DDS for eXtremely Resource Constrained Environments

FTF Beta 1

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# Table of Contents

Preface ............................................................................................................................................ 1

1 Scope ........................................................................................................................................ 3

2 Conformance ............................................................................................................................ 4

3 References ................................................................................................................................ 5

3.1 Normative References ........................................................................................................... 5

3.2 Non-normative References .................................................................................................... 5

4 Terms and Definitions .............................................................................................................. 6

5 Symbols .................................................................................................................................... 7

6 Additional Information ............................................................................................................. 8

6.1 Changes to Adopted OMG Specifications ............................................................................... 8

6.2 Acknowledgements ................................................................................................................ 8

7 XRCE Object Model ................................................................................................................ 9

7.1 General .................................................................................................................................... 9

7.2 XRCE Client .......................................................................................................................... 10

7.3 XRCE Agent .......................................................................................................................... 11

7.4 Model Overview .................................................................................................................. 13

7.5 XRCE DDS Proxy Objects .................................................................................................. 14

7.6 XRCE Object Identification ................................................................................................. 14

7.7 Data types used to model operations on XRCE Objects ....................................................... 15

7.7.1 Data and Samples ........................................................................................................... 15

7.7.2 DataRepresentation ........................................................................................................ 16

7.7.3 ObjectVariant ................................................................................................................. 18

7.7.4 ObjectId ....................................................................................................................... 31

7.7.5 ObjectKind .................................................................................................................... 31

7.7.6 ObjectIdPrefix .............................................................................................................. 31

7.7.7 ResultStatus .................................................................................................................. 32

7.7.8 BaseObjectRequest ....................................................................................................... 33

7.7.9 BaseObjectReply .......................................................................................................... 34

7.7.10 RelatedObjectRequest ................................................................................................. 34

7.7.11 CreationMode ............................................................................................................... 35

7.7.12 ActivityInfoVariant ..................................................................................................... 35

7.7.13 ObjectInfo ................................................................................................................... 36

7.7.14 ReadSpecification ....................................................................................................... 36

7.8 XRCE Object operations ...................................................................................................... 37
B.3.3. Writing a single data sample with timestamp metadata ................................................ 135
B.3.4. Writing a disposed data sample .................................................................................... 138

B.4. READ_DATA message examples ............................................................................................ 140
B.4.1. Reading a single data sample ..................................................................................... 140
B.4.2. Reading a sequence of data samples with a content filter ............................................. 142

B.5. DATA message examples ....................................................................................................... 145
B.5.1. Receiving a single data sample ..................................................................................... 145
B.5.2. Receiving a sequence of samples without SampleInfo ................................................. 146
B.5.3. Receiving a single sample that includes SampleInfo .................................................... 148
B.5.4. Receiving a sequence of samples that includes SampleInfo ......................................... 150
B.5.5. Receiving a sequence of packed samples ..................................................................... 152
Preface

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1 Scope

This specification defines a XRCE Protocol between a resource constrained, low-powered device (client) and an Agent (the server). The XRCE Protocol enables the device to communicate with a DDS network and publish and subscribe to topics in a DDS domain via an intermediate service (the XRCE Agent). The specification’s purpose and scope are to ensure that applications based on different vendors’ implementations of the XRCE Protocol and XRCE Agent are compatible and interoperable.

Figure 1— Scope of XRCE Protocol

The XRCE protocol is a client-server protocol between resource-constrained devices (clients) and an XRCE Agent (server). The protocol allows the resource constrained devices with sleep/wake cycles to have access to the DDS Global Data Space over limited-bandwidth networks.
2 Conformance

This specification defines ten profiles. Each constitutes a separate conformance point:

- **Read Access profile.** Provides the clients the ability to read data on pre-configured Topics with pre-configured QoS policies. Requires implementation of all submessage types except for CREATE, INFO, WRITE_DATA, and DELETE, including the associated behaviors.

- **Write Access profile.** Provides the clients the ability to write data on pre-configured Topics with pre-configured QoS policies. Requires implementation of all submessage types except for CREATE, INFO, READ_DATA, DATA, and DELETE, including the associated behaviors.

- **Configure Entities profile.** Provides the clients the ability define DomainParticipant, Topic, Publisher, Subscriber, DataWriter, and DataReader entities using pre-configured QoS policies and data-types. Requires implementation of the CREATE_CLIENT, DELETE_CLIENT, CREATE, and DELETE submessage and the associated behaviors.

- **Configure QoS profile.** Provides client the ability to define QoS profiles to be used by DDS entities. Requires implementation of the CREATE submessage and the associated behaviors for object kind OBJK_QOSPROFILE.

- **Configure types profile.** Provides client the ability to explicitly define data types to be used for DDS Topics. Requires implementation of the CREATE submessage and the associated behaviors for object kind OBJK_TYPE.

- **Discovery access profile.** Provides the clients the ability to discover the Topics and Types available on the DDS Global Data Space. Requires implementation of the GET_INFO and INFO submessage and the associated behaviors.

- **File based configuration profile.** Provides a standard way to configure the Agent using XML files. Requires implementation of the file-based configuration mechanism described in clause 9.3

- **UDP Transport profile.** Implements the mapping of the protocol to the UDP transport. Requires implementing the mechanisms described in clause 11.2 (UDP Transport).

- **TCP Transport profile.** Implements the mapping of the protocol to the UDP transport. Requires implementing the mechanisms described in clause 11.3 (TCP Transport).

- **Complete profile.** Requires implementation of the complete specification.
3 References

3.1 Normative References

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


3.2 Non-normative References

4 Terms and Definitions

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

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

**DDS Domain**
Represents a global data space. It is a logical scope (or “address space”) for Topic and Type definitions. Each Domain is uniquely identified by an integer Domain ID. Domains are completely independent from each other. For two DDS applications to communicate with each other they must join the same DDS Domain.

**DDS DomainParticipant**
A DomainParticipant is the DDS Entity used by an application to join a DDS Domain. It is the first DDS Entity created by an application and serves as a factory for other DDS Entities. A DomainParticipant can join a single DDS Domain. If an application wants to join multiple DDS Domains, then it must create corresponding DDS DomainParticipant entities, one per domain.

**DDS Global Data Space**
The “DDS Global Data Space” consists of a collection of peers communicating over the Data Distribution Service and the collection of data observable by those peers.

**GUID**
Globally Unique Identifier
## 5 Symbols

<table>
<thead>
<tr>
<th>Acronyms</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDS</td>
<td>Data Distribution Service</td>
</tr>
<tr>
<td>IDL</td>
<td>Interface Definition Language</td>
</tr>
<tr>
<td>RTPS</td>
<td>Real-Time Publish-Subscribe</td>
</tr>
<tr>
<td>XRCE</td>
<td>Extremely Resource Constrained Environments</td>
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</tbody>
</table>
6 Additional Information

6.1 Changes to Adopted OMG Specifications
This specification does not change any adopted OMG specification.

6.2 Acknowledgements
The following companies submitted this specification:

- Real-Time Innovations, Inc.
- eProsima
- TwinOaks Computing
7 XRCE Object Model

7.1 General

This specification defines a wire protocol, the DDS-XRCE protocol, to be used between an XRCE Client and XRCE Agent. The XRCE Agent is a DDS Participant in the DDS Global Data Space. The DDS-XRCE protocol allows the client to use the XRCE Agent as a proxy in order to produce and consume data in the DDS Global Data Space.

Figure 2— Scope of XRCE Protocol

The XRCE protocol is a client-server protocol between resource-constrained devices (clients) and an XRCE Agent (server). The protocol allows the resource-constrained devices with sleep/wake cycles to have access to the DDS Global Data Space over limited-bandwidth networks.

To model the interaction between the XRCE Client and XRCE Agent, this specification defines a UML model for the XRCE Agent. This model, called the DDS-XRCE Object Model, defines the objects, interfaces, and operations to be implemented by the agent. It also defines how they relate to operations on the Standard DDS Object Model as defined in the OMG Data-Distribution Service Specification [DDS].

Because the target environment is a resource-constrained device, the goal with the DDS-XRCE object model is not to expose the complete Standard DDS object model. It is understood that much of the configuration can be performed directly on the Agent and therefore does not require explicit interaction from the client. Instead, the focus is on the core set of features required to enable DDS-XRCE clients to participate in a meaningful way in the DDS data-space. In addition to the exposed object from the Standard DDS Object model, the DDS-XRCE object model defines new objects needed to manage disconnected clients, as well as to enable access control and access rights.

The DDS-XRCE protocol is defined as a set of logical messages exchanged between the XRCE Client and the DDS-XRCE Agent. These messages perform logical actions on the DDS-XRCE Object Model that result in corresponding actions on the Standard DDS Object Model. The specification of these logical actions fully describes the observable behavior of the XRCE Agent and its interactions both with the Client and the DDS Global Data Space.

The DDS-XRCE Object Model is similar to the Standard DDS Object Model. Compared to the DDS Object Model it is simpler having a reduced number of objects and operations. This makes the model suitable for resource-constrained, low-power clients. However it also it includes additional features that support remote clients, such as, an access control model and application management model. Despite being simpler, the DDS-XRCE Object Model provides XRCE clients complete access to the DDS Global Data space. Any DDS Topic may be published or subscribed to on any DDS with...
any QoS. This is illustrated in Figure 3.

![Figure 3 — DDS-XRCE Object Model Overview](image)

The DDS-XRCE Object Model is contained in the package DDS-XRCE. It acts as a façade to the Standard DDS Object Model (defined in the DDS specification. The Standard DDS Objects are shown contained in the DDS package.

### 7.2 XRCE Client

The DDS-XRCE Client (XRCE Client) is exposed to the DDS-XRCE Object Model and the façade object. Logically, one can think of this as equivalent to the “DDS Object Model”. However, a client never interacts directly with objects in the Standard Object Model, and there is not a one-to-one mapping between the operations on the DDS-XRCE Object Model and the “DDS Object Model”. This specification does not simply reuse the standard “DDS Object Model” and operations for three reasons:

1. The DDS Object Model is intended for use with a local programming API. For this reason, the DDS Object Model contains many objects and methods with strongly typed parameters, as well as a direct callback interface by means of listener objects that the application registers with the middleware. Such an API is not suitable for resource-constrained, low-power clients that typically prefer more “resource-oriented interfaces.” These clients expect a simplified interface with no callbacks, and use parameters encoded in text.

2. The XRCE Client connectivity is assumed to be inherently intermittent due to potentially aggressive use of low-power mode and deep sleep to conserve battery or loss of radio connectivity. The DDS-XRCE DDS Object Model must overcome intermittent connectivity by introducing a “session,” which can exist across repeated sleep-wakeup cycles by a device.

3. The XRCE Client can access a DDS Service from any location. Therefore, it is desirable to have an access control model that authenticates each client application/principal, controls whether the principal can access the DDS Global Data Space, and controls which operations each principal can perform (e.g., which DDS Topics it can publish and subscribe).
This specification recognizes that XRCE Client entities may have very different needs. Therefore, it supports clients with a wide range of requirements:

- Simple devices may not need to perform any discovery interaction with the XRCE Agent other than (a) having their presence detected by the agent, (b) establishing a presence in the DDS data-space, and (c) being able to publish data of a well-known DDS Topic using a DDS QoS policy. Such a client does not need any of the QoS configuration and dynamic entity creation capabilities of DDS.

- More capable devices may need to publish and subscribe to well-known Topics; however, an XRCE Client may not want the data to be pushed by the XRCE Agent at an arbitrary time, for example due to network constraints. Thus, the DDS model of “pushing” data from Writers to Readers may not work well. This specification addresses this constraint by enabling a device to activate/deactivate “data push” from the Agent.

- Advanced clients may choose to utilize DDS concepts and create their own XRCE Agent resources that map to DDS Objects. These clients may also want to control the QoS of the DDS Objects. This specification enables these types of Clients by exposing a set of operations to dynamically create/update/delete Agent objects. This handling of agents/clients stands in contrast to the first two cases, in which all resources are known in advance and pre-configured on the Agent.

- Finally, complex clients may need to be aware of advanced concepts, such as sequence-numbers (or sample IDs), timestamps, and DDS sources.

As shown by this list, this specification enables simple devices with little to no configuration ability to communicate with fully capable DDS devices.

### 7.3 XRCE Agent

The purpose of the DDS-XRCE Agent (XRCE Agent) is to establish and maintain the presence of the XRCE Client in the DDS data-space. This specification does not dictate any particular implementation; instead the required behavior is described as a set of logical operations on the DDS-XRCE Object Model.

An important feature of this specification is the simplified interaction with the XRCE Agent. The agent presents an Object Model that describes resources. At a high-level, a resource is an object that can be accessed with a name and has properties and behavior. Resources may be preconfigured with well-known names, or dynamically created by an XRCE Client.

Examples of named resources in the XRCE Agent are:

- XRCE Type
- XRCE DataWriter
- XRCE DataReader

Any XRCE Client that is allowed to communicate with the XRCE Agent and has the required access rights can refer to these resources by name. Thus, if an XRCE Agent is preconfigured with a resource named “MySquareWriter” that can publish a type “ShapeDemoTypes::ShapeType”, a Client that has access to this resource can write data using this resource simply by referring to the existing “MySquareWriter”. The Client does not have to create a resource.

Some resource implementation details are outside the scope of this specification. For example, a resource “MySquareWriter” may be associated with a DDS DataWriter shared by many DDS-XRCE clients, or an XRCE Client may have its own dedicated “MySquareWriter”, as long as the DDS DataWriter supports the client’s required QoS policies.

An important feature of the DDS-XRCE Object Model is a Client’s ability to query the Model, as opposed to the typical behavior in the Standard DDS Object Model, in which changes are updated and pushed in real-time. That model is likely not suitable for target environments where disconnected devices are expected to be common. This specification enables Clients to be in charge of when data is received, and to request the XRCE Agent to return data that matches a set of
constraints. Thus, an XRCE Client that is disconnected will not be woken up by an XRCE Agent (it may not be possible); instead, an XRCE Client queries the XRCE Agent when it wakes up.

It is important to distinguish between the operations on the DDS-XRCE Object Model and the Standard DDS Object Model. There is not a 1-to-1 mapping between the operations. Specifically, any reference to the Standard DDS Object Model refers to the behavior and semantics defined in the DDS specification. The DDS operations on the Standard DDS Object Model are not necessarily exposed to, or have an equivalent in, the DDS-XRCE Object Model. The XRCE Agent is not required to expose any programming APIs; the standard interactions occurring with the XRCE Client use the DDS-XRCE protocol, while interactions with other DDS domain participants use the DDS-RTPS protocol.
7.4 Model Overview

At the highest level, the DDS-XRCE Object Model consists of 5 classes: The Root singleton, ProxyClient, Application, AccessController, and DomainParticipant.

The Root singleton is the entry point for the service. It functions as a factory for all the Objects managed by the XRCE Agent.

The ProxyClient class models the XRCE Client application that interacts with the XRCE Agent using the XRCE protocol. Each Application object is associated with a single XRCE ProxyClient and gets its access rights from those assigned to the XRCE Client.

The Application class models a software application that connects with the XRCE Client and manages the DDS objects needed to publish and subscribe data on one or more DDS Domains. An XRCE Application can be associated with zero of more DomainParticipant objects.

The AccessController is responsible for making decisions regarding the resources and operations a particular XRCE ProxyClient is allowed to perform. It contains rules that associate a Client with privileges, which determine which DDS domain an application executing on behalf of a client may join, which DDS Topics the application can read and write, and so on.

The DDS-XRCE DomainParticipant is a proxy for a DDS DomainParticipant and models the association with a DDS domain and the capability of the Application to publish and subscribe to Topics on that domain.
7.5 XRCE DDS Proxy Objects

Several of the DDS-XRCE objects act as proxies to corresponding DDS objects. These proxy objects allow the client application to participate as first-class citizens on the DDS network by delegating the actual DDS behavior and DDS-RTPS protocol implementation to the proxy DDS objects.

This relationship is shown in Figure 5.

![Figure 5 -- XRCE objects that proxy DDS Entities](image)

7.6 XRCE Object Identification

Each XRCE Object managed by the XRCE Agent on behalf of a specific XRCE Client is identified by means of an ObjectId. This implies that the ObjectId shall be unique within the scope of an Agent and a ClientKey. The value of the ObjectId for a particular object shall be configured on the XRCE Agent or specified by the XRCE Client at the time the object is created.
There are two reserved values for ObjectId. The value \{0x00, 0x00\} is referred as OBJECTID_INVALID and represents an invalid object. The value \{0xFF, 0xFF\} is referred as OBJECTID_CLIENT and represents the XRCE ProxyClient object.

Alternatively, objects may also be identified by a string resourceName. The format of this name depends on the resource and provides a way to refer to a resource configured on the agent using a configuration file or similar means.

### 7.7 Data types used to model operations on XRCE Objects

The operations on the XRCE objects accept parameters. The format of these parameters is described as a set of IDL data types. These IDL descriptions are used in the description of the XRCE Object operations as well as used to define the wire representation of the messages exchanged between the Client and the Agent.

The IDL definitions for the data types shall be as specified in Annex A IDL Types. When serializing these types into a binary representation the encoding shall follow the rules defined in in [DDS-XTYPES] for XCDR version 2 encoding.

The following sub clauses provide explanations for some of the key data types specified in Annex A IDL Types.

#### 7.7.1 Data and Samples

When the XRCE Agent sends data to the XRCE Client, it may use one of five possible formats. The formats differ depending on whether the data is sent by itself or accompanied by meta-data such as timestamp and sequence numbers. Another difference is whether the message contains a single sample or a sequence of samples.

While it would be possible to combine all of these representations into a single type (e.g. a union), doing so would introduce additional overhead in the serialization. This overhead is undesirable in bandwidth-constrained environments.

The five possible representation are: SampleData, Sample, SampleDataSeq, SampleSeq, and SamplePackedData. They respectively correspond to the DataFormat values FORMAT_DATA, FORMAT_DATA_SEQ, FORMAT_SAMPLE, FORMAT_SAMPLE_SEQ, and FORMAT_PACKED. Their IDL definition shall be as specified in Annex A IDL Types.

All of these representations serialize the data using the XCDR representation defined in [DDS-XTYPES]. For example, the definition of the SampleData is given by the IDL:

```idl
@extensibility(FINAL)
struct SampleData {
    XCDRSerializedBuffer serialized_data;
};
```

In this structure the XCDRSerializedBuffer represents the bytes resulting from serializing the application-specific data type that is being sent using the XCDR version 2 rules defined in clause 7.4 of [DDS-XTYPES].

Other representations include additional information but still rely on a SampleData to hold the serialized application-specific data. For example, the DataFormat FORMAT_SAMPLE uses the IDL type Sample defined below:

```idl
@bit_bound(8)
bitmask SampleInfoFlags {
    @position(0) INSTANCE_STATE_UNREGISTERED,
    @position(1) INSTANCE_STATE_DISPOSED,
    @position(2) VIEW_STATE_NEW,
    @position(3) SAMPLE_STATE_READ,
};
```
@extensibility(FINAL)
struct SampleInfo {
    SampleInfoFlags state; // Combines SampleState, InstanceState, ViewState
    unsigned long sequence_number;
    unsigned long session_time_offset; // milliseconds up to 53 days
};

@extensibility(FINAL)
struct Sample {
    SampleInfo info;
    SampleData data;
};

The most compact DataFormat that includes sample information is FORMAT_PACKED. This format uses the IDL type PackedSamples defined below:

typedef unsigned short DeciSecond; // 10e-1 seconds

@extensibility(FINAL)
struct SampleInfoDelta {
    SampleInfoFlags state; // Combines SampleState, InstanceState, ViewState
    octet seq_number_delta;
    DeciSecond timestamp_delta; // In 1/10 of seconds
};

@extensibility(FINAL)
struct SampleDelta {
    SampleInfoDelta info_delta;
    SampleData data;
};

@extensibility(FINAL)
struct PackedSamples {
    SampleInfo info_base;
    sequence<SampleDelta> sample_delta_seq;
};

7.7.2 DataRepresentation

The DataRepresentation type is used to hold values of data samples as well as additional sample information, such as sequence number or timestamps. It is used by the XRCE ProxyClient write operation.

The DataRepresentation is defined as a union discriminated by a DataFormat. Depending on the discriminator it selects one of the formats defined in clause 7.7.1.

The possible values for the DataFormat and the resulting representation are described in Table 1 below.
<table>
<thead>
<tr>
<th>DataFormat</th>
<th>Selected DataRepresentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORMAT_DATA</td>
<td>struct SampleData defined in Annex A IDL Types. Contains the data for a single sample without additional sample information.</td>
</tr>
<tr>
<td>FORMAT_DATA_SEQ</td>
<td>struct SampleDataSeq defined in Annex A IDL Types. Contains a sequence of data samples. Each data sample contains only the data without additional sample information.</td>
</tr>
<tr>
<td>FORMAT_SAMPLE</td>
<td>struct Sample defined in Annex A IDL Types. Contains a single sample with both the data and the additional sample information (SampleInfo). The SampleInfo holds the DDS InstanceState, SampleState, and ViewState of the corresponding DDS Sample. It also contains the sample sequence number and timestamp. The timestamp is represented as an offset relative to the session timestamp established when the session was created. The session timestamp corresponds to the client_timestamp attribute in CLIENT_Representation; see 7.8.2.1 and Annex A IDL Types.</td>
</tr>
<tr>
<td>FORMAT_SAMPLE_SEQ</td>
<td>struct SampleSeq defined in Annex A IDL Types. Contains a sequence of samples, each containing both the data and the additional sample information.</td>
</tr>
</tbody>
</table>
| FORMAT_PACKED     | struct PackedSamples defined in Annex A IDL Types. Contains a sequence of samples, each containing both the data and the additional sample information but using a more compact representation than SampleSeq. This representation is limited to samples that are close in sequence number (no more than 256 apart) and timestamp (100 minutes). It also uses timestamps with lower resolution (1/10 sec). The type PackedSamples contains a common SampleInfo (info_base) and a sequence of SampleDelta. Each SampleDelta contains a SampleData as well as an associated SampleInfoDelta (info_delta). The SampleInfo for each sample shall be computed by combining the common info_base with the info_delta that corresponds to that sample. The resulting SampleInfo (resulting_info) is defined as: resulting_info.state := info_delta.state
resulting_info.sequence_number := info_base.sequence_number + info_delta.seq_number_delta
resulting_info.session_time_offset := info_base.session_time_offset + info_delta.timestamp_delta |
The DataRepresentation type shall be as specified in Annex A IDL Types:
@extensibility(FINAL)

union DataRepresentation switch(DataFormat) {
    case FORMAT_DATA:
        SampleData data;
    case FORMAT_SAMPLE:
        Sample sample;
    case FORMAT_DATA_SEQ:
        SampleDataSeq data_seq;
    case FORMAT_SAMPLE_SEQ:
        SampleSeq sample_seq;
    case FORMAT_PACKED_SAMPLES:
        PackedSamples packed_samples;
};

7.7.3 ObjectVariant

The ObjectVariant type is used to hold the representation of a XRCE Object. It is used by the XRCE ProxyClient create, update, and get_info operations.

The ObjectVariant type is defined as a union discriminated by ObjectKind. Each value of the discriminator selects an appropriate object representation for that kind. See struct ObjectVariant defined in Annex A IDL Types.

For a given ObjectKind the, ObjectVariant type also supports multiple representation formats. Each format is identified by a value of the RepresentationFormat. Some formats are optimized for expressiveness and ease of configuration whereas others minimize the size used to transmit the representation.

The next sub clause defines the three possible formats; subsequent sub clauses provide details of the ObjectVariant representation for each kind of object and for each format.

7.7.3.1 Object Representation Formats

There are three RepresentationFormat values: REPRESENTATION_BY_REFERENCE, REPRESENTATION_AS_XML_STRING, and REPRESENTATION_IN_BINARY.

Some object kinds support all three formats; in this case the corresponding representation extends the type struct OBJK_Representation3_Base. Other object kinds support only two formats and therefore extend the type struct OBJK_RepresentationRefAndXML_Base or the type OBJK_RepresentationBinAndXML_Base.

These types are defined by the IDL below; see also Annex A, IDL Types.

    const long REFERENCE_MAX_LEN = 128;

@extensibility(FINAL)
union OBJK_Representation3Formats switch(RepresentationFormat) {
    case REPRESENTATION_BY_REFERENCE :
        string<REFERENCE_MAX_LEN> object_reference
case REPRESENTATION_AS_XML_STRING :
    string xml_string_representation;
case REPRESENTATION_IN_BINARY :
    sequence<octet> binary_representation;
};

@extensibility(FINAL)
union OBJK_RepresentationRefAndXMLFormats switch(RepresentationFormat) {
    case REPRESENTATION_BY_REFERENCE :
        string<REFERENCE_MAX_LEN> object_reference;
    case REPRESENTATION_AS_XML_STRING :
        string string_representation;
};

@extensibility(FINAL)
union OBJK_RepresentationBinAndXMLFormats switch(RepresentationFormat) {
    case REPRESENTATION_IN_BINARY :
        sequence<octet> binary_representation;
    case REPRESENTATION_AS_XML_STRING :
        string string_representation;
};

@extensibility(FINAL)
struct OBJK_RepresentationRefAndXML_Base {
    OBJK_RepresentationRefAndXMLFormats representation;
};

@extensibility(FINAL)
struct OBJK_RepresentationBinAndXML_Base {
    OBJK_RepresentationBinAndXMLFormats representation;
};

@extensibility(FINAL)
struct OBJK_Representation3_Base {
    OBJK_Representation3Formats representation;
};
It is expected that additional representations may be added after they are defined in other OMG specifications. For example, there is ongoing work on a DDS-JSON RFP that would define a JSON format for describing DDS resources analogous to the XML format defined by the [DDS-XML] specification. This could be added as an additional REPRESENTATION_AS_JSON_STRING representation.

7.7.3.1.1 REPRESENTATION_BY_REFERENCE format

The REPRESENTATION_BY_REFERENCE represents the object using an object_reference encoded in a string. The string shall refer by name to a description already known to the XRCE Agent.

This format may be used to represent any object in an extremely compact manner. However it requires pre-configuration of the XRCE Agent. The pre-configuration may be done off-line prior to starting the XRCE Agent or may be done on-line using the DDS-XRCE protocol in combination with the REPRESENTATION_AS_XML_STRING.

The object_reference shall be a string formatted as defined by the XSD simpleType elementNameReference defined in the [DDS-XML] specification file dds-xml_domain_definitions_nonamespace.xsd.

It is expected that most XRCE Clients will use the object_reference to create resources in the XRCE Agent. This is because client applications are deployed as part of a system, and the system configuration and management process can configure the XRCE Agent for the intended deployment.

The following string is an example of an object_reference used to represent a XRCE QosProfile: "MyQosLibrary::MyQosProfile".

This format is available for the XRCE Object kinds that can be configured as libraries in the XRCE Agent. These are XRCE Type, QosProfile, Domain, DomainParticipant, and Application.

7.7.3.1.2 REPRESENTATION_AS_XML_STRING format

The REPRESENTATION_AS_XML_STRING represents the object using an xml_string_representation string. The string shall contain an XML element formatted according to the [DDS-XML] specification. The format of the string is defined for each Object kind in clauses 7.7.3.2 to 7.7.3.11.

This format may be used to dynamically represent any XRCE Object. The disadvantage of this format is that it is more verbose due to the use of XML.

This format is intended for remotely configuring the agent. Typically it will not be used by the XRCE Clients except in deployments where the client-to-agent connection has sufficient bandwidth.

The following XML string is an example of a REPRESENTATION_AS_XML_STRING for the XRCE object QosProfile:

"<qos_library name='MyQosLibrary'>
<qos_profile name='MyQosProfile'>
<data_reader_qos>
  <reliability><kind>RELIABLE_RELIABILITY_QOS</kind><reliability>
  <time_based_filter>
    <minimum_separation><sec>10</sec></minimum_separation>
  </time_based_filter>
</data_reader_qos>
</qos_profile>
</qos_library>"

7.7.3.1.3 REPRESENTATION_IN_BINARY format

The REPRESENTATION_IN_BINARY represents objects using a binary_representation octet sequence. The octet sequence is the result of serializing an IDL-defined data-structure that depends on the kind of object using the XCDR version 2 format defined in [DDS-XTYPES].

This representation has the advantage of being very compact, but it can only be used to represent a subset of the XRCE Objects. Moreover not all DDS QoS can be expressed using the binary representation.
For example, the binary_representation for XRCE Topic is obtained by serializing an object of type struct OBJK.Topic.Binary defined in Annex A, IDL Types:

```c
@extensibility(FINAL)
struct OBJK.Topic.Binary {
    string<256> topic_name;
    @optional string<256> type_reference
    @optional DDS:XTypes::TypeIdentifier type_identifier;
};
```

For example, assuming little endian encoding, for a Topic with topic_name “Square” and type_reference “MyTypes::ShapeType” the binary_representation octet sequence would contain the 36 bytes:

```
{ 0x07, 0x00, 0x00, 0x00, 'S', 'q', 'u', 'r', 'e', '\0', 0x01, 0x13, 0x00, 0x00, 0x00, 'M', 'y', 'T', 'y', 'p', 'e', ':', 'S', 'h', 'a', 'p', 'e', 'T', 'y', 'p', 'e', '\0', 0x00 }
```

In the above note, the length of the two strings is 7 and 19 (in hexadecimal, 0x7 and 0x13), which are encoded in little endian so the least significant byte appears first.

Note also that the boolean value true (0x01) appears before the serialization of the type_reference indicating the presence of the optional member. The boolean value false (0x00) at the end indicates that the optional member type_identifier is not present.

### 7.7.3.2 XRCE QosProfile

The OBJK.QOSPROFILE_Representation supports the REPRESENTATION_BY_REFERENCE and REPRESENTATION_AS_XML_STRING formats. It is defined in Annex A, IDL Types as:

```c
@extensibility(FINAL)
struct OBJK.QOSPROFILE_Representation : OBJK.RepresentationRefAndXML_Base {
};
```

#### 7.7.3.2.1 Representation by reference

When using the REPRESENTATION_BY_REFERENCE the object_reference field shall contain the fully qualified name of a QosProfile known to the XRCE Agent. The fully qualified name is composed of the name of the Qos library and the name of the QosProfile within the library. For example: "MyLibrary::MyProfile".

#### 7.7.3.2.2 XML string representation

When using the REPRESENTATION_AS_XML_STRING the string_representation field shall contain a single <qos_library> top-level XML element with the syntax defined by the XSD complexType qosLibrary defined in the [DDS-XML] machine-readable file dds-xml_qos_definitions.xsd. The <qos_library> element shall contain a single <qos_profile> child element.

The REPRESENTATION_AS_XML_STRING representation may reference other QoS profiles already known to the Agent. This feature also allows a compact way to represent a QosProfile that differs slightly from an existing one.
For example, the following XML defines a profile QosProfile called "MyQosLib::ModifiedProfile" that is based on an already defined profile "MyQosLib::MyQosProfile":

```xml
<qos_library name="MyQosLib">
  <qos_profile name="ModifiedProfile" base_name="MyQosLib:MyQosProfile">
    <data_reader_qos>
      <reliability><kind>RELIABLE_RELIABILITY_QOS</kind></reliability>
    </data_reader_qos>
  </qos_profile>
</qos_library>
```

The `string_representation` may reference other Qos Profiles already known to the XRCE Agent.

### 7.7.3.3 XRCE Type

The [OBJK_TYPE_Representation](#) supports the REPRESENTATION_BY_REFERENCE and REPRESENTATION_AS_XML_STRING formats. It is defined in Annex A, IDL Types as:

```c
@extensibility(FINAL)
struct OBJK_TYPE_Representation : OBJK_RepresentationRefAndXML_Base {
  ...
};
```

#### 7.7.3.3.1 Representation by reference

When using the REPRESENTATION_BY_REFERENCE, the `object_reference` field shall contain the fully qualified name of a XRCE Type known to the XRCE Agent. The fully qualified name is composed of the name of the type prepended by the names of the enclosing modules. For example: "MyModule::ShapeType".

#### 7.7.3.3.2 XML string representation

When using the REPRESENTATION_AS_XML_STRING, the `string_representation` field shall contain a single `<types>` top-level XML element representation with the syntax defined by the XSD complexType `typeLibrary` defined in the [DDS-XML] machine-readable file `dds-xml_type_definitions_nonamespace.xsd`.

Within the `<types>` element there may be multiple types defined. In this case only one type shall have the nested annotation (see [DDS-XTYPES]) set to false. This corresponds to the XRCE Type being created. Any types with nested annotation set to true, if present, may be used to represent the dependent types.

For example, the following XML defines a structure data-type "ShapeType" inside a module named "MyModule" referenceable as "MyModule::ShapeType":

```xml
<types>
  <module name="MyModule">
    <struct name="ShapeType">
      <member name="color" key="true" type="string" stringMaxLength="32"/>
      <member name="x" type="int32"/>
      <member name="y" type="int32"/>
      <member name="shapesize" type="int32"/>
    </struct>
  </module>
</types>
```

The `string_representation` may reference other Types already known to the Agent.

### 7.7.3.4 XRCE Domain

The [OBJK_DOMAIN_Representation](#) supports the REPRESENTATION_BY_REFERENCE and REPRESENTATION_AS_XML_STRING formats. It is defined in Annex A, IDL Types as:
struct OBJK_DOMAIN_Representation : OBJK_RepresentationRefAndXML_Base {
};

7.7.3.4.1 Representation by reference
When using the REPRESENTATION_BY_REFERENCE, the object_reference field shall contain the fully qualified name of a XRCE Domain definition known to the Agent. The fully qualified name is composed of the name of the Domain library and the name of the Domain within the library. For example: "MyDomainLib::ShapesDomain".

7.7.3.4.2 XML string representation
When using the REPRESENTATION_AS_XML_STRING, the string_representation field shall contain the XML representation of a Domain as defined in [DDS-XML]. The XML shall contain a single <domain_library> top-level XML element with the syntax defined by the XSD complexType qosDomain defined in the [DDS-XML] machine-readable file dds-xml_domain_definitions_nonamespace.xsd. The <domain_library> element shall contain a single <domain> child element.

For example, the following XML defines a domain referenceable as "MyDomainLib::ShapesDomain".

```xml
<domain_library name="MyDomainLib">
  <domain name="ShapesDomain" domain_id="0">
    <topic name="Square" register_type_ref="ShapeType" />
  </domain>
</domain_library>
```

The string_representation may reference Types already known to the XRCE Agent.

7.7.3.5 XRCE Application
The OBJK_TYPE_Representation supports the REPRESENTATION_BY_REFERENCE and REPRESENTATION_AS_XML_STRING formats. It is defined in Annex A, IDL Types as:

```c
@extensibility(FINAL)
struct OBJK_APPLICATION_Representation : OBJK_RepresentationRefAndXML_Base {
};
```

7.7.3.5.1 Representation by reference
When using the REPRESENTATION_BY_REFERENCE, the object_reference field shall contain the fully qualified name of a XRCE Application definition known to the Agent. The fully qualified name is composed of the name of the Application library and the name of the Application within the library. For example: "MyAppLibrary::ShapePublisherApp".

7.7.3.5.2 XML string representation
When using the REPRESENTATION_AS_XML_STRING, the string_representation field shall contain the XML representation of an Application as defined in [DDS-XML]. The XML shall contain a single <application_library> top-level XML element with the syntax defined by the XSD complexType applicationLibrary defined in the [DDS-XML] machine-readable file dds-xml_application_definitions_nonamespace.xsd. This element shall contain a single <application> child element.

For example, the following XML defines an application referencable as “MyAppLibrary::ShapePublisherApp”:
The `string_representation` may reference XRCE Types, Qos Profiles, Domains, or DomainParticipants already known to the XRCE Agent.

### 7.7.3.6 XRCE DomainParticipant

The `OBJK_PARTICIPANT_Representation` supports three representation formats. It is defined in Annex A, IDL Types as:

```
@extensibility(FINAL)
struct OBJK_PARTICIPANT_Representation : OBJK_Representation3_Base {
}
```

#### 7.7.3.6.1 Representation by reference

When using the `REPRESENTATION_BY_REFERENCE`, the `object_reference` field shall contain the fully qualified name of a XRCE DomainParticipant definition known to the Agent. The fully qualified name is composed of the name of the DomainParticipant library and the name of the DomainParticipant within the library. For example: "MyParticipantLibrary::ShapePublisherApp".

#### 7.7.3.6.2 XML string representation

When using the `REPRESENTATION_AS_XML_STRING`, the `string_representation` field shall contain a single `domain_participant_library` top-level XML element with the syntax defined by the XSD complexType `domainParticipantLibrary` defined in the [DDS-XML] machine-readable file `dds-xml_domain_participant_definitions_nonamespace.xsd`. This element shall contain a single `domain_participant` child element.

For example, the following XML string defines a DDS-XML DomainParticipant referenceable as "MyParticipantLibrary::MyParticipant".

```
<domain_participant_library name="MyParticipantLibrary">
  <domain_participant name="MyParticipant" domain_id="0">
    <register_type name="ShapeType" type_ref="MyTypes::ShapeType" />
    <topic register_type_ref="ShapeType" name="Square" />
    <publisher name="MyPublisher">
      <data_writer name="MyWriter" topic_ref="Square" />
    </publisher>
  </domain_participant>
</domain_participant_library>
```
The string_representation may reference XRCE Types, Qos Profiles, Domains, or DomainParticipants already known to the XRCE Agent.

### 7.7.3.6.3 Binary representation

When using the REPRESENTATION_IN_BINARY, the binary_representation octet sequence shall contain the XCDR version 2 serialized representation [DDS-XTYPES] of the structure OBJK_DomainParticipant_Binary defined in Annex A IDL Types.

```plaintext
@extensibility(FINAL)
struct OBJK_DomainParticipant_Binary {
    long domain_id;
    @optional string<128> domain_reference;
    @optional string<128> qos_profile_reference;
};
```

The optional domain_reference field may be used to reference a XRCE Domain definition known to the Agent. It shall represent the reference by definition of the domain as defined in 7.7.3.4.1. For example: "MyDomainLib::ShapesDomain".

Any XRCE Topic and Type definitions contained in the referenced domain are considered defined within the scope of the XRCE DomainParticipant and become available as references to construct XRCE objects contained by the DomainParticipant.

The optional qos_profile_reference field may be used to reference a XRCE QosProfile definition known to the Agent. It shall contain the representation by reference of the QosProfile defined in 7.7.3.2.1. For example: "MyQosLib:MyQosProfile". If specified, the corresponding DDS DomainPaticipant shall be created using that Qos. Otherwise, the DomainParticipant shall be created using the DDS default Qos.

### 7.7.3.7 XRCE Topic

The OBJK_TOPIC_Representation supports three representation formats. It is defined in Annex A, IDL Types as:

```plaintext
@extensibility(FINAL)
struct OBJK_TOPIC_Representation : OBJK_Representation3_Base {
    ObjectId participant_id;
};
```

Independent of the representation format, the field participant_id shall contain the ObjectId of a XRCE DomainParticipant object. The referenced or created Topic will belong to the specified DomainParticipant.

#### 7.7.3.7.1 Representation by reference

When using the REPRESENTATION_BY_REFERENCE, the object_reference field shall contain the bare name of a XRCE Topic defined in XRCE DomainParticipant identified by the participant_id. The Topic could be defined directly on the XRCE DomainParticipant, or else in the XRCE Domain associated with the DomainParticipant.

For example, if the DomainParticipant had been defined with a reference to the XRCE Domain "MyDomainLib::ShapesDomain" shown as an example in 7.7.3.4.2, then the object_reference "Square" could be used to reference the namesake Topic of type "ShapeType" defined there.
7.7.3.7.2 XML string representation

When using the REPRESENTATION_AS_XML_STRING, the string_representation field shall contain a single <topic> top-level XML element with the syntax defined by the XSD complexType topic defined in the [DDS-XML] machine-readable file dds-xml_domain_definitions_nonamespace.xsd.

For example, the following XML string defines a DDS-XML Topic with name "Square".

```
<topic name="Square" register_type_ref="ShapeType" />
```

The string_representation may reference XRCE Types or QosProfiles already known to the XRCE Agent.

7.7.3.7.3 Binary representation

When using the REPRESENTATION_IN_BINARY, the binary_representation octet sequence shall contain the XCDR version 2 serialized representation [DDS-XTYPES] of the structure OBJK_Topic_Binary defined in Annex A IDL Types:

```c
@extensibility(FINAL)
struct OBJK_Topic_Binary {
    string<256> topic_name;
    @optional string<256> type_reference;
    @optional DDS:XTypes::TypeIdentifier type_identifier;
};
```

Either type_reference or type_identifier may be used to identify the XRCE Type associated with the Topic. Either member may be omitted, but not both. If both are present the type_identifier shall take precedence.

The type_identifier, if present, shall contain the DDS-XTYPES TypeIdentifier for the data-type. See clause 7.3.2 of [DDS-XTYPES].

The type_reference, if present, shall contain the fully qualified name of the type, including containing modules as specified in 7.7.3.3.1. The referenced type shall be known to the XRCE Agent either via pre-configuration, or as a result of a prior create operation executed on the XRCE ProxyClient; see 7.8.3.1.

7.7.3.8 XRCE Publisher

The OBJK_PUBLISHER_Representation supports the REPRESENTATION_IN_BINARY and REPRESENTATION_AS_XML_STRING formats. It is defined in Annex A, IDL Types as:

```c
@extensibility(FINAL)
struct OBJK_PUBLISHER_Representation : OBJK_RepresentationBinAndXML_Base {
    ObjectId participant_id;
};
```

Independent of the representation format, the member participant_id shall contain the ObjectId of a XRCE DomainParticipant object. The referenced or created Publisher shall belong to the specified DomainParticipant.

7.7.3.8.1 XML string representation

When using the REPRESENTATION_AS_XML_STRING, the string_representation field shall contain a single <publisher> top-level XML element with the syntax defined by the XSD complexType publisher defined in the [DDS-XML] machine-readable file dds-xml_domain_participant_definitions_nonamespace.xsd.

For example, the following XML string defines a XML Publisher referenceable within the XRCE DomainParticipant as "MyPublisher".
Note that the XML representation of a Publisher allows specifying Qos policies and including nested DataWriter objects. These additional definitions may reference other XRCE objects (Qos profiles or topics). Any referenced object must have been previously created or configured on the XRCE Agent. For example, the following XML string defines a XRCE Publisher with a Qos and a contained DataWriter:

```
<publisher name="MyPublisher"/>
<publisher_qos base_name="MyQosLib:MyProfile" />
<data_writer name="MySquareWriter" topic_ref="Square" />
</publisher>
```

### 7.7.3.8.2 Binary representation

When using the REPRESENTATION_IN_BINARY, the `binary_representation` shall contain the XCDR version 2 serialized representation [DDS-XTYPES] of the structure `OBJK_Publisher_Binary` defined in A IDL Types:

```latex
@extensibility(FINAL)
struct OBJK_PUBLISHER_QosBinary {
    @optional sequence<string> partitions;
    @optional sequence<octet> group_data;
};
@extensibility(FINAL)
struct OBJK_Publisher_Binary {
    @optional string publisher_name;
    @optional OBJK_PUBLISHER_QosBinary qos;
};
```

### 7.7.3.9 XRCE Subscriber

The `OBJK_SUBSCRIBER_Representation` supports the REPRESENTATION_IN_BINARY and REPRESENTATION_AS_XML_STRING formats. It is defined in Annex A, IDL Types as:

```latex
@extensibility(FINAL)
struct OBJK_SUBSCRIBER_Representation : OBJK_RepresentationBinAndXML_Base {
    ObjectId participant_id;
};
```

Independent of the representation format, the member `participant_id` shall contain the `ObjectId` of a XRCE DomainParticipant object. The referenced or created Subscriber shall belong to the specified DomainParticipant.

### 7.7.3.9.1 XML string representation

When using the REPRESENTATION_AS_XML_STRING, the `string_representation` field shall contain a single `<subscriber>` top-level XML element with the syntax defined by the XSD complexType `subscriber` defined in the [DDS-XML] machine-readable file `dds-xml_domain Participant_definitions_nonamespace.xsd`.

For example, the following XML string defines a XRCE Subscriber referenceable within the DomainParticipant as "MySubscriber":

```
<subscriber name="MySubscriber"/>
```
Note that the XML representation of a Subscriber allows specifying Qos policies and including nested DataReader objects. These additional definitions may reference other XRCE objects (Qos profiles or topics). Any referenced object must have been previously created or configured on the XRCE Agent. For example, the following XML string defines a XRCE Subscriber with a Qos and a contained DataReader:

```xml
<subscriber name="MySubscriber"/>
  <subscriber_qos base_name="MyQosLib:MyProfile"/>
  <data_reader name="MySquareReader" topic_ref="Square"/>
</subscriber>
```

### 7.7.3.9.2 Binary representation

When using the REPRESENTATION_IN_BINARY, the binary_representation shall contain the XCDR version 2 serialized representation [DDS-XTYPES] of the structure OBJK_Subscriber_Binary defined in Annex A IDL Types.

```c
@extensibility(FINAL)
struct  OBJK_SUBSCRIBER_QosBinary {
    @optional sequence<string>  partitions;
    @optional sequence<octet>   group_data;
};
@extensibility(FINAL)
struct  OBJK_Subscriber_Binary {
    @optional string subscriber_name;
    @optional OBJK_SUBSCRIBER_QosBinary  qos;
};
```

### 7.7.3.10 XRCE DataWriter

The DATAWRITER_Representation supports the REPRESENTATION_IN_BINARY and REPRESENTATION_AS_XML_STRING formats. It is defined in Annex A, IDL Types as:

```c
@extensibility(FINAL)
struct DATAWRITER_Representation    : OBJK_RepresentationBinAndXML_Base {
    ObjectId publisher_id;
};
```

Independent of the representation format, the member publisher_id shall contain the ObjectId of a XRCE Publisher object. The referenced or created DataWriter shall belong to the specified Publisher.

#### 7.7.3.10.1 XML string representation

When using the REPRESENTATION_AS_XML_STRING, the string_representation field shall contain a single <data_writer> top-level XML element with the syntax defined by the XSD complexType dataWriter defined in the [DDS-XML] machine-readable file dds-xml_domain_participantDefinitions_nonamespace.xsd.

For example, the following XML string defines a XRCE DataWriter for Topic "Square" referenceable within the XRCE Subscriber as "MySquareWriter":

```xml
<data_writer name="MySquareWriter" topic_ref="Square"/>
```

The referenced Topic must have been previously created or configured on the XRCE DomainParticipant to which the Publisher and DataWriter belong.
The XML representation of a DataWriter allows specifying Qos policies. These may reference other XRCE (Qos profiles. Any referenced object must have been previously created or configured on the XRCE Agent. For example, the following XML string defines a XRCE DataWriter with a Qos that extends the profile "MyQosLib:MyProfile" additionally setting the DEADLINE Qos policy.

```xml
<data_writer name="MySquareWriter" topic_ref="Square">
  <data_writer_qos base_name="MyQosLib:MyProfile">
    <deadline>
      <period><sec>120</sec></period>
    </deadline>
  </data_writer_qos>
</data_writer>
```

### 7.7.3.10.2 Binary representation

When using the REPRESENTATION_IN_BINARY, the binary_representation shall contain the XCDR version 2 serialized representation [DDS-XTYPES] of the structure OBJK_DataWriter_Binary defined in Annex A IDL Types:

```c
@bit_bound(16)
bitmask EndpointQosFlags {
  @position(0) is_reliable,
  @position(1) is_history_keep_last,
  @position(2) is_ownership_exclusive,
  @position(3) is_durability_transient_local,
  @position(4) is_durability_transient,
  @position(5) is_durability_persistent,
};
@extensibility(FINAL)
struct  OBJK_Endpoint_QosBinary {
  EndpointQosFlags            qos_flags;
  @optional unsigned short    history_depth;
  @optional unsigned long     deadline_msec;
  @optional unsigned long     lifespan_msec;
  @optional sequence<octet>   user_data;
};
@extensibility(FINAL)
struct  OBJK_DataWriter_Binary {
  string                      topic_name;
  OBJK_Endpoint_QosBinary     endpoint_qos;
  @optional unsigned long     ownership_strength;
};
```
7.7.3.11 XRCE DataReader

The DATAREADER_Representation supports the REPRESENTATION_IN_BINARY and REPRESENTATION_AS_XML_STRING formats. It is defined in Annex A, IDL Types as:

```plaintext
@extensibility(FINAL)
struct DATAREADER_Representation : OBJK_RepresentationBinAndXML_Base {
    ObjectId subscriber_id;
};
```

Independent of the representation format, the member `subscriber_id` shall contain the `ObjectId` of a XRCE Subscriber object. The referenced or created DataReader will belong to the specified Subscriber.

7.7.3.11.1 XML string representation

When using the REPRESENTATION_AS_XML_STRING, the `string_representation` field shall contain a single `<data_reader>` top-level XML element with the syntax defined by the XSD complexType `dataReader` defined in the [DDS-XML] machine-readable file `dds-xml_domain_participant_definitions_nonamespace.xsd`.

For example, the following XML string defines a XRCE DataReader for Topic "Square" referenceable within the XRCE Publisher as "MySquareReader":

```xml
<data_reader name="MySquareReader" topic_ref="Square"/>
```

The referenced Topic must have been previously created or configured on the XRCE DomainParticipant to which the Subscriber and DataReader belong.

The XML representation of a DataReader allows specifying Qos policies. These may reference other XRCE Qos profiles. Any referenced objects must have been previously created or configured on the XRCE Agent.

The XML representation of a DataReader may also contain time-based and content-based filters.

For example, the following XML string defines a XRCE DataReader with a Qos that extends the profile "MyQosLib:MyProfile" assing/setting the DEADLINE Qos policy and sets a content filter.

```xml
<data_reader name="MySquareReader" topic_ref="Square">
    <data_reader_qos base_name="MyQosLib:MyProfile">
        <deadline>
            <period><sec>120</sec></period>
        </deadline>
        <content_filter name="MyFilter">
            <expression> x &gt; 5 </expression>
        </content_filter>
    </data_reader_qos>
</data_reader>
```

7.7.3.11.2 Binary representation

When using the REPRESENTATION_IN_BINARY, the `binary_representation` shall contain the XCDR version 2 serialized representation [DDS-XTYPES] of the structure `OBJK_DataReader_Binary` defined in A IDL Types. See also Binary representation of the DataWriter in 7.7.3.10.2 for the definition of `OBJK_Endpoint_QosBinary`.

```plaintext
@extensibility(FINAL)
struct OBJK_DataReader_Binary {
    string topic_name;
    OBJK_Endpoint_QosBinary endpoint_qos;
    @optional unsigned long timebasedfilter_msec;
};
```
@optional string contentbased_filter;

7.7.4 ObjectId

The XRCE ObjectId is used to hold the unique identification of an XRCE Object. Each ObjectId is scoped to an XRCE Client and Agent pair. Consequently, the ObjectId values managed by an Agent need to be unique only for each XRCE Client. An XRCE Client normally connects to a single XRCE Agent. In this situation, the XRCE Client can treat the ObjectId as globally unique.

The ObjectId is defined in A IDL Types as:

typedef octet ObjectId [2];

7.7.5 ObjectKind

The XRCE ObjectKind is used to enumerate and identify the kind of XRCE Object. XRCE objects are classified into 14 kinds. The possible kinds are defined in A IDL Types as:

typedef octet ObjectKind;

const ObjectKind OBJK_INVALID = 0x00;
const ObjectKind OBJK_PARTICIPANT = 0x01;
const ObjectKind OBJK_TOPIC = 0x02;
const ObjectKind OBJK_PUBLISHER = 0x03;
const ObjectKind OBJK_SUBSCRIBER = 0x04;
const ObjectKind OBJK_DATAWRITER = 0x05;
const ObjectKind OBJK_DATAREADER = 0x06;
const ObjectKind OBJK_TYPE = 0x0A;
const ObjectKind OBJK_QOSPROFILE = 0x0B;
const ObjectKind OBJK_APPLICATION = 0x0C;
const ObjectKind OBJK_AGENT = 0x0D;
const ObjectKind OBJK_CLIENT = 0x0E;

7.7.6 ObjectIdPrefix

The ObjectIdPrefix is used to hold the unique identification of an XRCE object of a specific ObjectKind. The ObjectId of an object is composed combining 12 bits from the ObjectIdPrefix and four bits from the ObjectKind.

The ObjectIdPrefix is defined in A IDL Types as:

typedef octet ObjectIdPrefix [2];

Assuming an XRCE object has ObjectIdPrefix objectid_prefix, ObjectKind object_kind, and ObjectId object_id the following relationships shall hold:

object_id[0] = objectid_prefix[0]
object_id[1] = (objectid_prefix[1]&0xF0) + object_kind
7.7.7 ResultStatus

The `ResultStatus` is used to hold the return value of the operations on the XCRE objects. It contains a `StatusValue` that encodes whether the operation succeeded or failed as well as the reason for the failure. It also contains a specialized implementation-specific status, which is used to return vendor or implementation-specific information.

The `StatusValue` and `ResultStatus` are defined in Annex A IDL Types as:

```cpp
@bit_bound(8)
enum StatusValue {
    @value(0x00) STATUS_OK,
    @value(0x01) STATUS_OK_MATCHED,
    @value(0x80) STATUS_ERR_DDS_ERROR,
    @value(0x81) STATUS_ERR_MISMATCH,
    @value(0x82) STATUS_ERR_ALREADY_EXISTS,
    @value(0x83) STATUS_ERR_DENIED,
    @value(0x84) STATUS_ERR_UNKNOWN_REFERENCE,
    @value(0x85) STATUS_ERR_INVALID_DATA,
    @value(0x86) STATUS_ERR_INCOMPATIBLE,
    @value(0x87) STATUS_ERR_RESOURCES
};

struct ResultStatus {
    StatusValue status;
    octet implementation_status;
};
```

The interpretation of the `StatusValue` is specified in below.
Table 2—Interpretation of StatusValue

<table>
<thead>
<tr>
<th>StatusValue</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATUS_OK</td>
<td>Indicates a successful execution of the operation</td>
</tr>
<tr>
<td>STATUS_OK_MATCHED</td>
<td>Indicates a successful execution of a create or update operation on a resource when the resource already existed on the Agent and the resource state already matched the one requested by the operation. As a consequence, no actual change was made to the resource.</td>
</tr>
<tr>
<td>STATUS_ERR_DDS_ERROR</td>
<td>Indicates a failure in the execution of the operation caused by an error when creating or operating on the DDS resource related to the operation.</td>
</tr>
<tr>
<td>STATUS_ERR_MISMATCH</td>
<td>Indicates a failure in the execution of a create or update operation on a resource when the resource already existed on the Agent, the state did not match the one requested by the operation, and it was not possible to change the state of the resource.</td>
</tr>
<tr>
<td>STATUS_ERR_ALREADY_EXISTS</td>
<td>Indicates a failure in the execution of a create operation due to the fact that the resource already existed.</td>
</tr>
<tr>
<td>STATUS_ERR_DENIED</td>
<td>Indicates a failure in the execution of an operation due to lack of permissions.</td>
</tr>
<tr>
<td>STATUS_ERR_UNKNOWN_REFERENCE</td>
<td>Indicates a failure in the execution of an operation due to the fact that the referenced resource is not known to the Agent.</td>
</tr>
<tr>
<td>STATUS_ERR_INVALID_DATA</td>
<td>Indicates a failure in the execution due to wrong or invalid input parameter data.</td>
</tr>
<tr>
<td>STATUS_ERR_INCOMPATIBLE</td>
<td>Indicates a failure in the execution of an operation due to an incompatibility between the Client and the Agent.</td>
</tr>
<tr>
<td>STATUS_ERR_RESOURCES</td>
<td>Indicates a failure in the execution of an operation due to a resource error on the Agent.</td>
</tr>
</tbody>
</table>

**7.7.8 BaseObjectRequest**

The `BaseObjectRequest` type is used to hold the common parameters of the requests sent from the XRCE Client to the Agent. It is defined in Annex A IDL Types as:

```plaintext
@extensibility(FINAL)
struct BaseObjectRequest {
    RequestId request_id;
    ObjectId object_id;
};
```

The interpretation of the members of this type (i.e. parameters sent as part of the requests) shall be:

- `request_id` (RequestId) identifies each request. It is used to correlate a reply with the related request. It is scoped to each XRCE Client and Agent pair. Note that it is possible to reuse a value of the `request_id` for future
requests as long as the previous request with that value is known by Client and Agent to no longer be active.

- **object_id** (ObjectId) the ObjectId that is the target of the request. For requests that create objects, the **object_id** conveys the ObjectIdPrefix for the created object. See 7.7.6.

### 7.7.9 BaseObjectReply

The BaseObjectReply type is used to hold the common parameters of the replies sent from the XRCE Agent back to the Client. It is defined in Annex A IDL Types as:

```c
struct ResultStatus {
    StatusValue status;
    octet implementation_status;
};

@extensibility(FINAL)
struct BaseObjectReply {
    BaseObjectRequest related_request;
    ResultStatus result;
};
```

The interpretation of the members of these types (i.e. parameters sent as part of the requests) shall be:

- **related_request** contains the **request_id** and **object_id** of the request that caused the reply to be sent:
  - The **request_id** (RequestId) identifies the request. It is used to correlate a reply with the request.
  - The **object_id** (ObjectId) is the target of the request. For requests that create objects, the **object_id** conveys the desired ObjectId for the created object. In this case the **object_id** is interpreted as a prefix to be combined with the ObjectKind to obtain the final ObjectId.

- **status** (ResultStatus). Enumerated value indicating whether the related request operation succeeded or failed. If the operation succeeded the StatusValue shall be set to STATUS_OK or STATUS_OK_MATCHED. If it failed it shall be set to the value that corresponds to the type of error encountered.

- **implementation_status** (octet) provides an implementation-specific (vendor-specific) return status. The value is scoped by the XrceVendorId of the Agent. It shall only be interpreted by clients that understand the implementation status values of the XrceVendorId of the Agent that returned it.

### 7.7.10 RelatedObjectRequest

The RelatedObjectRequest type is used to hold the common parameters of the messages sent from the XRCE Agent back to the Client that are indirectly related to a prior request from the Client. For example, DATA messages that related to a previous read operation, see 7.8.5.1.

It is defined in Annex A IDL Types as:

```c
typedef RelatedObjectRequest BaseObjectRequest;
```

The interpretation is the same as for the **related_request** that appears in the BaseObjectReply, see 7.7.9.
7.7.11 CreationMode

The CreationMode type is used to control the behavior of the ProxyClient create operation. See clause 7.8.3.1. It is defined in Annex A IDL Types as:

```c
struct CreationMode {
    boolean reuse;
    boolean replace;
};
```

7.7.12 ActivityInfoVariant

The ActivityInfoVariant type is used to hold information on the activity of a XRCE object. It is used by the ProxyClient get_info operation. See clause 7.8.3.3. It is defined in Annex A IDL Types as:

```c
bitmask InfoMask {
    @position(0) INFO_CONFIGURATION,
    @position(1) INFO_ACTIVITY
};

@extensibility(APPENDABLE)
struct AGENT_ActivityInfo {
    short availability;
    TransportLocatorSeq address_seq;
};

@extensibility(APPENDABLE)
struct DATAREADER_ActivityInfo {
    short highest_acked_num;
};

@extensibility(APPENDABLE)
struct DATAWRITER_ActivityInfo {
    unsigned long long sample_seq_num;
    short stream_seq_num;
};

union ActivityInfoVariant (ObjectKind) {
    case OBJK_DATAWRITER :
```
7.7.13 ObjectInfo

The ObjectInfo type is used to hold information on the configuration and activity of a XRCE object. It is used by the ProxyClient get_info operation. See clause 7.8.3.3. It is defined in Annex A IDL Types. See also clause 7.7.3 for a description of ObjectVariant and 7.7.12 for a description of ActivityInfoVariant.

```
@extensibility(FINAL)
struct ObjectInfo {
    @optional ActivityInfoVariant activity;
    @optional ObjectVariant config;
};
```

7.7.14 ReadSpecification

The ReadSpecification type is used to control the information returned by the ProxyClient read operation. See clause 7.8.5.1. It is defined in Annex A IDL Types as:

```
@extensibility(APPENDABLE)
struct DataDeliveryControl {
    unsigned short max_samples;
    unsigned short max_elapsed_time;
    unsigned short max_bytes_per_second;
    unsigned short min_pace_period;  // milliseconds
};

@extensibility(FINAL)
struct ReadSpecification {
    DataFormat data_format;
    @optional string content_filter_expression;
    @optional DataDeliveryControl delivery_control;
};
```
7.8 XRCE Object operations

7.8.1 Use of the ClientKey

All operations are performed within the context of a ClientKey, which is used both to authenticate and identify the client:

- The ClientKey is assigned to each client. The ClientKey uniquely identifies the client to a particular agent. The ClientKey is associated with a set of permissions for the client within the agent.
- The ClientKey shall be considered secret. It must be configured both on the Client and in the Agent. The creation and configuration are outside the scope of this specification.
- The ClientKey shall not be interpreted.

With the exception of the operations create_client and get_info on the XRCE Root, all other operations expect that the ClientKey references an already exiting XRCE ProxyClient. If this is not the case, the operation shall fail.

To avoid information leakage that could compromise security, the failure to locate a ClientKey may in some cases result in a returnValue having STATUS_ERR_NOCLIENT while in others it may silently drop the connection to the client.

The Agent shall maintain a counter on the number of times the STATUS_ERR_NOCLIENT was sent on an established connection, and once a certain threshold is crossed it shall close the connection. The Agent may subsequently refuse or throttle new connections originating from the same client transport endpoint that was previously closed. The specific details of this behavior are implementation-specific and left outside the scope of this specification.

7.8.2 XRCE Root

The XRCE Root object represents the Agent. An XRCE Agent is a singleton object that all agents shall instantiate.

The XRCE Root is responsible for authenticating client applications and creating the XRCE ProxyClient object associated with each client.

The logical operations on the XRCE Root are shown in Table 3.
### Table 3-- XRCE Root operations

<table>
<thead>
<tr>
<th>Operation</th>
<th>Input/Output</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>create_client</code></td>
<td>object_representation</td>
<td>CLIENT_Representation</td>
</tr>
<tr>
<td></td>
<td>out: agent_info</td>
<td>AGENT_Representation</td>
</tr>
<tr>
<td><code>get_info</code></td>
<td>info_mask</td>
<td>InfoMask</td>
</tr>
<tr>
<td></td>
<td>client_info</td>
<td>ObjectInfo</td>
</tr>
<tr>
<td></td>
<td>out: agent_info</td>
<td>ObjectInfo</td>
</tr>
<tr>
<td><code>delete_client</code></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 7.8.2.1 create_client

**Inputs**

- `client_representation` (CLIENT_Representation): a representation of the Client.

**Outputs**

- `returnValue` (ResultStatus): indicates whether the operation succeeded and the current status of the XRCE ProxyClient object.
- `agent_info` (AGENT_Representation): a representation of the Agent.

The `client_representation` shall contain a CLIENT_Representation which is used to initialize the XRCE ProxyClient. This type is defined in Annex A, IDL Types as:

```cpp
@extensibility(FINAL)
struct CLIENT_Representation {
    XrceCookie   xrce_cookie;  // XRCE_COOKIE
    XrceVersion  xrce_version;
    XrceVendorId xrce_vendor_id;
    Time_t       client_timestamp;
    ClientKey    client_key;
    SessionId    session_id;
    @optional  PropertySeq properties;
};
```

The `agent_representation` shall contain an AGENT_Representation which informs the Client about the configuration of the Agent. This type is defined in Annex A, IDL Types as:
@extensibility(FINAL)

struct AGENT_Representation {
    XrceCookie    xrce_cookie;  // XRCE_COOKIE
    XrceVersion   xrce_version;
    XrceVendorId  xrce_vendor_id;
    Time_t        agent_timestamp;
    @optional PropertySeq  properties;
};

The XRCE Agent shall perform the following checks and actions based on the information found within the client_representation:

- Check the xrce_cookie to ensure it matches the predefined XRCE_COOKIE constant. If it does not match the creation shall fail and set the returnValue StatusValue to STATUS_ERR_INVALID_DATA.
- Check that the major version (xrce_version[0]) matches the XRCE_VERSION_MAJOR. If it does not match, the creation shall fail and set the returnValue StatusValue to STATUS_ERR_INCOMPATIBLE.
- Check that the Client identified by the client_key is authorized to connect to the XRCE Agent. If this check fails the operation shall fail and set the returnValue StatusValue to STATUS_ERR_DENIED.
- Check the Client properties, if present. These may contain vendor-specific information that may prevent the Agent from accepting the connection from the Client. The properties field may include extra authentication tokens (e.g. username and password) or other configuration information. If this check fails the operation shall fail and set the returnValue StatusValue to the appropriate value.
- Check if there is an existing XRCE ProxyClient object associated with the same client_key and, if so, compare the session_id of the existing ProxyClient with the one in the client_representation:
  - If a ProxyClient exists and has the same session_id, then the operation shall not perform any action and shall set the returnValue StatusValue to STATUS_OK.
  - If a ProxyClient exists and has a different session_id then the operation shall delete the existing XRCE ProxyClient object and subsequently take the same actions as if there had not been a ProxyClient associated with the client_key.
- Check that there are sufficient internal resources to complete the create operation. If there are not, then the operation shall fail and set the returnValue StatusValue to STATUS_ERR_RESOURCES.

The communication state between an XRCE Client and an XRCE Agent is managed by the associated ProxyClient. Therefore deletion of an existing ProxyClient resets any prior communication state between the client and the agent. Any messages that were cached pending acknowledgments shall be discarded.

If the Agent creates a ProxyClient object it shall:

- Initialize its state to have the specified session_id.
- Initialize the built-in streams with sequence number 0.
- Set the returnValue StatusValue to STATUS_OK.
- Return a representation of the XRCE Agent in the agent_info.

The Agent and Client may use the client_timestamp and agent_timestamp to detect time-synchronization differences between the XRCE Client and the XRCE Agent. The use of this information is left outside the scope of this specification.

The Agent and Client may use the XrceVersion and XrceVendorId to further configure their protocol.

7.8.2.2 get_info

Inputs

- info_mask (InfoMask): selects the kind of information to retrieve.
• **client_info** (ObjectInfo): a representation of the Client.

**Outputs**

• **returnValue** (ResultStatus): indicates whether the operation succeeded and the current status of the XRCE ProxyClient object.

• **agent_info** (ObjectInfo): a representation of the Agent.

Both **client_info** and **agent_info** use the type **ObjectInfo** defined in Annex A, IDL Types as:

```plaintext
@extensibility(FINAL)
struct ObjectInfo {
    @optional ActivityInfoVariant activity;
    @optional ObjectVariant config;
};
```

The operation **get_info** returns information on the XRCE Agent and may be used prior to establishing a **Session** with the XRCE Agent—that is, before calling the operation **create_client** on the XRCE Root.

The operation **get_info** may be used over a different transport or connection, allowing a Client to search and discover the presence of XRCE Agent objects and select one (or more) with a suitable configuration and availability.

The **ObjectVariant** member within **client_info** shall contain a CLIENT_Representation, which provides information on the XRCE Client that makes the request. This type is defined in Annex A, IDL Types and also shown in 7.8.2.1.

The **client_key** field of **CLIENT_Representation** shall be set to the value CLIENTKEY_INVALID (see Annex A, IDL Types) in order to not unnecessarily disclose the ClientKey.

The **ObjectVariant** member within **agent_info** shall contain an AGENT_ActivityInfo which contains activity information on the XRCE Agent. This type is defined in Annex A, IDL Types and also shown in 7.8.2.1.

The **ActivityInfoVariant** member within **agent_info** shall contain an AGENT_Representation, which contains information on the XRCE Agent. This type is defined in Annex A, IDL Types

**ActivityInfoVariant** member **address_seq** shall be used to inform the XRCE Client of the transport addresses over which it can be reached and can receive calls to **create_client**.

The **properties** field of type PropertySeq available both in the **CLIENT_Representation** and the **AGENT_Representation** may be used to implement an authentication protocol for the XRCE Agent. The specific mechanism is outside the scope of this specification.

**7.8.2.3 delete_client**

**Outputs**

• **returnValue** (ResultStatus): indicates whether the operation succeeded and the current status of the object.

The XRCE Agent shall check the ClientKey to locate an existing XRCE: ProxyClient. If the object is not found the operation shall fail and **returnValue** StatusValue shall be set to STATUS_ERR_UNKNOWN_REFERENCE. If the object is found it shall be delete and **returnValue** StatusValue shall be set to STATUS_OK.
7.8.3 XRCE ProxyClient

The XRCE ProxyClient object represents a specific XRCE Client inside a concrete XRCE Agent. The ProxyClient object is identified by the ClientKey.

The logical operations on the ProxyClient are shown in Table 4.

Table 4 XRCE ProxyClient operations

<table>
<thead>
<tr>
<th>Operation</th>
<th>Inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>create</td>
<td>creation_mode (CreationMode): controls the behavior of the operation when there is an existing object that partially matches the description of the object that the client wants to create.</td>
</tr>
<tr>
<td></td>
<td>objectid_prefix (ObjectIdPrefix): configures the desired ObjectId for the created object.</td>
</tr>
<tr>
<td></td>
<td>object_representation (ObjectVariant): a representation of the object that the client wants to create.</td>
</tr>
<tr>
<td>update</td>
<td>objectid_prefix (ObjectIdPrefix)</td>
</tr>
<tr>
<td></td>
<td>object_representation (ObjectVariant)</td>
</tr>
<tr>
<td>get_info</td>
<td>out: object_info (ObjectInfo)</td>
</tr>
<tr>
<td></td>
<td>info_mask (InfoMask)</td>
</tr>
<tr>
<td></td>
<td>object_id (ObjectId)</td>
</tr>
<tr>
<td>delete</td>
<td>object_id (ObjectId)</td>
</tr>
</tbody>
</table>

7.8.3.1 create

Inputs

- **creation_mode** (CreationMode): controls the behavior of the operation when there is an existing object that partially matches the description of the object that the client wants to create.
- **objectid_prefix** (ObjectIdPrefix): configures the desired ObjectId for the created object.
- **object_representation** (ObjectVariant): a representation of the object that the client wants to create.

Outputs

- **returnValue** (ResultStatus): indicates whether the operation succeeded and the current status of the object. The object_id in the returnValue shall be derived from the object_prefix input parameter.

This operation attempts to create a XRCE object according to the specification provided in the object_representation parameter. The ObjectVariant is a union discriminated by the ObjectKind that is used to define the kind of XRCE object being created, see 7.7.3. We will refer to this ObjectKind as the “input_objectkind”.
The **object_prefix** parameter contains the **ObjectIdPrefix** used to determine the **ObjectId** for the object. See 7.7.6. The combination of the **objectId_prefix** and the **ObjectKind** contained in the **object_representation** discriminator shall be used to construct the “input” **ObjectId**. We shall refer to this **ObjectId** as the “**input_objectid**”.

The selected member of the **ObjectVariant** contains the information required to construct an object of **ObjectKind** **input_objectkind**.

The **creation_mode** affects the behavior of the create operation as specified in Table 5.

**Table 5 -- CreationMode influence on create operation**

<table>
<thead>
<tr>
<th>creation_mode</th>
<th>creation_mode</th>
<th>input objectid exists</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>reuse</td>
<td>replace</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don’t care</td>
<td>Don’t care</td>
<td>NO</td>
<td>Create object according to Table 6.</td>
</tr>
<tr>
<td>FALSE</td>
<td>FALSE</td>
<td>YES</td>
<td>No action taken. Set the StatusValue within <strong>returnValue</strong> to: STATUS_ERR_ALREADY_EXISTS.</td>
</tr>
<tr>
<td>FALSE</td>
<td>TRUE</td>
<td>YES</td>
<td>Delete existing object as specified by the <strong>delete</strong> operation. Create object according to Table 6. Set the StatusValue within <strong>returnValue</strong> to: STATUS_OK.</td>
</tr>
<tr>
<td>TRUE</td>
<td>FALSE</td>
<td>YES</td>
<td>Check if <strong>object_representation</strong> matches the existing Object: If it matches no action is taken. Set the StatusValue within <strong>returnValue</strong> to: STATUS_OK_MATCHES. If it does not match no action is taken. Set the StatusValue within <strong>returnValue</strong> to: STATUS_ERR_MISMATCH.</td>
</tr>
<tr>
<td>TRUE</td>
<td>TRUE</td>
<td>YES</td>
<td>Check if <strong>object_representation</strong> matches the existing Object: If it matches, no action is taken. Set the StatusValue within <strong>returnValue</strong> to: STATUS_OK MATCHES. If it does not match, delete existing object as specified by the <strong>delete</strong> operation and then create a new object according to Table 6. Set the StatusValue within <strong>returnValue</strong> to: STATUS_OK.</td>
</tr>
</tbody>
</table>
As described in 7.7.3 the ObjectVariant type used for the object_representation is a union type discriminated by the ObjectKind. However the representations for the different kinds of objects all derive from either OBJK_Representation2_Base or OBJK_Representation3_Base. Therefore they all have at least the REPRESENTATION_BY_REFERENCE and the REPRESENTATION_AS_XML_STRING. Object representations deriving OBJK_Representation3_Base also have a REPRESENTATION_IN_BINARY.

Certain representations support the representation of nested objects. For example, as seen in 7.7.3.6.2, the XML representation of a XRCE DomainParticipant may contain representations of nested Topic, Publisher, Subscriber, DataWriter, and DataReader objects. In this case, the creation of the XRCE object shall also create the nested objects and the failure to create any nested entity shall be considered a failure to create the contained entity as well.

Some of the XRCE objects may be defined by this specification as proxies for DDS entities. In this case the creation of the XRCE Object will automatically trigger the creation of the proxy DDS Entity. Failure to create a DDS Entity shall be considered a failure to create the proxy XRCE object as well.

If the creation of the XRCE object fails then there should be no associated DDS-RTPS discovery traffic generated by the Agent. This means that all DDS entities shall be created disabled, such that the creation does not result in DDS-RTPS discovery traffic, and enabled (if so configured by their QoS) only after it has been determined that the creation has succeeded.

If the creation succeeds the Agent shall set the StatusValue within returnStatus to STATUS_OK.

The creation of XRCE objects is done in accordance to the object_representation parameter. The specific behavior depends on the ObjectKind. See Table 6.
<table>
<thead>
<tr>
<th>ObjectKind</th>
<th>Create behavior</th>
</tr>
</thead>
</table>
| OBJK_QOSPROFILE    | The ObjectVariant is a OBJK_QOSPROFILE_Representation which references or contains a QosProfile definition.  
The agent shall use that definition to create a XRCE QosProfile in accordance to the representation defined in 7.7.3.2.                                                                                                                                              |
| OBJK_TYPE          | The ObjectVariant is a OBJK_TYPE_Representation which references or contains a Type definition.  
The agent shall use that definition to create a XRCE Type in accordance to the representation defined in 7.7.3.3.                                                                                                                                                   |
| OBJK_APPLICATION   | The ObjectVariant is a OBJK_APPLICATION_Representation which references or contains XRCE Application definition.  
The agent shall use that definition to create a XRCE Application with all the contained entities found within the definition in accordance to the representation defined in 7.7.3.5.                                                                                       |
| OBJK_PARTICIPANT   | The ObjectVariant is a OBJK_PARTICIPANT_Representation which references or contains a DomainParticipant definition.  
The agent shall use that definition to create a XRCE DomainParticipant and an associated DDS DomainParticipant with all the contained entities found within the definition in accordance to the representation defined in 7.7.3.6.                                                                 |
| OBJK_TOPIC         | The ObjectVariant is a OBJK_TOPIC_Representation which references or contains a Topic definition.  
The agent shall locate the XRCE DomainParticipant identified by the `participant_id`.  
If this object is not found the operation shall fail and return STATUS_ERR_UNKNOWN_REFERENCE.  
The agent shall use the definition to create a XRCE Topic in accordance with the representation defined in 7.7.3.7 and an associated DDS Topic. The DDS Topic shall be created using the DomainParticipant identified by the `participant_id`. |
| OBJK PUBLISHER     | The ObjectVariant is a OBJK_PUBLISHER_Representation which references or contains a Publisher definition.  
The agent shall locate the XRCE DomainParticipant identified by the `participant_id`.  
If this object is not found the operation shall fail and return STATUS_ERR_UNKNOWN_REFERENCE.  
The agent shall use the definition to create a XRCE Publisher in accordance with the representation defined in 7.7.3.8 and an associated DDS Publisher. The DDS Publisher shall be created using the DomainParticipant identified by the `participant_id`. |
| OBJK SUBSCRIBER    | The ObjectVariant is a OBJK_SUBSCRIBER_Representation which references or contains a Subscriber definition.  
The agent shall locate the XRCE DomainParticipant identified by the `participant_id`.  
If this object is not found the operation shall fail and return STATUS_ERR_UNKNOWN_REFERENCE.  
The agent shall use the definition to create a XRCE Subscriber in accordance with the representation defined in 7.7.3.9 and an associated DDS Subscriber. The DDS Subscriber shall be created using the DomainParticipant identified by the `participant_id`. |
**OBJK_DATAWRITER**

The **ObjectVariant** is a **DATAWRITER** Representation which references or contains a **DataWriter** definition.

The agent shall locate the XRCE **Publisher** identified by the *publisher_id*. If this object is not found the operation shall fail and return **STATUS_ERR_UNKNOWN_REFERENCE**.

The agent shall use the definition to create a XRCE **DataWriter** in accordance with the representation defined in 7.7.3.10 and an associated DDS **DataWriter**. The DDS **DataWriter** shall be created using the Publisher identified by the *publisher_id*.

**OBJK_DATEREADER**

The **ObjectVariant** is a **DATAWRITER** Representation which references or contains a **DataReader** definition.

The agent shall locate the XRCE **Subscriber** identified by the *subscriber_id*. If this object is not found the operation shall fail and return **STATUS_ERR_UNKNOWN_REFERENCE**.

The agent shall use the definition to create a XRCE **DataReader** in accordance with the representation defined in 7.7.3.11 and an associated DDS **DataReader**. The DDS **DataReader** shall be created using the Subscriber identified by the *subscriber_id*.

### 7.8.3.2 update

**Inputs**
- *object_id* (ObjectId): the object being updated.
- *object_representation* (ObjectVariant): of the updated object.

**Outputs**
- *returnValue* (ResultStatus): indicates whether the operation succeeded and the current status of the object.

This operation shall attempt to update an existing object in the XRCE Agent. If the object exists and the update is successful **STATUS_OK** shall be returned, otherwise a status indicating an error shall be returned:
- If the object does not already exist **STATUS_ERR_UNKNOWN_REFERENCE** shall be returned.
- If the update was unsuccessful due to invalid parameters, **STATUS_ERR_INVALID_DATA** shall be returned.
- If an update is unsuccessful the referenced object shall return to its previous configuration.
- If the object cannot be updated due to permission restrictions, **STATUS_ERR_DENIED** shall be returned.

### 7.8.3.3 get_info

**Inputs**
- *objectid_id* (ObjectId): the object queried.
- *info_mask* (InfoMask): selects the kind of information to retrieve.

**Outputs**
- *returnValue* (ResultStatus): indicates whether the operation succeeded.
- *object_info* (ObjectInfo): contains the current activity and configuration of the specified object.

This operation returns the configuration and activity data for an existing object.
- If the object does not already exist **STATUS_ERR_UNKNOWN_REFERENCE** shall be returned.
• If the object cannot be accessed due to permission restrictions STATUS_ERR_DENIED shall be returned.

7.8.3.4 delete

Inputs

• object_id (ObjectIdPrefix): the object being deleted.

Outputs

• returnValue (ResultStatus): indicates whether the operation succeeded.

This operation deletes an existing object. If the object is successfully deleted STATUS_OK shall be returned.

• If the object does not exist STATUS_ERR_UNKNOWN_REFERENCE shall be returned.

• If the object cannot be deleted due to permission restrictions, STATUS_ERR_DENIED shall be returned.

7.8.4 XRCE DataWriter

The operations are defined in Table 7.

Table 7 XRCE DataWriter operations

<table>
<thead>
<tr>
<th>write</th>
<th>ResultStatus</th>
</tr>
</thead>
<tbody>
<tr>
<td>object_id</td>
<td>ObjectId</td>
</tr>
<tr>
<td>data</td>
<td>DataRepresentation</td>
</tr>
</tbody>
</table>

7.8.4.1 write

Inputs

• object_id (ObjectId): the object that shall publish the data.

• data (DataRepresentation): data to be written.

Outputs

• returnValue (ResultStatus): indicates whether the operation succeeded and the current status of the object. The object_id in the returnValue shall be set to match the object_id input parameter.

This operation writes one or more samples using the XRCE DataWriter identified by the object_id.

• If the data is successfully written STATUS_OK shall be returned.

• If the XRCE DataWriter object identified by the object_id does not exist, the ResultStatus STATUS_ERR_UNKNOWN_REFERENCE shall be returned.

• If the client is not allowed to write data using the referenced object_id due to permission restrictions, the ResultStatus STATUS_ERR_DENIED shall be returned.

• If the data could not be written successfully due, for example invalid data format, the ResultStatus STATUS_ERR_INVALID_DATA shall be returned.

The DataRepresentation type (see 7.7.2) supports multiple DataFormats. This allows sending single data items (FORMAT_DATA) as well as sequences (batches) of data items (FORMAT_SAMPLE_SEQ).

The DataRepresentation type also supports sending sample information in addition to the data. This is encoded in the SampleInfo type (see 7.7.1) allowing sending timestamps and also notifications of dispose and unregister.
If the DataRepresentation contains a Sample where the SampleInfo has the “dispose” flag set, the XRCE Agent shall call the dispose operation on the corresponding DDS DataWriter for the instance identified in the associated data. Similarly there is a Sample where the SampleInfo has the “unregister” flag set, the XRCE Agent shall call the unregister operation on the corresponding DDS DataWriter for the instance identified in the associated data.

7.8.5 XRCE DataReader

The operations are defined in Table 8.

Table 8 XRCE DataReader operations

<table>
<thead>
<tr>
<th>read</th>
<th>ResultStatus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>out: read_data</td>
</tr>
<tr>
<td></td>
<td>object_id</td>
</tr>
<tr>
<td></td>
<td>read_specification</td>
</tr>
<tr>
<td></td>
<td>DataRepresentation</td>
</tr>
<tr>
<td></td>
<td>Objectld</td>
</tr>
<tr>
<td></td>
<td>ReadSpecification</td>
</tr>
</tbody>
</table>

7.8.5.1 read

Inputs

- **object_id** (ObjectId): the object to read data from.
- **read_specification** (ReadSpecification): the operation will only return data that matches the constraint.

Outputs

- **returnValue** (ResultStatus): indicates whether the operation succeeded.
- **data_read** (DataRepresentation): data matching the read_spec or nil if there was an error.

This operation reads one or more samples from the XRCE DataReader identified by the object_id. If the data is successfully read STATUS_OK shall be returned.

- If the object does not exist STATUS_ERR_UNKNOWN_REFERENCE shall be returned.
- If the client is not allowed to read data using the referenced object_id due to permission restrictions, STATUS_ERR_DENIED shall be returned.

The read_spec parameter controls the data returned by this operation. The fields of this structure shall be interpreted as described in Table 9.

Table 9 Interpretation of the ReadSpecification

<table>
<thead>
<tr>
<th>field</th>
<th>type</th>
<th>interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>data_format</td>
<td>DataFormat</td>
<td>Selects one the data formats. See 7.7.1</td>
</tr>
<tr>
<td>content_filter_expression</td>
<td>string</td>
<td>A content filter expression selecting which data to read. The syntax shall be as specified in Annex B (Syntax for Queries and Filters) of the DDS specification [DDS].</td>
</tr>
<tr>
<td>max_samples</td>
<td>unsigned short</td>
<td>Maximum number of samples to return as a result of the read. The special value MAX_SAMPLES_ZERO =0 is used to cancel any</td>
</tr>
</tbody>
</table>
prior read operation that may still be active. The special value MAX_SAMPLES_UNLIMITED =0xffff is used to indicate that there is limit on the number of samples returned.

max_elapsed_time (DataDeliveryControl) unsigned short Maximum amount of time in seconds that may be spent delivering the samples from the read operation. The units are seconds from the time the call is made. The special value MAX_ELAPSED_TIME_UNLIMITED = 0 indicates there is no maximum and the operation shall continue until some other condition is met or the operation is explicitly cancelled.

max_bytes_per_sec (DataDeliveryControl) unsigned short Maximum rate in bytes per second at which the data may be returned to the read operation.

min_pace_period (DataDeliveryControl) unsigned short Minimum separation between data messages returned from the read operation in milliseconds.

The setting of the data_format controls whether the read operation returns a single sample per message or a collection of samples. It also determines whether the data or it includes the additional information that appears in the SampleInfo (see Annex A IDL Types). The additional information contains sequence numbers and time stamps.

The setting of the content_filter_expression configures a content filter that is applied to the samples in the DataReader cache. Only samples for which the filter evaluates to TRUE shall be returned to the XRCE Client.

The setting of the max_samples configures the read operation to terminate after the specified number of samples has been returned. The value MAX_SAMPLES_ZERO can be used to cancel the currently active read operation without sending any more samples. The value MAX_SAMPLES_UNLIMITED indicates there is no limit to the number of samples returned.

The setting of the max_elapsed_time configures the read operation to terminate after the specified time has elapsed from the moment the read operation was made. The value MAX_ELAPSED_TIME_UNLIMITED indicates that there is no termination condition based on the elapsed time.

The setting of the max_bytes_per_sec configures the maximum rate in bytes per second at which samples may be returned.

The setting of the min_pace_period configures the minimum interval in milliseconds between the sample messages sent from the Agent to the Client. This period makes it possible for the client to go into a sleep cycle between messages.
8 XRCE Protocol

8.1 General
The XRCE Agent implements the operations specified in the DDS-XRCE Object Model that are driven by messages between the XRCE Client and XRCE Agent. The DDS-XRCE message protocol is designed specifically to address the limited CPU, power, and network bandwidth found in many types of low-powered devices and to enable the device to be discoverable in the larger DDS network. Specifically, it is designed to meet the unique challenges posed by these types of devices. The main features include:

- Operate over networks with bandwidth limited to 40-100Kbps.
- Work with devices that undergo sleep cycles. These devices may be active once every few minutes, days, months, or even years.
- Be simple and programming-language independent, supporting devices that are programmed in a highly specialized language or frameworks.
- Support a minimal discovery protocol, allowing plug-and-play deployments where the Agent location is dynamically discovered.
- Support accessing the full capabilities of DDS. Any data type can be published or subscribed to with any DDS QoS.
- Support sending updates to multiple data-times on the same or multiple DDS Topics efficiently.
- Support receiving information both reliably and in a best effort manner, even if the information was sent while the Client was undergoing a sleep cycle.
- Support secure communication at the transport level.
- Provide full read/write access to any data in the DDS Global Data Space (subject to access control limits).
- Provide a full implementation requiring less than 100KB of code.

In contrast to applications that use the DDS API directly, XRCE Clients:

- Do not have a standard API, so they are not portable across vendor implementations.
- Cannot operate without infrastructure support. They need an XRCE Agent to be reachable to them. This is a necessary consequence of the need for XRCE Clients to undergo deep sleep cycles.
- Do not communicate directly peer-to-peer. All communications are brokered (relayed) by one or more DDS-XRCE Agents. This is also a necessary consequence of the need for Clients to undergo deep sleep cycles.

8.2 Definitions
XRCE Clients and XRCE Agents exchange messages to execute operations on the XRCE Agent and return results. The DDS-XRCE Protocol uses the terms client, agent, session, and message defined in the subclauses below.

At a high level, a client communicates with an agent using the DDS-XRCE protocol, exchanging messages on a stream belonging to a session.

8.2.1 Message
A message is the unit of information sent via the transport and is a structured sequence of bytes sent on a DDS-XRCE transport. A message has a sequence number that is used for ordering of messages, or for identifying messages that have been dropped by the transport.

The underlying XRCE Transport shall transfer each message as a unit. A single XRCE Transport “message” shall transport a single XRCE message.

XRCE messages shall be encoded assuming the first byte has a 16-byte alignment. Therefore the encoding is independent of any transport heading or prefix that may precede it.
8.2.2 Session

A session defines a bi-directional connection between a client and an agent that has been established with a handshake. The session is needed to exchange messages with the XRCE agent. An XRCE client may send messages over multiple sessions, for example if it communicates with multiple XRCE agents.

A session can contain independent, reliable, and best-effort message streams. Each session may have up to 256 streams. There can be at most one active session between an XRCE client and an XRCE agent. Creation of a new session closes any previous sessions.

8.2.3 Stream

A stream represents an independent ordered flow of messages within a session. Messages are ordered within a stream by means of a sequence number. The sequence numbers used by different streams are independent of each other.

Streams can be reliable or best efforts. Each stream uses a constant endianness to encode the data in the message/submessage headers and payload.

8.2.4 Client

An XRCE client is the entity that initiates the establishment of a session with an XRCE agent. An XRCE client may send and receive messages to the agent on streams belonging to an established XRCE session.

8.2.5 Agent

An XRCE agent is the entity that listens to and accepts requests to establish sessions from XRCE clients. An XRCE agent may send and receive messages to a client on streams belonging to an established session.

8.3 Message Structure

8.3.1 General

An XRCE message is composed of a message header followed by one or more submessages and shall be transferred as a unit by the underlying XRCE Transport.

![Message structure](image)

Figure 6 — Message structure

8.3.2 Message Header

The header is structured as follows:
8.3.2.1 Sessions and the sessionId

An XRCE session is established between the XRCE Client and XRCE Agent to establish an initial context for the communications. This includes the exchange of protocol versions, vendor identification, and other information needed to correctly process messages.

A session is identified by an 8-bit sessionId. The sessionId is unique to an XRCE Agent for a given XRCE Client. The sessionId also determines whether the Header includes a clientKey or not.

- If the sessionId is between 0 and 127 (0x00 to 0x7f), both included, then the Header shall include the clientKey and the sessionId is scoped by the clientKey.
- If the sessionId is between 128 and 255 (0x80 to 0xff), both included, then the Header shall not include the clientKey and the sessionId is scoped by the source address of the message.

If the clientKey does not appear explicitly in the message header, the XRCE Agent must be able to locate it from the source address of the message (see clause 8.3.2.4).

The following two values of the sessionId are reserved:

- The value 0 (0x00) shall be used to indicate the lack of a session within a Header containing a clientKey. This value is referred to as SESSION_ID_NONE_WITH_CLIENT_KEY.
- The value 128 (0x80) shall be used to indicate the lack of a session within a Header that does not contain a clientKey. This value is referred to as SESSION_ID_NONE_WITHOUT_CLIENT_KEY.

8.3.2.2 Streams and the streamId

An XRCE stream represents an independent flow of information between a XRCE Client and a XRCE Agent. Each XRCE message belongs to a single stream. Messages belonging to the same stream must be delivered in the order they are sent. Messages belonging to different streams are not ordered relative to each other.

Streams are scoped by the session they belong to.

The streamId with value 0 (0x00) is referred as STREAMID_NONE. This stream is used for messages exclusively containing submessages that do not belong to any stream.

The streams with streamId between 1 (0x01) and 127 (0x7F), both included, shall be best-effort streams.

The streams with streamId between 128 (0x80) and 255 (0xFF), both included, shall be reliable streams.

Based on the rules above if the streamId is not STREAMID_NONE, then the leading bit of the streamId can be interpreted as a flag that indicates the reliability of the stream.

There are two built-in streams that are created whenever a session is created:

- A built-in best-effort stream identified by a streamId with value 1 (0x01). This is referred to as STREAMID_BUILTIN_BEST_EFFORTS.
A built-in reliable stream identified by a streamId with value 128 (0x80). This is referred to as STREAMID_BUILTIN_RELIABLE.

8.3.2.3 sequenceNr
The sequenceNr is used to order messages within a stream and it is scoped to the stream. Messages belonging to different streams are unordered relative to each other:

- For the stream with streamId STREAMID_NONE, the sequenceNr does not impose any order; however it still may be used to discard duplicate messages.
- For the stream with streamId different from STREAMID_NONE, the sequenceNr imposes an order. Messages within a stream shall not be delivered out of order. In addition duplicate messages shall be discarded.

Addition and comparison of sequence numbers shall use Serial Number Arithmetic as defined by [IETF RFC-1982] with SERIAL_BITS set to 16. This implies that the maximum number of outstanding (unacknowledged) messages for a specific client session stream is limited to $2^{15}$—that is, 32768.

The sequenceNr shall be encoded using little endian format.

8.3.2.4 clientKey
The clientKey uniquely identifies and authenticates an XRCE Client to the XRCE Agent.

The clientKey shall be present on the Header if the sessionId is between 0 and 127. See clause 8.3.2.1:

- If the clientKey is present, it shall contain the ClientKey associated with the XRCE Client.
- If the clientKey is not present, the XRCE Agent shall be able to derive the ClientKey associated with the XRCE Client from the source address of the message. This means that the ClientKey has either been pre-configured on the XRCE Agent for that particular source address, or it has been exchanged as part of the session establishment. See clause 7.8.2.1.

Any exchange of the clientKey is protected by the security mechanisms provided by the XRCE transport. These security mechanisms are transport-specific and may involve a pairing of each device with the agent or some initial handshake used to establish a secure transport connection. The specific transport security mechanisms are outside the scope of this specification.

8.3.3 Submessage Structure
Following the message header there shall be one or more submessages. A Submessage shall be composed of a SubmessageHeader and a payload.

```
 0 4 8 16 24 31
+-------+----------------+----------------+----------------+----------------+----------------+
|               submessageHeader    (4 Bytes)                    |
+---------------+----------------+----------------+----------------+----------------+
~               payload             (up to to 64 KB)                ~
+---------------+----------------+----------------+----------------+----------------+
```

The ability to place multiple Submessages within a single message reduces bandwidth by enabling multiple resources to be operated on with a single message.

Submessages shall start at an offset that is a multiple of 4 relative to the beginning of the Message. This means that additional padding may be added between the end of a submessage and the beginning of the next submessage.

8.3.4 Submessage Header
Every Submessage shall start with a SubmessageHeader. The SubmessageHeader shall be structured as follows:
8.3.4.1 submessageId

The submessageId identifies the kind of submessage. The kinds of submessages are defined in 8.3.5.

8.3.4.2 flags

The flags field contains information about the content of the Submessage.

Bit 0, the ‘Endianness’ bit, shall indicate the endianness used to encode the submessage header and payload. If the Endianness bit is set to 0, the encoding shall be big endian and otherwise little endian.

The flags field for all submessage kinds shall have the Endianness bit. Specific submessage kinds may define additional flag bits.

8.3.4.3 submessageLength

The submessageLength indicates the length of the Submessage (excluding the Submessage header).

The submessageLength shall be encoded using little endian format, independent of the value of the flags.

8.3.4.4 payload

The payload contains information specific to the submessage whose format depends on the kind of submessage identified by the submessageId.

The definition of the payload shall use the data types defined in clause 7.7. See clause 8.3.5 and its subclauses.

8.3.5 Submessage Types

DDS-XRCE defines the 13 kinds of Submessages shown in the figure below:

![ DDS-XRCE Submessages Diagram ]

Figure 7 — DDS-XRCE submessages
Each submessage is identified by the `submessageId`. Some submessages may only be sent in one direction (e.g. only XRCE Client to XRCE Agent or only XRCE Agent to XRCE Client) whereas others are bi-directional.

Table 10 – List of SubmesageId values and their purpose

<table>
<thead>
<tr>
<th>SubmessageId</th>
<th>Value</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>CREATE_CLIENT</td>
<td>0</td>
<td>Client to Agent. Initiates the connection between Client and Agent. Creates a ProxyClient on the Agent. Causes the Agent to call the <code>Root::create_client</code> operation.</td>
</tr>
<tr>
<td>CREATE</td>
<td>1</td>
<td>Client to Agent. Creates an XRCE Object. Causes the Agent to call the <code>ProxyClient::create</code> operation.</td>
</tr>
<tr>
<td>GET_INFO</td>
<td>2</td>
<td>Client to Agent. Requests information on an XRCE Object. Causes the Agent to call the operation <code>Root::get_info</code> or <code>ProxyClient::get_info</code>.</td>
</tr>
<tr>
<td>DELETE</td>
<td>3</td>
<td>Client to Agent. Deletes an object or set of XRCE Objects. Causes the Agent to call the <code>ProxyClient::delete</code> operation or the <code>Root::delete_client</code> operation.</td>
</tr>
<tr>
<td>STATUS_AGENT</td>
<td>4</td>
<td>Agent to Client. Sent in response to CREATE_CLIENT. Contains information about the Agent. Carries the return value of the <code>Root::create_client</code> operation.</td>
</tr>
<tr>
<td>STATUS</td>
<td>5</td>
<td>Agent to Client; typically in response to CREATE, UPDATE or DELETE. Contains information about the status of an Xrce object. Carries the return value of the <code>ProxyClient::create, update, or delete</code> operations.</td>
</tr>
<tr>
<td>INFO</td>
<td>6</td>
<td>Agent to Client. Typically sent in response to a GET_INFO. Contains detailed information about an Xrce: Object or the XRCE Agent. Carries the return value of the operation <code>Root::get_info</code> or <code>ProxyClient::get_info</code>.</td>
</tr>
<tr>
<td>WRITE_DATA</td>
<td>7</td>
<td>Client to Agent. Used to write data using a XRCE DataWriter. Causes the Agent to call the <code>ProxyClient::write</code> operation.</td>
</tr>
<tr>
<td>READ_DATA</td>
<td>8</td>
<td>Client to Agent. Used to read data using a XRCE DataReader. Causes the Agent to call the <code>ProxyClient::read</code> operation.</td>
</tr>
<tr>
<td>DATA</td>
<td>9</td>
<td>Agent to Client in response to a READ_DATA provides data received by a XRCE DataReader. Carries the return value of the <code>ProxyClient::read</code> operation.</td>
</tr>
<tr>
<td>ACKNACK</td>
<td>10</td>
<td>Bi-directional. Sends a positive and/or negative acknowledgment to a range of sequence numbers.</td>
</tr>
</tbody>
</table>
8.3.5.1 \textbf{CREATE\_CLIENT}

The \texttt{CREATE\_CLIENT} submessage shall be sent by the XRCE Client to create a XRCE ProxyClient.

Reception of this submessage shall result in the XRCE Agent calling the \texttt{create\_client} operation on the XRCE Root object, see 7.8.2.1. The parameters to this operation are obtained from the \texttt{payload}.

The XRCE Agent shall send a \texttt{STATUS\_AGENT} message in response, see 0.

8.3.5.1.1 flags

The \texttt{CREATE\_CLIENT} submessage does not define any additional flag bits beyond the common ones specified in 8.3.4.2.

8.3.5.1.2 payload

The payload shall contain the XCDR representation of the \texttt{CREATE\_CLIENT\_Payload} object defined in Annex A IDL Types as:

@extensibility(FINAL)
struct CLIENT\_Representation {
    XrceCookie xrc_cookie; // XRCE\_COOKIE
    XrceVersion xrc_version;
    XrceVendorId xrc_vendor_id;
    Time_t client_timestamp;
    ClientKey client_key;
    SessionId session_id;
    @optional PropertySeq properties;
};

@extensibility(FINAL)
struct CREATE\_CLIENT\_Payload : BaseObjectRequest {
    CLIENT\_Representation client_representation;
};

The payload contains the \texttt{client\_representation} input parameter to the \texttt{create\_client} call.

8.3.5.2 \textbf{CREATE}

The \texttt{CREATE} submessage shall be sent by the XRCE Client to create a XRCE Object. An example is creating an XRCE:DataWriter with a QoS profile.
Reception of this submessage shall result in the XRCE Agent calling the `create` operation on the XRCE ProxyClient object, see 7.8.3.1. The parameters to this operation shall be obtained from the `SubmessageHeader` flags and `payload`.

The XRCE Agent shall send a `STATUS` submessage in response, see 8.3.5.6.

### 8.3.5.2.1 flags

The `CREATE` submessage defines two additional flag bits that encode the `creation_mode` input parameter to the `create` call:

- Bit 1, the ‘Reuse’ bit, encodes the value of the `CreationMode` `reuse` field.
- Bit 2, the ‘Replace’ bit, encodes the value of the `CreationMode` `replace` field.

These flag bits modify the behavior of the XRCE Agent receiving the `CREATE` message. See clause 7.8.3.1.

### 8.3.5.2.2 payload

The payload shall contain the XCDR representation of the `CREATE_Payload` object defined in Annex A IDL Types and also shown below. See also 7.7.3 for the definition and interpretation of the `ObjectVariant`:

```c
@extensibility(FINAL)
struct CREATE_Payload : BaseObjectRequest {
    ObjectVariant object_representation;
};
```

The payload derives from `BaseObjectRequest`, which contains the `object_id` parameter to the `create` call. The payload contains the `object_representation` input parameter to the `create` call.

### 8.3.5.3 GET_INFO

The `GET_INFO` submessage shall be sent by the XRCE Client to get information about a resource identified by its `object_id`.

Reception of this submessage shall result in the XRCE Agent calling the `get_info` operation. The targeted XRCE Object shall depend on the `ObjectKind` encoded in the last 4 bits of the `object_id`:

- If the `ObjectKind` is set to OBJK_AGENT, then it shall result in the XRCE Agent calling the `get_info` operation on the XRCE Root object (see 7.8.3.3).
- If the `ObjectKind` is set to one of OBJK_PARTICIPANT, OBJK_PUBLISHER, OBJK_SUBSCRIBER, OBJK_DATAWRITER, OBJK_DATAREADER, OBJK_TYPE, OBJK_QOSPROFILE, or OBJK_APPLICATION. That is to a value between 0x01 and 0x0c (both included), then it shall result in the XRCE Agent calling the `get_info` operation on the XRCE ProxyClient object (see 7.8.3.3).

The parameters to this operation shall be obtained from the `payload`.

The XRCE Agent shall send an `INFO` submessage in response to this message, see 8.3.5.6.

### 8.3.5.3.1 flags

The `GET_INFO` submessage does not define any additional flag bits beyond the common ones specified in 8.3.4.2.

### 8.3.5.3.2 payload

The payload shall contain the XCDR representation of the `GET_INFO_Payload` object defined in Annex A IDL Types as:

```c
@extensibility(FINAL)
struct GET_INFO_Payload : BaseObjectRequest {
    ObjectVariant object_representation;
};
```
bitmask InfoMask {
    @position(0) INFO_CONFIGURATION,
    @position(1) INFO_ACTIVITY
};
@extensibility(FINAL)
struct GET_INFO_Payload : BaseObjectRequest {
    InfoMask  info_mask;
};

The payload derives from BaseObjectRequest, which contains the object_id parameter to the get_info call. The payload also contains the info_mask input parameter to the get_info call.

8.3.5.4 DELETE

The DELETE submessage shall be sent by the XRCE Client to delete the XRCE:ProxyClient or any other XRCE Object (e.g. XRCE:DataWriter).

Reception of this submessage shall result in the XRCE Agent calling either the delete_client operation on the XRCE Root (see 7.8.2.3), or else the delete operation on the XRCE ProxyClient object (see 7.8.3.4).

The related XRCE Object is identified by the object_id field in the payload.

If the ObjectVariant contained within the payload has ObjectKind set to OBJK_CLIENT, then the XRCE Agent shall call the delete_client operation. Otherwise it shall call the delete operation.

The parameters to the delete_client or the delete operation shall be obtained from the payload.

The XRCE Agent shall send a STATUS submessage in response, see 8.3.5.6.

8.3.5.4.1 flags

The DELETE submessage does not define any additional flag bits beyond the common ones specified in 8.3.4.2.

8.3.5.4.2 payload

The payload shall contain the XCDR representation of the DELETE_Payload object defined in Annex A IDL Types as:

@extensibility(FINAL)
struct DELETE_Payload : BaseObjectRequest {
};

The payload derives from BaseObjectRequest which contains the object_id that identifies the XRCE Object to delete.

8.3.5.5 STATUS_AGENT

The STATUS_AGENT submessage shall be sent by the XRCE Agent in response to a CREATE_CLIENT submessage.

The submessage shall contain the returnStatus to the create_client operation invocation that was triggered by the reception of the corresponding CREATE_CLIENT message.
8.3.5.5.1 flags

The STATUS_AGENT submessage does not define any additional flag bits beyond the common ones specified in 8.3.4.2.

8.3.5.5.2 payload

The payload shall contain the XCDR representation of the STATUS_AGENT_Payload object defined in Annex A IDL Types as:

```
@extensibility(FINAL)
struct AGENT_Representation {
    xrce_cookie; // XRCE_COOKIE
    XrceVersion  xrce_version;
    XrceVendorId xrce_vendor_id;
    Time_t       agent_timestamp;
    @optional  PropertySeq  properties;
};
```

```
@extensibility(FINAL)
struct STATUS_AGENT_Payload : BaseObjectReply {
    AGENT_Representation agent_info;
};
```

If the operation fails, the STATUS_AGENT_Payload shall have the ResultStatus within the BaseObjectReply set to with the StatusValue that corresponds to the type of error encountered. Otherwise, it shall have it set to STATUS_OK.

The request_id and object_id within the BaseObjectReply shall match the namesake fields in the BaseObjectRequest of the corresponding CREATE_CLIENT message.

The xrce_cookie shall be set to the four bytes {‘X’, ‘R’, ‘C’, ‘E’}.

The xrce_version shall be set to the version of the XRCE protocol that the Agent will implement in its connection to the Client.

8.3.5.6 STATUS

The STATUS submessage shall be sent by the XRCE Agent in response to a CREATE or DELETE.

The STATUS submessage shall also be sent by the XRCE Agent in response to a READ_DATA submessage when the returnStatus to the read_data operation is anything other than STATUS_OK.

The STATUS submessage shall contain the returnStatus to the operation that was triggered by the corresponding request message. For example, if the request message was a CREATE, the STATUS payload shall contain the returnStatus to the create operation.

8.3.5.6.1 flags

The STATUS submessage does not define any additional flag bits beyond the common ones specified in 8.3.4.2.
8.3.5.6.2 payload

The payload shall contain the XCDR representation of the STATUS_Payload object defined in Annex A IDL Types as:

```c
@extensibility(FINAL)
struct STATUS_Payload : BaseObjectReply {
};
```

If the operation fails, the ResultStatus within the BaseObjectReply shall be set to the StatusValue that corresponds to the type of error encountered. Otherwise, it shall have it set to STATUS_OK.

The request_id and object_id within the BaseObjectReply shall match the namesake fields in the corresponding request message.

8.3.5.7 INFO

The INFO submessage shall be sent by the XRCE Agent to the XRCE Client in response to a GET_INFO message.

The submessage contains the returnStatus and output parameters of the get_info operation that was triggered by the corresponding request message.

8.3.5.7.1 flags

The INFO submessage does not define any additional flag bits beyond the common ones specified in 8.3.4.2.

8.3.5.7.2 payload

The payload shall contain the XCDR representation of the INFO_Payload object defined in Annex A IDL Types. See also clause 7.7.13 for a description of the ObjectInfo contained in the payload.

```c
@extensibility(FINAL)
struct ObjectInfo {
    @optional ActivityInfoVariant activity;
    @optional ObjectVariant config;
};

@extensibility(FINAL)
struct INFO_Payload : BaseObjectReply {
    ObjectInfo object_info;
};
```

If the operation fails the ResultStatus within the BaseObjectReply shall be set to the StatusValue that corresponds to the type of error encountered. Otherwise it shall have it set to STATUS_OK.

The request_id and object_id within the BaseObjectReply shall match the identically named fields in the BaseObjectRequest of the corresponding GET_INFO message.

The activity and config within members within the INFO_Payload shall contain the value of the identically named output parameters of the get_info operation.
8.3.5.8 WRITE_DATA

The WRITE_DATA submessage is used by the XRCE Client to write data using a XRCE DataWriter object within the XRCE Agent.

Reception of this submessage shall result in the XRCE Agent calling the write operation on a XRCE DataWriter object (see 7.8.4.1). The XRCE Agent shall respond with a STATUS submessage.

The data parameter to the write operation shall be obtained from the payload.

The related XRCE DataWriter is identified by the object_id field in the payload.

Upon reception of this message the XRCE Agent shall located the XRCE DataWriter identified by the object_id and use it to write the data to the DDS domain.

8.3.5.8.1 flags

The WRITE_DATA sub-message uses the lowest order 4 bits of the flags:

- Bit 0 indicates the ‘Endianness’ as specified in 8.3.4.2.
- Bits 1, 2, and 3 shall be set to indicate the DataFormat used for the payload. The possible values are as indicated in Table 11 below.

Table 11 – Flag bits used by the WRITE_DATA and DATA submessages

<table>
<thead>
<tr>
<th>DataFormat</th>
<th>Lowest order 4 bits of flags. Bit 0 encodes the Endianness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Big Endian</td>
</tr>
<tr>
<td>FORMAT_DATA</td>
<td>0000 = 0x0</td>
</tr>
<tr>
<td>FORMAT_SAMPLE</td>
<td>0010 = 0x2</td>
</tr>
<tr>
<td>FORMAT_DATA_SEQ</td>
<td>1000 = 0x8</td>
</tr>
<tr>
<td>FORMAT_SAMPLE_SEQ</td>
<td>1010 = 0xA</td>
</tr>
<tr>
<td>FORMAT_PACKED_SAMPLES</td>
<td>1110 = 0xE</td>
</tr>
</tbody>
</table>

For example, if the payload of the WRITE_DATA message uses FORMAT_DATA_SEQ and is encoded as Little Endian, the corresponding 8-bit options would be set to binary 00001001, hexadecimal 0x09. The lowest order bit (bit 0) is set to 1 to indicate Little Endian encoding, and bits 1-3 are set to 0, 0, and 1, respectively, to indicate FORMAT_DATA_SEQ.

8.3.5.8.2 payload

The format the payload depends on the DataFormat encoded in the flags (see 8.3.5.8.1). The correspondence shall be as shown in Table 12 below.
Table 12 – Payload format associated with each DataFormat

<table>
<thead>
<tr>
<th>DataFormat</th>
<th>Contents of payload.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORMAT_DATA</td>
<td>struct WRITE_DATA_Payload_Data</td>
</tr>
<tr>
<td>FORMAT_SAMPLE</td>
<td>struct WRITE_DATA_Payload_Sample</td>
</tr>
<tr>
<td>FORMAT_DATA_SEQ</td>
<td>struct WRITE_DATA_Payload_DataSeq</td>
</tr>
<tr>
<td>FORMAT_SAMPLE_SEQ</td>
<td>struct WRITE_DATA_Payload_SampleSeq</td>
</tr>
<tr>
<td>FORMAT_PACKED_SAMPLES</td>
<td>struct WRITE_DATA_Payload_PackedSamples</td>
</tr>
</tbody>
</table>

The types referenced shall be as defined in Annex A IDL Types. All the WRITE_DATA payload representations extend BaseObjectRequest:

@extensibility(FINAL)
struct SampleData {
    XCDRSerializedBuffer serialized_data;
};

@extensibility(FINAL)
struct Sample {
    SampleInfo info;
    SampleData data;
};

@extensibility(FINAL)
struct WRITE_DATA_Payload_Data : BaseObjectRequest {
    SampleData data;
};

@extensibility(FINAL)
struct WRITE_DATA_Payload_Sample : BaseObjectRequest {
    Sample sample;
};

@extensibility(FINAL)
struct WRITE_DATA_Payload_DataSeq : BaseObjectRequest {
    sequence<SampleData> data_seq;
};
@extensibility(FINAL)
struct WRITE_DATA_Payload_SampleSeq : BaseObjectRequest {
    sequence<Sample> sample_seq;
};

@extensibility(FINAL)
struct WRITE_DATA_Payload_PackedSamples : BaseObjectRequest {
    PackedSamples packed_samples;
};

8.3.5.9 READ_DATA

The READ_DATA submessage is used by the XRCE Client to initiate a reception (read) of data from a XRCE DataReader object within the XRCE Agent.

Reception of this submessage shall result in the XRCE Agent calling the read operation on a XRCE DataReader object (see 7.8.5.1) one or more times. Depending on the returnStatus, the XRCE Agent may respond with a DATA submessages or a STATUS submessage.

The read_specification parameters to the read operation shall be obtained from the payload.

The payload also configures whether there is a single or multiple calls to the read operation.

The XRCE Agent shall send one or more DATA submessages in response to this message, see 8.3.5.10.

The related XRCE DataReader is identified by the object_id field in the payload.

After reception of this message, the XRCE Agent shall continue to send DATA submessages to the client until either the “end criteria” specified in the payload read_specification and continuous_read_options attained or else a new READ_DATA message for the same object_id is received from the XRCE Client.

The read operation also allows a XRCE Client to control when data may be sent by the XRCE Agent so that the Agent does not unnecessarily wake up the Client during its sleep cycle.

8.3.5.9.1 flags

The READ_DATA submessage does not define any additional flag bits beyond the common ones specified in 8.3.4.2.

8.3.5.9.2 payload

The payload shall contain the XCDR representation of the READ_DATA_Payload object defined in Annex A IDL Types as:

@extensibility(APPENDABLE)
struct DataDeliveryControl {
    unsigned short max_samples;
    unsigned short max_elapsed_time;
    unsigned short max_bytes_per_second;
}
unsigned short min_pace_period;  // milliseconds
}
@extensibility(FINAL)
struct ReadSpecification  {
   DataFormat data_format;
   @optional string content_filter_expression;
   @optional DataDeliveryControl delivery_control;
};

@extensibility(FINAL)
struct READ_DATA_Payload : BaseObjectRequest {
   ReadSpecification                      read_specification;
};
The payload derives from BaseObjectRequest which contains the object_id parameter to the read call.
The payload also contains the read_specification input parameter to the read call.
The max_samples may take two special values:

- The value MAX_SAMPLES_ZERO shall be used to cancel the currently active read operation without sending any more samples.
- The value MAX_SAMPLES_UNLIMITED indicates there is no limit in the number of samples returned from a single call to the read operation.

The setting of the max_bytes_per_sec configures the maximum rate at which DATA messages may be returned.
The optional member continuous_read_options configures whether the Agent will perform one or multiple read calls:

- If the continuous_read_options member is not present, then the Agent shall call the read operation just once. As a result the only data returned will be the one already in the DDS DataReader cache.
- If the continuous_read_options member is present, then the Agent shall call the read operation multiple times. The period of calling shall be no faster than the pace_period. As a result the data returned may contain data that arrives to the DDS DataReader in the future. The Agent shall stop calling the read operation once either max_total_samples have been returned, or else max_total_elapsed_time has elapsed.

The member max_total_samples may take the special value MAX_ELAPSED_TIME_UNLIMITED. This value shall indicate that there is no termination condition based on the elapsed time.
The member min_pace_period may take the special value MIN_PACE_PERIOD_NONE. This value shall indicate that there is no minimum time interval between samples.

8.3.5.10 DATA

The DATA submessage shall be sent by the XRCE Agent to the XRCE Client in response to a READ_DATA message when the read operation performed by the XRCE Agent returns STATUS_OK. If the read operation returns any other status the XRCE Agent shall send a STATUS message, not a DATA message.
The submessage contains output parameters of the read operation on the XRCE DataReader that was triggered by the READ_DATA message. The returnStatus is implied to be STATUS_OK.
A single **READ_DATA** message may result on multiple, possible an open-ended sequence, of **DATA** submessages sent as a response by the XRCE Agent. The **DATA** messages will continue to be sent until the one of the terminating conditions on the **READ_DATA** operation is reached, or until it is explicitly cancelled.

The *request_id* and *object_id* within the **DATA** payload shall match the namesake fields in the corresponding **READ_DATA** message.

### 8.3.5.10.1 flags

The **DATA** submessage uses the lowest order 4 bits of the *flags*. The *flags* shall be interpreted the same way as the flags of the **WRITE_DATA** submessage. See 8.3.5.8.1.

### 8.3.5.10.2 payload

The format the *payload* shall match the one requested in the **READ_DATA** message having the matching *request_id*. It shall also match the **DataFormat** encoded in the flags as shown in Table 11 – Flag bits used by the **WRITE_DATA** and **DATA** submessages. The correspondence shall be as shown in Table 13 below.

**Table 13 – Payload format associated with each **DataFormat****

<table>
<thead>
<tr>
<th><strong>DataFormat</strong></th>
<th><strong>Contents of payload.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>FORMAT_DATA</td>
<td>struct <strong>DATA_Payload_Data</strong></td>
</tr>
<tr>
<td>FORMAT_SAMPLE</td>
<td>struct <strong>DATA_Payload_Sample</strong></td>
</tr>
<tr>
<td>FORMAT_DATA_SEQ</td>
<td>struct <strong>DATA_Payload_DataSeq</strong></td>
</tr>
<tr>
<td>FORMAT_SAMPLE_SEQ</td>
<td>struct <strong>DATA_Payload_SampleSeq</strong></td>
</tr>
<tr>
<td>FORMAT_PACKED_SAMPLES</td>
<td>struct <strong>DATA_Payload_PackedSamples</strong></td>
</tr>
</tbody>
</table>

The types referenced in Table 13 shall be as defined in Annex A IDL Types:

```cpp
@extensibility(FINAL)
struct SampleData {
    XCDRSerializedBuffer serialized_data;
};
@extensibility(FINAL)
struct Sample {
    SampleInfo   info;
    SampleData   data;
};

@extensibility(FINAL)
struct **DATA_Payload_Data** : RelatedObjectRequest {
    SampleData         data;
};
```
All the DATA payload representations extend RelatedObjectRequest. The request_id and object_id within the RelatedObjectRequest shall match the namesake fields in the corresponding READ_DATA message.

8.3.5.11 ACKNACK

The ACKNACK submessage is used to enable a transport independent reliability protocol to be implemented. If the transport used for a session is able to reliably send messages in case of disconnection or a wakeup/sleep cycle then these messages may not be required.

This specification does not dictate whether ACKNACK messages shall be sent only in response to HEARTBEAT messages or can also be sent whenever one side detects message loss. However, in general it is expected that it is the XRCE Client that initiates any synchronization and therefore the XRCE Agent will only send ACKNACK messages in response to HEARTBEAT messages. This is because a XRCE Client may not be continually available as it goes on sleep cycles.

The ACKNACK message is directed to the same session and stream indicated in the MessageHeader (see 8.3.2). For this reason, it does not contain an ObjectId.

The sequenceNr present in the MessageHeader (see 8.3.2) shall not be interpreted as a sequence number belonging to the session. Rather it is interpreted as an epoch that mat be used to discard old or duplicate ACKNACK messages.

8.3.5.11.1 flags

The ACKNACK submessage does not define any additional flag bits beyond the common ones specified in 8.3.4.2.
8.3.5.11.2 payload

The ACKNACK submessage payload shall contain information about the state of the Session and Stream. The payload shall contain the XCDR representation of the ACKNACK_Payload object defined in Annex A IDL Types:

```c
struct ACKNACK_Payload {
    short  first_unacked_seq_num;
    octet[2]  nack_bitmap;
};
```

The `first_unacked_seq_num` shall indicate that all sequence numbers up to but not including it have been received. The `nack_bitmap` shall indicate missing sequence numbers, starting from `first_unacked_seq_num`.

For example, an ACKNACK_Payload having `first_unacked_seq_num` set to 100 and `nack_bitmap` set to 0x4009 (in binary 0100 0000 0000 1001) would indicate that all sequence numbers up to and including 99 have been received. Furthermore it would also indicate that sequence numbers 100, 103, and 114 are missing.

8.3.5.12 HEARTBEAT

The HEARTBEAT submessage is used to enable a transport independent reliability protocol to be implemented.

This specification does not limit a session to use a particular type of transport. If a session transport is able to reliably send messages in case of disconnection or a wakeup/sleep cycle then these messages may not be required.

This specification does not dictate the timing of HEARTBEAT messages. However, in general it is expected that it is the XRCE Agent will only send HEARTBEAT messages when it has some indication that the XRCE Client is active and not in a sleep cycle. This is to avoid awakening the XRCE Client unnecessarily.

The HEARTBEAT message is directed to the same Session and Stream indicated in the MessageHeader. For this reason it does not contain an ObjectId.

The `sequenceNr` present in the MessageHeader (see 8.3.2) shall not be interpreted as a sequence number belonging to the session. Rather it is interpreted as an epoch that may be used to discard old or duplicate ACKNACK messages.

8.3.5.12.1 flags

The HEARTBEAT submessage does not define any additional flag bits beyond the common ones specified in 8.3.4.2.

8.3.5.12.2 payload

The HEARTBEAT submessage payload shall contain information about the state of the Session and Stream. The payload shall contain the XCDR representation of the HEARTBEAT_Payload object defined in Annex A IDL Types:

```c
@extensibility(FINAL)
struct HEARTBEAT_Payload {
    short  first_unacked_seq_nr;
    short  last_unacked_seq_nr;
};
```

The `first_unacked_seq_nr` indicates the first available message sequence number on the sending side.

The `last_unacked_seq_nr` indicates the first available message sequence number on the sending side.
8.3.5.13 RESET

The RESET submessage shall be used to reset and re-establish a session. It contains no payload. It shall cause the XRCE Agent to reset all state associated with the session_id indicated in the submessage header.

8.3.5.13.1 flags

The RESET submessage does not define any additional flag bits beyond the common ones specified in 8.3.4.2.

8.3.5.13.2 payload

The RESET submessage shall have an empty payload.

8.3.5.14 FRAGMENT

This FRAGMENT submessage is used to enable sending of other submessages whose length exceeds the transport MTU.

The FRAGMENT message shall only be sent within reliable streams.

When a message is broken into fragments all FRAGMENT submessage except for the last shall have the ‘Last Fragment’ bit in the flags set to 0. The last FRAGMENT submessage shall have the ‘Last Fragment’ flag set 1.

Upon reception of the last fragment submessage the Agent shall concatenate the payload bytes of all FRAGMENT messages for that Stream in the order of the stream sequence number without sequence number gaps. The concatenated payloads shall be interpreted as XRCE submessages as if they had been received following the HEADER that came with the last fragment.

8.3.5.14.1 flags

The FRAGMENT submessage uses the lowest order 2 bits of the flags:

- Bit 0 indicates the ‘Endianness’ as specified in 8.3.4.2.
- Bit 1, the ‘Last Fragment’ bit, indicates the last fragment in the sequence.

8.3.5.14.2 payload

The payload of the FRAGMENT submessage is opaque. The Agent shall cache the payload bytes of all FRAGMENT submessages for a Stream in the order of the stream sequence number until the last FRAGMENT submessage is received.

8.4 Interaction Model

8.4.1 General

This section describes typical message flows.

The XRCE protocol is defined such that it is possible to implement clients that minimize discovery and setup traffic. For this reason some of the message flows are optional and may be replaced by out-of-band configuration of the XRCE Client and Agent.

8.4.2 Sending data using a pre-configured DataWriter

The message flow below illustrates the complete set of messages used by an XRCE Client to write data using the XRCE Agent. The XRCE Agent has been pre-configured to create a XRCE Application containing a DomainParticipant, Publisher and DataWriter. The DataWriter pre-configured object_id is known to
An XRCE Agent has been pre-configured for a Client (identified by the ClientKey) such that it recognizes the application_object_id present in the CREATE_CLIENT message. The reception of the CREATE_CLIENT triggers the creation or reuse of the corresponding XRCE objects. These include XRCE DataWriters with their corresponding DDS DataWriters. Subsequent WRITE_DATA messages reference the ObjectIds of those DataWriters in order to publish data using DDS.

8.4.3 Receiving data using a pre-configured DataReader

The message flow below illustrates the complete set of messages used by an XRCE Client to receive data via the XRCE Agent. The XRCE Agent has been pre-configured to create a XRCE Application containing a DomainParticipant, Subscriber and DataReader. The DataReader pre-configured object_id is known to the XRCE Client.
Figure 9— Message flow to receive data using a pre-configured DataReader

An Agent has been pre-configured for a Client (identified by the ClientKey) such that it recognizes the application_object_id present in the CREATE_CLIENT message. The reception of the CREATE_CLIENT triggers the creation or reuse of the corresponding XRCE objects. These include XRCE DataReaders with their corresponding DDS DataReaders. A subsequent READ message references the ObjectId of those DataReaders in order to receive data from the DDS domain.

8.4.4 Discovering an Agent

The message flow below illustrates the messages needed for an XRCE Client to discover XRCE Agents. This flow is only required when the Client is not pre-configured with the TransportLocator of the XRCE Agent. It allows an XRCE Client to be configured to content one or more TransportLocators (which may include multicast addresses) in order to dynamically discover the presence and actual Address of the Agents.

As a result of this process, the XRCE Client may discover more than one XRCE Agent. In that case it may use the information received about the XRCE Agent configuration (e.g. the fields version, vendor_id, or properties found within the AGENT_Representation) and the XRCE Agent activity (e.g. the availability field within the ActivityInfo) to select the most appropriate XRCE Agent and even connect to more than one XRCE Agents.
8.4.5 Connecting to an Agent

The message flow below illustrates the messages needed for an XRCE Client to connect to XRCE Agent. After the Client is connected it may create resources or invoke operations on existing resources.
An XRCE Client connects to an Agent using the CREATE_CLIENT message. The Agent responds with a STATUS_AGENT indicating whether the connection succeeded and the ClientProxy was created on behalf of the XRCE Client.

### 8.4.6 Creating a complete Application

The message flow below illustrates the messages needed for an already connected XRCE Client to create a complete XRCE Application.

**Figure 12— Message flow for a Client to create an Application**

An XRCE Client uses the CREATE message to create an XRCE Application. The CREATE message carries a CREATE_Payload containing an ObjectVariant with ObjectKind set to OBJK_APPLICATION. The corresponding OBJK_APPLICATION_Representation may use the REPRESENTATION_BY_REFERENCE to refer to an Application pre-configured in the Agent or it may use the REPRESENTATION_AS_XML_STRING to fully describe the Application including any necessary Types, Qos, and DDS Entities.

### 8.4.7 Defining Qos configurations

The message flow below illustrates the messages needed for an already connected XRCE Client to dynamically define XRCE QosProfiles which may later be used to create other XRCE Objects.

**Figure 13— Message flow for a Client to define Qos Profiles**

An XRCE Client uses the CREATE message to define Qos Profile. The CREATE message carries a CREATE_Payload containing an ObjectVariant with ObjectKind set to OBJK_QOSPROFILE. The corresponding OBJK_QOSPROFILE_Representation may use the REPRESENTATION_AS_XML_STRING to fully describe the Qos Profile.
8.4.8 Defining Types

The message flow below illustrates the messages needed for an already connected XRCE Client to dynamically define XRCE Types which may later be used to create XRCE Topic objects.

![Diagram](sdDefine_Type)

**Figure 14— Message flow for a Client to define Types**

An XRCE Client uses the CREATE message to create an XRCE Type. The CREATE message carries a CREATE Payload containing an ObjectVariant with ObjectKind set to OBJK_TYPE. The corresponding OBJK_TYPE_Representation may use the REPRESENTATION_AS_XML_STRING to fully describe the DDS-XTYPES Type including any referenced types.

8.4.9 Creating a Topic

The message flow below illustrates the messages needed for an already connected XRCE Client to dynamically create a XRCE Topic, which may later be used to create XRCE DataWriter and DataReader objects.

![Diagram](sdCreate_Topic)

**Figure 15— Message flow for a Client to define a Topic**

An XRCE Client uses the CREATE message to create an XRCE Topic. The CREATE message carries a CREATE Payload containing an ObjectVariant with ObjectKind set to OBJK_TOPIC. The corresponding OBJK_TOPIC_Representation may use the REPRESENTATION_IN_BINARY or the REPRESENTATION_AS_XML_STRING to fully define the Topic.
8.4.10 Creating a DataWriter

The message flow below illustrates the messages needed for an already connected XRCE Client to dynamically create a XRCE DataWriter with all the resources needed resources to publish data.

The XRCE Agent may have a-priory knowledge of QoS profiles, allowing the XRCE Client to refer to those by name rather than explicitly define them. Alternatively the XRCE Client may include them as part definition of the XRCE DataWriter resource.

![Diagram of message flow for creating a DataWriter]

**Figure 16— Message flow for a Client to create a DataWriter**

*An XRCE Client uses the CREATE message to create an XRCE DataWriter. The CREATE message carries a CREATE_Payload containing an ObjectVariant with ObjectKind set to OBJK_DATAWRITER. The corresponding DATAREADER_Representation may use the REPRESENTATION_IN_BINARY or the REPRESENTATION_AS_XML_STRING to fully define the DataWriter. Both these representations allow specification of the DataWriter Qos. The DATAREADER_Representation may also use the REPRESENTATION_BY_REFERNCES to refer to a DataWriter definition known to the Agent.*

8.4.11 Creating a DataReader

The message flow below illustrates the messages needed for an already connected XRCE Client to dynamically create a XRCE DataReader with all the resources needed resources to publish data.

The XRCE Agent may have a-priory knowledge of QoS profiles, allowing the XRCE Client to refer to those by name rather than explicitly define them. Alternatively the XRCE Client may include them as part definition of the XRCE DataReader resource.
An XRCE Client uses the CREATE message to create an XRCE DataReader. The CREATE message carries a CREATE_Payload containing an ObjectVariant with ObjectKind set to OBJK_DATAREADER. The corresponding OBJK_DATAREADER_Representation may use the REPRESENTATION_IN_BINARY or the REPRESENTATION_AS_XML_STRING to fully define the DataReader. Both these representations allow specification of the DataReader Qos. The OBJK_DATAREADER_Representation may also use the REPRESENTATION_BY_REFERENCE to refer to a DataReader definition known to the Agent.

**8.4.12 Getting Information on a Resource**

The message flow below illustrates how an XRCE Client may query information on a resource. An XRCE Client may use this mechanism to determine the QoS of any of the DDS proxy entities that the XRCE Agent manages on behalf of the XRCE Client. It may also be used to read QoS profiles and type declarations that are known to the XRCE Agent.

An XRCE Client uses the GET_INFO message to get information from an XRCE Object identified by its ObjectId. The XRCE Agent responds with an INFO message containing an ObjectVariant. The ObjectKind of the ObjectVariant is the appropriate for the specified ObjectId.
8.4.13 Updating a Resource

The message flow below illustrates how a XRCE Client may update an XRCE DataReader. A XRCE Client may use this mechanism to change the QoS parameters of any of the DDS proxy entities that the XRCE Agent manages on behalf of the XRCE Client.

![Diagram showing message flow for updating a Resource](image)

**Figure 19— Message flow for a Client to create a DataReader**

*An XRCE Client uses the CREATE message with the attribute *reuse* set to TRUE and the attribute *replace* set to TRUE to indicate it wants to update the Object identified by the ObjectId. The CREATE message contains an ObjectVariant with ObjectKind set to the appropriate value for the specified ObjectId. The XRCE Agent updates the Object using the new configuration contained in the ObjectVariant and responds with a STATUS message.*

8.4.14 Reliable Communication

Reliability is implemented separately for each Stream, and only for the reliable streams which are identified by the stream_id value being between 0x80 and 0xFF. See clause 8.3.2.2 Streams and the streamId.

A Stream has exactly two endpoints, the sending endpoint and the receiving endpoint. Note that for some streams the sender is the XRCE Client, e.g. when the XRCE Client uses a stream to write data to the XRCE Agent. Likewise in other streams the sender may be the XRCE Agent, for example when the XRCE Agent uses a stream to send the data the XRCE Client requested in a READ operation.

The sender and receiver endpoint on a Stream each execute its own protocol state machine. These are illustrated in the following subsections.

Sequence number arithmetic and comparisons shall use Serial Number Arithmetic as specified in clause 8.3.2.3 sequenceNr.

**8.4.14.1 Reliable sender state machine**

The protocol executed by the endpoint that is sending on a stream is shown in Figure 20
The sender maintains two state variables associated with the stream. The \textit{HighestSentSequenceNumber} and the \textit{HighestAcknowledgedSequenceNumber}.

Each time a message is sent the HighestSentSequenceNumber is increased. The reception of \texttt{ACKNACK} messages updates the HiguestAcknowledgedSequenceNumber.

While the \textit{HighestAcknowledgedSequenceNumber} is less than the \textit{HighestSentSequenceNumber} the sender sends HeartBeat messages that announce the \textit{HighestSentSequenceNumber} to the receiver. These HeartBeat messages may be periodic or optimized using on vendor specific mechanism. The requirement is that they are sent at some rate until \textit{HighestAcknowledgedSequenceNumber} matches the \textit{HighestSentSequenceNumber}.

### 8.4.14.2 Reliable receiver state machine

The protocol executed by the endpoint that is receiving on a reliable stream is shown in Figure 21

The receiver maintains two state variables associated with the stream. The \textit{HighestReceivedSequenceNumber} and the \textit{HighestAnnouncedSequenceNumber}.

Each time a Message is received the \textit{HighestReceivedSequenceNumber} may be updated (assuming all previous messages have been received). The \textit{HighestAnnouncedSequenceNumber} may also be adjusted.
Each time a **HEARTBEAT** is received the *HighestAnnouncedSequenceNumber* may be adjusted.

If the receiver is a XRCE **Client**, then while the *HighestReceivedSequenceNumber* is less than the *HighestAnnouncedSequenceNumber*, the received sends **ACKNACK** messages to request the messages corresponding to the missing sequence numbers. These **ACKNACK** messages may be periodic or optimized using on vendor specific mechanism.

If the receiver is the XRCE **Agent**, then it only sends **ACKNACK** messages in response to receiving a **HEARTBEAT**. This is done to avoid overwhelming the XRCE **Client** or waking it up at a non-opportune time.

### 8.5 XRCE Object Operation Traceability

This clause summarizes the messages used to implement each operation on the XRCE **Object** model ensuring that all operations have been covered.

The messages used trigger each operation and receive the result are summarized in Table 14

<table>
<thead>
<tr>
<th>XRCE Object Kind</th>
<th>Operation</th>
<th>Message used for Invocation</th>
<th>Message used for Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>XRCE Root</td>
<td>create_client</td>
<td>CREATE_CLIENT</td>
<td>STATUS_AGENT</td>
</tr>
<tr>
<td>XRCE Root</td>
<td>get_info</td>
<td>GET_INFO</td>
<td>INFO</td>
</tr>
<tr>
<td>XRCE Root</td>
<td>delete_client</td>
<td>DELETE</td>
<td>STATUS_AGENT</td>
</tr>
<tr>
<td>XRCE ProxyClient</td>
<td>create</td>
<td>CREATE (flags for creation)</td>
<td>STATUS</td>
</tr>
<tr>
<td>XRCE ProxyClient</td>
<td>update</td>
<td>CREATE (flags for reuse)</td>
<td>STATUS</td>
</tr>
<tr>
<td>XRCE ProxyClient</td>
<td>get_info</td>
<td>GET_INFO</td>
<td>INFO</td>
</tr>
<tr>
<td>XRCE ProxyClient</td>
<td>delete</td>
<td>DELETE</td>
<td>STATUS</td>
</tr>
<tr>
<td>XRCE DataWriter</td>
<td>write</td>
<td>WRITE_DATA, FRAGMENT</td>
<td>STATUS</td>
</tr>
<tr>
<td>XRCE DataReader</td>
<td>read</td>
<td>READ_DATA</td>
<td>DATA, FRAGMENT, STATUS</td>
</tr>
</tbody>
</table>
This page intentionally left blank.
9 XRCE Agent Configuration

9.1 General

The XRCE Agent may be configured such that it has a priori knowledge XRCE Objects. This allows XRCE Clients to reference and create XRCE Objects in a very compact manner using the representation format REPRESENTATION_BY_REFERENCE, see clause 7.7.3.1 REPRESENTATION_BY_REFERENCE format.

This specification provides two standard mechanisms to configure the XRCE Agent. Implementations may also provide additional mechanisms:

- Remote configuration using the XRCE Protocol
- Local file-based configuration

These mechanisms are described in the clauses that follow.

9.2 Remote configuration using the XRCE Protocol

An application may use a XRCE Client with the only purpose of defining and creating XRCE Objects that are intended for other applications. This type of application is called a XRCE ConfigurationClient.

The protocol used by the XRCE ConfigurationClient is the same used by any other XRCE Client. The only difference is that an XRCE ConfigurationClient never uses the READ_DATA or WRITE messages. It only uses the messages that create, update, or retrieve information about the XRCE objects.

Any other XRCE Client can reference XRCE Objects created by an XRCE ConfigurationClient.

A typical use of the remote configuration mechanism are tools that may be used to configure an Agent prior to deployment or to interactively configure the system.

Note that the XRCE ConfigurationClient may be communicating with the Agent using a different network or transport, which may not have the same constraints as a typical XRCE Client.
9.3 File-based Configuration

The XRCE Agent shall provide a configuration or run-time option to load an XML file formatted according to the schema defined in the [DDS-XML] machine-readable file `dds-xml_system_example.xsd`.

The XRCE Agent shall parse the XML file and for each of the elements defined in Table 15, it shall construct the corresponding XRCE Object specified in Table 15. All the created XRCE Objects shall be made available to XRCE clients such that they may refer to them using the representation format `REPRESENTATION_BY_REFERENCE`.

**Table 15 – XRCE Object created from the elements in the configuration XML file**

<table>
<thead>
<tr>
<th>XML Element(s)</th>
<th>XRCE Object</th>
<th>REPRESENTATION_BY_REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;types&gt;</code></td>
<td>XRCE Type.</td>
<td>The created XRCE Types shall be referenceable using their fully qualified name, which includes the names of enclosing modules.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For example: “MyModule::MyNestedModule::MyStructType”</td>
</tr>
<tr>
<td><code>&lt;qos_profile&gt;</code></td>
<td>XRCE QosProfile.</td>
<td>The created XRCE Types shall be referenceable using their fully qualified name, which includes the names of enclosing Qos Profile Library.</td>
</tr>
<tr>
<td>(Child of <code>&lt;qos_library&gt;</code>)</td>
<td></td>
<td>For example: “MyProfileLibrary::MyQosProfile”</td>
</tr>
<tr>
<td><strong>&lt;domain&gt;</strong></td>
<td>XRCE Domain.</td>
<td>The created XRCE Domain shall be referenceable using their fully qualified name, which includes the names of enclosing Domain Library. For example: “MyDomainLibrary::MyDomain”</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>(Child of  <strong>&lt;domain_library&gt;</strong>)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>&lt;topic&gt;</strong></td>
<td>XRCE Topic</td>
<td>The created XRCE Topic shall be referenceable using its name from any DomainParticipant that references the Domain where the Topic is defined. For example: “ExampleTopic”</td>
</tr>
<tr>
<td>(Child of  <strong>&lt;domain&gt;</strong>)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>&lt;application&gt;</strong></td>
<td>XRCE Application.</td>
<td>The created XRCE Application shall be referenceable using their fully qualified name, which includes the names of enclosing Application Library. For example: “MyApplicationLibrary::MyApplication”</td>
</tr>
<tr>
<td>(Child of  <strong>&lt;application_library&gt;</strong>)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>&lt;domainParticipant&gt;</strong></td>
<td>XRCE DomainParticipant</td>
<td>The created XRCE DomainParticipant shall be referenceable using their fully qualified name, which includes the names of enclosing DomainParticipant Library. For example: “MyParticipantLibrary::MyParticipant”</td>
</tr>
<tr>
<td>(Child of  <strong>&lt;domainParticipant_library&gt;</strong>)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>&lt;topic&gt;</strong></td>
<td>XRCE Topic</td>
<td>The created XRCE Topic shall be referenceable using its name from any objects in the same DomainParticipant. For example: “ExampleTopic”</td>
</tr>
<tr>
<td>(Child of  <strong>&lt;domainParticipant&gt;</strong>)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>&lt;publisher&gt;</strong></td>
<td>XRCE Publisher</td>
<td>The created XRCE Publisher or Subscriber shall be referenceable using their name. No qualification is necessary since these entities are always referenced within the scope of a DomainParticipant. For example: “MyPublisher”, “MySubscriber”</td>
</tr>
<tr>
<td><strong>&lt;subscriber&gt;</strong></td>
<td>XRCE Subscriber</td>
<td></td>
</tr>
<tr>
<td>(Child of  <strong>&lt;domainParticipant&gt;</strong>)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>&lt;dataWriter&gt;</strong></td>
<td>XRCE DataWriter</td>
<td>The created XRCE DataWriter or DataReader shall be referenceable using their name. No qualification is necessary since these entities are always referenced within the scope of a Publisher or Subscriber. For example: “MyWriter”, “MyReader”</td>
</tr>
<tr>
<td><strong>&lt;dataReader&gt;</strong></td>
<td>XRCE DataReader</td>
<td></td>
</tr>
<tr>
<td>(Child of  <strong>&lt;domainParticipant&gt;</strong>)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The XRCE Objects created from the file-based configuration shall have their **ObjectId** automatically derived from the `REPRESENTATION_BY_REFERENCE` string. Specifically, the **ObjectIdPrefix** (see 7.7.6) shall be set to the first 2 bytes of the MD5 hash computed on the `REPRESENTATION_BY_REFERENCE` string. The MD5 treats each string character as a byte and does not include the NUL terminating character of the string.

For example assuming the `REPRESENTATION_BY_REFERENCE` string is “MyWriter” in that case:

- The MD5 hash shall be: 0x03e26181adfe529038bf0dce7cab871
- The **ObjectIdPrefix** shall be the two-byte array: {0x03, 0xe2}.
- The **ObjectIdPrefix** shall be computed by combining the **ObjectIdPrefix** with the **ObjectKind** as specified in clause 7.7.6.
9.3.1 Example Configuration File

The following XML file could be used to configure a XRCE Agent.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<dds xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
     xmlns="http://www.omg.org/dds"
     xsi:schemaLocation="http://www.omg.org/spec/DDS-XML/20170301/dds-
xml_system_example.xsd">
  <types>
    <module name="ShapesDemoTypes">
      <const name="MAX_COLOR_LEN" type="int32" value="128"/>
      <struct name="ShapeType">
        <member name="color" key="true" type="string"
               stringMaxLength="MAX_COLOR_LEN"/>
        <member name="x" type="int32"/>
        <member name="y" type="int32"/>
        <member name="shapesize" type="int32"/>
      </struct>
    </module>
  </types>
  <qos_library name="MyQosLibrary">
    <qos_profile name="MyQosProfile">
      <datareader_qos>
        <durability>
          <kind>TRANSIENT_LOCAL_DURABILITY_QOS</kind>
        </durability>
        <reliability>
          <kind>RELIABLE_RELIABILITY_QOS</kind>
        </reliability>
        <history>
          <kind>KEEP_LAST_HISTORY_QOS</kind>
          <depth>6</depth>
        </history>
      </datareader_qos>
      <datawriter_qos>
        <durability>
          <kind>TRANSIENT_LOCAL_DURABILITY_QOS</kind>
        </durability>
        <reliability>
          <kind>RELIABLE_RELIABILITY_QOS</kind>
        </reliability>
        <history>
          <kind>KEEP_LAST_HISTORY_QOS</kind>
          <depth>20</depth>
        </history>
        <lifespan>
          <duration>
            <sec>10</sec>
            <nanosec>0</nanosec>
          </duration>
        </lifespan>
      </datawriter_qos>
    </qos_profile>
  </qos_library>
</dds>
```
<application_library name="MyApplications">
    <application name="ShapesDemoApp">
        <domain_participant name="MyParticipant"
            domain_ref="ShapesDomainLibrary::ShapesDomain">
            <register_type name="ShapeType" type_ref="ShapeType" />
            <topic name="Square" register_type_ref="ShapeType" />
            <topic name="Circle" register_type_ref="ShapeType" />
            <topic name="Triangle" register_type_ref="ShapeType" />
        </domain_participant>
    </application>
</application_library>
</dds>
An XRCE Agent loading the above configuration file would have the pre-defined XRCE Objects shown in Table 16.

<table>
<thead>
<tr>
<th>XRCE Object Kind</th>
<th>REPRESENTATION_BY_REFERENCE</th>
<th>ObjectPrefix</th>
<th>ObjectId</th>
</tr>
</thead>
<tbody>
<tr>
<td>XRCE Type</td>
<td>“ShapesDemoTypes::ShapeType”</td>
<td>{0x59, 0x51}</td>
<td>{0x59, 0x5a}</td>
</tr>
<tr>
<td>XRCE Qos Profile</td>
<td>“MyQosLibrary::MyQosProfile”</td>
<td>{0x3a, 0x38}</td>
<td>{0x3a, 0x3b}</td>
</tr>
<tr>
<td>XRCE Application</td>
<td>“MyApplications::SimpleShapesDemoApplication”</td>
<td>{0x1b, 0xec}</td>
<td>{0x1b, 0xec}</td>
</tr>
<tr>
<td>XRCE DomainParticipant</td>
<td>“MyApplications::ShapesDemoApp::MyParticipant”</td>
<td>{0x56, 0xcc}</td>
<td>{0x56, 0xc1}</td>
</tr>
<tr>
<td>XRCE Topic</td>
<td>“Square”</td>
<td>{0xce, 0xb4}</td>
<td>{0xce, 0xb2}</td>
</tr>
<tr>
<td>XRCE Topic</td>
<td>“Circle”</td>
<td>{0x30, 0x95}</td>
<td>{0x30, 0x92}</td>
</tr>
<tr>
<td>XRCE Topic</td>
<td>“Triangle”</td>
<td>{0x5e, 0x55}</td>
<td>{0x5e, 0x52}</td>
</tr>
<tr>
<td>XRCE Publisher</td>
<td>“MyPublisher”</td>
<td>{0x13, 0xe3}</td>
<td>{0x13, 0xe3}</td>
</tr>
<tr>
<td>XRCE Subscriber</td>
<td>“MySubscriber”</td>
<td>{0xae, 0x0d}</td>
<td>{0xae, 0x04}</td>
</tr>
<tr>
<td>XRCE DataWriter</td>
<td>“MySquareWriter”</td>
<td>{0x1c, 0xc4}</td>
<td>{0x1c, 0xc5}</td>
</tr>
<tr>
<td>XRCE DataWriter</td>
<td>“MyCircleWriter”</td>
<td>{0xcf, 0x80}</td>
<td>{0xcf, 0x85}</td>
</tr>
<tr>
<td>XRCE DataReader</td>
<td>“MyTriangleReader”</td>
<td>{0xaf, 0x32}</td>
<td>{0xaf, 0x36}</td>
</tr>
</tbody>
</table>
10 XRCE Deployments

All the operations described in the DDS-XRCE PIM pertain to the interaction of a client application with a single DDS-XRCE Agent. The scope of all the operations is therefore limited to the interactions with that DDS-XRCE Agent. Yet client applications may interact with each other despite connecting to different DDS-XRCE Agents. These interactions would happen as a consequence of the DDS-XRCE Agents creating and performing operations on DDS DomainParticipant entities, which exchange information in accordance to the DDS specification.

10.1 XRCE Client to DDS communication

The specification defines the protocol used by an XRCE Client to communicate with a XRCE Agent that proxies for Client in the DDS Domain. The primary consequence of this is that the XRCE Client can now communicate with any DDS DomainParticipant.

The DDS DomainParticipant will discover the proxy DDS Entities that the XRCE Agent creates on behalf of the Client and with use the standard DDS-RTPS Interoperability protocol to communicate with the Agent.

The XRCE Client will communicate with the XRCE Agent using the XRCE Protocol. Using this protocol it can direct the XRCE Agent to create new DDS entities and use these entities to read and write data on the DDS Global Data Space.

This type of deployment is shown in illustrated in Figure 23 below.

![Figure 23 — XRCE Agent proxying for an XRCE Client on a DDS Domain](image)

The XRCE Client communicates with the XRCE Agent using the XRCE Protocol. The XRCE Agent communicates with other DDS DomainParticipants in the DDS Domain using the DDS-RTPS Protocol.

10.2 XRCE Client to Client via DDS

XRCE Agents appear as DDS DomainParticipants in the DDS Domain. For this reason XRCE Client applications that are connected to different XRCE Agents will communicate with each other without the need for further configuration.

Each XRCE Agent will perceive other XRCE Agents as DDS DomainParticipants, indistinguishable from any other DDS DomainParticipant and communicate with them using DDS-RTPS. The XRCE Agents will relay that communication to their respective XRCE Clients.

This type of scenario is shown in illustrated in Figure 24 below.
10.3 Client-to-Client communication brokered by an Agent

Multiple XRCE Client applications may be connected to the same XRCE Agent.

In it up to the implementation of the XRCE Agent whether the DDS Entities it creates are exclusive to each XRCE Client or alternatively are shared across XRCE Clients. However the behavior observable by the XRCE Client shall be as if the DDS XRCE Agent creates separate DDS Objects exclusive to each XRCE Client.

If the XRCE Agent creates separate DDS entities on behalf of each XRCE Client, then each will have its own proxy DDS DomainParticipant. These two DDS DomainParticipants will communicate with each other on the DDS Domain. In this situation the two XRCE Clients will communicate with each other “brokered” by the XRCE Agent without the need for additional configuration or logic in the XRCE Agent.

If the XRCE Agent shares DDS entities among different XRCE Clients, then the requirement to behave “as if” each had its own separate entities requires that the local DDS DataWriter entities discover and match the local DDS DataReader entities in the same DomainParticipant. This will automatically cause the XRCE Clients to communicate with each other using the Agent as a “broker” without further configuration.

An implementation of an XRCE Agent may choose to create faster communication path between the local XRCE DataWriter and DataReader objects so that data from an XRCE DataWriter can go directly to the matched XRCE DataReader without having to go via the associated DDS Entities. This “shortcut” can be implemented as an optimization as it does not impact any of the protocols nor it impacts interoperability with other XRCE Clients, Agents, or DDS DomainParticipants.

This type of scenario is shown in illustrated in Figure 25 below.
Figure 25— XRCE Clients communicating using the XRCE Agent as a broker

Multiple XRCE Clients may be connected to the same XRCE Agent. The XRCE Clients communicate with each other using the XRCE Agent as a “broker”. This “client-to-client” communication may utilize the related DDS Objects, or may use an optimized path inside the Agent that shortcuts the use of the DDS Objects.

10.4 Federated deployment

The specification supports federated deployments where XRCE Agents appear as Clients to other XRCE Agents.

In order to support these deployments the XRCE Agent implementation must implement the client-side of the XRCE Protocol in addition to the server part.

Supporting this kind of deployment is an implementation decision, as it does not impact any of the protocols nor it impacts interoperability with other XRCE Clients, Agents, or DDS DomainParticipants.

This type of scenario is shown in illustrated in Figure 26 below.
The XRCE Agents can communicate with each other using the same DDS-XRCE protocol. The Agents enable federations and store-and-forward dataflow. This type of deployment is transparent to the XRCE Client applications and the DDS applications.

10.5 Direct Peer-to-Peer communication between client Applications

The specification supports applications having direct communications using only the XRCE Protocol. In order to do this each application must implement both the XRCE Client and the XRCE Agent part of the protocol.

This deployment requires the application to create a separate XRCE Client to manage the communication with each XRCE Agent. The application would also create an XRCE Agent to manage communication with all the clients.

This deployment does not impact any of the protocols nor it impacts interoperability with other XRCE Clients, Agents, or DDS DomainParticipants.

Compared with the communication brokered by an XRCE Agent, the drawback of the direct peer-to-peer communication is that the applications need to consume more resources to instantiate the additional XRCE Clients needed to maintain the separate state with each peer XRCE Agent. Of course implementations could optimize this to nor have to create all these extra objects. However they will still need to keep separate state, especially for reliable communications.

An additional drawback of the direct peer to peer communication is that the applications cannot easily go into sleep cycles as the XRCE Agents they contain need to be active in order to process the messages from the XRCE Clients. Therefore is not suitable for many resource-constrained scenarios.

This type of scenario is shown in illustrated in Figure 27 below.
Figures 27—Direct peer-to-peer communication between XRCE Clients

Applications can communicate directly peer-to-peer without having the communication brokered by a separate XRCE Agent. To do this each Application must implement both the XRCE Client and the XRCE Agent parts of the protocol.

10.6 Combined deployment

Figure 28 below illustrates a scenario where the different deployments are combined into a single system.
Figure 28— Combined deployment scenario

Illustrates interoperability between applications using XRCE abmd applications using DDS-RTPS. XRCE Applications may communicate via XRCE Agents acting as proxies. They can communicate peer to peer with each other using XRCE Agents as brokers or directly by implementing both the XRCE Client and Agent part of the protocol.
11 Transport Mappings

11.1 Transport Model

The XRCE protocol is not limited to any specific transports. It can be mapped to most existing network transports such as UDP, TCP and low bandwidth transports such as Bluetooth, ZigBee and 6LoWPAN.

To run without additional overhead it is expected that the transport supports the following functionality:

1. Deliver messages of at least 64 bytes.
2. Handle the integrity of messages, dropping any messages that are corrupted. This capability does not restrict the usable transports; it simply requires appending a CRC to messages from transports that do not handle integrity natively.
3. Provide the size of the received message as well as the source address. This requirement does not restrict the usable transports; it simply requires prepending source information and size to messages from transports that do not include the information natively.
4. Support bi-directional communication.
5. Provide transport-level security, specifically the means for the Client to authenticate the Agent and the means for secure (encrypted and authenticated) message exchange. Alternatively the XRCE Agent and Client can be deployed on top of a secure network layer (e.g. an encrypted VPN).

The following functionality is explicitly not required from the transport:

1. It does not need to provide reliability. Messages may be dropped.
2. It does not need to provide ordering. Messages may arrive out of order.
3. It does not need to provide notification of dropped messages.

Transports that do not meet some of the above pre-requisites may still be used by adding the missing information as an envelope around the XRCE message. This would be done as part of the mapping to that specific protocol.

For example if the source address or message size are missing they could be added as a prefix to the XRCE message. If the transport does not support integrity a CRC suffix could be added to the XRCE message.

11.2 UDP Transport

The UDP transport meets all the functionality listed in clause 11.1. Except that it does not provide security.

For applications requiring security there is the “Datagram Transport Layer Security” (DTLS) standard [DTLS] that provides security in top of UDP/IP. Alternatively UDP may be deployed on a private network (VPN), which provides security at the IP layer below UDP.

Since the XRCE protocol does not require for the transport to provide reliability, ordering, or notification of failures it can be trivially mapped to “datagram” transports such as UDP/IP.

11.2.1 Transport Locators

When XRCE is mapped to the UDP v4, the TransportLocator union shall use the TransportLocatorFormat discriminator ADDRESS_FORMAT_MEDIUM. This selects the member medium_locator of type TransportLocatorMedium defined in Annex A IDL Types as:

```c
struct TransportLocatorMedium {
    octet address[4];
    unsigned short port;
};
```

When XRCE is mapped to the UDP v6, the TransportLocator union shall use the TransportLocatorFormat discriminator ADDRESS_FORMAT_LARGE. This selects the member large_locator of type TransportLocatorLarge defined in Annex A IDL Types as:
struct TransportLocatorLarge {
  octet address[16];
  unsigned long port;
};

The *address* field shall contain the IP v6 address and the *port* field shall contain the UDP/IP v6 port number.

### 11.2.2 Connection establishment

UDP is a connectionless transport. Communication occurs between a UDP Server and a UDP Client. Each has an associated UDP/IP address and port.

- The UDP Server listens to a server port, which is known to the client.
- The UDP Client sends UDP datagrams to the UDP Server address and server port.
- The UDP Server receives the message, which includes the UDP address and port of the sending Client.
- The UDP Server sends replies back the Client using the address and port received in the message.
- The UDP Client receives replies from the server coming back to the client’s address and port.

When communicating over UDP the XRCE Agent shall behave as an UDP Server and the XRCE Client as the UDP Client.

The XRCE Agent shall be pre-configured with the port number it shall listen to.

The XRCE Client shall be pre-configured with the UDP/IP address and port of the XRCE Agent.

### 11.2.3 Message Envelopes

The mapping of the XRCE Protocol to UDP/IP does not add any additional envelopes around the XRCE message. The UDP/IP payload shall contain exactly one XRCE message.

### 11.2.4 Agent Discovery

XRCE Agent discovery may be done using UDP/IP multicast. The XRCE Agents shall be pre-configured with the multicast address and port number they shall listen to. By default they shall be the address 239.255.0.2 and the port 7400.

To discover Agents via multicast the XRCE Client shall send the GET_INFO message (see 8.3.5.3) periodically to the configured multicast address and port. This message shall invoke the get_info operation (see 7.8.2.2) on the XRCE Agent, which shall respond and include its TransportLocators. The XRCE Client shall stop sending the periodic message once it receives a suitable response from an Agent.

XRCE Agent discovery may be done using UDP/IP unicast. The XRCE Clients shall be pre-configured with a list of candidate UDP addresses and ports where XRCE Agents may be located.

To discover Agents via unicast the XRCE Client shall send the GET_INFO message (see 8.3.5.3) periodically to the configured addresses and ports. This message shall invoke the get_info operation (see 7.8.2.2) on the XRCE Agent, which shall respond and include its TransportLocators. The XRCE Client shall stop sending the periodic message once it receives a suitable response from an Agent.

### 11.3 TCP Transport

The TCP transport meets all the functionality listed in clause 11.1, except it does not provide security nor information on the message size.
For applications requiring security there is the “Transport Layer Security (TLS)” standard [TLS] that provides security in top of TCP/IP. Alternatively TCP/IP may be deployed on a private network (VPN), which provides security at the IP layer below TCP.

The message size shall be added as a prefix ahead of the XRCE message as defined in 11.3.3.

### 11.3.1 Transport Locators

When XRCE is mapped to the UDP/IP version 4, the `TransportLocator` union shall use the `TransportLocatorFormat` discriminator `ADDRESS_FORMAT_MEDIUM`. This selects the member `medium_locator` of type `TransportLocatorMedium` defined in Annex A IDL Types as:

```c
struct TransportLocatorMedium {
    octet address[4];
    unsigned short port;
};
```

When XRCE is mapped to the TCP/IP version 6, the `TransportLocator` union shall use the `TransportLocatorFormat` discriminator `ADDRESS_FORMAT_LARGE`. This selects the member `large_locator` of type `TransportLocatorLarge` defined in Annex A IDL Types as:

```c
struct TransportLocatorLarge {
    octet address[16];
    unsigned long port;
};
```

The `address` field shall contain the IP v6 address and the `port` field shall contain the TCP/IP v6 port number.

### 11.3.2 Connection establishment

TCP is a connection-oriented transport. Communication occurs between a TCP Client and a TCP Server. Each has an associated TCP/IP address and port.

- The TCP Server listens to a server port, which is known to the client.
- The TCP Client connects to the Server.
- The TCP Server accepts the connection from the Client. This establishes a bi-directional communication channel. Both ends can send and receive on that channel.
- The TCP Client can send and receive messages to and from the Server.
- The TCP Server can send and receive messages to and from the Client.

When communicating over TCP the XRCE Agent shall behave as a TCP Server and the XRCE Client as the TCP Client. The XRCE Agent shall be pre-configured with the port number it shall listen to.

The XRCE Client shall be pre-configured with the TCP/IP address and port of the XRCE Agent.

### 11.3.3 Message Envelopes

The mapping of the XRCE Protocol to TCP/IP adds a 2-byte prefix as an envelope the XRCE message. The 2-byte prefix shall contain the length of the XRCE message that follows encoded as little endian.

After the 2-byte envelope the TCP/IP payload shall contain exactly one XRCE message. The alignment of the XRCE message shall not be changed by the added 2-byte prefix. Stated differently the XRCE message shall consider its first byte to be aligned to an 8-byte (XCDR maximum alignment) boundary.
11.3.4 Agent Discovery

XRCE Agent discovery may be done using UDP/IP multicast even if the communication will be over TCP.

The XRCE Agents may be pre-configured with the multicast address and port number they shall listen to. By default they shall be the address 239.255.0.2 and the port 7400.

To discover Agents via multicast the XRCE Client shall send the GET_INFO message (see 8.3.5.3) periodically to the configured multicast address and port. This message shall invoke the get_info operation (see 7.8.2.2) on the XRCE Agent, which shall respond and include its TransportLocators. The XRCE Client shall stop sending the periodic message once it receives a suitable response from an Agent.

XRCE Agent discovery may be done using TCP/IP. The XRCE Clients shall be pre-configured with a list of candidate TCP addresses and ports where XRCE Agents may be located.

To discover Agents via unicast the XRCE Client shall periodically attempt to establish TCP connections to the configured addresses and ports. One a connection is established it shall send the CREATE_CLIENT message (see 8.3.5.1). This message shall invoke the create_client operation (see 7.8.2.1) on the XRCE Agent, which shall either accept or produce an error. The XRCE Client shall stop making periodic connection attempts once it receives a suitable response from an Agent.

11.4 Other Transports

The XRCE Protocol is well suited to be mapped to other transports, even transport with small bandwidth and MTUs such as IEEE 802.15.4, Zigbee, Bluetooth, and 6LoWPAN.

The fact that the XRCE Protocol has minimal requirements on the transport (i.e. does not require ordering or reliable delivery), provides the means for authentication, and can do its own data fragmentation and re-assembly means that most transports mappings can simply include the XRCE message as a payload without additional envelopes.

However, in order to get transparent interoperability between vendors it is required to define the precise encoding of the transport locators as well as the means to discover agents and establish initial communicators. Therefore it is expected that future revisions of this specification will provide additional transport mappings.
A IDL Types

module dds { module xrce {

    typedef octet ClientKey[4];

    // IDL does not have a syntax to express array constants so we
    // use #define with is legal in IDL
    #define  CLIENTKEY_INVALID {0x00, 0x00, 0x00, 0x00}

    typedef octet ObjectKind;

    const ObjectKind OBJK_INVALID     = 0x00;
    const ObjectKind OBJK_PARTICIPANT = 0x01;
    const ObjectKind OBJK_TOPIC       = 0x02;
    const ObjectKind OBJK_PUBLISHER   = 0x03;
    const ObjectKind OBJK_SUBSCRIBER  = 0x04;
    const ObjectKind OBJK_DATAWRITER  = 0x05;
    const ObjectKind OBJK_DATAREADER  = 0x06;
    const ObjectKind OBJK_TYPE        = 0x0A;
    const ObjectKind OBJK_QOSPROFILE  = 0x0B;
    const ObjectKind OBJK_APPLICATION = 0x0C;
    const ObjectKind OBJK_AGENT       = 0x0D;
    const ObjectKind OBJK_CLIENT      = 0x0E;
    const ObjectKind OBJK_OTHER       = 0x0F;

    typedef octet ObjectId     [2];
    typedef octet ObjectPrefix [2];

    // There are three predefined values ObjectId
    // IDL does not have a syntax to express array constants so we
    // use #define with is legal in IDL
    #define  OBJECTID_INVALID {0x00,0x00}
    #define  OBJECTID_AGENT   {0xFF,0xFD}
    #define  OBJECTID_CLIENT  {0xFF,0xFE}
    #define  OBJECTID_SESSION {0xFF,0xFF}
typedef octet XrceCookie[4];
   // Spells 'X' 'R' 'C' 'E'
define XRCE_COOKIE { 0x58, 0x52, 0x43, 0x45 }

typedef octet XrceVersion[2];
define XRCE_VERSION_MAJOR 0x01
define XRCE_VERSION_MINOR 0x00
define XRCE_VERSION { XRCE_VERSION_MAJOR, XRCE_VERSION_MINOR }

typedef octet XrceVendorId[2];
define XRCE_VENDOR_INVALID1 0x00
define XRCE_VENDOR_INVALID1 0x00

struct Time_t {
   long seconds;
   unsigned long nanoseconds;
};

typedef octet SessionId;
const SessionId SESSIONID_NONE_WITH_CLIENT_KEY = 0x00;
const SessionId SESSIONID_NONE_WITHOUT_CLIENT_KEY = 0x80;

typedef octet StreamId;
const SessionId STREAMID_NONE = 0x00;
const SessionId STREAMID_BUILTIN_BEST_EFFORTS = 0x01;
const SessionId STREAMID_BUILTIN_RELIABLE = 0x80;

@bit_bound(8)
enum TransportLocatorFormat {
   ADDRESS_FORMAT_SMALL,
   ADDRESS_FORMAT_MEDIUM,
   ADDRESS_FORMAT_LARGE,
   ADDRESS_FORMAT_STRING
};

struct TransportLocatorSmall {

octet address[2];
octet locator_port;
};
struct TransportLocatorMedium {
octet address[4];
unsigned short locator_port;
};
struct TransportLocatorLarge {
octet address[16];
unsigned long locator_port;
};
struct TransportLocatorString {
string value;
};

union TransportLocator switch (TransportLocatorFormat) {
case ADDRESS_FORMAT_SMALL:
TransportLocatorSmall small_locator;
case ADDRESS_FORMAT_MEDIUM:
TransportLocatorMedium medium_locator;
case ADDRESS_FORMAT_LARGE:
TransportLocatorLarge medium_locator;
case ADDRESS_FORMAT_STRING:
TransportLocatorString string_locator;
};
typedef sequence<TransportLocator> TransportLocatorSeq;

struct Property {
string name;
string value;
};
typedef sequence<Property> PropertySeq;

@extensibility(FINAL)
struct CLIENT_Representation {
XrceCookie xrce_cookie; // XRCE_COOKIE
XrceVersion xrce_version;
XrceVendorId xrce_vendor_id;
}
Time_t client_timestamp;
ClientKey client_key;
SessionId session_id;
@optional PropertySeq properties;
};

@extensibility(FINAL)
struct AGENT_Representation {
    XrceCookie xrce_cookie;  // XRCE_COOKIE
    XrceVersion xrce_version;
    XrceVendorId xrce_vendor_id;
    Time_t agent_timestamp;
    @optional PropertySeq properties;
};

typedef octet RepresentationFormat;
const RepresentationFormat REPRESENTATION_BY_REFERENCE = 0x01;
const RepresentationFormat REPRESENTATION_AS_XML_STRING = 0x02;
const RepresentationFormat REPRESENTATION_IN_BINARY = 0x03;

const long REFERENCE_MAX_LEN = 128;

@extensibility(FINAL)
union OBJK_Representation3Formats switch(RepresentationFormat) {
    case REPRESENTATION_BY_REFERENCE :
        string<REFERENCE_MAX_LEN> object_reference;
    case REPRESENTATION_AS_XML_STRING :
        string xml_string_representation;
    case REPRESENTATION_IN_BINARY :
        sequence<octet> binary_representation;
};

@extensibility(FINAL)
union OBJK_RepresentationRefAndXMLFormats switch(RepresentationFormat) {
    case REPRESENTATION_BY_REFERENCE :
        string<REFERENCE_MAX_LEN> object_reference;
    case REPRESENTATION_AS_XML_STRING :
        string xml_string_representation;
};
string string_representation;
;
@extensibility(FINAL)
union OBJK_RepresentationBinAndXMLFormats switch(RepresentationFormat) {
  case REPRESENTATION_IN_BINARY :
    sequence<octet> binary_representation;
  case REPRESENTATION_AS_XML_STRING :
    string string_representation;
};

@extensibility(FINAL)
struct OBJK_RepresentationRefAndXML_Base {
  OBJK_RepresentationRefAndXMLFormats representation;
};

@extensibility(FINAL)
struct OBJK_RepresentationBinAndXML_Base {
  OBJK_RepresentationBinAndXMLFormats representation;
};

@extensibility(FINAL)
struct OBJK_Representation3_Base {
  OBJK_Representation3Formats representation;
};

/*@ Objects supporting by Reference and XML formats */

@extensibility(FINAL)
struct OBJK_QOSPROFILE_Representation : OBJK_RepresentationRefAndXML_Base {
};

@extensibility(FINAL)
struct OBJK_TYPE_Representation : OBJK_RepresentationRefAndXML_Base {
};

@extensibility(FINAL)
struct OBJK_DOMAIN_Representation : OBJK_RepresentationRefAndXML_Base {

};

@extensibility(FINAL)
struct OBJK_APPLICATION_Representation : OBJK_RepresentationRefAndXML_Base {
}

=localhost

/* Objects supporting Binary and XML formats */
@extensibility(FINAL)
struct OBJK_PUBLISHER_Representation : OBJK_RepresentationBinAndXML_Base {
    ObjectId participant_id;
};

@extensibility(FINAL)
struct OBJK_SUBSCRIBER_Representation : OBJK_RepresentationBinAndXML_Base {
    ObjectId participant_id;
};

@extensibility(FINAL)
struct DATAWRITER_Representation : OBJK_RepresentationBinAndXML_Base {
    ObjectId publisher_id;
};

@extensibility(FINAL)
struct DATAREADER_Representation : OBJK_RepresentationBinAndXML_Base {
    ObjectId subscriber_id;
};

/* Objects supporting all 3 representation formats */
@extensibility(FINAL)
struct OBJK_PARTICIPANT_Representation : OBJK_Representation3_Base {
    short    domain_id;
};

@extensibility(FINAL)
struct OBJK_TOPIC_Representation : OBJK_Representation3_Base {
    ObjectId participant_id;
};
/

Binary representations /

@extensibility(APPENDABLE)
struct OBJK_DomainParticipant_Binary {
    @optional string<128> domain_reference;
    @optional string<128> qos_profile_reference;
};

@extensibility(APPENDABLE)
struct OBJK_Topic_Binary {
    string<256> topic_name;
    @optional string<256> type_reference;
    @optional DDS:XTypes::TypeIdentifier type_identifier;
};

@extensibility(FINAL)
struct OBJK_Publisher_Binary_Qos {
    @optional sequence<string> partitions;
    @optional sequence<octet> group_data;
};

@extensibility(APPENDABLE)
struct OBJK_Publisher_Binary {
    @optional string publisher_name;
    @optional OBJK_Publisher_Binary_Qos qos;
};

@extensibility(FINAL)
struct OBJK_Subscriber_Binary_Qos {
    @optional sequence<string> partitions;
    @optional sequence<octet> group_data;
};

@extensibility(APPENDABLE)
struct OBJK_Subscriber_Binary {
    @optional string subscriber_name;
    @optional OBJK_Subscriber_Binary_Qos qos;
}
@bit_bound(16)

bitmask EndpointQosFlags {
    @position(0) is_reliable,
    @position(1) is_history_keep_all,
    @position(2) is_ownership_exclusive,
    @position(3) is_durability_transient_local,
    @position(4) is_durability_transient,
    @position(5) is_durability_persistent,
};

@extensibility(FINAL)
struct OBJK_Endpoint_Binary_Qos {
    EndpointQosFlags            qos_flags;
    @optional unsigned short    history_depth;
    @optional unsigned long     deadline_msec;
    @optional unsigned long     lifespan_msec;
    @optional sequence<octet>   user_data;
};

@extensibility(FINAL)
struct OBJK_DataWriter_Binary_Qos : OBJK_Endpoint_Binary_Qos {
    @optional unsigned long     ownership_strength;
};

@extensibility(FINAL)
struct OBJK_DataReader_Binary_Qos : OBJK_Endpoint_Binary_Qos {
    @optional unsigned long     timebasedfilter_msec;
    @optional string            contentbased_filter;
};

@extensibility(APPENDABLE)
struct OBJK_DataReader_Binary {
    string                                  topic_name;
    @optional OBJK_DataReader_Binary_Qos    qos;
};
@extensibility(APPENDABLE)
struct OBJK_DataWriter_Binary {
    string topic_name;
    @optional OBJK_DataWriter_Binary_Qos qos;
};

@extensibility(FINAL)
union ObjectVariant switch(ObjectKind) {
    case OBJK_INVALID : indicates default or selected by Agent. No data.
    case OBJK_AGENT :
        AGENT_Representation client;
    case OBJK_CLIENT :
        CLIENT_Representation client;
    case OBJK_APPLICATION :
        OBJK_APPLICATION_Representation application;
    case OBJK_PARTICIPANT :
        OBJK_PARTICIPANT_Representation participant;
    case OBJK_QOSPROFILE :
        OBJK_QOSPROFILE_Representation qos_profile;
    case OBJK_TYPE :
        OBJK_TYPE_Representation type;
    case OBJK_TOPIC :
        OBJK_TOPIC_Representation topic;
    case OBJK_PUBLISHER :
        OBJK_PUBLISHER_Representation publisher;
    case OBJK_SUBSCRIBER :
        OBJK_SUBSCRIBER_Representation subscriber;
    case OBJK_DATAWRITER :
        DATAWRITER_Representation data_writer;
    case OBJK_DATAREADER :
        DATAREADER_Representation data_reader;
};

struct CreationMode {
    boolean reuse;
    boolean replace;
};
typedef octet RequestId[2];

@bit_bound(8)
enum StatusValue {
    @value(0x00) STATUS_OK,
    @value(0x01) STATUS_OK_MATCHED,
    @value(0x80) STATUS_ERR_DDS_ERROR,
    @value(0x81) STATUS_ERR_MISMATCH,
    @value(0x82) STATUS_ERR_ALREADY_EXISTS,
    @value(0x83) STATUS_ERR_DENIED,
    @value(0x84) STATUS_ERR_UNKNOWN_REFERENCE,
    @value(0x85) STATUS_ERR_INVALID_DATA,
    @value(0x86) STATUS_ERR_INCOMPATIBLE,
    @value(0x87) STATUS_ERR_RESOURCES
};

struct ResultStatus {
    StatusValue  status;
    octet        implementation_status;
};

const octet STATUS_LAST_OP_NONE      = 0;
const octet STATUS_LAST_OP_CREATE    = 1;
const octet STATUS_LAST_OP_UPDATE    = 2;
const octet STATUS_LAST_OP_DELETE    = 3;
const octet STATUS_LAST_OP_LOOKUP    = 4;
const octet STATUS_LAST_OP_READ      = 5;
const octet STATUS_LAST_OP_WRITE     = 6;

bitmask InfoMask {
    @position(0) INFO_CONFIGURATION,
    @position(1) INFO_ACTIVITY
};

@extensibility(APPENDABLE)
struct AGENT_ActivityInfo {
    short availability;
}
TransportLocatorSeq address_seq;
};

@extensibility(APPENDABLE)
struct DATAREADER_ActivityInfo {
    short highest_acked_num;
};

@extensibility(APPENDABLE)
struct DATAWRITER_ActivityInfo {
    unsigned long long sample_seq_num;
    short stream_seq_num;
};

@extensibility(FINAL)
union ActivityInfoVariant switch (ObjectKind) {
    case OBJK_DATAWRITER :
        DATAWRITER_ActivityInfo data_writer;
    case OBJK_DATAREADER :
        DATAREADER_ActivityInfo data_reader;
};

@extensibility(FINAL)
struct ObjectInfo {
    @optional  ActivityInfoVariant  activity;
    @optional  ObjectVariant        config;
};

@extensibility(FINAL)
struct BaseObjectRequest {
    RequestId     request_id;
    ObjectId      object_id;
};

typedef RelatedObjectRequest BaseObjectRequest;
@extensibility(FINAL)
struct BaseObjectReply {
    BaseObjectRequest related_request;
    ResultStatus result;
};

typedef octet DataFormat;
const DataFormat FORMAT_DATA = 0x00; // 0b0000 0000
const DataFormat FORMAT_SAMPLE = 0x02; // 0b0000 0010
const DataFormat FORMAT_DATA_SEQ = 0x08; // 0b0000 1000
const DataFormat FORMAT_SAMPLE_SEQ = 0x0A; // 0b0000 1010
const DataFormat FORMAT_PACKED_SAMPLES = 0x0E; // 0b0000 1110
const DataFormat FORMAT_MASK = 0x0E; // 0b0000 1110

@extensibility(APPENDABLE)
struct DataDeliveryControl {
    unsigned short max_samples;
    unsigned short max_elapsed_time;
    unsigned short max_bytes_per_second;
    unsigned short min_pace_period; // milliseconds
};

@extensibility(FINAL)
struct ReadSpecification {
    DataFormat data_format;
    @optional string content_filter_expression;
    @optional DataDeliveryControl delivery_control;
};

@bit_bound(8)
bitmask SampleInfoFlags {
    @position(0) INSTANCE_STATE_UNREGISTERED,
    @position(1) INSTANCE_STATE_DISPOSED,
    @position(2) VIEW_STATE_NEW,
    @position(3) SAMPLE_STATE_READ,
};
const SampleInfoFormat FORMAT_EMPTY      = 0x00; // 0b0000 0000
const SampleInfoFormat FORMAT_SEQNUM     = 0x01; // 0b0000 0001
const SampleInfoFormat FORMAT_TIMESTAMP  = 0x02; // 0b0000 0010
const SampleInfoFormat FORMAT_SEQN_TIMS  = 0x03; // 0b0000 0011

@extensibility(FINAL)
struct SeqNumberAndTimestamp {
    unsigned long   sequence_number;
    unsigned long   session_time_offset; // milliseconds up to 53 days
};

@extensibility(FINAL)
union SampleInfoDetail switch(SampleInfoFormat) {
    case FORMAT_EMPTY:
    case FORMAT_SEQNUM:
        unsigned long   sequence_number;
    case FORMAT_TIMESTAMP:
        unsigned long   session_time_offset; // milliseconds up to 53 days
    case FORMAT_TIMESTAMP:
        SeqNumberAndTimestamp seqnum_n_timestamp;
};

@extensibility(FINAL)
struct SampleInfo {
    SampleInfoFlags  state; //Combines SampleState, InstanceState, ViewState
    SampleInfoDetail detail;
};

typedef unsigned short  DeciSecond; // 10e-1 seconds
@extensibility(FINAL)
struct SampleInfoDelta {
    SampleInfoFlags state; // Combines SampleState, InstanceState, ViewState
    octet           seq_number_delta;
    DeciSecond      timestamp_delta; // In 1/10 of seconds
};

@extensibility(FINAL)
struct SampleData {
XCDRSerializedBuffer serialized_data;
};
typedef sequence<SampleData> SampleDataSeq;

@extensibility(FINAL)
struct Sample {
    SampleInfo   info;
    SampleData   data;
};
typedef sequence<Sample> SampleSeq;

@extensibility(FINAL)
struct SampleDelta {
    SampleInfoDelta   info_delta;
    SampleData        data;
};

@extensibility(FINAL)
struct PackedSamples {
    SampleInfo             info_base;
    sequence<SampleDelta>  sample_delta_seq;
};
typedef sequence<SamplePacked> SamplePackedSeq;

@extensibility(FINAL)
union DataRepresentation switch(DataFormat) {
    case FORMAT_DATA:
        SampleData data;
    case FORMAT_SAMPLE:
        Sample sample;
    case FORMAT_DATA_SEQ:
        SampleDataSeq data_seq;
    case FORMAT_SAMPLE_SEQ:
        SampleSeq sample_seq;
    case FORMAT_PACKED_SAMPLES:
        PackedSamples packed_samples;
};
// Message Payloads
@extensibility(FINAL)
struct CREATE_CLIENT_Payload : BaseObjectRequest {
    CLIENT_Representation client_representation;
};

@extensibility(FINAL)
struct CREATE_Payload : BaseObjectRequest {
    ObjectVariant object_representation;
};

@extensibility(FINAL)
struct GET_INFO_Payload : BaseObjectRequest {
    InfoMask info_mask;
};

@extensibility(FINAL)
struct DELETE_Payload : BaseObjectRequest {
};

@extensibility(FINAL)
struct STATUS_AGENT_Payload : BaseObjectReply {
    AGENT_Representation agent_info;
};

@extensibility(FINAL)
struct STATUS_Payload : BaseObjectReply {
};

@extensibility(FINAL)
struct INFO_Payload : BaseObjectReply {
    ObjectInfo object_info;
};

@extensibility(FINAL)
struct READ_DATA_Payload : BaseObjectRequest {
    ReadSpecification read_specification;
};
// There are 5 types of DATA and WRITE_DATA payloads
@extensibility(FINAL)
struct WRITE_DATA_Payload_Data : BaseObjectRequest {
    SampleData data;
};

@extensibility(FINAL)
struct WRITE_DATA_Payload_Sample : BaseObjectRequest {
    Sample sample;
};

@extensibility(FINAL)
struct WRITE_DATA_Payload_DataSeq : BaseObjectRequest {
    sequence<SampleData> data_seq;
};

@extensibility(FINAL)
struct WRITE_DATA_Payload_SampleSeq : BaseObjectRequest {
    sequence<Sample> sample_seq;
};

@extensibility(FINAL)
struct WRITE_DATA_Payload_PackedSamples : BaseObjectRequest {
    PackedSamples packed_samples;
};

@extensibility(FINAL)
struct DATA_Payload_Data : RelatedObjectRequest {
    SampleData data;
};

@extensibility(FINAL)
struct DATA_Payload_Sample : RelatedObjectRequest {
    Sample sample;
};
struct DATA_Payload_DataSeq : RelatedObjectRequest {
    sequence<SampleData> data_seq;
};

@extensibility(FINAL)
struct DATA_Payload_SampleSeq : RelatedObjectRequest {
    sequence<Sample> sample_seq;
};

@extensibility(FINAL)
struct DATA_Payload_PackedSamples : RelatedObjectRequest {
    PackedSamples packed_samples;
};

struct ACKNACK_Payload {
    short first_unacked_seq_num;
    octet nack_bitmap[2];
};

@extensibility(FINAL)
struct HEARTBEAT_Payload {
    short first_unacked_seq_nr;
    short last_unacked_seq_nr;
};

@bit_bound(8)
enum SubmessageId {
    @value(0) CREATE_CLIENT,
    @value(1) CREATE,
    @value(2) GET_INFO,
    @value(3) DELETE,
    @value(4) STATUS,
    @value(5) INFO,
    @value(6) WRITE_DATA,
    @value(7) READ_DATA,
    @value(8) DATA,
    @value(9) ACKNACK,
    @value(10) HEARTBEAT,
@value(12) FRAGMENT,
@value(13) FRAGMENT_END
};

}; };
B Example Messages (Non-Normative)

B.1. CREATE_CLIENT message example

The following message could be used by a XRCE Client request a XRCE ProxyClient to be created.

The Client is from vendor_id \{0x0F, 0x0F\} and is using xrce_version \{0x01, 0x00\}.

The request_id is \{0xAA, 0x00\}, the client_timestamp is \{1518905996, 500000000\} (in hexadecimal \{0x5A88AA8C, 0x1DCD6500\}), the client_key is \{0x22, 0x33, 0x44, 0x55\} and the requested session_id is 0xDD.

```
0               8              16              24              31
+---------------+---------------+---------------+---------------+
|     0x80      |      0x00     |             0x00              | 4
+-------+-------+---------------+---------------+---------------+
| CREATE_CLIENT |      flags    |        submessageLength       | 8
+-------+-------+---------------+---------------+---------------+
| request_id          |         object_id             | 12
+-------+-------+---------------+---------------+---------------+
| xrce_cookie                           | 16
+-------+-------+-------+-------+-------+-------+-------+-------+
| xrce_version        |         xrce_vendor_id        | 20
+-------+-------+---------------+---------------+---------------+
| client_timestamp.seconds                  | 24
+ +
| client_timestamp.nanoseconds              | 28
+-------+-------+---------------+---------------+---------------+
| client_key                                | 32
+-------+-------+---------------+---------------+---------------+
| session_id   |  properties?  |
+-------+-------+-------+-------+
```

Table 17 describes each of the bytes in the message.

<table>
<thead>
<tr>
<th>Table 17 Description of the CREATE_CLIENT example bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bytes</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>0-3</td>
</tr>
<tr>
<td>Byte 0</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Byte 1</td>
</tr>
</tbody>
</table>
Indicates there is no stream see 8.3.2.2

<table>
<thead>
<tr>
<th>Bytes 2-3</th>
<th>sequenceNr = 0</th>
</tr>
</thead>
</table>

**4-7**

**Submessage Header**

<table>
<thead>
<tr>
<th>Byte 4</th>
<th>submessageId = CREATE_CLIENT = 0x00</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>See 8.3.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Byte 5</th>
<th>flags = 0x07 (reuse, replace, little endian)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Bytes 6-7</th>
<th>submessageLength = 26 = 0x001B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Represented in little endian as {0x1B, 0x00}</td>
</tr>
</tbody>
</table>

**8-32**

**CREATE_CLIENT_Payload**

<table>
<thead>
<tr>
<th>Bytes 8-11</th>
<th>used for BaseObjectRequest</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Bytes 8-9</th>
<th>request_id = {0xAA, 0x00}</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Bytes 10-11</th>
<th>object_id = {0xFF, 0xFE}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Set to OBJECTID_CLIENT, see 7.6.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bytes 12-32</th>
<th>used for the CLIENT_Representation</th>
</tr>
</thead>
</table>

|-------------|-----------------------------------|

<table>
<thead>
<tr>
<th>Bytes 16-17</th>
<th>xrce_version = {0x01, 0x00}</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Bytes 18-19</th>
<th>xrce_vendor_id = {0x0F, 0x0F}</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Bytes 20-27</th>
<th>client_timestamp = {0x5A88AA8C, 0x1DCD6500}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Since flags has the Endianness bit set to 1 the timestamp is represented as little endian as {0x8C, 0xAA, 0x99, 0x5A}, {0x00, 0x65, 0xCD, 0x1D}</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bytes 28-31</th>
<th>client_key = {0x22, 0x33, 0x44, 0x55}</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Byte 32</th>
<th>The requested session_id = 0xDD</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Byte 33</th>
<th>properties? = FALSE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Indicates that the optional field properties is not present.</td>
</tr>
</tbody>
</table>
B.2. CREATE message examples

B.2.1. Create a DomainParticipant using REPRESENTATION_BY_REFERENCE

The following message would be used by a XRCE Client request a XRCE ProxyClient to create an XRCE DomainParticipant with ObjectID {0xDD, 0xD1} with preconfigured entities and Qos.

The DomainParticipant is represented by a reference to a pre-configured definition known to the XRCE Agent. Therefore the RepresentationFormat is set to REPRESENTATION_BY_REFERENCE.

The representation by reference uses a string containing the fully qualified name of DomainParticipant. See 7.7.3.6.1. In this example the reference is “MyLibrary::MyParticipant”:

The corresponding message is:

<table>
<thead>
<tr>
<th>0</th>
<th>8</th>
<th>16</th>
<th>24</th>
<th>31</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x81</td>
<td>0x80</td>
<td>0x07</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>CREATE</td>
<td>flags</td>
<td>submessageLength</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>request_id</td>
<td>object_id</td>
<td></td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>OBJK_PARTICIPAN</td>
<td>0x01</td>
<td>padding</td>
<td>padding</td>
<td>16</td>
</tr>
<tr>
<td>string_reference.length = 25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘M’</td>
<td>‘y’</td>
<td>‘L’</td>
<td>‘i’</td>
<td>28</td>
</tr>
<tr>
<td>‘b’</td>
<td>‘r’</td>
<td>‘a’</td>
<td>‘r’</td>
<td>32</td>
</tr>
<tr>
<td>‘y’</td>
<td>‘:’</td>
<td>‘:’</td>
<td>‘M’</td>
<td>36</td>
</tr>
<tr>
<td>‘y’</td>
<td>‘P’</td>
<td>‘a’</td>
<td>‘r’</td>
<td>40</td>
</tr>
<tr>
<td>‘t’</td>
<td>‘i’</td>
<td>‘c’</td>
<td>‘i’</td>
<td>44</td>
</tr>
<tr>
<td>‘p’</td>
<td>‘a’</td>
<td>‘n’</td>
<td>‘t’</td>
<td>48</td>
</tr>
<tr>
<td>‘\0’</td>
<td>padding</td>
<td>domain_id</td>
<td>52</td>
<td></td>
</tr>
</tbody>
</table>

Table 20 describes the bytes in the CREATE message.
<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Message Header</td>
</tr>
<tr>
<td></td>
<td>sessionId = 0x81</td>
</tr>
<tr>
<td></td>
<td>Indicates session 1 with no client key included in the message.</td>
</tr>
<tr>
<td></td>
<td>streamId=0x80</td>
</tr>
<tr>
<td></td>
<td>Selects the builtin reliable stream, see 8.3.2.2</td>
</tr>
<tr>
<td></td>
<td>sequenceNr = 0x07</td>
</tr>
<tr>
<td>4-7</td>
<td>Submessage Header</td>
</tr>
<tr>
<td></td>
<td>submessageId = CREATE = 0x01</td>
</tr>
<tr>
<td></td>
<td>See 8.3.5.2</td>
</tr>
<tr>
<td></td>
<td>flags = 0x07 (reuse, replace, little endian)</td>
</tr>
<tr>
<td></td>
<td>submessageLength = 26</td>
</tr>
<tr>
<td></td>
<td>Represented in little endian as {0x1A, 0x00}</td>
</tr>
<tr>
<td>8-51</td>
<td>CREATE_Payload</td>
</tr>
<tr>
<td>Bytes 8-11</td>
<td>used for BaseObjectRequest (base class of CREATE_Payload)</td>
</tr>
<tr>
<td>Bytes 8-9</td>
<td>BaseObjectRequest  request_id = {0xAA , 0x01</td>
</tr>
<tr>
<td>Bytes 10-11</td>
<td>BaseObjectRequest  object_id = {0xDD, 0xD1}</td>
</tr>
<tr>
<td></td>
<td>For a description of the ObjectID see 7.6.</td>
</tr>
<tr>
<td>Bytes 12-32</td>
<td>used for the ObjectVariant</td>
</tr>
<tr>
<td>Byte 12</td>
<td>ObjectVariant  discriminator = 0x01</td>
</tr>
<tr>
<td></td>
<td>Set to OBJK_PARTICIPANT</td>
</tr>
<tr>
<td>Bytes 13-32</td>
<td>are OBJK_Representation3_Base (base class of PARTICIPANT_Representation)</td>
</tr>
<tr>
<td>Byte 13</td>
<td>OBJK_Representation3_Base  discriminator = 0x01</td>
</tr>
<tr>
<td></td>
<td>RepresentationFormat  set to REPRESENTATION_BY_REFERENCE</td>
</tr>
<tr>
<td>Bytes 14-15</td>
<td>padding</td>
</tr>
</tbody>
</table>
B.2.2. Create a DomainParticipant using REPRESENTATION_IN_BINARY

The following message would be used by a XRCE Client request a XRCE ProxyClient to create an XRCE DomainParticipant with ObjectID {0xDD, 0xD1} using default Qos.

The DomainParticipant is represented in binary. Therefore the RepresentationFormat is set to REPRESENTATION_IN_BINARY. In this example it will use little endian encoding.

The binary representation of a DomainParticipant uses the XCDR serialized representation of the type OBJK_DomainParticipant_Binary defined in Annex A IDL Types as:

```
@extensibility(APPENDABLE)
struct OBJK_DomainParticipant_Binary {
    @optional string<128> domain_reference;
    @optional string<128> qos_profile_reference;
};
```

The corresponding message is:
Table 20 describes the bytes in the CREATE message.

### Table 19 Description of the CREATE message for the DomainParticipant using binary representation

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-8</td>
<td>Message Header. Same as Table 18.</td>
</tr>
<tr>
<td>4-7</td>
<td>Submessage Header. Similar to Table 18.</td>
</tr>
<tr>
<td>8-23</td>
<td>CREATE_Payload</td>
</tr>
<tr>
<td>Bytes 8-11 used for BaseObjectRequest (base class of CREATE_Payload). Same as Table 18.</td>
<td></td>
</tr>
<tr>
<td>Bytes 12-32 used for the ObjectVariant</td>
<td></td>
</tr>
<tr>
<td>Byte 12</td>
<td>ObjectVariant discriminator = 0x01</td>
</tr>
<tr>
<td></td>
<td>Set to OBJK_PARTICIPANT</td>
</tr>
<tr>
<td>Bytes 13-32 are OBJK_Representation3_Base (base class of PARTICIPANT_Representation)</td>
<td></td>
</tr>
<tr>
<td>Byte 13</td>
<td>OBJK_Representation3_Base discriminator = 0x03</td>
</tr>
<tr>
<td></td>
<td>RepresentationFormat set to REPRESENTATION_IN_BINARY</td>
</tr>
<tr>
<td>Bytes 14-15</td>
<td>padding</td>
</tr>
</tbody>
</table>
| Bytes 16-19 | DHEADER of OBJK_DomainParticipant_Binary (because extensibility is APPENDABLE)  
|            | Encodes the endianness and length of the serialized OBJK_DomainParticipant_Binary object  
|            | Since the length is 2 and the desired endianness is little endian the value of DHEADER is:  
|            | 0x80000002 = {0x02, 0x00, 0x00, 0x80}  
| Byte 20   | Optional field domain_reference = 0x00  
|           | Set to 0x00 (FALSE) to indicate the field is not present  
| Byte 21   | Optional field qos_profile_reference = 0x00  
|           | Set to 0x00 (FALSE) to indicate the field is not present  
| Bytes 22-23 used for the PARTICIPANT_Representation beyond its base class  
| Bytes 22-23 | domain_id = {0x00, 0x00}  
|           | Little endian representation of domain_id 0.  

### B.2.3. Create a DataWriter using REPRESENTATION_IN_BINARY

The following message would be used by a XRCE Client request a XRCE ProxyClient to create an XRCE DataWriter with ObjectID {0xDD, 0xD5} for topic “Square” using default Qos.

The created XRCE DataWriter should belong to an XRCE Publisher with subscriber_id {0xBB, 0xB3}.

The DataWriter is represented in binary. Therefore the RepresentationFormat is set to REPRESENTATION_IN_BINARY. In this example it will use little endian encoding.

The binary representation of a DataWriter uses the XCDR serialized representation of the type OBJK_DataWriter_Binary defined in Annex A IDL Types as:

```c
@extensibility(APPENDABLE)

struct OBJK_DataWriter_Binary {
    string topic_name;
    @optional OBJK_DataWriter_Binary_Qos qos;
};
```

The corresponding message is:
Table 20 describes the bytes in the *CREATE* message.

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Message Header</td>
</tr>
<tr>
<td></td>
<td>sessionId = 0x81</td>
</tr>
<tr>
<td></td>
<td>Indicates session 1 with no client key included in the message.</td>
</tr>
<tr>
<td></td>
<td>streamId=0x80</td>
</tr>
<tr>
<td></td>
<td>Selects the builtin reliable stream, see 8.3.2.2</td>
</tr>
<tr>
<td></td>
<td>sequenceNr = 0x07</td>
</tr>
<tr>
<td>4-7</td>
<td>Submessage Header</td>
</tr>
<tr>
<td></td>
<td>submessageId = CREATE = 0x01</td>
</tr>
<tr>
<td></td>
<td>See 8.3.5.2</td>
</tr>
<tr>
<td></td>
<td>flags = 0x07 (reuse, replace, little endian)</td>
</tr>
<tr>
<td></td>
<td>submessageLength = 26</td>
</tr>
</tbody>
</table>
Represented in little endian as \{0x1A, 0x00\}

<table>
<thead>
<tr>
<th>8-33</th>
<th>CREATE_Payload</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bytes 8-11 used for BaseObjectRequest (base class of CREATE_Payload)</td>
<td></td>
</tr>
<tr>
<td>Bytes 8-9</td>
<td>BaseObjectRequest request_id = {0xAA, 0x01}</td>
</tr>
<tr>
<td>Bytes 10-11</td>
<td>BaseObjectRequest object_id = {0xDD, 0xD5}</td>
</tr>
<tr>
<td>For a description of the ObjectID see 7.6.</td>
<td></td>
</tr>
</tbody>
</table>

Bytes 12-32 used for the ObjectVariant

| Byte 12 | ObjectVariant discriminator = 0x05 |
| Set to OBJK_DATAWRITER |

Bytes 13-32 are OBJK_RepresentationBinAndXML_Base (base class of DATAWRITER_Representation)

| Byte 13 | OBJK_RepresentationBinAndXML Base discriminator = 0x03 |
| RepresentationFormat set to REPRESENTATION_IN_BINARY |

Bytes 14-15 | padding |

Bytes 16-31 are OBJK_DataWriter_Binary

| Bytes 16-19 | DHEADER of OBJK_DataWriter_Binary (because extensibility is APPENDABLE) |
| Encodes the endianness and length of the serialized OBJK_DataWriter_Binary object |
| Since the length is 12 and the desired endianness is little endian the value of DHEADER is: 0x8000000C encoded in little endian as \{0x0C, 0x00, 0x00, 0x80\} |

Bytes 20-23 | topic_name.length = 0x07 |
| Encodes length of the string represented in little endian as \{0x07, 0x00, 0x00, 0x00\} |

Bytes 24-30 | Characters of the topic_name string, including the terminating NUL. Total of 7 characters |

Byte 31 | Optional field qos = 0x00 |
| Set to 0x00 (FALSE) to indicate the qos field is not present |

Bytes 32-33 used for the DATAWRITER_Representation beyond its base class

Bytes 32-33 | publisher_id = \{0xBB, 0xB3\} |

### B.2.4. Create a DataWriter with Qos using REPRESENTATION_IN_BINARY

DDS-XRCE, Beta 1  121
The following message would be used by a XRCE Client request a XRCE ProxyClient to create an XRCE DataWriter with ObjectID \{0xDD, 0xD5\} for topic “Square” specifying the Qos in binary.

The created XRCE DataWriter should belong to an XRCE Publisher with publisher_id \{0xBB, 0xB3\}.

The desired DataWriter Qos deviates from the DDS default in that it has RELIABILITY policy set to BEST\_EFFORT, HISTORY policy set to KEEP\_ALL and DEADLINE policy set to a period of 2 minutes.

The DataWriter is represented in binary. Therefore the RepresentationFormat is set to REPRESENTATION\_IN\_BINARY. In this example it will use little endian encoding.

The binary representation of a DataWriter uses the XCDR serialized representation of the type OBJK\_DataWriter\_Binary defined in Annex A IDL Types as:

```plaintext
@extensibility(APPENDABLE)
struct  OBJK_DataWriter_Binary {
    string                                topic_name;
    @optional OBJK_DataWriter_Binary_Qos  qos;
}
```

Where OBJK\_DataWriter\_Binary\_Qos is defined in Annex A IDL Types as:

```plaintext
@extensibility(FINAL)
struct  OBJK_Endpoint_Binary_Qos {
    EndpointQosFlags            qos_flags;
    @optional unsigned short    history_depth;
    @optional unsigned long     deadline_msec;
    @optional unsigned long     lifespan_msec;
    @optional sequence<octet>   user_data;
}
@extensibility(FINAL)
struct  OBJK_DataWriter_Binary_Qos :  OBJK_Endpoint_Binary_Qos {
    @optional unsigned long     ownership_strength;
}
```

The corresponding message is:
Table 21 describes the bytes in the CREATE message.

**Table 21 Description of the CREATE message for the DataWriter using binary representation and Qos**

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-8</td>
<td>Message Header. Same as Table 20.</td>
</tr>
<tr>
<td>4-7</td>
<td>Submessage Header. Similar to Table 20.</td>
</tr>
<tr>
<td>8-45</td>
<td>CREATE_Payload</td>
</tr>
</tbody>
</table>

Bytes 8-11 used for BaseObjectRequest (base class of CREATE_Payload). Same as Table 20

Bytes 12-32 used for the ObjectVariant

Byte 12 -30 Same as Table 20
| Byte 31 | qos? Set to 0x01 (TRUE) to indicate the qos field is present |
| Bytes 32-45: OBJK_Endpoint_Binary_Qos (base class of OBJK_DataWriter_Binary_Qos ) |
| Bytes 32-33 | qos_flags = 0x0003 |
| Indicates the flags for is_reliable and is_history_keep_all are both set. |
| Byte 34 | history_depth? Set to 0x00 (FALSE) |
| Byte 35 | padding |
| Bytes 36-39 | deadline = 120000 = 0x1D4C0 |
| Period of 2 minutes in milliseconds. In little endian = {0xC0, 0xD4, 0x01, 0x00} |
| Byte 40 | lifespan? Set to 0x00 (FALSE) |
| Byte 41 | user_data? Set to 0x00 (FALSE) |
| Byte 42 | ownership_strength? Set to 0x00 (FALSE) |
| Byte 43 | padding |
| Bytes 44-45 | publisher_id = {0xBB, 0xB3} |

**B.2.5. Create a DataWriter using REPRESENTATION_AS_XML_STRING**

The following message would be used by a XRCE Client request a XRCE ProxyClient to create a DataWriter with ObjectID {0xDD, 0xD5}.

The created XRCE DataWriter should belong to an XRCE Publisher with publisher_id {0xBB, 0xB3}.

The DataWriter is represented in XML. Therefore the RepresentationFormat is set to REPRESENTATION_AS_XML_STRING.

The XML representation references a Topic “Square” and QosProfile “MyQosLib:MyProfile” both known to the XRCE Agent and uses the XML element:

```xml
<data_writer name="MyWriter" topic_ref="Square">
  <data_writer_qos base_name="MyQosLib::MyProfile">
    <deadline>
      <period><sec>120</sec></period>
    </deadline>
  </data_writer_qos>
</data_writer>
```

The corresponding message is:
| 0  | 8  | 16 | 24 | 31 | +---------------+---------------+---------------+---------------+ | 0x81 | 0x80 | 0x07 | 4 | +---------------+---------------+---------------+---------------+ | CREATE | flags | submessageLength | 8 | +---------------+---------------+---------------+---------------+ | request_id | object_id | 12 | +---------------+---------------+---------------+---------------+ | OBJK_DATAWRITER | 0x01 | padding | padding | 16 | +---------------+---------------+---------------+---------------+ | xml_string_representation.length | 20 | +---------------+---------------+---------------+---------------+ | \0 | publisher_id | 204 | +--------------------------+---------------+---------------+---------------+ ~ The 180 characters of the String (extra whitespace removed): ~ ~ <data_writer name="MyWriter" topic_ref="Square"> ~ ~ <data_writer_qos base_name="MyQosLib::MyProfile"/> ~ ~ <deadline><period><sec>120</sec></period></deadline> ~ ~ </data_writer_qos></data_writer> ~ ~ +---------------+---------------+---------------+---------------+ | \0 | publisher_id | 204 | +--------------------------+---------------+---------------+---------------+

Table 22 describes the bytes in the CREATE message.

**Table 22 Description of the CREATE message for a DataWriter using XML representation**

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Message Header. Same as Table 20.</td>
</tr>
<tr>
<td>4-7</td>
<td>Submessage Header. Similar to Table 20.</td>
</tr>
<tr>
<td>8-202</td>
<td>CREATE_Payload</td>
</tr>
<tr>
<td>Bytes 8-11</td>
<td>used for BaseObjectRequest (base class of CREATE_Payload)</td>
</tr>
<tr>
<td>Bytes 8-9</td>
<td>BaseObjectRequest request_id = {0xAA, 0x01}</td>
</tr>
<tr>
<td>Bytes 10-11</td>
<td>BaseObjectRequest object_id = {0xD6, 0xD5}</td>
</tr>
<tr>
<td>For a description of the ObjectID see 7.6.</td>
<td></td>
</tr>
<tr>
<td>Bytes 12-202</td>
<td>used for the ObjectVariant</td>
</tr>
<tr>
<td>Byte 12</td>
<td>ObjectVariant discriminator = 0x05</td>
</tr>
<tr>
<td>Set to OBJK_DATAWRITER</td>
<td></td>
</tr>
</tbody>
</table>
### B.2.6. Create a DataReader using REPRESENTATION_IN_BINARY

The following message would be used by a XRCE Client request a XRCE ProxyClient to create an XRCE DataReader with ObjectID {0xDD, 0xD6} for topic “Square” using default Qos.

The created XRCE DataReader should belong to an XRCE Subscriber with subscriber_id {0xCC, 0xC4}.

The DataReader is represented in binary. Therefore the RepresentationFormat is set to REPRESENTATION_IN_BINARY. In this example it will use little endian encoding.

The binary representation of a DataWriter uses the XCDR serialized representation of the type OBJK_DataReader_Binary defined in Annex A IDL Types as:

```c
@extensibility(APPENDABLE)
struct OBJK_DataReader_Binary {
    string topic_name;
    @optional OBJK_DataReader_Binary_Qos qos;
};
```

The corresponding message is:
Table 23 describes the bytes in the `CREATE` message.

### Table 23 Description of the CREATE message for the DataReader using binary representation and default Qos

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Message Header</td>
</tr>
</tbody>
</table>
| Byte 0 | sessionId = 0x81  
Indicates session 1 with no client key included in the message. |
| Byte 1 | streamId=0x80  
Selects the builtin reliable stream, see 8.3.2.2 |
| Bytes 2-3 | sequenceNr = 0x07 |
| 4-7   | Submessage Header |
| Byte 4 | submessageId = CREATE = 0x01  
See 8.3.5.2 |
<p>| Byte 5 | flags = 0x07 (reuse, replace, little endian) |
| Bytes 6-7 | submessageLength = 26 |</p>
<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-33</td>
<td><strong>CREATE_Payload</strong></td>
</tr>
<tr>
<td>Bytes 8-11</td>
<td>used for BaseObjectRequest (base class of CREATE_Payload)</td>
</tr>
<tr>
<td>Bytes 8-9</td>
<td>BaseObjectRequest, request_id = {0xAA, 0x01}</td>
</tr>
<tr>
<td>Bytes 10-11</td>
<td>BaseObjectRequest, object_id = {0xDD, 0xD6}</td>
</tr>
<tr>
<td></td>
<td>For a description of the ObjectID see 7.6.</td>
</tr>
<tr>
<td>Bytes 12-32</td>
<td>used for the ObjectVariant</td>
</tr>
<tr>
<td>Byte 12</td>
<td>ObjectVariant, discriminator = 0x05</td>
</tr>
<tr>
<td></td>
<td>Set to OBJK_DATAREADER</td>
</tr>
<tr>
<td>Bytes 13-32</td>
<td>are OBJK_RepresentationBinAndXML_Base (base class of DATAREADER_Representation)</td>
</tr>
<tr>
<td>Byte 13</td>
<td>OBJK_RepresentationBinAndXML_Base, discriminator = 0x03</td>
</tr>
<tr>
<td></td>
<td>RepresentationFormat set to REPRESENTATION_IN_BINARY</td>
</tr>
<tr>
<td>Bytes 14-15</td>
<td>padding</td>
</tr>
<tr>
<td>Bytes 16-19</td>
<td>DHEADER of OBJK_DaraReader_Binary (because extensibility is APPENDABLE)</td>
</tr>
<tr>
<td></td>
<td>Encodes the endianness and length of the serialized OBJK_DaraReader_Binary object</td>
</tr>
<tr>
<td></td>
<td>Since the length is and the desired endianness is little endian the value of DHEADER is: {0xB5, 0x00, 0x00, 0x00}</td>
</tr>
<tr>
<td>Bytes 24-30</td>
<td>topic_name.length = 0x07</td>
</tr>
<tr>
<td></td>
<td>Encodes length of the string represented in little endian as {0x07, 0x00, 0x00, 0x00}</td>
</tr>
<tr>
<td>Bytes 24-30</td>
<td>Characters of the topic_name string, including the terminating NUL. Total of 7 characters</td>
</tr>
<tr>
<td>Byte 31</td>
<td>Optional field qos = 0x00</td>
</tr>
<tr>
<td></td>
<td>Set to 0x00 (FALSE) to indicate the qos field is not present</td>
</tr>
<tr>
<td>Bytes 32-33</td>
<td>used for the DATAREADER_Representation beyond its base class</td>
</tr>
<tr>
<td>Bytes 32-33</td>
<td>subscriber_id = {0xCC, 0xC4}</td>
</tr>
</tbody>
</table>

**B.2.7. Create a DataReader with Qos using REPRESENTATION_IN_BINARY**

The following message would be used by a XRCE Client request a XRCE ProxyClient to create an XRCE DataReader with ObjectID \{0xDD, 0xD6\} for topic “Square” specifying the Qos in binary.

The created XRCE DataReader should belong to an XRCE Subscriber with subscriber_id \{0xCC, 0xC4\}.
The desired DataReader Qos deviates from the DDS default in that it has HISTORY policy set to KEEP_ALL and DEADLINE policy set to a period of 5 minutes.

In addition the DataReader installs a filter with the expression “x>100”.

The DataReader is represented in binary. Therefore the RepresentationFormat is set to REPRESENTATION_IN_BINARY. In this example it will use little endian encoding.

The binary representation of a DataWriter uses the XCDR serialized representation of the type OBJK_DataReader_Binary defined in Annex A IDL Types as:

```c
@extensibility(APPENDABLE)
struct  OBJK_DataReader_Binary {
    string                                topic_name;
    @optional OBJK_DataReader_Binary_Qos  qos;
};
```

Where OBJK_DataReader_Binary_Qos is defined in Annex A IDL Types as:

```c
@extensibility(FINAL)
struct  OBJK_Endpoint_Binary_Qos {
    EndpointQosFlags            qos_flags;
    @optional unsigned short    history_depth;
    @optional unsigned long     deadline_msec;
    @optional unsigned long     lifespan_msec;
    @optional sequence<octet>   user_data;
};

@extensibility(FINAL)
struct  OBJK_DataReader_Binary_Qos :  OBJK_Endpoint_Binary_Qos {
    @optional unsigned long     timebasedfilter_msec;
    @optional string            contentbased_filter;
};
```

The corresponding message is:
Table 24 describes the bytes in the **CREATE** message.

**Table 24 Description of the CREATE message for the DataWriter using binary representation and Qos**

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-8</td>
<td>Message Header. Same as Table 23.</td>
</tr>
<tr>
<td>4-7</td>
<td>Submessage Header. Similar to Table 23.</td>
</tr>
<tr>
<td>8-55</td>
<td>CREATE_Payload</td>
</tr>
<tr>
<td></td>
<td>Bytes 8-11 used for BaseObjectRequest (base class of CREATE_Payload). Same as Table 23</td>
</tr>
</tbody>
</table>
B.3. WRITE_DATA message examples

B.3.1. Writing a single data sample

The following message could be used by a XRCE Client to write data using an already created XRCE DataWriter, identified by object_id {0x44, 0x05}. It uses an existing session with session_id 0xDD to send the request.

The XCREClient uses request_id = {0xAA, 0x01} to identify this request.
The XRCE Client writes a single sample of data with no meta-data. See 7.7.1 and 7.7.2 for a description of the different formats available to write and read data. Therefore the payload of the WRITE_DATA message is the XCDR serialized representation of the WRITE_DATA_Payload_Data type defined in Annex A IDL Types.

@extensibility(FINAL)
struct SampleData {
    XCDRSerializedBuffer serialized_data;
};

@extensibility(FINAL)
struct WRITE_DATA_Payload_Data : BaseObjectRequest {
    SampleData data;
};

In this example we assume the data written corresponds to a struct Temperature type described in the following IDL:

@extensibility(FINAL)
struct Temperature {
    short value;
};

Furthermore we assume that the value written is 25.

The corresponding message is:

```
0               8               16               24               31
+---------------+----------------+----------------+----------------+
|  session_id   |   stream_id    |          sequenceNr            | 4
+-------+-------+----------------+----------------+----------------+
|  WRITE_DATA   |   flags        |         submessageLength        | 8
+---------------+----------------+----------------+----------------+
|           request_id           |          object_id              | 12
+---------------+----------------+----------------+----------------+
|           serialized_data      |
+---------------+----------------+
```

Table 25 describes each of the bytes in the message.

**Table 25 Description of the READ_DATA (single sample) example bytes**

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Message Header</td>
</tr>
<tr>
<td>Byte 0</td>
<td>sessionId = 0xDD</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>
| Byte 1 | streamId=0x80  
Selects STREAMID_BUILTIN_RELIABLE, see 8.3.2.2 |
| Bytes 2-3 | sequenceNr = 1  
Represented in little endian (see 8.3.2.3) as {0x01, 0x00} |

4-7 Submessage Header

<table>
<thead>
<tr>
<th>Byte 4</th>
<th>submessageId = WRITE_DATA = 0x07</th>
</tr>
</thead>
</table>
| Byte 5 | flags = 0x01  
Bit 0 (lowest bit) = 1 indicate little endian encoding  
Bits 1, 2, 3 set to zero indicate payload DataFormat is FORMAT_DATA. See 8.3.5.8.1. |
| Bytes 6-7 | submessageLength = 6 = 0x0006  
Represented in little endian (see 8.3.4.3) as {0x06, 0x00} |

8-13 WRITE_DATA_Payload

<table>
<thead>
<tr>
<th>Bytes 8-11</th>
<th>used for BaseObjectRequest (base class of WRITE_DATA_Payload)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bytes 8-9</td>
<td>request_id = {0xAA, 0x01}</td>
</tr>
<tr>
<td>Bytes 10-11</td>
<td>object_id = {0x44, 0x05}</td>
</tr>
<tr>
<td>Bytes 12-13</td>
<td>are used for SampleData (remaining of WRITE_DATA_Payload after base class)</td>
</tr>
</tbody>
</table>
| Byte 12-13 | serialized_data = {0x19, 0x00}  
Little endian serialized representation of the Temperature value of 25 (in hex 0x0019). |

### B.3.2. Writing a sequence of data samples with no sample information

The following message could be used by a XRCE Client to write data using an already created XRCE DataWriter, identified by object_id {0x44, 0x05}. It uses an existing session with session_id 0xDD to send the request.

The XCREClient uses request_id = {0xAA, 0x01} to identify this request.

The XRCE Client writes a sequence of bare data samples with no meta-data. See 7.7.1 and 7.7.2 for a description of the different formats available to write and read data. Therefore the payload of the WRITE_DATA message is the XCDR serialized representation of the WRITE_DATA_Payload_DataSeq type defined in Annex A IDL Types.
struct SampleData {
    XCDRSerializedBuffer serialized_data;
};

@extensibility(FINAL)
struct WRITE_DATA_Payload_DataSeq : BaseObjectRequest {
    sequence<SampleData> data_seq;
};

In this example we assume the data written corresponds to a two values of the struct Temperature type described in the following IDL:

@extensibility(FINAL)
struct Temperature {
    short value;
};

Furthermore we assume that there are five values written: 20, 17, 26, and 40.

The corresponding message is:

Table 26 describes each of the bytes in the message.

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Submessage Header similar to Table 25</td>
</tr>
</tbody>
</table>
### B.3.3. Writing a single data sample with timestamp metadata

The following message could be used by a XRCE Client to write data using an already created XRCE DataWriter, identified by object_id \{0x44, 0x05\}. It uses an existing session with session_id 0xDD to send the request.

The XCREClient uses request_id = \{0xAA, 0x01\} to identify this request.

The XRCE Client writes a single sample of data with additional metadata allowing it to put a timestamp and also notify of instance lifecycle changes such as the deletion of an instance. See 7.7.1 and 7.7.2 for a description of the different formats available to write and read data.

The payload of the WRITE_DATA message is the XCDR serialized representation of the WRITE_DATA_Payload_Sample type defined in Annex A IDL Types.

```c
@bit_bound(8)
bitmask SampleInfoFlags {
    @position(0) INSTANCE_STATE_UNREGISTERED,
    @position(1) INSTANCE_STATE_DISPOSED,
    @position(2) VIEW_STATE_NEW,
    @position(3) SAMPLE_STATE_READ,
};
```
@extensibility(FINAL)
struct SeqNumberAndTimestamp {
    unsigned long sequence_number;
    unsigned long session_time_offset; // milliseconds up to 53 days
};

@extensibility(FINAL)
union SampleInfoDetail switch(SampleInfoFormat) {
    case FORMAT_EMPTY:
    case FORMAT_SEQNUM:
        unsigned long sequence_number;
    case FORMAT_TIMESTAMP:
        unsigned long session_time_offset; // milliseconds up to 53 days
    case FORMAT_TIMESTAMP:
        SeqNumberAndTimestamp seqnum_n_timestamp;
};

@extensibility(FINAL)
struct SampleInfo {
    SampleInfoFlags state; //Combines SampleState, InstanceState, ViewState
    SampleInfoDetail detail;
};

@extensibility(FINAL)
struct SampleData {
    XCDRSerializedBuffer serialized_data;
};

@extensibility(FINAL)
struct Sample {
    SampleInfo info;
    SampleData data;
};

@extensibility(FINAL)
struct WRITE_DATA_Payload_Sample : BaseObjectRequest {
    Sample sample;
};
In this example we assume the data written corresponds to a struct `Temperature` type described in the following IDL:

```c
@extensibility(FINAL)
struct Temperature {
    short value;
};
```

Furthermore we assume that the value written is 25.

The corresponding message is:

```
+---------------+----------------+----------------+----------------+   
|  session_id   |   stream_id    |          sequenceNr             | 4   
+---------------+----------------+----------------+----------------+   
|  WRITE_DATA   |   flags        |         submessageLength        | 8   
+---------------+----------------+----------------+----------------+   
|           request_id           |          object_id              | 12  
+---------------+----------------+----------------+----------------+   
|  info.state   |FORMAT_TIMESTAMP|    padding     |    padding     | 16  
+---------------+----------------+----------------+----------------+   
|               info.detail.session_time_offset                    | 20  
+---------------+----------------+----------------+----------------+   
|        serialized_data         |                                   24  
+---------------+----------------+                       
```

Table 27 describes each of the bytes in the message.

**Table 27 Description of the READ_DATA (single sample) example bytes**

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Submessage Header similar to Table 25</td>
</tr>
<tr>
<td>4-7</td>
<td>Submessage Header</td>
</tr>
<tr>
<td>Byte 4</td>
<td><code>submessageId = WRITE_DATA = 0x07</code></td>
</tr>
</tbody>
</table>
| Byte 5 | `flags = 0x03`  
  Bit 0 (lowest bit) = 1 indicate little endian encoding  
  Bits 3, 2, 1 respectively set to 0, 0, 1, indicate payload DataFormat is FORMAT_Sample. See 8.3.5.8.1. |
| Bytes 6-7 | `submessageLength = 13 = 0x000D`  
  Represented in little endian (see 8.3.4.3) as \{0x06, 0x00\} |
### B.3.4. Writing a disposed data sample

The following message could be used by a XRCE Client to write data using an already created XRCE DataWriter, identified by object_id {0x44, 0x05}. It uses an existing session with session_id 0xDD to send the request.

The XCREClient uses request_id = {0xAA, 0x01} to identify this request.

The XRCE Client writes a single sample of data with additional metadata allowing it to put a timestamp and also notify of instance lifecycle changes such as the deletion of an instance. See 7.7.1 and 7.7.2 for a description of the different formats available to write and read data.

The payload of the WRITE_DATA message is the XCDR serialized representation of the WRITE_DATA_Payload_Sample type defined in Annex A IDL Types. See also B.3.3 for the types used in this message.

In this example we assume the data written corresponds to a keyed data-type. The structure `TemperatureSensor` described in the following IDL:

```idl
@extensibility(FINAL)
struct TemperatureSensor {
  @key octet sensor_id[4];
  short sensor_value;
};
```

Furthermore the example assumes that the written data has sensor_id = {0x11, 0x22, 0x33, 0x64} and sensor_value = 25.

The corresponding message is:
Table 28 describes each of the bytes in the message.

**Table 28 Description of the READ_DATA (single sample) example bytes**

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Submessage Header similar to Table 25</td>
</tr>
<tr>
<td>4-7</td>
<td>Submessage Header</td>
</tr>
<tr>
<td>Byte 4</td>
<td>submessageId = WRITE_DATA = 0x07</td>
</tr>
<tr>
<td>Byte 5</td>
<td>flags = 0x03</td>
</tr>
<tr>
<td></td>
<td>Bit 0 (lowest bit) = 1 indicate little endian encoding</td>
</tr>
<tr>
<td></td>
<td>Bits 3, 2, 1 respectively set to 0, 0, 1, indicate payload DataFormat is FORMAT_Sample. See 8.3.5.8.1.</td>
</tr>
<tr>
<td>Bytes 6-7</td>
<td>submessageLength = 6 = 0x0006</td>
</tr>
<tr>
<td></td>
<td>Represented in little endian (see 8.3.4.3) as {0x06, 0x00}</td>
</tr>
<tr>
<td>8-19</td>
<td>WRITE_DATA_Payload</td>
</tr>
<tr>
<td>Bytes 8-11</td>
<td>used for BaseObjectRequest (base class of WRITE_DATA_Payload)</td>
</tr>
<tr>
<td>Same as Table 25</td>
<td></td>
</tr>
<tr>
<td>Bytes 12-19</td>
<td>are used for Sample (remaining of WRITE_DATA_Payload after base class)</td>
</tr>
<tr>
<td>Byte 12</td>
<td>info.state = 0x02</td>
</tr>
<tr>
<td></td>
<td>The state bits indicate the instance is DISPOSED (the flag for unregistered is zero but the flag for disposed is one).</td>
</tr>
</tbody>
</table>
### Byte 13

| Byte 13 | Info.detail.discriminator = FORMAT_NONE  
Indicates no additional information beyond the state. |
|---------|------------------------------------------------------------------------------------------|

### Bytes 14-19

| Bytes 14-19 | Serialized_data = \{ {0x11, 0x22, 0x33, 0x64}, {0x19, 0x00} \}  
Little endian serialized representation of the sensor data. First four bytes are the sender_id and following two bytes the sensor_value. |
|-------------|--------------------------------------------------------------------------------------------|

## B.4. READ_DATA message examples

### B.4.1. Reading a single data sample

The following message could be used by a XRCE Client to read data from an already created XRCE DataReader, identified by object_id \{0x44, 0x06\}. It uses an (already created) session with session_id 0xDD to send the request.

The XCREClient uses request_id = \{0xAA, 0x01\} to identify this request.

The ReadSpecification does not specify a content filter and requests a single data sample with no sample information.

The payload of the READ_DATA message is the XCDR serialized representation of the READ_DATA_Payload type defined in Annex A IDL Types.

```c
@extensibility(APPENDABLE)
struct DataDeliveryControl {
    unsigned short max_samples;
    unsigned short max_elapsed_time;
    unsigned short max_bytes_per_second;
    unsigned short min_pace_period;  // milliseconds
};

@extensibility(FINAL)
struct ReadSpecification {
    DataFormat data_format;
    @optional string content_filter_expression;
    @optional DataDeliveryControl delivery_control;
};

@extensibility(FINAL)
struct READ_DATA_Payload : BaseObjectRequest {
    ReadSpecification read Specification;
};
```
The corresponding message is:

```
<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>session_id</td>
<td>stream_id</td>
<td>sequenceNr</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>READ_DATA</td>
<td>flags</td>
<td>submessageLength</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>request_id</td>
<td>object_id</td>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>data_format</td>
<td>content_filter?</td>
<td>delivery_control?</td>
<td></td>
<td>16</td>
</tr>
</tbody>
</table>
```

Table 29 describes each of the bytes in the message.

### Table 29 Description of the READ_DATA (single sample) example bytes

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Message Header</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Byte 0</td>
<td>sessionId = 0xDD</td>
</tr>
<tr>
<td>Byte 1</td>
<td>streamId=0x80</td>
</tr>
<tr>
<td></td>
<td>Selects STREAMID_BUILTIN_RELIABLE, see 8.3.2.2</td>
</tr>
<tr>
<td>Bytes 2-3</td>
<td>sequenceNr = 1</td>
</tr>
<tr>
<td></td>
<td>Represented in little endian (see 8.3.2.3) as {0x01, 0x00}</td>
</tr>
<tr>
<td>4-7</td>
<td>Submessage Header</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Byte 4</td>
<td>submessageId = READ_DATA = 0x07</td>
</tr>
<tr>
<td>Byte 5</td>
<td>flags = 0x01 (little endian)</td>
</tr>
<tr>
<td>Bytes 6-7</td>
<td>submessageLength = 7= 0x0007</td>
</tr>
<tr>
<td></td>
<td>Represented in little endian (see 8.3.4.3) as {0x07, 0x00}</td>
</tr>
<tr>
<td>8-14</td>
<td>READ_DATA_Payload</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Bytes 8-11</td>
<td>used for BaseObjectRequest (base class of WRITE_DATA_Payload)</td>
</tr>
<tr>
<td>Bytes 8-9</td>
<td>request_id = {0xAA , 0x01}</td>
</tr>
<tr>
<td>Bytes 10-11</td>
<td>object_id = {0x44, 0x06}</td>
</tr>
</tbody>
</table>
B.4.2. Reading a sequence of data samples with a content filter

The following message could be used by a XRCE Client to request the streaming of data from an already created XRCE DataReader, identified by object_id \{0x44, 0x06\}. It uses an (already created) session with session_id 0xDD to send the request.

The XCREClient uses request_id = \{0xAA, 0x01\} to identify this request.

The ReadSpecification requests a stream of no more than 100 data samples, over a time window not to exceed 30 seconds with bandwidth not to exceed 1024 bytes per second and a minimum pace of 1000 milliseconds. It requests samples only with no associated sample information.

In addition the Client request data that matches the content filter expression “x>100”.

This message uses the same data types as B.4.1. The difference is that it selects the DataFormat FORMAT_DATA_SEQ, the read_specification contains a content filter expression and a DataDeliveryControl.
Table 30 describes each of the bytes in the message.

**Table 30 Description of the READ_DATA (multiple samples) example bytes**

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Message Header. Same as Table 29.</td>
</tr>
<tr>
<td>4-7</td>
<td>Submessage Header. Similar to Table 29.</td>
</tr>
<tr>
<td>8-36</td>
<td>READ_DATA_Payload</td>
</tr>
<tr>
<td></td>
<td>Bytes 8-11 used for BaseObjectRequest (base class of WRITE_DATA_Payload) Same as Table 29.</td>
</tr>
<tr>
<td></td>
<td>Bytes 12-36 are used for remaining of READ_DATA_Payload after base class</td>
</tr>
<tr>
<td></td>
<td>Bytes 12-36 are used for the read_specification of type ReadSpecification</td>
</tr>
<tr>
<td>Byte 12</td>
<td>read_specification.data_format = 0x08</td>
</tr>
<tr>
<td></td>
<td>Encodes the desired DataFormat. In this case selects FORMAT_DATA_SEQ.</td>
</tr>
<tr>
<td>Byte 13-25 is used for the content filter expression</td>
<td></td>
</tr>
</tbody>
</table>
| Byte 13 | content_filter_expression? = 0x01.  
Encodes whether the optional member content_filter_expression is present. In this case it is set to FALSE indicating there it is present. |
| Bytes 14-15 | padding |
| Bytes 16-19 | content_filter_expression .length = 6 = 0x00000006  
Length of the content_filter_expression string in little endian {0x06,0x00,0x00,0x00}. |
| Byte 20-25 | Characters of content filter expression, including terminating NUL character. |
| Bytes 26-35 are used for the delivery_control of type DataDeliveryControl |  
| Byte 26 | read_specification.delivery_control? = 0x01  
Encodes whether the optional member delivery_control is present. In this case it is set to FALSE indicating there is no DataDeliveryControl. |
| Bytes 27 | padding |
| Bytes 28-31 | DHEADER of DataDeliveryControl (because extensibility is APPENDABLE)  
Encodes the endianness and length of the serialized DataDeliveryControl object  
Since the length is 8 and the desired endianness is little endian the value of DHEADER is: 0x80000008 = {0x08, 0x00, 0x00, 0x80} |
| Byte 28-29 | max_samples = 100 = 0x64  
Represented in little endian (see flags) as {0x64, 0x00,} |
| Byte 30-31 | max_elapsed_time = 30000 = 0x7530.  
Represented in little endian (see flags) as {0x30, 0x75 } |
| Byte 32-33 | max_rate = 1024 = 0x0400  
Represented in little endian (see flags) as {0x00, 0x40} |
| Byte 34-35 | min_pace_period = 1000 = 0x03E8  
Represented in little endian (see flags) as {0xE8, 0x03} |
B.5. DATA message examples

B.5.1. Receiving a single data sample

The following message could be used by a XRCE Agent to send a single sample in response to a READ_DATA request from a XRCE Client that used DataFormat FORMAT_DATA.

The example illustrates the response to the request_id {0xAA, 0x01} from the XRCE DataReader with object_id {0x44, 0x06}. It uses the (already created) session with session_id 0xDD to send the data.

The data is sent using best-effort using the builtin stream identified by stream_id STREAM_ID_BUILTIN_BEST_EFFORTS.

This example also assumes the data being sent corresponds to an object foo of type FooType defined in the IDL below. In the example we assume foo.count is set to 19.

```c
@extensibility(FINAL)
struct FooType {
    long count;
};
```

```
+---------------+--------+-------+----------------+----------------+----------------+----------------+
|  session_id   |   stream_id    |          sequenceNr             | 4
| DATA         |   flags        |         submessageLength        | 8
|           request_id           |          object_id              | 12
| XCDR_Serialization(foo)                             | 16
+---------------+--------+-------+----------------+----------------+----------------+----------------+
```

Table 31 Description of the DATA (single samples) example bytes

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Message Header</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Byte 0</td>
<td>sessionId = 0xDD</td>
</tr>
<tr>
<td>Byte 1</td>
<td>streamId=0x01</td>
</tr>
<tr>
<td></td>
<td>Selects STREAM_ID_BUILTIN_BEST_EFFORTS, see 8.3.2.2</td>
</tr>
<tr>
<td>Bytes 2-3</td>
<td>sequenceNr = 1</td>
</tr>
<tr>
<td></td>
<td>Represented in little endian (see 8.3.2.3) as {0x01, 0x00}</td>
</tr>
<tr>
<td>4-7</td>
<td>Submessage Header</td>
</tr>
</tbody>
</table>
### B.5.2. Receiving a sequence of samples without SampleInfo

The following message could be used by a XRCE Agent to send a sequence of samples in response to a READ_DATA request from a XRCE Client that used DataFormat FORMAT_DATA_SEQ.

The example illustrates the response to the request_id {0xAA, 0x02} from the XRCE DataReader with object_id {0x44, 0x06}. It uses the (already created) session with session_id 0xDD to send the data.

The data is sent using best-effort using the builtin stream identified by stream_id STREAMID_BUILTIN_BEST_EFFORTS.

This example also assumes the data being sent corresponds to a sequence of two objects foo1 and foo1 of type FooType defined in the IDL below. In the example we assume foo1.count is set to 1 and foo2.count is set to 1.

```cpp
@extensibility(FINAL)
struct FooType {
    long count;
};
```
The serialization of DATA_Payload_SampleSeq can be expanded as:

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Message Header</td>
</tr>
<tr>
<td></td>
<td>Byte 0   session_id = 0xDD</td>
</tr>
<tr>
<td></td>
<td>Byte 1   stream_id=0x01</td>
</tr>
<tr>
<td></td>
<td>Selects STREAMID_BUILTIN_BEST_EFFORTS, see 8.3.2.2</td>
</tr>
<tr>
<td></td>
<td>Bytes 2-3 sequenceNr = 1</td>
</tr>
<tr>
<td></td>
<td>Represented in little endian (see 8.3.2.3) as {0x0A, 0x00}</td>
</tr>
<tr>
<td>4-7</td>
<td>Submessage Header</td>
</tr>
<tr>
<td></td>
<td>Byte 4   submessageId = DATA = 0x08</td>
</tr>
<tr>
<td></td>
<td>Byte 5   flags = 0x00 (big endian)</td>
</tr>
<tr>
<td></td>
<td>Bytes 6-7 submessageLength = 16 = 0x0010</td>
</tr>
<tr>
<td></td>
<td>Represented in little endian (see 8.3.4.3) as {0x10, 0x00}</td>
</tr>
</tbody>
</table>

Table 32 Description of the DATA (sample sequence) example bytes

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Message Header</td>
</tr>
<tr>
<td></td>
<td>Byte 0   session_id = 0xDD</td>
</tr>
<tr>
<td></td>
<td>Byte 1   stream_id=0x01</td>
</tr>
<tr>
<td></td>
<td>Selects STREAMID_BUILTIN_BEST_EFFORTS, see 8.3.2.2</td>
</tr>
<tr>
<td></td>
<td>Bytes 2-3 sequenceNr = 1</td>
</tr>
<tr>
<td></td>
<td>Represented in little endian (see 8.3.2.3) as {0x0A, 0x00}</td>
</tr>
<tr>
<td>4-7</td>
<td>Submessage Header</td>
</tr>
<tr>
<td></td>
<td>Byte 4   submessageId = DATA = 0x08</td>
</tr>
<tr>
<td></td>
<td>Byte 5   flags = 0x00 (big endian)</td>
</tr>
<tr>
<td></td>
<td>Bytes 6-7 submessageLength = 16 = 0x0010</td>
</tr>
<tr>
<td></td>
<td>Represented in little endian (see 8.3.4.3) as {0x10, 0x00}</td>
</tr>
</tbody>
</table>
B.5.3. Receiving a single sample that includes SampleInfo

The following message could be used by a XRCE Agent to send a sequence of samples in response to a READ_DATA request from a XRCE Client that used DataFormat FORMAT_DATA_SEQ.

The example illustrates the response to the request_id {0xAA, 0x02} from the XRCE DataReader with object_id {0x44, 0x06}. It uses the (already created) session with session_id 0xDD to send the data.

The data is sent using best-effort using the builtin stream identified by stream_id STREAMID_BUILTIN_BEST_EFFORTS.

This example also assumes the data being sent corresponds to a sequence of two objects `foo1` and `foo2` of type `FooType` defined in the IDL below. In the example we assume `foo1.count` is set to 1 and `foo2.count` is set to 1.

```idl
@extensibility(FINAL)
struct FooType {
  long count;
};
```

```
|  session_id   |   stream_id    |          sequenceNr             | 4 |
|---------------+----------------+----------------+----------------+----------------|
|      DATA     |   flags        |         submessageLength        | 8 |
|---------------+----------------+----------------+----------------+----------------|
|           request_id           |          object_id              | 12 |
|---------------+----------------+----------------+----------------+----------------|
|  ~             XDR_Serialization(DATA_Payload_Sample)              |
```

The serialization of DATA_Payload_Sample can be expanded as:

```idl`
@extensibility(FINAL)
union SampleInfoDetail switch(SampleInfoFormat) {
```
case FORMAT_EMPTY:
case FORMAT_SEQNUM:
    unsigned long sequence_number;
case FORMAT_TIMESTAMP:
    unsigned long session_time_offset; // milliseconds up to 53 days
    case FORMAT_TIMESTAMP:
        SeqNumberAndTimestamp seqnum_n_timestamp;
    
@bit_bound(8)
bitmask SampleInfoFlags {
    @position(0) INSTANCE_STATE_UNREGISTERED,
    @position(1) INSTANCE_STATE_DISPOSED,
    @position(2) VIEW_STATE_NEW,
    @position(3) SAMPLE_STATE_READ,
};

@extensibility(FINAL)
struct SampleInfo {
    SampleInfoFlags state; //Combines SampleState, InstanceState, ViewState
    SampleInfoDetail detail;
};

@extensibility(FINAL)
struct Sample {
    SampleInfo info;
    SampleData data;
};
B.5.4. Receiving a sequence of samples that includes SampleInfo

The following message could be used by a XRCE Agent to send a sequence of samples in response to a READ_DATA request from a XRCE Client that used DataFormat FORMAT_SAMPLE_SEQ.

The example illustrates the response to the request_id {0xAA, 0x02} from the XRCE DataReader with object_id {0x44, 0x06}. It uses the (already created) session with session_id 0xDD to send the data.

The data is sent using best-effort using the builtin stream identified by stream_id STREAMID_BUILTIN_BEST_EFFORTS.

This example also assumes the data being sent corresponds to a sequence of two objects foo1 and foo2 of type FooType defined in the IDL below. In the example we assume foo1.count is set to 1 and foo2.count is set to 1.

```c
@extensibility(FINAL)
struct FooType {
    long count;
};
```

The serialization of DATA_Payload_SampleSeq can be expanded as:

```c
XCDR_Serialization(boo) + 16
```
Table 33 Description of the DATA (sample sequence) example bytes

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Message Header</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Byte 0</td>
<td>sessionId = 0xDD</td>
</tr>
</tbody>
</table>
| Byte 1 | streamId=0x01  
Selects STREAMID_BUILTIN_BEST_EFFORTS, see 8.3.2.2 |
| Bytes 2-3 | sequenceNr = 1  
Represented in little endian (see 8.3.2.3) as {0x0A, 0x00} |
| 4-7   | Submessage Header |
|       |              |
| Byte 4 | submessageId = DATA = 0x08 |
| Byte 5 | flags = 0x00 (big endian) |
| Bytes 6-7 | submessageLength = 40 = 0x0028  
Represented in little endian (see 8.3.4.3) as {0x28, 0x00} |
DATA_Payload_SampleSeq  (DataFormat was FORMAT_SAMPLE_SEQ)

| Bytes 8-9          | request_id = \{0xAA , 0x01\} |
| Bytes 10-11        | object_id = \{0x44, 0x06\} |
| Bytes 12-15        | sample_seq.length = 2         |
| Bytes 16-27        | sample_seq[0].info            |
| Bytes 28-31        | sample_seq[0].data            |
| Bytes 32-43        | sample_seq[1].info            |
| Bytes 44-47        | sample_seq[1].data            |

### B.5.5. Receiving a sequence of packed samples

The following message could be used by a XRCE Agent to send a sequence of samples in response to a READ_DATA request from a XRCE Client that used DataFormat FORMAT_PACKED_SAMPLES.

The example illustrates the response to the request_id \{0xAA, 0x03\} from the XRCE DataReader with object_id \{0x44, 0x06\}. It uses the (already created) session with session_id 0xDD to send the data.

The data is sent using a reliable protocol using the builtin stream identified by stream_id STREAMID_BUILTIN_RELIABLE.

This example also assumes the data being sent corresponds to a sequence of two objects \texttt{foo1} and \texttt{foo2} of type \texttt{FooType} defined in the IDL below In the example we assume \texttt{foo1.count} is set to 1 and \texttt{foo2.count} is set to 1.

```idl
@extensibility(FINAL)
struct FooType {
    long count;
};
```

| 0       | 8       | 16      | 24      | 31       |
|---------+---------+---------+---------+---------|
| session_id | stream_id | sequenceNr | 4       |
| DATA     | flags    | submessageLength | 8       |
| request_id | object_id | 12       |
| ~        | XDR_Serialization(DATA_Payload_PackedSamples) ~ |

The serialization of DATA_Payload_SamplePackedSeq can be expanded as:
Table 34 Description of the DATA (packed samples) example bytes

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>Message Header</td>
</tr>
<tr>
<td>Byte 0</td>
<td>sessionId = 0xDD</td>
</tr>
</tbody>
</table>
| Byte 1 | streamId = 0x80  
        | Selects STREAMID_BUILTIN_RELIABLE, see 8.3.2.2 |
| Bytes 2-3 | sequenceNr = 1  
        | Represented in little endian (see 8.3.2.3) as {0x0A, 0x00} |
| 4-7   | Submessage Header |
| Byte 4 | submessageId = DATA = 0x08 |
| Byte 5 | flags = 0x00 (big endian) |
| Bytes 6-7 | submessageLength = 36 = 0x0024  
<pre><code>    | Represented in little endian (see 8.3.4.3) as {0x24, 0x00} |
</code></pre>
<p>| 8-47  | DATA_Payload_PackedSample   (DataFormat FORMAT_PACKED_SAMPLES) |
| Byte 8-19 | info_base |</p>
<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-23</td>
<td><code>sample_delta_seq.length = 2</code></td>
</tr>
<tr>
<td>24-27</td>
<td><code>sample_delta_seq[0].info_delta</code></td>
</tr>
<tr>
<td>28-31</td>
<td><code>sample_delta_seq[0].data</code></td>
</tr>
<tr>
<td>32-35</td>
<td><code>sample_delta_seq[1].info_delta</code></td>
</tr>
<tr>
<td>36-39</td>
<td><code>sample_delta_seq[1].data</code></td>
</tr>
</tbody>
</table>