &(msgSeq->_buffer[i]);
            if (msg->userID == TERMINATION_MESSAGE) {
                printf("Termination message received: exiting...\n");
                terminated = TRUE;
            } else {
                printf ("%s: %s\n", msg->userName, msg->content);
            }
        }

        status = Chat_NamedMessageDataReader_return_loan(
            chatAdmin, msgSeq, infoSeq);
        checkStatus(status, "Chat_ChatMessageDataReader_return_loan");

        /* Sleep for some amount of time, as not to consume
           too much CPU cycles. */
        usleep(100000);
    }

    /* Remove the DataReader */
    status = DDS_Subscriber_delete_datareader(chatSubscriber, chatAdmin);
    checkStatus(status, "DDS_Subscriber_delete_datareader");

    /* Remove the Subscriber. */
    status = DDS_DomainParticipant_delete_subscriber(
        participant, chatSubscriber);
    checkStatus(status, "DDS_DomainParticipant_delete_subscriber");

    /* Remove the Topics. */
    status = DDS_DomainParticipant_delete_simulated_multitopic(
        participant, namedMessageTopic);
    checkStatus(status, "DDS_DomainParticipant_delete_simulated_multitopic");

    status = DDS_DomainParticipant_delete_topic(
        participant, nameServiceTopic);
    checkStatus(
        status, "DDS_DomainParticipant_delete_topic (nameServiceTopic)");

    status = DDS_DomainParticipant_delete_topic(
        participant, chatMessageTopic);
    checkStatus(
        status, "DDS_DomainParticipant_delete_topic (chatMessageTopic)");

    /* De-allocate the QoS policies. */
    DDS_free(reliable_topic_qos);
    DDS_free(setting_topic_qos);
    DDS_free(sub_qos);  // Note that DDS_free recursively de-allocates
                        // all indirections as well!!

    /* De-allocate the type-names and TypeSupport objects. */
    DDS_free(namedMessageTypeName);
    DDS_free(nameServiceTypeName);
    DDS_free(chatMessageTypeName);
    DDS_free(namedMessageTS);
    DDS_free(nameServiceTS);
    DDS_free(chatMessageTS);

    /* Remove the DomainParticipant. */
    status = DDS_DomainParticipantFactory_delete_participant(
        dpf, participant);
    checkStatus(status, "DDS_DomainParticipantFactory_delete_participant");

    return 0;
}
```

multitopic.h

```
/************************************************************************
 *
 * Copyright (c) 2007
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 * All rights Reserved.
 *
 * LOGICAL_NAME:    multitopic.h
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the C programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the headers for all operations required to simulate
 * the MultiTopic behavior.
 *
 ***/

#include "dds_dcps.h"

DDS_TopicDescription
DDS_DomainParticipant_create_simulated_multitopic(
    DDS_DomainParticipant participant,
    const DDS_char *name,
    const DDS_char *type_name,
    const DDS_char *subscription_expression,
    const DDS_StringSeq *expression_parameters
);

DDS_ReturnCode_t
DDS_DomainParticipant_delete_simulated_multitopic(
    DDS_DomainParticipant participant,
    DDS_TopicDescription smt
);

void on_message_available (
    void *listener_data,
    DDS_DataReader reader
);
```

multitopic.c

```
/************************************************************************
 *
 * Copyright (c) 2007
 * PrismTech Ltd.
 * All rights Reserved.
 *
 * LOGICAL_NAME:    multitopic.c
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the C programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the implementation for all operations required to
 * simulate the MultiTopic behavior.
 *
 ***/


#include <string.h>

#include "multitopic.h"
#include "Chat.h"
#include "dds_dcps.h"
#include "CheckStatus.h"

/* DataReaderListener */
static struct DDS_DataReaderListener *msgListener = NULL;

struct MsgListenerState
{
    /* Type-specific DDS entities */
    Chat_ChatMessageDataReader      chatMessageDR;
    Chat_NameServiceDataReader      nameServiceDR;
    Chat_NamedMessageDataWriter     namedMessageDW;

    /* Query related stuff */
    DDS_QueryCondition              nameFinder;
    DDS_StringSeq                   *nameFinderParams;
```

```
};

/* Generic DDS entities */
static DDS_Topic                       chatMessageTopic;
static DDS_Topic                       nameServiceTopic;
static DDS_ContentFilteredTopic        filteredMessageTopic;
static DDS_Topic                       namedMessageTopic;
static DDS_Subscriber                  multiSub;
static DDS_Publisher                   multiPub;


DDS_MultiTopic
DDS_DomainParticipant_create_simulated_multitopic (
    DDS_DomainParticipant participant,
    const DDS_char *name,
    const DDS_char *type_name,
    const DDS_char *subscription_expression,
    const DDS_StringSeq *expression_parameters )
{
    /* Type-specific DDS entities */
    static Chat_ChatMessageDataReader       chatMessageDR;
    static Chat_NameServiceDataReader       nameServiceDR;
    static Chat_NamedMessageDataWriter      namedMessageDW;

    /* Query related stuff */
    static DDS_QueryCondition               nameFinder;
    static DDS_StringSeq                    *nameFinderParams;

    /* QosPolicy holders */
    DDS_TopicQos                    *namedMessageQos;
    DDS_SubscriberQos               *sub_qos;
    DDS_PublisherQos                *pub_qos;

    /* Others */
    const char                      *partitionName = "ChatRoom";
    const char                      *nameFinderExpr;
    DDS_Duration_t                  infiniteTimeOut  = DDS_DURATION_INFINITE;
    DDS_ReturnCode_t                status;

    /* Lookup both components that constitute the multi-topic. */
    chatMessageTopic = DDS_DomainParticipant_find_topic(
        participant,
        "Chat_ChatMessage",
        &infiniteTimeOut);
    checkHandle(
        chatMessageTopic,
        "DDS_DomainParticipant_find_topic (Chat_ChatMessage)");

    nameServiceTopic = DDS_DomainParticipant_find_topic(
        participant,
        "Chat_NameService",
        &infiniteTimeOut);
    checkHandle(
        nameServiceTopic,
        "DDS_DomainParticipant_find_topic (Chat_NameService)");

    /* Create a ContentFilteredTopic to filter out our own ChatMessages. */
    filteredMessageTopic = DDS_DomainParticipant_create_contentfilteredtopic(
        participant,
        "Chat_FilteredMessage",
        chatMessageTopic,
        "userID <> %0",
        expression_parameters);
    checkHandle(
        filteredMessageTopic,
        "DDS_DomainParticipant_create_contentfilteredtopic");


   /* Adapt the default SubscriberQos to read from the "ChatRoom" Partition. */
    sub_qos = DDS_SubscriberQos__alloc();
    checkHandle(sub_qos, "DDS_SubscriberQos__alloc");
    status = DDS_DomainParticipant_get_default_subscriber_qos(
        participant, sub_qos);
    checkStatus(status, "DDS_DomainParticipant_get_default_subscriber_qos");
    sub_qos->partition.name._length = 1;
    sub_qos->partition.name._maximum = 1;
    sub_qos->partition.name._buffer = DDS_StringSeq_allocbuf (1);
    checkHandle(sub_qos->partition.name._buffer, "DDS_StringSeq_allocbuf");
    sub_qos->partition.name._buffer[0] =
        DDS_string_alloc ( strlen(partitionName) );
    checkHandle(sub_qos->partition.name._buffer[0], "DDS_string_alloc");
    strcpy (sub_qos->partition.name._buffer[0], partitionName);

    /* Create a private Subscriber for the multitopic simulator. */
    multiSub = DDS_DomainParticipant_create_subscriber(
        participant, sub_qos, NULL, DDS_ANY_STATUS);
    checkHandle(
        multiSub, "DDS_DomainParticipant_create_subscriber (for multitopic)");

    /* Create a DataReader for the FilteredMessage Topic
       (using the appropriate QoS). */
    chatMessageDR = DDS_Subscriber_create_datareader(
        multiSub,
        filteredMessageTopic,
        DDS_DATAREADER_QOS_USE_TOPIC_QOS,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(
        chatMessageDR, "DDS_Subscriber_create_datareader (ChatMessage)");

    /* Create a DataReader for the nameService Topic
       (using the appropriate QoS). */
    nameServiceDR = DDS_Subscriber_create_datareader(
        multiSub,
        nameServiceTopic,
        DDS_DATAREADER_QOS_USE_TOPIC_QOS,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(
        nameServiceDR, "DDS_Subscriber_create_datareader (NameService)");

    /* Define the SQL expression (using a parameterized value). */
    nameFinderExpr = "userID = %0";

    /* Allocate and assign the query parameters. */
    nameFinderParams = DDS_StringSeq__alloc();
    checkHandle(nameFinderParams, "DDS_StringSeq__alloc");
    nameFinderParams->_length = 1;
    nameFinderParams->_maximum = 1;
    nameFinderParams->_buffer = DDS_StringSeq_allocbuf (1);
    checkHandle(nameFinderParams->_buffer, "DDS_StringSeq_allocbuf");
    nameFinderParams->_buffer[0] =
        DDS_string_alloc( strlen(expression_parameters->_buffer[0]) );
    checkHandle(nameFinderParams->_buffer[0], "DDS_string_alloc");
    strcpy(nameFinderParams->_buffer[0], expression_parameters->_buffer[0]);
    DDS_sequence_set_release(nameFinderParams, TRUE);

    /* Create a QueryCondition to only read corresponding nameService
       information by key-value. */
    nameFinder = DDS_DataReader_create_querycondition(
        nameServiceDR,
        DDS_ANY_SAMPLE_STATE,
        DDS_ANY_VIEW_STATE,
        DDS_ANY_INSTANCE_STATE,
        nameFinderExpr,
        nameFinderParams);
    checkHandle(
        nameFinder, "DDS_DataReader_create_querycondition (nameFinder)");

    /* Create the Topic that simulates the multi-topic
       (use Qos from chatMessage).*/
    namedMessageQos = DDS_TopicQos__alloc();
    checkHandle(namedMessageQos, "DDS_TopicQos__alloc");
    status = DDS_Topic_get_qos(chatMessageTopic, namedMessageQos);
    checkStatus(status, "DDS_Topic_get_qos");

    /* Create the NamedMessage Topic whose samples simulate the MultiTopic */
    namedMessageTopic = DDS_DomainParticipant_create_topic(
        participant,
        "Chat_NamedMessage",
        type_name,
        namedMessageQos,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(
        namedMessageTopic,
        "DDS_DomainParticipant_create_topic (NamedMessage)");

    /* Adapt the default PublisherQos to write into the
       "ChatRoom" Partition. */
    pub_qos = DDS_PublisherQos__alloc();
    checkHandle(pub_qos, "DDS_PublisherQos__alloc");
    status = DDS_DomainParticipant_get_default_publisher_qos (
        participant, pub_qos);
    checkStatus(status, "DDS_DomainParticipant_get_default_publisher_qos");
    pub_qos->partition.name._length = 1;
    pub_qos->partition.name._maximum = 1;
    pub_qos->partition.name._buffer = DDS_StringSeq_allocbuf (1);
    checkHandle(pub_qos->partition.name._buffer, "DDS_StringSeq_allocbuf");
    pub_qos->partition.name._buffer[0] =
        DDS_string_alloc( strlen(partitionName) );
    checkHandle(pub_qos->partition.name._buffer[0], "DDS_string_alloc");
    strcpy (pub_qos->partition.name._buffer[0], partitionName);

    /* Create a private Publisher for the multitopic simulator. */
    multiPub = DDS_DomainParticipant_create_publisher(
        participant, pub_qos, NULL, DDS_ANY_STATUS);
    checkHandle(
        multiPub,
        "DDS_DomainParticipant_create_publisher (for multitopic)");

    /* Create a DataWriter for the multitopic. */
    namedMessageDW = DDS_Publisher_create_datawriter(
        multiPub,
        namedMessageTopic,
        DDS_DATAWRITER_QOS_USE_TOPIC_QOS,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(
        namedMessageDW,
        "DDS_Publisher_create_datawriter (NamedMessage)");

    /* Allocate the DataReaderListener interface. */
    msgListener = DDS_DataReaderListener__alloc();
    checkHandle(msgListener, "DDS_DataReaderListener__alloc");

    /* Fill the listener_data with pointers to all entities needed
       by the Listener implementation. */
    struct MsgListenerState *listener_state =
        malloc(sizeof(struct MsgListenerState));
    checkHandle(listener_state, "malloc");
    listener_state->chatMessageDR = chatMessageDR;
    listener_state->nameServiceDR = nameServiceDR;
    listener_state->namedMessageDW = namedMessageDW;
    listener_state->nameFinder = nameFinder;
    listener_state->nameFinderParams = nameFinderParams;
    msgListener->listener_data = listener_state;

    /* Assign the function pointer attributes to their
       implementation functions. */
    msgListener->on_data_available =
        (void (*)(void *, DDS_DataReader)) on_message_available;
    msgListener->on_requested_deadline_missed = NULL;
    msgListener->on_requested_incompatible_qos = NULL;
    msgListener->on_sample_rejected = NULL;
    msgListener->on_liveliness_changed = NULL;
    msgListener->on_subscription_match = NULL;
    msgListener->on_sample_lost = NULL;

    /* Attach the DataReaderListener to the DataReader, only enabling
       the data_available event. */
    status = DDS_DataReader_set_listener(
        chatMessageDR, msgListener, DDS_DATA_AVAILABLE_STATUS);
    checkStatus(status, "DDS_DataReader_set_listener");

    /* Free up all resources that are no longer needed. */
    DDS_free(namedMessageQos);
    DDS_free(sub_qos);
    DDS_free(pub_qos);

    /* Return the simulated Multitopic. */
    return namedMessageTopic;
};

DDS_ReturnCode_t
DDS_DomainParticipant_delete_simulated_multitopic(
    DDS_DomainParticipant participant,
    DDS_TopicDescription smt
)
{
    DDS_ReturnCode_t status;
    struct MsgListenerState *listener_state;

    /* Obtain all entities mentioned in the listener state. */
    listener_state = (struct MsgListenerState *) msgListener->listener_data;

    /* Remove the DataWriter */
    status = DDS_Publisher_delete_datawriter(
        multiPub, listener_state->namedMessageDW);
    checkStatus(status, "DDS_Publisher_delete_datawriter");

    /* Remove the Publisher. */
    status = DDS_DomainParticipant_delete_publisher(participant, multiPub);
    checkStatus(status, "DDS_DomainParticipant_delete_publisher");

    /* Remove the QueryCondition and its parameters. */
    DDS_free(listener_state->nameFinderParams);
    status = DDS_DataReader_delete_readcondition(
        listener_state->nameServiceDR,
        listener_state->nameFinder);
    checkStatus(status, "DDS_DataReader_delete_readcondition");

    /* Remove the DataReaders. */
    status = DDS_Subscriber_delete_datareader(
        multiSub, listener_state->nameServiceDR);
    checkStatus(status, "DDS_Subscriber_delete_datareader");
    status = DDS_Subscriber_delete_datareader(
        multiSub, listener_state->chatMessageDR);
    checkStatus(status, "DDS_Subscriber_delete_datareader");

    /* Remove the DataReaderListener and its state. */
    free(listener_state);
    DDS_free(msgListener);

    /* Remove the Subscriber. */
    status = DDS_DomainParticipant_delete_subscriber(participant, multiSub);
    checkStatus(status, "DDS_DomainParticipant_delete_subscriber");

    /* Remove the ContentFilteredTopic. */
    status = DDS_DomainParticipant_delete_contentfilteredtopic(
        participant, filteredMessageTopic);
    checkStatus(status, "DDS_DomainParticipant_delete_contentfilteredtopic");

    /* Remove all other topics. */
    status = DDS_DomainParticipant_delete_topic(
        participant, namedMessageTopic);
    checkStatus(
        status,
        "DDS_DomainParticipant_delete_topic (namedMessageTopic)");
    status = DDS_DomainParticipant_delete_topic(
        participant, nameServiceTopic);
    checkStatus(
        status,
        "DDS_DomainParticipant_delete_topic (nameServiceTopic)");
    status = DDS_DomainParticipant_delete_topic(
        participant,
        chatMessageTopic);
    checkStatus(
        status,
        "DDS_DomainParticipant_delete_topic (chatMessageTopic)");

    return status;
};


```

```
/* Implementation for the callback function "on_data_available". */
void on_message_available (
    void *listener_data,
    DDS_DataReader reader )
{
    struct MsgListenerState        *listener_state;
    DDS_sequence_Chat_ChatMessage  msgSeq   = { 0, 0, DDS_OBJECT_NIL, FALSE };
    DDS_sequence_Chat_NameService  nameSeq  = { 0, 0, DDS_OBJECT_NIL, FALSE };
    DDS_SampleInfoSeq              infoSeq1 = { 0, 0, DDS_OBJECT_NIL, FALSE };
    DDS_SampleInfoSeq              infoSeq2 = { 0, 0, DDS_OBJECT_NIL, FALSE };
    DDS_ReturnCode_t               status;
    DDS_unsigned_long              i;
    DDS_long                       previous = 0x80000000;
    DDS_string                     userName = DDS_string_alloc(1);


    /* Obtain all entities mentioned in the listener state. */
    listener_state = (struct MsgListenerState *) listener_data;

    /* Take all messages. */
    status = Chat_ChatMessageDataReader_take(
        listener_state->chatMessageDR,
        &msgSeq,
        &infoSeq1,
        DDS_LENGTH_UNLIMITED,
        DDS_ANY_SAMPLE_STATE,
        DDS_ANY_VIEW_STATE,
        DDS_ANY_INSTANCE_STATE);
    checkStatus(status, "Chat_ChatMessageDataReader_take");

    /* For each message, extract the key-field and find
       the corresponding name. */
    for (i = 0; i < msgSeq._length; i++)
    {
        if (infoSeq1._buffer[i].valid_data)
        {
            Chat_NamedMessage joinedSample;

            /* Find the corresponding named message. */
            if (msgSeq._buffer[i].userID != previous)
            {
                previous = msgSeq._buffer[i].userID;
                snprintf(
                    listener_state->nameFinderParams->_buffer[0],
                    15,
                    "%d",
                    previous);
                status = DDS_QueryCondition_set_query_parameters(
                    listener_state->nameFinder,
                    listener_state->nameFinderParams);
               checkStatus(status, "DDS_QueryCondition_set_query_parameters");
                status = Chat_NameServiceDataReader_read_w_condition(
                    listener_state->nameServiceDR,
                    &nameSeq,
                    &infoSeq2,
                    DDS_LENGTH_UNLIMITED,
                    listener_state->nameFinder);
                checkStatus(
                    status, "Chat_NameServiceDataReader_read_w_condition");

                /* Extract Name (there should only be one result). */
```

```
                    DDS_free(userName);
                    if (status == DDS_RETCODE_NO_DATA)
                    {
                        userName = DDS_string_alloc(40);
                        checkHandle(userName, "DDS_string_alloc");
                      snprintf(userName, 40, "Name not found!! id = %d", previous);
                    }
                    else
                    {
                     userName = DDS_string_alloc(strlen(nameSeq._buffer[0].name));
                        checkHandle(userName, "DDS_string_alloc");
                        strcpy(userName, nameSeq._buffer[0].name);
                    }

                    /* Release the name sample again. */
                    status = Chat_NameServiceDataReader_return_loan(
                        listener_state->nameServiceDR, &nameSeq, &infoSeq2);
                    checkStatus(status, "Chat_NameServiceDataReader_return_loan");
                }
                /* Write merged Topic with both userName and userID. */
                /* StringCopy not required since sample runs out of
                   scope before string is released. */
                joinedSample.userName = userName;
                joinedSample.userID = msgSeq._buffer[i].userID;
                joinedSample.index = msgSeq._buffer[i].index;
                joinedSample.content = msgSeq._buffer[i].content;
                    status = Chat_NamedMessageDataWriter_write(
                    listener_state->namedMessageDW,
                    &joinedSample,
                    DDS_HANDLE_NIL);
                checkStatus(status, "Chat_NamedMessageDataWriter_write");
            }
        }
    status = Chat_ChatMessageDataReader_return_loan(
        listener_state->chatMessageDR, &msgSeq, &infoSeq1);
    checkStatus(status, "Chat_ChatMessageDataReader_return_loan");
}
```

UserLoad.c

```
/************************************************************************
 *
 * Copyright (c) 2007
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 *
 * LOGICAL_NAME:    UserLoad.c
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the C programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the implementation for the 'UserLoad' executable.
 *
 ***/

#include <stdio.h>
#include <unistd.h>
```

```
#include <pthread.h>
#include <string.h>
#include <assert.h>

#include "dds_dcps.h"
#include "CheckStatus.h"
#include "Chat.h"

/* entities required by all threads. */
static DDS_GuardCondition           escape;

/* Sleeper thread: sleeps 60 seconds and then triggers the WaitSet. */
void *
delayedEscape(
    void *arg)
{
    DDS_ReturnCode_t status;

    sleep(60);     /* wait for 60 sec. */
    status = DDS_GuardCondition_set_trigger_value(escape, TRUE);
    checkStatus(status, "DDS_GuardCondition_set_trigger_value");

    return NULL;
}

int
main (
    int argc,
    char *argv[])
{
    /* Generic DDS entities */
    DDS_DomainParticipant           participant;
    DDS_Topic                       chatMessageTopic;
    DDS_Topic                       nameServiceTopic;
    DDS_Subscriber                  chatSubscriber;
    DDS_QueryCondition              singleUser;
    DDS_ReadCondition               newUser;
    DDS_StatusCondition             leftUser;
    DDS_GuardCondition              guard;
    DDS_WaitSet                     userLoadWS;
    DDS_LivelinessChangedStatus     livChangStatus;

    /* QosPolicy holders */
    DDS_TopicQos                    *setting_topic_qos;
    DDS_TopicQos                    *reliable_topic_qos;
    DDS_SubscriberQos               *sub_qos;
    DDS_DataReaderQos               *message_qos;

    /* DDS Identifiers */
    DDS_DomainId_t                  domain = NULL;
    DDS_ReturnCode_t                status;
    DDS_ConditionSeq                *guardList = NULL;
    DDS_Duration_t                  timeout = DDS_DURATION_INFINITE;

    /* Type-specific DDS entities */
    Chat_ChatMessageTypeSupport     chatMessageTS;
    Chat_NameServiceTypeSupport     nameServiceTS;
    Chat_NameServiceDataReader      nameServer;
    Chat_ChatMessageDataReader      loadAdmin;
    DDS_sequence_Chat_ChatMessage   msgList  = { 0, 0, DDS_OBJECT_NIL, FALSE };
    DDS_sequence_Chat_NameService   nsList   = { 0, 0, DDS_OBJECT_NIL, FALSE };
    DDS_SampleInfoSeq               infoSeq  = { 0, 0, DDS_OBJECT_NIL, FALSE };
    DDS_SampleInfoSeq               infoSeq2 = { 0, 0, DDS_OBJECT_NIL, FALSE };

    /* Others */
    DDS_StringSeq                    args;
    int                              closed = 0;
    DDS_unsigned_long                i, j;
    DDS_long                         prevCount = 0;
    char                             *partitionName;
    char                             *chatMessageTypeName = NULL;
    char                             *nameServiceTypeName = NULL;
    pthread_t                        tid;

    /* Create a DomainParticipant (using the
       'TheParticipantFactory' convenience macro). */
    participant = DDS_DomainParticipantFactory_create_participant (
        DDS_TheParticipantFactory,
        domain,
        DDS_PARTICIPANT_QOS_DEFAULT,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(
        participant, "DDS_DomainParticipantFactory_create_participant");

    /* Register the required datatype for ChatMessage. */
    chatMessageTS = Chat_ChatMessageTypeSupport__alloc();
    checkHandle(chatMessageTS, "Chat_ChatMessageTypeSupport__alloc");
    chatMessageTypeName =
        Chat_ChatMessageTypeSupport_get_type_name(chatMessageTS);
    status = Chat_ChatMessageTypeSupport_register_type(
        chatMessageTS,
        participant,
        chatMessageTypeName);
    checkStatus(status, "Chat_ChatMessageTypeSupport_register_type");

    /* Register the required datatype for NameService. */
    nameServiceTS = Chat_NameServiceTypeSupport__alloc();
    checkHandle(nameServiceTS, "Chat_NameServiceTypeSupport__alloc");
    nameServiceTypeName =
        Chat_NameServiceTypeSupport_get_type_name(nameServiceTS);
    status = Chat_NameServiceTypeSupport_register_type(
        nameServiceTS,
        participant,
        nameServiceTypeName);
    checkStatus(status, "Chat_NameServiceTypeSupport_register_type");

    /* Set the ReliabilityQosPolicy to RELIABLE. */
    reliable_topic_qos = DDS_TopicQos__alloc();
    checkHandle(reliable_topic_qos, "DDS_TopicQos__alloc");
    status = DDS_DomainParticipant_get_default_topic_qos(
        participant, reliable_topic_qos);
    checkStatus(status, "DDS_DomainParticipant_get_default_topic_qos");
    reliable_topic_qos->reliability.kind = DDS_RELIABLE_RELIABILITY_QOS;

    /* Make the tailored QoS the new default. */
    status = DDS_DomainParticipant_set_default_topic_qos(
        participant, reliable_topic_qos);
    checkStatus(status, "DDS_DomainParticipant_set_default_topic_qos");

    /* Use the changed policy when defining the ChatMessage topic */
    chatMessageTopic = DDS_DomainParticipant_create_topic(
        participant,
        "Chat_ChatMessage",
        chatMessageTypeName,
        reliable_topic_qos,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(
        chatMessageTopic,
        "DDS_DomainParticipant_create_topic (ChatMessage)");

    /* Set the DurabilityQosPolicy to TRANSIENT. */
    setting_topic_qos = DDS_TopicQos__alloc();
    checkHandle(setting_topic_qos, "DDS_TopicQos__alloc");
    status = DDS_DomainParticipant_get_default_topic_qos(
        participant, setting_topic_qos);
    checkStatus(status, "DDS_DomainParticipant_get_default_topic_qos");
    setting_topic_qos->durability.kind = DDS_TRANSIENT_DURABILITY_QOS;

    /* Create the NameService Topic. */
    nameServiceTopic = DDS_DomainParticipant_create_topic(
        participant,
        "Chat_NameService",
        nameServiceTypeName,
        setting_topic_qos,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(nameServiceTopic, "DDS_DomainParticipant_create_topic");

    /* Adapt the default SubscriberQos to read from the
       "ChatRoom" Partition. */
    partitionName = "ChatRoom";
    sub_qos = DDS_SubscriberQos__alloc();
    checkHandle(sub_qos, "DDS_SubscriberQos__alloc");
    status = DDS_DomainParticipant_get_default_subscriber_qos(
        participant, sub_qos);
    checkStatus(status, "DDS_DomainParticipant_get_default_subscriber_qos");
    sub_qos->partition.name._length = 1;
    sub_qos->partition.name._maximum = 1;
    sub_qos->partition.name._buffer = DDS_StringSeq_allocbuf (1);
    checkHandle(sub_qos->partition.name._buffer, "DDS_StringSeq_allocbuf");
    sub_qos->partition.name._buffer[0] =
        DDS_string_alloc(strlen(partitionName) + 1);
    checkHandle(sub_qos->partition.name._buffer[0], "DDS_string_alloc");
    strcpy (sub_qos->partition.name._buffer[0], partitionName);

    /* Create a Subscriber for the UserLoad application. */
    chatSubscriber = DDS_DomainParticipant_create_subscriber(
        participant, sub_qos, NULL, DDS_ANY_STATUS);
    checkHandle(chatSubscriber, "DDS_DomainParticipant_create_subscriber");

    /* Create a DataReader for the NameService Topic
       (using the appropriate QoS). */
    nameServer = DDS_Subscriber_create_datareader(
        chatSubscriber,
        nameServiceTopic,
        DDS_DATAREADER_QOS_USE_TOPIC_QOS,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(nameServer, "DDS_Subscriber_create_datareader (NameService)");

    /* Adapt the DataReaderQos for the ChatMessageDataReader
```

```
       to keep track of all messages. */
    message_qos = DDS_DataReaderQos__alloc();
    checkHandle(message_qos, "DDS_DataReaderQos__alloc");
    status = DDS_Subscriber_get_default_datareader_qos(
        chatSubscriber, message_qos);
    checkStatus(status, "DDS_Subscriber_get_default_datareader_qos");
    status = DDS_Subscriber_copy_from_topic_qos(
        chatSubscriber, message_qos, reliable_topic_qos);
    checkStatus(status, "DDS_Subscriber_copy_from_topic_qos");
    message_qos->history.kind = DDS_KEEP_ALL_HISTORY_QOS;

    /* Create a DataReader for the ChatMessage Topic
       (using the appropriate QoS). */
    loadAdmin = DDS_Subscriber_create_datareader(
        chatSubscriber,
        chatMessageTopic,
        message_qos,
        NULL,
        DDS_ANY_STATUS);
    checkHandle(loadAdmin, "DDS_Subscriber_create_datareader (ChatMessage)");

    /* Initialize the Query Arguments. */
    args._length = 1;
    args._maximum = 1;
    args._buffer = DDS_StringSeq_allocbuf(1);
    checkHandle(args._buffer, "DDS_StringSeq_allocbuf");
    args._buffer[0] = DDS_string_alloc (12);  // Enough for max size numbers.
    checkHandle(args._buffer[0], "DDS_string_alloc");
    sprintf(args._buffer[0], "%d", 0);

    /* Create a QueryCondition that will contain all messages
       with userID = ownID */
    singleUser = DDS_DataReader_create_querycondition(
        loadAdmin,
        DDS_ANY_SAMPLE_STATE,
        DDS_ANY_VIEW_STATE,
        DDS_ANY_INSTANCE_STATE,
        "userID=%0",
        &args);
    checkHandle(
        singleUser,
        "DDS_DataReader_create_querycondition (singleUser Query)");

    /* Create a ReadCondition that will contain new users only */
    newUser = DDS_DataReader_create_readcondition(
        nameServer,
        DDS_NOT_READ_SAMPLE_STATE,
        DDS_NEW_VIEW_STATE,
        DDS_ALIVE_INSTANCE_STATE);
    checkHandle(newUser, "DDS_DataReader_create_readcondition (newUser)");

    /* Obtain a StatusCondition that triggers only when
       a Writer changes Liveliness */
    leftUser = DDS_DataReader_get_statuscondition(loadAdmin);
    checkHandle(leftUser, "DDS_DataReader_get_statuscondition");
    status = DDS_StatusCondition_set_enabled_statuses(
        leftUser, DDS_LIVELINESS_CHANGED_STATUS);
    checkStatus(status, "DDS_StatusCondition_set_enabled_statuses");

    /* Create a bare guard which will be used to close the room */
    escape = DDS_GuardCondition__alloc();
    checkHandle(escape, "DDS_GuardCondition__alloc");

    /* Create a waitset and add the ReadConditions */
    userLoadWS = DDS_WaitSet__alloc();
    checkHandle(userLoadWS, "DDS_WaitSet__alloc");
    status = DDS_WaitSet_attach_condition(userLoadWS, newUser);
    checkStatus(status, "DDS_WaitSet_attach_condition (newUser)");
    status = DDS_WaitSet_attach_condition(userLoadWS, leftUser);
    checkStatus(status, "DDS_WaitSet_attach_condition (leftUser)");
    status = DDS_WaitSet_attach_condition(userLoadWS, escape);
    checkStatus(status, "DDS_WaitSet_attach_condition (escape)");

    /* Initialize and pre-allocate the GuardList used to obtain
       the triggered Conditions. */
    guardList = DDS_ConditionSeq__alloc();
    checkHandle(guardList, "DDS_ConditionSeq__alloc");
    guardList->_maximum = 3;
    guardList->_length = 0;
    guardList->_buffer = DDS_ConditionSeq_allocbuf(3);
    checkHandle(guardList->_buffer, "DDS_ConditionSeq_allocbuf");

    /* Remove all known Users that are not currently active. */
    status = Chat_NameServiceDataReader_take(
        nameServer,
        &nsList,
        &infoSeq,
        DDS_LENGTH_UNLIMITED,
        DDS_ANY_SAMPLE_STATE,
        DDS_ANY_VIEW_STATE,
        DDS_NOT_ALIVE_INSTANCE_STATE);
    checkStatus(status, "Chat_NameServiceDataReader_take");
    status = Chat_NameServiceDataReader_return_loan(
        nameServer, &nsList, &infoSeq);
    checkStatus(status, "Chat_NameServiceDataReader_return_loan");

    /* Start the sleeper thread. */
    pthread_create (&tid, NULL, delayedEscape, NULL);

    while (!closed) {
        /* Wait until at least one of the Conditions in the
           waitset triggers. */
        status = DDS_WaitSet_wait(userLoadWS, guardList, &timeout);
        checkStatus(status, "DDS_WaitSet_wait");

        /* Walk over all guards to display information */
        for (i = 0; i < guardList->_length; i++) {
            guard = guardList->_buffer[i];
            if (guard == newUser) {
                /* The newUser ReadCondition contains data */
                status = Chat_NameServiceDataReader_read_w_condition(
                    nameServer,
                    &nsList,
                    &infoSeq,
                    DDS_LENGTH_UNLIMITED,
                    newUser);
                checkStatus(
                    status, "Chat_NameServiceDataReader_read_w_condition");

                for (j = 0; j < nsList._length; j++) {
                    printf ("New user: %s\n", nsList._buffer[j].name);
                }
```

```
                    status = Chat_NameServiceDataReader_return_loan(
                        nameServer, &nsList, &infoSeq);
                    checkStatus(status, "Chat_NameServiceDataReader_return_loan");

                } else if (guard == leftUser) {
                    /* Some liveliness has changed (either a DataWriter joined
                       or a DataWriter left) */
                    status = DDS_DataReader_get_liveliness_changed_status(
                        loadAdmin, &livChangStatus);
                    checkStatus(
                        status, "DDS_DataReader_get_liveliness_changed_status");
                    if (livChangStatus.alive_count < prevCount) {
                        /* A user has left the ChatRoom, since a DataWriter lost
                           its liveliness. Take the effected users so they will
                           not appear in the list later on. */
                        status = Chat_NameServiceDataReader_take(
                            nameServer,
                            &nsList,
                            &infoSeq,
                            DDS_LENGTH_UNLIMITED,
                            DDS_ANY_SAMPLE_STATE,
                            DDS_ANY_VIEW_STATE,
                            DDS_NOT_ALIVE_NO_WRITERS_INSTANCE_STATE);
                        checkStatus(status, "Chat_NameServiceDataReader_take");

                        for (j = 0; j < nsList._length; j++) {
                            /* re-apply query arguments */
                            sprintf(
                                args._buffer[0],
                                "%d",
                                nsList._buffer[j].userID);
                            status = DDS_QueryCondition_set_query_parameters(
                                singleUser, &args);
                            checkStatus(
                               status, "DDS_QueryCondition_set_query_parameters");

                            /* Read this users history */
                            status = Chat_ChatMessageDataReader_take_w_condition(
                                loadAdmin,
                                &msgList,
                                &infoSeq2,
                                DDS_LENGTH_UNLIMITED,
                                singleUser);
                            checkStatus(
                                status,
                                "Chat_ChatMessageDataReader_take_w_condition");

                            /* Display the user and his history */
                            printf (
                                "Departed user %s has sent %d messages\n",
                                nsList._buffer[j].name,
                                msgList._length);
                            status = Chat_ChatMessageDataReader_return_loan(
                                loadAdmin, &msgList, &infoSeq2);
                            checkStatus(
                                status, "Chat_ChatMessageDataReader_return_loan");
                        }
                        status = Chat_NameServiceDataReader_return_loan(
                            nameServer, &nsList, &infoSeq);
                        checkStatus(
                            status, "Chat_NameServiceDataReader_return_loan");
                    }
                    prevCount = livChangStatus.alive_count;

                } else if (guard == escape) {
                    printf ("UserLoad has terminated.\n");
                    closed = 1;
                }
                else
                {
                    assert(0);
                };
            } /* for */
        } /* while (!closed) */

        /* Remove all Conditions from the WaitSet. */
        status = DDS_WaitSet_detach_condition(userLoadWS, escape);
        checkStatus(status, "DDS_WaitSet_detach_condition (escape)");
        status = DDS_WaitSet_detach_condition(userLoadWS, leftUser);
        checkStatus(status, "DDS_WaitSet_detach_condition (leftUser)");
        status = DDS_WaitSet_detach_condition(userLoadWS, newUser);
        checkStatus(status, "DDS_WaitSet_detach_condition (newUser)");

        /* Free all resources */
        DDS_free(guardList);
        DDS_free(args._buffer);
        DDS_free(userLoadWS);
        DDS_free(escape);
        DDS_free(setting_topic_qos);
        DDS_free(reliable_topic_qos);
        DDS_free(nameServiceTypeName);
        DDS_free(chatMessageTypeName);
        DDS_free(nameServiceTS);
        DDS_free(chatMessageTS);
        status = DDS_DomainParticipant_delete_contained_entities(participant);
        checkStatus(status, "DDS_DomainParticipant_delete_contained_entities");
        status = DDS_DomainParticipantFactory_delete_participant(
            DDS_TheParticipantFactory,
            participant);
        checkStatus(status, "DDS_DomainParticipantFactory_delete_participant");

        return 0;
    }
```

Appendix

B C++ Language Examples' Code

This appendix lists the complete C++ source code for the examples provided in the C++ version of the OpenSplice DDS tutorial.

Chat.idl

```
/************************************************************************
 *
 * Copyright (c) 2006
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 * All rights Reserved.
 *
 * LOGICAL_NAME:    Chat.idl
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the C++ programming language.
 * DATE             june 2006.
 ************************************************************************
 *
 * This file contains the data definitions for the tutorial examples.
 *
 ***/

module Chat {

    const long MAX_NAME = 32;
    typedef string<MAX_NAME> nameType;

    struct ChatMessage {
        long      userID;          // owner of message
        long      index;           // message number
        string    content;         // message body
    };
#pragma keylist ChatMessage userID

    struct NameService {
        long     userID;           // unique user identification
        nameType name;             // name of the user
    };
#pragma keylist NameService userID

    struct NamedMessage {
        long     userID;           // unique user identification
        nameType userName;         // user name
        long     index;            // message number
        string   content;          // message body
    };
#pragma keylist NamedMessage userID

};
```

CheckStatus.h

```
/************************************************************************
 *
 * Copyright (c) 2007
 * PrismTech Ltd.
 * All rights Reserved.
 *
 * LOGICAL_NAME:    CheckStatus.h
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the C++ programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the headers for the error handling operations.
 *
 ***/

#ifndef __CHECKSTATUS_H__
#define __CHECKSTATUS_H__

#include "ccpp_dds_dcps.h"
#include <iostream>

using namespace std;

/**
 * Returns the name of an error code.
 **/
char *getErrorName(DDS::ReturnCode_t status);

/**
 * Check the return status for errors. If there is an error, then terminate.
 **/
void checkStatus(DDS::ReturnCode_t status, const char *info);

/**
 * Check whether a valid handle has been returned. If not, then terminate.
 **/
void checkHandle(void *handle, char *info);

#endif
```

CheckStatus.cpp

```
/************************************************************************
 *
 * Copyright (c) 2007
 * PrismTech Ltd.
 * All rights Reserved.
 *
 * LOGICAL_NAME:    CheckStatus.cpp
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the C++ programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the implementation for the error handling operations.
 *
 ***/

#include "CheckStatus.h"

/* Array to hold the names for all ReturnCodes. */
char *RetCodeName[13] = {
    "DDS_RETCODE_OK",
    "DDS_RETCODE_ERROR",
    "DDS_RETCODE_UNSUPPORTED",
    "DDS_RETCODE_BAD_PARAMETER",
    "DDS_RETCODE_PRECONDITION_NOT_MET",
    "DDS_RETCODE_OUT_OF_RESOURCES",
    "DDS_RETCODE_NOT_ENABLED",
    "DDS_RETCODE_IMMUTABLE_POLICY",
    "DDS_RETCODE_INCONSISTENT_POLICY",
    "DDS_RETCODE_ALREADY_DELETED",
    "DDS_RETCODE_TIMEOUT",
    "DDS_RETCODE_NO_DATA",
    "DDS_RETCODE_ILLEGAL_OPERATION" };

/**
 * Returns the name of an error code.
 **/
char *getErrorName(DDS::ReturnCode_t status)
{
    return RetCodeName[status];
}

/**
 * Check the return status for errors. If there is an error, then terminate.
 **/
void checkStatus(
    DDS::ReturnCode_t status,
    const char *info ) {


    if (status != DDS::RETCODE_OK && status != DDS::RETCODE_NO_DATA) {
        cerr << "Error in " << info << ": " << getErrorName(status) << endl;
        exit (0);
    }
}

/**
 * Check whether a valid handle has been returned. If not, then terminate.
 **/
void checkHandle(
    void *handle,
    char *info ) {

     if (!handle) {
        cerr << "Error in " << info <<
            ": Creation failed: invalid handle" << endl;
        exit (0);
     }
}
```

Chatter.cpp

```
/************************************************************************
 *
 * Copyright (c) 2007
 * PrismTech Ltd.
 * All rights Reserved.
 *
 * LOGICAL_NAME:    Chatter.cpp
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the C++ programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the implementation for the 'Chatter' executable.
 *
 ***/
#include <string>
#include <sstream>
#include <iostream>
#include <unistd.h>
#include "ccpp_dds_dcps.h"
#include "CheckStatus.h"
#include "ccpp_Chat.h"

#define MAX_MSG_LEN 256
#define NUM_MSG 10
#define TERMINATION_MESSAGE -1

using namespace DDS;
using namespace Chat;

int
main (
    int argc,
    char *argv[])
{
    /* Generic DDS entities */
    DomainParticipantFactory_var    dpf;
    DomainParticipant_var           participant;
    Topic_var                       chatMessageTopic;
    Topic_var                       nameServiceTopic;
    Publisher_var                   chatPublisher;
    DataWriter_ptr                  parentWriter;

    /* QosPolicy holders */
    TopicQos                        reliable_topic_qos;
    TopicQos                        setting_topic_qos;
    PublisherQos                    pub_qos;
    DataWriterQos                   dw_qos;

    /* DDS Identifiers */
    DomainId_t                      domain = NULL;
    InstanceHandle_t                userHandle;
    ReturnCode_t                    status;

    /* Type-specific DDS entities */
    ChatMessageTypeSupport_var      chatMessageTS;
    NameServiceTypeSupport_var      nameServiceTS;
    ChatMessageDataWriter_var       talker;
    NameServiceDataWriter_var       nameServer;

    /* Sample definitions */
    ChatMessage                     *msg;    /* Example on Heap */
    NameService                     ns;      /* Example on Stack */

    /* Others */
    int                             ownID = 1;
    int                             i;
    char                            *chatterName = NULL;
    const char                      *partitionName = "ChatRoom";
    char                            *chatMessageTypeName = NULL;
    char                            *nameServiceTypeName = NULL;
    ostringstream                   buf;



    /* Options: Chatter [ownID [name]] */
    if (argc > 1) {
        istringstream args(argv[1]);
        args >> ownID;
        if (argc > 2) {
            chatterName = argv[2];
        }
    }

    /* Create a DomainParticipantFactory and a DomainParticipant
       (using Default QoS settings. */
    dpf = DomainParticipantFactory::get_instance ();
    checkHandle(dpf.in(), "DDS::DomainParticipantFactory::get_instance");
    participant = dpf->create_participant(
        domain, PARTICIPANT_QOS_DEFAULT, NULL, ANY_STATUS);
    checkHandle(
        participant.in(),
        "DDS::DomainParticipantFactory::create_participant");

    /* Register the required datatype for ChatMessage. */
    chatMessageTS = new ChatMessageTypeSupport();
    checkHandle(chatMessageTS.in(), "new ChatMessageTypeSupport");
    chatMessageTypeName = chatMessageTS->get_type_name();
    status = chatMessageTS->register_type(
        participant.in(),
        chatMessageTypeName);
    checkStatus(status, "Chat::ChatMessageTypeSupport::register_type");

    /* Register the required datatype for NameService. */
    nameServiceTS = new NameServiceTypeSupport();
    checkHandle(nameServiceTS.in(), "new NameServiceTypeSupport");
    nameServiceTypeName =  nameServiceTS->get_type_name();
    status = nameServiceTS->register_type(
        participant.in(),
        nameServiceTypeName);
    checkStatus(status, "Chat::NameServiceTypeSupport::register_type");

    /* Set the ReliabilityQosPolicy to RELIABLE. */
    status = participant->get_default_topic_qos(reliable_topic_qos);
    checkStatus(status, "DDS::DomainParticipant::get_default_topic_qos");
    reliable_topic_qos.reliability.kind = RELIABLE_RELIABILITY_QOS;

    /* Make the tailored QoS the new default. */
    status = participant->set_default_topic_qos(reliable_topic_qos);
    checkStatus(status, "DDS::DomainParticipant::set_default_topic_qos");

    /* Use the changed policy when defining the ChatMessage topic */
    chatMessageTopic = participant->create_topic(
        "Chat_ChatMessage",
        chatMessageTypeName,
        reliable_topic_qos,
        NULL,
        ANY_STATUS);
    checkHandle(
        chatMessageTopic.in(),
        "DDS::DomainParticipant::create_topic (ChatMessage)");

    /* Set the DurabilityQosPolicy to TRANSIENT. */
    status = participant->get_default_topic_qos(setting_topic_qos);
    checkStatus(status, "DDS::DomainParticipant::get_default_topic_qos");
    setting_topic_qos.durability.kind = TRANSIENT_DURABILITY_QOS;

    /* Create the NameService Topic. */
    nameServiceTopic = participant->create_topic(
        "Chat_NameService",
        nameServiceTypeName,
        setting_topic_qos,
        NULL,
        ANY_STATUS);
    checkHandle(
        nameServiceTopic.in(),
        "DDS::DomainParticipant::create_topic (NameService)");

    /* Adapt the default PublisherQos to write into the
       "ChatRoom" Partition. */
    status = participant->get_default_publisher_qos (pub_qos);
    checkStatus(status, "DDS::DomainParticipant::get_default_publisher_qos");
    pub_qos.partition.name.length(1);
    pub_qos.partition.name[0] = partitionName;

    /* Create a Publisher for the chatter application. */
    chatPublisher = participant->create_publisher(pub_qos, NULL, ANY_STATUS);
    checkHandle(
        chatPublisher.in(), "DDS::DomainParticipant::create_publisher");

    /* Create a DataWriter for the ChatMessage Topic
       (using the appropriate QoS). */
    parentWriter = chatPublisher->create_datawriter(
        chatMessageTopic.in(),
        DATAWRITER_QOS_USE_TOPIC_QOS,
        NULL,
        ANY_STATUS);
    checkHandle(
        parentWriter, "DDS::Publisher::create_datawriter (chatMessage)");

    /* Narrow the abstract parent into its typed representative. */
    talker = ChatMessageDataWriter::_narrow(parentWriter);
    checkHandle(talker.in(), "Chat::ChatMessageDataWriter::_narrow");

    /* Create a DataWriter for the NameService Topic
       (using the appropriate QoS). */
    status = chatPublisher->get_default_datawriter_qos(dw_qos);
    checkStatus(status, "DDS::Publisher::get_default_datawriter_qos");
    status = chatPublisher->copy_from_topic_qos(dw_qos, setting_topic_qos);
    checkStatus(status, "DDS::Publisher::copy_from_topic_qos");
    dw_qos.writer_data_lifecycle.autodispose_unregistered_instances = FALSE;
    parentWriter = chatPublisher->create_datawriter(
        nameServiceTopic.in(),
        dw_qos,
        NULL,
        ANY_STATUS);
    checkHandle(
        parentWriter, "DDS::Publisher::create_datawriter (NameService)");

    /* Narrow the abstract parent into its typed representative. */
    nameServer = NameServiceDataWriter::_narrow(parentWriter);
    checkHandle(nameServer.in(), "Chat::NameServiceDataWriter::_narrow");

    /* Initialize the NameServer attributes located on stack. */
    ns.userID = ownID;
    if (chatterName) {
        ns.name = CORBA::string_dup(chatterName);
    } else {
        buf << "Chatter " << ownID;
        ns.name = CORBA::string_dup( buf.str().c_str() );
    }

    /* Write the user-information into the system
       (registering the instance implicitly). */
    status = nameServer->write(ns, HANDLE_NIL);
    checkStatus(status, "Chat::ChatMessageDataWriter::write");

    /* Initialize the chat messages on Heap. */
    msg = new ChatMessage();
    checkHandle(msg, "new ChatMessage");
    msg->userID = ownID;
    msg->index = 0;
    buf.str( string("") );
    if (ownID == TERMINATION_MESSAGE) {
        buf << "Termination message.";
    } else {
        buf << "Hi there, I will send you " << NUM_MSG << " more messages.";
    }
    msg->content = CORBA::string_dup( buf.str().c_str() );
    cout << "Writing message: \"" << msg->content  << "\"" << endl;

    /* Register a chat message for this user
       (pre-allocating resources for it!!) */
    userHandle = talker->register_instance(*msg);

    /* Write a message using the pre-generated instance handle. */
    status = talker->write(*msg, userHandle);
    checkStatus(status, "Chat::ChatMessageDataWriter::write");

    sleep (1); /* do not run so fast! */

    /* Write any number of messages, re-using the existing
       string-buffer: no leak!!. */
    for (i = 1; i <= NUM_MSG && ownID != TERMINATION_MESSAGE; i++) {
        buf.str( string("") );
        msg->index = i;
        buf << "Message no. " << i;
        msg->content = CORBA::string_dup( buf.str().c_str() );
        cout << "Writing message: \"" << msg->content << "\"" << endl;
        status = talker->write(*msg, userHandle);
        checkStatus(status, "Chat::ChatMessageDataWriter::write");
        sleep (1); /* do not run so fast! */
    }

    /* Leave the room by disposing and unregistering the message instance. */
    status = talker->dispose(*msg, userHandle);
    checkStatus(status, "Chat::ChatMessageDataWriter::dispose");
    status = talker->unregister_instance(*msg, userHandle);
    checkStatus(status, "Chat::ChatMessageDataWriter::unregister_instance");

    /* Also unregister our name. */
    status = nameServer->unregister_instance(ns, HANDLE_NIL);
    checkStatus(status, "Chat::NameServiceDataWriter::unregister_instance");

    /* Release the data-samples. */
    delete msg; // msg allocated on heap: explicit de-allocation required!!

    /* Remove the DataWriters */
    status = chatPublisher->delete_datawriter( talker.in() );
    checkStatus(status, "DDS::Publisher::delete_datawriter (talker)");

    status = chatPublisher->delete_datawriter( nameServer.in() );
    checkStatus(status, "DDS::Publisher::delete_datawriter (nameServer)");

    /* Remove the Publisher. */
    status = participant->delete_publisher( chatPublisher.in() );
    checkStatus(status, "DDS::DomainParticipant::delete_publisher");

    /* Remove the Topics. */
    status = participant->delete_topic( nameServiceTopic.in() );
    checkStatus(
        status, "DDS::DomainParticipant::delete_topic (nameServiceTopic)");

    status = participant->delete_topic( chatMessageTopic.in() );
    checkStatus(
        status, "DDS::DomainParticipant::delete_topic (chatMessageTopic)");

    /* Remove the type-names. */
    CORBA::string_free(chatMessageTypeName);
    CORBA::string_free(nameServiceTypeName);

    /* Remove the DomainParticipant. */
    status = dpf->delete_participant( participant.in() );
    checkStatus(status, "DDS::DomainParticipantFactory::delete_participant");

    return 0;
}
```

MessageBoard.cpp

```
/************************************************************************
 *
 * Copyright (c) 2007
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 * All rights Reserved.
 *
 * LOGICAL_NAME:    MessageBoard.cpp
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the C++ programming language.
 * DATE              june 2007.
 ***************************************************************************
 *
 * This file contains the implementation for the 'MessageBoard' executable.
 *
 ***/

#include <iostream>
#include <string.h>
#include <unistd.h>

#include "ccpp_dds_dcps.h"
#include "CheckStatus.h"
#include "ccpp_Chat.h"
#include "multitopic.h"

using namespace DDS;
using namespace Chat;



#define TERMINATION_MESSAGE -1



int
main (
    int argc,
    char *argv[])
{
    /* Generic DDS entities */
    DomainParticipantFactory_var    dpf;
    DomainParticipant_ptr           parentDP;
    ExtDomainParticipant_var        participant;
    Topic_var                       chatMessageTopic;
    Topic_var                       nameServiceTopic;
    TopicDescription_var            namedMessageTopic;
    Subscriber_var                  chatSubscriber;
    DataReader_ptr                  parentReader;

    /* Type-specific DDS entities */
    ChatMessageTypeSupport_var      chatMessageTS;
    NameServiceTypeSupport_var      nameServiceTS;
    NamedMessageTypeSupport_var     namedMessageTS;
    NamedMessageDataReader_var      chatAdmin;
    NamedMessageSeq_var             msgSeq = new NamedMessageSeq();
    SampleInfoSeq_var               infoSeq = new SampleInfoSeq();

    /* QosPolicy holders */
    TopicQos                        reliable_topic_qos;
    TopicQos                        setting_topic_qos;
    SubscriberQos                   sub_qos;
    DDS::StringSeq                  parameterList;

    /* DDS Identifiers */
    DomainId_t                      domain = NULL;
    ReturnCode_t                    status;

    /* Others */
    bool                            terminated = FALSE;
    const char *                    partitionName = "ChatRoom";
    char  *                         chatMessageTypeName = NULL;
    char  *                         nameServiceTypeName = NULL;
    char  *                         namedMessageTypeName = NULL;

    /* Options: MessageBoard [ownID] */
    /* Messages having owner ownID will be ignored */
    parameterList.length(1);

    if (argc > 1) {
        parameterList[0] = CORBA::string_dup(argv[1]);
    }
    else
    {
        parameterList[0] = "0";
    }

    /* Create a DomainParticipantFactory and a DomainParticipant
       (using Default QoS settings. */
    dpf = DomainParticipantFactory::get_instance();
    checkHandle(dpf.in(), "DDS::DomainParticipantFactory::get_instance");
    parentDP = dpf->create_participant (
        domain,
        PARTICIPANT_QOS_DEFAULT,
        NULL,
        ANY_STATUS);
    checkHandle(
        parentDP, "DDS::DomainParticipantFactory::create_participant");

    /* Narrow the normal participant to its extended representative */
    participant = ExtDomainParticipantImpl::_narrow(parentDP);
    checkHandle(participant.in(), "DDS::ExtDomainParticipant::_narrow");

    /* Register the required datatype for ChatMessage. */
    chatMessageTS = new ChatMessageTypeSupport();
    checkHandle(chatMessageTS.in(), "new ChatMessageTypeSupport");
    chatMessageTypeName = chatMessageTS->get_type_name();
    status = chatMessageTS->register_type(
        participant.in(),
        chatMessageTypeName);
    checkStatus(status, "Chat::ChatMessageTypeSupport::register_type");

    /* Register the required datatype for NameService. */
    nameServiceTS = new NameServiceTypeSupport();
    checkHandle(nameServiceTS.in(), "new NameServiceTypeSupport");
    nameServiceTypeName =  nameServiceTS->get_type_name();
    status = nameServiceTS->register_type(
        participant.in(),
        nameServiceTypeName);
    checkStatus(status, "Chat::NameServiceTypeSupport::register_type");

    /* Register the required datatype for NamedMessage. */
    namedMessageTS = new NamedMessageTypeSupport();
    checkHandle(namedMessageTS.in(), "new NamedMessageTypeSupport");
    namedMessageTypeName = namedMessageTS->get_type_name();
    status = namedMessageTS->register_type(
        participant.in(),
        namedMessageTypeName);
    checkStatus(status, "Chat::NamedMessageTypeSupport::register_type");

    /* Set the ReliabilityQosPolicy to RELIABLE. */
    status = participant->get_default_topic_qos(reliable_topic_qos);
    checkStatus(status, "DDS::DomainParticipant::get_default_topic_qos");
    reliable_topic_qos.reliability.kind = DDS::RELIABLE_RELIABILITY_QOS;

    /* Make the tailored QoS the new default. */
    status = participant->set_default_topic_qos(reliable_topic_qos);
    checkStatus(status, "DDS::DomainParticipant::set_default_topic_qos");

    /* Use the changed policy when defining the ChatMessage topic */
    chatMessageTopic = participant->create_topic(
        "Chat_ChatMessage",
        chatMessageTypeName,
        reliable_topic_qos,
        NULL,
        ANY_STATUS);
    checkHandle(
        chatMessageTopic.in(),
        "DDS::DomainParticipant::create_topic (ChatMessage)");

    /* Set the DurabilityQosPolicy to TRANSIENT. */
    status = participant->get_default_topic_qos(setting_topic_qos);
    checkStatus(status, "DDS::DomainParticipant::get_default_topic_qos");
    setting_topic_qos.durability.kind = DDS::TRANSIENT_DURABILITY_QOS;

    /* Create the NameService Topic. */
    nameServiceTopic = participant->create_topic(
        "Chat_NameService",
        nameServiceTypeName,
        setting_topic_qos,
        NULL,
        ANY_STATUS);
    checkHandle(
        nameServiceTopic.in(), "DDS::DomainParticipant::create_topic");

    /* Create a multitopic that substitutes the userID with its
       corresponding userName. */
    namedMessageTopic = participant->create_simulated_multitopic(
        "Chat_NamedMessage",
        namedMessageTypeName,
        "SELECT userID, name AS userName, index, content "
            "FROM Chat_NameService NATURAL JOIN Chat_ChatMessage "
            "WHERE userID <> %0",
        parameterList);
    checkHandle(
        namedMessageTopic.in(),
        "DDS::ExtDomainParticipant::create_simulated_multitopic");

    /* Adapt the default SubscriberQos to read from the
       "ChatRoom" Partition. */
    status = participant->get_default_subscriber_qos (sub_qos);
    checkStatus(
        status, "DDS::DomainParticipant::get_default_subscriber_qos");
    sub_qos.partition.name.length(1);
    sub_qos.partition.name[0] = partitionName;

    /* Create a Subscriber for the MessageBoard application. */
    chatSubscriber = participant->create_subscriber(
        sub_qos, NULL, ANY_STATUS);
    checkHandle(
        chatSubscriber.in(), "DDS::DomainParticipant::create_subscriber");

    /* Create a DataReader for the NamedMessage Topic
```

```
        (using the appropriate QoS). */
    parentReader = chatSubscriber->create_datareader(
        namedMessageTopic.in(),
        DATAREADER_QOS_USE_TOPIC_QOS,
        NULL,
        ANY_STATUS);
    checkHandle(parentReader, "DDS::Subscriber::create_datareader");

    /* Narrow the abstract parent into its typed representative. */
    chatAdmin = Chat::NamedMessageDataReader::_narrow(parentReader);
    checkHandle(chatAdmin.in(), "Chat::NamedMessageDataReader::_narrow");

    /* Print a message that the MessageBoard has opened. */
    cout << "MessageBoard has opened: send a ChatMessage with "
        "userID = -1 to close it...." << endl << endl;

    while (!terminated) {
        /* Note: using read does not remove the samples from
           unregistered instances from the DataReader. This means
           that the DataRase would use more and more resources.
           That's why we use take here instead. */

        status = chatAdmin->take(
            msgSeq,
            infoSeq,
            LENGTH_UNLIMITED,
            ANY_SAMPLE_STATE,
            ANY_VIEW_STATE,
            ALIVE_INSTANCE_STATE );
        checkStatus(status, "Chat::NamedMessageDataReader::take");

        for (CORBA::ULong i = 0; i < msgSeq->length(); i++) {
            NamedMessage *msg = &(msgSeq[i]);
            if (msg->userID == TERMINATION_MESSAGE) {
                cout << "Termination message received: exiting..." << endl;
                terminated = TRUE;
            } else {
                cout << msg->userName << ": " << msg->content << endl;
            }
        }

        status = chatAdmin->return_loan(msgSeq, infoSeq);
        checkStatus(status, "Chat::ChatMessageDataReader::return_loan");

        /* Sleep for some amount of time, as not to consume
           too much CPU cycles. */
        usleep(100000);
    }

    /* Remove the DataReader */
    status = chatSubscriber->delete_datareader(chatAdmin.in());
    checkStatus(status, "DDS::Subscriber::delete_datareader");

    /* Remove the Subscriber. */
    status = participant->delete_subscriber(chatSubscriber.in());
    checkStatus(status, "DDS::DomainParticipant::delete_subscriber");

    /* Remove the Topics. */
    status = participant->delete_simulated_multitopic(
        namedMessageTopic.in());
    checkStatus(
            status, "DDS::ExtDomainParticipant::delete_simulated_multitopic");

    status = participant->delete_topic(nameServiceTopic.in());
    checkStatus(
        status, "DDS::DomainParticipant::delete_topic (nameServiceTopic)");

    status = participant->delete_topic(chatMessageTopic.in());
    checkStatus(
        status, "DDS::DomainParticipant::delete_topic (chatMessageTopic)");

    /* De-allocate the type-names. */
    CORBA::string_free(namedMessageTypeName);
    CORBA::string_free(nameServiceTypeName);
    CORBA::string_free(chatMessageTypeName);

    /* Remove the DomainParticipant. */
    status = dpf->delete_participant(participant.in());
    checkStatus(status, "DDS::DomainParticipantFactory::delete_participant");

    exit(0);
}
```

multitopic.h

```
/************************************************************************
 *
 * Copyright (c) 2007
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 * All rights Reserved.
 *
 * LOGICAL_NAME:    multitopic.h
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the C++ programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the headers for all operations required to simulate
 * the MultiTopic behavior.
 *
 ***/

#include <string>

#include "ccpp_dds_dcps.h"
#include "ccpp_Chat.h"
#include "orb_abstraction.h"


namespace DDS {

class DataReaderListenerImpl : public virtual DDS::DataReaderListener {

    /* Caching variables */
    CORBA::Long                         previous;
    std::string                         userName;

public:
    /* Type-specific DDS entities */
    Chat::ChatMessageDataReader_var     chatMessageDR;
    Chat::NameServiceDataReader_var     nameServiceDR;
    Chat::NamedMessageDataWriter_var    namedMessageDW;

    /* Query related stuff */
    DDS::QueryCondition_var             nameFinder;
    DDS::StringSeq                      nameFinderParams;


    /* Constructor */
    DataReaderListenerImpl();

    /* Callback method implementation. */
    virtual void on_requested_deadline_missed (
        DDS::DataReader_ptr reader,
        const DDS::RequestedDeadlineMissedStatus & status
    ) THROW_ORB_EXCEPTIONS;

    virtual void on_requested_incompatible_qos (
        DDS::DataReader_ptr reader,
        const DDS::RequestedIncompatibleQosStatus & status
    ) THROW_ORB_EXCEPTIONS;

    virtual void on_sample_rejected (
        DDS::DataReader_ptr reader,
        const DDS::SampleRejectedStatus & status
    ) THROW_ORB_EXCEPTIONS;

    virtual void on_liveliness_changed (
        DDS::DataReader_ptr reader,
        const DDS::LivelinessChangedStatus & status
    ) THROW_ORB_EXCEPTIONS;

    virtual void on_data_available (
        DDS::DataReader_ptr reader
    ) THROW_ORB_EXCEPTIONS;

    virtual void on_subscription_matched (
        DDS::DataReader_ptr reader,
        const DDS::SubscriptionMatchedStatus & status
    ) THROW_ORB_EXCEPTIONS;

    virtual void on_sample_lost (
        DDS::DataReader_ptr reader,
        const DDS::SampleLostStatus & status
    ) THROW_ORB_EXCEPTIONS;
};

class ExtDomainParticipantImpl;

typedef ExtDomainParticipantImpl *ExtDomainParticipant_ptr;

class ExtDomainParticipant_var {
    ExtDomainParticipant_ptr ptr_;
public:
    ExtDomainParticipant_var() : ptr_(NULL){};
    ~ExtDomainParticipant_var();
    ExtDomainParticipant_var & operator=(
        const DDS::ExtDomainParticipant_ptr ep);
    DDS::ExtDomainParticipant_ptr operator->() const;
    operator const DDS::DomainParticipant_ptr() const;
    DDS::DomainParticipant_ptr in() const;
};


class ExtDomainParticipantImpl
    : public virtual DDS::DomainParticipant,
      public LOCAL_REFCOUNTED_OBJECT
{
    /***
     * Attributes
     ***/

    // Encapsulated DomainParticipant.
    DDS::DomainParticipant_var          realParticipant;

    /*Implementation for DataReaderListener */
    DDS::DataReaderListenerImpl         *msgListener;

    /* Generic DDS entities */
    DDS::Topic_var                      chatMessageTopic;
    DDS::Topic_var                      nameServiceTopic;
    DDS::ContentFilteredTopic_var       filteredMessageTopic;
    DDS::Topic_var                      namedMessageTopic;
    DDS::Subscriber_var                 multiSub;
    DDS::Publisher_var                  multiPub;

    /***
     * Operations
     ***/
public:

    // Simulating a narrow operation.
    static ExtDomainParticipant_ptr _narrow (
        DDS::DomainParticipant_ptr obj
    );

    // Simulating an in() parameter where a DomainParticipant is expected.
    DDS::DomainParticipant_ptr in();

    // Constructor
    ExtDomainParticipantImpl(DomainParticipant_ptr participant);

    virtual DDS::Topic_ptr create_simulated_multitopic (
        const char * name,
        const char * type_name,
        const char * subscription_expression,
        const DDS::StringSeq & expression_parameters
    );

    virtual DDS::ReturnCode_t delete_simulated_multitopic (
        DDS::TopicDescription_ptr a_topic
    );

    virtual DDS::ReturnCode_t enable (
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::StatusCondition_ptr get_statuscondition (
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::StatusKindMask get_status_changes (
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::InstanceHandle_t get_instance_handle (
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::Publisher_ptr create_publisher (
        const DDS::PublisherQos & qos,
        DDS::PublisherListener_ptr a_listener,
        DDS::StatusMask mask
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t delete_publisher (
        DDS::Publisher_ptr p
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::Subscriber_ptr create_subscriber (
        const DDS::SubscriberQos & qos,
        DDS::SubscriberListener_ptr a_listener,
        DDS::StatusMask mask
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t delete_subscriber (
        DDS::Subscriber_ptr s
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::Subscriber_ptr get_builtin_subscriber (
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::Topic_ptr create_topic (
        const char * topic_name,
        const char * type_name,
        const DDS::TopicQos & qos,
        DDS::TopicListener_ptr a_listener,
        DDS::StatusMask mask
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t delete_topic (
        DDS::Topic_ptr a_topic
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::Topic_ptr find_topic (
        const char * topic_name,
        const DDS::Duration_t & timeout
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::TopicDescription_ptr lookup_topicdescription (
        const char * name
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ContentFilteredTopic_ptr create_contentfilteredtopic (
        const char * name,
        DDS::Topic_ptr related_topic,
        const char * filter_expression,
        const DDS::StringSeq & filter_parameters
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t delete_contentfilteredtopic (
        DDS::ContentFilteredTopic_ptr a_contentfilteredtopic
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::MultiTopic_ptr create_multitopic (
        const char * name,
        const char * type_name,
        const char * subscription_expression,
        const DDS::StringSeq & expression_parameters
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t delete_multitopic (
        DDS::MultiTopic_ptr a_multitopic
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t delete_contained_entities (
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t set_qos (
        const DDS::DomainParticipantQos & qos
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t get_qos (
        DDS::DomainParticipantQos & qos
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t set_listener (
        DDS::DomainParticipantListener_ptr a_listener,
        DDS::StatusKindMask mask
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::DomainParticipantListener_ptr get_listener (
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t ignore_participant (
        DDS::InstanceHandle_t handle
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t ignore_topic (
        DDS::InstanceHandle_t handle
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t ignore_publication (
        DDS::InstanceHandle_t handle
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t ignore_subscription (
        DDS::InstanceHandle_t handle
    ) THROW_ORB_EXCEPTIONS;

    virtual char * get_domain_id (
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t assert_liveliness (
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t set_default_publisher_qos (
        const DDS::PublisherQos & qos
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t get_default_publisher_qos (
        DDS::PublisherQos & qos
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t set_default_subscriber_qos (
        const DDS::SubscriberQos & qos
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t get_default_subscriber_qos (
        DDS::SubscriberQos & qos
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t set_default_topic_qos (
        const DDS::TopicQos & qos
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t get_default_topic_qos (
        DDS::TopicQos & qos
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t get_discovered_participants (
        DDS::InstanceHandleSeq & participant_handles
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t get_discovered_participant_data (
        DDS::InstanceHandle_t participant_handle,
        DDS::ParticipantBuiltinTopicData & participant_data
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t get_discovered_topics (
        DDS::InstanceHandleSeq & topic_handles
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t get_discovered_topic_data (
        DDS::InstanceHandle_t topic_handle,
        DDS::TopicBuiltinTopicData & topic_data
    ) THROW_ORB_EXCEPTIONS;

    virtual CORBA::Boolean contains_entity (
        DDS::InstanceHandle_t a_handle
    ) THROW_ORB_EXCEPTIONS;

    virtual DDS::ReturnCode_t get_current_time (
        DDS::Time_t & current_time
    ) THROW_ORB_EXCEPTIONS;
};

};
```

multitopic.cpp

```
/************************************************************************
 *
 * Copyright (c) 2007
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 *
 * LOGICAL_NAME:    multitopic.cpp
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the C++ programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the headers for all operations required to simulate
 * the MultiTopic behavior.
```

```
  *
  ***/

#include "multitopic.h"
#include "CheckStatus.h"
#include <sstream>

DDS::DataReaderListenerImpl::DataReaderListenerImpl() : previous(0x80000000) {
    nameFinderParams.length(1);
}

void
DDS::DataReaderListenerImpl::on_requested_deadline_missed (
    DDS::DataReader_ptr reader,
    const DDS::RequestedDeadlineMissedStatus & status
) THROW_ORB_EXCEPTIONS { };

void
DDS::DataReaderListenerImpl::on_requested_incompatible_qos (
    DDS::DataReader_ptr reader,
    const DDS::RequestedIncompatibleQosStatus & status
) THROW_ORB_EXCEPTIONS { };

void
DDS::DataReaderListenerImpl::on_sample_rejected (
    DDS::DataReader_ptr reader,
    const DDS::SampleRejectedStatus & status
) THROW_ORB_EXCEPTIONS { };

void
DDS::DataReaderListenerImpl::on_liveliness_changed (
    DDS::DataReader_ptr reader,
    const DDS::LivelinessChangedStatus & status
) THROW_ORB_EXCEPTIONS { };

void
DDS::DataReaderListenerImpl::on_subscription_matched (
    DDS::DataReader_ptr reader,
    const DDS::SubscriptionMatchedStatus & status
) THROW_ORB_EXCEPTIONS { };

void
DDS::DataReaderListenerImpl::on_sample_lost (
    DDS::DataReader_ptr reader,
    const DDS::SampleLostStatus & status
) THROW_ORB_EXCEPTIONS { };

void
DDS::DataReaderListenerImpl::on_data_available (
    DDS::DataReader_ptr reader
) THROW_ORB_EXCEPTIONS {
    Chat::ChatMessageSeq                msgSeq;
    Chat::NameServiceSeq                nameSeq;
    DDS::SampleInfoSeq                  infoSeq1;
    DDS::SampleInfoSeq                  infoSeq2;
    DDS::ReturnCode_t                   status;

    /* Take all messages. */
    status = chatMessageDR->take(
        msgSeq,
        infoSeq1,
        DDS::LENGTH_UNLIMITED,
        DDS::ANY_SAMPLE_STATE,
        DDS::ANY_VIEW_STATE,
        DDS::ANY_INSTANCE_STATE);
    checkStatus(status, "Chat::ChatMessageDataReader::take");

    /* For each message, extract the key-field and find
       the corresponding name. */
    for (CORBA::ULong i = 0; i < msgSeq.length(); i++)
    {
        if (infoSeq1[i].valid_data)
        {
            Chat::NamedMessage joinedSample;

            /* Find the corresponding named message. */
            if (msgSeq[i].userID != previous)
            {
                ostringstream numberStr;
                previous = msgSeq[i].userID;
                numberStr << previous;
                nameFinderParams[0UL] = numberStr.str().c_str();
                status = nameFinder->set_query_parameters(nameFinderParams);
             checkStatus(status, "DDS::QueryCondition::set_query_parameters");
                status = nameServiceDR->read_w_condition(
                    nameSeq,
                    infoSeq2,
                    DDS::LENGTH_UNLIMITED,
                    nameFinder.in());
                checkStatus(
                    status, "Chat::NameServiceDataReader::read_w_condition");

                /* Extract Name (there should only be one result). */
                if (status == DDS::RETCODE_NO_DATA)
                {
                    ostringstream msg;
                    msg << "Name not found!! id = " << previous;
                    userName = msg.str();
                }
                else
                {
                    userName = nameSeq[0].name;
                }

                /* Release the name sample again. */
                status = nameServiceDR->return_loan(nameSeq, infoSeq2);
              checkStatus(status, "Chat::NameServiceDataReader::return_loan");
        }
            /* Write merged Topic with userName instead of userID. */
            joinedSample.userName = userName.c_str();
            joinedSample.userID = msgSeq[i].userID;
            joinedSample.index = msgSeq[i].index;
            joinedSample.content = msgSeq[i].content;
            status = namedMessageDW->write(joinedSample, DDS::HANDLE_NIL);
            checkStatus(status, "Chat::NamedMessageDataWriter::write");
        }
    }
    status = chatMessageDR->return_loan(msgSeq, infoSeq1);
    checkStatus(status, "Chat::ChatMessageDataReader::return_loan");
};


```

```
DDS::ExtDomainParticipant_ptr
DDS::ExtDomainParticipantImpl::_narrow(DDS::DomainParticipant_ptr obj) {
    return new DDS::ExtDomainParticipantImpl(obj);
};

DDS::DomainParticipant_ptr
DDS::ExtDomainParticipantImpl::in() {
    return realParticipant.in();
};


DDS::ExtDomainParticipantImpl::ExtDomainParticipantImpl(
    DDS::DomainParticipant_ptr participant
) {
    realParticipant = DDS::DomainParticipant::_duplicate(participant);
};



DDS::Topic_ptr
DDS::ExtDomainParticipantImpl::create_simulated_multitopic (
    const char * name,
    const char * type_name,
    const char * subscription_expression,
    const DDS::StringSeq & expression_parameters)
{
    /* Type-specific DDS entities */
    Chat::ChatMessageDataReader_ptr     chatMessageDR;
    Chat::NameServiceDataReader_ptr     nameServiceDR;
    Chat::NamedMessageDataWriter_ptr    namedMessageDW;

    /* Query related stuff */
    DDS::QueryCondition_ptr             nameFinder;

    /* QosPolicy holders */
    DDS::TopicQos                       namedMessageQos;
    DDS::SubscriberQos                  sub_qos;
    DDS::PublisherQos                   pub_qos;

    /* Others */
    DDS::DataReader_ptr                 parentReader;
    DDS::DataWriter_ptr                 parentWriter;
    char                                *nameFinderExpr;
    const char                          *partitionName = "ChatRoom";
    DDS::ReturnCode_t                   status;

    /* Lookup both components that constitute the multi-topic. */
    chatMessageTopic = realParticipant->find_topic(
        "Chat_ChatMessage", DDS::DURATION_INFINITE);
    checkHandle(
        chatMessageTopic.in(),
        "DDS::DomainParticipant::find_topic (Chat_ChatMessage)");

    nameServiceTopic = realParticipant->find_topic(
        "Chat_NameService", DDS::DURATION_INFINITE);
    checkHandle(
        nameServiceTopic.in(),
        "DDS::DomainParticipant::find_topic (Chat_NameService)");

    /* Create a ContentFilteredTopic to filter out our own ChatMessages. */
    filteredMessageTopic = realParticipant->create_contentfilteredtopic(
        "Chat_FilteredMessage",
        chatMessageTopic.in(),
        "userID <> %0",
        expression_parameters);
    checkHandle(
        filteredMessageTopic.in(),
        "DDS::DomainParticipant::create_contentfilteredtopic");


    /* Adapt the default SubscriberQos to read from the
       "ChatRoom" Partition. */
    status = realParticipant->get_default_subscriber_qos (sub_qos);
    checkStatus(status, "DDS::DomainParticipant::get_default_subscriber_qos");
    sub_qos.partition.name.length(1);
    sub_qos.partition.name[0] = partitionName;

    /* Create a private Subscriber for the multitopic simulator. */
    multiSub = realParticipant->create_subscriber(
        sub_qos, NULL, DDS::ANY_STATUS);
    checkHandle(
        multiSub.in(),
        "DDS::DomainParticipant::create_subscriber (for multitopic)");

    /* Create a DataReader for the FilteredMessage Topic
       (using the appropriate QoS). */
    parentReader = multiSub->create_datareader(
        filteredMessageTopic.in(),
        DATAREADER_QOS_USE_TOPIC_QOS,
        NULL,
        DDS::ANY_STATUS);
    checkHandle(
        parentReader,
        "DDS::Subscriber::create_datareader (ChatMessage)");

    /* Narrow the abstract parent into its typed representative. */
    chatMessageDR = Chat::ChatMessageDataReader::_narrow(parentReader);
    checkHandle(chatMessageDR, "Chat::ChatMessageDataReader::_narrow");

    /* Allocate the DataReaderListener Implementation. */
    msgListener = new DDS::DataReaderListenerImpl();
    checkHandle(msgListener, "new DDS::DataReaderListenerImpl");

    /* Attach the DataReaderListener to the DataReader, only enabling
       the data_available event. */
    status = chatMessageDR->set_listener(
        msgListener, DDS::DATA_AVAILABLE_STATUS);
    checkStatus(status, "DDS::DataReader_set_listener");

    /* Create a DataReader for the nameService Topic
       (using the appropriate QoS). */
    parentReader = multiSub->create_datareader(
        nameServiceTopic.in(),
        DATAREADER_QOS_USE_TOPIC_QOS,
        NULL,
        DDS::ANY_STATUS);
    checkHandle(
        parentReader, "DDS::Subscriber::create_datareader (NameService)");

    /* Narrow the abstract parent into its typed representative. */
    nameServiceDR = Chat::NameServiceDataReader::_narrow(parentReader);
    checkHandle(nameServiceDR, "Chat::NameServiceDataReader::_narrow");

    /* Define the SQL expression (using a parameterized value). */
    nameFinderExpr = "userID = %0";

    /* Create a QueryCondition to only read corresponding nameService
       information by key-value. */
    nameFinder = nameServiceDR->create_querycondition(
        DDS::ANY_SAMPLE_STATE,
        DDS::ANY_VIEW_STATE,
        DDS::ANY_INSTANCE_STATE,
        nameFinderExpr,
        expression_parameters);
    checkHandle(
        nameFinder, "DDS::DataReader::create_querycondition (nameFinder)");

    /* Create the Topic that simulates the multi-topic
       (use Qos from chatMessage).*/
    status = chatMessageTopic->get_qos(namedMessageQos);
    checkStatus(status, "DDS::Topic::get_qos");

    /* Create the NamedMessage Topic whose samples simulate the MultiTopic */
    namedMessageTopic = realParticipant->create_topic(
        "Chat_NamedMessage",
        type_name,
        namedMessageQos,
        NULL,
        DDS::ANY_STATUS);
    checkHandle(
    namedMessageTopic.in(),
    "DDS::DomainParticipant::create_topic (NamedMessage)");

    /* Adapt the default PublisherQos to write into the
       "ChatRoom" Partition. */
    status = realParticipant->get_default_publisher_qos(pub_qos);
    checkStatus(status, "DDS::DomainParticipant::get_default_publisher_qos");
    pub_qos.partition.name.length(1);
    pub_qos.partition.name[0] = partitionName;

    /* Create a private Publisher for the multitopic simulator. */
    multiPub = realParticipant->create_publisher(
        pub_qos, NULL, DDS::ANY_STATUS);
    checkHandle(
        multiPub.in(),
        "DDS::DomainParticipant::create_publisher (for multitopic)");

    /* Create a DataWriter for the multitopic. */
    parentWriter = multiPub->create_datawriter(
        namedMessageTopic.in(),
        DATAWRITER_QOS_USE_TOPIC_QOS,
        NULL,
        DDS::ANY_STATUS);
    checkHandle(
        parentWriter, "DDS::Publisher::create_datawriter (NamedMessage)");

    /* Narrow the abstract parent into its typed representative. */
    namedMessageDW = Chat::NamedMessageDataWriter::_narrow(parentWriter);
    checkHandle(namedMessageDW, "Chat::NamedMessageDataWriter::_narrow");

    /* Store the relevant Entities in our Listener. */
    msgListener->chatMessageDR = chatMessageDR;
    msgListener->nameServiceDR = nameServiceDR;
    msgListener->namedMessageDW = namedMessageDW;
    msgListener->nameFinder = nameFinder;

    /* Return the simulated Multitopic. */
    return DDS::Topic::_duplicate( namedMessageTopic.in() );
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::delete_simulated_multitopic(
    DDS::TopicDescription_ptr smt
)
{
    DDS::ReturnCode_t status;

    /* Remove the DataWriter */
    status = multiPub->delete_datawriter(msgListener->namedMessageDW.in());
    checkStatus(status, "DDS::Publisher::delete_datawriter");

    /* Remove the Publisher. */
    status = realParticipant->delete_publisher(multiPub.in());
    checkStatus(status, "DDS::DomainParticipant::delete_publisher");

    /* Remove the QueryCondition. */
    status = msgListener->nameServiceDR->delete_readcondition(
        msgListener->nameFinder.in());
    checkStatus(status, "DDS::DataReader::delete_readcondition");

    /* Remove the DataReaders. */
    status = multiSub->delete_datareader(msgListener->nameServiceDR.in());
    checkStatus(status, "DDS::Subscriber::delete_datareader");
    status = multiSub->delete_datareader(msgListener->chatMessageDR.in());
    checkStatus(status, "DDS::Subscriber::delete_datareader");

    /* Remove the DataReaderListener. */
    CORBA::release(msgListener);

    /* Remove the Subscriber. */
    status = realParticipant->delete_subscriber(multiSub.in());
    checkStatus(status, "DDS::DomainParticipant::delete_subscriber");

    /* Remove the ContentFilteredTopic. */
    status = realParticipant->delete_contentfilteredtopic(
        filteredMessageTopic.in());
    checkStatus(
        status, "DDS::DomainParticipant::delete_contentfilteredtopic");

    /* Remove all other topics. */
    status = realParticipant->delete_topic(namedMessageTopic.in());
    checkStatus(
        status, "DDS::DomainParticipant::delete_topic (namedMessageTopic)");
    status = realParticipant->delete_topic(nameServiceTopic.in());
    checkStatus(
        status, "DDS::DomainParticipant::delete_topic (nameServiceTopic)");
    status = realParticipant->delete_topic(chatMessageTopic.in());
    checkStatus(
        status, "DDS::DomainParticipant::delete_topic (chatMessageTopic)");

    return status;
};


```

```

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::enable (
) THROW_ORB_EXCEPTIONS {
    return realParticipant->enable();
};

DDS::StatusCondition_ptr
DDS::ExtDomainParticipantImpl::get_statuscondition (
) THROW_ORB_EXCEPTIONS {
    return realParticipant->get_statuscondition();
};

DDS::StatusKindMask
DDS::ExtDomainParticipantImpl::get_status_changes (
) THROW_ORB_EXCEPTIONS {
    return realParticipant->get_status_changes();
};

DDS::InstanceHandle_t
DDS::ExtDomainParticipantImpl::get_instance_handle (
) THROW_ORB_EXCEPTIONS {
    return realParticipant->get_instance_handle();
};

DDS::Publisher_ptr
DDS::ExtDomainParticipantImpl::create_publisher (
    const DDS::PublisherQos & qos,
    DDS::PublisherListener_ptr a_listener,
    DDS::StatusMask mask
) THROW_ORB_EXCEPTIONS {
    return realParticipant->create_publisher(qos, a_listener, mask);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::delete_publisher (
    DDS::Publisher_ptr p
) THROW_ORB_EXCEPTIONS {
    return realParticipant->delete_publisher(p);
};

DDS::Subscriber_ptr
DDS::ExtDomainParticipantImpl::create_subscriber (
    const DDS::SubscriberQos & qos,
    DDS::SubscriberListener_ptr a_listener,
    DDS::StatusMask mask
) THROW_ORB_EXCEPTIONS {
    return realParticipant->create_subscriber(qos, a_listener, mask);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::delete_subscriber (
    DDS::Subscriber_ptr s
) THROW_ORB_EXCEPTIONS {
    return realParticipant->delete_subscriber(s);
};

DDS::Subscriber_ptr
DDS::ExtDomainParticipantImpl::get_builtin_subscriber (
) THROW_ORB_EXCEPTIONS {
    return realParticipant->get_builtin_subscriber();
```

```
};

DDS::Topic_ptr
DDS::ExtDomainParticipantImpl::create_topic (
    const char * topic_name,
    const char * type_name,
    const DDS::TopicQos & qos,
    DDS::TopicListener_ptr a_listener,
    DDS::StatusMask mask
) THROW_ORB_EXCEPTIONS {
    return realParticipant->create_topic(topic_name, type_name, qos,
a_listener, mask);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::delete_topic (
    DDS::Topic_ptr a_topic
) THROW_ORB_EXCEPTIONS {
    return realParticipant->delete_topic(a_topic);
};

DDS::Topic_ptr
DDS::ExtDomainParticipantImpl::find_topic (
    const char * topic_name,
    const DDS::Duration_t & timeout
) THROW_ORB_EXCEPTIONS {
    return realParticipant->find_topic(topic_name, timeout);
};

DDS::TopicDescription_ptr
DDS::ExtDomainParticipantImpl::lookup_topicdescription (
    const char * name
) THROW_ORB_EXCEPTIONS {
    return realParticipant->lookup_topicdescription(name);
};

DDS::ContentFilteredTopic_ptr
DDS::ExtDomainParticipantImpl::create_contentfilteredtopic (
    const char * name,
    DDS::Topic_ptr related_topic,
    const char * filter_expression,
    const DDS::StringSeq & filter_parameters
) THROW_ORB_EXCEPTIONS {
    return realParticipant->create_contentfilteredtopic(
        name,
        related_topic,
        filter_expression,
        filter_parameters);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::delete_contentfilteredtopic (
    DDS::ContentFilteredTopic_ptr a_contentfilteredtopic
) THROW_ORB_EXCEPTIONS {
    return realParticipant->delete_contentfilteredtopic(
        a_contentfilteredtopic);
};

DDS::MultiTopic_ptr
DDS::ExtDomainParticipantImpl::create_multitopic (
    const char * name,
    const char * type_name,
    const char * subscription_expression,
    const DDS::StringSeq & expression_parameters
) THROW_ORB_EXCEPTIONS {
    return realParticipant->create_multitopic(
        name,
        type_name,
        subscription_expression,
        expression_parameters);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::delete_multitopic (
    DDS::MultiTopic_ptr a_multitopic
) THROW_ORB_EXCEPTIONS {
    return realParticipant->delete_multitopic(a_multitopic);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::delete_contained_entities (
) THROW_ORB_EXCEPTIONS {
    return realParticipant->delete_contained_entities();
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::set_qos (
    const DDS::DomainParticipantQos & qos
) THROW_ORB_EXCEPTIONS {
    return realParticipant->set_qos(qos);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::get_qos (
    DDS::DomainParticipantQos & qos
) THROW_ORB_EXCEPTIONS {
    return realParticipant->get_qos(qos);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::set_listener (
    DDS::DomainParticipantListener_ptr a_listener,
    DDS::StatusKindMask mask
) THROW_ORB_EXCEPTIONS {
    return realParticipant->set_listener(a_listener, mask);
};

DDS::DomainParticipantListener_ptr
DDS::ExtDomainParticipantImpl::get_listener (
) THROW_ORB_EXCEPTIONS {
    return realParticipant->get_listener();
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::ignore_participant (
    DDS::InstanceHandle_t handle
) THROW_ORB_EXCEPTIONS {
    return realParticipant->ignore_participant(handle);
};

DDS::ReturnCode_t
```

```
DDS::ExtDomainParticipantImpl::ignore_topic (
    DDS::InstanceHandle_t handle
) THROW_ORB_EXCEPTIONS {
    return realParticipant->ignore_topic(handle);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::ignore_publication (
    DDS::InstanceHandle_t handle
) THROW_ORB_EXCEPTIONS {
    return realParticipant->ignore_publication(handle);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::ignore_subscription (
    DDS::InstanceHandle_t handle
) THROW_ORB_EXCEPTIONS {
    return realParticipant->ignore_subscription(handle);
};

char *
DDS::ExtDomainParticipantImpl::get_domain_id (
) THROW_ORB_EXCEPTIONS {
    return realParticipant->get_domain_id();
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::assert_liveliness (
) THROW_ORB_EXCEPTIONS {
    return realParticipant->assert_liveliness();
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::set_default_publisher_qos (
    const DDS::PublisherQos & qos
) THROW_ORB_EXCEPTIONS {
    return realParticipant->set_default_publisher_qos(qos);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::get_default_publisher_qos (
    DDS::PublisherQos & qos
) THROW_ORB_EXCEPTIONS {
    return realParticipant->get_default_publisher_qos(qos);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::set_default_subscriber_qos (
    const DDS::SubscriberQos & qos
) THROW_ORB_EXCEPTIONS {
    return realParticipant->set_default_subscriber_qos(qos);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::get_default_subscriber_qos (
    DDS::SubscriberQos & qos
) THROW_ORB_EXCEPTIONS {
    return realParticipant->get_default_subscriber_qos(qos);
};

DDS::ReturnCode_t
```

```
DDS::ExtDomainParticipantImpl::set_default_topic_qos (
    const DDS::TopicQos & qos
) THROW_ORB_EXCEPTIONS {
    return realParticipant->set_default_topic_qos(qos);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::get_default_topic_qos (
    DDS::TopicQos & qos
) THROW_ORB_EXCEPTIONS {
    return realParticipant->get_default_topic_qos(qos);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::get_discovered_participants (
    DDS::InstanceHandleSeq & participant_handles
) THROW_ORB_EXCEPTIONS {
    return realParticipant->get_discovered_participants(participant_handles);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::get_discovered_participant_data (
    DDS::InstanceHandle_t participant_handle,
    DDS::ParticipantBuiltinTopicData & participant_data
) THROW_ORB_EXCEPTIONS {
    return realParticipant->get_discovered_participant_data(
        participant_handle, participant_data);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::get_discovered_topics (
    DDS::InstanceHandleSeq & topic_handles
) THROW_ORB_EXCEPTIONS {
    return realParticipant->get_discovered_topics(topic_handles);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::get_discovered_topic_data (
    DDS::InstanceHandle_t topic_handle,
    DDS::TopicBuiltinTopicData & topic_data
) THROW_ORB_EXCEPTIONS {
    return realParticipant->get_discovered_topic_data(
        topic_handle, topic_data);
};

CORBA::Boolean
DDS::ExtDomainParticipantImpl::contains_entity (
    DDS::InstanceHandle_t a_handle
) THROW_ORB_EXCEPTIONS {
    return realParticipant->contains_entity(a_handle);
};

DDS::ReturnCode_t
DDS::ExtDomainParticipantImpl::get_current_time (
    DDS::Time_t & current_time
) THROW_ORB_EXCEPTIONS {
    return realParticipant->get_current_time(current_time);
};

DDS::ExtDomainParticipant_var::~ExtDomainParticipant_var() {
    CORBA::release(ptr_);
};

DDS::ExtDomainParticipant_var &
DDS::ExtDomainParticipant_var::operator=(
    const DDS::ExtDomainParticipant_ptr ep
) {
    ptr_ = ep;
    return *this;
};

DDS::ExtDomainParticipant_ptr
DDS::ExtDomainParticipant_var::operator->() const {
    return ptr_;
};

DDS::ExtDomainParticipant_var::operator const
DDS::DomainParticipant_ptr() const {
    return ptr_->in();
};

DDS::DomainParticipant_ptr DDS::ExtDomainParticipant_var::in() const {
    return ptr_->in();
};
```

UserLoad.cpp

```
/************************************************************************
 *
 * Copyright (c) 2007
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 *
 * LOGICAL_NAME:    UserLoad.cpp
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the C++ programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the implementation for the 'UserLoad' executable.
 *
 ***/

#include <iostream>
#include <sstream>
#include <unistd.h>
#include <string.h>
#include <pthread.h>
#include <assert.h>

#include "ccpp_dds_dcps.h"
#include "CheckStatus.h"
#include "ccpp_Chat.h"

using namespace DDS;
using namespace Chat;

/* entities required by all threads. */
static DDS::GuardCondition_var          escape;
```

```

/* Sleeper thread: sleeps 60 seconds and then triggers the WaitSet. */
void *
delayedEscape(
    void *arg)
{
    DDS::ReturnCode_t status;

    sleep(60);     /* wait for 60 sec. */
    status = escape->set_trigger_value(TRUE);
    checkStatus(status, "DDS::GuardCondition::set_trigger_value");

    return NULL;
}

int
main (
    int argc,
    char *argv[])
{
    /* Generic DDS entities */
    DomainParticipant_var           participant;
    Topic_var                       chatMessageTopic;
    Topic_var                       nameServiceTopic;
    Subscriber_var                  chatSubscriber;
    DataReader_ptr                  parentReader;
    QueryCondition_var              singleUser;
    ReadCondition_var               newUser;
    StatusCondition_var             leftUser;
    WaitSet_var                     userLoadWS;
    LivelinessChangedStatus         livChangStatus;

    /* QosPolicy holders */
    TopicQos                        setting_topic_qos;
    TopicQos                        reliable_topic_qos;
    SubscriberQos                   sub_qos;
    DataReaderQos                   message_qos;

    /* DDS Identifiers */
    DomainId_t                      domain = NULL;
    ReturnCode_t                    status;
    ConditionSeq                    guardList;

    /* Type-specific DDS entities */
    ChatMessageTypeSupport_var      chatMessageTS;
    NameServiceTypeSupport_var      nameServiceTS;
    NameServiceDataReader_var       nameServer;
    ChatMessageDataReader_var       loadAdmin;
    ChatMessageSeq                  msgList;
    NameServiceSeq                  nsList;
    SampleInfoSeq                   infoSeq;
    SampleInfoSeq                   infoSeq2;

    /* Others */
    StringSeq                       args;
    char *                          chatMessageTypeName = NULL;
    char *                          nameServiceTypeName = NULL;

    bool                            closed = false;
    CORBA::Long                     prevCount = 0;
    pthread_t                       tid;

    /* Create a DomainParticipant (using the 'TheParticipantFactory'
       convenience macro). */
    participant = TheParticipantFactory->create_participant (
        domain,
        PARTICIPANT_QOS_DEFAULT,
        NULL,
        ANY_STATUS);
    checkHandle(
    participant.in(), "DDS::DomainParticipantFactory::create_participant");

    /* Register the required datatype for ChatMessage. */
    chatMessageTS = new ChatMessageTypeSupport();
    checkHandle(chatMessageTS.in(), "new ChatMessageTypeSupport");
    chatMessageTypeName = chatMessageTS->get_type_name();
    status = chatMessageTS->register_type(
        participant.in(), chatMessageTypeName);
    checkStatus(status, "Chat::ChatMessageTypeSupport::register_type");

    /* Register the required datatype for NameService. */
    nameServiceTS = new NameServiceTypeSupport();
    checkHandle(nameServiceTS.in(), "new NameServiceTypeSupport");
    nameServiceTypeName =  nameServiceTS->get_type_name();
    status = nameServiceTS->register_type(
        participant.in(), nameServiceTypeName);
    checkStatus(status, "Chat::NameServiceTypeSupport::register_type");

    /* Set the ReliabilityQosPolicy to RELIABLE. */
    status = participant->get_default_topic_qos(reliable_topic_qos);
    checkStatus(status, "DDS::DomainParticipant::get_default_topic_qos");
    reliable_topic_qos.reliability.kind = RELIABLE_RELIABILITY_QOS;

    /* Make the tailored QoS the new default. */
    status = participant->set_default_topic_qos(reliable_topic_qos);
    checkStatus(status, "DDS::DomainParticipant::set_default_topic_qos");

    /* Use the changed policy when defining the ChatMessage topic */
    chatMessageTopic = participant->create_topic(
        "Chat_ChatMessage",
        chatMessageTypeName,
        reliable_topic_qos,
        NULL,
        ANY_STATUS);
    checkHandle(
        chatMessageTopic.in(),
        "DDS::DomainParticipant::create_topic (ChatMessage)");

    /* Set the DurabilityQosPolicy to TRANSIENT. */
    status = participant->get_default_topic_qos(setting_topic_qos);
    checkStatus(status, "DDS::DomainParticipant::get_default_topic_qos");
    setting_topic_qos.durability.kind = TRANSIENT_DURABILITY_QOS;

    /* Create the NameService Topic. */
    nameServiceTopic = participant->create_topic(
        "Chat_NameService",
        nameServiceTypeName,
        setting_topic_qos,
        NULL,
        ANY_STATUS);
    checkHandle(
        nameServiceTopic.in(), "DDS::DomainParticipant::create_topic");

    /* Adapt the default SubscriberQos to read from the "ChatRoom" Partition. */
    status = participant->get_default_subscriber_qos (sub_qos);
    checkStatus(
        status, "DDS::DomainParticipant::get_default_subscriber_qos");
    sub_qos.partition.name.length(1);
    sub_qos.partition.name[0UL] = "ChatRoom";

    /* Create a Subscriber for the UserLoad application. */
    chatSubscriber = participant->create_subscriber(
        sub_qos, NULL, ANY_STATUS);
    checkHandle(
        chatSubscriber.in(), "DDS::DomainParticipant::create_subscriber");

    /* Create a DataReader for the NameService Topic
       (using the appropriate QoS). */
    parentReader = chatSubscriber->create_datareader(
        nameServiceTopic.in(),
        DATAREADER_QOS_USE_TOPIC_QOS,
        NULL,
        ANY_STATUS);
    checkHandle(
        parentReader, "DDS::Subscriber::create_datareader (NameService)");

    /* Narrow the abstract parent into its typed representative. */
    nameServer = NameServiceDataReader::_narrow(parentReader);
    checkHandle(nameServer.in(), "Chat::NameServiceDataReader::_narrow");

    /* Adapt the DataReaderQos for the ChatMessageDataReader to
       keep track of all messages. */
    status = chatSubscriber->get_default_datareader_qos(message_qos);
    checkStatus(status, "DDS::Subscriber::get_default_datareader_qos");
    status = chatSubscriber->copy_from_topic_qos(
        message_qos, reliable_topic_qos);
    checkStatus(status, "DDS::Subscriber::copy_from_topic_qos");
    message_qos.history.kind = KEEP_ALL_HISTORY_QOS;

    /* Create a DataReader for the ChatMessage Topic (using the appropriate
QoS). */
    parentReader = chatSubscriber->create_datareader(
        chatMessageTopic.in(),
        message_qos,
        NULL,
        ANY_STATUS);
    checkHandle(
        parentReader, "DDS::Subscriber::create_datareader (ChatMessage)");

    /* Narrow the abstract parent into its typed representative. */
    loadAdmin = ChatMessageDataReader::_narrow(parentReader);
    checkHandle(loadAdmin.in(), "Chat::ChatMessageDataReader::_narrow");

    /* Initialize the Query Arguments. */
    args.length(1);
    args[0UL] = "0";

    /* Create a QueryCondition that will contain all messages
       with userID=ownID */
    singleUser = loadAdmin->create_querycondition(
        ANY_SAMPLE_STATE,
        ANY_VIEW_STATE,
        ANY_INSTANCE_STATE,
        "userID=%0",
        args);
    checkHandle(singleUser.in(), "DDS::DataReader::create_querycondition");

    /* Create a ReadCondition that will contain new users only */
    newUser = nameServer->create_readcondition(
        NOT_READ_SAMPLE_STATE,
        NEW_VIEW_STATE,
        ALIVE_INSTANCE_STATE);
    checkHandle(newUser.in(), "DDS::DataReader::create_readcondition");

    /* Obtain a StatusCondition that triggers only when a
       Writer changes Liveliness */
    leftUser = loadAdmin->get_statuscondition();
    checkHandle(leftUser.in(), "DDS::DataReader::get_statuscondition");
    status = leftUser->set_enabled_statuses(LIVELINESS_CHANGED_STATUS);
    checkStatus(status, "DDS::StatusCondition::set_enabled_statuses");

    /* Create a bare guard which will be used to close the room */
    escape = new GuardCondition();

    /* Create a waitset and add the ReadConditions */
    userLoadWS = new WaitSet();
    status = userLoadWS->attach_condition(newUser.in());
    checkStatus(status, "DDS::WaitSet::attach_condition (newUser)");
    status = userLoadWS->attach_condition(leftUser.in());
    checkStatus(status, "DDS::WaitSet::attach_condition (leftUser)");
    status = userLoadWS->attach_condition(escape.in());
    checkStatus(status, "DDS::WaitSet::attach_condition (escape)");

    /* Initialize and pre-allocate the GuardList used to
       obtain the triggered Conditions. */
    guardList.length(3);


    /* Remove all known Users that are not currently active. */
    status = nameServer->take(
        nsList,
        infoSeq,
        LENGTH_UNLIMITED,
        ANY_SAMPLE_STATE,
        ANY_VIEW_STATE,
        NOT_ALIVE_INSTANCE_STATE);
    checkStatus(status, "Chat::NameServiceDataReader::take");
    status = nameServer->return_loan(nsList, infoSeq);
    checkStatus(status, "Chat::NameServiceDataReader::return_loan");

    /* Start the sleeper thread. */
    pthread_create (&tid, NULL, delayedEscape, NULL);

    while (!closed) {
        /* Wait until at least one of the Conditions in the
           waitset triggers. */
        status = userLoadWS->wait(guardList, DURATION_INFINITE);
        checkStatus(status, "DDS::WaitSet::wait");

        /* Walk over all guards to display information */
        for (CORBA::ULong i = 0; i < guardList.length(); i++) {
            if ( guardList[i] == newUser.in() ) {
                /* The newUser ReadCondition contains data */
                status = nameServer->read_w_condition(
                    nsList,
                    infoSeq,
                    LENGTH_UNLIMITED,
                    newUser.in() );
                checkStatus(
                    status, "Chat::NameServiceDataReader::read_w_condition");

                for (CORBA::ULong j = 0; j < nsList.length(); j++) {
                    cout << "New user: " << nsList[j].name << endl;
                }
                status = nameServer->return_loan(nsList, infoSeq);
                checkStatus(
                    status, "Chat::NameServiceDataReader::return_loan");

            } else if ( guardList[i] == leftUser.in() ) {
                /* Some liveliness has changed (either a DataWriter joined
                   or a DataWriter left) */
                status = loadAdmin->get_liveliness_changed_status(
                    livChangStatus);
                checkStatus(
                    status,
                    "DDS::DataReader::get_liveliness_changed_status");
                if (livChangStatus.alive_count < prevCount) {
                    /* A user has left the ChatRoom, since a DataWriter lost
                       its liveliness. Take the effected users so they will
                       not appear in the list later on. */
                    status = nameServer->take(
                        nsList,
                        infoSeq,
                        LENGTH_UNLIMITED,
                        ANY_SAMPLE_STATE,
                        ANY_VIEW_STATE,
                        NOT_ALIVE_NO_WRITERS_INSTANCE_STATE);
                    checkStatus(status, "Chat::NameServiceDataReader::take");

                    for (CORBA::ULong j = 0; j < nsList.length(); j++) {
                        /* re-apply query arguments */
                        ostringstream numberString;
                        numberString << nsList[j].userID;
                        args[0UL] = numberString.str().c_str();
                        status = singleUser->set_query_parameters(args);
                        checkStatus(
                            status,
                            "DDS::QueryCondition::set_query_parameters");

                        /* Read this users history */
                        status = loadAdmin->take_w_condition(
                            msgList,
                            infoSeq2,
                            LENGTH_UNLIMITED,
                            singleUser.in() );
                        checkStatus(
                            status,
                            "Chat::ChatMessageDataReader::take_w_condition");

                        /* Display the user and his history */
                        cout << "Departed user " << nsList[j].name <<
                            " has sent " << msgList.length() <<
                            " messages." << endl;
                        status = loadAdmin->return_loan(msgList, infoSeq2);
                        checkStatus(
                            status,
                            "Chat::ChatMessageDataReader::return_loan");
                    }
                    status = nameServer->return_loan(nsList, infoSeq);
                    checkStatus(
                        status, "Chat::NameServiceDataReader::return_loan");
                }
                prevCount = livChangStatus.alive_count;

            } else if ( guardList[i] == escape.in() ) {
                cout << "UserLoad has terminated." << endl;
                closed = true;
            }
            else
            {
                assert(0);
            };
        } /* for */
    } /* while (!closed) */

    /* Remove all Conditions from the WaitSet. */
    status = userLoadWS->detach_condition( escape.in() );
    checkStatus(status, "DDS::WaitSet::detach_condition (escape)");
    status = userLoadWS->detach_condition( leftUser.in() );
    checkStatus(status, "DDS::WaitSet::detach_condition (leftUser)");
    status = userLoadWS->detach_condition( newUser.in() );
    checkStatus(status, "DDS::WaitSet::detach_condition (newUser)");

    /* Remove the type-names. */
    CORBA::string_free(chatMessageTypeName);
    CORBA::string_free(nameServiceTypeName);

    /* Free all resources */
    status = participant->delete_contained_entities();
    checkStatus(status, "DDS::DomainParticipant::delete_contained_entities");
    status = TheParticipantFactory->delete_participant( participant.in() );
    checkStatus(status, "DDS::DomainParticipantFactory::delete_participant");

    return 0;
}
```

Appendix

C Java Language Examples' Code

This appendix lists the complete Java source code for the examples provided in the Java version of the OpenSplice DDS tutorial.

Chat.idl

```
/************************************************************************
 *
 * Copyright (c) 2006
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 * All rights Reserved.
 *
 * LOGICAL_NAME:    Chat.idl
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the Java programming language.
 * DATE             june 2006.
 ************************************************************************
 *
 * This file contains the data definitions for the tutorial examples.
 *
 ***/

module Chat {

    const long MAX_NAME = 32;
    typedef string<MAX_NAME> nameType;

    struct ChatMessage {
        long      userID;          // owner of message
        long      index;           // message number
        string    content;         // message body
    };
#pragma keylist ChatMessage userID

    struct NameService {
        long     userID;           // unique user identification
        nameType name;             // name of the user
    };
#pragma keylist NameService userID

    struct NamedMessage {
        long     userID;           // unique user identification
        nameType userName;         // user name
        long     index;            // message number
        string   content;          // message body
    };
#pragma keylist NamedMessage userID

};
```

ErrorHandler.java

```
/************************************************************************
 *
 * Copyright (c) 2007
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 * All rights Reserved.
 *
 * LOGICAL_NAME:    ErrorHandler.java
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the Java programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the implementation for the error handling operations.
 *
 ***/

package chatroom;

import DDS.*;

public class ErrorHandler {

   public static final int NR_ERROR_CODES = 13;

   /* Array to hold the names for all ReturnCodes. */
   public static String[] RetCodeName = new String[NR_ERROR_CODES];

   static {
      RetCodeName[0] = new String("DDS_RETCODE_OK");
      RetCodeName[1] = new String("DDS_RETCODE_ERROR");
      RetCodeName[2] = new String("DDS_RETCODE_UNSUPPORTED");
      RetCodeName[3] = new String("DDS_RETCODE_BAD_PARAMETER");
      RetCodeName[4] = new String("DDS_RETCODE_PRECONDITION_NOT_MET");
      RetCodeName[5] = new String("DDS_RETCODE_OUT_OF_RESOURCES");
      RetCodeName[6] = new String("DDS_RETCODE_NOT_ENABLED");
      RetCodeName[7] = new String("DDS_RETCODE_IMMUTABLE_POLICY");
      RetCodeName[8] = new String("DDS_RETCODE_INCONSISTENT_POLICY");
      RetCodeName[9] = new String("DDS_RETCODE_ALREADY_DELETED");
      RetCodeName[10] = new String("DDS_RETCODE_TIMEOUT");
      RetCodeName[11] = new String("DDS_RETCODE_NO_DATA");
       RetCodeName[12] = new String("DDS_RETCODE_ILLEGAL_OPERATION");
   }

   /**
    * Returns the name of an error code.
    **/
   public static String getErrorName(int status) {
      return RetCodeName[status];
   }

   /**
    * Check the return status for errors. If there is an error,
     * then terminate.
    **/
   public static void checkStatus(int status, String info) {
      if ( status != RETCODE_OK.value &&
            status != RETCODE_NO_DATA.value) {
           System.out.println(
               "Error in " + info + ": " + getErrorName(status) );
           System.exit(-1);
       }
   }

   /**
    * Check whether a valid handle has been returned. If not, then terminate.
    **/
   public static void checkHandle(Object handle, String info) {
      if (handle == null) {
           System.out.println(
               "Error in " + info + ": Creation failed: invalid handle");
           System.exit(-1);
      }
   }

}
```

Chatter.java

```
/************************************************************************
 *
 * Copyright (c) 2007
 * PrismTech Ltd.
 * All rights Reserved.
 *
 * LOGICAL_NAME:    Chatter.java
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the Java programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the implementation for the 'Chatter' executable.
 *
 ***/

package chatroom;

import DDS.*;
import Chat.*;

public class Chatter {

    public static final int NUM_MSG = 10;
    public static final int TERMINATION_MESSAGE = -1;

    public static void main(String[] args) {
        /* Generic DDS entities */
        DomainParticipantFactory   dpf;
        DomainParticipant          participant;
        Topic                      chatMessageTopic;
        Topic                      nameServiceTopic;
        Publisher                  chatPublisher;
        DataWriter                 parentWriter;

        /* EntityQos holders */
        TopicQosHolder        reliableTopicQos    = new TopicQosHolder();
        TopicQosHolder        settingTopicQos     = new TopicQosHolder();
        PublisherQosHolder     pubQos               = new PublisherQosHolder();
        DataWriterQosHolder    dwQos                = new DataWriterQosHolder();

        /* QosPolicy fields. */
        WriterDataLifecycleQosPolicy writerDataLifecycle;

        /* DDS Identifiers */
        String                 domain = null;
        long                   userHandle;
        int                    status;

        /* Type-specific DDS entities */
        ChatMessageTypeSupport chatMessageTS;
        NameServiceTypeSupport nameServiceTS;
        ChatMessageDataWriter  talker;
        NameServiceDataWriter  nameServer;

        /* Sample definitions */
        ChatMessage            msg                 = new ChatMessage();
        NameService            ns                  = new NameService();

        /* Others */
        int                    ownID = 1;
        int                    i;
        String                 chatterName = null;
        String                 partitionName = new String("ChatRoom");
         String                 chatMessageTypeName;
         String                 nameServiceTypeName;


        /* Options: Chatter [ownID [name]] */
        if (args.length > 0) {
            ownID = Integer.parseInt(args[0]);
            if (args.length > 1) {
                chatterName = args[1];
            }
        }

        /* Create a DomainParticipantFactory and a DomainParticipant
            (using Default QoS settings. */
        dpf = DomainParticipantFactory.get_instance ();
        ErrorHandler.checkHandle(
             dpf, "DDS.DomainParticipantFactory.get_instance");
        participant = dpf.create_participant(
             domain, PARTICIPANT_QOS_DEFAULT.value, null, ANY_STATUS.value);
        ErrorHandler.checkHandle(
             participant, "DDS.DomainParticipantFactory.create_participant");

        /* Register the required datatype for ChatMessage. */
        chatMessageTS = new ChatMessageTypeSupport();
         ErrorHandler.checkHandle(
             chatMessageTS, "new ChatMessageTypeSupport");
         chatMessageTypeName = chatMessageTS.get_type_name();
        status = chatMessageTS.register_type(
             participant, chatMessageTypeName);
        ErrorHandler.checkStatus(
             status, "Chat.ChatMessageTypeSupport.register_type");

        /* Register the required datatype for NameService. */
        nameServiceTS = new NameServiceTypeSupport();
         ErrorHandler.checkHandle(
             nameServiceTS, "new NameServiceTypeSupport");
         nameServiceTypeName = nameServiceTS.get_type_name();
        status = nameServiceTS.register_type(
             participant, nameServiceTypeName);
        ErrorHandler.checkStatus(
             status, "Chat.NameServiceTypeSupport.register_type");

        /* Set the ReliabilityQosPolicy to RELIABLE. */
        status = participant.get_default_topic_qos(reliableTopicQos);
         ErrorHandler.checkStatus(
             status, "DDS.DomainParticipant.get_default_topic_qos");
        reliableTopicQos.value.reliability.kind =
             ReliabilityQosPolicyKind.RELIABLE_RELIABILITY_QOS;

         /* Make the tailored QoS the new default. */
         status = participant.set_default_topic_qos(reliableTopicQos.value);
         ErrorHandler.checkStatus(
             status, "DDS.DomainParticipant.set_default_topic_qos");

        /* Use the changed policy when defining the ChatMessage topic */
        chatMessageTopic = participant.create_topic(
            "Chat_ChatMessage",
            chatMessageTypeName,
            reliableTopicQos.value,
            null,
             ANY_STATUS.value);
        ErrorHandler.checkHandle(
        chatMessageTopic,
        "DDS.DomainParticipant.create_topic (ChatMessage)");

         /* Set the DurabilityQosPolicy to TRANSIENT. */
         status = participant.get_default_topic_qos(settingTopicQos);
         ErrorHandler.checkStatus(
             status, "DDS.DomainParticipant.get_default_topic_qos");
        settingTopicQos.value.durability.kind =
             DurabilityQosPolicyKind.TRANSIENT_DURABILITY_QOS;

        /* Create the NameService Topic. */
        nameServiceTopic = participant.create_topic(
            "Chat_NameService",
            nameServiceTypeName,
            settingTopicQos.value,
            null,
             ANY_STATUS.value);
        ErrorHandler.checkHandle(
            nameServiceTopic,
             "DDS.DomainParticipant.create_topic (NameService)");

        /* Adapt the default PublisherQos to write into the
            "ChatRoom" Partition. */
        status = participant.get_default_publisher_qos (pubQos);
         ErrorHandler.checkStatus(
             status, "DDS.DomainParticipant.get_default_publisher_qos");
        pubQos.value.partition.name = new String[1];
        pubQos.value.partition.name[0] = partitionName;

        /* Create a Publisher for the chatter application. */
        chatPublisher = participant.create_publisher(
             pubQos.value, null, ANY_STATUS.value);
         ErrorHandler.checkHandle(
             chatPublisher, "DDS.DomainParticipant.create_publisher");

        /* Create a DataWriter for the ChatMessage Topic
            (using the appropriate QoS). */
        parentWriter = chatPublisher.create_datawriter(
            chatMessageTopic,
            DATAWRITER_QOS_USE_TOPIC_QOS.value,
            null,
             ANY_STATUS.value);
         ErrorHandler.checkHandle(
             parentWriter, "DDS.Publisher.create_datawriter (chatMessage)");

        /* Narrow the abstract parent into its typed representative. */
        talker = ChatMessageDataWriterHelper.narrow(parentWriter);
         ErrorHandler.checkHandle(
             talker, "Chat.ChatMessageDataWriterHelper.narrow");

         /* Create a DataWriter for the NameService Topic
            (using the appropriate QoS). */
        status = chatPublisher.get_default_datawriter_qos(dwQos);
        ErrorHandler.checkStatus(
            status, "DDS.Publisher.get_default_datawriter_qos");
        status = chatPublisher.copy_from_topic_qos(
            dwQos, settingTopicQos.value);
        ErrorHandler.checkStatus(status, "DDS.Publisher.copy_from_topic_qos");
        writerDataLifecycle = dwQos.value.writer_data_lifecycle;
        writerDataLifecycle.autodispose_unregistered_instances = false;
         parentWriter = chatPublisher.create_datawriter(
             nameServiceTopic,
             dwQos.value,
             null,
             ANY_STATUS.value);
         ErrorHandler.checkHandle(
             parentWriter, "DDS.Publisher.create_datawriter (NameService)");

         /* Narrow the abstract parent into its typed representative. */
         nameServer = NameServiceDataWriterHelper.narrow(parentWriter);
         ErrorHandler.checkHandle(
             nameServer, "Chat.NameServiceDataWriterHelper.narrow");

         /* Initialize the NameServer attributes. */
         ns.userID = ownID;
         if (chatterName != null) {
             ns.name = chatterName;
         } else {
             ns.name = "Chatter " + ownID;
         }

         /* Write the user-information into the system
            (registering the instance implicitly). */
         status = nameServer.write(ns, HANDLE_NIL.value);
         ErrorHandler.checkStatus(status, "Chat.ChatMessageDataWriter.write");

         /* Initialize the chat messages. */
         msg.userID = ownID;
         msg.index = 0;
         if (ownID == TERMINATION_MESSAGE) {
             msg.content = "Termination message.";
         } else {
             msg.content = "Hi there, I will send you " +
                 NUM_MSG + " more messages.";
         }
         System.out.println("Writing message: \"" + msg.content + "\"");

         /* Register a chat message for this user
            (pre-allocating resources for it!!) */
         userHandle = talker.register_instance(msg);

         /* Write a message using the pre-generated instance handle. */
         status = talker.write(msg, userHandle);
         ErrorHandler.checkStatus(status, "Chat.ChatMessageDataWriter.write");

         try {
             Thread.sleep (1000); /* do not run so fast! */
         } catch (InterruptedException e) {
             e.printStackTrace();
         }

         /* Write any number of messages . */
         for (i = 1; i <= NUM_MSG && ownID != TERMINATION_MESSAGE; i++) {
             msg.index = i;
             msg.content = "Message no. " + i;
             System.out.println("Writing message: \"" + msg.content + "\"");
             status = talker.write(msg, userHandle);
             ErrorHandler.checkStatus(
                 status, "Chat.ChatMessageDataWriter.write");
             try {
                 Thread.sleep (1000); /* do not run so fast! */
             } catch (InterruptedException e) {
                 e.printStackTrace();
             }
         }

        /* Leave the room by disposing and unregistering the message instance */
         status = talker.dispose(msg, userHandle);
         ErrorHandler.checkStatus(
             status, "Chat.ChatMessageDataWriter.dispose");
         status = talker.unregister_instance(msg, userHandle);
         ErrorHandler.checkStatus(
             status, "Chat.ChatMessageDataWriter.unregister_instance");

         /* Also unregister our name. */
         status = nameServer.unregister_instance(ns, HANDLE_NIL.value);
         ErrorHandler.checkStatus(
             status, "Chat.NameServiceDataWriter.unregister_instance");

         /* Remove the DataWriters */
         status = chatPublisher.delete_datawriter(talker);
         ErrorHandler.checkStatus(
             status, "DDS.Publisher.delete_datawriter (talker)");

         status = chatPublisher.delete_datawriter(nameServer);
         ErrorHandler.checkStatus(status,
             "DDS.Publisher.delete_datawriter (nameServer)");

         /* Remove the Publisher. */
         status = participant.delete_publisher(chatPublisher);
         ErrorHandler.checkStatus(
             status, "DDS.DomainParticipant.delete_publisher");

         /* Remove the Topics. */
         status = participant.delete_topic(nameServiceTopic);
         ErrorHandler.checkStatus(
             status, "DDS.DomainParticipant.delete_topic (nameServiceTopic)");

         status = participant.delete_topic(chatMessageTopic);
         ErrorHandler.checkStatus(
             status, "DDS.DomainParticipant.delete_topic (chatMessageTopic)");

         /* Remove the DomainParticipant. */
         status = dpf.delete_participant(participant);
         ErrorHandler.checkStatus(
             status, "DDS.DomainParticipantFactory.delete_participant");
     }
 }
```

MessageBoard.java

```
/************************************************************************
 *
 * Copyright (c) 2007
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 * All rights Reserved.
 *
 * LOGICAL_NAME:    MessageBoard.java
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the Java programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the implementation for the 'MessageBoard' executable.
 *
 ***/

package chatroom;

import DDS.*;
import Chat.*;

public class MessageBoard {


    public static final int TERMINATION_MESSAGE = -1;


    public static void main(String[] args) {
        /* Generic DDS entities */
        DomainParticipantFactory  dpf;
        DomainParticipant         parentDP;
        ExtDomainParticipant      participant;
        Topic                     chatMessageTopic;
        Topic                     nameServiceTopic;
        TopicDescription          namedMessageTopic;
        Subscriber                chatSubscriber;
        DataReader                parentReader;

        /* Type-specific DDS entities */
        ChatMessageTypeSupport  chatMessageTS;
        NameServiceTypeSupport  nameServiceTS;
        NamedMessageTypeSupport namedMessageTS;
        NamedMessageDataReader  chatAdmin;
        NamedMessageSeqHolder   msgSeq          = new NamedMessageSeqHolder();
        SampleInfoSeqHolder     infoSeq          = new SampleInfoSeqHolder();

        /* QosPolicy holders */
        TopicQosHolder          reliableTopicQos = new TopicQosHolder();
        TopicQosHolder          settingTopicQos  = new TopicQosHolder();
        SubscriberQosHolder     subQos           = new SubscriberQosHolder();
        String[]                parameterList;

        /* DDS Identifiers */
        String                  domain           = null;
        int                     status;

        /* Others */
        boolean                 terminated       = false;
        String                  partitionName    = new String("ChatRoom");
        String                  chatMessageTypeName;
        String                  nameServiceTypeName;
        String                  namedMessageTypeName;

        /* Options: MessageBoard [ownID] */
        /* Messages having owner ownID will be ignored */
        parameterList = new String[1];

        if (args.length >0) {
            parameterList[0] = args[0];
        }
        else
        {
            parameterList[0] = new String("0");
        }

        /* Create a DomainParticipantFactory and a DomainParticipant
           (using Default QoS settings. */
        dpf = DomainParticipantFactory.get_instance ();
        ErrorHandler.checkHandle(
            dpf, "DDS.DomainParticipantFactory.get_instance");
        parentDP = dpf.create_participant(
            domain, PARTICIPANT_QOS_DEFAULT.value, null, ANY_STATUS.value);
        ErrorHandler.checkHandle(
            parentDP, "DDS.DomainParticipantFactory.create_participant");

        /* Register the required datatype for ChatMessage. */
        chatMessageTS = new ChatMessageTypeSupport();
        ErrorHandler.checkHandle(
            chatMessageTS, "new ChatMessageTypeSupport");
        chatMessageTypeName = chatMessageTS.get_type_name();
        status = chatMessageTS.register_type(parentDP, chatMessageTypeName);
        ErrorHandler.checkStatus(
            status, "Chat.ChatMessageTypeSupport.register_type");

        /* Register the required datatype for NameService. */
        nameServiceTS = new NameServiceTypeSupport();
        ErrorHandler.checkHandle(
            nameServiceTS, "new NameServiceTypeSupport");
        nameServiceTypeName = nameServiceTS.get_type_name();
        nameServiceTS.register_type(parentDP, nameServiceTypeName);
        ErrorHandler.checkStatus(
            status, "Chat.NameServiceTypeSupport.register_type");

        /* Register the required datatype for NamedMessage. */
        namedMessageTS = new NamedMessageTypeSupport();
        ErrorHandler.checkHandle(
            namedMessageTS, "new NamedMessageTypeSupport");
        namedMessageTypeName = namedMessageTS.get_type_name();
        status = namedMessageTS.register_type(parentDP, namedMessageTypeName);
        ErrorHandler.checkStatus(
            status, "Chat.NamedMessageTypeSupport.register_type");

        /* Narrow the normal participant to its extended representative */
        participant = ExtDomainParticipantHelper.narrow(parentDP);
        ErrorHandler.checkHandle(
            participant, "ExtDomainParticipantHelper.narrow");

        /* Set the ReliabilityQosPolicy to RELIABLE. */
        status = participant.get_default_topic_qos(reliableTopicQos);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.get_default_topic_qos");
        reliableTopicQos.value.reliability.kind =
            ReliabilityQosPolicyKind.RELIABLE_RELIABILITY_QOS;

        /* Make the tailored QoS the new default. */
        status = participant.set_default_topic_qos(reliableTopicQos.value);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.set_default_topic_qos");

        /* Use the changed policy when defining the ChatMessage topic */
        chatMessageTopic = participant.create_topic(
            "Chat_ChatMessage",
            chatMessageTypeName,
            reliableTopicQos.value,
            null,
            ANY_STATUS.value);
        ErrorHandler.checkHandle(
            chatMessageTopic,
            "DDS.DomainParticipant.create_topic (ChatMessage)");

        /* Set the DurabilityQosPolicy to TRANSIENT. */
        status = participant.get_default_topic_qos(settingTopicQos);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.get_default_topic_qos");
        settingTopicQos.value.durability.kind =
            DurabilityQosPolicyKind.TRANSIENT_DURABILITY_QOS;

        /* Create the NameService Topic. */
        nameServiceTopic = participant.create_topic(
            "Chat_NameService",
            nameServiceTypeName,
            settingTopicQos.value,
            null,
            ANY_STATUS.value);
        ErrorHandler.checkHandle(
            nameServiceTopic,
            "DDS.DomainParticipant.create_topic (NameService)");

        /* Create a multitopic that substitutes the userID
           with its corresponding userName. */
        namedMessageTopic = participant.create_simulated_multitopic(
            "Chat_NamedMessage",
            namedMessageTypeName,
            "SELECT userID, name AS userName, index, content " +
                "FROM Chat_NameService NATURAL JOIN Chat_ChatMessage " +
                "WHERE userID <> %0",
            parameterList);
        ErrorHandler.checkHandle(
            namedMessageTopic,
            "ExtDomainParticipant.create_simulated_multitopic");

        /* Adapt the default SubscriberQos to read from the
           "ChatRoom" Partition. */
        status = participant.get_default_subscriber_qos (subQos);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.get_default_subscriber_qos");
        subQos.value.partition.name = new String[1];
        subQos.value.partition.name[0] = partitionName;

        /* Create a Subscriber for the MessageBoard application. */
        chatSubscriber = participant.create_subscriber(
            subQos.value, null, ANY_STATUS.value);
        ErrorHandler.checkHandle(
            chatSubscriber, "DDS.DomainParticipant.create_subscriber");

        /* Create a DataReader for the NamedMessage Topic
           (using the appropriate QoS). */
        parentReader = chatSubscriber.create_datareader(
            namedMessageTopic,
            DATAREADER_QOS_USE_TOPIC_QOS.value,
            null,
            ANY_STATUS.value);
        ErrorHandler.checkHandle(
            parentReader, "DDS.Subscriber.create_datareader");

        /* Narrow the abstract parent into its typed representative. */
        chatAdmin = NamedMessageDataReaderHelper.narrow(parentReader);
        ErrorHandler.checkHandle(
            chatAdmin, "Chat.NamedMessageDataReaderHelper.narrow");

        /* Print a message that the MessageBoard has opened. */
        System.out.println(
                "MessageBoard has opened: send a ChatMessage " +
                "with userID = -1 to close it....\n");

        while (!terminated) {
            /* Note: using read does not remove the samples from
               unregistered instances from the DataReader. This means
               that the DataRase would use more and more resources.
               That's why we use take here instead. */

            status = chatAdmin.take(
                msgSeq,
                infoSeq,
                LENGTH_UNLIMITED.value,
                ANY_SAMPLE_STATE.value,
                ANY_VIEW_STATE.value,
                ALIVE_INSTANCE_STATE.value );
            ErrorHandler.checkStatus(
                status, "Chat.NamedMessageDataReader.take");

            for (int i = 0; i < msgSeq.value.length; i++) {
                if (msgSeq.value[i].userID == TERMINATION_MESSAGE) {
                    System.out.println(
                        "Termination message received: exiting...");
                    terminated = true;
                } else {
                    System.out.println(
                        msgSeq.value[i].userName + ": " +
                        msgSeq.value[i].content);
                }
            }

            status = chatAdmin.return_loan(msgSeq, infoSeq);
            ErrorHandler.checkStatus(
                status, "Chat.ChatMessageDataReader.return_loan");

            msgSeq.value = null;
            infoSeq.value = null;

            /* Sleep for some amount of time, as not to consume
               too much CPU cycles. */
            try {
                Thread.sleep(100);
            } catch (InterruptedException e) {
                e.printStackTrace();
            }
        }

        /* Remove the DataReader */
        status = chatSubscriber.delete_datareader(chatAdmin);
        ErrorHandler.checkStatus(
            status, "DDS.Subscriber.delete_datareader");

        /* Remove the Subscriber. */
        status = participant.delete_subscriber(chatSubscriber);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.delete_subscriber");

        /* Remove the Topics. */
        status = participant.delete_simulated_multitopic(namedMessageTopic);
        ErrorHandler.checkStatus(
            status, "DDS.ExtDomainParticipant.delete_simulated_multitopic");

        status = participant.delete_topic(nameServiceTopic);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.delete_topic (nameServiceTopic)");

        status = participant.delete_topic(chatMessageTopic);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.delete_topic (chatMessageTopic)");

        /* Remove the DomainParticipant. */
        status = dpf.delete_participant(parentDP);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipantFactory.delete_participant");
    }

}
```

DataReaderListenerImpl.java

```
/************************************************************************
 *
```

```
  * Copyright (c) 2007
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  *
  * LOGICAL_NAME:    DataReaderListenerImpl.java
  * FUNCTION:        OpenSplice DDS Tutorial example code.
  * MODULE:          Tutorial for the Java programming language.
  * DATE             june 2007.
  ************************************************************************
  *
  * This file contains the implementation for a DataReader listener, that
  * simulates MultiTopic behavior by writing a NamedMessage sample (which
  * contains the merged information from both the ChatMessage and NameService
  * topics) for each incoming ChatMessage.
  *
  ***/

package chatroom;

import DDS.*;
import Chat.*;

public class DataReaderListenerImpl implements DataReaderListener {

    /***
     * Attributes
     ***/
    /* Caching variables */
    private int                    previous      = 0x80000000;
    private String                 userName;
    private ChatMessageSeqHolder  msgSeq        = new ChatMessageSeqHolder();
    private NameServiceSeqHolder  nameSeq       = new NameServiceSeqHolder();
    private SampleInfoSeqHolder   infoSeq1      = new SampleInfoSeqHolder();
    private SampleInfoSeqHolder   infoSeq2      = new SampleInfoSeqHolder();
    private NamedMessage          joinedSample  = new NamedMessage();


    /* Type-specific DDS entities */
    public ChatMessageDataReader        chatMessageDR;
    public NameServiceDataReader        nameServiceDR;
    public NamedMessageDataWriter       namedMessageDW;

    /* Query related stuff */
    public QueryCondition               nameFinder;
    public String[]                     nameFinderParams;

    /***
     * Operations
     ***/
    public void on_requested_deadline_missed(
            DataReader the_reader,
            RequestedDeadlineMissedStatus status) { }

    public void on_requested_incompatible_qos(
            DataReader the_reader,
            RequestedIncompatibleQosStatus status) { }

    public void on_sample_rejected(
        DataReader the_reader, SampleRejectedStatus status) { }

    public void on_liveliness_changed(
        DataReader the_reader, LivelinessChangedStatus status) { }

    public void on_data_available(DataReader the_reader) {

        /* Take all messages. */
        int status = chatMessageDR.take(
            msgSeq,
            infoSeq1,
            LENGTH_UNLIMITED.value,
            ANY_SAMPLE_STATE.value,
            ANY_VIEW_STATE.value,
            ANY_INSTANCE_STATE.value);
        ErrorHandler.checkStatus(
            status, "Chat.ChatMessageDataReader.take");

        /* For each message, extract the key-field and find
           the corresponding name. */
        for (int i = 0; i < msgSeq.value.length; i++)
        {
            if (infoSeq1.value[i].valid_data)
            {
                /* Find the corresponding named message. */
                if (msgSeq.value[i].userID != previous)
                {
                    previous = msgSeq.value[i].userID;
                    nameFinderParams[0] = Integer.toString(previous);
                   status = nameFinder.set_query_parameters(nameFinderParams);
                    ErrorHandler.checkStatus(
                        status, "DDS.QueryCondition.set_query_parameters");
                    status = nameServiceDR.read_w_condition(
                        nameSeq,
                        infoSeq2,
                        LENGTH_UNLIMITED.value,
                        nameFinder);
                    ErrorHandler.checkStatus(
                       status, "Chat.NameServiceDataReader.read_w_condition");

                    /* Extract Name (there should only be one result). */
                    if (status == RETCODE_NO_DATA.value)
                    {
                        userName = new String(
                                "Name not found!! id = " + previous);
                    }
                    else
                    {
                        userName = nameSeq.value[0].name;
                    }

                    /* Release the name sample again. */
                    status = nameServiceDR.return_loan(nameSeq, infoSeq2);
                    ErrorHandler.checkStatus(
                        status, "Chat.NameServiceDataReader.return_loan");
                }
                /* Write merged Topic with userName instead of userID. */
                joinedSample.userName = userName;
                joinedSample.userID = msgSeq.value[i].userID;
                joinedSample.index = msgSeq.value[i].index;
                joinedSample.content = msgSeq.value[i].content;
                status = namedMessageDW.write(joinedSample, HANDLE_NIL.value);
                ErrorHandler.checkStatus(
                    status, "Chat.NamedMessageDataWriter.write");
            }
        }
        status = chatMessageDR.return_loan(msgSeq, infoSeq1);
        ErrorHandler.checkStatus(
            status, "Chat.ChatMessageDataReader.return_loan");

    }

    public void on_subscription_matched(
        DataReader the_reader, SubscriptionMatchedStatus status) { }

    public void on_sample_lost(
        DataReader the_reader, SampleLostStatus status) { }

}
```

ExtDomainParticipant.java

```
/************************************************************************
 *
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 *
 * LOGICAL_NAME:    ExtDomainParticipant.java
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the Java programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the implementation for an extended DomainParticipant
 * class, that adds a new operations named 'simulate_multitopic', which
 * simulates the behavior of a multitopic by combining a ContentFilteredTopic
 * with a QueryCondition and a DataReaderListener.
 *
 ***/

package chatroom;

import DDS.*;
import Chat.*;

public class ExtDomainParticipant implements DomainParticipant {

    /***
     * Attributes
     ***/

    // Encapsulated DomainParticipant.
    private DomainParticipant               realParticipant;

    /*Implementation for DataReaderListener */
    private DataReaderListenerImpl          msgListener;

    /* Generic DDS entities */
    private Topic                           chatMessageTopic;
    private Topic                           nameServiceTopic;
    private ContentFilteredTopic            filteredMessageTopic;
    private Topic                          namedMessageTopic;
    private Subscriber                     multiSub;
    private Publisher                      multiPub;


    /***
     * Constructor
     ***/
    ExtDomainParticipant(DomainParticipant aParticipant) {
        this.realParticipant = aParticipant;
    }


    /***
     * Operations
     ***/
    public Topic create_simulated_multitopic (
        String name,
        String type_name,
        String subscription_expression,
        String[] expression_parameters)
    {

        /* Type-specific DDS entities */
        ChatMessageDataReader   chatMessageDR;
        NameServiceDataReader   nameServiceDR;
        NamedMessageDataWriter  namedMessageDW;

        /* Query related stuff */
        QueryCondition          nameFinder;
        String[]                nameFinderParams;

        /* QosPolicy holders */
        TopicQosHolder          namedMessageQos = new TopicQosHolder();
        SubscriberQosHolder     subQos          = new SubscriberQosHolder();
        PublisherQosHolder      pubQos          = new PublisherQosHolder();

        /* Others */
        DataReader              parentReader;
        DataWriter              parentWriter;
        String                  partitionName   = new String("ChatRoom");
        String                  nameFinderExpr;
        int                     status;

        /* Lookup both components that constitute the multi-topic. */
        chatMessageTopic = realParticipant.find_topic(
            "Chat_ChatMessage", DURATION_INFINITE.value);
        ErrorHandler.checkHandle(
            chatMessageTopic,
            "DDS.DomainParticipant.find_topic (Chat_ChatMessage)");

        nameServiceTopic = realParticipant.find_topic(
            "Chat_NameService", DURATION_INFINITE.value);
        ErrorHandler.checkHandle(
            nameServiceTopic,
            "DDS.DomainParticipant.find_topic (Chat_NameService)");

        /* Create a ContentFilteredTopic to filter out
           our own ChatMessages. */
        filteredMessageTopic = realParticipant.create_contentfilteredtopic(
            "Chat_FilteredMessage",
            chatMessageTopic,
            "userID <> %0",
            expression_parameters);
        ErrorHandler.checkHandle(
            filteredMessageTopic,
            "DDS.DomainParticipant.create_contentfilteredtopic");


        /* Adapt the default SubscriberQos to read from the
           "ChatRoom" Partition. */
        status = realParticipant.get_default_subscriber_qos (subQos);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.get_default_subscriber_qos");
        subQos.value.partition.name = new String[1];
        subQos.value.partition.name[0] = partitionName;

        /* Create a private Subscriber for the multitopic simulator. */
        multiSub = realParticipant.create_subscriber(
            subQos.value, null, ANY_STATUS.value);
        ErrorHandler.checkHandle(
            multiSub,
            "DDS.DomainParticipant.create_subscriber (for multitopic)");

        /* Create a DataReader for the FilteredMessage Topic
           (using the appropriate QoS). */
        parentReader = multiSub.create_datareader(
            filteredMessageTopic,
            DATAREADER_QOS_USE_TOPIC_QOS.value,
            null,
            ANY_STATUS.value);
        ErrorHandler.checkHandle(
            parentReader, "DDS.Subscriber.create_datareader (ChatMessage)");

        /* Narrow the abstract parent into its typed representative. */
        chatMessageDR = ChatMessageDataReaderHelper.narrow(parentReader);
        ErrorHandler.checkHandle(
            chatMessageDR, "Chat.ChatMessageDataReaderHelper.narrow");

        /* Allocate the DataReaderListener Implementation. */
        msgListener = new DataReaderListenerImpl();
        ErrorHandler.checkHandle(msgListener, "new DataReaderListenerImpl");

        /* Attach the DataReaderListener to the DataReader,
           only enabling the data_available event. */
        status = chatMessageDR.set_listener(
            msgListener, DDS.DATA_AVAILABLE_STATUS.value);
        ErrorHandler.checkStatus(status, "DDS.DataReader_set_listener");

        /* Create a DataReader for the nameService Topic
           (using the appropriate QoS). */
        parentReader = multiSub.create_datareader(
            nameServiceTopic,
            DATAREADER_QOS_USE_TOPIC_QOS.value,
            null,
            ANY_STATUS.value);
        ErrorHandler.checkHandle(
            parentReader, "DDS.Subscriber.create_datareader (NameService)");

        /* Narrow the abstract parent into its typed representative. */
        nameServiceDR = NameServiceDataReaderHelper.narrow(parentReader);
        ErrorHandler.checkHandle(
            nameServiceDR, "Chat.NameServiceDataReaderHelper.narrow");

        /* Define the SQL expression (using a parameterized value). */
        nameFinderExpr = new String("userID = %0");

        /* Allocate and assign the query parameters. */
        nameFinderParams = new String[1];
        nameFinderParams[0] = expression_parameters[0];

        /* Create a QueryCondition to only read corresponding
           nameService information by key-value. */
        nameFinder = nameServiceDR.create_querycondition(
            ANY_SAMPLE_STATE.value,
            ANY_VIEW_STATE.value,
            ANY_INSTANCE_STATE.value,
            nameFinderExpr,
            nameFinderParams);
        ErrorHandler.checkHandle(
            nameFinder, "DDS.DataReader.create_querycondition (nameFinder)");

        /* Create the Topic that simulates the multi-topic
           (use Qos from chatMessage).*/
        status = chatMessageTopic.get_qos(namedMessageQos);
        ErrorHandler.checkStatus(status, "DDS.Topic.get_qos");

        /* Create the NamedMessage Topic whose samples simulate
           the MultiTopic */
        namedMessageTopic = realParticipant.create_topic(
            "Chat_NamedMessage",
            type_name,
            namedMessageQos.value,
            null,
            ANY_STATUS.value);
        ErrorHandler.checkHandle(
            namedMessageTopic,
            "DDS.DomainParticipant.create_topic (NamedMessage)");

        /* Adapt the default PublisherQos to write into the
           "ChatRoom" Partition. */
        status = realParticipant.get_default_publisher_qos(pubQos);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.get_default_publisher_qos");
        pubQos.value.partition.name = new String[1];
        pubQos.value.partition.name[0] = partitionName;

        /* Create a private Publisher for the multitopic simulator. */
        multiPub = realParticipant.create_publisher(
            pubQos.value, null, ANY_STATUS.value);
        ErrorHandler.checkHandle(
            multiPub,
            "DDS.DomainParticipant.create_publisher (for multitopic)");

        /* Create a DataWriter for the multitopic. */
        parentWriter = multiPub.create_datawriter(
            namedMessageTopic,
            DATAWRITER_QOS_USE_TOPIC_QOS.value,
            null,
            ANY_STATUS.value);
        ErrorHandler.checkHandle(
            parentWriter, "DDS.Publisher.create_datawriter (NamedMessage)");

        /* Narrow the abstract parent into its typed representative. */
        namedMessageDW = NamedMessageDataWriterHelper.narrow(parentWriter);
        ErrorHandler.checkHandle(
            namedMessageDW, "Chat.NamedMessageDataWriterHelper.narrow");

        /* Store the relevant Entities in our Listener. */
        msgListener.chatMessageDR = chatMessageDR;
        msgListener.nameServiceDR = nameServiceDR;
        msgListener.namedMessageDW = namedMessageDW;
        msgListener.nameFinder = nameFinder;
        msgListener.nameFinderParams = nameFinderParams;

        /* Return the simulated Multitopic. */
        return namedMessageTopic;

    }

    public int delete_simulated_multitopic(
        TopicDescription smt)
    {
        int status;

        /* Remove the DataWriter */
        status = multiPub.delete_datawriter(msgListener.namedMessageDW);
        ErrorHandler.checkStatus(status, "DDS.Publisher.delete_datawriter");

        /* Remove the Publisher. */
        status = realParticipant.delete_publisher(multiPub);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.delete_publisher");

        /* Remove the QueryCondition. */
        status = msgListener.nameServiceDR.delete_readcondition(
            msgListener.nameFinder);
        ErrorHandler.checkStatus(
            status, "DDS.DataReader.delete_readcondition");

        /* Remove the DataReaders. */
        status = multiSub.delete_datareader(msgListener.nameServiceDR);
        ErrorHandler.checkStatus(status, "DDS.Subscriber.delete_datareader");
        status = multiSub.delete_datareader(msgListener.chatMessageDR);
        ErrorHandler.checkStatus(status, "DDS.Subscriber.delete_datareader");

        /* Remove the Subscriber. */
        status = realParticipant.delete_subscriber(multiSub);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.delete_subscriber");

        /* Remove the ContentFilteredTopic. */
        status = realParticipant.delete_contentfilteredtopic(
            filteredMessageTopic);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.delete_contentfilteredtopic");

        /* Remove all other topics. */
        status = realParticipant.delete_topic(namedMessageTopic);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.delete_topic (namedMessageTopic)");
        status = realParticipant.delete_topic(nameServiceTopic);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.delete_topic (nameServiceTopic)");
        status = realParticipant.delete_topic(chatMessageTopic);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.delete_topic (chatMessageTopic)");

        return status;
    };

    public Publisher create_publisher(
            PublisherQos qos, PublisherListener a_listener, int mask) {
        return realParticipant.create_publisher(qos, a_listener, mask);
    }

    public int delete_publisher(Publisher p) {
        return realParticipant.delete_publisher(p);
    }

    public Subscriber create_subscriber(
            SubscriberQos qos, SubscriberListener a_listener, int mask) {
        return realParticipant.create_subscriber(qos, a_listener, mask);
    }

    public int delete_subscriber(Subscriber s) {
        return realParticipant.delete_subscriber(s);
    }

    public Subscriber get_builtin_subscriber() {
        return realParticipant.get_builtin_subscriber();
    }

    public Topic create_topic(
            String topic_name,
            String type_name,
            TopicQos qos,
            TopicListener a_listener,
            int mask) {
        return realParticipant.create_topic(
            topic_name, type_name, qos, a_listener, mask);
    }

    public int delete_topic(Topic a_topic) {
        return realParticipant.delete_topic(a_topic);
    }

    public Topic find_topic(String topic_name, Duration_t timeout) {
        return realParticipant.find_topic(topic_name, timeout);
    }

    public TopicDescription lookup_topicdescription(String name) {
        return realParticipant.lookup_topicdescription(name);
    }

    public ContentFilteredTopic create_contentfilteredtopic(
            String name,
            Topic related_topic,
            String filter_expression,
            String[] filter_parameters) {
        return realParticipant.create_contentfilteredtopic(
                name,
                related_topic,
                filter_expression,
                filter_parameters);
    }

    public int delete_contentfilteredtopic(
            ContentFilteredTopic a_contentfilteredtopic) {
        return realParticipant.delete_contentfilteredtopic(
                a_contentfilteredtopic);
    }

    public MultiTopic create_multitopic(
            String name,
            String type_name,
            String subscription_expression,
            String[] expression_parameters) {
        return realParticipant.create_multitopic(
                name,
                type_name,
                subscription_expression,
                expression_parameters);
    }

    public int delete_multitopic(MultiTopic a_multitopic) {
        return realParticipant.delete_multitopic(a_multitopic);
    }

    public int delete_contained_entities() {
        return realParticipant.delete_contained_entities();
    }

    public int set_qos(DomainParticipantQos qos) {
        return realParticipant.set_qos(qos);
    }

    public int get_qos(DomainParticipantQosHolder qos) {
        return realParticipant.get_qos(qos);
    }

    public int set_listener(DomainParticipantListener a_listener, int mask) {
        return realParticipant.set_listener(a_listener, mask);
    }

    public DomainParticipantListener get_listener() {
        return realParticipant.get_listener();
    }

    public int ignore_participant(long handle) {
        return realParticipant.ignore_participant(handle);
    }

    public int ignore_topic(long handle) {
        return realParticipant.ignore_topic(handle);
    }

    public int ignore_publication(long handle) {
        return realParticipant.ignore_publication(handle);
    }

    public int ignore_subscription(long handle) {
        return realParticipant.ignore_subscription(handle);
    }

    public String get_domain_id() {
        return realParticipant.get_domain_id();
    }

    public int assert_liveliness() {
        return realParticipant.assert_liveliness();
    }

    public int set_default_publisher_qos(PublisherQos qos) {
        return realParticipant.set_default_publisher_qos(qos);
    }

    public int get_default_publisher_qos(PublisherQosHolder qos) {
        return realParticipant.get_default_publisher_qos(qos);
    }

    public int set_default_subscriber_qos(SubscriberQos qos) {
        return realParticipant.set_default_subscriber_qos(qos);
    }

    public int get_default_subscriber_qos(SubscriberQosHolder qos) {
        return realParticipant.get_default_subscriber_qos(qos);
    }

    public int set_default_topic_qos(TopicQos qos) {
        return realParticipant.set_default_topic_qos(qos);
    }

    public int get_default_topic_qos(TopicQosHolder qos) {
        return realParticipant.get_default_topic_qos(qos);
    }

    public int get_discovered_participants(InstanceHandleSeqHolder handles) {
        return realParticipant.get_discovered_participants(handles);
    }

    public int get_discovered_participant_data(
            long participant_handle,
            ParticipantBuiltinTopicDataHolder participant_data) {
        return realParticipant.get_discovered_participant_data(
                participant_handle, participant_data);
    }

    public int get_discovered_topics(InstanceHandleSeqHolder handles) {
        return realParticipant.get_discovered_topics(handles);
    }

    public int get_discovered_topic_data(
            long topic_handle,
            TopicBuiltinTopicDataHolder topic_data) {
        return realParticipant.get_discovered_topic_data(
                topic_handle, topic_data);
    }

    public boolean contains_entity(long a_handle) {
        return realParticipant.contains_entity(a_handle);
    }

    public int get_current_time(Time_tHolder current_time) {
        return realParticipant.get_current_time(current_time);
    }

    public int enable() {
        return realParticipant.enable();
    }

    public StatusCondition get_statuscondition() {
        return realParticipant.get_statuscondition();
    }

    public int get_status_changes() {
        return realParticipant.get_status_changes();
    }

    public long get_instance_handle() {
        return realParticipant.get_instance_handle();
    }

}
```

ExtDomainParticipantHelper.java

```
/************************************************************************
 *
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 *
 * LOGICAL_NAME:    ExtDomainParticipantHelper.java
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the Java programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the implementation for a Helper class of the extended
* DomainParticipant, that simulates the behavior of a Helper class with respect
 * to narrowing an existing DomainParticipant into its extended representation.
 *
 ***/

package chatroom;

import DDS.DomainParticipant;

public class ExtDomainParticipantHelper {
    public static ExtDomainParticipant narrow(
            DomainParticipant participant) {
        return new ExtDomainParticipant(participant);
    }
}
```

UserLoad.java

```
/************************************************************************
 *
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 *
 * LOGICAL_NAME:    UserLoad.java
 * FUNCTION:        OpenSplice DDS Tutorial example code.
 * MODULE:          Tutorial for the Java programming language.
 * DATE             june 2007.
 ************************************************************************
 *
 * This file contains the implementation for the 'UserLoad' executable.
 *
 ***/

package chatroom;

import DDS.*;
import Chat.*;

public class UserLoad extends Thread {

    /* entities required by all threads. */
    public static GuardCondition            escape;

    /**
     * Sleeper thread: sleeps 60 seconds and then triggers the WaitSet.
     */
    public void run() {
        int status;

        try {
            sleep(60000);
        } catch (InterruptedException e) {
            e.printStackTrace();
        }
        status = escape.set_trigger_value(true);
        ErrorHandler.checkStatus(
            status, "DDS.GuardCondition.set_trigger_value");
    }

    public static void main(String[] args) {
        /* Generic DDS entities */
        DomainParticipant               participant;
        Topic                           chatMessageTopic;
        Topic                           nameServiceTopic;
        Subscriber                      chatSubscriber;
        DataReader                      parentReader;
        QueryCondition                  singleUser;
        ReadCondition                   newUser;
        StatusCondition                 leftUser;
        WaitSet                         userLoadWS;
        LivelinessChangedStatusHolder   livChangStatus =
            new LivelinessChangedStatusHolder();

        /* QosPolicy holders */
        TopicQosHolder          settingTopicQos  = new TopicQosHolder();
        TopicQosHolder          reliableTopicQos = new TopicQosHolder();
        SubscriberQosHolder     subQos           = new SubscriberQosHolder();
        DataReaderQosHolder     messageQos       = new DataReaderQosHolder();

        /* DDS Identifiers */
        String                  domain           = null;
        int                     status;
        ConditionSeqHolder      guardList        = new ConditionSeqHolder();

        /* Type-specific DDS entities */
        ChatMessageTypeSupport  chatMessageTS;
        NameServiceTypeSupport  nameServiceTS;
        NameServiceDataReader   nameServer;
        ChatMessageDataReader   loadAdmin;
        ChatMessageSeqHolder    msgList          = new ChatMessageSeqHolder();
        NameServiceSeqHolder    nsList           = new NameServiceSeqHolder();
        SampleInfoSeqHolder     infoSeq          = new SampleInfoSeqHolder();
        SampleInfoSeqHolder     infoSeq2         = new SampleInfoSeqHolder();

        /* Others */
        String[]                params;
        String                  chatMessageTypeName;
        String                  nameServiceTypeName;
        boolean                 closed           = false;
        int                     prevCount        = 0;

        /* Create a DomainParticipant (using the
           'TheParticipantFactory' convenience macro). */
        participant = TheParticipantFactory.value.create_participant (
            domain,
            PARTICIPANT_QOS_DEFAULT.value,
            null,
            ANY_STATUS.value);
        ErrorHandler.checkHandle(
            participant, "DDS.DomainParticipantFactory.create_participant");

        /* Register the required datatype for ChatMessage. */
        chatMessageTS = new ChatMessageTypeSupport();
        ErrorHandler.checkHandle(
            chatMessageTS, "new ChatMessageTypeSupport");
        chatMessageTypeName = chatMessageTS.get_type_name();
        status = chatMessageTS.register_type(
            participant, chatMessageTypeName);
        ErrorHandler.checkStatus(
            status, "Chat.ChatMessageTypeSupport.register_type");

        /* Register the required datatype for NameService. */
        nameServiceTS = new NameServiceTypeSupport();
        ErrorHandler.checkHandle(
            nameServiceTS, "new NameServiceTypeSupport");
        nameServiceTypeName = nameServiceTS.get_type_name();
        status = nameServiceTS.register_type(
            participant, nameServiceTypeName);
        ErrorHandler.checkStatus(
            status, "Chat.NameServiceTypeSupport.register_type");

        /* Set the ReliabilityQosPolicy to RELIABLE. */
        status = participant.get_default_topic_qos(reliableTopicQos);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.get_default_topic_qos");
        reliableTopicQos.value.reliability.kind =
            ReliabilityQosPolicyKind.RELIABLE_RELIABILITY_QOS;

        /* Make the tailored QoS the new default. */
        status = participant.set_default_topic_qos(reliableTopicQos.value);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.set_default_topic_qos");

        /* Use the changed policy when defining the ChatMessage topic */
        chatMessageTopic = participant.create_topic(
            "Chat_ChatMessage",
            chatMessageTypeName,
            reliableTopicQos.value,
            null,
            ANY_STATUS.value);
        ErrorHandler.checkHandle(
            chatMessageTopic,
            "DDS.DomainParticipant.create_topic (ChatMessage)");

        /* Set the DurabilityQosPolicy to TRANSIENT. */
        status = participant.get_default_topic_qos(settingTopicQos);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.get_default_topic_qos");
        settingTopicQos.value.durability.kind =
            DurabilityQosPolicyKind.TRANSIENT_DURABILITY_QOS;

        /* Create the NameService Topic. */
        nameServiceTopic = participant.create_topic(
            "Chat_NameService",
            nameServiceTypeName,
            settingTopicQos.value,
            null,
            ANY_STATUS.value);
        ErrorHandler.checkHandle(
            nameServiceTopic, "DDS.DomainParticipant.create_topic");

        /* Adapt the default SubscriberQos to read from the
           "ChatRoom" Partition. */
        status = participant.get_default_subscriber_qos (subQos);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.get_default_subscriber_qos");
        subQos.value.partition.name = new String[1];
        subQos.value.partition.name[0] = new String("ChatRoom");

        /* Create a Subscriber for the UserLoad application. */
        chatSubscriber = participant.create_subscriber(
            subQos.value, null, ANY_STATUS.value);
        ErrorHandler.checkHandle(
            chatSubscriber, "DDS.DomainParticipant.create_subscriber");

        /* Create a DataReader for the NameService Topic
           (using the appropriate QoS). */
        parentReader = chatSubscriber.create_datareader(
            nameServiceTopic,
            DATAREADER_QOS_USE_TOPIC_QOS.value,
            null,
            ANY_STATUS.value);
        ErrorHandler.checkHandle(
            parentReader, "DDS.Subscriber.create_datareader (NameService)");

        /* Narrow the abstract parent into its typed representative. */
        nameServer = NameServiceDataReaderHelper.narrow(parentReader);
        ErrorHandler.checkHandle(
            nameServer, "Chat.NameServiceDataReaderHelper.narrow");

        /* Adapt the DataReaderQos for the ChatMessageDataReader to
           keep track of all messages. */
        status = chatSubscriber.get_default_datareader_qos(messageQos);
        ErrorHandler.checkStatus(
            status, "DDS.Subscriber.get_default_datareader_qos");
        status = chatSubscriber.copy_from_topic_qos(
            messageQos, reliableTopicQos.value);
        ErrorHandler.checkStatus(
            status, "DDS.Subscriber.copy_from_topic_qos");
        messageQos.value.history.kind =
            HistoryQosPolicyKind.KEEP_ALL_HISTORY_QOS;

        /* Create a DataReader for the ChatMessage Topic
           (using the appropriate QoS). */
        parentReader = chatSubscriber.create_datareader(
            chatMessageTopic,
            messageQos.value,
            null,
            ANY_STATUS.value);
        ErrorHandler.checkHandle(
            parentReader, "DDS.Subscriber.create_datareader (ChatMessage)");

        /* Narrow the abstract parent into its typed representative. */
        loadAdmin = ChatMessageDataReaderHelper.narrow(parentReader);
        ErrorHandler.checkHandle(
            loadAdmin, "Chat.ChatMessageDataReaderHelper.narrow");

        /* Initialize the Query Arguments. */
        params = new String[1];
        params[0] = new String("0");

        /* Create a QueryCondition that will contain all messages
           with userID=ownID */
        singleUser = loadAdmin.create_querycondition(
            ANY_SAMPLE_STATE.value,
            ANY_VIEW_STATE.value,
            ANY_INSTANCE_STATE.value,
            "userID=%0",
            params);
        ErrorHandler.checkHandle(
            singleUser, "DDS.DataReader.create_querycondition");

        /* Create a ReadCondition that will contain new users only */
        newUser = nameServer.create_readcondition(
            NOT_READ_SAMPLE_STATE.value,
            NEW_VIEW_STATE.value,
            ALIVE_INSTANCE_STATE.value);
        ErrorHandler.checkHandle(
            newUser, "DDS.DataReader.create_readcondition");

        /* Obtain a StatusCondition that triggers only when a Writer
           changes Liveliness */
        leftUser = loadAdmin.get_statuscondition();
        ErrorHandler.checkHandle(
            leftUser, "DDS.DataReader.get_statuscondition");
        status = leftUser.set_enabled_statuses(
            LIVELINESS_CHANGED_STATUS.value);
        ErrorHandler.checkStatus(
            status, "DDS.StatusCondition.set_enabled_statuses");

        /* Create a bare guard which will be used to close the room */
        escape = new GuardCondition();

        /* Create a waitset and add the ReadConditions */
        userLoadWS = new WaitSet();
        status = userLoadWS.attach_condition(newUser);
        ErrorHandler.checkStatus(
            status, "DDS.WaitSet.attach_condition (newUser)");
        status = userLoadWS.attach_condition(leftUser);
        ErrorHandler.checkStatus(
            status, "DDS.WaitSet.attach_condition (leftUser)");
        status = userLoadWS.attach_condition(escape);
        ErrorHandler.checkStatus(
            status, "DDS.WaitSet.attach_condition (escape)");

        /* Initialize and pre-allocate the GuardList used to obtain
           the triggered Conditions. */
        guardList.value = new Condition[3];

        /* Remove all known Users that are not currently active. */
        status = nameServer.take(
            nsList,
            infoSeq,
            LENGTH_UNLIMITED.value,
            ANY_SAMPLE_STATE.value,
            ANY_VIEW_STATE.value,
            NOT_ALIVE_INSTANCE_STATE.value);
        ErrorHandler.checkStatus(
            status, "Chat.NameServiceDataReader.take");
        status = nameServer.return_loan(nsList, infoSeq);
        ErrorHandler.checkStatus(
            status, "Chat.NameServiceDataReader.return_loan");

        /* Start the sleeper thread. */
        new UserLoad().start();

        while (!closed) {
            /* Wait until at least one of the Conditions in the
               waitset triggers. */
            status = userLoadWS._wait(guardList, DURATION_INFINITE.value);
            ErrorHandler.checkStatus(status, "DDS.WaitSet._wait");

            /* Walk over all guards to display information */
            for (int i = 0; i < guardList.value.length; i++) {
                if ( guardList.value[i] == newUser ) {
                    /* The newUser ReadCondition contains data */
                    status = nameServer.read_w_condition(
                        nsList,
                        infoSeq,
                        LENGTH_UNLIMITED.value,
                        newUser);
                    ErrorHandler.checkStatus(
                        status,
                        "Chat.NameServiceDataReader.read_w_condition");

                    for (int j = 0; j < nsList.value.length; j++) {
                        System.out.println(
                            "New user: " + nsList.value[j].name);
                    }
                    status = nameServer.return_loan(nsList, infoSeq);
                    ErrorHandler.checkStatus(
                        status, "Chat.NameServiceDataReader.return_loan");

                } else if ( guardList.value[i] == leftUser ) {
                    // Some liveliness has changed (either a DataWriter
                    // joined or a DataWriter left)
                    status = loadAdmin.get_liveliness_changed_status(
                        livChangStatus);
                    ErrorHandler.checkStatus(
                        status,
                        "DDS.DataReader.get_liveliness_changed_status");
                    if (livChangStatus.value.alive_count < prevCount) {
                        /* A user has left the ChatRoom, since a DataWriter
                           lost its liveliness. Take the effected users
                           so they will not appear in the list later on. */
                        status = nameServer.take(
                            nsList,
                            infoSeq,
                            LENGTH_UNLIMITED.value,
                            ANY_SAMPLE_STATE.value,
                            ANY_VIEW_STATE.value,
                            NOT_ALIVE_NO_WRITERS_INSTANCE_STATE.value);
                        ErrorHandler.checkStatus(
                            status, "Chat.NameServiceDataReader.take");

                        for (int j = 0; j < nsList.value.length; j++) {
                            /* re-apply query arguments */
                            params[0] =
                                Integer.toString(nsList.value[j].userID);
                            status = singleUser.set_query_parameters(params);
                            ErrorHandler.checkStatus(
                                status,
                                "DDS.QueryCondition.set_query_parameters");

                            /* Read this users history */
                            status = loadAdmin.take_w_condition(
                                msgList,
                                infoSeq2,
                                LENGTH_UNLIMITED.value,
                                singleUser );
                            ErrorHandler.checkStatus(
                                status,
                               "Chat.ChatMessageDataReader.take_w_condition");

                            /* Display the user and his history */
                            System.out.println(
                                "Departed user " + nsList.value[j].name +
                                " has sent " + msgList.value.length +
                                " messages.");
                            status = loadAdmin.return_loan(msgList, infoSeq2);
                            ErrorHandler.checkStatus(
                                status,
                                "Chat.ChatMessageDataReader.return_loan");
                            msgList.value = null;
                            infoSeq2.value = null;
                        }
                        status = nameServer.return_loan(nsList, infoSeq);
                        ErrorHandler.checkStatus(
                            status,
                            "Chat.NameServiceDataReader.return_loan");
                        nsList.value = null;
                        infoSeq.value = null;
                    }
                    prevCount = livChangStatus.value.alive_count;

                } else if ( guardList.value[i] == escape ) {
                    System.out.println("UserLoad has terminated.");
                    closed = true;
                }
                else
                {
                    assert false : "Unknown Condition";
                };
            } /* for */
        } /* while (!closed) */

        /* Remove all Conditions from the WaitSet. */
        status = userLoadWS.detach_condition(escape);
        ErrorHandler.checkStatus(
            status, "DDS.WaitSet.detach_condition (escape)");
        status = userLoadWS.detach_condition(leftUser);
        ErrorHandler.checkStatus(
            status, "DDS.WaitSet.detach_condition (leftUser)");
        status = userLoadWS.detach_condition(newUser);
        ErrorHandler.checkStatus(
            status, "DDS.WaitSet.detach_condition (newUser)");

        /* Free all resources */
        status = participant.delete_contained_entities();
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipant.delete_contained_entities");
        status = TheParticipantFactory.value.delete_participant(participant);
        ErrorHandler.checkStatus(
            status, "DDS.DomainParticipantFactory.delete_participant");

    }

}
```
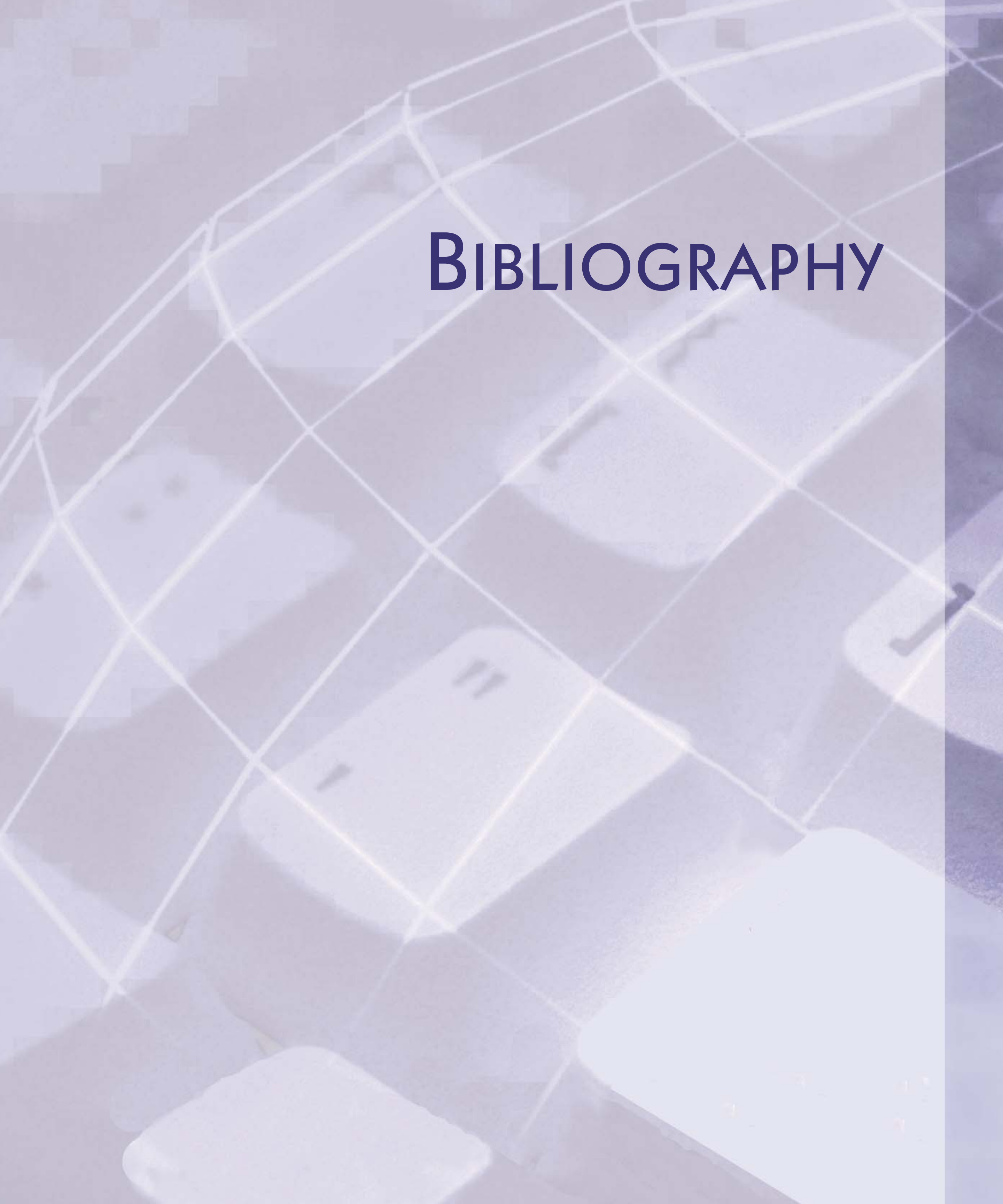

Bibliography



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