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DDS Security

FTF Beta 1

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http://www.omg.org/spec/DDS-SECURITY/20140301/dds_security_governance.xsd
http://www.omg.org/spec/DDS-SECURITY/20140301/dds_security_permissions.xsd
http://www.omg.org/spec/DDS-SECURITY/20140301/dds_security_plugins_model.xmi

Non-normative:

http://www.omg.org/spec/DDS-SECURITY/20140301/dds_security_governance_example.xml
http://www.omg.org/spec/DDS-SECURITY/20140301/dds_security_permissions_example.xml
http://www.omg.org/spec/DDS-SECURITY/20140301/dds_security_plugins_model.eap

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This OMG document replaces the submission document (mars/14-02-03, Alpha). It is an OMG Adopted Beta Specification and is currently in the finalization phase. Comments on the content of this document are welcome, and should be directed to *issues@omg.org* by October 15, 2014.

You may view pending issues for this specification from the OMG revision issues web page *http://www.omg.org/issues*.

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Preface

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OMG

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

- **CORBAServices**
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OMG Domain Specifications

CORBA Embedded Intelligence Specifications

CORBA Security Specifications

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1 Scope

1.1 General

This submission adds several new “DDS Security Support” compliance points (“profile”) to the DDS Specification. See the compliance levels within the Conformance Clause below.

1.2 Overview of this Specification

This specification defines the Security Model and Service Plugin Interface (SPI) architecture for compliant DDS implementations. The DDS Security Model is enforced by the invocation of these SPIs by the DDS implementation. This specification also defines a set of builtin implementations of these SPIs.

- The specified builtin SPI implementations enable out-of-the box security and interoperability between compliant DDS applications.
- The use of SPIs allows DDS users to customize the behavior and technologies that the DDS implementations use for Information Assurance, specifically customization of Authentication, Access Control, Encryption, Message Authentication, Digital Signing, Logging and Data Tagging.

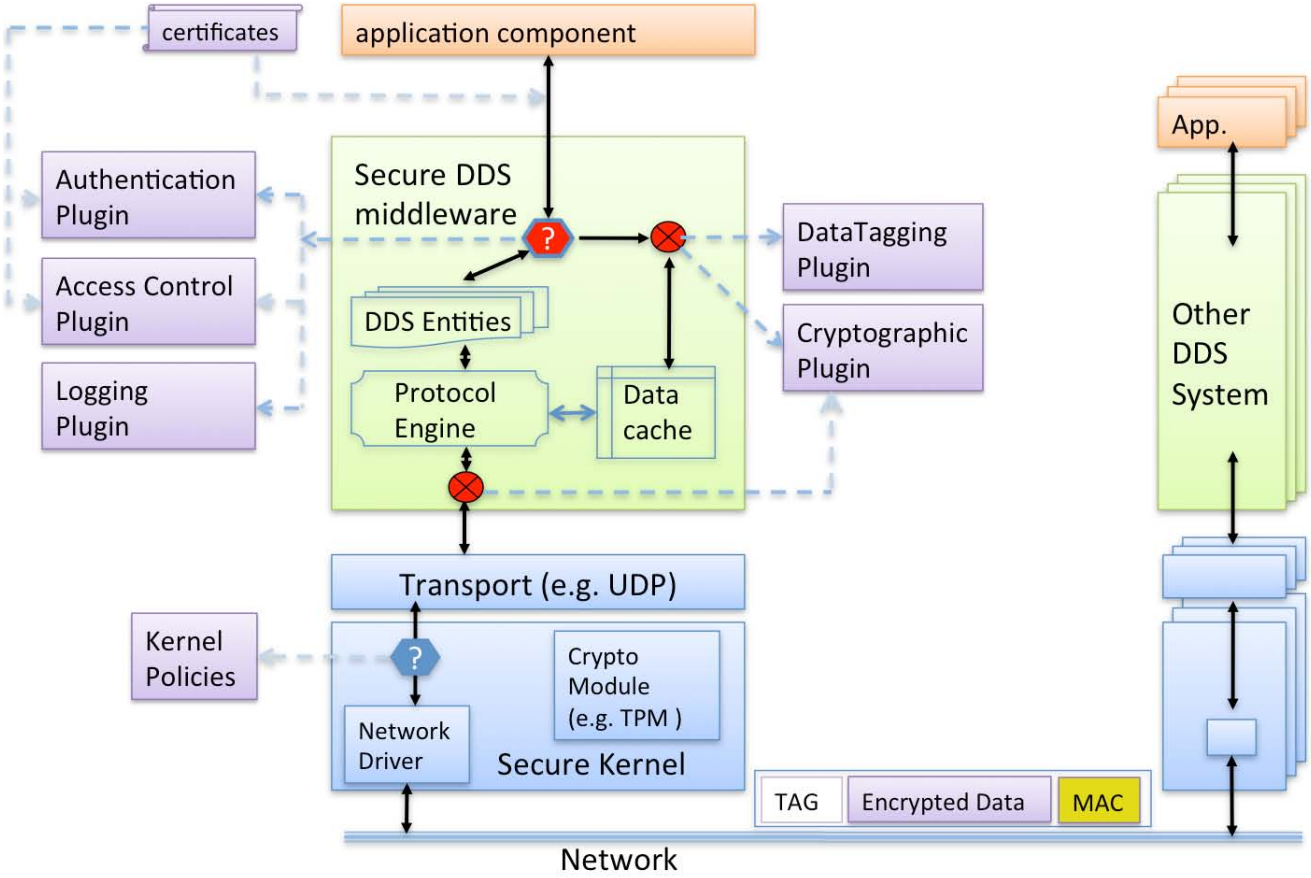


Figure 1 – Overall architecture for DDS Security

This specification defines five SPIs that when combined together provide Information Assurance to DDS systems:

- **Authentication** Service Plugin. Provides the means to verify the identity of the application and/or user that invokes operations on DDS. Includes facilities to perform mutual authentication between participants and establish a shared secret.
- **AccessControl** Service Plugin. Provides the means to enforce policy decisions on what DDS related operations an authenticated user can perform. For example, which domains it can join, which Topics it can publish or subscribe to, etc.
- **Cryptographic** Service Plugin. Implements (or interfaces with libraries that implement) all cryptographic operations including encryption, decryption, hashing, digital signatures, etc. This includes the means to derive keys from a shared secret.
- **Logging** Service Plugin. Supports auditing of all DDS security-relevant events
- **Data Tagging** Service Plugin. Provides a way to add tags to data samples**.**

2 Conformance

2.1 Changes to Adopted OMG Specifications

This specification does not modify any existing adopted OMG specifications. It reuses and/or adds functionality on top of the current set of OMG specifications.

- **DDS**: This specification does not modify or invalidate any existing DDS profiles or compliance levels. It extends some of the DDS builtin Topics to carry additional information in a compatible way with existing implementations of DDS.
- **DDS-RTPS**: This specification does not require any modifications to RTPS; however, it may impact interoperability with existing DDS-RTPS implementations. In particular, DDS-RTPS implementations that do *not* implement the DDS Security specification will have limited interoperability with implementations that *do* implement the mechanisms introduced by this specification. Interoperability is limited to systems configured to allow “unauthorized” DomainParticipant entities and within those systems, only to Topics configured to be “unprotected.”
- **DDS-XTYPES**: This specification depends on the IDL syntax introduced by and the Extended CDR encoding defined in the DDS-XTYPES specification. It does not require any modifications of DDS-XTYPES.
- **OMG IDL**: This specification does not modify any existing IDL-related compliance levels.

2.2 Conformance points

This specification defines the following conformance points:

(1) Builtin plugin interoperability (mandatory)
(2) Plugin framework (mandatory)
(3) Plugin language APIs (optional)
(4) Logging and Tagging (optional)

Conformance with the “DDS Security” specification requires conformance with all the mandatory conformance points.

2.2.1 Builtin plugin interoperability (mandatory)

This point provides interoperability with all the builtin plugins with the exception of the Logging plugin. Conformance to this point requires conformance to:

- Clause 7 (the security model and the support for interoperability between DDS Security implementations).
- The configuration of the plugins and the observable wire-protocol behavior specified in Clause 9, (the builtin-plugins) except for sub clause 9.6. This conformance point does not require implementation of the APIs between the DDS implementation and the plugins.

2.2.2 Plugin framework (mandatory):

This point provides the architectural framework and abstract APIs needed to develop new security plugins and "plug them" into a DDS middeware implementation. Plugins developed using this framework are portable between conforming DDS implementations. However portability for a specific programming language also requires conformance to the specific language API (see 2.2.3).

Conformance to this point requires conformance to:

- Clause 7 (the security model and the support for interoperability between DDS Security implementations).
- Clause 8 (the plugin model) with the exception of 8.6 and 8.7 (Logging and Data Tagging plugins). The conformance to the plugin model is at the UML level; it does not mandate a particular language mapping.
- Clause 9, the builtin-plugins, except for 9.6 (Builtin Logging Plugin).

In addition it requires the conforming DDS implementation to provide a public API to insert the plugins that conform to the aforementioned sections.

2.2.3 Plugin Language APIs (optional):

These conformance points provide portability across compliant DDS implementations of the security plugins developed using a specific programming language.

Conformance to any of the language portability points requires conformance to the (mandatory) plugin architecture framework point.

These are 5 "plugin language API" points, each corresponding to a different programming language used to implement the plugins.

Each language point is a separate independent conformance point. Conformance with the "plugin language API" point requires conformance with at least one of the 5 language APIs enumerated below:

- C Plugin APIs. Conformance to sub clauses 10.2 and 10.3
- C++ classic Plugin APIs. Conformance to sub clauses 10.2 and 10.4
- Java classic Plugin APIs. Conformance to sub clauses 10.2 and 10.5
- C++11 Plugin APIs. Conformance to sub clauses 10.2 and 10.6
- Java5+ Plugin APIs. Conformance to sub clauses 10.2 and 10.7.

2.2.4 Logging and Tagging profile (optional):

This point adds support for logging and tagging. Conformance to this point requires conformance to sub clauses 8.6, 8.7, and 9.6.

3 Normative References

- DDS: Data-Distribution Service for Real-Time Systems version 1,2. http://www.omg.org/spec/DDS/1.2
- DDS-RTPS: Data-Distribution Service Interoperability Wire Protocol version 2.1, http://www.omg.org/spec/DDS-RTPS/2.1/
- DDS-XTYPES: Extensible and Dynamic Topic-Types for DDS version 1.0 http://www.omg.org/spec/DDS-XTypes/1.0/
- OMG-IDL: Interface Definition Language (IDL) version 3.5 http://www.omg.org/spec/IDL35/
- HMAC: Keyed-Hashing for Message Authentication. H. Krawczyk, M. Bellare, and R.Canetti, IETF RFC 2104, http://tools.ietf.org/html/rfc2104
- PKCS #7: Cryptographic Message Syntax Version 1.5. IETF RFC 2315. http://tools.ietf.org/html/rfc2315

4 Terms and Definitions

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

Access Control

Mechanism that enables an authority to control access to areas and resources in a given physical facility or computer-based information system.

Authentication

Security measure(s) designed to establish the identity of a transmission, message, or originator.

Authorization

Access privileges that are granted to an entity; conveying an “official” sanction to perform a security function or activity.

Ciphertext

Data in its encrypted or signed form.

Certification authority

The entity in a Public Key Infrastructure (PKI) that is responsible for issuing certificates, and exacting compliance to a PKI policy.

Confidentiality

Assurance that information is not disclosed to unauthorized individuals, processes, or devices.

Cryptographic algorithm

A well-defined computational procedure that takes variable inputs, including a cryptographic key and produces an output.

Cryptographic key

A parameter used in conjunction with a cryptographic algorithm that operates in such a way that another agent with knowledge of the key can reproduce or reverse the operation, while an agent without knowledge of the key cannot.

Examples include:

1. The transformation of plaintext data into ciphertext
2. The transformation of ciphertext data into plaintext
3. The computation of a digital signature from data
4. The verification of a digital signature
5. The computation of a message authentication code from data
6. The verification of a message authentication code from data and a received authentication code

Data-Centric Publish-Subscribe (DCPS)

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

Data Distribution Service (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 the implementation language.

Digital signature

The result of a cryptographic transformation of data that, when properly implemented with supporting infrastructure and policy, provides the services of:

1. origin authentication
2. data integrity
3. signer non-repudiation

Extended IDL

Extended Interface Definition Language (IDL) used to describe data types in a way that can be represented in a machine neutral format for network communications. This syntax was introduced as part of the DDS-XTYPES specification [3].

Hashing algorithm

A one-way algorithm that maps an input byte buffer of arbitrary length to an output fixed-length byte array in such a way that:

(a) Given the output it is computationally infeasible to determine the input.
(b) It is computationally infeasible to find any two distinct inputs that map to the same output.

Information Assurance

The practice of managing risks related to the use, processing, storage, and transmission of information or data and the systems and processes used for those purposes.

Integrity

Protection against unauthorized modification or destruction of information.

Key management

The handling of cryptographic material (e.g., keys, Initialization Vectors) during their entire life cycle of the keys from creation to destruction.

Message authentication code (MAC)

A cryptographic hashing algorithm on data that uses a symmetric key to detect both accidental and intentional modifications of data.

Non-Repudiation

Assurance that the sender of data is provided with proof of delivery and the recipient is provided with proof of the sender's identity, so neither can later deny having received or processed the data.

Public key

A cryptographic key used with a public key cryptographic algorithm that is uniquely associated with an entity and that may be made public. The public key is associated with a private key. The public key may be known by anyone and, depending on the algorithm, may be used to:

1. Verify a digital signature that is signed by the corresponding private key,
2. Encrypt data that can be decrypted by the corresponding private key, or
3. Compute a piece of shared data.

Public key certificate

A set of data that uniquely identifies an entity, contains the entity's public key and possibly other information, and is digitally signed by a trusted party, thereby binding the public key to the entity.

Public key cryptographic algorithm

A cryptographic algorithm that uses two related keys, a public key and a private key. The two keys have the property that determining the private key from the public key is computationally infeasible.

Public Key Infrastructure

A framework that is established to issue, maintain and revoke public key certificates.

5 Symbols

This specification does not define any symbols or abbreviations.

6 Additional Information

6.1 Acknowledgments

The following individuals and companies submitted content that was incorporated into this specification:

Submitting contributors:

- (lead) Gerardo Pardo-Castellote, Ph.D., Real-Time Innovations. gerardo.pardo AT rti.com
- Jaime Martin-Losa, eProsima JaimeMartin AT eprosima.com
- Angelo Corsaro, Ph.D., PrismTech. angelo.corsaro AT prismtech.com

Supporting contributors:

- Char Wales, MITRE charwing AT mitre.org
- Clark Tucker, Twin Oaks Computing, Inc. ctucker AT twinoakscomputing.com

7 Support for DDS Security

7.1 Security Model

The Security Model for DDS defines the security principals (users of the system), the objects that are being secured, and the operations on the objects that are to be restricted. DDS applications share information on DDS Global Data Spaces (called DDS Domains) where the information is organized into Topics and accessed by means of read and write operations on data-instances of those Topics.

Ultimately what is being secured is a specific DDS Global Data Space (domain) and, within the domain, the ability to access (read or write) information (specific Topic or even data-object instances within the Topic) in the DDS Global Data Space.

Securing DDS means providing:

- Confidentiality of the data samples
- Integrity of the data samples and the messages that contain them
- Authentication of DDS writers and readers
- Authorization of DDS writers and readers
- Non-repudiation of data

To provide secure access to the DDS Global Data Space, applications that use DDS must first be authenticated, so that the identity of the application (and potentially the user that interacts with it) can be established. Once authentication has been obtained, the next step is to enforce access control decisions that determine whether the application is allowed to perform specific actions. Examples of actions are: joining a DDS Domain, defining a new Topic, reading or writing a specific DDS Topic, and even reading or writing specific Topic instances (as identified by the values of key fields in the data). Enforcement of access control shall be supported by cryptographic techniques so that information confidentiality and integrity can be maintained, which in turn requires an infrastructure to manage and distribute the necessary cryptographic keys.

7.1.1 Threats

In order to understand the decisions made in the design of the plugins, it is important to understand some of the specific threats impacting applications that use DDS and DDS Interoperability Wire Protocol (RTPS).

Most relevant are four categories of threats:

1. Unauthorized subscription
2. Unauthorized publication
3. Tampering and replay
4. Unauthorized access to data

These threats are described in the context of a hypothetical communication scenario with six actors all attached to the same network:

- **Alice**. A DDS DomainParticipant who is authorized to publish data on a Topic T.
- **Bob**. A DDS DomainParticipant who is authorized to subscribe to data on a Topic T.
- **Eve**. An eavesdropper. Someone who is **not authorized** to subscribe to data on Topic T. However Eve uses the fact that she is connected to the same network to try to see the data.
- **Trudy**. An intruder. A DomainParticipant who is **not authorized** to publish on Topic T. However, Trudy uses the fact that she is connected to the same network to try to send data.
- **Mallory**. A malicious DDS DomainParticipant. Mallory is authorized to subscribe to data on Topic T but she is **not authorized** to publish on Topic T. However, Mallory will try to use information gained by subscribing to the data to publish in the network and try to convince Bob that she is a legitimate publisher.
- **Trent**. A trusted service who needs to receive and send information on Topic T. For example, Trent can be a persistence service or a relay service. He is trusted to relay information without having malicious intent. However he is not trusted to see the content of the information.

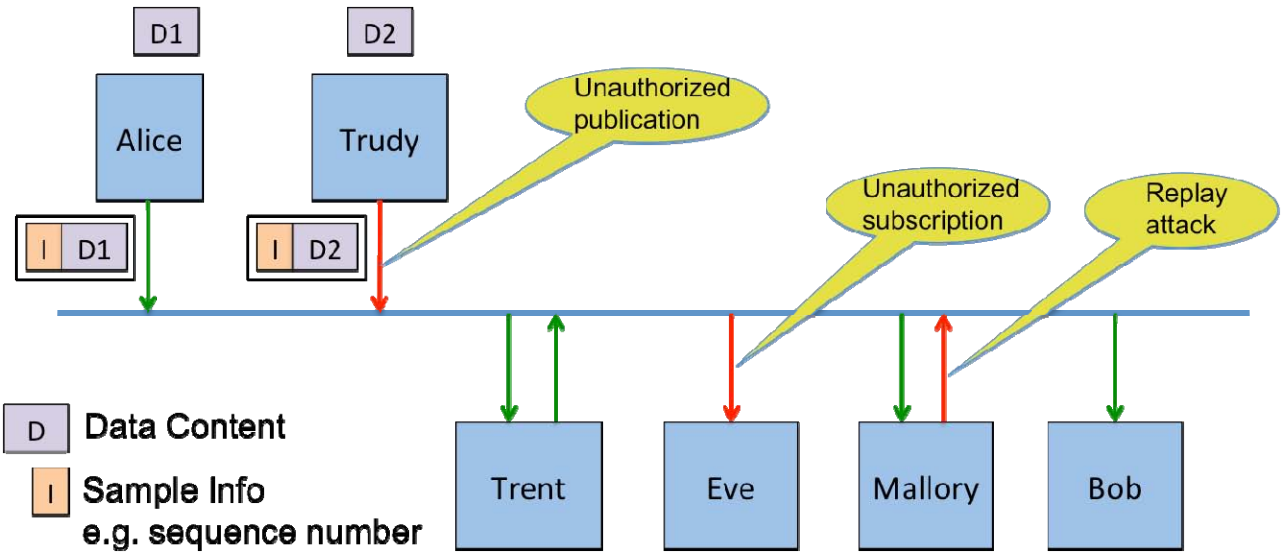


Figure 2 – Threat actors

7.1.1.1 Unauthorized Subscription

The DomainParticipant Eve is connected to the same network infrastructure as the rest of the agents and is able to observe the network packets despite the fact that the messages are not intended to be sent to Eve. Many scenarios can lead to this situation. Eve could tap into a network switch or observe the communication channels. Alternatively, in situations where Alice and Bob are communicating over multicast, Eve could simply subscribe to the same multicast address.

Protecting against Eve is reasonably simple. All that is required is for Alice to encrypt the data she writes using a secret key that is only shared with authorized receivers such as Bob, Trent, and Mallory.

7.1.1.2 Unauthorized Publication

The DomainParticipant Trudy is connected to the same network infrastructure as the rest of the agents and is able to inject network packets with any data contents, headers and destination she wishes (e.g., Bob). The network infrastructure will route those packets to the indicated destination.

To protect against Trudy, Bob, Trent and Mallory need to realize that the data is not originating from Alice. They need to realize that the data is coming from someone not authorized to send data on Topic T and therefore reject (i.e., not process) the packet.

Protecting against Trudy is also reasonably simple. All that is required is for the protocol to require that the messages include either a hash-based message authentication code (HMAC) or digital signature.

- An HMAC creates a message authentication code using a secret key that is shared with the intended recipients. Alice would only share the secret key with Bob, Mallory and Trent so that they can recognize messages that originate from Alice. Since Trudy is not authorized to publish Topic T, Bob and the others will not recognize any HMACs Trudy produces (i.e., they will not recognize Trudy's key).
- A digital signature is based on public key cryptography. To create a sigital signature, Alice encrypts a digest of the message using Alice's private key. Everybody (including Bob, Mallory and Trent) has access to Alice's public key. Similar to the HMAC above, the recipients can identify messages from Alice, as they are the only ones whose digital signature can be interpreted with Alice's public key. Any digital signatures Trudy may use will be rejected by the recipients, as Trudy is not authorized to write Topic T.

The use of HMACs versus digital signatures presents tradeoffs that will be discussed further in subsequent sections. Suffice it to say that in many situations the use of HMACs is preferred because the performance to compute and verify them is about 1000 times faster than the performance of computing/verifying digital signatures.

7.1.1.3 Tampering and Replay

Mallory is authorized to subscribe to Topic T. Therefore Alice has shared with Mallory the secret key to encrypt the topic and also, if an HMAC is used, the secret key used for the HMAC.

Assume Alice used HMACs instead of digital signatures. Then Mallory can use her knowledge of the secret keys used for data encryption and the HMACs to create a message on the network and pretend it came from Alice. Mallory can fake all the TCP/UDP/IP headers and any necessary RTPS identifiers (e.g., Alice's RTPS DomainParticipant and DataWriter GUIDs). Mallory has the secret key that was used to encrypt the data so she can create encrypted data payloads with any contents she wants. She has the secret key used to compute HMACs so she can also create a valid HMAC for the new message. Bob and the others will have no way to see that message came from Mallory and will accept it, thinking it came from Alice.

So if Alice used an HMAC, the only solution to the problem is that the secret key used for the HMAC when sending the message to Mallory cannot be the same as the key used for the HMAC when sending messages to Bob. In other words, Alice must share a **different** secret key for the HMAC with each recipient. Then Mallory will not have the HMAC key that Bob expects from Alice and the messages from Mallory to Bob will not be misinterpreted as coming from Alice.

Recall that Alice needs to be able to use multicast to communicate efficiently with multiple receivers. Therefore, if Alice wants to send an HMAC with a different key for every receiver, the only solution is

to append multiple HMACs to the multicast message with some key-id that allows the recipient to select the correct HMAC to verify.

If Alice uses digital signatures to protect the integrity of the message, then this ‘masquerading’ problem does not arise and Alice can send the same digital signature to all recipients. This makes using multicast simpler. However, the performance penalty of using digital signatures is so high that in many situations it will be better to compute and send multiple HMACs as described earlier.

7.1.1.4 Unauthorized Access to Data by Infrastructure Services

Infrastructure services, such as the DDS Persistence Service or relay services need to be able to receive messages, verify their integrity, store them, and send them to other participants on behalf of the original application.

These services can be trusted not to be malicious; however, often it is not desirable to grant them the privileges they would need to understand the contents of the data. They are allowed to store and forward the data, but not to see inside the data.

Trent is an example of such a service. To support deployment of these types of services, the security model needs to support the concept of having a participant, such as Trent, who is allowed to receive, process, and relay RTPS messages, but is not allowed to see the contents of the data within the message. In other words, he can see the headers and sample information (writer GUID, sequence numbers, keyhash and such) but not the message contents.

To support services like Trent, Alice needs to accept Trent as a valid destination for her messages on topic T and share with Trent only the secret key used to compute the HMAC for Trent, but not the secret key used to encrypt the data itself. In addition, Bob, Mallory and others need to accept Trent as someone who is able to write on Topic T and relay messages from Alice. This means two things: (1) accept and interpret messages encrypted with Alice’s secret key and (2) allow Trent to include in his sample information, the information he got from Alice (writer GUID, sequence number and anything else needed to properly process the relayed message).

Assume Alice used an HMAC in the message sent to Trent. Trent will have received from Alice the secret key needed to verify the HMAC properly. Trent will be able to store the messages, but lacking the secret key used for its encryption, will be unable to see the data. When he relays the message to Bob, he will include the information that indicates the message originated from Alice and produce an HMAC with its own secret HMAC key that was shared with Bob. Bob will receive the message, verify the HMAC and see it is a relayed message from Alice. Bob recognizes Trent is authorized to relay messages, so Bob will accept the sample information that relates to Alice and process the message as if it had originated with Alice. In particular, he will use Alice’s secret key to decrypt the data.

If Alice had used digital signatures, Trent would have two choices. If the digital signature only covered the data and the sample information he needs to relay from Alice, Trent could simply relay the digital signature as well. Otherwise, Trent could strip out the digital signature and put in his own HMAC. Similar to before, Bob recognizes that Trent is allowed to relay messages from Alice and will be able to properly verify and process the message.

7.2 Types used by DDS Security

The DDS security specification includes extensions to the DDS Interoperability Wire Protocol (DDS-RTPS), as well as, new API-level functions in the form of Security Plugins. The types described in sub clause 7.2 are used in these extensions.

7.2.1 Property

`Property` is a data type that holds a pair of strings. One string is considered the property "name" and the other is the property "value" associated with that name. `Property` sequences are used as a generic data type to configure the security plugins, pass metadata and provide an extensible mechanism for vendors to configure the behavior of their plugins without breaking portability or interoperability.

`Property` objects with names that start with the prefix "`dds.sec.`" are reserved by this specification, including future versions of this specification. Plugin implementers can also use this mechanism to pass metadata and configure the behavior of their plugins. In order to avoid collisions with the value of the "name" attribute, implementers shall use property names that start with a prefix to an ICANN domain name they own, in reverse order. For example,the prefix would be "com.acme." for plugins developed by a hypothetical vendor that owns the domain "acme.com".

The names and interpretation of the expected properties shall be specified by each plugin implementation.

Table 1 – Property class

Property	
Attributes	
`name`	`String`
`value`	`String`

7.2.1.1 IDL Representation for Property

The `Property` type may be used for information exchange over the network. When a `Property` is sent over the network it shall be serialized using Extended CDR format according to the Extended IDL representation [3] below.

```
@Extensibility (EXTENSIBLE_EXTENSIBILITY)
struct Property {
   string key;
   string value;
};
typedef sequence< Property > Properties;
```

7.2.2 BinaryProperty

`BinaryProperty` is a data type that holds a string and an octet sequence. The string is considered the property "name" and the octet sequence the property "value" associated with that name. Sequences of `BinaryProperty` are used as a generic data type to configure the plugins, pass metadata and provide an extensible mechanism for vendors to configure the behavior of their plugins without breaking portability or interoperability.

`BinaryProperty` objects with a "name" attribute that start with the prefix "`dds.sec.`" are reserved by this specification, including future versions of this specification.

Plugin implementers may use this mechanism to pass metadata and configure the behavior of their plugins. In order to avoid collisions with the value of the "name" attribute implementers, shall use

property names that start with a prefix to an ICANN domain name they own, in reverse order. For example, the prefix would be “com.acme.” for plugins developed by a hypothetical vendor that owns the domain “acme.com”.

The valid values of the “name” attribute and the interpretation of the associated “value” shall be specified by each plugin implementation.

Table 2 – BinaryProperty class

BinaryProperty	
Attributes	
`name`	`String`
`value`	`OctetSeq`

7.2.2.1 IDL Representation for BinaryProperty

The `BinaryProperty` type may be used for information exchange over the network. When a `BinaryProperty` is sent over the network, it shall be serialized using Extended CDR format according to the Extended IDL representation [3] below.

```
@Extensibility (EXTENSIBLE_EXTENSIBILITY)
struct BinaryProperty {
   string key;
   OctetSeq value;
};
typedef sequence< BinaryProperty > BinaryProperties;
```

7.2.3 DataHolder

`DataHolder` is a data type used to hold generic data. It contains various attributes used to store data of different types and formats. `DataHolder` appears as a building block for other types, such as `Token` and `GenericMessageData`.

Table 3 – DataHolder class

DataHolder	
Attributes	
`class_id`	`String`
`string_properties`	`PropertySeq`
`binary_properties`	`BinaryPropertySeq`
`string_values`	`StringSeq`
`binary_value1`	`OctetSeq`
`binary_value2`	`OctetSeq`
`longlongs_value`	`LongLongSeq`

7.2.3.1 IDL representation for DataHolder

The `DataHolder` type may be used for information exchange over the network. When a `DataHolder` is sent over the network, it shall be serialized using Extended CDR format according to the Extended IDL representation [3] below.

```
typedef sequence<string>     StringSeq;
typedef sequence<octet>      OctetSeq;
typedef sequence<long long>  LongLongSeq;

@Extensibility (EXTENSIBLE_EXTENSIBILITY)
struct DataHolder {
    string            class_id;
    @Optional Properties        string_properties;
    @Optional BinaryProperties  binary_properties;
    @Optional StringSeq         string_values;
    @Optional OctetSeq          binary_value1;
    @Optional OctetSeq          binary_value2;
    @Optional LongLongSeq       longlongs_value;
};

typedef sequence<DataHolder> DataHolderSeq;
```

7.2.4 Credential

`Credential` objects provide a generic mechanism to pass information from DDS to the security plugins. This information is used to identify the application that is running and its permissions. The `Credential` class provides a generic container for security credentials and certificates. The actual interpretation of the credentials and how they are configured is specific to each implementation of the security plugins and shall be specified by each security plugin.

The typical use of credentials would be signed certificates or signed permissions documents. `Credential` objects are only exchanged locally between the DDS implementation and plugins running in the same process space. They are never sent between processes or over a network.

The `Credential` class is structurally identical to the `DataHolder` class and therefore has the same structure for all plugin implementations. However the contents and interpretation of the `Credential` attributes shall be specified by each plugin implementation.

There are several specializations of the `Credential` class. They all share the same format but are used for different purposes. This is modeled by defining specialized classes.

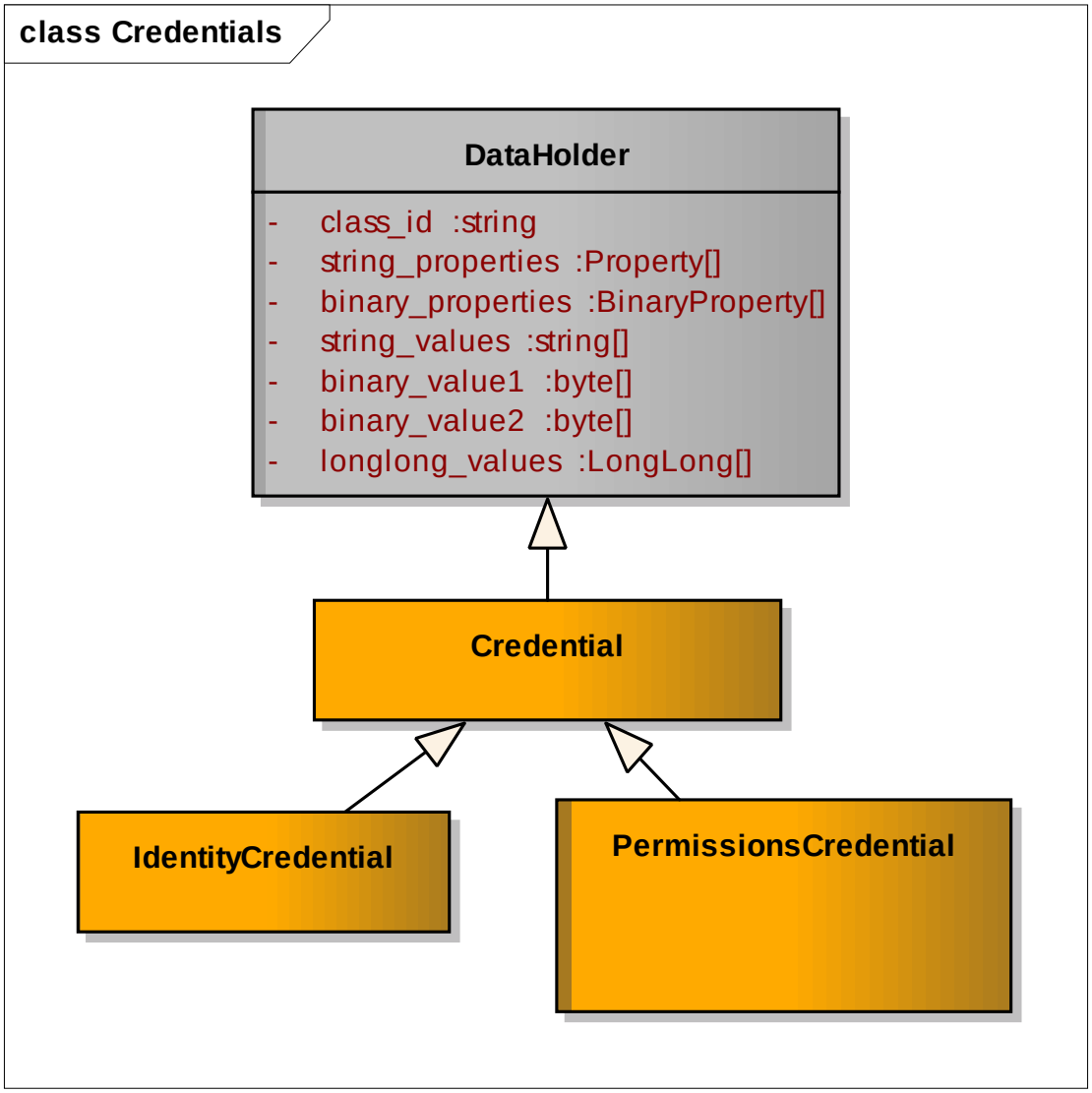


Figure 3 – Credential Model

7.2.4.1 Attribute: `class_id`

When used as a `Credential` class, the ***class_id*** attribute in the `DataHolder` identifies the kind of `Credential`.

Values of the ***class_id*** with the prefix "`dds.sec.`" are reserved for this specification, including future versions of the specification. Implementers of this specification can use this attribute to identify non-standard credentials. In order to avoid collisions, the ***class_id*** they use shall start with a prefix to an ICANN domain name they own, using the same rules specified in 7.2.1 for property names.

7.2.4.2 IDL Representation for Credential and Specialized Classes

The `Credential` class is used to hold information passed as parameters to the plugin operations. Its structure can be defined in IDL such that the mapping to different programming languages is unambiguously defined.

```
typedef DataHolder Credential;
```

```
typedef Credential IdentityCredential;
typedef Credential PermissionsCredential;
```

7.2.5 Token

The `Token` class provides a generic mechanism to pass information between security plugins using DDS as the transport. `Token` objects are meant for transmission over the network using DDS either embedded within the builtin topics sent via DDS discovery or via special DDS Topic entities defined in this specification.

The `Token` class is structurally identical to the `DataHolder` class and therefore has the same structure for all plugin implementations. However, the contents and interpretation of the `Token` objects shall be specified by each plugin implementation.

There are multiple specializations of the `Token` class. They all share the same format, but are used for different purposes. This is modeled by defining specialized classes.

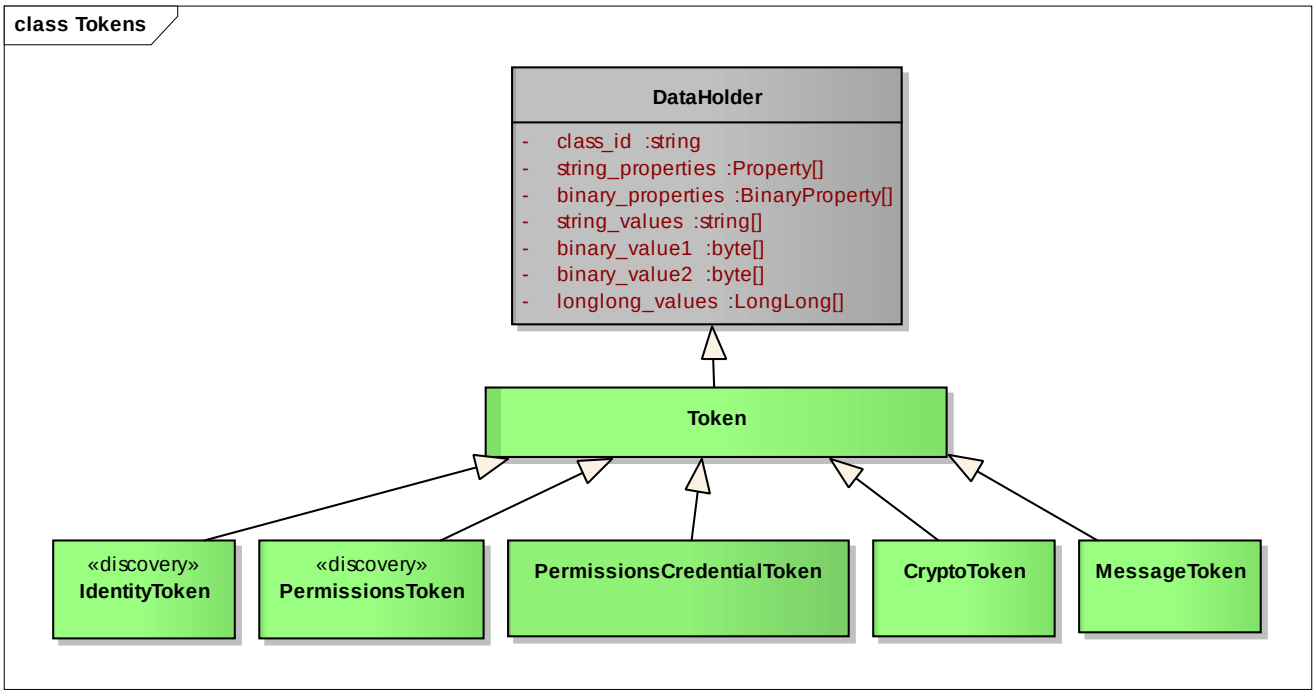


Figure 4 – Token Model

7.2.5.1 Attribute: `class_id`

When used as a `Token` class, the ***class_id*** attribute in the `DataHolder` identifies the kind of `Token`.

Strings with the prefix "`dds.sec.`" are reserved for this specification, including future versions of the specification. Implementers of this specification can use this attribute to identify non-standard tokens. In order to avoid collisions, the ***class_id*** they use shall start with a prefix to an ICANN domain name they own, using the same rules specified in 7.2.1 for property names.

7.2.5.2 IDL Representation for Token and Specialized Classes

The `Token` class is used to hold information exchanged over the network. When a `Token` is sent over the network, it shall be serialized using Extended CDR format according to the Extended IDL representation below:

```
typedef DataHolder Token;

typedef Token HandshakeMessageToken;
typedef Token IdentityToken;
typedef Token PermissionsToken;
typedef Token IdentityCredentialToken;
typedef Token PermissionsCredentialToken;

typedef Token CryptoToken;
typedef Token ParticipantCryptoToken;
typedef Token DatawriterCryptoToken;
typedef Token DatareaderCryptoToken;

typedef sequence<HandshakeMessageToken> HandshakeMessageTokenSeq;
typedef sequence<CryptoToken> CryptoTokenSeq;
typedef CryptoTokenSeq ParticipantCryptoTokenSeq;
typedef CryptoTokenSeq DatawriterCryptoTokenSeq;
typedef CryptoTokenSeq DatareaderCryptoTokenSeq;
```

7.2.6 ParticipantGenericMessage

This specification introduces additional builtin `DataWriter` and `DataReader` entities used to send generic messages between the participants. To support these entities, this specification uses a general-purpose data type called `ParticipantGenericMessage`, which is defined by the following extended IDL:

```
typedef octet[16] BuiltinTopicKey_t;

@Extensibility (EXTENSIBLE_EXTENSIBILITY)
struct MessageIdentity {
   BuiltinTopicKey_t source_guid;
   long long sequence_number;
};


typedef string<> GenericMessageClassId;

@Extensibility (EXTENSIBLE_EXTENSIBILITY)
struct ParticipantGenericMessage {
   /* target for the request. Can be GUID_UNKNOWN */
   MessageIdentity message_identity;
   MessageIdentity related_message_identity;
   BuiltinTopicKey_t destination_participant_key;
   BuiltinTopicKey_t destination_endpoint_key;
   BuiltinTopicKey_t source_endpoint_key;
   GenericMessageClassId   message_class_id;
   DataHolderSeq           message_data;
};
```

7.2.7 Additional DDS Return Code: NOT_ALLOWED_BY_SEC

The DDS specification defines a set of return codes that may be returned by the operations on the DDS API (see sub clause 7.1.1 of the DDS specification).

The DDS Security specification add an additional return code NOT_ALLOWED_BY_SEC, which shall be returned by any operation on the DDS API that fails because the security plugins do not allow it.

7.3 Securing DDS Messages on the Wire

OMG DDS uses the Real-Time Publish-Subscribe (RTPS) on-the-wire protocol [2] for communicating data. The RTPS protocol includes specifications on how discovery is performed, the metadata sent during discovery, and all the protocol messages and handshakes required to ensure reliability. RTPS also specifies how messages are put together.

7.3.1 RTPS Background (Non-Normative)

In a secure system where efficiency and message latency are also considerations, it is necessary to define exactly what needs to be secured. Some applications may require only the data payload to be confidential and it is acceptable for the discovery information, as well as, the reliability meta-traffic (HEARTBEATs, ACKs, NACKs, etc.) to be visible, as long as it is protected from modification. Other applications may also want to keep the metadata (sequence numbers, in-line QoS) and/or the reliability traffic (ACKs, NACKs, HEARTBEATs) confidential. In some cases, the discovery information (who is publishing what and its QoS) may need to be kept confidential as well.

To help clarify these requirements, sub clause 7.3.1 explains the structure of the RTPS `Message` and the different `Submessages` it may contain.

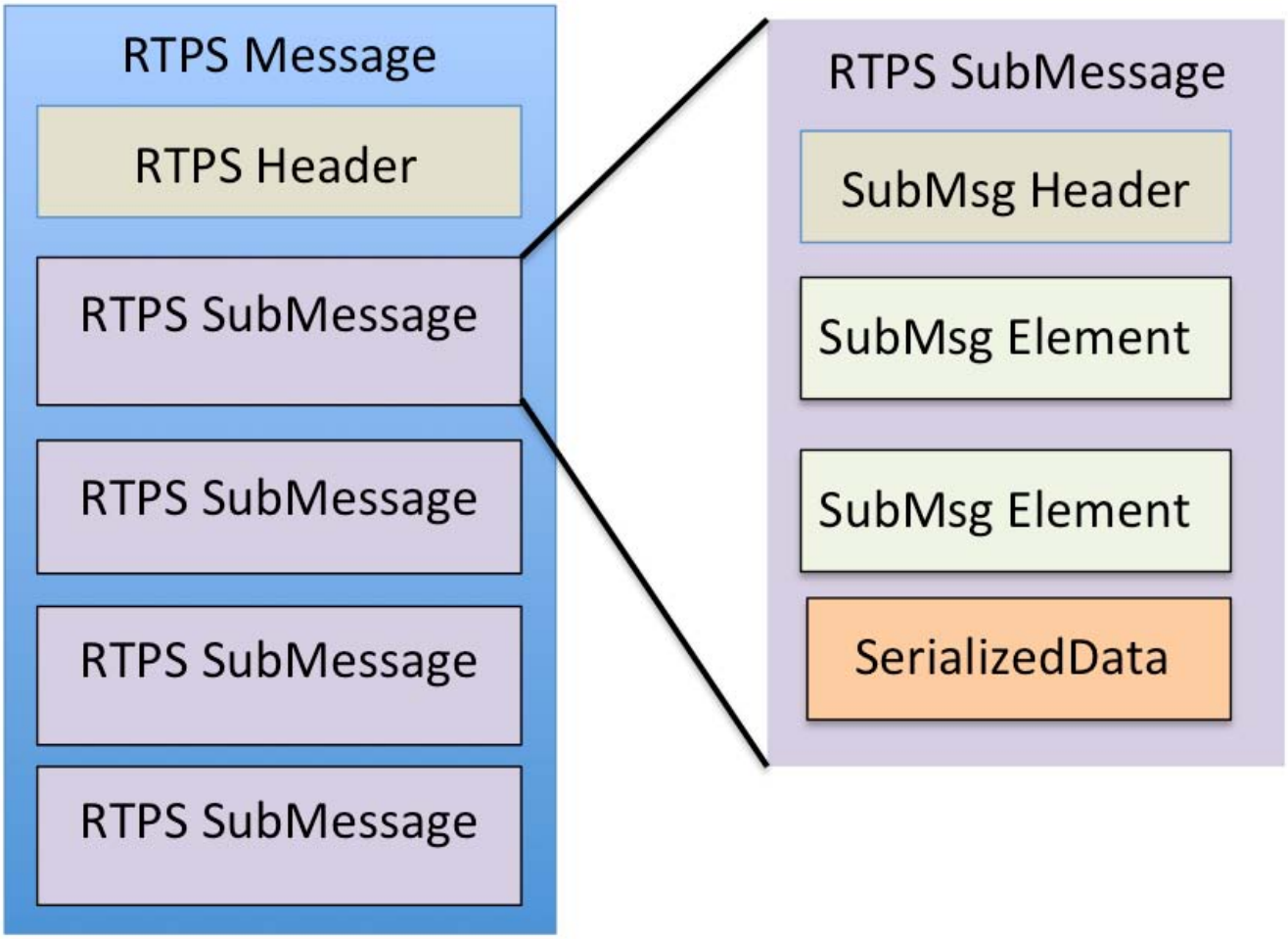


Figure 5 – RTPS message structure

An RTPS Message is composed of a leading RTPS `Header` followed by a variable number of RTPS `Submessages`. Each RTPS `Submessage` is composed of a `SubmessageHeader` followed by a variable number of `SubmessagElements`. There are various kinds of `SubmessageElements` to communicate things like sequence numbers, unique identifiers for DataReader and DataWriter entities, SerializedKeys or KeyHash of the application data, source timestamps, QoS, etc. There is one kind of `SubmessageElement` called `SerializedData` that is used to carry the data sent by DDS applications.

For the purposes of securing communications we distinguish three types of RTPS `Submessages`:

1. **DataWriter Submessages**. These are the RTPS submessages sent by a DataWriter to one or more DataReader entities. These include the `Data`, `DataFrag`, `Gap`, `Heartbeat`, and `HeartbeatFrag` submessages.
2. **DataReader Submessages.** These are the RTPS submessages sent by a DataReader to one or more DataWriter entities. These include the `AckNack` and `NackFrag` submessages
3. **Interpreter Submessages.** These are the RTPS submessages that are destined to the Message Interpreter and affect the interpretation of subsequent submessages. These include all the "`Info`" messages.

The only RTPS submessages that contain application data are the `Data` and `DataFrag`. The application data is contained within the `SerializedData` submessage element. In addition to the

SerializedData, these submessages contain sequence numbers, inline QoS, the Key Hash, identifiers of the originating DataWriter and destination DataReader, etc.

The KeyHash submessage element may only appear in the Data and DataFrag submessages. Depending on the data type associated with the DataWriter that wrote the data, the KeyHash submessage contains either:

- A serialized representation of the values of all the attributes declared as ‘key’ attributes in the associated data type, or
- An MD5 hash computed over the aforementioned serialized key attributes.

Different RTPS Submessage within the same RTPS Message may originate on different DataWriter or DataReader entities within the DomainParticipant that sent the RTPS message.

It is also possible for a single RTPS Message to combine submessages that originated on different DDS DomainParticipant entities. This is done by preceding the set of RTPS Submessages that originate from a common DomainParticipant with an InfoSource RTPS submessage.

7.3.2 Secure RTPS Messages

Sub clause 7.1.1 identified the threats addressed by the DDS Security specification. To protect against the “Unauthorized Subscription” threat it is necessary to use encryption to protect the sensitive parts of the RTPS message.

Depending on the application requirements, it may be that the only thing that should be kept confidential is the content of the application data; that is, the information contained in the SerializedData RTPS submessage element. However, other applications may also consider the information in other RTPS SubmessageElements (e.g., sequence numbers, KeyHash, and unique writer/reader identifiers) to be confidential. So the entire Data (or DataFrag) submessage may need to be encrypted. Similarly, certain applications may consider other submessages such as Gap, AckNack, Heartbeat, HeartbeatFrag, etc. also to be confidential.

For example, a Gap RTPS Submessage instructs a DataReader that a range of sequence numbers is no longer relevant. If an attacker can modify or forge a Gap message from a DataWriter, it can trick the DataReader into ignoring the data that the DataWriter is sending.

To protect against “Unauthorized Publication” and “Tampering and Replay” threats, messages must be signed using secure hashes or digital signatures. Depending on the application, it may be sufficient to sign only the application data (SerializedData submessage element), the whole Submessage, and/or the whole RTPS Message.

To support different deployment scenarios, this specification uses a “message transformation” mechanism that gives the Security Plugin Implementations fine-grain control over which parts of the RTPS Message need to be encrypted and/or signed.

The Message Transformation performed by the Security Plugins transforms an RTPS Message into another RTPS Message. A new RTPS Header may be added and the content of the original RTPS Message may be encrypted, protected by a Secure Message Authentication Code (MAC), and/or signed. The MAC and/or signature can also include the RTPS Header to protect its integrity.

7.3.3 Constraints of the DomainParticipant BuiltinTopicKey_t (GUID)

The DDS and the DDS Interoperability Wire Protocol specifications state that DDS `DomainParticipant` entities are identified by a unique 16-byte GUID.

This `DomainParticipant` GUID is communicated as part of DDS Discovery in the `ParticipantBuiltinTopicData` in the attribute ***participant_key*** of type `BuiltinTopicKey_t` defined as:

```
typedef octet BuiltinTopicKey_t[16];
```

Allowing a `DomainParticipant` to select its GUID arbitrarily would allow hostile applications to perform a "squatter" attack, whereby a `DomainParticipant` with a valid certificate could announce itself into the DDS Domain with the GUID of some other `DomainParticipant`. Once authenticated the "squatter" `DomainParticipant` would preclude the real DomainParticipant from being discovered, because its GUID would be detected as a duplicate of the already existing one.

To prevent the aforementioned "squatter" attack, this specification constrains the GUID that can be chosen by a `DomainParticipant,` so that it is tied to the Identity of the `DomainParticipant`. This is enforced by the `Authentication` plugin.

7.3.4 Mandatory use of the KeyHash for encrypted messages

The RTPS `Data` and `DataFrag` submessages can optionally contain the `KeyHash` as an inline Qos (see sub clause 9.6.3.3, titled "KeyHash (PID_KEY_HASH)") of the DDS-RTPS specification version 2.3. In this sub clause it is specified that when present, the key hash shall be computed either as the serialized key or as an MD5 on the serialized key.

The key values are logically part of the data and therefore in situations where the data is considered sensitive the key should also be considered sensitive.

For this reason the DDS Security specification imposes additional constrains in the use of the key hash. These constraints apply only to the `Data` or `DataFrag` RTPS `SubMessages` where the `SerializedData` `SubmessageElement` is encrypted by the operation `encode_serialized_data` of the `CryptoTransform` plugin:

(1) The `KeyHash` shall be included in the Inline Qos.
(2) The `KeyHash` shall be computed as the 128 bit MD5 Digest (IETF RFC 1321) applied to the CDR Big- Endian encapsulation of all the Key fields in sequence. Unlike the rule stated in sub clause 9.6.3.3 of the DDS specification, the MD5 hash shall be used regardless of the maximum-size of the serialized key.

These rules accomplish two objectives:

(1) Avoid leaking the value of the key fields in situations where the data is considered sensitive and therefore appears encrypted within the Data or DataFrag submessages.
(2) Enable the operation of infrastructure services without needed to leak to them the value of the key fields (see 7.1.1.4).

Note that the use of the MD5 hashing function for these purposes does not introduce significant vulnerabilities. While MD5 is considered broken as far as resistance to collisions (being able to find

two inputs that result in an identical unspecified hash) there are still no known practical preimage attacks on MD5 (being able to find the input that resulted on a given hash).

7.3.5 Immutability of Publisher Partition Qos in combination with non-volatile Durability kind

The DDS specification allows the `PartitionQos` policy of a `Publisher` to be changed after the `Publisher` has been enabled. See sub clause 7.1.3 titled “Supported QoS) of the DDS 1.2 specification.

The DDS Security specification restricts this situation.

The DDS implementation shall not allow a `Publisher` to change `PartitionQos` policy after the `Publisher` has been enabled if it contains any `DataWriter` that meets the following two criteria:

(1) The `DataWriter` either encrypts the `SerializedData` submessage element or encrypts the `Data` or `DataFrag` submessage elements.
(2) The `DataWriter` has the `DurabilityQos` policy kind set to something other than `VOLATILE`.

This rule prevents data that was published while the `DataWriter` had associated a set of `Partitions` from being sent to `DataReaders` that were not matching before the `Partition` change and match after the `Partition` is changed

7.3.6 Platform Independent Description

7.3.6.1 RTPS Secure Submessage Elements

This specification introduces new RTPS `SubmessageElements` that may appear inside RTPS `Submessages`.

7.3.6.1.1 CryptoTransformIdentifier

The `CryptoTransformIdentifier` submessage element identifies the kind of cryptographic transformation that was performed in an RTPS `Submessage` or an RTPS `SubmessageElement` and also provides a unique identifier of the key material used for the cryptographic transformation.

The way in which attributes in the `CryptoTransformIdentifier` are set shall be specified for each Cryptographic plugin implementation. However, all Cryptographic plugin implementations shall be set in a way that allows the operations `preprocess_secure_submsg, decode_datareader_submessage, decode_datawriter_submessage,` and `decode_serialized_data` to uniquely recognize the cryptographic material they shall use to decode the message, or recognize that they do not have the necessary key material.

7.3.6.1.2 SecuredPayload

The `SecuredPayload` submessage element is used to wrap either a Submessage or a complete RTPS Message. It is the result of applying one of the encoding transformations on the CryptoTransform plugin.

The leading bytes in the `SecuredPayload` shall encode the `CryptoTransformIdentifier`. Therefore, the ***transformationKind*** is guaranteed to be the first element within the

SecuredPayload. The specific format of this shall be defined by each Cryptographic plugin implementation.

7.3.6.2 RTPS Submessage: SecureSubMsg

This specification introduces a new RTPS submessage: SecureSubMsg. The format of the SecureSubMsg complies with the RTPS SubMessage format mandated in the RTPS specification. It consists of the RTPS SubmessageHeader followed by a set of RTPS SubmessageElement elements.

Since the SecureSubMsg conforms to the general structure of RTPS submessages, it can appear inside a well-formed RTPS message.

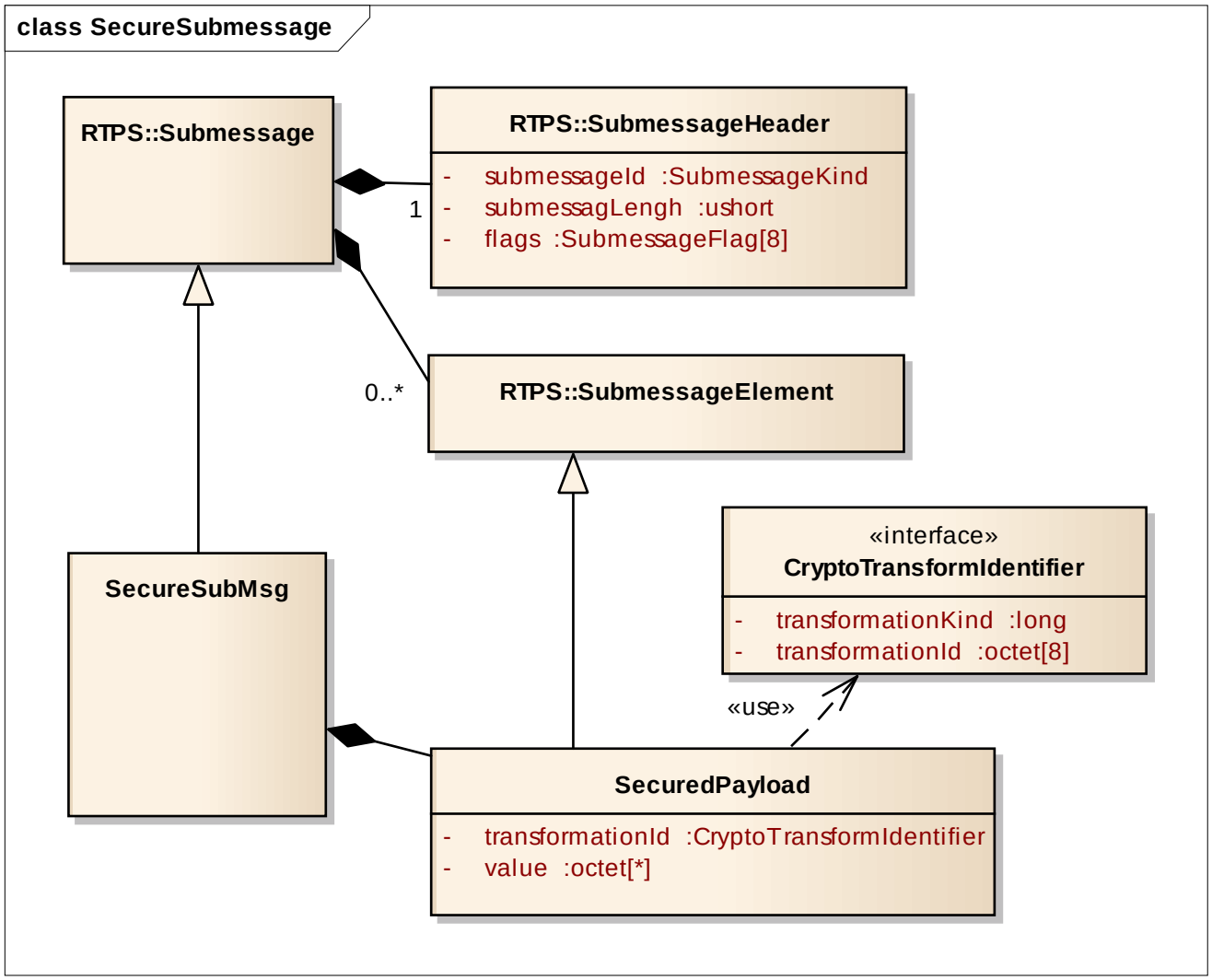


Figure 6 – Secure Submessage and Secured Payload Model

7.3.6.2.1 Purpose

The SecureSubMsg submessage is used to wrap one or more regular RTPS submessages in such a way that their contents are secured via encryption, message authentication, and/or digital signatures.

7.3.6.2.2 Content

The elements that form the structure of the RTPS SecureSubMsg are described in the table below.

Table 4 – SecureSubMsg class

Element	Type	Meaning
SecureSubMsgKind	SubmessageKind	The presence of this field is common to RTPS submessages. It identifies the kind of submessage. The value indicates it is a SecureSubMsg
submessageLength	ushort	The presence of this field is common to RTPS submessages. It identifies the length of the submessage.
EndianessFlag	SubmessageFlag	Appears in the Submessage header flags. Indicates endianess.
SingleSubmsgFlag	SubmessageFlag	Appears in the Submessage header flags. Indicates the submessage contains potentially multiple submessages within.
payload	SecuredPayload	Contains the result of transforming the original message. Depending on the plugin implementation and configuration, it may contain encrypted content, message access codes, and/or digital signatures

7.3.6.2.3 Validity

The RTPS `Submessage` is invalid if the ***submessageLength*** in the Submessage header is too small.

7.3.6.2.4 Logical Interpretation

The `SecureSubMsg` provides a way to send secure content inside a legal RTPS submessage.

A `SecureSubMsg` may wrap a single RTPS `Submessage` or a whole RTPS `Message`. These two situations are distinguished by the value of the `MultisubmsgFlag`.

The `SecuredPayload` shall follow immediately after the SubmessageHeader.

If the `SingleSubmsgFlag` is `true`, the `SecuredPayload` contains a single RTPS submessage that was obtained as a result of the `encode_datawriter_submessage` or `encode_datawriter_submessage` operations on the CryptoTransform plugin.

If the `SingleSubmsgFlag` is `false`, the `SecuredPayload` contains the whole RTPS message obtained as a result of the `encode_rtps_message` operation on the `CryptoTransform` plugin.

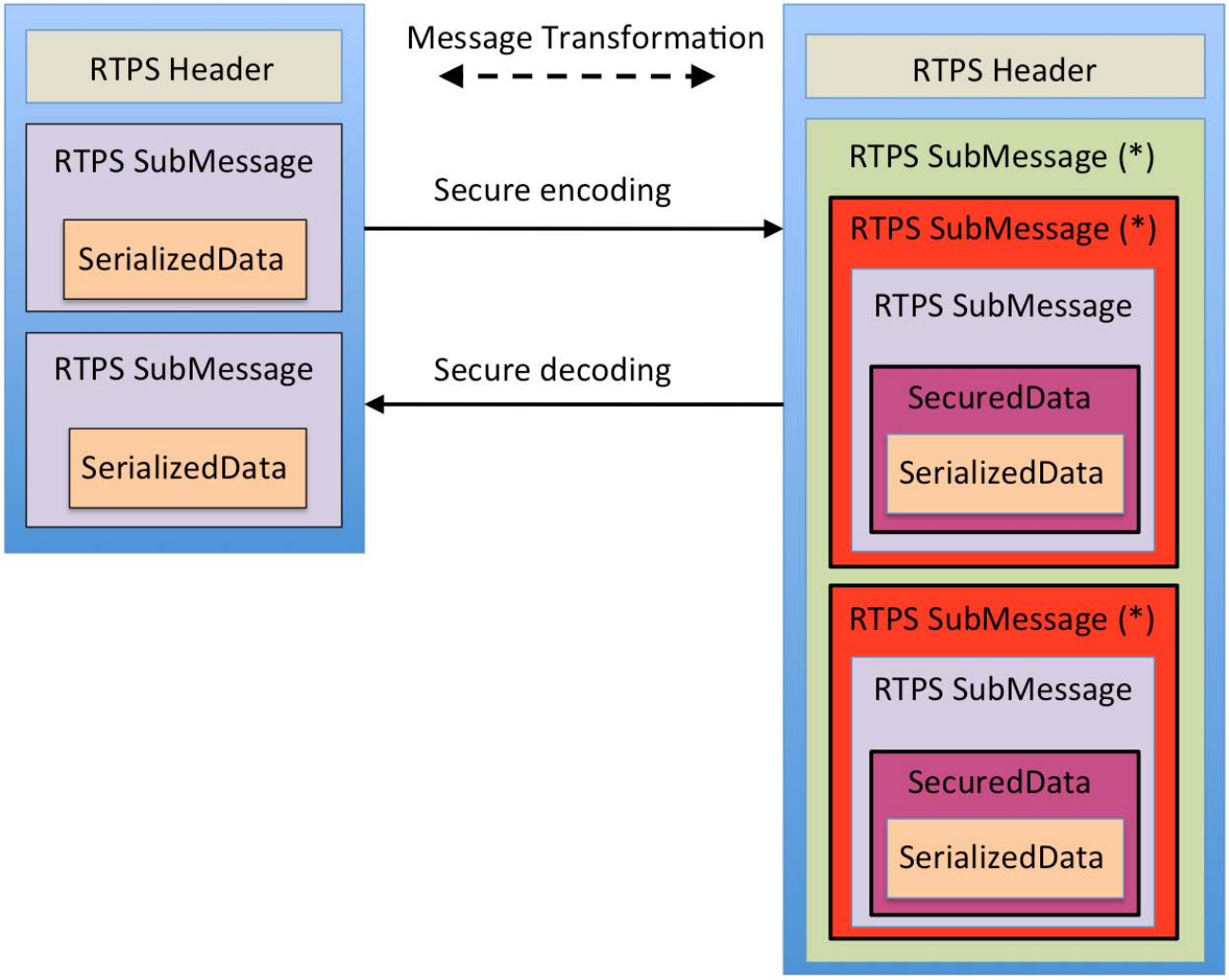


Figure 7 – RTPS message transformations

7.3.7 Mapping to UDP/IP PSM

The DDS-RTPS specification defines the RTPS protocol in terms of a platform-independent model (PIM) and then maps it to a UDP/IP transport PSM (see clause 9, “Platform Specific Model (PSM): UDP/IP” of the DDS-RTPS specification [2]).

Sub clause 7.3.7 does the same thing for the new RTPS submessage elements and submessages introduced by the DDS Security specification.

7.3.7.1 Mapping of the EntityIds for the Builtin DataWriters and DataReaders

Sub clause 7.4 defines a set of builtin Topics and corresponding DataWriter and DataReader entities that shall be present on all compliant implementations of the DDS Security specification. The corresponding EntityIds used when these endpoints are used on the UDP/IP PSM are given in the table below.

Table 5 – EntityId values for secure builtin data writers and data readers

Entity	EntityId_t name	EntityId_t value
SEDPbuiltinPublicationsSecureWr	ENTITYID_SEDP_BUILTIN_PUBLICATIONS_SECURE_WRITER	{{ff, 00, 03}, c2}

iter		
SEDPbuiltinPublicationsSecureReader	ENTITYID_SEDP_BUILTIN_PUBLICATIONS_SECURE_READER	{{ff, 00, 03}, c7}
SEDPbuiltinSubscriptionsSecureWriter	ENTITYID_SEDP_BUILTIN_SUBSCRIPTIONS_SECURE_WRITER	{{ff, 00, 04}, c2}
SEDPbuiltinSubscriptionsSecureReader	ENTITYID_ SEDP_BUILTIN_ SUBSCRITIONS_SECURE_READER	{{ff, 00, 04}, c7}
BuiltinParticipantMessageSecureWriter	ENTITYID_P2P_BUILTIN_PARTICIPANT_MESSAGE_SECURE_WRITER	{{ff, 02, 00}, c2}
BuiltinParticipantMessageSecureReader	ENTITYID_P2P_BUILTIN_PARTICIPANT_MESSAGE_SECURE_READER	{{ff, 02, 00}, c7}
BuiltinParticipantStatelessMessageWriter	ENTITYID_P2P_BUILTIN_PARTICIPANT_STATELESS_WRITER	{{00, 02, 01}, c2}
BuiltinParticipantStatelessMessageReader	ENTITYID_P2P_BUILTIN_PARTICIPANT_STATELESS_READER	{{00, 02, 01}, c7}
BuiltinParticipantVolatileMessageSecureWriter	ENTITYID_P2P_BUILTIN_PARTICIPANT_VOLATILE_SECURE_WRITER	{{ff, 02, 02}, c2}
BuiltinParticipantVolatileMessageSecureReader	ENTITYID_P2P_BUILTIN_PARTICIPANT_VOLATILE_SECURE_READER	{{ff, 02, 02}, c7}

7.3.7.2 Mapping of the CryptoTransformIdentifier Type

The UDP/IP PSM maps the `CryptoTransformIdentifier` to the following extended IDL structure:

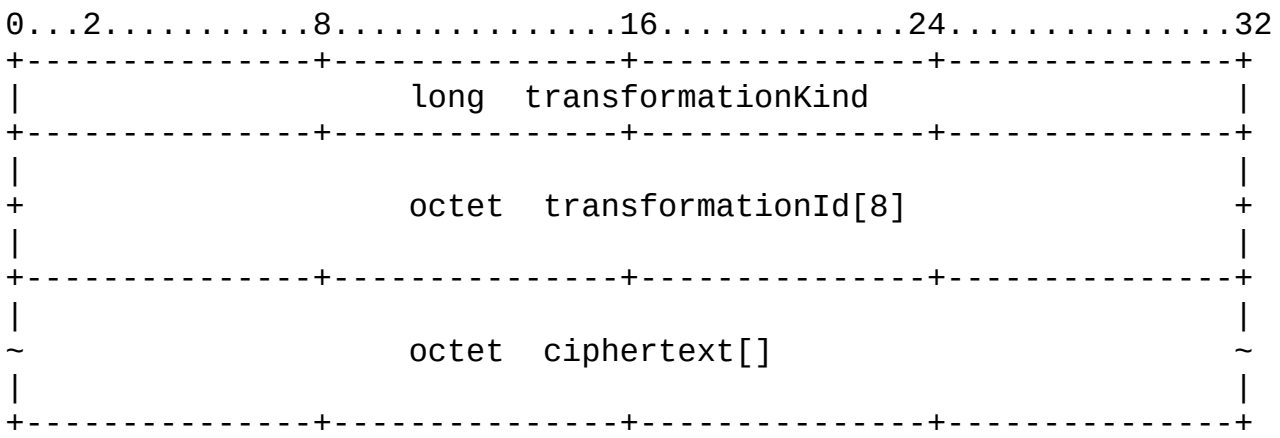
```
typedef octet OctetArray8[8];
@Extensibility(FINAL_EXTENSIBILITY)
struct CryptoTransformIdentifier {
    long transformationKind;
    OctetArray8 transformationId;
};
```

The `CryptoTransformIdentifier` shall be serialized using CDR using the endianess specified by the `EndianessFlag` in the `SubmessageHeader`.

7.3.7.3 Mapping of the SecuredPayload SubmessageElement

A `SecuredPayload SubmessageElement` contains the result of cryptographically transforming either an RTPS Message or a single RTPS Submessage. In both cases the `SecuredPayload` shall start with the `CryptoTransformIdentifier` and be followed by the ciphertext returned by the encoding transformation.

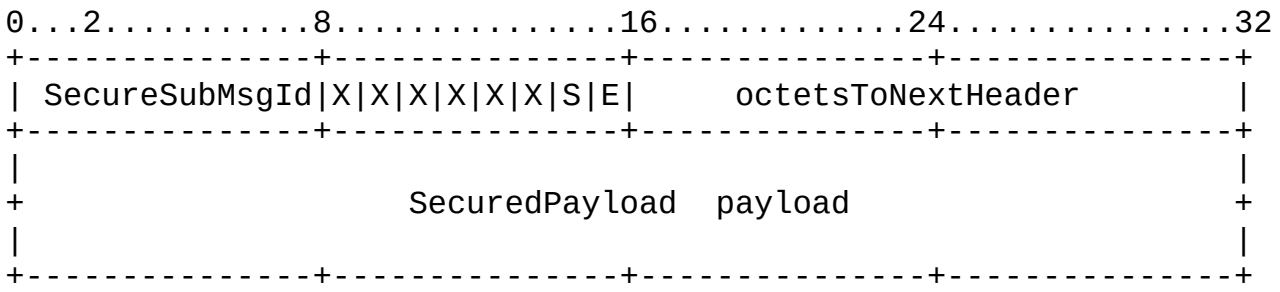
The UDP/IP wire representation for the `SecuredPayload` shall be:



7.3.7.4 SecureSubMsg Submessage

7.3.7.4.1 Wire Representation

The UDP/IP wire representation for the `SecureSubMsg` shall be:



7.3.7.4.2 Submessage Id

The `SecureSubMsg` shall have the ***submessageId*** set to the value 0x30.

7.3.7.4.3 Flags in the Submessage Header

In addition to the EndiannessFlag, the SecureSubMsg introduces the SingleSubmessageFlag (see 7.3.6.2.2). The PSM maps these flags as follows:

The SingleSubmessageFlag is represented with the literal ‘S.’ The value of the InlineQosFlag can be obtained from the expression:

```
S = SubmessageHeader.flags & 0x02
```

The SingleSubmessageFlag is interpreted as follows:

- S=0 means that the SecureSubMsg submessage is an envelope for a full RTPS message.
- S=1 means that the SecureSubMsg submessage is an envelope for a single RTPS submessage.

7.4 DDS Support for Security Plugin Information Exchange

In order to perform their function, the security plugins associated with different DDS `DomainParticipant` entities need to exchange information representing things such as Identity and Permissions of the `DomainParticipant` entities, authentication challenge messages, tokens representing key material, etc.

DDS already has several mechanisms for information exchange between `DomainParticipant` entities. Notably the builtin `DataWriter` and `DataReader` entities used by the Simple Discovery Protocol (see sub clause 8.5 of the DDS Interoperability Wire Protocol [2]) and the ***BuiltinParticipantMessageWriter*** and ***BuiltinParticipantMessageReader*** (see sub clause 9.6.2.1 of the DDS Interoperability Wire Protocol [2]).

Where possible, this specification tries to reuse and extend existing DDS concepts and facilities so that they can fulfill the needs of the security plugins, rather than defining entirely new ones. This way, the Security Plugin implementation can be simplified and it does not have to implement a separate messaging protocol.

7.4.1 Secure builtin Discovery Topics

7.4.1.1 Background (Non-Normative)

DDS discovery information is sent using builtin DDS `DataReaders` and `DataWriters`. These are regular DDS `DataReaders` and `DataWriters,` except they are always present in the system and their `Topic` names, associated data types, QoS, and RTPS `EntityIds` are all specified as part of the DDS and RTPS specifications, so they do not need to be discovered.

The DDS specification defines three discovery builtin `Topic` entities: the ***DCPSParticipants*** used to discover the presence of `DomainParticipants`, the ***DCPSPublications*** used to discover `DataWriters`, and the ***DCPSSubscriptions*** used to discover `DataReaders` (see sub clause 8.5 of the DDS Interoperability Wire Protocol [2]).

Much of the discovery information could be considered sensitive in secure DDS systems. Knowledge of things like the `Topic` names that an application is publishing or subscribing to could reveal sensitive information about the nature of the application. In addition, the integrity of the discovery information needs to be protected against tampering, since could cause erroneous behaviors or malfunctions.

One possible approach to protecting discovery information would be to require that the discovery builtin `Topic` entities always be protected via encryption and message authentication. However, this would entail the problems explained below.

The ***DCPSParticipants*** builtin Topic is used to bootstrap the system, detect the presence of `DomainParticipant` entities, and kick off subsequent information exchanges and handshakes. It contains the bare minimum information needed to establish protocol communications (addresses, port numbers, version number, vendor IDs, etc.). If this `Topic` were protected, the Secure DDS system would have to create an alternative mechanism to bootstrap detection of other participants and gather the same information—which needs to happen prior to being able to perform mutual authentication and exchange of key material. This mechanism would, in essence, duplicate the information in the ***DCPSParticipants*** builtin `Topic`. Therefore, it makes little sense to protect the ***DCPSParticipants*** builtin `Topic`. A better approach is to augment the information sent using the ***DCPSParticipants***

builtin `Topic` with any additional data the Secure DDS system needs for bootstrapping communications (see 7.4.1.3).

Secure DDS systems need to co-exist in the same network and, in some cases, interoperate with non-secure DDS systems. There may be systems built using implementations compliant with the DDS Security specification which do not need to protect their information. Or there may be systems implemented with legacy DDS implementations that do not support DDS Security. In this situation, the fact that a secure DDS implementation is present on the network should not impact the otherwise correct behavior of the non-secure DDS systems. In addition, even in secure systems not all Topics are necessarily sensitive, so it is desirable to provide ways to configure a DDS Secure system to have Topics that are "unprotected" and be able to communicate with non-secure DDS systems on those "unprotected" Topics.

To allow co-existence and interoperability between secure DDS systems and DDS systems that do not implement DDS security, secure DDS systems must retain the same builtin Topics as the regular DDS systems (with the same GUIDs, topics names, QoS, and behavior). Therefore, to protect the discovery and liveliness information of Topics that are considered sensitive, Secure DDS needs to use additional builtin discovery Topics protected by the DDS security mechanisms.

7.4.1.2 Extending the Data Types used by DDS Discovery

The DDS Interoperability Wire Protocol specifies the serialization of the data types used for the discovery of builtin Topics (***ParticipantBuiltinTopicData***, ***PublicationBuiltinTopicData***, and ***SubscriptionBuiltinTopicData)*** using a representation called using a *ParameterList*. Although this description precedes the DDS-XTYPES specification, the serialization format matches the Extended CDR representation defined in DDS-XTYPES for data types declared with MUTABLE extensibility. This allows the data type associated with discovery topics to be extended without breaking interoperability.

Given that DDS-XTYPES formalized the *ParameterList* serialization approach, first defined in the DDS Interoperability and renamed it to "Extended CDR," this specification will use the DDS Extensible Types notation to define the data types associated with the builtin Topics. This does not imply that compliance to the DDS-XTYPES is required to comply with DDS Security. All that is required is to serialize the specific data types defined here according to the format described in the DDS-XTYPES specification.

7.4.1.3 Extension to RTPS Standard DCPSParticipants Builtin Topic

The DDS specification specifies the existence of the ***DCPSParticipants*** builtin `Topic` and a corresponding builtin `DataWriter` and `DataReader` to communicate this `Topic`. These endpoints are used to discover `DomainParticipant` entities.

The data type associated with the ***DCPSParticipants*** builtin `Topic` is ***ParticipantBuiltinTopicData***, defined in sub clause 7.1.5 of the DDS specification.

The DDS Interoperability Wire Protocol specifies the serialization of ***ParticipantBuiltinTopicData.*** The format used is what the DDS Interoperability Wire Protocol calls a *ParameterList* whereby each member of the ***ParticipantBuiltinTopicData*** is serialized using CDR but preceded in the stream by the serialization of a short ParameterID identifying the member, followed by another short containing the length of the serialized member, followed by the serialized member. See sub clause 8.3.5.9 of the DDS Interoperability Wire Protocol [2]. This serialization format allows the ***ParticipantBuiltinTopicData*** to be extended without breaking interoperability.

This DDS Security specification adds several new members to the ***ParticipantBuiltinTopicData*** structure. The member types and the ***ParameterIDs*** used for the serialization are described below.

Table 6 Additional parameter IDs in ParticipantBuiltinTopicData

Member name	*Member type*	*Parameter ID name*	*Parameter ID value*
identity_token	IdentityToken (see 7.2.5)	PID_IDENTITY_TOKEN	0x1001
permissions_token	PermissionsToken (see 7.2.5)	PID_PERMISSIONS_TOKEN	0x1002

```
@extensibility(MUTABLE_EXTENSIBILITY)
struct ParticipantBuiltinTopicDataSecure: ParticipantBuiltinTopicData {
    @ID(0x1001) IdentityToken     identity_token;
    @ID(0x1002) PermissionsToken  permissions_token;
};
```

7.4.1.4 New DCPSPublicationsSecure Builtin Topic

The DDS specification specifies the existence of the ***DCPSPublications*** builtin `Topic` with topic name “DCPSPublications” and corresponding builtin `DataWriter` and `DataReader` entities to communicate on this `Topic`. These endpoints are used to discover non-builtin `DataWriter` entities.

The data type associated with the ***DCPSPublications*** `Topic` is ***PublicationBuiltinTopicData***, defined in sub clause 7.1.5 of the DDS specification.

Implementations of the DDS Security shall use that same ***DCPSPublications*** `Topic` to communicate the `DataWriter` information for `Topic` entities that **are not** considered sensitive.

Implementations of the DDS Security specification shall have an additional builtin `Topic` referred as ***DCPSPublicationsSecure*** and associated builtin `DataReader` and `DataWriter` entities to communicate the `DataWriter` information for `Topic` entities that **are** considered sensitive.

The determination of which `Topic` entities are considered sensitive shall be specified by the `AccessControl` plugin.

The `Topic` name for the ***DCPSPublicationsSecure*** `Topic` shall be “DCPSPublicationsSecure”.

The data type associated with the ***DCPSPublicationsSecure*** `Topic` shall be ***PublicationBuiltinTopicDataSecure***, defined to be the same as the ***PublicationBuiltinTopicData*** structure used by the ***DCPSPublications*** `Topic,` except the structure has the additional member ***data_tags*** with the data type and ***ParameterIds*** described below.

Table 7 Additional parameter IDs in PublicationBuiltinTopicDataSecure

Member name	*Member type*	*Parameter ID name*	*Parameter ID value*
data_tags	DataTags	PID_DATA_TAGS	0x1003

```
struct Tag {
   string name;
   string value;
```

```
};

typedef sequence<Tag> TagSeq;
struct DataTags {
   TagSeq tags;
};

@extensibility(MUTABLE_EXTENSIBILITY)
struct PublicationBuiltinTopicDataSecure: PublicationBuiltinTopicData {
    @ID(0x1003) DataTags data_tags;
};
```

The QoS associated with the ***DCPSPublicationsSecure*** `Topic` shall be the same as for the ***DCPSPublications*** `Topic`.

The builtin `DataWriter` for the ***DCPSPublicationsSecure*** `Topic` shall be referred to as the ***SEDPbuiltinPublicationsSecureWriter***. The builtin `DataReader` for the ***DCPSPublicationsSecure*** `Topic` shall be referred to as the ***SEDPbuiltinPublicationsSecureReader***.

The RTPS `EntityId_t` associated with the ***SEDPbuiltinPublicationsSecureWriter*** and ***SEDPbuiltinPublicationsSecureReader*** shall be as specified in 7.4.5.

7.4.1.5 New DCPSSubscriptionsSecure Builtin Topic

The DDS specification specifies the existence of the ***DCPSSubscriptions*** builtin `Topic` with `Topic` name “DCPSSubscriptions” and corresponding builtin `DataWriter` and `DataReader` entities to communicate on this `Topic`. These endpoints are used to discover non-builtin `DataReader` entities.

The data type associated with the ***DCPSSubscriptions*** is ***SubscriptionBuiltinTopicData*** is defined in sub clause 7.1.5 of the DDS specification.

Implementations of the DDS Security specification shall use that same ***DCPSSubscriptions*** `Topic` to send the `DataReader` information for `Topic` entities that **are not** considered sensitive. The existence and configuration of `Topic` entities as non-sensitive shall be specified by the `AccessControl` plugin.

Implementations of the DDS Security specification shall have an additional builtin `Topic` referred to as ***DCPSSubscriptionsSecure*** and associated builtin `DataReader` and `DataWriter` entities to communicate the `DataReader` information for `Topic` entities that are considered sensitive.

The determination of which `Topic` entities are considered sensitive shall be specified by the `AccessControl` plugin.

The data type associated with the ***DCPSSubscriptionsSecure*** `Topic` shall be ***SubscriptionBuiltinTopicDataSecure*** defined to be the same as the ***SubscriptionBuiltinTopicData*** structure used by the ***DCPSSubscriptions*** `Topic`, except the structure has the additional member ***data_tags*** with the data type and ***ParameterIds*** described below.

Table 8 Additional parameter IDs in SubscriptionBuiltinTopicDataSecure

Member name	*Member type*	*Parameter ID name*	*Parameter ID value*
data_tags	DataTags	PID_DATA_TAGS	0x1003

```
@extensibility(MUTABLE_EXTENSIBILITY)
struct SubscriptionBuiltinTopicDataSecure: SubscriptionBuiltinTopicData {
    @ID(0x1003) DataTags data_tags;
};
```

The QoS associated with the ***DCPSSubscriptionsSecure*** `Topic` shall be the same as for the ***DCPSSubscriptions*** `Topic`.

The builtin `DataWriter` for the ***DCPSSubscriptionsSecure*** `Topic` shall be referred to as the ***SEDPbuiltinSubscriptionsSecureWriter***. The builtin `DataReader` for the ***DCPSPublicationsSecure*** `Topic` shall be referred to as the ***SEDPbuiltinSubscriptionsSecureReader***.

The RTPS `EntityId_t` associated with the ***SEDPbuiltinSubscriptionsSecureWriter*** and ***SEDPbuiltinSubscriptionsSecureReader*** shall be as specified in 7.4.5.

7.4.2 New ParticipantMessageSecure builtin Topic

The DDS Interoperability Wire Protocol specifies the ***BuiltinParticipantMessageWriter*** and ***BuiltinParticipantMessageReader*** (see sub clauses 8.4.13 and 9.6.2.1 of the DDS Interoperability Wire Protocol[2]). These entities are used to send information related to the LIVELINESS QoS. This information could be considered sensitive and therefore secure DDS systems need to provide an alternative protected way to send liveliness information.

The data type associated with these endpoints is ***ParticipantMessageData*** defined in sub clause 9.6.2.1 of the DDS Interoperability Wire Protocol specification [2].

To support coexistence and interoperability with non-secure DDS applications, implementations of the DDS Security specification shall use the same standard ***BuiltinParticipantMessageWriter*** and ***BuiltinParticipantMessageReader*** to communicate liveliness information on `Topic` entities that **are not** considered sensitive.

Implementations of the DDS Security specification shall have an additional ***ParticipantMessageSecure*** builtin `Topic` and associated builtin `DataReader` and `DataWriter` entities to communicate the liveliness information for `Topic` entities that **are** considered sensitive.

The data type associated with the ***ParticipantMessageSecure*** `Topic` shall be the same as the ***ParticipantMessageData*** structure.

The QoS associated with the ***ParticipantMessageSecure*** `Topic` shall be the same as for the ***ParticipantMessageSecure*** `Topic` as defined in sub clause 8.4.13 of the DDS Interoperability Wire Protocol [2].

The builtin `DataWriter` for the ***ParticipantMessageSecure*** `Topic` shall be referred to as the ***BuiltinParticipantMessageSecureWriter***. The builtin `DataReader` for the ***ParticipantMessageSecure*** `Topic` shall be referred to as the ***BuiltinParticipantMessageSecureReader***.

The RTPS `EntityId_t` associated with the ***BuiltinParticipantMessageSecureWriter*** and ***BuiltinParticipantMessageSecureReader*** shall be as specified in 7.4.5.

7.4.3 New ParticipantStatelessMessage builtin Topic

To perform mutual authentication between DDS `DomainParticipant` entities, the security plugins associated with those participants need to be able to send directed messages to each other. As described in 7.4.3.1 below, the mechanisms provided by existing DDS builtin `Topic` entities are not adequate for this purpose. For this reason, this specification introduces a new ***ParticipantStatelessMessage*** builtin `Topic` and corresponding builtin `DataReader` and `DataWriter` entities to read and write the `Topic`.

7.4.3.1 Background: Sequence Number Attacks (non normative)

DDS has a builtin mechanism for participant-to-participant messaging: the ***BuiltinParticipantMessageWriter*** and ***BuiltinParticipantMessageReader*** (see sub clause 9.6.2.1 of the DDS Interoperability Wire Protocol [2]). However this mechanism cannot be used for mutual authentication because it relies on the RTPS reliability protocol and suffers from the sequence-number prediction vulnerability present in unsecured reliable protocols:

- The RTPS reliable protocol allows a `DataWriter` to send to a `DataReader` `Heartbeat` messages that advance the *first available sequence number* associated with the `DataWriter`. A `DataReader` receiving a `Heartbeat` from a `DataWriter` will advance its *first available sequence number* for that `DataWriter` and ignore any future messages it receives with sequence numbers lower than the *first available sequence number* for the `DataWriter`. The reliable `DataReader` will also ignore duplicate messages for that same sequence number.
- The behavior of the reliability protocol would allow a malicious application to prevent other applications from communicating by sending `Heartbeats` pretending to be from other `DomainParticipants` that contain large values of the *first available sequence number.* All the malicious application needs to do is learn the GUIDs of other applications, which can be done from observing the initial discovery messages on the wire, and use that information to create fake `Heartbeats`.

Stated differently: prior to performing mutual authentication and key exchange, the applications cannot rely on the use of encryption and message access codes to protect the integrity of the messages. Therefore, during this time window, they are vulnerable to this kind of sequence-number attack. This attack is present in most reliable protocols. Stream-oriented protocols such as TCP are also vulnerable to sequence-number-prediction attacks but they make it more difficult by using a random initial sequence number on each new connection and discarding messages with sequence numbers outside the window. This is something that RTPS cannot do given the data-centric semantics of the protocol.

In order to avoid this vulnerability, the Security plugins must exchange messages using writers and readers sufficiently robust to sequence number prediction attacks. The RTPS protocol specifies endpoints that meet this requirement: the RTPS `StatelessWriter` and `StatelessReader` (see 8.4.7.2 and 8.4.10.2 of the DDS Interoperability Wire Protocol [2]) but there are not DDS builtin endpoints that provide access to this underlying RTPS functionality.

7.4.3.2 BuiltinParticipantStatelessMessageWriter and BuiltinParticipantStatelessMessageReader

The DDS Security specification defines two builtin Endpoints: the ***BuiltinParticipantStatelessMessageWriter*** and the ***BuiltinParticipantStatelessMessageReader***. These two endpoints shall be present in compliant implementations of this specification. These endpoints are used to write and read the builtin ***ParticipantStatelessMessage*** `Topic`.

The ***BuiltinParticipantStatelessMessageWriter*** is an RTPS Best-Effort `StatelessWriter` (see sub clause 8.4.7.2 of the DDS Interoperability Wire Protocol [2]).

The ***BuiltinParticipantStatelessMessageReader*** is an RTPS Best-Effort `StatelessReader` (see sub clause 8.4.10.2 of the DDS Interoperability Wire Protocol [2]).

The data type associated with these endpoints is `ParticipantStatelessMessage` defined below (see also 7.2.6):

```
typedef ParticipantStatelessMessage ParticipantGenericMessage;
```

The RTPS `EntityId_t` associated with the ***BuiltinParticipantStatelessMessageWriter*** and ***BuiltinParticipantStatelessMessageReader*** shall be as specified in 7.4.5.

7.4.3.3 Contents of the ParticipantStatelessMessage

The `ParticipantStatelessMessage` is intended as a holder of information that is sent point-to-point from a `DomainParticipant` to another.

The ***message_identity*** uniquely identifies each individual `ParticipantStatelessMessage:`

- The ***source_guid*** field within the ***message_identity*** shall be set to match the `BuiltinTopicKey_t` of the ***BuiltinParticipantStatelessMessageWriter*** that writes the message.
- The ***sequence_number*** field within the ***message_identity*** shall start with the value set to one and be incremented for each different message sent by the ***BuiltinParticipantStatelessMessageWriter***.

The ***related_message_identity*** uniquely identifies another `ParticipantStatelessMessage` that is related to the message being processed. It shall be set to either the tuple {***GUID_UNKNOWN, 0}*** if the message is not related to any other message, or else set to match the ***message_identity*** of the related `ParticipantStatelessMessage.`

The ***destination_participant_key*** shall contain either the value ***GUID_UNKNOWN*** (see sub clause 9.3.1.5 of the DDS Interoperability Wire Protocol [2]) or else the `BuiltinTopicKey_t` of the destination `DomainParticipant`.

The ***destination_endpoint_key*** provides a mechanism to specify finer granularity on the intended recipient of a message beyond the granularity provided by the ***destination_participant_key***. It can contain either ***GUID_UNKNOWN*** or else the GUID of a specific endpoint within destination `DomainParticipant`. The targeted endpoint is the one whose Endpoint (`DataWriter` or `DataReader)` `BuiltinTopic_t` matches the ***destination_endpoint_key***.

The contents ***message_data*** depend on the value of the ***message_class_id*** and are defined in this specification in the sub clause that introduces each one of the pre-defined values of the `GenericMessageClassId`. See 7.4.3.5 and 7.4.3.6.

7.4.3.4 Destination of the ParticipantStatelessMessage

If the ***destination_participant_key*** member is not set to ***GUID_UNKNOWN***, the message written is intended only for the ***BuiltinParticipantStatelessMessageReader*** belonging to the `DomainParticipant` with a matching Participant Key.

This is equivalent to saying that the ***BuiltinParticipantStatelessMessageReader*** has an implied content filter with the logical expression:

“destination_participant_key == GUID_UNKNOWN

|| destination_participant_key == BuiltinParticipantStatelessMessageReader.participant.key”

Implementations of the specification can use this content filter or some other mechanism as long as the resulting behavior is equivalent to having this content filter.

If the ***destination_endpoint_key*** member is not set to ***GUID_UNKNOWN***, the message written targets the specific endpoint within the destination `DomainParticipant` with am matching Endpoint Key.

7.4.3.5 Reserved values of ParticipantStatelessMessage GenericMessageClassId

This specification, including future versions of this specification reserves ***GenericMessageClassId*** values that start with the prefix “`dds.sec.`” (without quotes) .

The specification defines and uses the following specific values for the ***GenericMessageClassId***:

```
#define GMCLASSID_SECURITY_AUTH_HANDSHAKE                \
            “dds.sec.auth”
```

Additional values of the ***GenericMessageClassId*** may be defined with each plugin implementation.

7.4.3.6 Format of data within ParticipantStatelessMessage

Each value for the `GenericMessageClassId` uses different schema to store data within the generic attributes in the ***message_data***.

7.4.3.6.1 Data for message class GMCLASSID_SECURITY_AUTH_HANDSHAKE

If `GenericMessageClassId` is `GMCLASSID_SECURITY_AUTH_HANDSHAKE` the ***message_data*** attribute shall contain the `HandshakeMessageTokenSeq` containing one element. The specific contents of the `HandshakeMessageToken` element shall be defined by the Authentication Plugin.

The ***destination_participant_key*** shall be set to the `BuiltinTopicKey_t` of the destination `DomainParticipant`.

The ***destination_endpoint_key*** shall be set to ***GUID_UNKNOWN***. This indicates that there is no specific endpoint targeted by this message: It is intended for the whole `DomainParticipant`.

The ***source_endpoint_key*** shall be set to ***GUID_UNKNOWN***.

7.4.4 New ParticipantVolatileMessageSecure builtin Topic

7.4.4.1 Background (Non-Normative)

In order to perform key exchange between DDS `DomainParticipant` entities, the security plugins associated with those participants need to be able to send directed messages to each other using a reliable and secure channel. These messages are intended only for Participants that are currently in the system and therefore need a DURABILITY Qos of kind VOLATILE.

The existing mechanisms provided by DDS are not adequate for this purpose:

- The new ***ParticipantStatelessMessage*** is not suitable because it is a stateless best-effort channel not protected by the security mechanisms in this specification and therefore requires the message data

to be explicitly encrypted and signed prior to being given to the ***ParticipantStatelessMessageWriter***.

- The new ***ParticipantMessageSecure*** is not suitable because its QoS is has DURABILITY kind TRANSIENT_LOCAL (see sub clause 8.4.13 of the DDS Interoperability Wire Protocol [2]) rather than the required DURABILITY kind VOLATILE.

For this reason, implementations of the DDS Security specification shall have an additional builtin `Topic` ***ParticipantVolatileMessageSecure*** and corresponding builtin `DataReader` and `DataWriter` entities to read and write the Topic.

7.4.4.2 BuiltinParticipantVolatileMessageSecureWriter and BuiltinParticipantVolatileMessageSecureReader

The DDS Security specification defines two new builtin Endpoints: The ***BuiltinParticipantVolatileMessageSecureWriter*** and the ***BuiltinParticipantVolatileMessageSecureReader***. These two endpoints shall be present in compliant implementations of this specification. These endpoints are used to write and read the builtin ***ParticipantVolatileSecureMessage*** `Topic`.

The ***BuiltinParticipantVolatileMessageSecureWriter*** is an RTPS Reliable StatefulWriter (see sub clause 8.4.9.2 of the DDS Interoperability Wire Protocol [2]). The DDS `DataWriter` Qos associated with the `DataWriter` shall be as defined in the table below. Any policies that are not shown in the table shall be set corresponding to the DDS defaults.

Table 9 – Non-default Qos policies for BuiltinParticipantVolatileMessageSecureWriter

DataWriter Qos policy	Policy Value
RELIABILITY	kind= RELIABLE
HISTORY	kind= KEEP_ALL
DURABILITY	kind= VOLATILE

The ***BuiltinParticipantVolatileMessageSecureReader*** is an RTPS Reliable StatefulReader (see sub clause 8.4.11.2 of the DDS Interoperability Wire Protocol [2]). The DDS `DataReader` Qos associated with the `DataReader` shall be as defined in the table below. Any policies that are not shown in the table shall be set corresponding to the DDS defaults.

Table 10 – Non-default Qos policies for BuiltinParticipantVolatileMessageSecureReader

DataReader Qos policy	Policy Value
RELIABILITY	kind= RELIABLE
HISTORY	kind= KEEP_ALL
DURABILITY	kind= VOLATILE

The data type associated with these endpoints is `ParticipantVolatileSecureMessage` defined as:

```
typedef ParticipantVolatileSecureMessage ParticipantGenericMessage;
```

The RTPS `EntityId_t` associated with associated with the ***BuiltinParticipantVolatileMessageSecureWriter*** and ***BuiltinParticipantVolatileMessageSecureReader*** shall be as specified in 7.4.5.

7.4.4.3 Contents of the ParticipantVolatileSecureMessage

The `ParticipantVolatileSecureMessage` is intended as a holder of secure information that is sent point-to-point from a `DomainParticipant` to another.

The ***destination_participant_key*** shall contain either the value ***GUID_UNKNOWN*** (see sub clause 9.3.1.5 of the DDS Interoperability Wire Protocol [2] or else the `BuiltinTopicKey_t` of the destination `DomainParticipant`.

The ***message_identity*** uniquely identifies each individual `ParticipantVolatileSecureMessage:`

- The ***source_guid*** field within the ***message_identity*** shall be set to match the `BuiltinTopicKey_t` of the ***BuiltinParticipantVolatileMessageSecureWriter*** that writes the message.
- The ***sequence_number*** field within the ***message_identity*** shall start with the value set to one and be incremented for each different message sent by the ***BuiltinParticipantVolatileMessageSecureWriter***.

The ***related_message_identity*** uniquely identifies another `ParticipantVolatileSecureMessage` that is related to the message being processed. It shall be set to either the tuple {***GUID_UNKNOWN, 0}*** if the message is not related to any other message, or else set to match the ***message_identity*** of the related `ParticipantVolatileSecureMessage.`

The contents ***message_data*** depend on the value of the ***message_class_id*** and are defined in this specification in the sub clause that introduces each one of the defined values of the `GenericMessageClassId`, see 7.4.4.5.

7.4.4.4 Destination of the ParticipantVolatileSecureMessage

If the ***destination_participant_key*** member is not set to ***GUID_UNKNOWN***, the message written is intended only for the ***BuiltinParticipantVolatileMessageSecureReader*** belonging to the `DomainParticipant` with a matching Participant Key.

This is equivalent to saying that the ***BuiltinParticipantVolatileMessageSecureReader*** has an implied content filter with the logical expression:

> “destination_participant_key == GUID_UNKNOWN
>
> || destination_participant_key == BuiltinParticipantVolatileMessageSecureReader.participant.key”

Implementations of the specification can use this content filter or some other mechanism as long as the resulting behavior is equivalent to having this filter.

If the ***destination_endpoint_key*** member is not set to ***GUID_UNKNOWN*** the message written targets a specific endpoint within the destination DomainParticipant. The targeted endpoint is the one whose Endpoint Key (DataWriter or DataReader BuiltinTopic_t) matches the ***destination_endpoint_key***. This

attribute provides a mechanism to specify finer granularity on the intended recipient of a message beyond the granularity provided by the ***destination_participant_key***.

7.4.4.5 Reserved values of ParticipantVolatileSecureMessage GenericMessageClassId

This specification, including future versions of this specification reserves ***GenericMessageClassId*** values that start with the prefix "`dds.sec.`" (without the quotes) .

The specification defines and uses the following specific values for the ***GenericMessageClassId***:

```
#define GMCLASSID_SECURITY_PARTICIPANT_CRYPTO_TOKENS \
            "dds.sec.participant_crypto_tokens"
#define GMCLASSID_SECURITY_DATAWRITER_CRYPTO_TOKENS  \
            "dds.sec.datawriter_crypto_tokens"
#define GMCLASSID_SECURITY_DATAREADER_CRYPTO_TOKENS  \
            "dds.sec.datareader_crypto_tokens"
```

Additional values of the ***GenericMessageClassId*** may be defined with each plugin implementation.

7.4.4.6 Format of data within ParticipantVolatileSecureMessage

Each value for the `GenericMessageClassId` uses different schema to store data within the generic attributes in the ***message_data***.

7.4.4.6.1 Data for message class GMCLASS_SECURITY_PARTICIPANT_CRYPTO_TOKENS

If `GenericMessageClassId` is `GMCLASSID_SECURITY_PARTICIPANT_CRYPTO_TOKENS` the ***message_data*** attribute shall contain the `ParticipantCryptoTokenSeq`.

This message is intended to send cryptographic material from one `DomainParticipant` to another when the cryptographic material applies to the whole `DomainParticipant` and not a specific `DataReader` or `DataWriter` within.

The concrete contents of the `ParticipantCryptoTokenSeq` shall be defined by the Cryptographic Plugin (CryptoKeyFactory).

The ***destination_participant_key*** shall be set to the `BuiltinTopicKey_t` of the destination `DomainParticipant`.

The ***destination_endpoint_key*** shall be set to ***GUID_UNKNOWN***. This indicates that there is no specific endpoint targeted by this message: It is intended for the whole `DomainParticipant`.

The ***source_endpoint_key*** shall be set to ***GUID_UNKNOWN***.

7.4.4.6.2 Data for message class GMCLASSID_SECURITY_DATAWRITER_CRYPTO_TOKENS

If `GenericMessageClassId` is `GMCLASSID_SECURITY_DATAWRITER_CRYPTO_TOKENS`, the ***message_data*** shall contain the `DatawriterCryptoTokenSeq`.

This message is intended to send cryptographic material from one `DataWriter` to a `DataReader` whom it wishes to send information to. The cryptographic material applies to a specific 'sending' `DataWriter` and it is constructed for a specific 'receiving' `DataReader`. This may be used to send the crypto keys used by a `DataWriter` to encrypt data and sign the data it sends to a `DataReader`.

The concrete contents of the `DatawriterCryptoTokenSeq` shall be defined by the Cryptographic Plugin (CryptoKeyFactory).

The ***destination_endpoint_key*** shall be set to the `BuiltinTopicKey_t` of the `DataReader` that should receive the `CryptoToken` values in the message.

The ***source_endpoint_key*** shall be set to the `BuiltinTopicKey_t` of the `DataWriter` that what will be using the `CryptoToken` values to encode the data it sends to the `DataReader`.

7.4.4.6.3 Data for message class GMCLASSID_SECURITY_DATAREADER_CRYPTO_TOKENS

If `GenericMessageClassId` is `GMCLASSID_SECURITY_DATAWRITER_CRYPTO_TOKENS`, the ***message_data*** attribute shall contain the `DatareaderCryptoTokenSeq`.

This message is intended to send cryptographic material from one `DataReader` to a `DataWriter` whom it wishes to send information to. The cryptographic material applies to a specific 'sending' `DataReader` and it is constructed for a specific 'receiving' `DataWriter`. This may be used to send the crypto keys used by a `DataReader` to encrypt data and sign the ACKNACK messages it sends to a `DataWriter`.

The concrete contents of the `DatareaderCryptoTokenSeq` shall be defined by the Cryptographic Plugin (CryptoKeyFactory).

The ***destination_endpoint_key*** shall be set to the `BuiltinTopicKey_t` of the `DataWriter` that should receive the `CryptoToken` values in the message.

The ***source_endpoint_key*** shall be set to the `BuiltinTopicKey_t` of the `DataReader` that what will be using the `CryptoToken` values to encode the data it sends to the `DataWriter`.

7.4.5 Definition of the "Builtin Secure Endpoints"

The complete list of builtin Endpoints that are protected by the security mechanism introduced in the DDS Security specification is: ***SEDPbuiltinPublicationsSecureWriter, SEDPbuiltinPublicationsSecureReader, SEDPbuiltinSubscriptionsSecureWriter, SEDPbuiltinSubscriptionsSecureReader, BuiltinParticipantMessageSecureWriter, BuiltinParticipantMessageSecureReader, BuiltinParticipantVolatileMessageSecureWriter,*** and ***BuiltinParticipantVolatileMessageSecureReader.***

This list shall be referred to as the **builtin secure endpoints**.

8 Plugin Architecture

8.1 Introduction

There are five plugin SPIs: Authentication, Access-Control, Cryptographic, Logging, and Data Tagging.

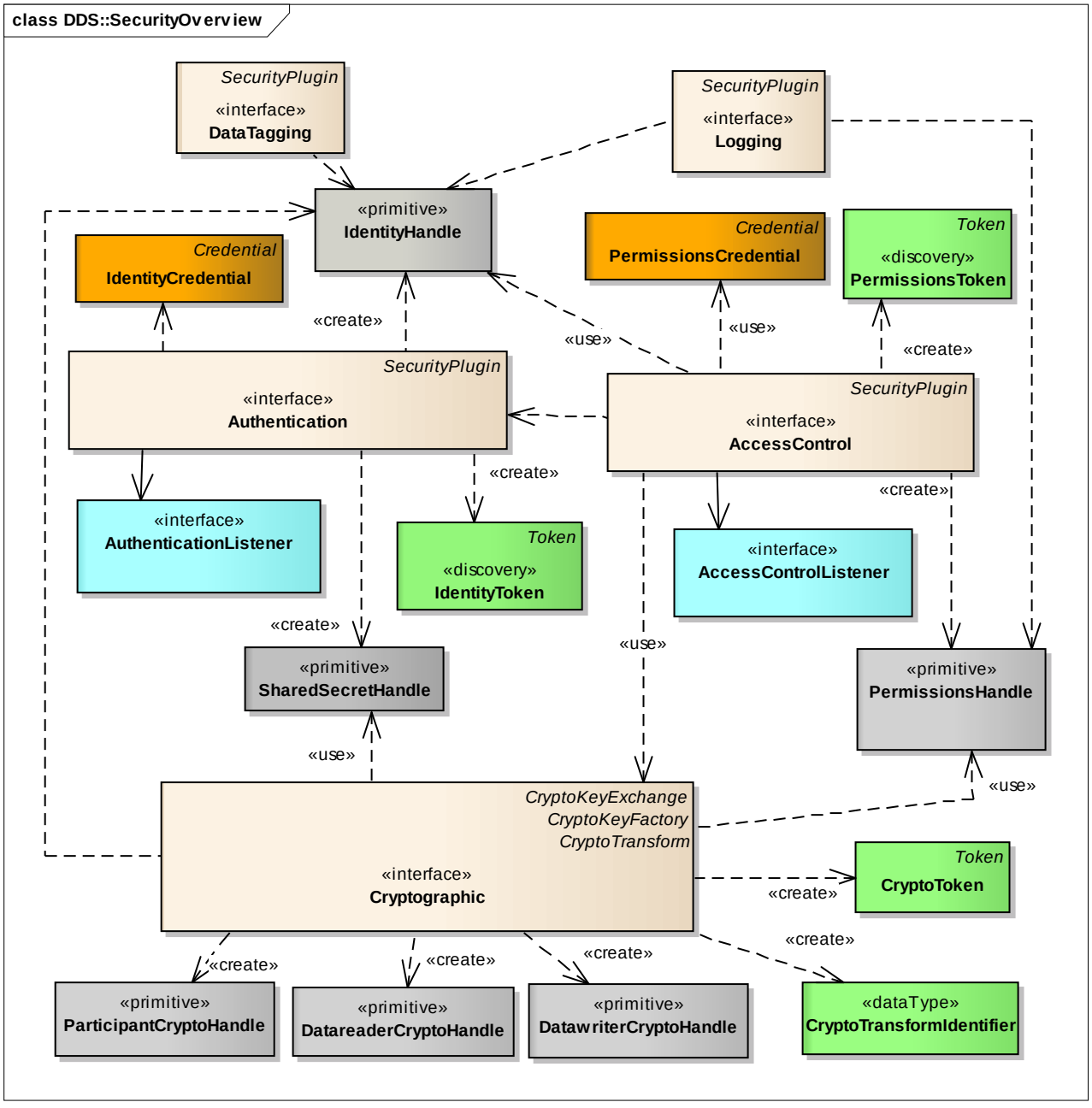


Figure 8 – Plugin Architecture Model

The responsibilities and interactions between these Service Plugins are summarized in the table below and detailed in the sections that follow.

Table 11 – Purpose of each Security Plugin

Service Plugin	*Purpose*	*Interactions*
`Authentication`	Authenticate the principal that is joining a DDS Domain. Support mutual authentication between participants and establish a shared secret.	The principal may be an application/process or the user associated with that application or process.
`AccessControl`	Decide whether a principal is allowed to perform a protected operation.	Protected operations include joining a specific DDS domain, creating a Topic, reading a Topic, writing a Topic, etc.
`Cryptography`	Generate keys. Perform Key Exchange. Perform the encryption and decryption operations. Compute digests, compute and verify Message Authentication Codes. Sign and verify signatures of messages.	This plugin implements 3 complementary interfaces: CryptoKeyFactory, CryptoKeyExchange, and CryptoTransform.
`Logging`	Log all security relevant events	This plugin is accessible to all other plugins such that they can log the relevant events
`DataTagging`	Add a data tag for each data sample	

8.2 Common Types

8.2.1 Security Exception

`SecurityException` is a data type used to hold error information. `SecurityException` objects are potentially returned from many of the calls in the Security plugins. They are used to return an error code and message.

Table 12 – SecurityException class

SecurityException	
Attributes	
`code`	`SecurityExceptionCode`
`minor_code`	`long`
`message`	`String`

8.3 Authentication Plugin

The Authentication Plugin SPI defines the types and operations necessary to support the authentication of DDS `DomainParticipants`.

8.3.1 Background (Non-Normative)

Without the security enhancements, any DDS `DomainParticipant` is allowed to join a DDS `Domain` without authenticating. However, in the case of a secure DDS system, every DDS participant will be required to authenticate to avoid data contamination from unauthenticated participants.

The DDS protocol uses its native discovery mechanism to detects when participants enter the DDS `Domain`.

The discovery mechanism that registers participants with the DDS middleware is enhanced with an authentication protocol. For protected DDS Domains a `DomainParticipant` that enables the authentication plugin will only communicate with another `DomainParticipant` that has the authentication plugin enabled.

The plugin SPI is designed to support multiple implementations with varying numbers of message exchanges. The message exchanges may be used by two DomainParticipant entities to challenge each other so that their identity can be authenticated. Often a shared secret is also derived from a successful authentication message exchange. The shared secret can be used to exchange cryptographic materal in support encryption and message authentication.

8.3.2 Authentication Plugin Model

The Authentication Plugin model is presented in the figure below.

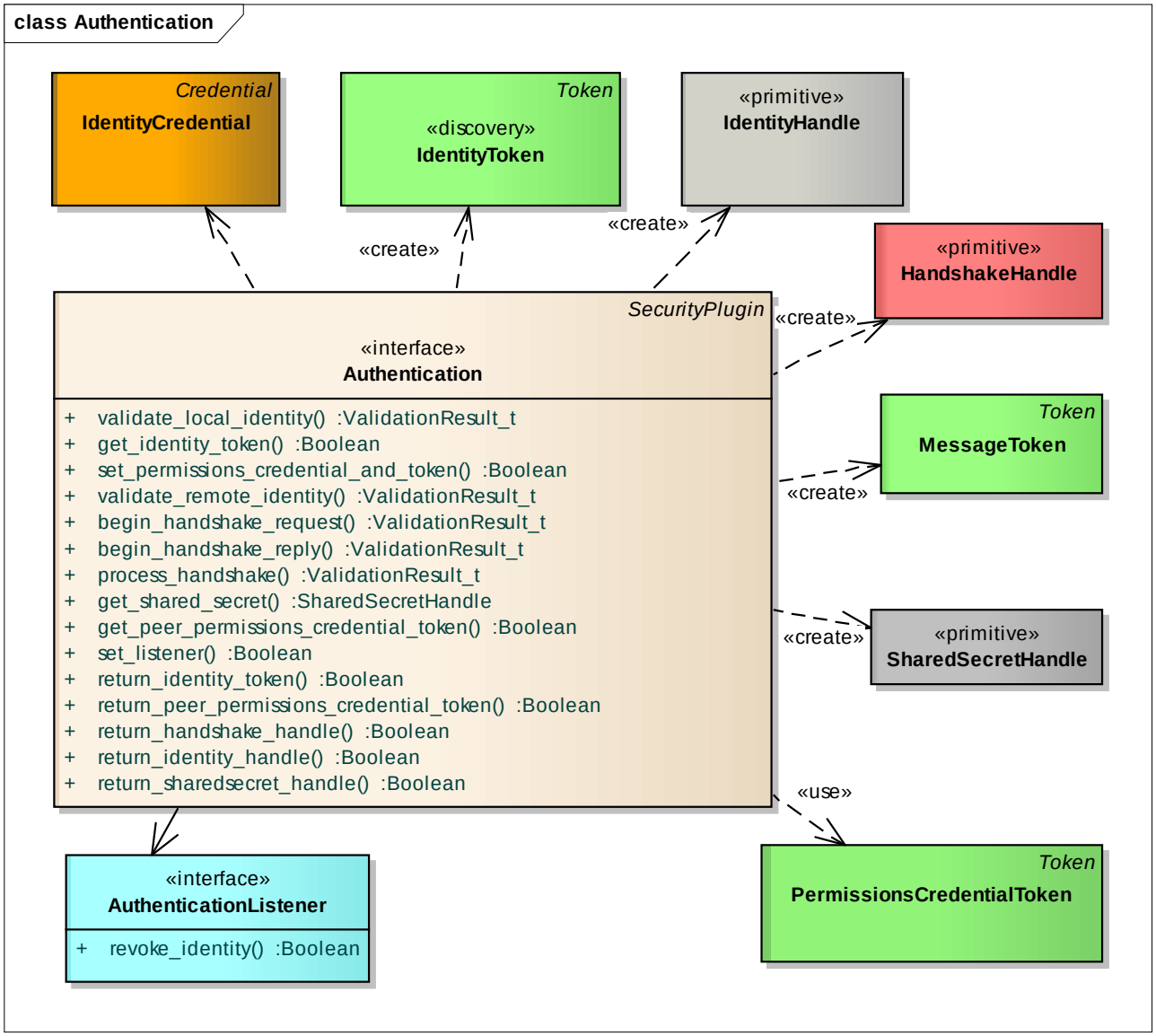


Figure 9 – Authentication plugin model

8.3.2.1 IdentityCredential

The `IdentityCredential` encodes the identity information of a `DomainParticipant` in a manner that can be communicated to the `Authentication` plugin to verify the identity of a local `DomainParticipant`.

The `IdentityCredential` is only used as part of local operations that occur within a single process boundary.

The specific content of the `IdentityCredential` shall be defined by each Authentication plugin specialization and it may not be used by some `Authentication` plugin specializations. The interpretation of the contents as well as the mechanism used to pass it to the `Authentication` plugin shall be specified by each plugin implementation.

8.3.2.2 IdentityToken

An `IdentityToken` contains summary information on the identity of a `DomainParticipant` in a manner that can be externalized and propagated via DDS discovery. The specific content of the `IdentityToken` shall be defined by each `Authentication` plugin specialization. The intent is to provide only summary information on the permissions or derived information such as a hash.

8.3.2.3 IdentityCredentialToken

An `IdentityCredentialToken` contains information on the identity of a `DomainParticipant` in a manner that can be externalized and send over the network. The `IdentityCredentialToken` may be exchanged by the `DomainParticipant` entities as part of the authentication handshake. The specific content of the `IdentityCredentialToken` shall be defined by each `Authentication` plugin specialization.

8.3.2.4 IdentityHandle

An `IdentityHandle` is an opaque local reference to internal state within the `Authentication` plugin, which uniquely identifies a `DomainParticipant`. It is understood only by the `Authentication` plugin and references the authentication state of the `DomainParticipant`. This object is returned by the `Authentication` plugin as part of the validation of the identity of a `DomainParticipant` and is used whenever a client of the `Authentication` plugin needs to refer to the identity of a previously identified `DomainParticipant`.

8.3.2.5 HandshakeHandle

A `HandshakeHandle` is an opaque local reference used to refer to the internal state of a possible mutual authentication or handshake protocol.

8.3.2.6 HandshakeMessageToken

A `HandshakeMessageToken` encodes plugin-specific information that the Authentication plugins associated with two DomainParticipant entities exchange as part of the mutual authentication handshake. The `HandshakeMessageToken` are understood only by the `AuthenticationPlugin` implementations on either side of the handshake. The `HandshakeMessageToken` are sent and received by the DDS implementation under the direction of the `AuthenticationPlugins`.

8.3.2.7 SharedSecretHandle

A `SharedSecretHandle` is an opaque local reference to internal state within the `AuthenticationPlugin` containing a secret that is shared between the `AuthenticationPlugin` implementation and the peer `AuthenticationPlugin` implementation associated with a remote `DomainParticipant.` It is understood only by the two `AuthenticationPlugin` implementations that share the secret. The shared secret is used to encode Tokens, such as the `CryptoToken`, such that they can be exchanged between the two `DomainParticipants` in a secure manner.

8.3.2.8 Authentication

This interface is the starting point for all the security mechanisms. When a `DomainParticipant` is either locally created or discovered, it needs to be authenticated in order to be able to communicate in a DDS `Domain`.

The interaction between the DDS implementation and the Authentication plugin has been designed in a flexible manner so it is possible to support various authentication mechanisms, including those that require a handshake and/or perform mutual authentication between participants. It also supports the establish a shared secret. This interaction is described in the state machine illustrated in the figure below.

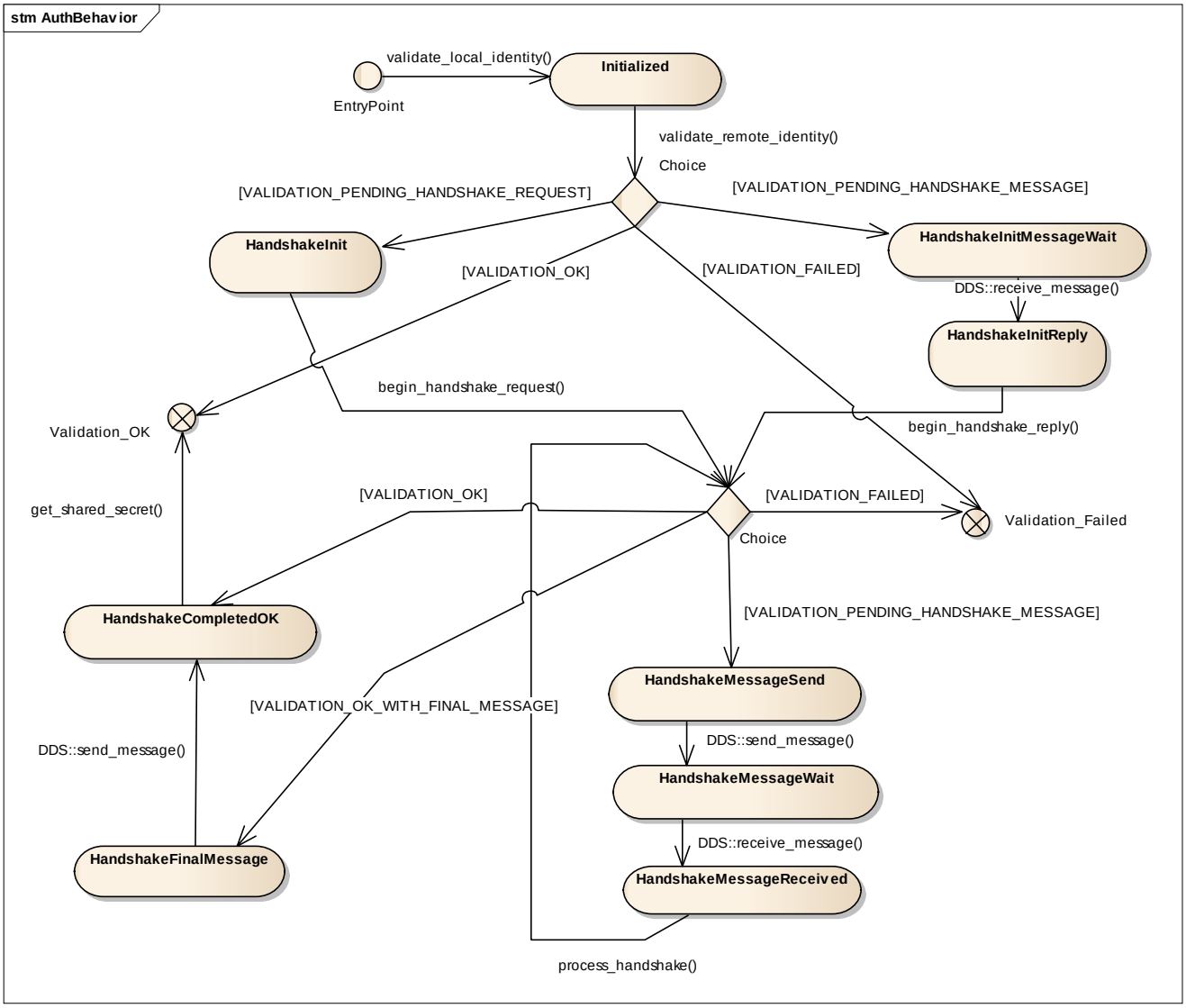


Figure 10 – Authentication plugin interaction state machine

8.3.2.8.1 Reliability of the Authentication Handshake

In order to be sufficiently robust to avert sequence number attacks (7.4.3.1), the Authentication Handshake uses the ***BuiltinParticipantStatelessMessageWriter*** and ***BuiltinParticipantStatelessMessageReader*** endpoints (7.4.3) with `GenericMessageClassId` set to GMCLASSID_SECURITY_AUTH_HANDSHAKE (7.4.3.5). These stateless endpoints send messages best-effort without paying attention to any sequence number information to remove

duplicates or attempt ordered delivery. Despite this, the Authentication Handshake needs to be able to withstand the message loss that may occur on the network.

In order to operate robustly in the presence of message loss and sequence number attacks DDS Security implementations shall follow the rules below:

1. The DDS security implementation shall pass to the AuthenticationPlugin any message received by the ***BuiltinParticipantStatelessMessageReader*** that has a `GenericMessageClassId` set to GMCLASSID_SECURITY_AUTH_HANDSHAKE.
2. Any time the state-machine indicates that a message shall be sent using the ***BuiltinParticipantStatelessMessageWriter*** and a reply message needs to be received by the ***BuiltinParticipantStatelessMessageReader***, the DDS implementation shall cache the message that was sent and set a timer. If a correct reply message is not received when the timer expires, the ***BuiltinParticipantStatelessMessager*** shall send the same message again. This process shall be repeated multiple times until a correct message is received.
3. Whenever a message is sent using the ***BuiltinParticipantStatelessMessageWriter,*** a reply message is received by the ***BuiltinParticipantStatelessMessageReader***. The reply is then passed to the AuthenticationPlugin. If the plugin operation returns VALIDATION_NOT_OK, the implementation transitions back to the previous state that caused the message to be sent and resends the same message.

Rule #2 makes authentication robust to message loss.

Rule #3 makes authentication robust to an attacker trying to disrupt an authentication exchange by sending bad replies.

Example application of rule #2: Assume the DDS implementation transitioned to the *HandshakeMessageSend* state, sent the message M1 and is now in the *HandshakeMessageWait* state waiting for the reply. If not reply is received within an implementation-specific retry-time, the same message M1 shall be sent again and the process repeated until either a reply is received or an implementation-specific timeout elapses (or a maximum number of retries is reached).

Example application of rule #3: Assume the DDS implementation transitioned to the *HandshakeMessageSend* state, sent the message M2, transitions to *HandshakeMessageWait*, receives the reply, transitions to *HandshakeMessageReceived*, calls process_handshake() and the operation returns VALIDATION_NOT_OK. In this situation the DDS implementation shall transition back to *HandshakeMessageSend* and resent M2 again.

8.3.2.9 Unauthenticated DomainParticipant entities

The term “Unauthenticated” `DomainParticipant` entity refers to a discovered `DomainParticipant` that cannot be authenticated by the Authentication plugin. This can be either because they lack support for the `Authentication` plugin being used, have incompatible plugins, or simply fail the authentication protocol.

8.3.2.9.1 Authentication plugin interface

The `Authentication` plugin shall have the operations shown in the table below.

Table 13 – Authentication plugin interface

Authentication
No Attributes

Operations		
validate_local_identity		ValidationResult_t
	out: local_identity_handle	IdentityHandle
	out: adjusted_participant_key	BuiltinTopicKey_t
	credential	IdentityCredential
	candidate_participant_key	BuiltinTopicKey_t
	exception	SecurityException
get_identity_token		Boolean
	out: identity_token	IdentityToken
	handle	IdentityHandle
	exception	SecurityException
set_permissions_credential_and_token		Boolean
	handle	IdentityHandle
	permissions_credential	PermissionsCredential
	permissions_token	PermissionsToken
	exception	SecurityException
validate_remote_identity		ValidationResult_t
	out: remote_identity_handle	IdentityHandle
	local_identity_handle	IdentityHandle
	remote_identity_token	IdentityToken
	remote_participant_key	BuiltinTopicKey_t
	out: exception	SecurityException
begin_handshake_request		ValidationResult_t
	out: handshake_handle	HandshakeHandle
	out: handshake_message	HandshakeMessageToken
	initiator_identity_handle	IdentityHandle
	replier_identity_handle	IdentityHandle

	exception	SecurityException
begin_handshake_reply		ValidationResult_t
	out: handshake_handle	HandshakeHandle
	out: handshake_message_out	HandshakeMessageToken
	handshake_message_in	HandshakeMessageToken
	initiator_identity_handle	IdentityHandle
	replier_identity_handle	IdentityHandle
	out: exception	SecurityException
process_handshake		ValidationResult_t
	out: handshake_message_out	HandshakeMessageToken
	handshake_message_in	HandshakeMessageToken
	handshake_handle	HandshakeHandle
	out: exception	SecurityException
get_shared_secret		SharedSecretHandle
	handshake_handle	HandshakeHandle
	out: exception	SecurityException
get_peer_permissions_credential_token		Boolean
	out: permissions_credential_token	PermissionsCredentialToken
	handshake_handle	HandshakeHandle
	out: exception	SecurityException
set_listener		Boolean
	listener	AuthenticationListener
	out: exception	SecurityException
return_identity_token		Boolean
	token	IdentityToken
	out: exception	SecurityException

return_peer_permissions_credential_token		Boolean
	permissions_redential_token	PermissionsCredentialToken
	out: exception	SecurityException
return_handshake_handle		Boolean
	handshake_handle	HandshakeHandle
	out: exception	SecurityException
return_identity_handle		Boolean
	identity_handle	IdentityHandle
	out: exception	SecurityException
return_sharedsecret_handle		Boolean
	sharedsecret_handle	SharedSecretHandle
	out: exception	SecurityException

8.3.2.9.2 Type: ValidationResult_t

Enumerates the possible return values of the `validate_local_identity` and `validate_remote_identity` operations.

Table 14 – Values for ValidationResult_t

ValidationResult_t	
VALIDATION_OK	Indicates the validation has succeeded
VALIDATION_FAILED	Indicates the validation has failed
VALIDATION_PENDING_RETRY	Indicates that validation is still proceeding. The operation shall be retried at a later point in time.
VALIDATION_PENDING_HANDSHAKE_REQUEST	Indicates that validation of the submitted `IdentityToken` requires sending a handshake message. The DDS Implementation shall call the operation `begin_handshake_request` and send the `HandshakeMessageToken` obtained from this call using the ***InterParticipantStatelessWriter*** with `GenericMessageClassId` set to GMCLASSID_SECURITY_AUTH_HANDSHAKE.
VALIDATION_PENDING_HANDSHAKE_MESSAGE	Indicates that validation is still pending. The DDS Implementation shall wait for a message on the ***InterParticipantStatelessReader*** and, once this is received, call `process_handshake` to pass the information received in that message.
VALIDATION_OK_FINAL_MESSAGE	Indicates that validation has succeeded but the DDS Implementation shall send a final message using the ***InterParticipantStatelessWriter***

	with `GenericMessageClassId` set to GMCLASID_SECURITY_AUTH_HANDSHAKE.

8.3.2.9.3 Operation: `validate_local_identity`

Validates the identity of the local `DomainParticipant`, provided by an `IdentityCredential`. The operation returns as an output parameter the `IdentityHandle`, which can be used to locally identify the local Participant to the `Authentication Plugin`.

In addition to validating the identity, this operation also returns the `DomainParticipant BuiltinTopicKey_t` that shall be used by the DDS implementation to uniquely identify the `DomainParticipant` on the network.

If an error occurs, this method shall return VALIDATION_FAILED and fill the `SecurityException`.

The method shall return either VALIDATION_OK if the validation succeeds, or VALIDATION_FAILED if it fails, or VALIDATION_PENDING_RETRY if the verification has not finished.

If VALIDATION_PENDING_RETRY has been returned, the operation shall be called again after a configurable delay to check the status of verification. This shall continue until the operation returns either VALIDATION_OK (if the validation succeeds), or VALIDATION_FAILED. This approach allows non-blocking interactions with services whose verification may require invoking remote services.

Parameter (out) local_identity_handle: A handle that can be used to locally refer to the Authenticated Participant in subsequent interactions with the `Authentication` plugin. The nature of the handle is specific to each `Authentication` plugin implementation. The handle will only be meaningful if the operation returns VALIDATION_OK.

Parameter (out) adjusted_participant_key: The `BuiltinTopicKey_t` that the DDS implementation shall use to uniquely identify the `DomainParticipant` on the network. The returned ***adjusted_participant_key*** shall be the one that eventually appears in the participant_key attribute of the `ParticipantBuiltinTopicData` sent via discovery.

Parameter credential: A credential that the Authentication plugin implementation may use to validate the identity of the local `DomainParticipant`. The nature and configuration of the credential is specific to each `Authentication` plugin implementation.

Parameter candidate_participant_key: The `BuiltinTopicKey_t` that the DDS implementation would have used to uniquely identify the `DomainParticipant` if the Security plugins were not enabled.

Parameter exception: A `SecurityException` object.

Return: The operation shall return

- VALIDATION_OK if the validation was successful
- VALIDATION_FAILED if it failed.
- VALIDATION_PENDING_RETRY if verification has not completed and the operation should be retried later.

8.3.2.9.4 Operation: `validate_remote_identity`

Initiates the process of validating the identity of the discovered remote `DomainParticipant`, represented as an `IdentityToken` object. The operation returns the `ValidationResult_t` indicating whether the validation succeeded, failed, or is pending a handshake. If the validation succeeds, an `IdentityHandle` object is returned, which can be used to locally identify the remote `DomainParticipant` to the `Authentication` plugin.

If the validation can be performed with the information passed and succeeds, the operation shall return VALIDATION_OK. If it can be performed with the information passed and it fails, it shall return VALIDATION_FAILED.

The validation of a remote participant might require the remote participant to perform a handshake. In this situation, the `validate_remote_identity` operation shall return VALIDATION_PENDING_HANDSHAKE_REQUEST or VALIDATION_PENDING_HANDSHAKE_MESSAGE.

If the operation returns VALIDATION_PENDING_HANDSHAKE_REQUEST, then the DDS implementation shall call the operation `begin_handshake_request` to continue the validation process.

If the operation returns VALIDATION_PENDING_HANDSHAKE_MESSAGE, then the DDS implementation shall wait until it receives a `InterParticipantStatelessMessage` from the remote participant identified by the ***remote_participant_key*** using the contents described in 8.3.2.9.6 and then call the operation `begin_handshake_reply.`

If an error occurs, this method shall return VALIDATION_FAILED and fill the `SecurityException`.

Parameter remote_identity_token : A token received as part of `ParticipantBuiltinTopicData,` representing the identity of the remote `DomainParticipant`.

Parameter local_identity_handle: A handle to the local `DomainParticipant` requesting the remote participant to be validated. The local handle shall be the result of an earlier call to `validate_local_identity`.

Parameter (out) remote_identity_handle: A handle that can be used to locally refer to the remote Authenticated Participant in subsequent interactions with the `AuthenticationPlugin`. The nature of the **remote_identity_handle** is specific to each `AuthenticationPlugin` implementation. The handle will only be provided if the operation returns something other than VALIDATION_FAILED.

Parameter exception: A SecurityException object.

Return: The operation shall return:

- VALIDATION_OK if the validation was successful.
- VALIDATION_FAILED if it failed.
- VALIDATION_PENDING_HANDSHAKE_REQUEST if validation has not completed. If this is returned, the DDS implementation shall call `begin_handshake_request`, to continue the validation.

- VALIDATION_PENDING_HANDSHAKE_MESSAGE if validation has not completed. If this is returned, the DDS implementation shall wait for a message on the ***InterParticipantStatelessReader*** with the ***message_identity*** containing a ***source_guid*** that matches the ***remote_participant_key*** and a ***message_class_id*** set to GMCLASSID_SECURITY_AUTH_HANDSHAKE.
- VALIDATION_PENDING RETRY if the validation has not completed. If this is returned, the operation should be called again at a later point in time to check the validation status.

8.3.2.9.5 Operation: `begin_handshake_request`

This operation is used to initiate a handshake. It shall be called by the DDS middleware solely as a result of having a previous call to `validate_remote_identity` returns VALIDATION_PENDING_HANDSHAKE_REQUEST.

This operation returns a `HandshakeMessageToken` that shall be used to send a handshake to the remote participant identified by the ***replier_identity_handle***.

The contents of the `HandshakeMessageToken` are specified by the plugin implementation.

If an error occurs, this method shall return VALIDATION_FAILED and fill the `SecurityException`.

Parameter (out) handshake_handle: A handle returned by the `Authentication` plugin used to keep the state of the handshake. It is passed to other operations in the `Authentication` plugin.

Parameter (out) handshake_message_token: A `HandshakeMessageToken` to be sent using the ***InterParticipantStatelessWriter.*** The contents shall be specified by each plugin implementation.

Parameter initiator_identity_handle: Handle to the local participant that originated the handshake.

Parameter replier_identity_handle: Handle to the remote participant whose identity is being validated.

Parameter exception: A `SecurityException` object.

Return: The operation shall return:

- VALIDATION_OK if the validation was successful.
- VALIDATION_FAILED if it failed.
- VALIDATION_PENDING_HANDSHAKE_MESSAGE if validation has not completed. If this is returned, the DDS implementation shall send the ***handshake_message_out*** using the ***InterParticipantStatelessWriter*** and then wait for the reply message on the ***InterParticipantStatelessReader.*** The DDS implementation shall set the `InterParticipantStatelessMessage participantGuidPrefix` message_class_id to GMCLASSID_SECURITY_AUTH_HANDSHAKE and fill the ***message_data*** with the ***handshake_message*** `HandshakeMessageToken` and set the ***destination_participant_key*** to match the DDS `BuiltinTopicKey_t` of the destination `DomainParticipant`. When the reply message is received the DDS implementation shall call the operation `begin_handshake_reply`, to continue the validation.
- VALIDATION_OK_FINAL_MESSAGE if the validation succeeded. If this is returned, the DDS implementation shall send the returned ***handshake_message*** using the ***InterParticipantStatelessReader.***

- VALIDATION_PENDING RETRY if the validation has not completed. If this is returned, the DDS implementation shall call the operation again at a later point in time to check the validation status.

In the cases where the return code indicates that a message shall be sent using the ***InterParticipantStatelessWriter,*** the DDS implementation shall set the `InterParticipantStatelessMessage` as follows:

- The ***message_class_id*** shall be set to `GMCLASSID_SECURITY_AUTH_HANDSHAKE`.
- The ***destination_participant_key*** shall be set to match the DDS `BuiltinTopicKey_t` of the destination `DomainParticipant`.
- The ***message_identity*** shall be set to have the ***source_guid*** matching the DDS `BuiltinTopicKey_t` of the `DomainParticipant` that is sending the message and the ***sequence_number*** to the value in the previous message sent by the ***InterParticipantStatelessWriter,*** incremented by one.
- The ***related_message_identity*** shall be set with ***source_guid*** as ***GUID_UNKNOWN*** and ***sequence_number*** to zero.
- The ***message_data*** shall be filled with the CDR serialization of the ***handshake_message*** `HandshakeMessageToken.`

8.3.2.9.6 Operation: `begin_handshake_reply`

This operation shall be invoked by the DDS implementation in reaction to the reception of the initial handshake message that originated on a `DomainParticipant` that called the `begin_handshake_request` operation. It shall be called by the DDS implementation solely as a result of having a previous call to `validate_remote_identity` returns VALIDATION_PENDING_HANDSHAKE_MESSAGE and having received a message on the ***InterParticipantStatelessReader*** with attributes set as follows:

- ***message_class_id*** `GMCLASSID_SECURITY_AUTH_HANDSHAKE`
- ***message_identity source_guid*** matching the `BuiltinTopicKey_t` of the `DomainParticipant` associated with the ***initiator_identity_handle***
- ***destination_participant_key*** matching the `BuiltinTopicKey_t` of the receiving `DomainParticipant`

This operation generates a ***handshake_message_out*** in response to a received ***handshake_message_in***. Depending on the return value of the operation, the DDS implementation shall send the ***handshake_message_out*** using the ***InterParticipantStatelessWriter*** to the participant identified by the ***initiator_identity_handle***.

The contents of the ***handshake_message_out*** `HandshakeMessageToken` are specified by the plugin implementation.

If an error occurs, this method shall return VALIDATION_FAILED and fill the `SecurityException`.

Parameter (out) handshake_handle: A handle returned by the Authentication Plugin used keep the state of the handshake. It is passed to other operations in the Plugin.

Parameter (out) handshake_message_out: A `HandshakeMessageToken` containing a message to be sent using the ***InterParticipantStatelessWriter.*** The contents shall be specified by each plugin implementation.

Parameter handshake_message_in: A `HandshakeMessageToken` containing a message received from the ***InterParticipantStatelessReader.*** The contents shall be specified by each plugin implementation.

Parameter initiator_identity_handle: Handle to the remote participant that originated the handshake.

Parameter replier_identity_handle: Handle to the local participant that is initiating the handshake response.

Parameter exception: A `SecurityException` object.

Return: The operation shall return:

- VALIDATION_OK if the validation was successful.
- VALIDATION_FAILED if it failed.
- VALIDATION_PENDING_HANDSHAKE_MESSAGE if validation has not completed. If this is returned, the DDS implementation shall send the ***handshake_message_out*** using the ***InterParticipantStatelessWriter*** and then wait for a reply message on the ***InterParticipantStatelessReader*** from that remote `DomainParticipant`.
- VALIDATION_OK_FINAL_MESSAGE if the validation succeeded. If this is returned, the DDS implementation shall send the returned ***handshake_message_out*** using the ***InterParticipantStatelessWriter.***
- VALIDATION_PENDING RETRY if the validation has not completed. If this is returned, the DDS implementation shall call the operation again at a later point in time to check the validation status.

In cases where the return code indicates that a message shall be sent using the ***InterParticipantStatelessWriter,*** the DDS implementation shall set the `InterParticipantStatelessMessage` as follows:

- The ***message_class_id*** shall be set to `GMCLASSID_SECURITY_AUTH_HANDSHAKE`.
- The ***destination_participant_key*** shall be set to match the DDS `BuiltinTopicKey_t` of the destination `DomainParticipant`.
- The ***message_identity*** shall be set to have the ***source_guid*** matching the DDS `BuiltinTopicKey_t` of the `DomainParticipant` that is sending the message and the ***sequence_number*** to the value in the previous message sent by the ***InterParticipantStatelessWriter,*** incremented by one.
- The ***related_message_identity*** shall be set to match the ***message_identity*** of the `InterParticipantStatelessMessage` received that triggered the execution of the `begin_handshake_reply` operation.
- The ***message_data*** shall be filled with the CDR serialization of the ***handshake_message_out*** `HandshakeMessageToken.`

8.3.2.9.7 Operation: `process_handshake`

This operation is used to continue a handshake. It shall be called by the DDS middleware solely as a result of having a previous call to ***begin_handshake_request*** or ***begin_handshake_reply*** that returned VALIDATION_PENDING_HANDSHAKE_MESSAGE and having also received a `InterParticipantStatelessMessage` on the ***InterParticipantStatelessReader*** with attributes set as follows:

- ***message_class_id*** `GMCLASSID_SECURITY_AUTH_HANDSHAKE`

- ***message_identity source_guid*** matching the `BuiltinTopicKey_t` of the peer `DomainParticipant` associated with the ***handshake_handle***
- ***related_message_identity*** matching the ***message_identity*** of the last `InterParticipantStatelessMessage` sent to the peer DomainParticipant associated with the ***handshake_handle***.
- ***destination_participant_key*** matching the `BuiltinTopicKey_t` of the receiving `DomainParticipant`.

This operation generates a ***handshake_message_out*** `HandshakeMessageToken` in response to a received ***handshake_message_in*** `HandshakeMessageToken`. Depending on the return value of the function the DDS implementation shall send the ***handshake_message_out*** using the ***InterParticipantStatelessWriter*** to the peer participant identified by the ***handshake_handle***.

The contents of the ***handshake_message_out*** `HandshakeMessageToken` are specified by the plugin implementation.

If an error occurs, this method shall return VALIDATION_FAILED and fill the `SecurityException`.

Parameter (out) handshake_message_out: A `HandshakeMessageToken` containing the ***message_data*** that should be placed in a `InterParticipantStatelessMessage` to be sent using the ***InterParticipantStatelessWriter.*** The contents shall be specified by each plugin implementation.

Parameter handshake_message_in: The `HandshakeMessageToken` contained in the ***message_data*** attribute of the `InterParticipantStatelessMessage` received**.** The interpretation of the contents shall be specified by each plugin implementation.

Parameter handshake_handle: Handle returned by a corresponding previous call to ***begin_handshake_request*** or ***begin_handshake_reply***.

Parameter exception: A `SecurityException` object.

Return: The operation shall return:

- VALIDATION_OK if the validation was successful.
- VALIDATION_FAILED if it failed.
- VALIDATION_PENDING_HANDSHAKE_MESSAGE if validation has not completed. If this is returned, the DDS implementation shall send an `InterParticipantStatelessMessage` continuing the returned ***handshake_message_out*** using the ***InterParticipantStatelessWriter*** and then wait for a reply message on the ***InterParticipantStatelessReader*** from that remote `DomainParticipant`.
- VALIDATION_OK_FINAL_MESSAGE if the validation succeeded. If this is returned, the DDS implementation shall send a `InterParticipantStatelessMessage` containing the returned ***handshake_message_out*** using the ***InterParticipantStatelessWriter*** but not wait for any replies**.**
- VALIDATION_PENDING RETRY if the validation has not completed. If this is returned, the DDS implementation shall call the operation again at a later point in time to check the validation status.

In the cases where the return code indicates that a `InterParticipantStatelessMessage` shall be sent using the ***InterParticipantStatelessWriter*** the DDS implementation shall set the fields of the `InterParticipantStatelessMessage` as follows:

- The ***message_class_id*** shall be set to `GMCLASSID_SECURITY_AUTH_HANDSHAKE`.
- The ***destination_participant_key*** shall be set to match the DDS `BuiltinTopicKey_t` of the destination `DomainParticipant`.
- The ***message_identity*** shall be set to have the ***source_guid*** matching the DDS `BuiltinTopicKey_t` of the `DomainParticipant` that is sending the message and the ***sequence_number*** to the value in the previous message sent by the ***InterParticipantStatelessWriter,*** incremented by one.
- The ***related_message_identity*** shall be set to match the ***message_identity*** of the `InterParticipantStatelessMessage` received that triggered the execution of the `begin_handshake_reply` operation.
- The ***message_data*** shall be filled with the CDR serialization of the ***handshake_message_out*** `HandshakeMessageToken.`

8.3.2.9.8 Operation: get_shared_secret

Retrieves the `SharedSecretHandle` resulting with a successfully completed handshake.

This operation shall be called by the DDS middleware after on each `HandshakeHandle` after the handshake that uses that handle completes successfully, that is after the last ‘handshake’ operation called on that handle (`begin_handshake_request`, `begin_handshake_reply`, `or process_handshake`) returns VALIDATION_OK or VALIDATION_OK_FINAL_MESSAGE.

The retrieved `SharedSecretHandle` shall be used by the DDS middleware in conjunction with the `CryptoKeyExchange` interface of the `Cryptographic` Plugin to exchange cryptographic key material with other `DomainParticipant` entities.

If an error occurs, this method shall return the `NILHandle` and fill the `SecurityException`.

Parameter handshake_handle: Handle returned by a corresponding previous call to ***begin_handshake_request*** or ***begin_handshake_reply***, which has successfully completed the handshake operations.

Parameter exception: A `SecurityException` object.

8.3.2.9.9 Operation: get_peer_permissions_credential_token

Retrieves the `PermissionsCredentialToken` resulting with a successfully completed authentication of a discovered `DomainParticipant`.

This operation shall be called by the DDS middleware on each `HandshakeHandle` after the handshake that uses that handle completes successfully, that is after the last ‘handshake’ operation called on that handle (`begin_handshake_request`, `begin_handshake_reply`, `or process_handshake`) returns VALIDATION_OK or VALIDATION_OK_FINAL_MESSAGE.

The retrieved `PermissionsCredentialToken` shall match the `PermissionsCredentialToken` that was set using the operation

set_permissions_credential_and_token on the peer DomainParticipant that completed the handshake represented by the HandshakeHandle.

If an error occurs, this method shall return false and fill the SecurityException.

Parameter permissions_credential_token (out): A placeholder for the returned PermissionsCredentialToken.

Parameter handshake_handle: HandshakeHandle returned by a corresponding previous call to begin_handshake_request or begin_handshake_reply, which has successfully completed the handshake operations.

Parameter exception: A SecurityException object.

8.3.2.9.10 Operation: get_identity_token

Retrieves an IdentityToken used to represent on the network the identity of the DomainParticipant identified by the specified IdentityHandle.

Parameter identity_token (out): The returned IdentityToken.

Parameter handle: The handle used to locally identify the DomainParticipant for which an IdentityToken is desired. The handle must have been returned by a successful call to validate_local_identity, otherwise the operation shall return false and fill the SecurityException.

Parameter exception: A SecurityException object.

Return: If an error occurs, this method shall return false and fill the SecurityException. otherwise it shall return the IdentityToken.

8.3.2.9.11 Operation: set_permissions_credential_and_token

Associates the PermissionsCredentialToken (see 8.4.2.3) and the PermissionsToken (see 8.4.2.2) returned by the AccessControl plugin operation get_permissions_credential_token and get_permissions_token with the local DomainParticipant identified by the IdentityHandle.

This operation shall be called by the middleware after calling validate_local_identity and prior to any calls to validate_remote_identity.

Parameter handle: The handle used to locally identify the DomainParticipant whose PermissionsCredential is being supplied. The handle must have been returned by a successful call to ***validate_local_identity***, otherwise the operation shall return false and fill the SecurityException.

Parameter permissions_credential_token: The PermissionsCredentialToken associated with the DomainParticipant identified by the IdentityHandle. The ***permissions_credential_token*** must have been returned by a successful call to get_permissions_credential_token, on the AccessControl plugin. Otherwise the operation shall return false and fill the SecurityException.

Parameter permissions_token: The `PermissionsToken` associated with the `DomainParticipant` identified by the `IdentityHandle`. The permissions_token must have been returned by a successful call to ***get_permissions_token***, on the `AccessControl` plugin. Otherwise the operation shall return false and fill the `SecurityException`.

Parameter exception: A `SecurityException` object.

Return: If an error occurs, this method shall return `false`, otherwise it shall return `true`.

8.3.2.9.12 Operation: set_listener

Sets the `AuthenticationListener` that the `Authentication` plugin will use to notify the DDS middleware infrastructure of events relevant to the Authentication of DDS Participants.

If an error occurs, this method shall return `false` and fill the `SecurityException`.

Parameter listener: An `AuthenticationListener` object to be attached to the `Authentication` object. If this argument is `nil`, it indicates that there shall be no listener.

Parameter exception: A `SecurityException` object, which provides details in case the operation returns `false`.

8.3.2.9.13 Operation: return_identity_token

Returns the `IdentityToken` object to the plugin so it can be disposed of.

Parameter token: An `IdentityToken` issued by the plugin on a prior call to `get_identity_token`.

Parameter exception: A `SecurityException` object, which provides details in the case this operation returns `false`.

8.3.2.9.14 Operation: return_peer_permissions_credential_token

Returns the `PermissionsCredentialToken` object to the plugin so it can be disposed of.

Parameter permissions_credential_token: A `PermissionsCredentialToken` issued by the plugin on a prior call to `get_peer_permissions_credential_token`.

Parameter exception: A `SecurityException` object, which provides details in the case this operation returns `false`.

8.3.2.9.15 Operation: return_handshake_handle

Returns the `HandshakeHandle` object to the plugin so it can be disposed of.

Parameter handshake_handle: A `HandshakeHandle` issued by the plugin on a prior call to ***begin_hadshake_request*** or ***begin_handshake_reply***.

Parameter exception: A `SecurityException` object, which provides details in the case this operation returns `false`.

8.3.2.9.16 Operation: return_identity_handle

Returns the `IdentityHandle` object to the plugin so it can be disposed of.

Parameter identity_handle: An `IdentityHandle` issued by the plugin on a prior call to ***validate_local_identity*** or ***validate_remote_identity***.

Parameter exception: A `SecurityException` object, which provides details in the case this operation returns `false`.

8.3.2.9.17 Operation: return_sharedsecret_handle

Returns the `SharedSecretHandle` object to the plugin so it can be disposed of.

Parameter sharedsecret_handle: An `IdentityHandle` issued by the plugin on a prior call to ***get_shared_secret***.

Parameter exception: A `SecurityException` object, which provides details in the case this operation returns `false`.

8.3.2.10 AuthenticationListener

The `AuthenticationListener` provides the means for notifying the DDS middleware infrastructure of events relevant to the authentication of DDS `DomainParticipant` entities. For example, identity certificates can expire; in this situation, the `AuthenticationListener` shall call the `AuthenticationListener` to notify the DDS implementation that the identity of a specific `DomainParticipant` is being revoked.

Table 15 – Authentication listener class

AuthenticationListener		
No Attributes		
Operations		
`on_revoke_identity`		`Boolean`
	`plugin`	`Authentication`
	`handle`	`IdentityHandle`
	`exception`	`SecurityException`

8.3.2.10.1 Operation: on_revoke_identity

Revokes the identity of the participant identified by the `IdentityHandle`. The corresponding `IdentityHandle` becomes invalid. As a result of this, the DDS middleware shall terminate any communications with the `DomainParticipant` associated with that handle.

If an error occurs, this method shall return `false`.

Parameter plugin: An `Authentication` plugin object that has this listener allocated.

Parameter handle: An `IdentityHandle` object that corresponds to the Identity of a DDS Participant whose identity is being revoked.

8.4 Access Control Plugin

The Access Control Plugin API defines the types and operations necessary to support an access control mechanism for DDS `DomainParticipants`.

8.4.1 Background (Non-Normative)

Once a `DomainParticipant` is authenticated, its permissions need to be validated and enforced. Permissions or access rights are often described using an access control matrix where the rows are subjects (i.e., users), the columns are objects (i.e., resources), and a cell defines the access rights that a given subject has over a resource. Typical implementations provide either a column-centric view (i.e., access control lists) or a row-centric view (i.e., a set of capabilities stored with each subject). With the proposed `AccessControl` SPI, both approaches can be supported.

Before we can describe the access control plugin SPI, we need to define the permissions that can be attached to a `DomainParticipant`. Every DDS application uses a `DomainParticipant` to access or produce information on a `Domain`; hence the `DomainParticipant` has to be allowed to run in a certain `Domain`. Moreover, a `DomainParticipant` is responsible for creating `DataReaders` and `DataWriters` that communicate over a certain `Topic`. Hence, a `DomainParticipant` has to have the permissions needed to create a `Topic`, to publish through its `DataWriters` certain `Topics`, and to subscribe via its `DataReaders` to certain `Topics`. There is a very strong relationship between the `AccessControl` plugin and the `Cryptographic` plugin because encryption keys need to be generated for `DataWriters` based on the `DomainParticipant`'s permissions.

8.4.2 AccessControl Plugin Model

The `AccessControl` plugin model is presented in the figure below.

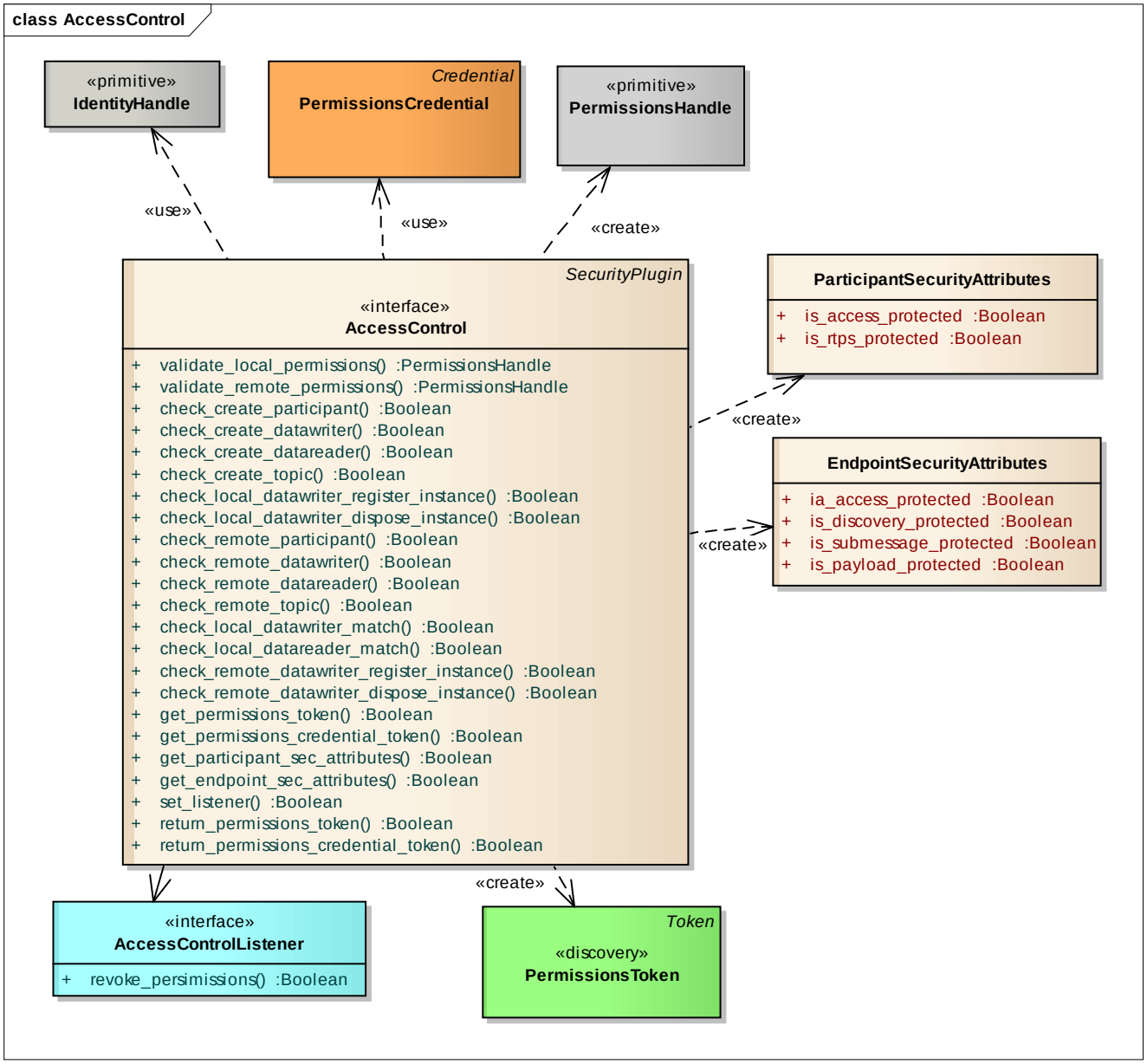


Figure 11 – AccessControl Plugin Model

8.4.2.1 PermissionsCredential

The `PermissionsCredential` encodes the permissions and access information for a `DomainParticipant` in a manner that can be communicated to the `AccessControl` plugin to verify the permissions of a local `DomainParticipant` and perform all the access-control decisions related to the local `DomainParticipant`, including determining whether it can join a domain, create local `DataWriters` or `DataReaders`, etc.

The `PermissionsCredential` is only used as part of local operations that occur within a single process boundary.

The specific content of the `PermissionsCredential` shall be defined by each `AccessControl` plugin specialization and it may not be used by some `AccessControl` plugin

specializations. The interpretation of the contents as well as the mechanism used to pass it to the `AccessControl` plugin shall be specified by each plugin implementation.

8.4.2.2 PermissionsToken

A `PermissionsToken` contains summary information on the permissions for a `DomainParticipant` in a manner that can be externalized and propagated over DDS discovery. The specific content of the `PermissionsToken` shall be defined by each `AccessControlPlugin` specialization. The intent is to provide only summary information on the permissions or derived information such as a hash.

8.4.2.3 PermissionsCredentialToken

A `PermissionsCredentialToken` encodes the permissions and access information for a `DomainParticipant` in a manner that can be externalized and sent over the network. The `PermissionsCredential` is used by the `AccessControl` plugin to verify the permissions of a peer `DomainParticipant` and perform all the access-control decisions related to that peer `DomainParticipant`, including determining whether it can join a domain, match specific local `DataWriters` or `DataReaders`, etc.

The `PermissionsCredentialToken` is intended for dissemination during the authentication handshake. The specific content of the `PermissionsCredentialToken` shall be defined by each `AccessControl` plugin specialization and it may not be used by some `AccessControl` plugin specializations.

8.4.2.4 PermissionsHandle

A `PermissionsHandle` is an opaque local reference to internal state within the `AccessControl` plugin. It is understood only by the `AccessControl` plugin and characterizes the permissions associated with a specific `DomainParticipant.` This object is returned by the `AccessControl` plugin as part of the validation of the permissions of a `DomainParticipant` and is used whenever a client of the `AccessControl` plugin needs to refer to the permissions of a previously validated `DomainParticipant`.

8.4.2.5 ParticipantSecurityAttributes

The `ParticipantSecurityAttributes` describe how the middleware should protect the `DomainParticipant`. This is a structured type whose members are described in the table below:

Table 16 – Description of the ParticipantSecurityAttributes

Member	Type	Meaning
allow_unauthenticated_participants	Boolean	Indicates whether the DomainParticipant shall only match discovered DomainParticipants that Authenticate successfully. If ***allow_unauthenticated_participants*** is TRUE, the DomainParticipant shall match other DomainParticipants—even if the remote DomainParticipant cannot authenticate. If ***allow_unauthenticated_participants*** is FALSE, the

		DomainParticipant shall enforce the authentication of remote DomainParticipants and only match those that successfully authenticate.
is_access_protected	Boolean	Indicates whether the matching of the DomainParticipant with a remote DomainParticipant that has successfully authenticated is protected by the AccessControl plugin. If ***is_access_protected*** is FALSE, the DomainParticipant shall automatically match other DomainParticipants that authenticate successfully. If ***is_access_protected*** is TRUE, the DomainParticipant shall call the validate_remote_permissions operation on the discovered DomainParticipant entities that successfully authenticate and only match those for which the validate_remote_permissions operation returns TRUE.
is_rtps_protected	Boolean	Indicates whether the whole RTPS Message needs to be transformed by the CryptoTransform operation encode_rtps_message. If ***is_rtps_protected*** is TRUE then: (1) The DDS middleware shall call the operations on the CryptoKeyFactory for the DomainParticipant. (2) The DDS middleware shall call the operations on the CryptoKeyExchange for matched DomainParticipants that have been authenticated. (3) The RTPS messages sent by the DomainParticiapant to matched DomainParticipants that have been authenticated shall be transformed using the CryptoTransform operation encode_rtps_message and the messages received from the matched authenticated DomainParticipants shall be transformed using the CryptoTransform operation decode_rtps_message. If ***is_rtps_protected*** is FALSE then the above actions shall not be taken.

8.4.2.6 EndpointSecurityAttributes

The `EndpointSecurityAttributes` describe how the middleware shall protect the Entity. This is a structured type, whose members are described in the table below:

Table 17 – Description of the EndpointSecurityAttributes

Member	Type	Meaning
is_access_protected	Boolean	Indicates if the access to the Entity by a matching Entity is protected. If ***access is_access_protected*** is FALSE, the entity shall be matched without further access-control mechanisms imposed on remote entities that match it. Otherwise the entity match

		shall be checked using the AccessControl plugin operations.
is_discovery_protected	Boolean	Indicates the discovery information for the entity shall be sent using a secure builtin discovery topics or the regular builtin discovery topics: If ***is_discoverye_protected*** is TRUE then discovery information for that entity shall be sent using the ***SEDPbuiltinPublicationsSecureWriter SEDPbuiltinPublicationsSecureReader.*** If ***is_discoverye_protected*** is FALSE then discovery information for that entity shall be sent using the ***SEDPbuiltinPublicationsWriter*** or ***SEDPbuiltinSubscriptionsSecureWriter.***
is_submessage_protected	Boolean	Indicates the DDS middleware shall call the operations on the CryptoKeyFactory, CryptoKeyExchange, and CryptoTransform for the entity: If ***is_submessage_protected*** is TRUE then the CryptoKeyFactory, CryptoKeyExchange operations shall be called for that entitity to create the associated cryptographic material and send it to the matched entities. If ***is_submessage_protected*** is FALSE then the CryptoKeyFactory, CryptoKeyExchange and CryptoTransform operations are called only if is_payload_protected is TRUE. If ***is_submessage_protected*** is TRUE and the entity is a DataWriter the submessages sent by the DataWriter shall be transformed using the CryptoTransform operation encode_datawriter_submessage and the messages received from the matched DataReaders shall be transformed using the CryptoTransform operation decode_datareader_submessage. If ***is_submessage_protected*** is TRUE and the entity is a DataReader the submessages sent by the DataReader shall be transformed using the CryptoTransform operation encode_datareader_submessage and the messages received from the matched DataWriters shall be transformed using the CryptoTransform operation decode_datawriter_submessage.
is_payload_protected	Boolean	Indicates the DDS middleware shall call the operations on the CryptoKeyFactory, CryptoKeyExchange, and CryptoTransform for the entity. If ***is_payload_protected*** is TRUE then the CryptoKeyFactory, CryptoKeyExchange operations shall be called for that entitity to create the associated cryptographic material and send it to the matched entities. If ***is_payload_protected*** is FALSE then the CryptoKeyFactory, CryptoKeyExchange and CryptoTransform operations are called only if is_payload_protected is TRUE.

		If ***is_ payload_protected*** is TRUE and the entity is a DataWriter the serialized data sent by the DataWriter shall be transformed by calling encode_serialized_data. If ***is_ payload_protected*** is TRUE and the entity is a DataReader the serialized data received by the DataReader shall be transformed by calling decode_serialized_data

8.4.2.7 AccessControl interface

Table 18 – AccessControl Interface

AccessControl		
No Attributes		
Operations		
`validate_local_permissions`		`PermissionsHandle`
	`auth_plugin`	`AuthenticationPlugin`
	`identity`	`IdentityHandle`
	`credential`	`PermissionsCredential`
	`out: exception`	`SecurityException`
`validate_remote_permissions`		`PermissionsHandle`
	`auth_plugin`	`AuthenticationPlugin`
	`local_identity_handle`	`IdentityHandle`
	`remote_identity_handle`	`IdentityHandle`
	`remote_permissions_token`	`PermissionsToken`
	`remote_permissions_credential_token`	`PermissionsCredentialToken`
	`out: exception`	`SecurityException`
`check_create_participant`		`Boolean`
	`permissions_handle`	`PermissionsHandle`
	`domain_id`	`DomainId_t`
	`qos`	`DomainParticipantQoS`

	out: exception	SecurityException
check_create_datawriter		Boolean
	permissions_handle	PermissionsHandle
	domain_id	DomainId_t
	topic_name	String
	qos	DataWriterQoS
	partition	PartitionQosPolicy
	data_tag	DataTag
	out: exception	SecurityException
check_create_datareader		Boolean
	permissions_handle	PermissionsHandle
	domain_id	DomainId_t
	topic_name	String
	qos	DataReaderQoS
	partition	PartitionQosPolicy
	data_tag	DataTag
	out: exception	SecurityException
check_create_topic		Boolean
	permissions_handle	PermissionsHandle
	domain_id	DomainId_t
	topic_name	String
	property	Properties
	qos	TopicQoS
	out: exception	SecurityException
check_local_datawriter_register_instance		Boolean
	permissions_handle	PermissionsHandle
	writer	DataWriter
	key	DynamicData

	out: exception	SecurityException
check_local_datawriter_dispose_instance		Boolean
	permissions_handle	PermissionsHandle
	writer	DataWriter
	key	DynamicData
	out: exception	SecurityException
check_remote_participant		Boolean
	permissions_handle	PermissionsHandle
	domain_id	DomainId_t
	participant_data	ParticipantBuiltinTopicDataSecure
	out: exception	SecurityException
check_remote_datawriter		Boolean
	permissions_handle	PermissionsHandle
	domain_id	DomainId_t
	publication_data	PublicationBuiltinTopicDataSecure
	out: exception	SecurityException
check_remote_datareader		Boolean
	permissions_handle	PermissionsHandle
	domain_id	DomainId_t
	subscription_data	SubscriptionBuiltinTopicDataSecure
	out: relay_only	Boolean
	out: exception	SecurityException
check_remote_topic		Boolean
	permissions_handle	PermissionsHandle
	DomainId_t	domain_id

	topic_data	TopicBuiltinTopicData
	out: exception	SecurityException
check_local_datawriter_match		Boolean
	writer_permissions_handle	PermissionsHandle
	reader_permissions_handle	PermissionsHandle
	writer_data_tag	DataTag
	reader_data_tag	DataTag
	out: exception	SecurityException
check_local_datareader_match		Boolean
	reader_permissions_handle	PermissionsHandle
	writer_permissions_handle	PermissionsHandle
	reader_data_tag	DataTag
	writer_data_tag	DataTag
	out: exception	SecurityException
check_remote_datawriter_register_instance		Boolean
	permissions_handle	PermissionsHandle
	reader	DataReader
	publication_handle	InstanceHandle_t
	key	DynamicData
	instance_handle	InstanceHandle_t
	out: exception	SecurityException
check_remote_datawriter_dispose_instance		Boolean
	permissions_handle	PermissionsHandle
	reader	DataReader
	publication_handle	InstanceHandle_t

	key	DynamicData
	out: exception	SecurityException
get_permissions_token		PermissionsToken
	handle	PermissionsHandle
	exception	SecurityException
get_permissions_credential_token		PermissionsCredentialToken
	handle	PermissionsHandle
	out: exception	SecurityException
set_listener		Boolean
	listener	AccessControlListener
	out: exception	SecurityException
return_permissions_token		Boolean
	token	PermissionsToken
	out: exception	SecurityException
return_permissions_credential_token		Boolean
	permissions_credential_token	PermissionsCredentialToken
	out: exception	SecurityException
get_participant_sec_attributes		Boolean
	permissions_handle	PermissionsHandle
	out: attributes	ParticipantSecurityAttributes
	out: exception	SecurityException
get_endpoint_sec_attributes		Boolean
	permissions_handle	PermissionsHandle
	out: attributes	EndpointSecurityAttributes
	out: exception	SecurityException

8.4.2.7.1 Operation: `validate_local_permissions`

Validates the permissions of the local DomainParticipant, provided the PermissionsCredential. The operation returns a PermissionsHandle object, if successful. The PermissionsHandle can be used to locally identify the permissions of the local DomainParticipant to the AccessControl plugin.

If an error occurs, this method shall return HandleNIL.

Parameter auth_plugin: The Authentication plugin, which validated the identity of the local DomainParticipant. If this argument is nil, the operation shall return HandleNIL.

Parameter identity: The IdentityHandle returned by the authentication plugin from a successful call to validate_local_identity.

Parameter credential: A credential that can be used to validate the permissions of the local DomainParticipant. The nature of the credential is specific to each AccessControl plugin implementation.

Parameter exception: A SecurityException object, which provides details, in case this operation returns HandleNIL.

8.4.2.7.2 Operation: validate_remote_permissions

Validates the permissions of the previously authenticated remote DomainParticipant, given the PermissionsToken object received via DDS discovery and the PermissionsCredentialToken obtained as part of the authentication process. The operation returns a PermissionsHandle object, if successful.

If an error occurs, this method shall return HandleNIL.

Parameter auth_plugin: The Authentication plugin, which validated the identity of the remote DomainParticipant. If this argument is nil, the operation shall return HandleNIL.

Parameter local_identity_handle: The IdentityHandle returned by the authentication plugin.

Parameter remote_identity_handle: The IdentityHandle returned by a successful call to the validate_remote_identity operation on the Authentication plugin.

Parameter remote_permissions_token: The PermissionsToken of the remote DomainParticipant received via DDS discovery inside the ***permissions_token*** member of the ***ParticipantBuiltinTopicData***. See 7.4.1.3.

Parameter remote_permissions_credential_token: The PermissionsCredentialToken of the remote DomainParticipant returned by the operation get_peer_participant_credential_token on the Authentication plugin.

Parameter exception: A SecurityException object, which provides details, in case this operation returns HandleNIL.

8.4.2.7.3 Operation: check_create_participant

Enforces the permissions of the local DomainParticipant. When the local DomainParticipant is created, its permissions must allow it to join the DDS Domain specified

by the ***domain_id.*** Optionally the use of the specified value for the `DomainParticipantQoS` must also be allowed by its permissions. The operation returns a `Boolean` value.

If an error occurs, this method shall return `false`.

Parameter permissions_handle: The `PermissionsHandle` object associated with the local `DomainParticipant`. If this argument is `nil`, the operation shall return `false`.

Parameter domain_id: The domain id where the local `DomainParticipant` is about to be created. If this argument is `nil`, the operation shall return `false`.

Parameter qos: The QoS policies of the local `DomainParticipant.` If this argument is nil, the operation shall return `false`.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.4.2.7.4 Operation: check_create_datawriter

Enforces the permissions of the local `DomainParticipant`. When the local `DomainParticipant` creates a `DataWriter` for `topic_name` with the specified `DataWriterQos` associated with the `data_tag`, its permissions must allow this. The operation returns a `Boolean` object.

If an error occurs, this method shall return `false`.

Parameter permissions_handle: The `PermissionsHandle` object associated with the local `DomainParticipant`. If this argument is `nil`, the operation shall return `false`.

Parameter domain_id: The `DomainId_t` of the local `DomainParticipant` to which the local `DataWriter` will belong.

Parameter topic_name: The topic name that the `DataWriter` is supposed to write. If this argument is `nil`, the operation shall return `false`.

Parameter qos: The QoS policies of the local `DataWriter.` If this argument is nil, the operation shall return `false`.

Parameter partition: The `PartitionQosPolicy` of the local `Publisher` to which the `DataWriter` will belong.

Parameter data_tag: The data tags that the local `DataWriter` is requesting to be associated with its data. This argument can be `nil` if it is not considered for access control.

Parameter exception: A SecurityException object, which provides details in case this operation returns `false`.

8.4.2.7.5 Operation: check_create_datareader

Enforces the permissions of the local `DomainParticipant`. When the local `DomainParticipant` creates a `DataReader` for a `Topic` for `topic_name` with the specified `DataReaderQos` `qos` associated with the `data_tag`, its permissions must allow this. The operation returns a `Boolean` value.

If an error occurs, this method shall return `false`.

Parameter permissions_handle: The `PermissionsHandle` object associated with the local `DomainParticipant`. If this argument is `nil`, the operation shall return `false`.

Parameter domain_id: The `DomainId_t` of the local `DomainParticipant` to which the local `DataReader` will belong.

Parameter topic_name: The topic name that the `DataReader` is supposed to read. If this argument is `nil`, the operation shall return `false`.

Parameter qos: The QoS policies of the local `DataReader.` If this argument is nil, the operation shall return `false`.

Parameter partition: The `PartitionQosPolicy` of the local `Subscriber` to which the `DataReader` will belong.

Parameter data_tag: The data tags that the local `DataReader` is requesting read access to. This argument can be `nil` if it is not considered for access control.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.4.2.7.6 Operation: check_create_topic

Enforces the permissions of the local `DomainParticipant`. When an entity of the local `DomainParticipant` creates a `Topic` with `topic_name` and `TopicQos` `qos` its permissions must allow this. The operation returns a `Boolean` value.

If an error occurs, this method shall return `false`.

Parameter permissions_handle: The `PermissionsHandle` object associated with the local `DomainParticipant`. If this argument is `nil`, the operation shall return `false`.

Parameter domain_id: The `DomainId_t` of the local `DomainParticipant` that creates the Topic.

Parameter topic_name: The topic name to be created. If this argument is `nil`, the operation shall return `false`.

Parameter qos: The QoS policies of the local `Topic.` If this argument is nil, the operation shall return `false`.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.4.2.7.7 Operation: check_local_datawriter_register_instance

Enforces the permissions of the local `DomainParticipant`. In case the access control requires a finer granularity at the instance level, this operation enforces the permissions of the local `DataWriter`. The `key` identifies the instance being registered and permissions are checked to determine if registration of the specified instance is allowed. The operation returns a `Boolean` value.

If an error occurs, this method shall return `false`.

Parameter permissions_handle: The `PermissionsHandle` object associated with the local `DomainParticipant`. If this argument is `nil`, the operation shall return `false`.

Parameter writer: `DataWriter` object that registers the instance. If this argument is `nil`, the operation shall return `false`.

Parameter key: The `key` of the instance for which the registration permissions are being checked. If this argument is `nil`, the operation shall return `false`.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.4.2.7.8 Operation: check_local_datawriter_dispose_instance

Enforces the permissions of the local `DomainParticipant`. In case the access control requires a finer granularity at the instance level, this operation enforces the permissions of the local `DataWriter`. The `key` has to match the permissions for disposing an instance. The operation returns a `Boolean` object.

If an error occurs, this method shall return `false`.

Parameter permissions_handle: The `PermissionsHandle` object associated with the local `DomainParticipant`. If this argument is `nil`, the operation shall return `false`.

Parameter writer: `DataWriter` object that registers the instance. If this argument is `nil`, the operation shall return `false`.

Parameter key: The `key` identifies the instance being registered and the permissions are checked to determine if disposal of the specified instance is allowed. If this argument is `nil`, the operation shall return `false`.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `nil`.

8.4.2.7.9 Operation: check_remote_participant

Enforces the permissions of the remote `DomainParticipant`. When the remote `DomainParticipant` is discovered, the domain_id and, optionally, the `DomainParticipantQoS` are checked to verify that joining that DDS Domain and using that QoS is allowed by its permissions. The operation returns a `Boolean` result.

If an error occurs, this method shall return `false`.

Parameter permissions_handle: The `PermissionsHandle` object associated with the remote `DomainParticipant`. If this argument is `nil`, the operation shall return `false`.

Parameter domain_id: The domain id where the remote `DomainParticipant` is about to be created. If this argument is `nil`, the operation shall return `false`.

Parameter participant_data: The `ParticipantBuiltInTopicDataSecure` object associated with the remote `DomainParticipant`. If this argument is nil, the operation shall return `false`.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `nil`.

8.4.2.7.10 Operation: check_remote_datawriter

Enforces the permissions of a remote `DomainParticipant`.

This operation shall be called by a `DomainParticipant` prior to matching a local `DataReader` belonging to that `DomainParticipant` with a `DataWriter` belonging to a different (peer) `DomainParticipant`.

This operation shall also be called whenever a `DomainParticipant` detects a QoS change for a `DataWriter` belonging to a different (peer) `DomainParticipant` that is matched with a local `DataReader`.

This operation verifies that the peer `DomainParticipant` has the permissions necessary to publish data on the DDS `Topic` with name ***topic_name*** using the `DataWriterQoS` that appears in ***publication_data***. The operation returns a `Boolean` value.

If an error occurs, this method shall return `false`.

Parameter permissions_handle: The `PermissionsHandle` object associated with the remote `DomainParticipant`. If this argument is `nil`, the operation shall return `false`.

Parameter publication_data: The `PublicationBuiltInTopicDataSecure` object associated with the remote `DataWriter`. If this argument is `nil`, the operation shall return `false`.

Parameter subscriber_partition: The `PartitionQosPolicy` of the local `Subscriber` that contains the local `DataReader` that is matched with the remote `DataWriter`.

Parameter subscription_data_tag: The data tags associated with the local `DataReader`. This argument can be `nil` if it is not considered for access control.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.4.2.7.11 Operation: check_remote_datareader

Enforces the permissions of a remote `DomainParticipant`.

This operation shall be called by a `DomainParticipant` prior to matching a local `DataWriter` belonging to that `DomainParticipant` with a `DataReader` belonging to a different (peer) `DomainParticipant`.

This operation shall also be called whenever a `DomainParticipant` detects a QoS change for a `DataReader` belonging to a different (peer) `DomainParticipant` that is matched with a local `DataWriter`.

This operation verifies that the peer `DomainParticipant` has the permissions necessary to subscribe to data on the DDS `Topic` with name ***topic_name*** using the `DataReaderQoS` that appears in ***subscription_data***. The operation returns a `Boolean` value and also sets the ***relay_only*** output parameter.

If the operation returns `true,` the DDS middleware shall allow the local `DataWriter` to match with the remote `DataReader`, if it returns `false`, it shall not allow it.

If the operation returns `true`, the ***relay_only*** parameter shall be remembered by the DDS middleware and passed to the `register_matched_remote_datareader` operation on the `CryptoKeyFactory`.

If an error occurs, this method shall return `false`.

Parameter permissions_handle: The `PermissionsHandle` object associated with the local `DomainParticipant`. If this argument is `nil`, the operation shall return `false`.

Parameter subscription_data: The `SubscriptionBuiltInTopicDataSecure` object associated with the remote `DataReader.` If this argument is `nil`, the operation shall return `false`.

Parameter publisher_partition: The `PartitionQosPolicy` of the local `Publisher` that contains the local `DataWriter` that is matched with the remote `DataReader`.

Parameter data_tag: The data tag that the remote `DataReader` is about to read. This argument can be `nil` if it is not considered for access control.

Parameter (out) relay_only: Boolean indicating whether the permissions of the remote `DataReader` are restricted to relaying the information (understanding sequence numbers and other `SubmessageHeader` information) but not decoding the data itself. This parameter is only meaningful if the operation returns `true`.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.4.2.7.12 Operation: check_remote_topic

Enforces the permissions of the remote `DomainParticipant`. When the remote `DomainParticipant` creates a certain topic, the ***topic_name*** and optionally the `TopicQoS` extracted from the ***topic_data*** are verified to ensure the remote `DomainParticipant` permissions allow it to create the DDS `Topic` with the specified QoS. The operation returns a `Boolean` value.

If an error occurs, this method shall return `false`.

Parameter permissions_handle: The `PermissionsHandle` object associated with the remote `DomainParticipant`. If this argument is `nil`, the operation shall return `false`.

Parameter topic_data: The `TopicBuiltInTopicData` object associated with the `Topic.` If this argument is `nil`, the operation shall return `false`.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.4.2.7.13 Operation: check_local_datawriter_match

Provides the means for the `AccessControl` plugin to enforce access control rules that are based on the `DataTag` associated with `DataWriter` and a matching `DataReader`.

The operation shall be called for any local `DataWriter` that matches a `DataReader`. The operation shall be called after the operation `check_local_datawriter` has been called on the local

DataWriter and either check_local_datareader or check_remote_datareader has been called on the DataReader.

This operation shall also be called when a local DataWriter, matched with a DataReader, detects a change on the Qos of the DataReader.

The operation shall be called only if the aforementioned calls to check_local_datawriter and check_local_datareader or check_remote_datareader are returned successfully.

The operation returns a Boolean value. If an error occurs, this method shall return false and the SecurityException filled.

Parameter writer_permissions_handle: The PermissionsHandle object associated with the DomainParticipant that contains the local DataWriter. If this argument is nil, the operation shall return false.

Parameter reader_permissions_handle: The PermissionsHandle object associated with the remote DomainParticipant. If this argument is nil, the operation shall return false.

Parameter writer_data_tag: The DataTag associated with the local DataWriter.

Parameter reader_data_tag: The DataTag associated with the matched DataReader.

Parameter exception: A SecurityException object, which provides details in case this operation returns false.

8.4.2.7.14 Operation: check_local_datareader_match

Provides the means for the AccessControl plugin to enforce access control rules that are based on the DataTag associated with a DataReader and a matching DataWriter.

The operation shall be called for any local DataReader that matches a DataWriter. The operation shall be called after the operation check_local_datareader has been called on the local DataReader and either check_local_datawriter or check_remote_datawriter has been called on the DataWriter.

This operation shall also be called when a local DataReader, matched with a DataWriter, detects a change on the Qos of the DataWriter.

The operation shall be called only if the aforementioned calls to check_local_datareader and check_local_datawriter or check_remote_datarwriter are returned successfully.

The operation returns a Boolean value. If an error occurs, this method shall return false and the SecurityException filled.

Parameter writer_permissions_handle: The PermissionsHandle object associated with the DomainParticipant that contains the local DataReader. If this argument is nil, the operation shall return false.

Parameter reader_permissions_handle: The PermissionsHandle object associated with the remote DomainParticipant. If this argument is nil, the operation shall return false.

Parameter writer_data_tag: The DataTag associated with the local DataWriter.

Parameter reader_data_tag: The `DataTag` associated with the matched `DataReader`.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.4.2.7.15 Operation: check_remote_datawriter_register_instance

Enforces the permissions of the remote `DomainParticipant`. In case the access control requires a finer granularity at the instance level, this operation enforces the permissions of the remote `DataWriter`. The `key` has to match the permissions for registering an instance. The operation returns a `Boolean` value.

If an error occurs, this method shall return `false`.

Parameter permissions_handle: The `PermissionsHandle` object associated with the remote `DomainParticipant`. If this argument is `nil`, the operation shall return `false`.

Parameter reader: The local `DataReader` object that is matched to the remote `DataWriter` that registered an instance.

Parameter publication handle: Handle that identifies the remote `DataWriter` .

Parameter key: The `key` of the instance that needs to match the permissions for registering an instance. If this argument is `nil`, the operation shall return `false`.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.4.2.7.16 Operation: check_remote_datawriter_dispose_instance

Enforces the permissions of the remote `DomainParticipant`. In case the access control requires a finer granularity at the instance level, this operation enforces the permissions of the remote `DataWriter`. The `key` has to match the permissions for disposing an instance. The operation returns a `Boolean` value.

If an error occurs, this method shall return `false`.

Parameter permissions_handle: The `PermissionsHandle` object associated with the remote `DomainParticipant`. If this argument is `nil`, the operation shall return `false`.

Parameter reader: The local `DataReader` object that is matched to the Publication that disposed an instance.

Parameter publication handle: Handle that identifies the remote Publication.

Parameter key: The `key` of the instance that needs to match the permissions for disposing an instance. If this argument is `nil`, the operation shall return `false`.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.4.2.7.17 Operation: `get_permissions_token`

Retrieves a `PermissionsToken` object. The `PermissionsToken` is propagated via DDS discovery to summarize the permissions of the `DomainParticipant` identified by the specified `PermissionsHandle` .

If an error occurs, this method shall return `false`.

Parameter permissions_token (out): The returned `PermissionsToken`

Parameter handle: The handle used to locally identify the permissions of the DomainParticipant for which a `PermissionsToken` is desired. If this argument is `nil`, the operation shall return `nil`.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.4.2.7.18 Operation: `get_permissions_credential_token`

Retrieves a `PermissionsCredentialToken` object that can be used to represent on the network the pemissions of the `DomainParticipant` identified by the specified `PermissionsHandle`.

If an error occurs, this method shall return `false`.

Parameter permissions_credential_token (out): The returned `PermissionsCredentialToken.`

Parameter handle: The `PermissionsHandle` used to locally identify the permissions of the `DomainParticipant` for which a `PermissionsCredentialToken` is desired. If this argument is `nil`, the operation shall return `nil`.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.4.2.7.19 Operation: `set_listener`

Sets the listener for the `AccessControl` plugin.

If an error occurs, this method shall return `false`.

Parameter listener: An `AccessControlListener` object to be attached to the `AccessControl` plugin. If this argument is `nil`, the operation returns `false`.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.4.2.7.20 Operation: `return_permissions_token`

Returns the `PermissionsToken` to the plugin for disposal**.**

Parameter token: A `PermissionsToken` to be disposed of. It should correspond to the `PermissionsToken` returned by a prior call to `get_permissions_token` on the same plugin.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.4.2.7.21 Operation: `return_permissions_credential_token`

Returns the `PermissionsCredentialToken` to the plugin for disposal**.**

Parameter permissions_credential_token: A `PermissionsCredentialToken` to be disposed of. It should correspond to the `PermissionsCredentialToken` returned by a prior call to `get_permissions_credential_token` on the same plugin.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.4.2.7.22 Operation: get_participant_sec_attributes

Retrieves the `ParticipantSecurityAttributes`, which describe how the DDS middleware should enforce the security and integrity of the information produced and consumed via the DomainParticipant.

8.4.2.7.23 Operation: get_endpoint_sec_attributes

Retrieves the `EndpointSecurityAttributes`, which describe how the DDS middleware should enforce the security and integrity of the information related to the endpoint: DDS DataReader or DDS DataWriter.

8.4.2.8 AccessControlListener interface

The purpose of the `AccessControlListener` is to be notified of all status changes for different identities. For example, permissions can change; hence, the `AccessControlListener` is notified and enforces the new permissions.

Table 19 – AccessControlListener interface

AccessControlListener		
No Attributes		
Operations		
`on_revoke_permissions`		`Boolean`
	`plugin`	`AccessControl`
	`handle`	`PermissionsHandle`

8.4.2.8.1 Operation: `on_revoke_permissions`

`DomainParticipants`' Permissions can be revoked/changed. This listener provides a callback for permission revocation/changes.

If an error occurs, this method shall return `false`.

Parameter plugin: The correspondent `AccessControl` object.

Parameter handle: A `PermissionsHandle` object that corresponds to the Permissions of a DDS Participant whose permissions are being revoked.

8.5 Cryptographic Plugin

The `Cryptographic` plugin defines the types and operations necessary to support encryption, digest, message authentication codes, and key exchange for DDS `DomainParticipants`, `DataWriters` and DDS `DataReaders`.

Users of DDS may have specific cryptographic libraries they use for encryption, as well as, specific requirements regarding the algorithms for digests, message authentication, and signing. In addition, applications may require having only some of those functions performed, or performed only for certain DDS `Topics` and not for others. Therefore, the plugin API has to be general enough to allow flexible configuration and deployment scenarios.

8.5.1 Cryptographic Plugin Model

The `Cryptographic` plugin model is presented in the figure below. It combines related cryptographic interfaces for key creation, key exchange, encryption, message authentication, hashing, and signature.

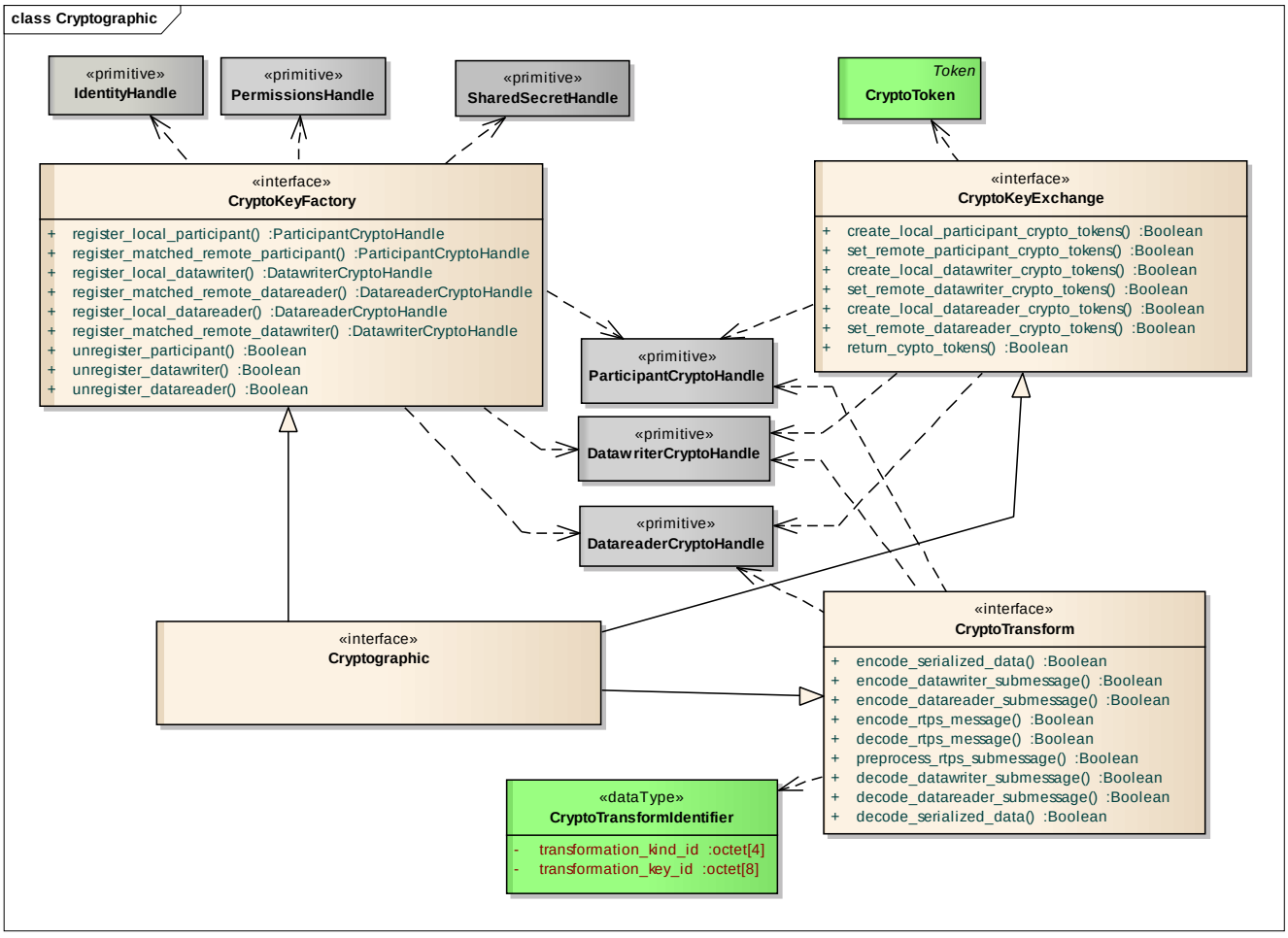


Figure 12 – Cryptographic Plugin Model

8.5.1.1 CryptoToken

This class represents a generic holder for key material. A `CryptoToken` object contains all the information necessary to construct a set of keys to be used to encrypt and/or sign plain text transforming it into cipher-text or to reverse those operations.

The format and interpretation of the CryptoToken depends on the implementation of the Cryptographic plugin. Each plugin implementation shall fully define itself, so that applications are able to interoperate. In general, the CryptoToken will contain one or more keys and any other necessary material to perform crypto-transformation and/or verification, such as, initialization vectors (IVs), salts, etc.

8.5.1.2 ParticipantCryptoHandle

The ParticipantCryptoHandle object is an opaque local reference that represents the key material used to encrypt and sign whole RTPS Messages. It is used by the operations encode_rtps_message and decode_rtps_message.

8.5.1.3 DatawriterCryptoHandle

The DatawriterCryptoHandle object is an opaque local reference that represents the key material used to encrypt and sign RTPS submessages sent from a DataWriter. This includes the RTPS submessages Data, DataFrag, Gap, Heartbeat, and HeartbeatFrag, as well as, the SerializedData submessage element that appears in the Data and DataFrag submessages.

It is used by the operations encode_datawriter_submessage, decode_datawriter_submessage, encode_serialized_data, and decode_serialized_data.

8.5.1.4 DatareaderCryptoHandle

The DatareaderCryptoHandle object is an opaque local reference that represents the key material used to encrypt and sign RTPS Submessages sent from a DataReader. This includes the RTPS Submessages AckNack and NackFrag.

It is used by the operations encode_datareader_submessage, decode_datareader_submessage.

8.5.1.5 CryptoTransformIdentifier

The CryptoTransformIdentifier object used to uniquely identify the transformation applied on the sending side (encoding) so that the receiver can locate the necessary key material to perform the inverse transformation (decoding). The generation of CryptoTransformIdentifier is performed by the Cryptographic plugin.

To enable interoperability and avoid misinterpretation of the key material, the structure of the CryptoTransformIdentifier is defined for all Cryptographic plugin implementations as follows:

Table 20 – CryptoTranformIdentifier class

CryptoTransformIdentifier	
Attributes	
transformation_kind_id	octet[4]
transformation_key_id	octet[8]

8.5.1.5.1 Attribute: transformation_kind_id

Uniquely identifies the type of cryptographic transformation.

Values of `transformation_kind_id` having the first two octets set to zero are reserved by this specification, including future versions of this specification.

Implementers can use the `transformation_kind_id` attribute to identify non-standard cryptographic transformations. In order to avoid collisions, the first two octets in the `transformation_kind_id` shall be set to a registered `RTPS VendorId` [36]. The `RTPS VendorId` used shall either be one reserved to the implementer of the Cryptographic Plugin, or else the implementer of the `Cryptographic` Plugin shall secure permission from the registered owner of the `RTPS VendorId` to use it.

8.5.1.5.2 Attribute: transformation_key_id

Uniquely identifies the key material used to perform a cryptographic transformation within the scope of all transformations that could be performed by transformations belonging to that `transformation_kind_id`.

In combination with the `transformation_kind_id`, the `transformation_key_id` attribute allows the receiver to select the proper key material to decrypt/verify a message that has been encrypted and/or signed. The use of this attribute allows a receiver to be robust to dynamic changes in keys and key material in the sense that it can identify the correct key or at least detect that it does not have the necessary keys and key material.

The values of the `transformation_key_id` are defined by the `Cryptographic` plugin implementation and understood only by that plugin.

8.5.1.6 SecureSubmessageCategory_t

Enumerates the possible categories of RTPS submessages.

Table 21 – SecureSubmessageCategory_t

SecureSubmessageCategory_t	
`INFO_SUBMESSAGE`	Indicates an RTPS Info submesage: InfoSource, InfoDestination, or InfoTimestamp.
`DATAWRITER_SUMBESSAGE`	Indicates an RTPS submessage that was sent from a DataWriter: Data, DataFrag, HeartBeat, Gap.
`DATAREADER_SUMBESSAGE`	Indicates an RTPS submessage that was sent from a DataReader: AckNack, NackFrag.

8.5.1.7 CryptoKeyFactory interface

This interface groups the operations related to the creation of keys used for encryption and digital signing of both the data written by DDS applications and the RTPS submessage and message headers, used to implement the discovery protocol, distribute the DDS data, implement the reliability protocol, etc.

Table 22 – CryptoKeyFactory Interface

CryptoKeyFactory		
No Attributes		
Operations		
register_local_participant		ParticipantCryptoHandle
	participant_identity	IdentityHandle
	participant_permissions	PermissionsHandle
	participant_properties	Properties
	out: exception	SecurityException
register_matched_remote_participant		ParticipantCryptoHandle
	local_participant_crypto_handle	ParticipantCryptoHandle
	remote_participant_identity	IdentityHandle
	remote_participant_permissions	PermissionsHandle
	shared_secret	SharedSecretHandle
	out: exception	SecurityException
register_local_datawriter		DatawriterCryptoHandle
	participant_crypto	ParticipantCryptoHandle
	datawriter_properties	Properties
	out: exception	SecurityException
register_matched_remote_datareader		DatareaderCryptoHandle
	local_datawritert_crypto_handle	DatawriterCryptoHandle
	remote_participant_crypto	ParticipantCryptoHandle
	shared_secret	SharedSecretHandle

	relay_only	Boolean
	out: exception	SecurityException
register_local_datareader		DatareaderCryptoHandle
	participant_crypto	ParticipantCryptoHandle
	datareader_properties	Properties
	out: exception	SecurityException
register_matched_remote_datawriter		DatawriterCryptoHandle
	local_datareader_crypto_handle	DatareaderCryptoHandle
	remote_participant_crypt	ParticipantCryptoHandle
	shared_secret	SharedSecretHandle
	out: exception	SecurityException
unregister_participant		Boolean
	participant_crypto_handle	ParticipantCryptoHandle
	out: exception	SecurityException
unregister_datawriter		Boolean
	datawriter_crypto_handle	DatawriterCryptoHandle
	out: exception	SecurityException
unregister_datareader		Boolean
	datareader_crypto_handle	DatareaderCryptoHandle
	out: exception	SecurityException

8.5.1.7.1 Operation: register_local_participant

Registers a local `DomainParticipant` with the Cryptographic Plugin. The `DomainParticipant` must have been already authenticated and granted access to the DDS Domain. The operation shall create any necessary key material that is needed to Encrypt and Sign secure messages that are directed to other DDS `DomainParticipant` entities on the DDS Domain.

Parameter **participant_identity**: An `IdentityHandle` returned by a prior call to `validate_local_identity`. If this argument is `nil`, the operation returns `HandleNIL`.

Parameter **participant_permissions**: A `PermissionsHandle` returned by a prior call to `validate_local_permissions`. If this argument is `nil`, the operation returns `HandleNIL.`

Parameter **participant_property**: The QoS properties of the local `DomainParticipant` (name/values pairs that can be used to configure certain parameters and are not exposed through formal QoS policies).

Parameter **exception**: A `SecurityException` object, which provides details in case this operation returns `HandleNIL`.

8.5.1.7.2 Operation: register_matched_remote_participant

Registers a remote `DomainParticipant` with the `Cryptographic` Plugin. The remote `DomainParticipant` must have been already Authenticated and granted Access to the DDS Domain. The operation performs two functions:

1. It shall create any necessary key material needed to decrypt and verify the signatures of messages received from that remote `DomainParticipant` and directed to the local `DomainParticipant`.
2. It shall create any necessary key material that will be used by the local `DomainParticipant` when encrypting or signing messages that are intended only for that remote `DomainParticipant`.

Parameter **local_participant_crypto_handle**: A `ParticipantCryptoHandle` returned by a prior call to `register_local_participant`. If this argument is `nil`, the operation returns `false`.

Parameter **remote_participant_identity**: An `IdentityHandle` returned by a prior call to `validate_remote_identity`. If this argument is `nil`, the operation returns `nil`.

Parameter **participant_permissions**: A `PermissionsHandle` returned by a prior call to `validate_remote_permissions`. If this argument is `nil`, the operation returns `nil`

Parameter **shared_secret**: The `SharedSecretHandle` returned by a prior call to `get_shared_secret` as a result of the successful completion of the Authentication handshake between the local and remote `DomainParticipant` entities.

Parameter **exception**: A `SecurityException` object, which provides details in case this operation returns `false`.

8.5.1.7.3 Operation: register_local_datawriter

Registers a local `DataWriter` with the `Cryptographic` Plugin. The fact that the `DataWriter` was successfully created indicates that the `DomainParticipant` to which it belongs was authenticated, granted access to the DDS Domain, and granted permission to create the `DataWriter` on its `Topic`.

This operation shall create the cryptographic material necessary to encrypt and/or sign the data written by the `DataWriter` and returns a `DatawriterCryptoHandle` to be used for any cryptographic operations affecting messages sent or received by the `DataWriter`.

If an error occurs, this method shall return false. If it succeeds, the operation shall return an opaque handle that can be used to refer to that key material.

Parameter **local_participant_identity**: An `IdentityHandle` returned by a prior call to `validate_local_identity`. It shall correspond to the `DomainParticipant` to which the `DataWriter` belongs. If this argument is `nil`, the operation returns `nil`.

Parameter **participant_crypto**: A `ParticipantCryptoHandle` returned by a prior call to `register_local_participant`. It shall correspond to the `ParticipantCryptoHandle` of the `DomainParticipant` to which the `DataWriter` belongs. If this argument is `nil`, the operation returns `false`.

Parameter **local_datawriter_properties**: The `Properties` of the local `DataWriter` (name/values pairs that can be used to configure certain parameters and are not exposed through formal QoS policies). This parameter shall contain all the properties in the `DataWriter` whose name has the prefix "`dds.sec.`crypto." The purpose of this parameter is to allow configuration of the `Cryptographic` Plugin by the `DataWriter`, e.g., selection of the cryptographic algorithm, key size, or even setting of the key. The use of this parameter depends on the particular implementation of the plugin and shall be specified for each implementation.

Parameter **exception**: A `SecurityException` object, which provides details in case this operation returns `false`.

8.5.1.7.4 Operation: register_matched_remote_datareader

Registers a remote `DataReader` with the `Cryptographic` Plugin. The remote `DataReader` shall correspond to one that has been granted permissions to match with the local `DataWriter`.

This operation shall create the cryptographic material necessary to encrypt and/or sign the RTPS submessages (`Data`, `DataFrag`, `Gap`, `Heartbeat`, `HeartbeatFrag`) sent from the local `DataWriter` to that `DataReader`. It shall also create the cryptographic material necessary to process RTPS Submessages (`AckNack`, `NackFrag`) sent from the remote `DataReader` to the `DataWriter`.

The operation shall associate the value of the ***relay_only*** parameter with the returned `DatawriterCryptoHandle`. This information shall be used in the generation of the `KeyToken` objects to be sent to the `DataReader`.

Parameter **local_datawriter_crypto_handle**: A `DatawriterCryptoHandle` returned by a prior call to `register_local_datawriter`. If this argument is `nil`, the operation returns `HandleNIL`.

Parameter **remote_participant_crypto**: A `ParticipantCryptoHandle` returned by a prior call to `register_matched_remote_participant`. It shall correspond to the `ParticipantCryptoHandle` of the `DomainParticipant` to which the remote `DataReader` belongs. If this argument is `nil`, the operation returns `HandleNIL`.

Parameter **remote_participant_permissions**: A `PermissionsHandle` returned by a prior call to `validate_remote_permissions`. It shall correspond to the `DomainParticipant` to which the `DataReader` belongs. If this argument is `nil`, the operation returns `HandleNIL`

Parameter **shared_secret**: The `SharedSecretHandle` returned by a prior call to `get_shared_secret` as a result of the successful completion of the Authentication handshake between the local and remote `DomainParticipant` entities.

Parameter (out) relay_only: Boolean indicating whether the cryptographic material to be generated for the remote `DataReader` shall contain everything, or only the material necessary to relay (store and forward) the information (i.e., understand the `SubmessageHeader`) without being able to decode the data itself (i.e., decode the `SecureData`).

Parameter **exception**: A `SecurityException` object, which provides details in case this operation returns `HandleNIL.`

8.5.1.7.5 Operation: register_local_datareader

Registers a local `DataReader` with the `Cryptographic` Plugin. The fact that the `DataReader` was successfully created indicates that the DomainParticipant to which it belongs was authenticated, granted access to the DDS Domain, and granted permission to create the `DataReader` on its `Topic`.

This operation shall create the cryptographic material necessary to encrypt and/or sign the messages sent by the `DataReader` when the encryption/signature is independent of the targeted `DataWriter`.

If successful, the operation returns a `DatareaderCryptoHandle` to be used for any cryptographic operations affecting messages sent or received by the DataWriter.

Parameter **participant_crypto**: A `ParticipantCryptoHandle` returned by a prior call to `register_local_participant`. It shall correspond to the `ParticipantCryptoHandle` of the `DomainParticipant` to which the `DataReader` belongs. If this argument is `nil`, the operation returns `HandleNIL`.

Parameter **local_datareader_properties**: The `Properties` of the local `DataReader` (name/values pairs that can be used to configure certain parameters and are not exposed through formal QoS policies).

Parameter **exception**: A `SecurityException` object, which provides details in case this operation returns `HandleNIL`.

8.5.1.7.6 Operation: register_matched_remote_datawriter

Registers a remote `DataWriter` with the `Cryptographic` Plugin. The remote `DataWriter` shall correspond to one that has been granted permissions to match with the local `DataReader`.

This operation shall create the cryptographic material necessary to decrypt and/or verify the signatures of the RTPS submessages (`Data`, `DataFrag`, `Heartbeat`, `HeartbeatFrag`, `Gap`) sent from the remote `DataWriter` to the `DataReader`. The operation shall also create the cryptographic material necessary to encrypt and/or sign the RTPS submessages (`AckNack`, `NackFrag`) sent from the local `DataReader` to the remote `DataWriter`.

Parameter **local_datawriter_crypto_handle**: A `DatawriterCryptoHandle` returned by a prior call to `register_local_datawriter`. If this argument is `nil`, the operation returns `nil`.

Parameter **remote_participant_crypto**: A `ParticipantCryptoHandle` returned by a prior call to `register_matched_remote_participant`. It shall correspond to the

ParticipantCryptoHandle of the DomainParticipant to which the remote DataWriter belongs. If this argument is nil, the operation returns nil.

Parameter **shared_secret**: The SharedSecretHandle returned by a prior call to get_shared_secret as a result of the successful completion of the Authentication handshake between the local and remote DomainParticipant entities.

Parameter **exception**: A SecurityException object, which provides details in case this operation returns HandleNIL.

8.5.1.7.7 Operation: unregister_participant

Releases the resources, associated with a DomainParticipant, that the Cryptographic plugin maintains. After calling this function, the DDS Implementation shall not use the participant_crypto_handle anymore.

The DDS Implementation shall call this function when it determines that there will be no further communication with the DDS DomainParticipant associated with the participant_crypto_handle. Specifically, it shall be called when the application deletes a local DomainParticipant and also when the DDS Discovery mechanism detects that a matched DomainParticipant is no longer in the system.

Parameter **participant_crypto_handle**: A ParticipantCryptoHandle returned by a prior call to register_local_participant, or register_matched_remote_participant if this argument is nil, the operation returns false.

Parameter **exception**: A SecurityException object, which provides details in case this operation returns false.

8.5.1.7.8 Operation: unregister_datawriter

Releases the resources, associated with a DataWriter, that the Cryptographic plugin maintains. After calling this function, the DDS Implementation shall not use the datawriter_crypto_handle anymore.

The DDS Implementation shall call this function when it determines that there will be no further communication with the DDS DataWriter associated with the datawriter_crypto_handle. Specifically it shall be called when the application deletes a local DataWriter and also when the DDS Discovery mechanism detects that a matched DataWriter is no longer in the system.

Parameter **datawriter_crypto_handle**: A ParticipantCryptoHandle returned by a prior call to register_local_datawriter, or register_matched_remote_datawriter if this argument is nil, the operation returns false.

Parameter **exception**: A SecurityException object, which provides details in case this operation returns false.

8.5.1.7.9 Operation: unregister_datareader

Releases the resources, associated with a DataReader, that the Cryptographic plugin maintains. After calling this function, the DDS Implementation shall not use the datareader_crypto_handle anymore.

The DDS Implementation shall call this function when it determines that there will be no further communication with the DDS `DataReader` associated with the `datareader_crypto_handle`. Specifically it shall be called when the application deletes a local `DataReader` and also when the DDS Discovery mechanism detects that a matched `DataReader` is no longer in the system.

Parameter **datareader_crypto_handle**: A `ParticipantCryptoHandle` returned by a prior call to `register_local_datareader`, or `register_matched_remote_datareader` if this argument is `nil`, the operation returns `false`.

Parameter **exception**: A `SecurityException` object, which provides details in case this operation returns `false`.

8.5.1.8 CryptoKeyExchange Interface

The key exchange interface manages the creation of keys and assist in the secure distribution of keys and key material.

Table 23 – CryptoKeyExchange Interface

CryptoKeyExchange		
No Attributes		
Operations		
`create_local_participant_crypto_tokens`		`Boolean`
	`local_participant_crypto_tokens`	`ParticipantCryptoTokenSeq`
	`local_participant_crypto`	`ParticipantCryptoHandle`
	`remote_participant_crypto`	`ParticipantCryptoHandle`
	`out: exception`	`SecurityException`
`set_remote_participant_crypto_tokens`		`Boolean`
	`local_participant_crypto`	`ParticipantCryptoHandle`
	`remote_participant_crypto`	`ParticipantCryptoHandle`
	`remote_participant_tokens`	`ParticipantCryptoTokenSeq`
	`out: exception`	`SecurityException`
`create_local_datawriter_crypto_tokens`		`Boolean`
	`local_datawriter_crypto_tokens`	`DatawriterCryptoTokenSeq`
	`local_datawriter`	`DatawriterCryptoHandle`

	_crypto	
	remote_datareader_crypto	DatareaderCryptoHandle
	out: exception	SecurityException
set_remote_datawriter_crypto_tokens		Boolean
	local_datareader_crypto	DatareaderCryptoHandle
	remote_datawriter_crypto	DatawriterCryptoHandle
	remote_datawriter_tokens	DatawriterCryptoTokenSeq
	out: exception	SecurityException
create_local_datareader_crypto_tokens		Boolean
	local_datareader_crypto_tokens	DatareaderCryptoTokenSeq
	local_datareader_crypto	DatareaderCryptoHandle
	remote_datawriter_crypto	DatawriterCryptoHandle
	out: exception	SecurityException
set_remote_datareader_crypto_tokens		Boolean
	local_datawriter_crypto	DatawriterCryptoHandle
	remote_datareader_crypto	DatareaderCryptoHandle
	remote_datareader_tokens	DatareaderCryptoTokenSeq
	out: exception	SecurityException
return_crypto_tokens		Boolean
	crypto_tokens	CryptoTokenSeq
	out: exception	SecurityException

8.5.1.8.1 Operation: create_local_participant_crypto_tokens

This operation creates a sequence of `CryptoToken` tokens containing the information needed to correctly interpret cipher text encoded using the ***local_participant_crypto***. That is, the `CryptoToken`

sequence contains the information needed to decrypt any data encrypted using the ***local_participant_crypto*,** as well as, verify any signatures produced using the ***local_participant_crypto***.

The returned `CryptoToken` sequence contains opaque data, which only the plugins understand. The returned `CryptoToken` sequence is intended for transmission in "clear text" to the remote `DomainParticipant` associated with the ***remote_participant_crypto*** so that the remote `DomainParticipant` has access to the necessary key material. For this reason, the `CryptoKeyExchange` plugin implementation may encrypt the sensitive information inside the `CryptoToken` using shared secrets and keys obtained from the ***remote_participant_crypto***. The specific ways in which this is done depend on the plugin implementation.

The DDS middleware implementation shall call this operation for each remote `DomainParticipant` that matches a local `DomainParticipant`. That is, remote participants that have been successfully authenticated and granted access by the `AccessControl` plugin. The returned `ParticipantCryptoTokenSeq` shall be sent to the remote `DomainParticipant` using the ***BuiltinParticipantVolatileMessageSecureWriter*** with kind set to `GMCLASSID_SECURITY_PARTICIPANT_CRYPTO_TOKENS` (see 7.4.3.5). The returned `ParticipantCryptoTokenSeq` sequence shall appear in the ***message_data*** attribute of the `ParticipantVolatileSecureMessage` (see 7.4.4).

Parameter local_participant_crypto_tokens (out): The returned `ParticipantCryptoTokenSeq`.

Parameter local_participant_crypto: A `ParticipantCryptoHandle`, returned by a previous call to `register_local_participant`, which corresponds to the `DomainParticipant` that will be encrypting and signing messages.

Parameter remote_participant_crypto: A `ParticipantCryptoHandle`, returned by a previous call to `register_matched_remote_participant`, that corresponds to the `DomainParticipant` that will be receiving the messages from the local `DomainParticipant` and will be decrypting them and verifying their signature.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.5.1.8.2 Operation: set_remote_participant_crypto_tokens

This operation shall be called by the DDS implementation upon reception of a message on the ***BuiltinParticipantVolatileMessageSecureReader*** with kind set to `GMCLASSID_SECURITY_PARTICIPANT_CRYPTO_TOKENS` (see 7.4.3.5).

The operation configures the `Cryptographic` plugin with the key material necessary to interpret messages encoded by the remote `DomainParticipant` associated with the ***remote_participant_crypto*** and destined to the local `DomainParticipant` associated with the ***local_participant_crypto***. The interpretation of the `CryptoToken` sequence is specific to each `Cryptographic` plugin implementation. The `CryptoToken` sequence may contain information that is encrypted and/or signed. Typical implementations of the `Cryptographic` plugin will use the previously configured shared secret associated with the local and remote `ParticipantCryptoHandle` to decode the `CryptoToken` sequence and retrieve the key material within.

Parameter remote_participant_crypto: A `ParticipantCryptoHandle`, returned by a previous call to `register_matched_remote_participant`, that corresponds to the `DomainParticipant` that will be sending the messages from the local `DomainParticipant` and will be encrypting/signing them with the key material encoded in the `CryptoToken` sequence.

Parameter local_participant_crypto: A `ParticipantCryptoHandle`, returned by a previous call to `register_local_participant`, that corresponds to the `DomainParticipant` that will be receiving messages from the remote `DomainParticipant` and will need to decrypt and/or verify their signature.

Parameter remote_participant_tokens: A `ParticipantCryptoToken` sequence received via the ***BuiltinParticipantVolatileMessageSecureReader***. The `CryptoToken` sequence shall correspond to the one returned by a call to `create_local_participant_crypto_tokens` performed by the remote `DomainParticipant` on the remote side.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.5.1.8.3 Operation: create_local_datawriter_crypto_tokens

This operation creates a `DatawriterCryptoTokenSeq` containing the information needed to correctly interpret cipher text encoded using the `local_datawriter_crypto`. That is, the `CryptoToken` sequence contains that information needed to decrypt any data encrypted using the ***local_datawriter_crypto*** as well as verify any signatures produced using the ***local_datawriter_crypto***.

The returned `CryptoToken` sequence contains opaque data, which only the plugins understand. The returned `CryptoToken` sequence shall be sent to the remote `DataReader` associated with the `remote_datareader_crypto` so that the remote `DataReader` has access to the necessary key material.

The operation shall take into consideration the value of the ***relay_only*** parameter associated with the `DatawriterCryptoHandle` (see 8.5.1.7.4) this parameter shall control whether the Tokens returned contain all the cryptographic material needed to decode/verify both the RTPS SubMessage and the SecuredPayload submessage element within or just part of it.

If the value of the ***relay_only*** parameter was FALSE, the Tokens returned contain all the cryptographic material.

If the value of the ***relay_only*** parameter was TRUE, the Tokens returned contain only the cryptographic material needed to verify and decode the RTPS SubMessage but not the SecuredPayload submessage element within.

The DDS middleware implementation shall call this operation for each remote `DataReader` that matches a local `DataWriter`. The returned `CryptoToken` sequence shall be sent by the DDS middleware to the remote `DataReader` using the ***BuiltinParticipantVolatileMessageSecureWriter*** with kind set to `GMCLASSID_SECURITY_DATAWRITER_CRYPTO_TOKENS(`see 7.4.3.5). The returned `DatawriterCryptoToken` shall appear in the ***message_data*** attribute of the ***ParticipantVolatileSecureMessage*** (see 7.4.4.2). The ***source_endpoint_key*** attribute shall be set to the `BuiltinTopicKey_t` of the local `DataWriter` and the ***destination_endpoint_key*** attribute shall be set to the `BuiltinTopicKey_t` of the remote `DataReader`.

Parameter local_datawriter_crypto_tokens: The returned `DatawriterCryptoTokenSeq`.

Parameter local_datawriter_crypto: A `DatawriterCryptoHandle`, returned by a previous call to `register_local_datawriter` that corresponds to the `DataWriter` that will be encrypting and signing messages.

Parameter remote_datareader_crypto: A `DatareaderCryptoHandle`, returned by a previous call to `register_matched_remote_datareader`, that corresponds to the `DataReader` that will be receiving the messages from the local `DataWriter` and will be decrypting them and verifying their signature.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.5.1.8.4 Operation: set_remote_datawriter_crypto_tokens

This operation shall be called by the DDS implementation upon reception of a message on the ***BuiltinParticipantVolatileMessageSecureReader*** with kind set to `GMCLASSID_SECURITY_DATAWRITER_CRYPTO_TOKENS` (see 7.4.3.5).

The operation configures the `Cryptographic` plugin with the key material necessary to interpret messages encoded by the remote `DataWriter` associated with the `remote_datawriter_crypto` and destined to the local `DataReader` associated with the `local_datareader_crypto`. The interpretation of the `DatawriterCryptoTokenSeq` sequence is specific to each `Cryptographic` plugin implementation. The `CryptoToken` sequence may contain information that is encrypted and/or signed. Typical implementations of the `Cryptographic` plugin will use the previously configured shared secret associated with the remote `DatawriterCryptoHandle` and local `DatareaderCryptoHandle` to decode the `CryptoToken` sequence and retrieve the key material within.

Parameter remote_datawriter_crypto: A `DatawriterCryptoHandle`, returned by a previous call to `register_matched_remote_datawriter`, that corresponds to the `DataWriter` that will be sending the messages to the local `DataReader` and will be encrypting/signing them with the key material encoded in the `CryptoToken`.

Parameter local_datareader_crypto: A `DatareaderCryptoHandle`, returned by a previous call to `register_local_datareader`, that corresponds to the `DataReader` that will be receiving messages from the remote `DataWriter` and will need to decrypt and/or verify their signature.

Parameter remote_datawriter_tokens: A `CryptoToken` sequence received via the ***BuiltinParticipantVolatileMessageSecureReader***. The `DatawriterCryptoToken` shall correspond to the one returned by a call to `create_local_datawriter_crypto_tokens` performed by the remote `DataWriter` on the remote side.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.5.1.8.5 Operation: create_local_datareader_crypto_tokens

This operation creates a `DatareaderCryptoTokenSeq` containing the information needed to correctly interpret cipher text encoded using the ***local_datareader_crypto***. That is, the `CryptoToken` sequence contains that information needed to decrypt any data encrypted using the ***local_datareader_crypto*** as well as verify any signatures produced using the ***local_datareader_crypto***.

The returned CryptoToken sequence contains opaque data, which only the plugins understand. The returned CryptoToken sequence shall be sent to the remote DataWriter associated with the ***remote_datawriter_crypto*** so that the remote DataWriter has access to the necessary key material. For this reason, the CryptoKeyExchange plugin implementation may encrypt the sensitive information inside the CryptoToken sequence using shared secrets and keys obtained from the ***remote_datawriter_crypto***. The specific ways in which this is done depend on the plugin implementation.

The DDS middleware implementation shall call this operation for each remote DataWriter that matches a local DataReader. The returned DatareaderCryptoTokenSeq shall be sent by the DDS middleware to the remote DataWriter using the ***BuiltinParticipantVolatileMessageSecureWriter*** with kind set to GMCLASSID_SECURITY_DATAREADER_CRYPTO_TOKENS(see 7.4.4.2). The returned DatareaderCryptoTokenSeq shall appear in the ***message_data*** attribute of the ParticipantVolatileSecureMessage (see 7.4.4.2). The ***source_endpoint_key*** attribute shall be set to the BuiltinTopicKey_t of the local DataReader and the ***destination_endpoint_key*** attribute shall be set to the BuiltinTopicKey_t of the remote DataWriter.

Parameter local_datareader_crypto_tokens (out): The returned DatareaderCryptoTokenSeq.

Parameter local_datareader_crypto: A DatareaderCryptoHandle, returned by a previous call to register_local_datareader, that corresponds to the DataReader that will be encrypting and signing messages.

Parameter remote_datawriter_crypto: A DatawriterCryptoHandle, returned by a previous call to register_matched_remote_datawriter, that corresponds to the DataWriter that will be receiving the messages from the local DataReader and will be decrypting them and verifying their signature.

Parameter exception: A SecurityException object, which provides details in case this operation returns false.

8.5.1.8.6 Operation: set_remote_datareader_crypto_tokens

This operation shall be called by the DDS implementation upon reception of a message on the ***BuiltinParticipantVolatileMessageSecureReader*** with kind set to GMCLASSID_SECURITY_DATAREADER_CRYPTO_TOKENS(see 7.4.4.2).

The operation configures the Cryptographic plugin with the key material necessary to interpret messages encoded by the remote DataReader associated with the ***remote_datareader_crypto*** and destined to the local DataWriter associated with the ***local_datawriter_crypto***. The interpretation of the DatareaderCryptoTokenSeq is specific to each Cryptographic plugin implementation. The CryptoToken sequence may contain information that is encrypted and/or signed. Typical implementations of the Cryptographic plugin will use the previously configured shared secret associated with the remote DatareaderCryptoHandle and local DatawriterCryptoHandle to decode the CryptoToken sequence and retrieve the key material within.

Parameter remote_datareader_crypto: A `DatareaderCryptoHandle`, returned by a previous call to `register_matched_remote_datareader`, that corresponds to the `DataReader` that will be sending the messages to the local `DataWriter` and will be encrypting/signing them with the key material encoded in the `CryptoToken` sequence.

Parameter local_datawriter_crypto: A `DatawriterCryptoHandle` returned by a previous call to `register_local_datawriter`, that corresponds to the `DataWriter` that will be receiving messages from the remote `DataReader` and will need to decrypt and/or verify their signature.

Parameter remote_datareader_tokens: A `CryptoToken` sequence received via the ***BuiltinParticipantVolatileMessageSecureReader***. The `DatareaderCryptoToken` shall correspond to the one returned by a call to `create_local_datareader_crypto_tokens` performed by the remote `DataReader` on the remote side.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.5.1.8.7 Operation: return_crypto_tokens

Returns the tokens in the `CryptoToken` sequence to the plugin so the plugin can release any information associated with it.

Parameter crypto_tokens: Contains `CryptoToken` objects issued by the plugin on a prior call to one of the following operations:

- create_local_participant_crypto_tokens
- create_local_datawriter_crypto_tokens
- create_local_datareader_crypto_tokens

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.5.1.9 CryptoTransform interface

This interface groups the operations related to encrypting/decrypting, as well as, computing and verifying both message digests (hashes) and Message Authentication Codes (MAC).

MACs may be used to verify both the (data) integrity and the authenticity of a message. The computation of a MAC (also known as a keyed cryptographic hash function), takes as input a secret key and an arbitrary-length message to be authenticated, and outputs a MAC. The MAC value protects both a message's data integrity, as well as, its authenticity by allowing verifiers (who also possess the secret key) to detect any changes to the message content.

A Hash-based Message Authentication Code (HMAC) is a specialized way to compute MACs. While an implementation of the plugin is not forced to use HMAC, and could use other MAC algorithms, the API is chosen such that plugins can implement HMAC if they so choose.

The operations in the `CryptoTransform` Plugin are defined to be quite generic, taking an input byte array to transform and producing the transformed array of bytes as an output. The DDS implementation is only responsible for calling the operations in the CryptoTransform plugin at the appropriate times as it generates and processes the `RTPS` messages, substitutes the input bytes with the transformed bytes produced by the `CryptoTransform` operations, and proceeds to generate/send or process the RTPS message as normal but with the replaced bytes. The decision of the kind of

transformation to perform (encrypt and/or produce a digest and/or a MAC and/or signature) is left to the plugin implementation.

Table 24 – CryptoTransform interface

CryptoTransform		
No Attributes		
Operations		
encode_serialized_data		Boolean
	out: encoded_buffer	octet[]
	plain_buffer	octet[]
	sending_datawriter_crypto	DatawriterCryptoHandle
	out: exception	SecurityException
encode_datawriter_submessage		Boolean
	out: encoded_rtps_submessage	octet[]
	plain_rtps_submessage	octet[]
	sending_datawriter_crypto	DatawriterCryptoHandle
	receiving_datareader_crypto_list	DatareaderCryptoHandle[]
	out: exception	SecurityException
encode_datareader_submessage		Boolean
	out: encoded_rtps_submessage	octet[]
	plain_rtps_submessage	octet[]
	sending_datareader_crypto	DatareaderCryptoHandle
	receiving_datawriter_crypto_list	DatawriterCryptoHandle[]
	out: exception	SecurityException
encode_rtps_message		Boolean

	out: encoded_rtps_message	octet[]
	plain_rtps_message	octet[]
	sending_crypto	ParticipantCryptoHandle
	receiving_crypto_list	ParticipantCryptoHandle[]
	out: exception	SecurityException
decode_rtps_message		Boolean
	out: plain_buffer	octet[]
	encoded_buffer	octet[]
	receiving_crypto	ParticipantCryptoHandle
	sending_crypto	ParticipantCryptoHandle
	out: exception	SecurityException
preprocess_secure_submsg		Boolean
	out: datawriter_crypto	DatawriterCryptoHandle
	out: datareader_crypto	DatareaderCryptoHandle
	out: secure_submessage_category	DDS_SecureSumessageCategory_t
	in: encoded_rtps_submessage	octet[]
	receiving_crypto	ParticipantCryptoHandle
	sending_crypto	ParticipantCryptoHandle
	out: exception	SecurityException
decode_datawriter_submessage		Boolean
	out: plain_rtps_subme	octet[]

	ssage	
	encoded_rtps_submessage	octet[]
	receiving_datareader_crypto	DatareaderCryptoHandle
	sending_datawriter_crypto	DatawriterCryptoHandle
	out: exception	SecurityException
decode_datareader_submessage		Boolean
	out: plain_rtps_submessage	octet[]
	encoded_rtps_submessage	octet[]
	receiving_datawriter_crypto	DatawriterCryptoHandle
	sending_datareader_crypto	DatareaderCryptoHandle
	out: exception	SecurityException
decode_serialized_data		Boolean
	out: plain_buffer	octet[]
	encoded_buffer	octet[]
	receiving_datareader_crypto	DatareaderCryptoHandle
	sending_datawriter_crypto	DatawriterCryptoHandle
	out: exception	SecurityException

8.5.1.9.1 Operation: encode_serialized_data

This operation shall be called by the DDS implementation as a result of the application calling the write operation on the DataWriter associated with the `DatawriterCryptoHandle` specified in the ***sending_datawriter_crypto*** parameter.

The operation receives the data written by the DataWriter in serialized form wrapped inside the RTPS `SerializedData` submessage element and shall output a RTPS `SecuredPayload` submessage element.

The DDS implementation shall call this operation for all outgoing RTPS Submessages with submessage kind `Data` and `DataFrag`. The DDS implementation shall substitute the `SerializedData` submessage element within the aforementioned RTPS submessages with the `SecuredPayload` produced by this operation.

The implementation of `encode_serialized_data` can perform any desired cryptographic transformation of the `SerializedData` using the key material in the `sending_datawriter_crypto,` including encryption, addition of a MAC, and/or signature. The `SecuredPayload` shall include within the `CryptoTransformIdentifier` any additional information beyond the one shared via the `CryptoToken` that would be needed to identify the key used and decode the `SecuredPayload` submessage element.

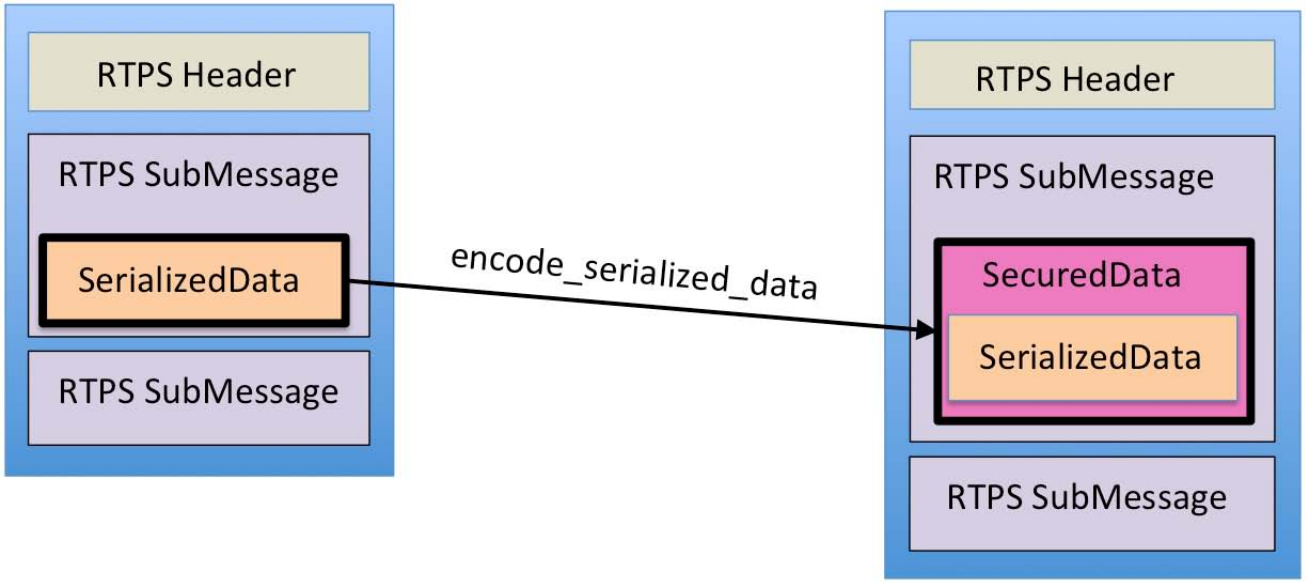


Figure 13 – Effect of encode_serialized_data within an RTPS message

If an error occurs, this method shall return `false`.

Parameter ***encoded_buffer***: The output containing the SecuredPayload RTPS submessage element, which shall be used to replace the input ***plain_buffer***.

Parameter **plain_buffer**: The input containing the `SerializedData` RTPS submessage element.

Parameter **sending_datawriter_crypto**: The `DatawriterCryptoHandle` returned by a previous call to `register_local_datawriter` for the `DataWriter` that wrote the `SerializedData`.

Parameter **exception**: A `SecurityException` object, which provides details in case this operation returns `false`.

8.5.1.9.2 Operation: encode_datawriter_submessage

This operation shall be called by the DDS implementation whenever it has constructed a RTPS submessage of kind `Data`, `DataFrag`, `Gap`, `Heartbeat`, or `HeartbeatFrag`.

The operation receives the `DatawriterCryptoHandle` of the `DataWriter` that is sending the submessage, as well as, a list of `DatareaderCryptoHandle` corresponding to all the `DataReader` entities to which the submessage is being sent.

The operation receives the complete RTPS submessage as it would normally go onto the wire in the parameter ***rtps_submessage*** and shall output a RTPS `SecureSubMsg` in the output parameter ***encoded_rtps_submessage***. The DDS implementation shall substitute the original RTPS submessage that was passed in the ***rtps_submessage*** with the `SecureSubMsg` returned in the ***encoded_rtps_submessage*** output parameter and use the `SecureSubMsg` in the construction of the RTPS message that is eventually sent to the intended recipients.

The implementation of `encode_datawriter_submessage` can perform any desired cryptographic transformation of the RTPS `Submessage` using the key material in the ***sending_datawriter_crypto***; it can also add one or more MACs and/or signatures. The fact that the cryptographic material associated with the list of intended `DataReader` entities is passed in the parameter ***receiving_datareader_crypto_list*** allows the plugin implementation to include MACs that may be computed differently for each `DataReader`.

The implementation of `encode_datawriter_submessage` shall include, within the `SecureSubMsg`, the `CryptoTransformIdentifier` containing any additional information necessary for the receiving plugin to identify the `DatawriterCryptoHandle` associated with the DataWriter that sent the message, as well as, the `DatareaderCryptoHandle` associated with the DataReader that is meant to process the submessage. How this is done depends on the plugin implementation.

The `CryptoTransformIdentifier` should also contain any additional information beyond the one shared via the `CryptoToken` that would be needed to identify the key used and decode the `SecureSubMsg` submessage back into the original RTPS submessage.

If an error occurs, this method shall return `false`.

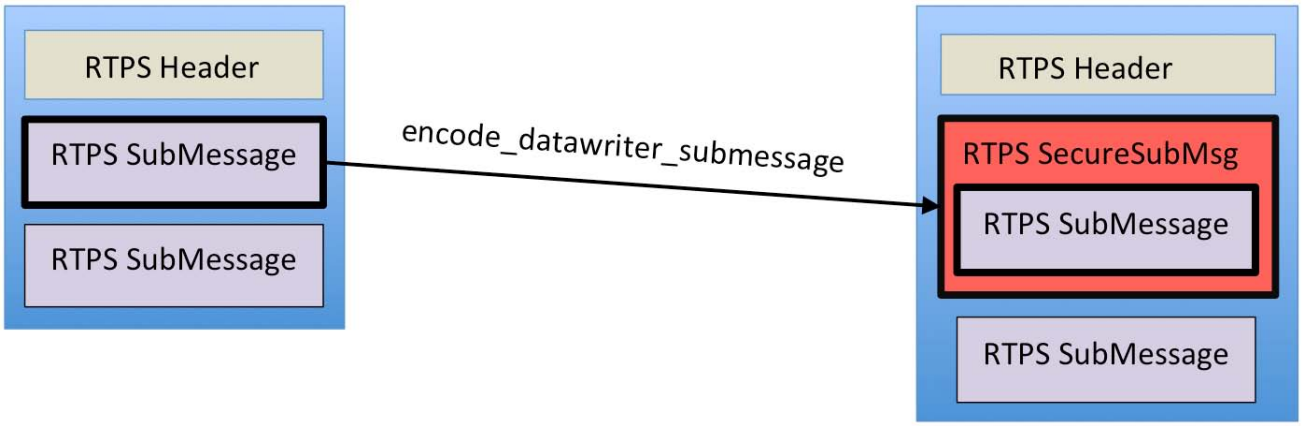


Figure 14 – Effect of encode_datawriter_submessage within an RTPS message

Parameter **encoded_rtps_submessage**: The output containing the RTPS `SecureSubMsg` submessage, which shall be used to replace the input ***rtps_submessage***.

Parameter **plain_rtps_submessage**: The input containing the RTPS submessage created by a DataWriter. This submessage will be one of following kinds: `Data`, `DataFrag`, `Gap`, `Heartbeat`, and `HeartbeatFrag`.

Parameter **sending_datawriter_crypto**: The `DatawriterCryptoHandle` returned by a previous call to register_local_datawriter for the DataWriter whose GUID is inside the `rtps_submessage`.

Parameter **receiving_datareader_crypto_list**: The list of `DatareaderCryptoHandle` returned by previous calls to `register_matched_remote_datareader` for the DataReader entities to which the submessage will be sent.

Parameter **exception**: A `SecurityException` object, which provides details in case this operation returns `false`.

8.5.1.9.3 Operation: encode_datareader_submessage

This operation shall be called by the DDS implementation whenever it has constructed a RTPS submessage of kind `AckNack` or `NackFrag`.

The operation receives the `DatareaderCryptoHandle` of the DataReader that is sending the submessage, as well as, a list of `DatawriterCryptoHandle` corresponding to all the DataWriter entities to which the submessage is being sent.

The operation receives the complete RTPS submessage as it would normally go onto the wire in the parameter ***rtps_submessage*** and shall output a RTPS `SecureSubMsg` in the output parameter ***encoded_rtps_submessage***. The DDS implementation shall substitute the original RTPS submessage that was passed in the ***rtps_submessage*** with the `SecureSubMsg` returned in the ***encoded_rtps_submessage*** output parameter and use the `SecureSubMsg` in the construction of the RTPS message that is eventually sent to the intended recipients.

The implementation of `encode_datareader_submessage` can perform any desired cryptographic transformation of the RTPS Submessage using the key material in the `sending_datareader_crypto,` it can also add one or more MACs, and/or signatures. The fact that the cryptographic material associated with the list of intended DataWriter entities is passed in the parameter `receiving_datawriter_crypto_list` allows the plugin implementation to include one of MAC that may be computed differently for each DataWriter.

The implementation of `encode_datareader_submessage` shall include within the `SecureSubMsg` the `CryptoTransformIdentifier` containing any additional information necessary for the receiving plugin to identify the `DatareaderCryptoHandle` associated with the DataReader that sent the message as well as the `DatawriterCryptoHandle` associated with the DataWriter that is meant to process the submessage. How this is done depends on the plugin implementation.

The `CryptoTransformIdentifier` should also contain any additional information beyond the one shared via the `CryptoToken` that would be needed to identify the key used and decode the `SecureSubMsg` submessage back into the original RTPS submessage.

If an error occurs, this method shall return `false`.

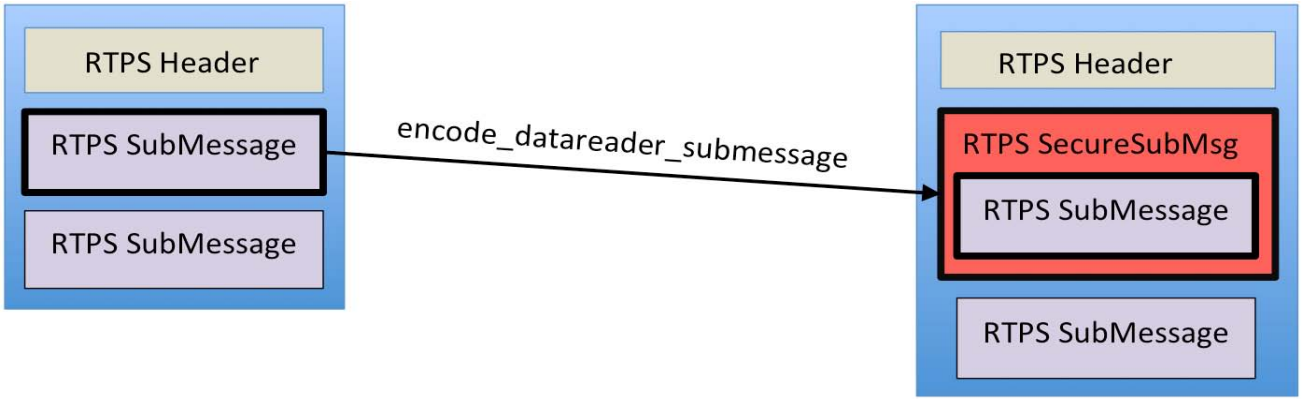


Figure 15 – Effect of encode_datareader_submessage within an RTPS message

Parameter **encoded_rtps_submessage**: The output containing the RTPS `SecureSubMsg` submessage, which shall be used to replace the input `rtps_submessage`.

Parameter **plain_rtps_submessage**: The input containing the RTPS submessage created by a DataReader. This submessage will be one of following kinds: `AckNack`, `NackFrag.`

Parameter **sending_datareader_crypto**: The `DatareaderCryptoHandle` returned by a previous call to register_local_datareader for the DataReader whose GUID is inside the `rtps_submessage`.

Parameter **receiving_datawriter_crypto_list**: The list of `DatawriterCryptoHandle` returned by previous calls to `register_matched_remote_datawriter` for the DataWriter entities to which the submessage will be sent.

Parameter **exception**: A `SecurityException` object, which provides details in case this operation returns `false`.

8.5.1.9.4 Operation: encode_rtps_message

This operation shall be called by the DDS implementation whenever it has constructed a RTPS message prior to sending it on the wire.

The operation receives the `ParticipantCryptoHandle` of the DomainParticipant that is sending the submessage, as well as, a list of `ParticipantCryptoHandle` corresponding to all the DomainParticipant entities to which the submessage is being sent.

The operation receives the complete RTPS message as it would normally go onto the wire in the parameter ***rtps_message*** and shall also output an RTPS message containing a single `SecureSubMsg` in the output parameter ***encoded_rtps_message***. The DDS implementation shall substitute the original RTPS message that was passed in the ***rtps_message*** with the ***encoded_rtps_message*** returned by this operation and proceed to send it to the intended recipients.

This operation may optionally not perform any transformation of the input RTPS message. In this case, the operation shall return false but not set the `exception` object. In this situation the DDS implementation shall send the original RTPS message.

If this operation performs any transformation of the original RTPS message, it shall output an RTPS Header followed by a single `SecureSubMsg` with the `MultiSubmsgFlag` (see 7.3.6.2) set to `true`. The output RTPS Header shall have its fields set as shown in the table below:

Table 25 – RTPS header resulting from the encode_rtps_message transformation

RTPS Header field	Mandatory values
protocol	It shall match the protocol field in the RTPS Header that was the input to the encode_rtps_message operation.
version	It shall match the version of the protocol in the RTPS Header that was the input to the encode_rtps_message operation.
vendorId	It shall be set to { 0x00, 0x01 }
guidPrefix	It shall be set to {0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff}

The purpose of using this specially-constructed RTPS Header is to let the ***encoded_rtps_message*** remain a legal RTPS message containing a valid protocol signature and version while at the same time hiding the vendorId and more importantly the guidPrefix which could be considered sensitive.

The implementation of `encode_rtps_message` may perform any desired cryptographic transformation of the whole RTPS Message using the key material in the `sending_participant_crypto`, it can also add one or more MACs, and/or signatures. The fact that the cryptographic material associated with the list of intended DataWriter entities is passed in the parameter `receiving_participant_crypto_list` allows the plugin implementation to include one of MAC that may be computed differently for each destination `DomainParticipant`.

The implementation of `encode_ rtps_message` shall include within the `SecureSubMsg` the `CryptoTransformIdentifier` containing any additional information beyond the one shared via the `CryptoToken` that would be needed to identify the key used and decode the `SecureSubMsg` submessage back into the original RTPS message.

If an error occurs, this method shall return `false` and set the `exception` object.

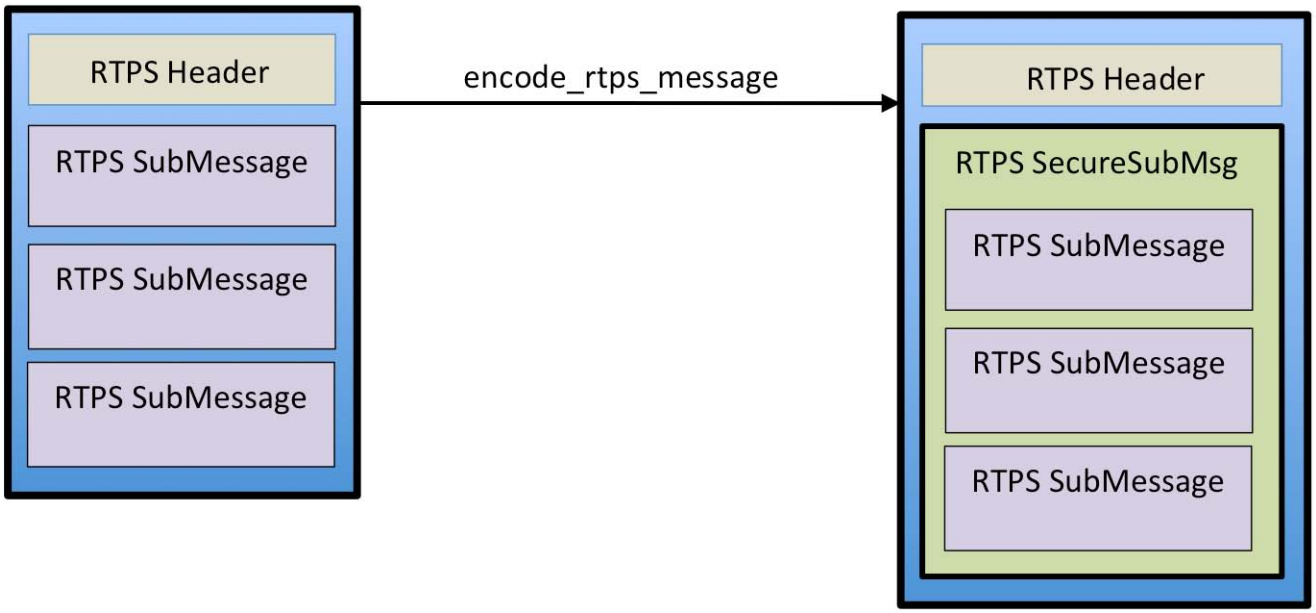


Figure 16 – Effect of encode_rtps within a RTPS message

Parameter **encoded_rtps_message**: The output containing the encoded RTPS message. The output message shall contain the modified RTPS Header followed by a single `SecureSubMsg` submessage with the `MultiSubmsgFlag` set to `true.`

Parameter **plain_rtps_message**: The input containing the RTPS messages the DDS implementation intended to send.

Parameter **sending_participant_crypto**: The `ParticipantCryptoHandle` returned by a previous call to register_local_participant for the DomainParticipant whose GUID is inside the RTPS Header.

Parameter **receiving_participant_crypto_list**: The list of `ParticipantCryptoHandle` returned by previous calls to `register_matched_remote_participant` for the DomainParticipant entities to which the message will be sent.

Parameter **exception**: A `SecurityException` object, which provides details in case this operation returns `false`.

8.5.1.9.5 Operation: decode_rtps_message

This operation shall be called by the DDS implementation whenever it receives an RTPS message prior to parsing it.

This operation shall reverse the transformation performed by the `encode_rtps_message` operation, decrypting the content if appropriate and verifying any MACs or digital signatures that were produced by the `encode_rtps_message` operation.

This operation expects the RTPS Header to be followed by a single `SecureSubMsg` with the `MultiSubmsgFlag` (see 7.3.6.2) set to `true`. If this is not the case the operation shall perform no transformation, return false, but not set the exception object. This situation is not considered an error. It simply indicates that the `encode_rtps_message` operation did not transform the original RTPS message.

If an error occurs, this method shall return an exception.

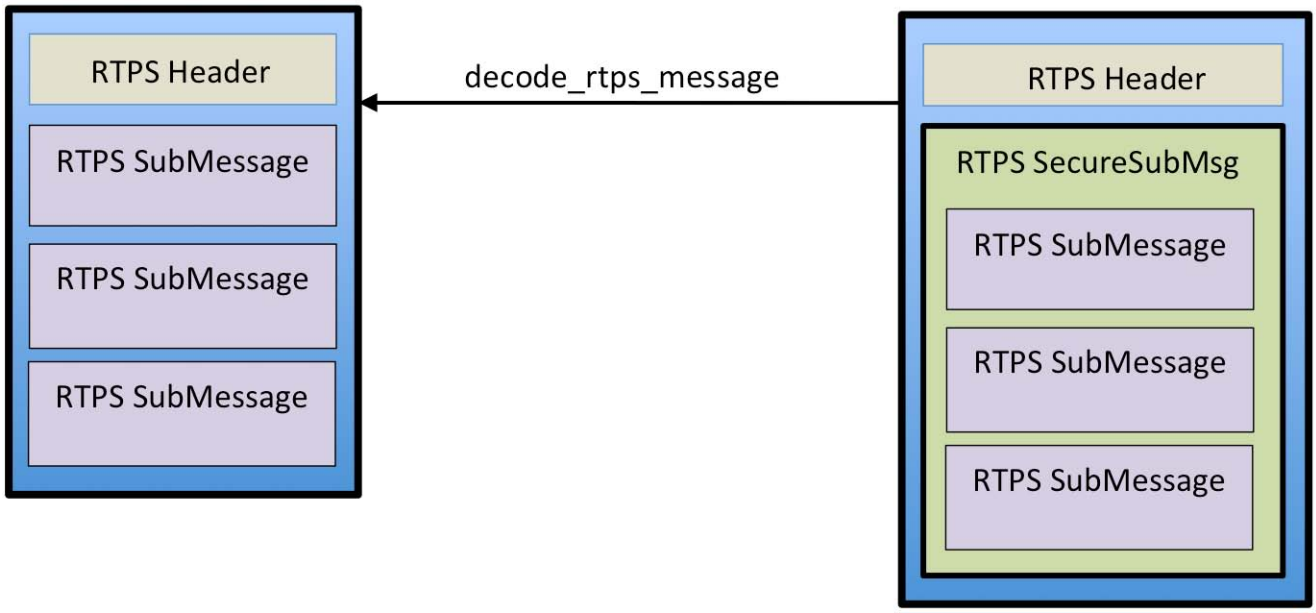


Figure 17 – Effect of decode_rtps within an RTPS message

Parameter **plain_rtps_message**: The output containing the decoded RTPS message. The output message shall contain the original RTPS Header and the set of RTPS `SubmessagesMsg` that were encapsulated inside the `SecureSubMsg` submessage.

Parameter **encoded_rtps_message**: The input containing the encoded RTPS message the DDS implementation received.

Parameter **receiving_participant_crypto**: The `ParticipantCryptoHandle` returned by previous calls to `register_local_participant` for the `DomainParticipant` entity that received the RTPS message.

Parameter **sending_participant_crypto**: The `ParticipantCryptoHandle` returned by a previous call to `register_matched_remote_participant` for the `DomainParticipant` that sent the RTPS message whose GUID is inside the RTPS Header.

Parameter **exception**: A `SecurityException` object, which provides details in case this operation returns `false`.

8.5.1.9.6 Operation: preprocess_secure_submsg

This operation shall be called by the DDS implementation as a result of a `DomainParticipant` receiving a RTPS `SecureSubMsg` with the `MultiSubmsgFlag` (see 7.3.6.2) set to `false`.

The purpose of the operation is to determine whether the secure submessage was produced as a result of a call to `encode_datawriter_submessage` or a call to `encode_datareader_submessage`, and retrieve the appropriate `DatawriterCryptoHandle` and `DatareaderCryptoHandle` needed to decode the submessage.

If the operation returns successfully, the DDS implementation shall call the appropriate decode operation based on the returned `SecureSubmessageCategory_t`:

- If the returned `SecureSubmessageCategory_t` equals DATAWRITER_SUBMESSAGE, then the DDS Implementation shall call `decode_datawriter_submessage`.
- If the returned `SecureSubmessageCategory_t` equals DATAREADER_SUBMESSAGE, then the DDS Implementation shall call `decode_datareader_submessage`.
- If the re returned `SecureSubmessageCategory_t` equals INFO_SUBMESSAGE, then the DDS Implementation proceed normally to process the submessage without further decoding.

Parameter **secure_submessage_category**: Output `SecureSubmessageCategory_t`. It shall be set to `DATAWRITER_SUBMESSAGE` if the `SecureSubMsg` was created by a call to `encode_datawriter_submessage` or set to `DATAREADER_SUBMESSAGE` if the `SecureSubMsg` was created by a call to `encode_datareader_submessage`. If none of these conditions apply, the operation shall return false.

Parameter **datawriter_crypto**: Output `DatawriterCryptoHandle`. The setting depends on the retuned value of `secure_submessage_category`:

- If `secure_submessage_category` is `DATAWRITER_SUBMESSAGE`, the `datawriter_crypto` shall be the `DatawriterCryptoHandle` returned by a previous call

to `register_matched_remote_datawriter` for the DataWriter that wrote the RTPS Submessage.

- If `secure_submessage_category` is `DATAREADER_SUBMESSAGE`, the `datawriter_crypto` shall be the `DatawriterCryptoHandle` returned by a previous call to `register_local_datawriter` for the DataWriter that is also the destination of the RTPS Submessage.

Parameter **datareader_crypto**: Output `DatareaderCryptoHandle`. The setting depends on the retuned value of `secure_submessage_category`:

- If `secure_submessage_category` is `DATAWRITER_SUBMESSAGE`, the `datareader_crypto` shall be the `DatareaderCryptoHandle` returned by a previous call to `register_local_datareader` for the DataReader that is the destination of the RTPS Submessage.
- If `secure_submessage_category` is `DATAREADER_SUBMESSAGE`, the `datareader_crypto` shall be the `DatareaderCryptoHandle` returned by a previous call to `register_matched_remote_datareader` for the DataReader that wrote the RTPS Submessage.

Parameter **encoded_rtps_message**: The input containing the received RTPS message.

Parameter **receiving_participant_crypto**: The `ParticipantCryptoHandle` returned by previous calls to `register_local_participant` for the DomainParticipant that received the RTPS message.

Parameter **sending_participant_crypto**: The `ParticipantCryptoHandle` returned by a previous call to `register_matched_remote_participant` for the DomainParticipant whose GUID is inside the RTPS Header.

Parameter **exception**: A `SecurityException` object, which provides details in case this operation returns `false`.

8.5.1.9.7 Operation: decode_datawriter_submessage

This operation shall be called by the DDS implementation as a result of receiving a `SecureSubMsg` with the `MultiSubmsgFlag` set to `false` whenever the preceding call to `preprecess_secure_submessage` identified the `SecureSubmessageCategory_t` as DATAWRITER_SUBMESSAGE.

This operation shall reverse the transformation performed by the `encode_datawriter_submessage` operation, decrypting the content if appropriate and verifying any MACs or digital signatures that were produced by the `encode_datawriter_submessage` operation.

The DDS implementation shall substitute the RTPS `SecureSubMsg` submessage within the received submessages with the RTPS `Submessage` produced by this operation.

If an error occurs, this method shall return `false`.

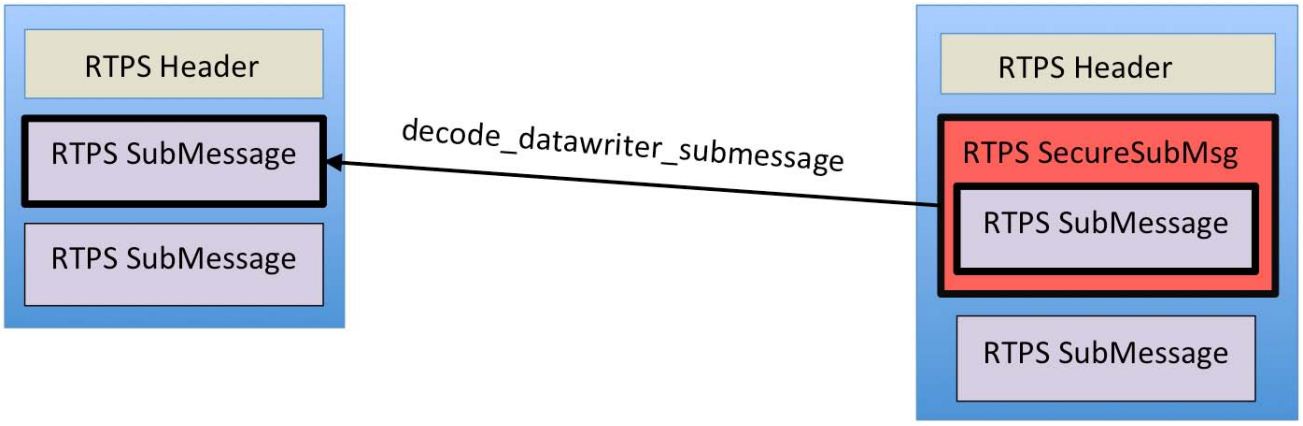


Figure 18 – Effect of decode_datawriter_submessage within an RTPS message

Parameter **plain_rtps_submessage**: The output containing the RTPS submessage created by a DataWriter. This submessage will be one of following kinds: `Data`, `DataFrag`, `Gap`, `Heartbeat`, and `HeartbeatFrag.`

Parameter **encoded_rtps_submessage**: The input containing the RTPS `SecureSubMsg` submessage, which was created by a call to `encode_datawriter_submessage`.

Parameter **receiving_datareader_crypto**: The `DatareaderCryptoHandle` returned by the preceding call to `preprocess_secure_submessage` performed on the received `SecureSubMsg`. It shall contain the `DatareaderCryptoHandle` corresponding to the DataReader that is receiving the RTPS Submessage.

Parameter **sending_datawriter_crypto**: The `DatawriterCryptoHandle` returned by the preceding call to `preprocess_secure_submsg` performed on the received `SecureSubMsg`. It shall contain the `DatawriterCryptoHandle` corresponding to the DataWriter that is sending the RTPS Submessage.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.5.1.9.8 Operation: decode_datareader_submessage

This operation shall be called by the DDS implementation as a result of receiving a `SecureSubMsg` with the `MultiSubmsgFlag` set to `false` whenever the preceding call `to preprocess_secure_submessage` identified the `SecureSubmessageCategory_t` as DATAREADER_SUBMESSAGE.

This operation shall reverse the transformation performed by the `encode_datareader_submessage` operation, decrypting the content if appropriate and verifying any MACs or digital signatures that were produced by the `encode_datareader_submessage` operation.

The DDS implementation shall substitute the RTPS `SecureSubMsg` submessage within the received submessages with the RTPS `Submessage` produced by this operation.

If an error occurs, this method shall return `false`.

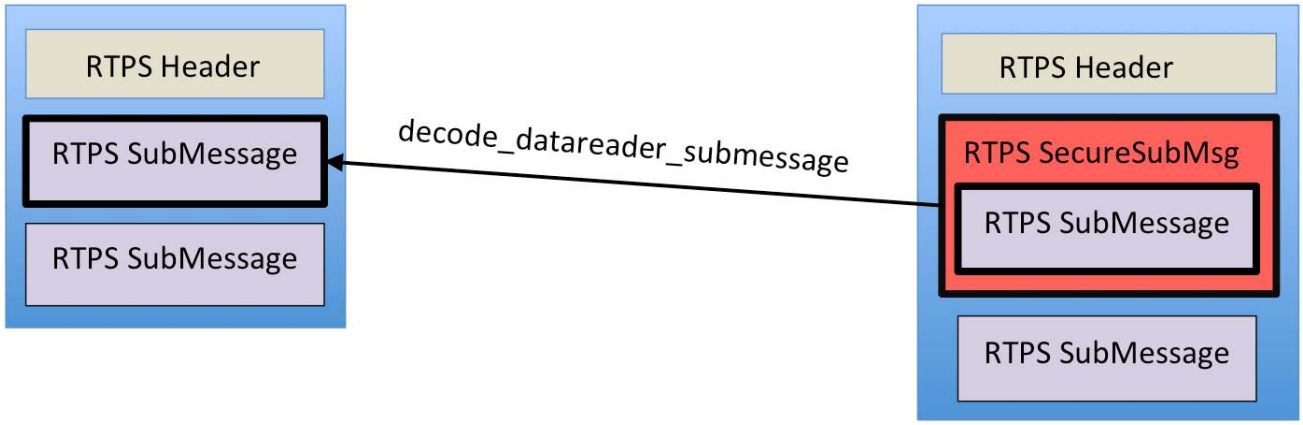


Figure 19 – Effect of decode_datawriter_submessage within an RTPS message

Parameter **plain_rtps_submessage**: The output containing the RTPS submessage created by a DataReader. This submessage will be one of following kinds: `AckNack`, `NackFrag.`

Parameter **encoded_rtps_submessage**: The input containing the RTPS `SecureSubMsg` submessage, which was created by a call to `encode_datareader_submessage`.

Parameter **receiving_datawriter_crypto**: The `DatawriterCryptoHandle` returned by the preceding call `to prepreprocess_secure_subessage` performed on the received `SecureSubMsg`. It shall contain the `DatawriterCryptoHandle` corresponding to the DataWriter that is receiving the RTPS Submessage.

Parameter **sending_datareader_crypto**: The `DatareaderCryptoHandle` returned by the preceding call to `preprocess_secure_submessage` performed on the received `SecureSubMsg`. It shall contain the `DatareaderCryptoHandle` corresponding to the DataReader that is sending the RTPS Submessage.

8.5.1.9.9 Operation: decode_serialized_data

This operation shall be called by the DDS implementation as a result of a DataReader receiving a `Data` or `DataFrag` submessage containing a `SecuredPayload` RTPS submessage element (instead of the normal `SerializedData`).

The DDS implementation shall substitute the `SecuredPayload` submessage element within the received submessages with the `SerializedData` produced by this operation.

The implementation of `decode_serialized_data` shall undo the cryptographic transformation of the `SerializedData` that was performed by the corresponding call to `encode_serialized_data` on the DataWriter side. The DDS implementation shall use the available information on the remote DataWriter that wrote the message and the receiving DataReader to locate the corresponding `DatawriterCryptoHandle` and `DatareaderCryptoHandle` and pass them as parameters to the operation. In addition, it shall use the `CryptoTransformIdentifier` present in the `SecuredPayload` to verify that the correct key us available and obtain any additional data needed to decode the `SecuredPayload`.

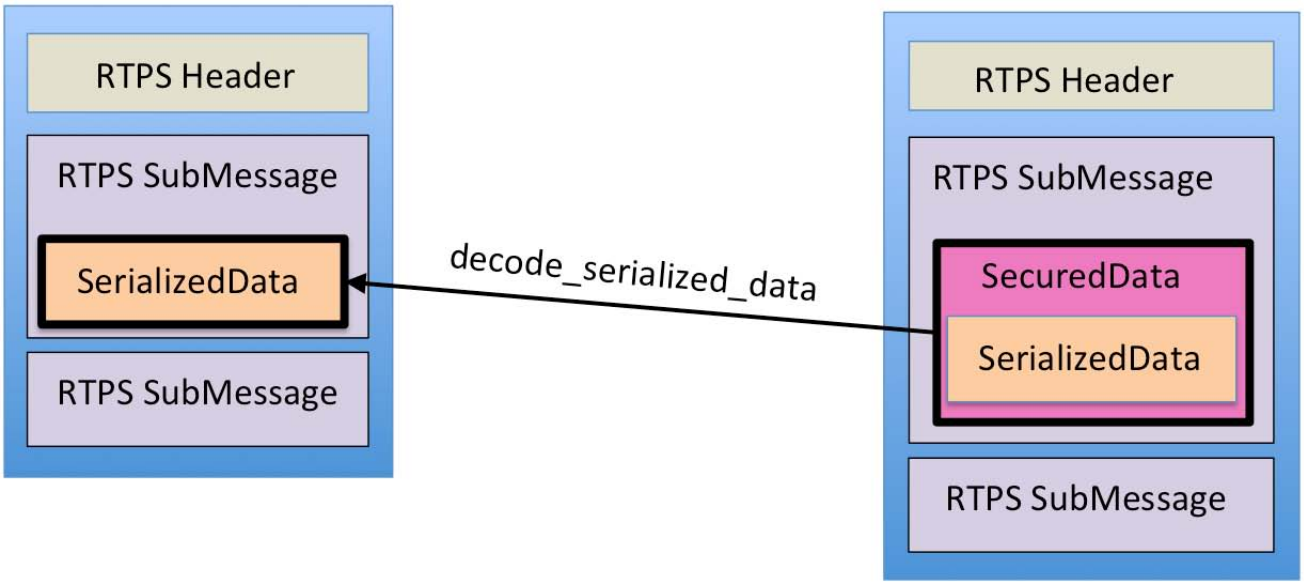


Figure 20 – Effect of decode_serialized_data within an RTPS message

If an error occurs, this method shall return `false`.

Parameter **plain_buffer**: The output containing the `SerializedData` RTPS submessage element, which shall be used to replace the input plain_buffer.

Parameter **encoded_buffer**: The input containing the `SecuredPayload` RTPS submessage element.

Parameter **receving_reader_crypto**: The `DatareaderCryptoHandle` returned by a previous call to `register_local_datareader` for the `DataReader` that received the Submessage containing the `SecuredPayload`.

Parameter **sending_datawriter_crypto**: The `DatawriterCryptoHandle` returned by a previous call to `register_matched_remote_datawriter` for the `DataWriter` that wrote the `SecuredPayload`.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.6 The Logging Plugin

The Logging Control Plugin API defines the types and operations necessary to support logging of security events for a DDS `DomainParticipant`.

8.6.1 Background (Non-Normative)

The `Logging` plugin provides the capability to log all security events, including expected behavior and all security violations or errors. The goal is to create security logs that can be used to support audits. The rest of the security plugins will use the logging API to log events.

The `Logging` plugin will add an ID to the log message that uniquely specifies the `DomainParticipant`. It will also add a time-stamp to each log message.

The `Logging` API has two options for collecting log data. The first is to log all events to a local file for collection and storage. The second is to distribute log events securely over DDS.

8.6.2 Logging Plugin Model

The logging model is shown in the figure below.

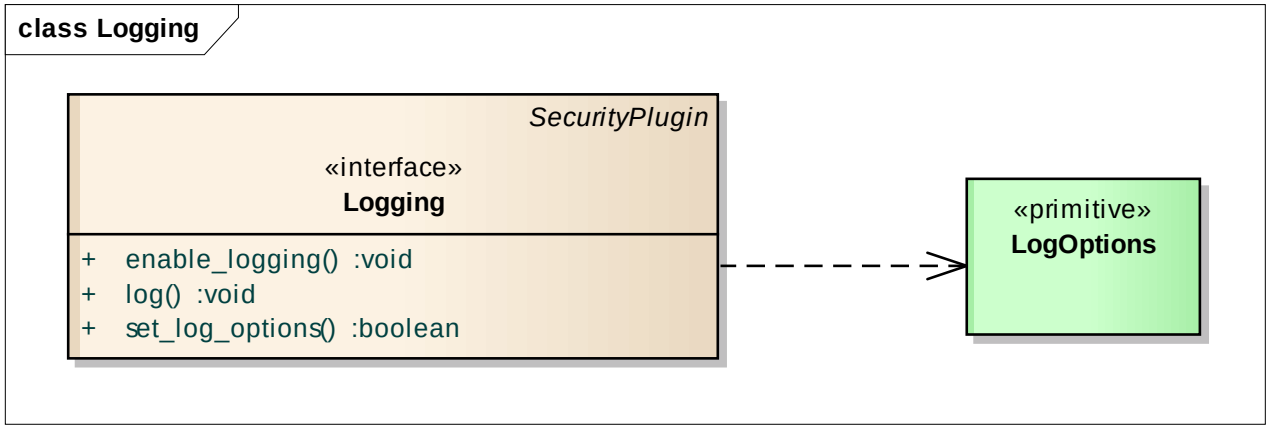


Figure 21 – Logging Plugin Model

8.6.2.1 LogOptions

The `LogOptions` let the user control the ***log level*** and where to log. The options must be set before logging starts and may not be changed at run-time after logging has commenced. This is to ensure that an attacker cannot temporarily suspend logging while they violate security rules, and then start it up again.

The options specify if the messages should be logged to a file and, if so, the file name. The `LogOptions` also specify whether the log messages should be distributed to remote services or only kept locally.

Table 26 – LogOptions values

LogOptions
Attributes

`log_level`	`Long`
`log_file`	`String`
`distribute`	`Boolean`

8.6.2.1.1 Attribute: log_level

Specifies what level of log messages will be logged. Messages at or below the ***log_level*** are logged. The levels are as follows, from low to high:

- FATAL_LEVEL – security error causing a shutdown or failure of the Domain Participant
- SEVERE_LEVEL – major security error or fault
- ERROR_LEVEL – minor security error or fault
- WARNING_LEVEL – undesirable or unexpected behavior
- NOTICE_LEVEL – important security event
- INFO_LEVEL – interesting security event
- DEBUG_LEVEL – detailed information on the flow of the security events
- TRACE_LEVEL – even more detailed information

8.6.2.1.2 Attribute: log_file

Specifies the full path to a local file for logging events. If the file already exists, the logger will append log messages to the file. If it is NULL, then the logger will not log messages to a file.

8.6.2.1.3 Attribute: distribute

Specifies whether the log events should be distributed over DDS. If it is TRUE, each log message at or above the `log_level` is published as a DDS `Topic`.

8.6.2.2 Logging

Table 27 – Logging Interface

Logging		
No Attributes		
Operations		
`set_log_options`		`Boolean`
	`options`	`LogOptions`
	`exception`	`SecurityException`
`log`		`void`
	`log_level`	`long`
	`message`	`String`

	`category`	`String`
	`exception`	`SecurityException`
`enable_logging`		`void`
	`exception`	`SecurityException`

8.6.2.2.1 Operation: set_log_options

Sets the options for the logger. This must be called before `enable_logging`; it is an error to set the options after logging has been enabled.

If the options are not successfully set, then the method shall return `false`.

Parameter options: the `LogOptions` object with the required options.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.6.2.2.2 Operation: log

Log a message. The logger shall log the message if its `log_level` is at or above the level set in the `LogOptions`. The Logger shall add to the message the RTPS GUID of the `DomainParticipant` whose operations are being logged. If it is sent out over DDS, then DDS shall add a timestamp. If it is logged locally, a timestamp shall be added when it is logged.

Parameter log_level: The level of the log message. It must correspond to one of the levels defined in 8.6.2.1.1.

Parameter message: The log message.

Parameter category: A category for the log message. This can be used to specify which security plugin generated the message.

Parameter exception: A `SecurityException` object that will return an exception if there is an error with logging.

8.6.2.2.3 Operation: enable_logging

Enables logging. After this method is called, any call to log shall log the messages according to the options. After this method is called, the options may not be modified. This is to ensure that the logger cannot be temporarily suspended to cover up an attack.

If the options are not successfully set, then the method shall return `false`.

Parameter options: the `LogOptions` object with the required options.

Parameter exception: A `SecurityException` object, which provides details in case this operation returns `false`.

8.7 Data Tagging

Data tagging is the ability to add a security label or tag to data. This is often used to specify a classification level of the data including information about its releasability. In a DDS context, it could have several uses:

- It can be used for access control – access control would be granted based on the tag
- It could be used for message prioritization
- It could not be used by the middleware, and instead used by the application or other service

8.7.1 Background (Non-Normative)

There are four different approaches to data tagging:

1. `DataWriter` tagging: data received from a certain `DataWriter` has the tag of the `DataWriter`. This solution does not require the tag to be added to each individual sample.
2. Data instance tagging: each instance of the data has a tag. This solution does not require the tag to be added to each individual sample.
3. Individual sample tagging: every DDS sample has its own tag attached.
4. Per-field sample tagging: very complex management of the tags.

This specification supports `DataWriter` tagging. This was considered the best choice as it meets the majority of uses cases. It fits into the DDS paradigm, as the metadata for all samples from a `DataWriter` is the same. It is also the highest performance, as the tag only needs to be exchanged once when the `DataWriter` is discovered, not sent with each sample.

This approach directly supports typical use cases where each application or `DomainParticipant` writes data on a `Topic` with a common set of tags (e.g., all at the same specified security level). For use cases where an application creates data at different classifications, that application can create multiple `DataWriters` with different tags.

8.7.2 DataTagging Model

The `DataWriter` tag will be associated with every sample written by the `DataWriter`. The `DataWriter` DataTag is implemented as an immutable `DataWriterQos`. The `DataWriter` DataTag shall be propagated via in the `PublicationBuiltinTopicData` as part of the DDS discovery protocol.

The `DataReader` DataTag is implemented as an immutable `DataReaderQos`. The `DataReader` DataTag shall be propagated via in the `SubscriptionBuiltinTopicData` as part of the DDS discovery protocol.

8.7.3 DataTagging Types

The following data types are used for the DataTag included as part of both DataReader and DataWriter Qos.

```
typedef DataTagQosPolicy DataTag;
```

8.8 Security Plugins Behavior

In the previous sub clauses, the functionality and APIs of each plugin have been described. This sub clause provides additional information on how the plugins are integrated with the middleware.

8.8.1 Authentication and AccessControl behavior with local DomainParticipant

The figure below illustrates the functionality of the security plugins with regards to a local `DomainParticipant`.

In this sub clause the term "*DDS application*" refers to the application code that calls the DDS API. The term "*DDS middleware*" refers to a DDS Implementation that complies with the DDS Security specification.

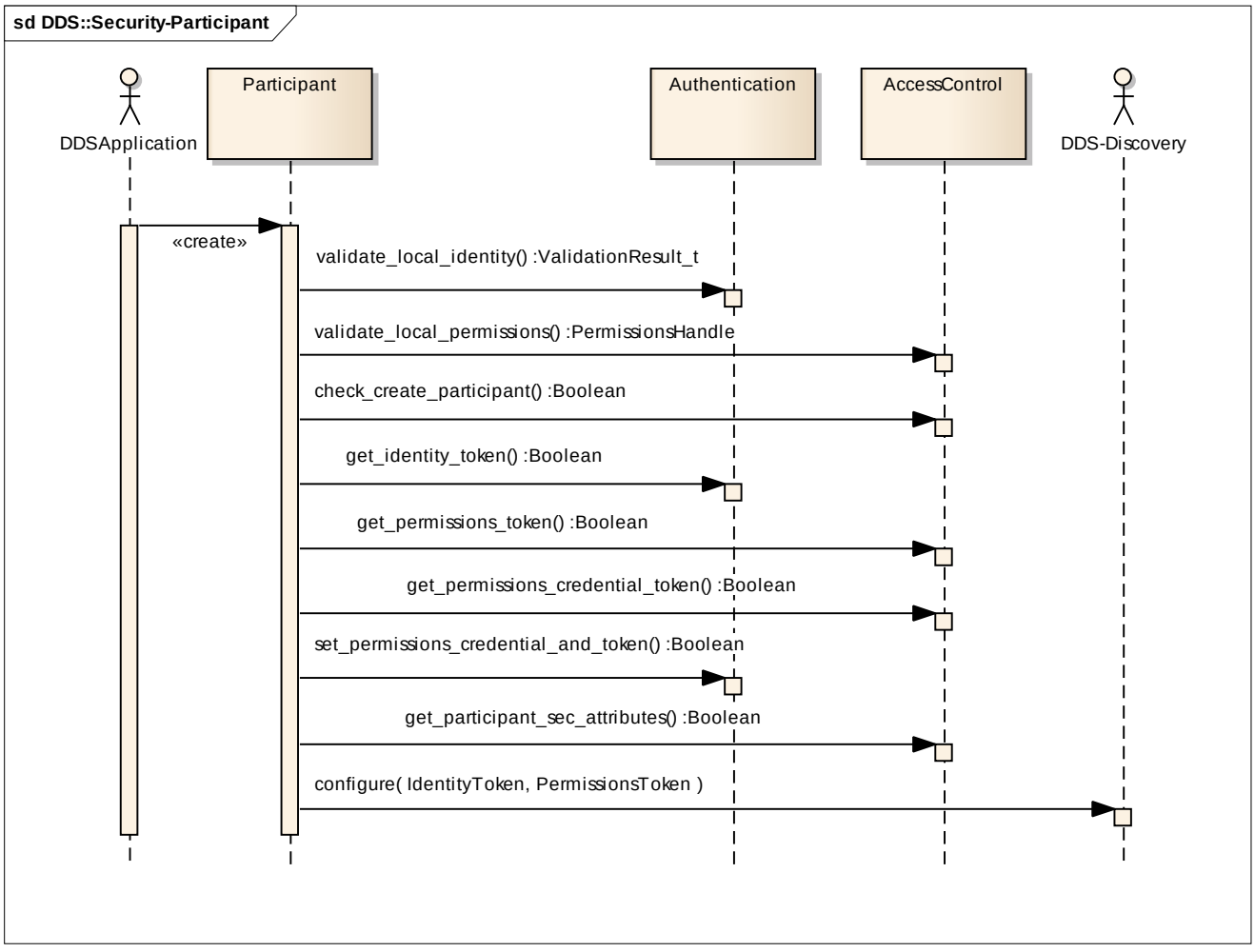


Figure 22 – Authentication and AccessControl sequence diagram with local DomainParticipant

This behavior sequence is triggered when the DDS application initiates the creation of a local `DomainParticpant` by calling the `create_participant` operation on the `DomainParticipantFactory`. The following are mandatory steps that the DDS middleware shall perform prior to creating the `DomainParticipant`. The steps need not occur exactly as described as long as the observable behavior matches the one described below.

1. The DDS middleware shall validate the identity of the application attempting to create the `DomainParticipant` by calling the `Authentication::validate_local_identity` operation, passing the `IdentityCredential` and a ***candidate_participant_key***. The Authentication plugin validates the identity of the local `DomainParticipant` and returns an `IdentityHandle` for the holder of the identity (`DomainParticipant`), which will be necessary for interacting with the access control plugin. The `validate_local_identity` operation also returns an adjusted_participant_key. If the identity is not successfully validated, the DDS middleware shall not create the `DomainParticipant` and the `create_participant` operation shall return NIL and set the return code to NOT_ALLOWED_BY_SEC.

2. The DDS middleware shall validate that the DDS application has the necessary permissions to join DDS domains by calling the `AccessControl::validate_local_permissions` operation. The Access Control plugin shall validates the permissions and issue a signed `PermissionsHandle` for the holder of the identity (`DomainParticipant`). If the permissions are not validated, the `DomainParticipant` shall not be created, the `create_participant` operation shall return NIL and set the return code to NOT_ALLOWED_BY_SEC.

3. The DDS middleware shall verify that the DDS application has the necessary permissions to join the specific Domain identified by the `domainId` by calling the operation `AccessControl::check_create_participant`. If this operation returns FALSE, the `DomainParticipant` shall not be created, the `create_participant` operation shall return NIL and set the return code to NOT_ALLOWED_BY_SEC.

4. The DDS middleware shall call the `get_identity_token` operation to obtain the `IdentityToken` object corresponding to the received `IdentityHandle.` The `IdentityToken` object shall be placed in the ParticipantBuiltinTopicData sent via discovery, see 7.4.1.3.

5. The middleware shall call the `get_permissions_token` operation on the AccessControl plugin to obtain the `PermissionsToken` object corresponding to the received `PermissionsHandle`. The `PermissionsToken` shall be placed in the ParticipantBuiltinTopicData sent via discovery, see 7.4.1.3.

6. The middleware calls `the get_permissions_credential` operation on the `AccessControl` plugin, which returns the `PermissionsCredential` object corresponding to the received `PermissionsHandle`. The `PermissionsCredential` object is necessary to configure the `Authentication` plugin.

7. The middleware calls the `set_permissions_credential_and_token` operation on the `Authentication` plugin such that it can be sent during the authentication handshake.

8. The middleware calls the `get_psrticipant_sec_attributes` operation on the `AccessControl` plugin to obtain the `ParticipantSecurityAttributes` such that it knows how to handle remote participants that fail to authenticate.

9. The `DomainParticipant`'s `IdentityToken` and `PermissionsToken` are used to configure DDS discovery such that they are propagated inside the ***identity_token*** and the ***permissions_token*** members of the ***ParticipantBuiltinTopicData***. This operation is internal to the DDS implementation and therefore this API is not specified by the DDS Security specification. It is mentioned here to provide guidance to implementers.

8.8.2 Authentication behavior with discovered DomainParticipant

Depending on the `ParticipantSecurityAttributes` returned by the `AccessControl` operation `get_participant_sec_attributes` the `DomainParticipant` may allow remote `DomainParticipants` that lack the ability to authenticate (e.g., do not implement DDS Security) to match.

8.8.2.1 Behavior when `is_access_protected` is set to FALSE

If the `ParticipantSecurityAttributes` returned by the operation `get_participant_sec_attributes` has the member `is_access_protected` set to FALSE, the `DomainParticipant` shall match remote `DomainParticipant` entities that are not able to authenticate. Specifically:

- Discovered `DomainParticipant` entities that do *not* implement the DDS Security specification or do not contain compatible Security Plugins shall be matched without the `DomainParticipant` attempting to authenticate them and shall be treated as "Unauthenticated" `DomainParticipant` entities.
- Discovered `DomainParticipant` entities that *do* implement the DDS Security specification and declare compatible Security Plugins but fail the Authentication protocol shall be matched and treated as "Unauthenticated" `DomainParticipants` entities.

  For any matched "Unauthenticated" `DomainParticipant` entities, the `DomainParticipant` shall **match only** the regular builtin Endpoints (***ParticipantMessage***, ***DCPSParticipants***, ***DCPSPublications***, ***DCPSSubscriptions***) **and not** the builtin secure Endpoints (see 7.4.5 for the complete list).

  For any matched authenticated `DomainParticipant` entities, the `DomainParticipant` shall match all the builtin endpoints.

8.8.2.2 Behavior when `is_access_protected` is set to TRUE

If the `ParticipantSecurityAttributes` has the member `is_access_protected` set to TRUE, the `DomainParticipant` shall reject remote `DomainParticipant` entities that are not able to authenticate. Specifically:

- Discovered `DomainParticipant` entities that do not implement the DDS Security specification or do not contain compatible Security Plugins shall be rejected without the `DomainParticipant` attempting to authenticate them.
- Discovered `DomainParticipant` entities that do implement the DDS Security specification, declare compatible Security Plugins but fail the Authentication protocol shall be rejected.
- Discovered `DomainParticipant` entities that do implement the DDS Security specification, declare compatible Security Plugins and pass the Authentication protocol successfully shall be

matched and the `DomainParticipant` shall also match all the builtin endpoints of the discovered `DomainParticipant`.

The figure below illustrates the behavior of the security plugins with regards to a discovered `DomainParticipant` that also implements the DDS Security specification and announces compatible security plugins. The exact operations depend on the plugin implementations. The sequence diagram shown below is just indicative of one possible sequence of events and matches what the builtin DDS:Auth:PKI-RSA/DSA-DH plugin (see 9.3.3) does.

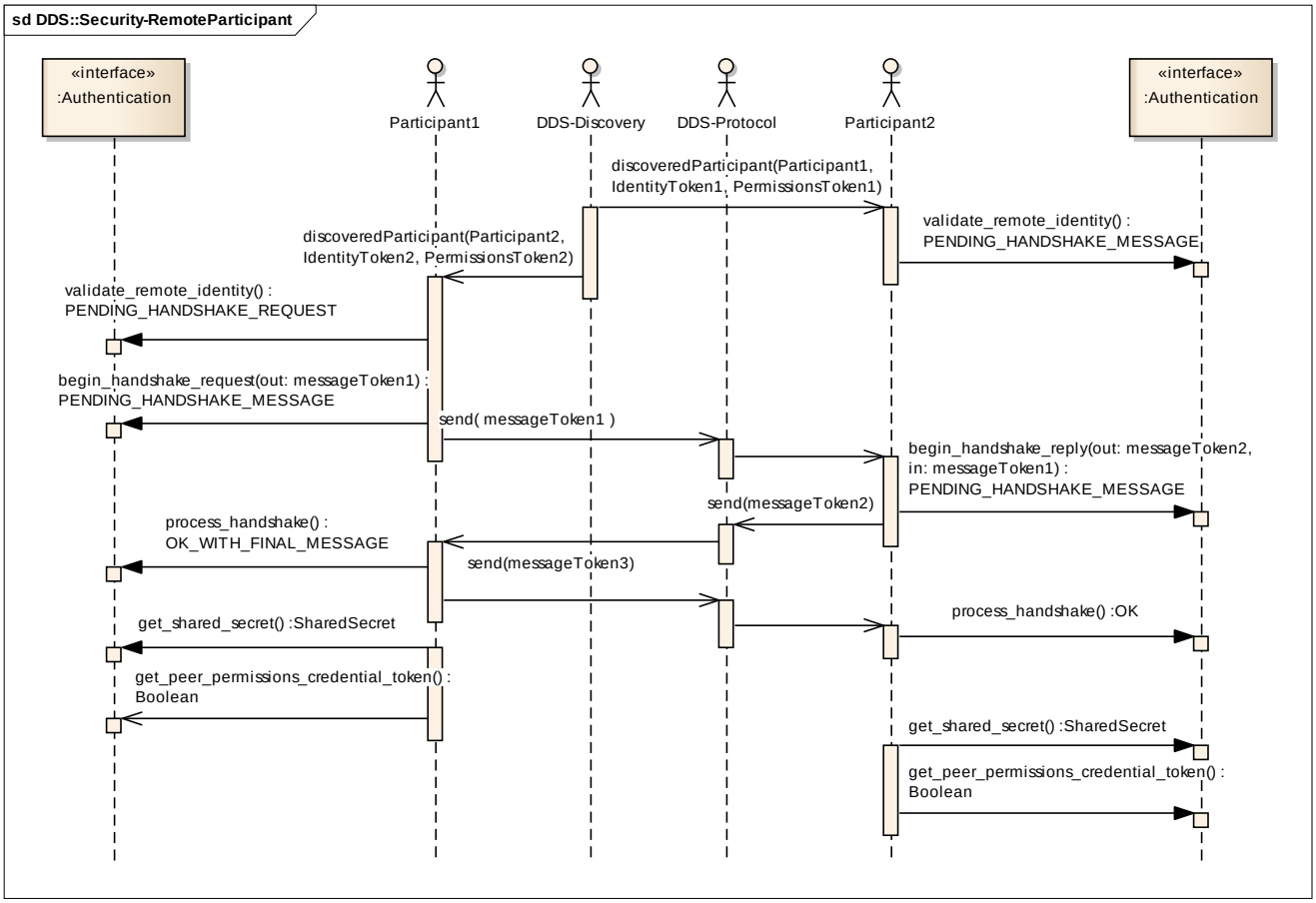


Figure 23 – Authentication sequence diagram with discovered DomainParticipant

1. Participant2 discovers Participant1via the discovery protocol. The `BuiltinParticipantTopicData` contains the `IdentityToken` and `PermissionsToken` of Participant1.

2. Participant2 calls the `validate_remote_identity` operation to validate the identity of Participant1 passing the `IdentityToken` and `PermissionsToken` of Participant1 received via discovery and obtains an `IdentityHandle` for Participant1, needed for further operations involving Participant1. The operation returns PENDING_HANDSHAKE_MESSAGE indicating that further handshake messages are needed to complete the validation and that Participant2 should wait for a `HandshakeMessageToken` to be received from Participant1. Participant2 waits for this message.

3. Participant1 discovers Participant2 via the DDS discovery protocol. The `BuiltinParticipantTopicData` contains the `IdentityToken` and `PermissionsToken` of Participant2.

4. Participant1 calls the operation `validate_remote_identity` to validate the identity of Participant2 passing the `IdentityToken` and `PermissionsToken` of Participant2 received via discovery and obtains an `IdentityHandle` for Participant2, needed for further operations involving Participant2. The operation returns PENDING_HANDSHAKE_REQUEST indicating further handshake messages are needed and Participant1 should initiate the handshake. .

5. Participant1 calls `begin_handshake_request` to begin the requested handshake. The operation outputs a `HandshakeHandle` and a `HandshakeMessageToken` (messageToken1). The operation returns PENDING_HANDSHAKE_MESSAGE indicating authentication is not complete and the returned messageToken1 needs to be sent to Participant2 and a reply should be expected..

6. Participant1 sends the `HandshakeMessageToken` (messageToken1) to Participant2 using the ***BuiltinParticipantMessageWriter***.

7. Participant2 receives the `HandshakeMessageToken` (messageToken1) on the ***BuiltinParticipantMessageReader***. Participant2 determines the message originated from a remote `DomainParticipant` (Participant1) for which it had already called `validate_remote_identity` where the function had returned PENDING_HANDSHAKE_REPLY.

8. Participant2 calls `begin_handshake_reply` passing the received `HandshakeMessageToken` (messageToken1). The `Authentication` plugin processes the `HandshakeMessageToken` (messageToken1) and outputs a `HandshakeMessageToken` (messageToken2) in response and a `HandshakeHandle`. The operation `begin_handshake_reply` returns PENDING_HANDSHAKE_MESSAGE, indicating authentication is not complete and an additional message needs to be received.

9. Participant2 sends the `HandshakeMessageToken` (messageToken2) back to Participant1 using the ***BuiltinParticipantMessageWriter***.

10. Participant1 receives the `HandshakeMessageToken` (messageToken2) on the ***BuiltinParticipantMessageReader***. Participant1 determines this is message originated from a remote `DomainParticipant` (Participant2) for which it had already called `validate_remote_identity` where the function had returned PENDING_HANDSHAKE_REQUEST.

11. Participant1 calls `process_handshake` passing the received `HandshakeMessageToken` (messageToken2). The Authentication plugin processes messageToken2, verifies it is a valid reply to the messageToken1 it had sent and outputs the `HandshakeMessageToken` messageToken3 in response. The `process_handshake` operation returns OK_WITH_FINAL_MESSAGE, indicating authentication is complete but the returned `HandshakeMessageToken` (messageToken3) must be sent to Participant2.

12. Participant1 sends the `HandshakeMessageToken` (messageToken3) to Participant2 using the ***BuiltinParticipantMessageWriter***.

13. Participant2 receives the `HandshakeMessageToken` (messageToken3) on the ***BuiltinParticipantMessageReader***. Participant2 determines this is message originated from a remote `DomainParticipant` (Participamt1) for which it had already called the operation `begin_handshake_reply` where the call had returned PENDING_HANDSHAKE_MESSAGE.

14. Participant2 calls the `process_handshake` operation, passing the received `HandshakeMessageToken` (messageToken3). The Authentication plugin processes the messageToken2, verifies it is a valid reply to the messageToken2 it had sent and returns OK, indicating authentication is complete and no more messages need to be sent or received.

15. Participant1, having completed the authentication of Participant2, calls the operation `get_shared_secret` to retrieve the `SharedSecret`, which is used with the other Plugins to create `Tokens` to exchange with Participant2.

16. Participant1, having completed the authentication of Participant2, calls the operation `get_peer_permissions_credential` to retrieve the `PermissionsCredential` associated with Participant2, which is used with the `AccessControl` plugin to determine the permissions that Participant1 will grant to Participant2.

17. Participant2, having completed the authentication of Participant1, calls the operation `get_shared_secret` to retrieve the `SharedSecret`, which is used with the other Plugins to create `Tokens` to exchange with Participant1.

18. Participant2, having completed the Authentication of Participant1, calls the operation `get_peer_permissions_credential` to retrieve the `PermissionsCredential` associated with Participant2 which is used with the `AccessControl` plugins to determine the permissions that Participant2 will grant to Participant1.

8.8.3 AccessControl behavior with local domain entity creation

The figure below illustrates the functionality of the security plugins with regards to the creation of local DDS domain entities: `Topic`, `DataWriter`, and `DataReader` entities.

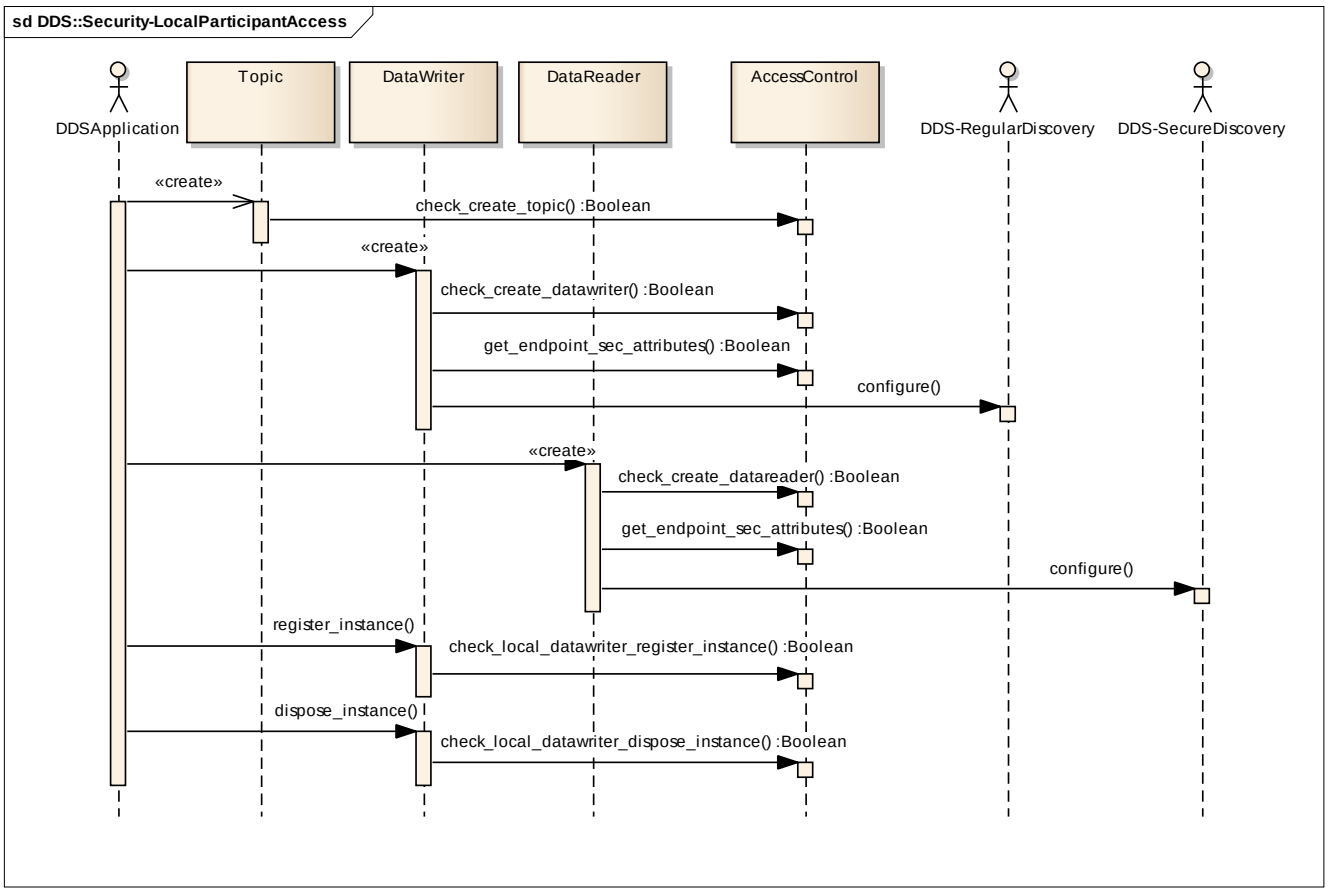


Figure 24 – AccessControl sequence diagram with local entities

1. The DDS application initiates the creation of a new `Topic` for the `DomainParticpant`.
2. The middleware verifies the `DomainParticipant` is allowed to create a Topic with name `topicName`. Operation `AccessControl::check_create_topic()` is called for this verification. If the verification fails, the Topic object is not created.
3. The DDS application initiates the creation of a local `DataWriter`.
4. The middleware verifies that the `DataWriter` has the right permissions to publish on Topic `topicName`. Operation `AccessControl::check_create_datawriter()` is called for this verification. As an optional behavior, `check_create_datawriter` () can also verify if the `DataWriter` is allowed to tag data with `dataTag`. If the verification doesn't succeed, the `DataWriter` is not created. As an optional behavior, `check_create_datawriter()` can also check the QoS associated with the `DataWriter` and grant permissions taking that into consideration.
5. The middleware calls `AccessControl::get_endpoint_sec_attributes` to obtain the `EndpointSecurityAttributes` for the created `DataWriter`.
6. This sequence diagram illustrates the situation where the `EndpointSecurityAttributes` for the created `DataWriter` has the ***is_discovery_protected*** attribute set to FALSE. In this situation the middleware configures Discovery to use regular (not secure) publications discovery endpoint (***DCPSPublications***) to propagate the `PublicationBuiltinTopicData` for the created `DataWriter`.

7. The DDS application initiates the creation of a local `DataReader`.
8. The middleware verifies that the `DataReader` has the right permissions to subscribe on Topic `topicName`. Operation `AccessControl::check_create_datareader()` is called for this verification. As an optional behavior, `check_create_datareader()` can also verify if the `DataReader` is allowed to receive data tagged with `dataTag`. If the verification doesn't succeed, the `DataReader` is not created. As an optional behavior `check_create_datareader()` can also check the QoS associated with the `DataReader` and grant permissions taking that into consideration.
9. The middleware calls the operation `AccessControl::get_endpoint_sec_attributes` to obtain the `EndpointSecurityAttributes` for the created `DataReader` entity.
10. This sequence diagram illustrates the situation where the `EndpointSecurityAttributes` for the created `DataReader` has the ***is_discovery_protected*** attribute set to TRUE. In this situation the middleware configures Discovery to use the secure subscriptions discovery endpoint (***DCPSSecureSubscritions***) to propagate the `SubscriptionBuiltinTopicData` for the created `DataReader`.
11. The DDS application initiates the registration of a data instance on the `DataWriter`.
12. The middleware verifies that the `DataWriter` has the right permissions to register the instance. The operation `AccessControl::check_local_datawriter_register_instance()` is called for this verification. If the verification doesn't succeed, the instance is not registered.
13. The DDS application initiates the disposal of an instance of the `DataWriter`.
14. The middleware verifies that the `DataWriter` has the right permissions to dispose the instance. The operation `AccessControl::check_local_datawriter_dispose_instance()` is called for this verification. If the verification doesn't succeed, the instance is not disposed.

8.8.4 AccessControl behavior with remote participant discovery

If the `ParticipantSecurityAttributes` object returned by the `AccessControl` operation `get_participant_sec_attributes` has the `is_access_protected` attribute set to FALSE, the `DomainParticipant` may discover DomainParticipants that cannot be authenticated because they either lack support for the authentication protocol or they fail the authentication protocol. These "Unauthenticated" `DomainParticipant` entities shall be matched and considered "Unauthenticated" DomainParticipant entities.

If the `DomainParticipant` discovers a DomainParticipant entity that it can authenticate successfully, then it shall validate with the AccessControl plugin that it has the permissions necessary to join the DDS domain:

- If the validation succeeds, the discovered DomainParticipant shall be considered "Authenticated" and all the builtin Topics automatically matched.
- If the validation fails, the discovered DomainParticipant shall be considered ignored and all the builtin Topics should not be matched.

The figure below illustrates the functionality of the security plugins with regards to the discovery of remote `DomainParticipant` entity that has been successfully authenticated by the Authentication plugin.

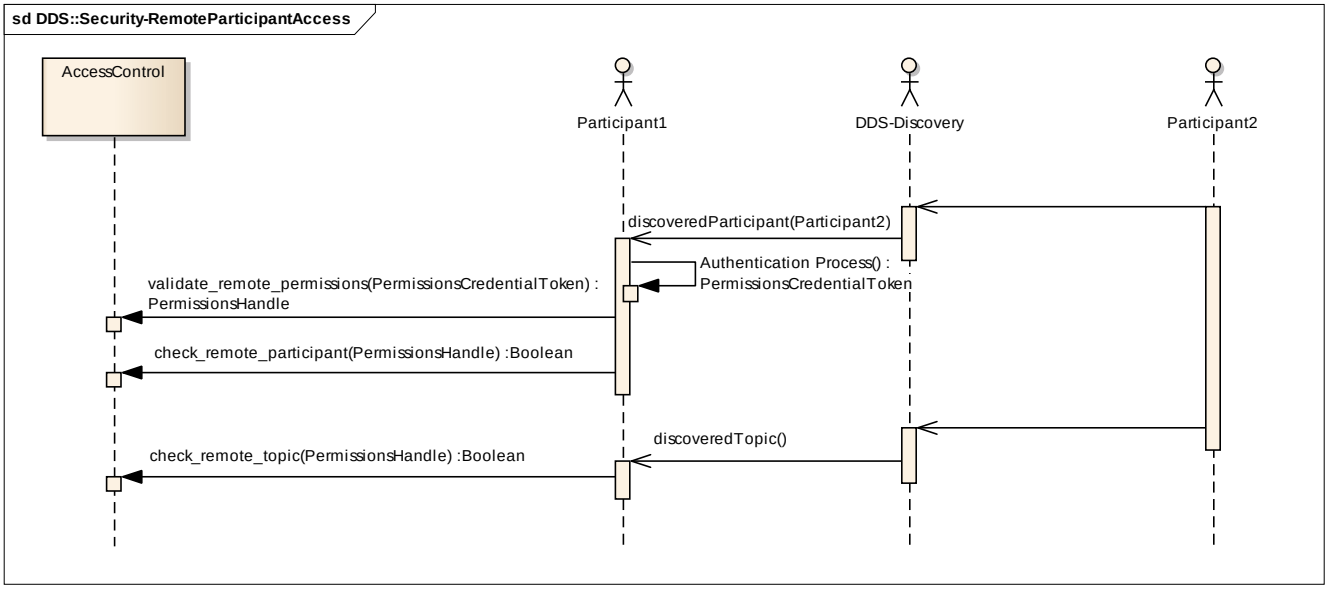


Figure 25 – AccessControl sequence diagram with discovered DomainParticipant

1. The `DomainParticipant` Participant1 discovers the `DomainParticipant` (Participant2) via the discovery protocol and successfully authenticates Participant2 and obtains the `PermissionsCredential` as described in 8.8.2.

2. Participant1 calls the operation `validate_remote_permissions` to validate the permissions of Participant2, passing the `PermissionsToken` obtained via discovery from Participant2 and the `PermissionsCredential` returned by the operation `get_peer_permissions_credential` on the `Authentication` plugin. The operation `validate_remote_permissions` returns a `PermissionsHandle`, which the middleware will use whenever an access control decision must be made for the remote `DomainParticipant`.

3. Participant1 calls the operation `check_remote_participant` to verify the remote `DomainParticipant` (Participant2) is allowed to join the DDS domain with the specified `domainId`, passing the `PermissionsHandle` returned by the `validate_remote_permissions` operation. If the verification fails, the remote `DomainParticipant` is ignored and all the endpoints corresponding to the builtin Topics are unmatched.

4. Participant1 discovers that `DomainParticipant` (Participant2) has created a new DDS `Topic`.

5. Participant1 verifies that the remote `DomainParticpant` (Participant2) has the permissions needed to create a DDS `Topic` with name `topicName`. The operation `check_remote_topic` is called for this verification. If the verification fails, the discovered `Topic` is ignored.

8.8.5 AccessControl behavior with remote domain entity discovery

This sub clause describes the functionality of the AccessControl plugin relative to the discovery of remote domain entities, that is, `Topic`, `DataWriter`, and `DataReader` entities.

If the `ParticipantSecurityAttributes` object returned by the `AccessControl` operation `get_participant_sec_attributes` has the `is_access_protected` attribute set to FALSE, the `DomainParticipant` may have matched a remote "Unauthenticated" `DomainParticipant`, i.e., a `DomainParticipant` that has not authenticated successfully and may therefore discover endpoints via the regular (non-secure) discovery endpoints from an "Unauthenticated" `DomainParticipant.`

8.8.5.1 AccessControl behavior with discovered endpoints from "Unauthenticated" DomainParticipant

If the `DomainParticipant` discovers endpoints from an "Unauthenticated" `DomainParticipant` it shall:

- Match automatically the local endpoints for whom the `EndpointSecurityAttributes` object returned by the operation `get_endpoint_sec_attributes` have the attribute ***is_access_protected*** set to FALSE.
- Not match automatically the local endpoints for whom the `EndpointSecurityAttributes` object returned by the operation `get_endpoint_sec_attributes` have the attribute ***is_access_protected*** set to TRUE.

Note that, as specified in 8.8.2.2, a `DomainParticipant` for whom the `ParticipantSecurityAttributes` object returned by the `AccessControl` operation `get_participant_sec_attributes` has the `is_access_protected` attribute set to TRUE, cannot be matched with an "Unauthenticated" `DomainParticipant` and therefore cannot discover any endpoints from an "Unauthenticated" `DomainParticipant`.

8.8.5.2 AccessControl behavior with discovered endpoints from "Authenticated" DomainParticipant

If the `DomainParticipant` discovers endpoints from an "authenticated" `DomainParticipant` it shall:

- Match automatically the local endpoints for whom the `EndpointSecurityAttributes` object returned by the operation `get_endpoint_sec_attributes` has the ***is_access_protected*** attribute set to FALSE.
- Perform the AccessControl checks for discovered endpoints that would match local endpoints for whom the ***is_access_protected*** attribute is set to TRUE, and only match the discovered endpoints for whom the access control checks succeed.

The figure below illustrates the behavior relative to discovered endpoints coming from an "Authenticated" `DomainParticipant` that would match local endpoints for whom the ***is_access_protected*** attribute set to FALSE.

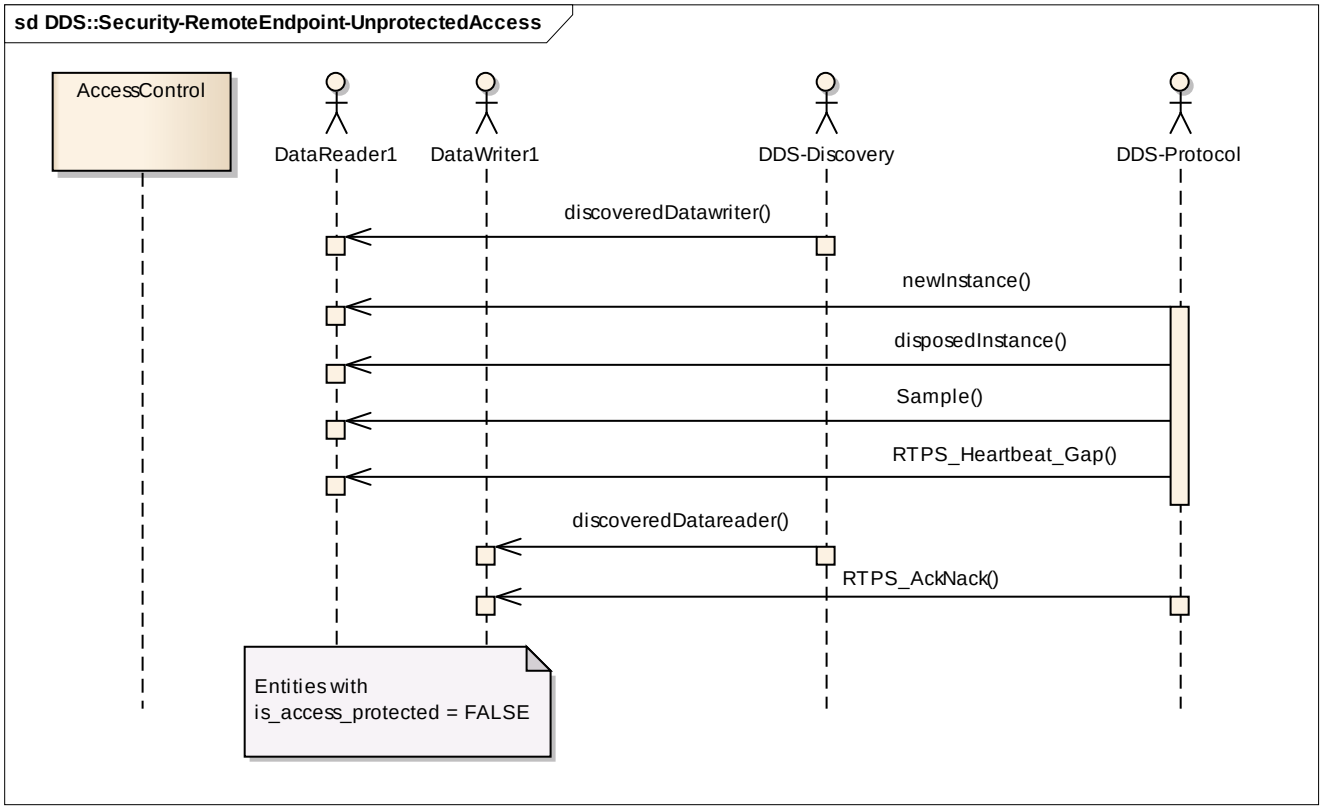


Figure 26 – AccessControl sequence diagram with discovered entities when is_access_protected==FALSE

1. DataReader1 discovers via the discovery protocol that a remote `DataWriter` (DataWriter2) on a `Topic` with name ***topicName***. The DataReader1 shall not call any operations on the `AccessControl` plugin and shall proceed to match DataWriter2 subject to the matching criteria specified in the DDS and DDS-XTypes specifications. `check_remote_datawriter` to verify that Partcipant2 has the permissions needed to publish the DDS `Topic` with name ***topicName***.
2. DataReader1 receives a Sample from DataWriter2 with DDS `ViewState` NEW, indicating this is the first sample for that instance received by the `DataReader`. This sample shall be processed according to the DDS specification without any calls to the `AccessControl` plugin.
3. DataReader1 receives a Sample from DataWriter2 with DDS `InstanceState` NOT_ALIVE_DISPOSED, indicating the remote `DataWriter` disposed an instance. This sample shall be processed according to the DDS specification without any calls to the `AccessControl` plugin.
4. DataReader1 receives a Sample from DataWriter2 with DDS `ViewState` NOT_NEW. DataReader1 shall operate according to the DDS and DDS-RTPS specifications without any calls to the `AccessControl` plugin.
5. DataReader1 receives a RTPS `HeartBeat` message or a RTPS `Gap` message from DataWriter2. In both these cases DataReader1 shall operate according to the DDS and DDS-RTPS specifications without any calls to the `AccessControl` plugin.
6. DataWriter1 discovers via the discovery protocol that a remote `DataReader` (DataReader2) on a `Topic` with name ***topicName***. DataWriter1 shall not call any

operations on the `AccessControl` plugin and shall to match DataWriter2 subject to the matching criteria specified in the DDS and DDS-XTypes specifications.

7. DataWriter1 receives an RTPS AckNack message from DataReader2. DataReader1 shall operate according to the DDS and DDS-RTPS specifications without any calls to the `AccessControl` plugin.

The figure below illustrates the behavior relative to discovered endpoints coming from an "Authenticated" `DomainParticipant` that would match local endpoints for whom the ***is_access_protected*** attribute set to TRUE.

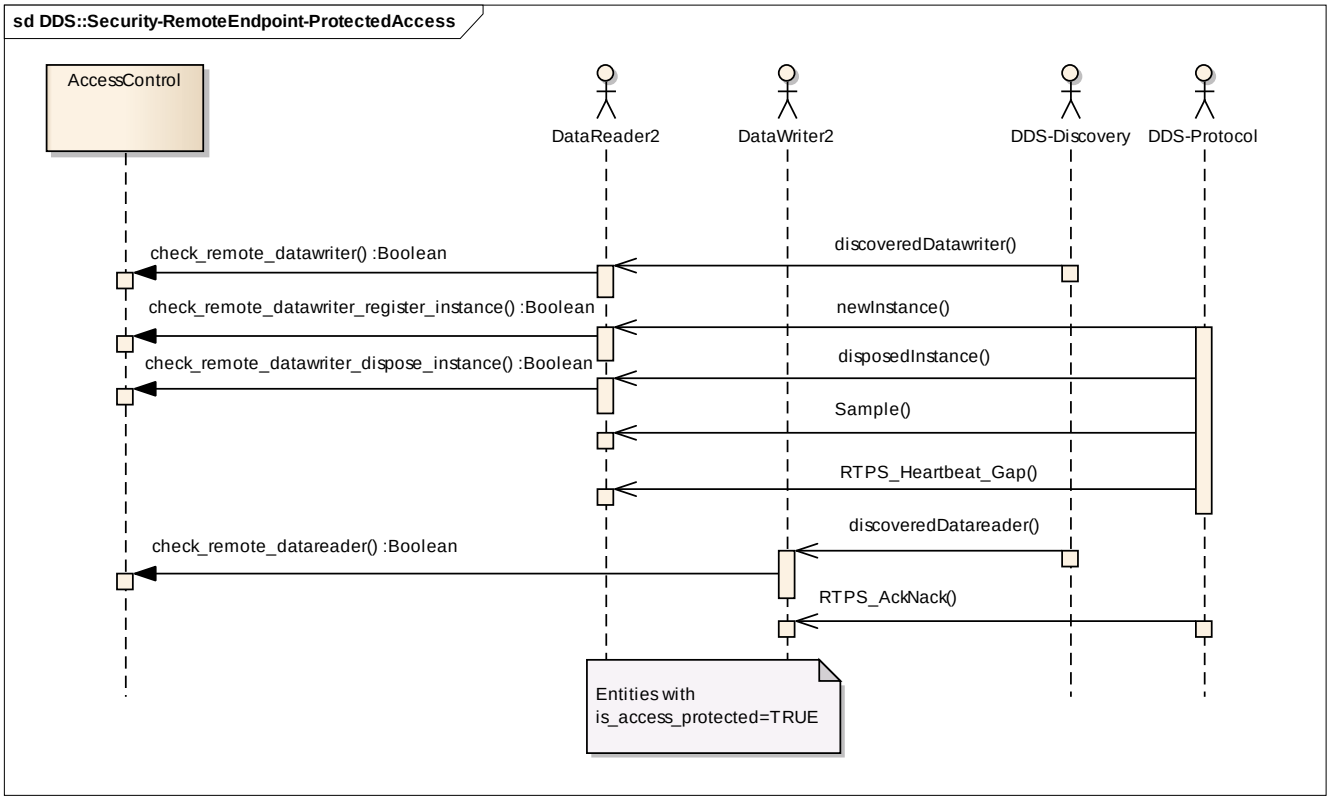


Figure 27 – AccessControl sequence diagram with discovered entities when is_access_protected==TRUE

1. DataReader1 discovers via the discovery protocol a remote `DataWriter` (DataWriter2) on a `Topic` with name ***topicName*** that matches the DataReader1 `Topic` ***topicName*****.**
2. DataReader1 shall call the operation `check_remote_datawriter` to verify that Partcipant2 (the `DomainParticipant` to whom DataWriter2 belongs) has the permissions needed to publish the DDS `Topic` with name ***topicName***. As an optional behavior, the same operation can also verify if the DataWriter2 is allowed to tag data with `dataTag` that are associated with it.
    1. If the verification doesn't succeed, the DataWriter2 is ignored.
    2. If the verification succeeds, DataReader1 shall proceed to match DataWriter2 subject to the matching criteria specified in the DDS and DDS-XTypes specifications.
3. DataReader1 receives a Sample from DataWriter2 with DDS ViewState NEW, indicating this is the first sample for that instance received by the `DataReader`. This sample shall be processed according to the DDS specification without any calls to the `AccessControl` plugin.

4. DataReader1 shall call the operation `check_remote_datawriter_register_instance` to verify that Participant2 has the permissions needed to register the instance. If the verification doesn't succeed, the sample shall be ignored.
5. DataReader1 receives a Sample from DataWriter2 with DDS `InstanceState` NOT_ALIVE_DISPOSED, indicating the remote `DataWriter` disposed an instance.
6. DataReader1 shall call the operation `check_remote_datawriter_dispose_instance` to verify that Participant2 has the permissions needed to dispose the instance. If the verification doesn't succeed, the instance disposal shall be ignored.
7. DataReader1 receives a Sample from DataWriter2 with DDS `ViewState` NOT_NEW, indicating this DataReader1 already received samples on that instance. This sample shall be processed according to the DDS specification without any calls to the `AccessControl` plugin.
8. DataReader1 receives a RTPS HeartBeat message or a RTPS `Gap` message from DataWriter2. In both these cases DataReader1 shall operate according to the DDS and DDS-RTPS specifications without any calls to the `AccessControl` plugin.
9. DataWriter1 discovers via the discovery protocol a remote `DataReader` (DataReader2) on a `Topic` with name ***topicName*** that matches the DataReader1 `Topic` ***topicName***.
10. DataWriter1 shall call the operation `check_remote_datareader` to verify that Partcipant2 (the DomainParticipant to whom DataReader2 belongs) has the permissions needed to subscribe the DDS `Topic` with name ***topicName***. As an optional behavior, the same operation can also verify if the DataReader2 is allowed to read data with `dataTag` that are associated with DataWriter1.
    1. If the verification doesn't succeed, DataReader2 is ignored.
    2. If the verification succeeds, DataWriter1 shall proceed to match DataReader2 subject to the matching criteria specified in the DDS and DDS-XTypes specifications.
11. DataWriter1 receives an RTPS `AckNack` message from DataReader2. DataReader1 shall operate according to the DDS and DDS-RTPS specifications without any calls to the `AccessControl` plugin.

8.8.6 Cryptographic Plugin key generation behavior

Key Generation is potentially needed for:

- The `DomainParticipant` as a whole
- Each `DomainParticipant` match pair
- Each builtin secure endpoint (`DataWriter` or `DataReader`)
- Each builtin secure endpoint match pair
- Each application secure endpoint (`DataWriter` or `DataReader`)
- Each application secure endpoint match pair

8.8.6.1 Key generation for the BuiltinParticipantVolatileMessageSecureWriter and BuiltinParticipantVolatileMessageSecureReader

The ***BuiltinParticipantVolatileMessageSecureWriter*** and ***BuiltinParticipantVolatileMessageSecureReader*** endpoints are special in that they are the ones used to securely send the Crytpo Tokens. Therefore the key material needed to secure this channel has to be

derivable from the SharedSecret without having access to Crytpo Tokens returned by the `create_local_datawriter_crypto_tokens` or `create_local_datareader_crypto_tokens.` Effectively this means the key material used for key-exchange is always derived from the SharedSecret.

For the ***BuiltinParticipantVolatileMessageSecureWriter*** the creation of the key material necessary to communicate with a matched ***BuiltinParticipantVolatileMessageSecureReader*** shall complete during the operation `register_matched_remote_datareader` and the DDS middleware shall not call the operation `create_local_datawriter_crypto_tokens` or the operation `set_remote_datareader_crypto_tokens` on the CryptoKeyExchange.

For the ***BuiltinParticipantVolatileMessageSecureReader*** the creation of the key material necessary to communicate with a matched ***BuiltinParticipantVolatileMessageSecureWriter*** shall complete during the operation `register_matched_remote_datawriter` and the DDS middleware shall not call the operation `create_local_datareader_crypto_tokens` or the operation `set_remote_datawriter_crypto_tokens` on the CryptoKeyExchange.

The DDS implementation shall add a property with name "`dds.sec.`builtin_endpoint_name" and value "BuiltinParticipantVolatileMessageSecureWriter" to the `Property` passed to the operation `register_local_datawriter` when it registers the ***BuiltinParticipantVolatileMessageSecureWriter*** with the CryptoKeyFactory.

The DDS implementation shall add a property with name "`dds.sec.`builtin_endpoint_name" and value "BuiltinParticipantVolatileMessageSecureReader" to the `Property` passed to the operation `register_local_datareader` when it registers the ***BuiltinParticipantVolatileMessageSecureReader*** with the CryptoKeyFactory.

Setting the `Property` as described above allows the CryptoKeyFactory to recognize the ***BuiltinParticipantVolatileMessageSecureWriter*** and the ***BuiltinParticipantVolatileMessageSecureReader.***

8.8.6.2 Key generation for the DomainParticipant

For each local `DomainParticipant` that is successfully created the DDS implementation shall call the operation `register_local_participant` on the `KeyFactory.`

For each discovered `DomainParticipant` that has successfully authenticated and has been matched to the local `DomainParticipant` the DDS middleware shall call the operation `register_matched_remote_participant` on the `KeyFactory.` Note that this operation takes as one parameter the SharedSecret obtained from the Authentication plugin`.`

8.8.6.3 Key generation for the builtin endpoints

For each `DataWriter` belonging to list of "Builtin Secure Endpoints", see 7.4.5, with the exception of the ***BuiltinParticipantVolatileMessageSecureWriter***, the DDS middleware shall call the operation `create_local_datawriter_crypto_tokens` on the `KeyFactory` to obtain the `DatawriterCryptoHandle` for the builtin `DataWriter`.

For each `DataReader` belonging to list of "Builtin Secure Endpoints", see 7.4.5, with the exception of the ***BuiltinParticipantVolatileMessageSecureReader***, the DDS middleware shall call the operation

`create_local_datareader_crypto_tokens` on the `KeyFactory` to obtain the `DatareaderCryptoHandle` for the corresponding builtin `DataReader`.

For each discovered `DomainParticipant` that has successfully authenticated and has been matched to the local `DomainParticipant` the DDS middleware shall:

1. Call the operation `KeyFactory::register_matched_remote_datawriter` for each local `DataWriter` belonging to the "Builtin Secure Endpoints" passing it the local `DataWriter` and the corresponding remote `DataReader` belonging to the "Builtin Secure Endpoints" of the discovered `DomainParticipant.`
2. Call the operation `KeyFactory::register_matched_remote_datareader` for each local `DataReader` belonging to the "Builtin Secure Endpoints" passing it the local `DataReader` , the corresponding remote `DataWriter` belonging to the "Builtin Secure Endpoints" of the discovered `DomainParticipant`, and the `SharedSecret` obtained from the Authentication plugin.

8.8.6.4 Key generation for the application-defined endpoints

Recall that for each application-defined (non-builtin) `DataWriter` and `DataReader` successfully created by the DDS Application the DDS middleware has an associated `EndpointSecurityAttributes` object which is the one returned by the `AccessControl::get_endpoint_sec_attributes`.

For each non-builtin `DataWriter` for whom the associated `EndpointSecurityAttributes` object has either the member ***is_submessage_protected*** or the member ***is_payload_protected*** set to TRUE, the DDS middleware shall:

1. Call the operation `create_local_datawriter_crypto_tokens` on the `KeyFactory` to obtain the `DatawriterCryptoHandle` for the `DataWriter`.
2. Call the operation `register_matched_remote_datawriter` for each discovered `DataReader` that matches the `DataWriter.`

For each non-builtin `DataReader` for whom the associated `EndpointSecurityAttributes` object has either the member ***is_submessage_protected*** or the member ***is_payload_protected*** set to TRUE, the DDS middleware shall:

1. Call the operation `create_local_datareader_crypto_tokens` on the `KeyFactory` to obtain the `DatareaderCryptoHandle` for the `DataReader`.
2. Call the operation `register_matched_remote_datawriter` for each discovered `DataReader` that matches the `DataWriter.`

8.8.7 Cryptographic Plugin key exchange behavior

Cryptographic key exchange is potentially needed for:

- Each `DomainParticipant` match pair
- Each builtin secure endpoint match pair
- Each application secure endpoint match pair

8.8.7.1 Key Exchange with discovered DomainParticipant

Cryptographic key exchange shall occur between each `DomainParticipant` and each discovered `DomainParticipant` that has successfully authenticated. This key exchange propagates the key material related to encoding/signing/decoding/verifying the whole RTPS message. In other words the key material needed to support the `CryptoTransform` operations `encode_rtps_message` and `decode_rtps_message`.

Given a local DomainParticipant the DDS middleware shall:

1. Call the operation `create_local_participant_crypto_tokens` on the `KeyFactory` for each discovered `DomainParticipant` that has successfully authenticated and has been matched to the local `DomainParticipant`. This operation takes as parameters the local and remote `ParticipantCryptoHandle.`
2. Send the `ParticipantCryptoTokenSeq` returned by operation `create_local_participant_crypto_tokens` to the discovered `DomainParticipant` using ***BuiltinParticipantVolatileMessageSecureWriter***.

The discovered `DomainParticipant` shall call the operation `set_remote_participant_crypto_tokens` passing the `ParticipantCryptoTokenSeq` received by the ***BuiltinParticipantVolatileMessageSecureWriter*** **.**

The figure below illustrates the functionality of the Cryptographic KeyExchange plugins with regards to the discovery and match of an authenticated remote `DomainParticipant` entity.

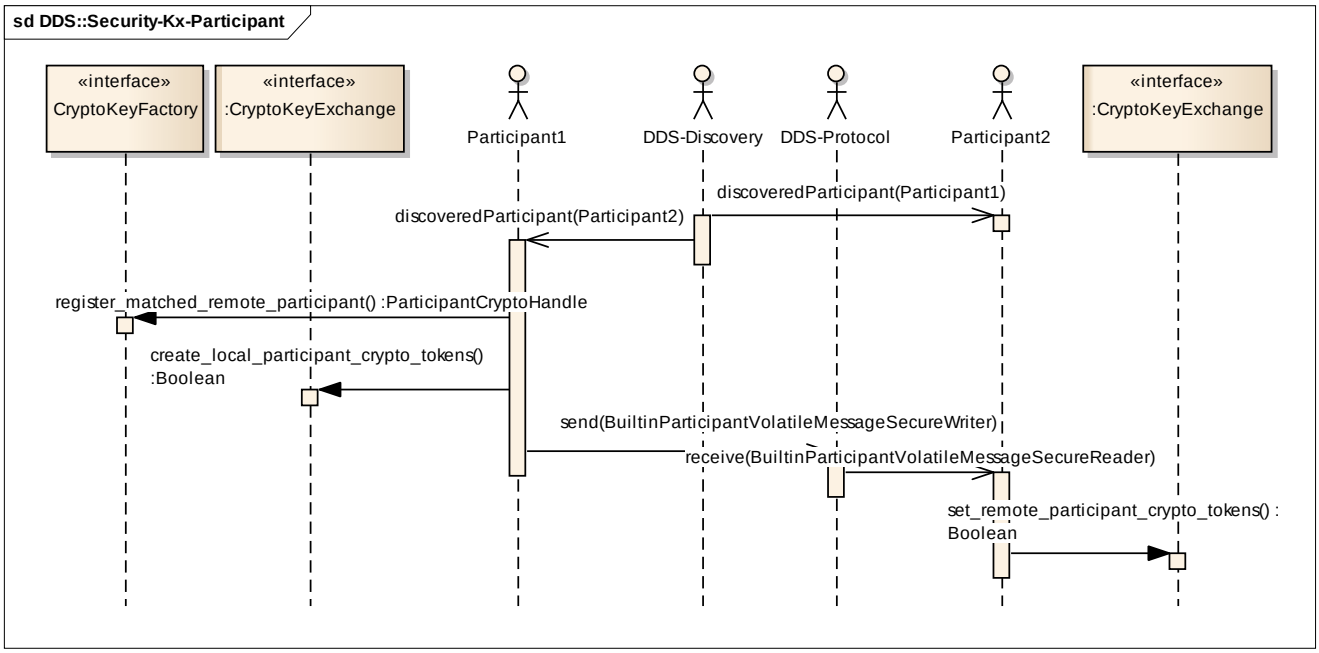


Figure 28 – Cryptographic KeyExchanage plugin sequence diagram with discovered DomainParticipant

1. Participant2 discovers the `DomainParticipant` (Participant1) via the DDS discovery protocol. This sequence is not described here as it equivalent to the sequence that Participant1 performs when it discovers Participant2.

2. Participant1 discovers the `DomainParticipant` (Participant2) via the DDS discovery protocol. Participant2 is authenticated and its permissions are checked as described in 8.8.2 and 8.8.4. This is not repeated here. The authentication and permissions checking resulted in the creation of an `IdentityHandle`, a `PermissionsHandle`, and a `SharedSecretHandle` for Participant2.

3. Participant1 calls the operation `register_matched_remote_participant` on the `Cryptographic` plugin (`CryptoKeyFactory` interface) to store the association of the remote identity and the SharedSecret.

4. Participant1 calls the operation `create_local_participant_crypto_tokens` on the `Cryptographic` plugin (`CryptoKeyExchange` interface) to obtain a collection of `CriptoToken` (cryptoTokensParticipant1ForParticipant2) to send to the remote `DomainParticipant` (Participant2).

5. Participant1 sends the collection of `CryptoToken` objects (cryptoTokensParticipant1ForParticipant2) to Participant2 using the ***BuiltinParticipantVolatileMessageSecureWriter***.

6. Participant2 receives the `CryptoToken` objects (cryptoTokensParticipant1ForParticipant2) and calls the operation `set_remote_participant_crypto_tokens()`to register the `CryptoToken` sequence with the `DomainParticipant`. This will enable the `Cryptographic` plugin on Participant2 to decode and verify MACs on the RTPS messages sent by Participant1 to Participant2.

8.8.7.2 Key Exchange with remote DataReader

Cryptographic key exchange shall occur between each builtin secure `DataWriter` and the matched builtin secure `DataReader` entities of authenticated matched `DomainParticipant` entities, see 7.4.5, with the exception of the ***BuiltinParticipantVolatileMessageSecureReader.***

Cryptographic key exchange shall also occur between each application `DataWriter` whose `EndpointSecurityAttributes` object has either the ***is_submessage_protected*** or the ***is_payload_protected*** members set to TRUE, and each of its matched `DataReader` entities.

Given a local `DataWriter` that is either a builtin secure `DataWriter` or an application `DataWriter` meeting the condition stated above the DDS middleware shall:

1. Call the operation `create_local_datawriter_crypto_tokens` on the `KeyFactory` for each matched `DataReader`. This operation takes as parameters the local `DatawriterCryptoHandle` and the remote `DatareaderCryptoHandle.`
2. Send the `DatawriterCryptoTokenSeq` returned by operation `create_local_datawriter_crypto_tokens` to the discovered `DomainParticipant` using ***BuiltinParticipantVolatileMessageSecureWriter***.

The matched `DataReader` shall call the operation `set_remote_datawriter_crypto_tokens` passing the `DatawriterCryptoTokenSeq` received by the ***BuiltinParticipantVolatileMessageSecureWriter* .**

The figure below illustrates the functionality of the Cryptographic `KeyExchange` plugin with regards to the discovery and match of a local secure `DataWriter` and a matched `DataReader`.

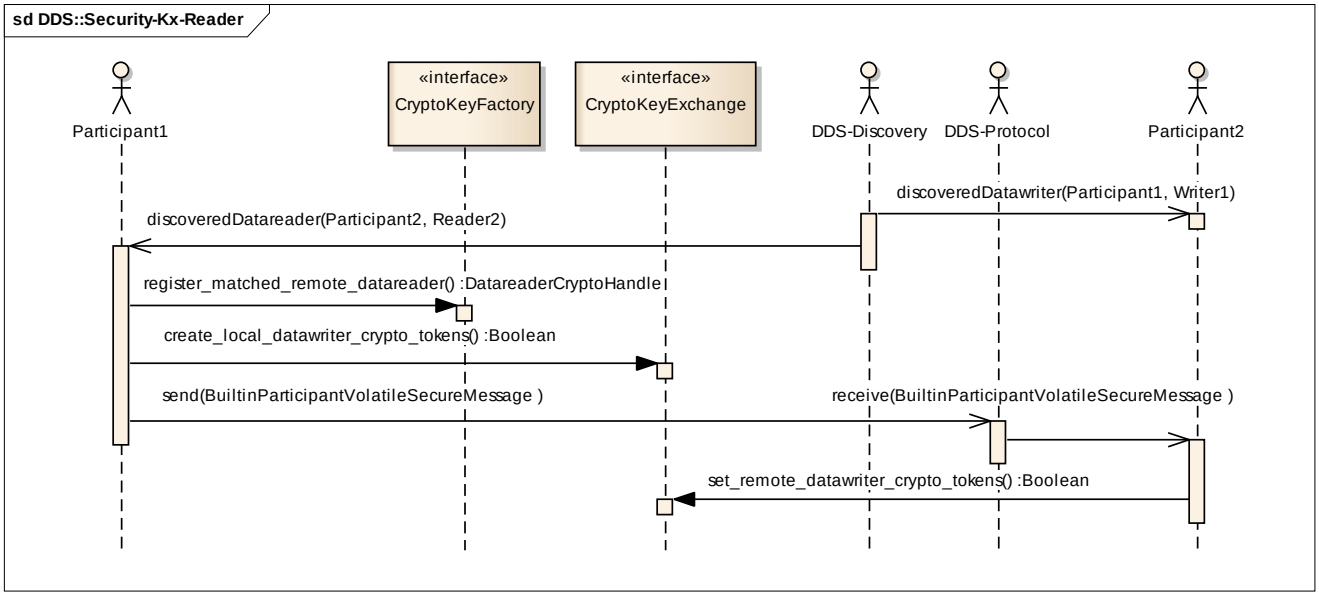


Figure 29 – Cryptographic KeyExchanage plugin sequence diagram with discovered DataReader

1. Participant2 discovers a `DataWriter` (Writer1) belonging to Participant1 that matches a local DataReader (Reader2) according to the constraints in the DDS security specification.
2. Participant1 discovers a `DataReader` (Reader2) belonging to Participant2 that matches a local DataWriter (Writer1) according to the constraints in the DDS security specification.
3. Participant1 calls the operation `register_matched_remote_datareader` as stated in 8.8.6.
4. Partcipant1 calls the operation `create_local_datawriter_crypto_tokens` on the `CryptoKeyExchange` to obtain a collection of `CriptoToken` objects (cryptoTokensWriter1ForReader2).
5. Participant1 sends the collection of `CryptoToken` objects (cryptoTokensWriter1ForReader2) to Participant2 using the ***BuiltinParticipantVolatileMessageSecureWriter***.
6. Participant2 receives the `CryptoToken` objects (cryptoTokensWriter1ForReader2) and calls the operation `set_remote_ datawriter_crypto_tokens()`to register the `CryptoToken` sequence with the `DataWriter (`Writer1`)`. This will enable the `Cryptographic` plugin on Participant2 to decode and verify MACs on the RTPS submessages and data payloads sent from Writer1to Reader2.

8.8.7.3 Key Exchange with remote DataWriter

Cryptographic key exchange shall occur between each builtin secure `DataReader` and the matched builtin secure `DataWriter` entities of authenticated matched `DomainParticipant` entities, see 7.4.5, with the exception of the ***BuiltinParticipantVolatileMessageSecureReader***.

Cryptographic key exchange shall also occur between each application `DataReader` whose `EndpointSecurityAttributes` object has the ***is_submessage_protected*** member set to TRUE, and each of its matched `DataWriter` entities.

Given a local `DataReader` that is either a builtin secure `DataReader` or an application `DataReader` meeting the condition stated above the DDS middleware shall:

1. Call the operation `create_local_datareader_crypto_tokens` on the `KeyFactory` for each matched `DataWriter`. This operation takes as parameters the local `DatareaderCryptoHandle` and the remote `DatawriterCryptoHandle.`
2. Send the `DatareaderCryptoTokenSeq` returned by operation `create_local_datareader_crypto_tokens` to the discovered `DomainParticipant` using ***BuiltinParticipantVolatileMessageSecureWriter***.

The matched `DataWriter` shall call the operation `set_remote_datareader_crypto_tokens` passing the `DatareaderCryptoTokenSeq` received by the ***BuiltinParticipantVolatileMessageSecureWriter*** **.**

The figure below illustrates the functionality of the Cryptographic `KeyExchange` plugin with regards to the discovery and match of a local secure `DataReader` and a matched `DataWriter`.

Cryptographic key exchange shall occur between each `DataReader` whose `EndpointSecurityAttributes` has the ***is_submessage_protected*** members set to TRUE and each of its matched `DataWriter` entities.

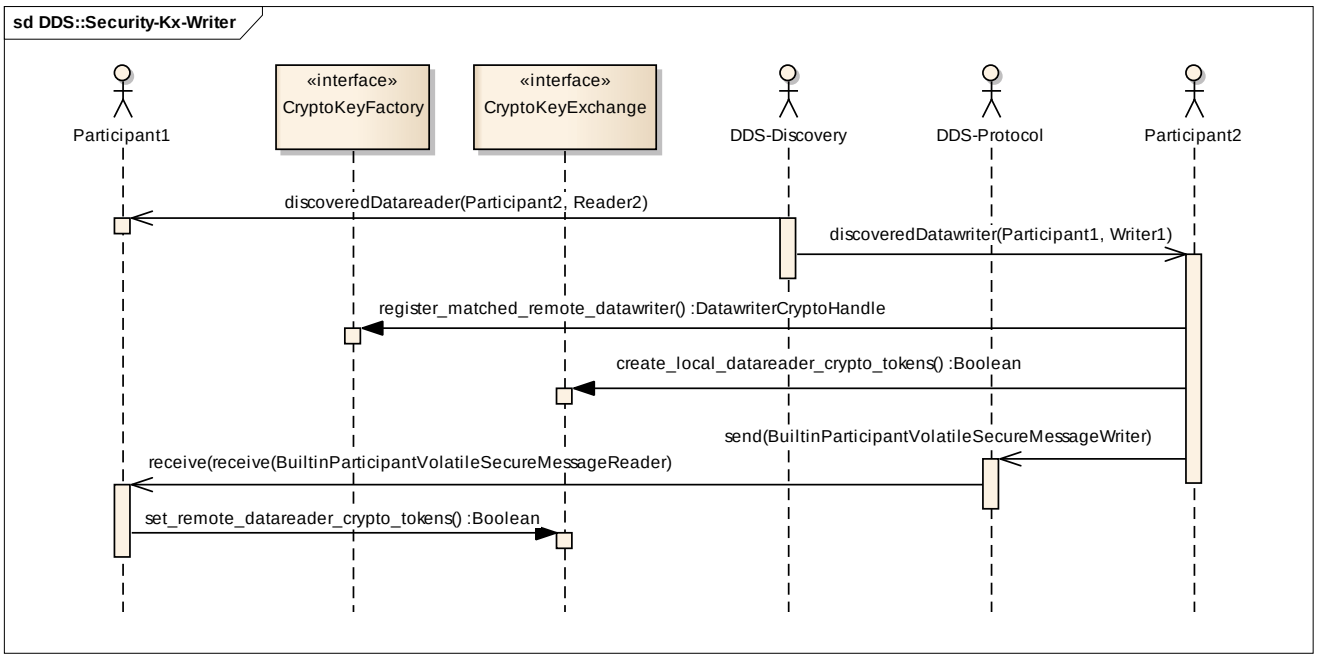


Figure 30 – Cryptographic KeyExchanage plugin sequence diagram with discovered DataWriter

1. Participant1 discovers a `DataReader` (Reader2) belonging to Participant2 that matches a local DataWriter (Writer1) according to the constraints in the DDS security specification.
2. Participant2 discovers a `DataWriter` (Writer1) belonging to Participant1 that matches a local DataReader (Reader2) according to the constraints in the DDS security specification.

3. Participant2 calls the operation `register_matched_remote_datawriter` as stated in 8.8.6.
4. Partcipant2 calls the operation `create_local_datareader_crypto_tokens` on the `CryptoKeyExchange` to obtain a collection of `CriptoToken` objects (cryptoTokensReader2ForWriter1).
5. Participant2 sends the collection of `CryptoToken` objects (cryptoTokensReader2ForWriter1) to Participant1 using the ***BuiltinParticipantVolatileMessageSecureWriter***.
6. Participant1 receives the `CryptoToken` objects (cryptoTokensReader2ForWriter1) and calls the operation `set_remote_ datareader_crypto_tokens()`to register the `CryptoToken` sequence with the `DataWriter (`Writer1`)`. This will enable the `Cryptographic` plugin on Participant1 to decode and verify MACs on the RTPS submessages sent from Reader2 to Writer1.

8.8.8 Cryptographic Plugins encoding/decoding behavior

This sub clause describes the behavior of the DDS implementation related to the `CryptoTransform` interface.

This specification does not mandate a specific DDS implementation in terms of the internal logic or timing when the different operations in the `CryptoTransform` plugin are invoked. The sequence charts below just express the requirements in terms of the operations that need to be called and their interleaving. This specification only requires that by the time the RTPS message appears on the wire the proper encoding operations have been executed first on each `SerializedData` submessage element, then on the enclosing RTPS `Submessage`, and finally on the RTPS `Message`. Similarly by the time a received RTPS `Message` is interpreted the proper decoding operations are executed on the reverse order. First on the encoded RTPS `Message`, then on each `SecureSubMsg`, and finally on each `SecuredPayload` submessage element.

8.8.8.1 Encoding/decoding of a single writer message on an RTPS message

The figure below illustrates the functionality of the security plugins with regards to encoding the data, Submessages and RTPS messages in the situation where the intended RTPS `Message` contains a single writer RTPS `Submessage`.

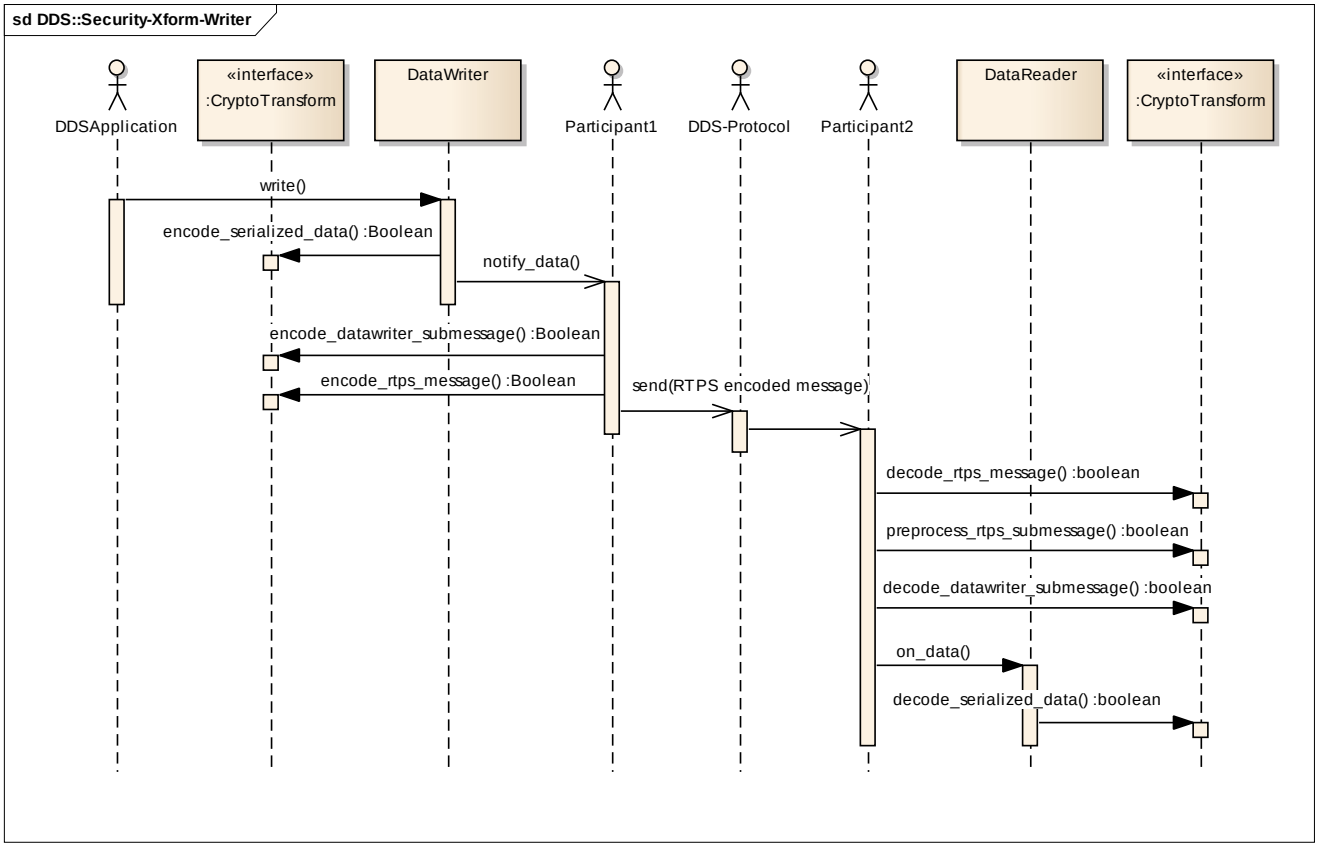


Figure 31 – Cryptographic CryptoTransform plugin sequence diagram for encoding/decoding a single DataWriter submessage

1. The application writes data using a `DataWriter` belonging to Participant1. The DDS implementation serializes the data.

2. The `DataWriter` in Participant1 constructs the `SerializedData` RTPS submessage element and calls the operation `encode_serialized_data`. This operation creates a RTPS `SecData` that protects the `SerializedData` potentially encrypting it, adding a MAC and/or digital signature.

3. This step is notional; the specific mechanism depends on the DDS Implementation. Participant1 realizes it is time to send the data written by the DataWriter to a remote `DataReader` in Participant2.

4. Participant1 constructs the RTPS `Data` Submessage to send to the DataReader and calls the operation `encode_datawriter_submessage` to transform the original `Data` submessage to a `SecureSubMsg`. This same transformation would be applied to any `DataWriter` submessage (`Data`, `Gap`, `Heartbeat`, `DataFrag`, `HeartbeatFrag`). The `encode_datawriter_submessage` receives as parameters the `DatawriterCryptoHandle` of the `DataWriter` and a list of `DatareaderCryptoHandle` for all the `DataReader` entities to which the message will be sent. Using a list allows the same `SecureSubMsg` to be sent to all those `DataReader` entities.

5. Participant1 constructs the RTPS `Message` it intends to send to the DataReader (or readers). It then calls `encode_rtps_message` to transform the original RTPS Message

into a new “encoded” RTPS Message with the same RTPS header and a single SecureSubMsg protecting the contents of the original RTPS Message. The encode_rtps_message receives as parameters the ParticipantCryptoHandle of the sending DomainParticipant (Participant1) and a list of ParticipantCryptoHandle for all the DomainParticipant entities to which the message will be sent (Participant2). Using a list enables the DomainParticipant to send the same message (potentially over multicast) to all those DomainParticipant entities.

6. Participant1 sends the new “encoded” RTPS Message obtained as a result of the previous step to Participant2.

7. Participant2 receives the “encoded” RTPS Message. Participant2 parses the message and detects a RTPS SecureSubMsg with the MultiSubmsgFlag (see 7.3.6.2) set to true. This indicates it shall call the operation decode_rtps_message to transform the “encoded” RTPS Message into an RTPS Message that decodes the RTPS SecureSubMsg and proceed to parse that instead.

8. Participant2 encounters parses the RTPS Message resulting from the previous step and encounters a RTPS SecureSubMsg with the MultiSubmsgFlag (see 7.3.6.2) set to false. This indicates it shall call the operation prepare_rtps_submessage to determine whether this is a Writer submessage or a Reader submessage and obtain the DatawriterCryptoHandle and DatareaderCryptoHandle handles it needs to decode the message. This function determines it is a Writer submessage.

9. Participant2 calls the operation decode_datawriter_submessage passing in the RTPS SecureSubMsg and obtains the original Data submessage that was the input to the encode_datawriter_submessage on the DataWriter side. From the Data submessage the DDS implementation extracts the SecuredPayload submessage element. This operation takes as arguments the DatawriterCryptoHandle and DatareaderCryptoHandle obtained in the previous step.

10. This step is notional; the specific mechanism depends on the DDS Implementation. Participant2 realizes it is time to notify the DataReader and retrieve the actual data sent by the DataWriter.

11. Participant2 calls decode_serialized_data passing in the RTPS SecuredPayload and obtains the original SerializedData submessage element was the input to the encode_serialized_data on the DataWriter side. This operation takes as arguments the DatawriterCryptoHandle and DatareaderCryptoHandle obtained in step 8.

8.8.8.2 Encoding/decoding of multiple writer messages on an RTPS message

The figure below illustrates the functionality of the security plugins in the situation where the intended RTPS message contains a multiple DataWriter RTPS Submessages, which can represent multiple samples, from the same DataWriter or from multiple DataWriter entities, as well as, a mix of Data, Heartbeat, Gap, and any other DataWriter RTPS Submessage as defined in 7.3.1.

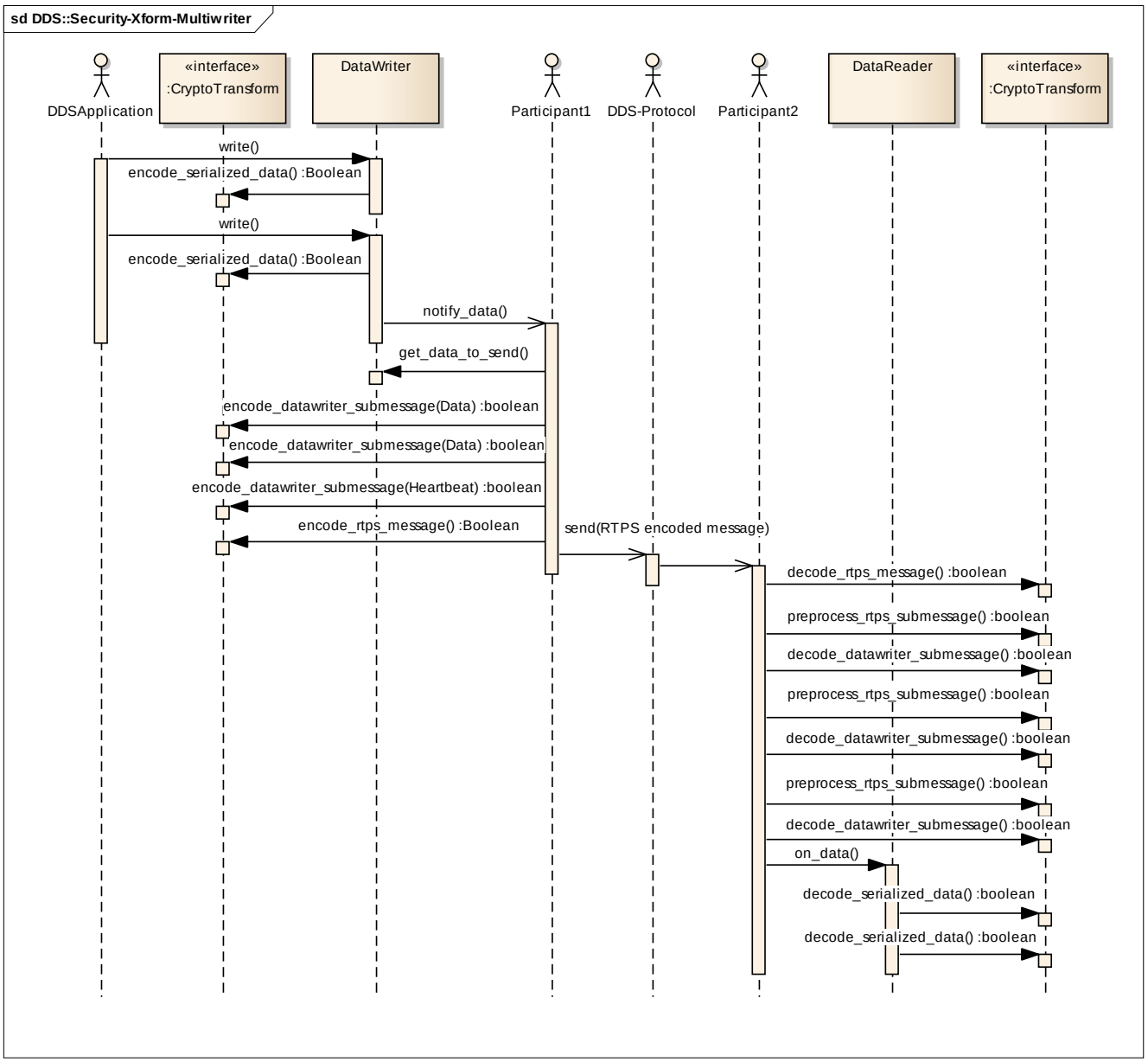


Figure 32 – Cryptographic CryptoTransform plugin sequence diagram for encoding/decoding multiple DataWriter submessages

The steps followed to encode and decode multiple DataWriter Submessages within the same RTPS message are very similar to the ones used for a single Writer message. The only difference is that on the writer side can create multiple RTPS Submessages. In this case, Participant1 creates two Data Submessages and a Heartbeat Submessage, transforms each separately using the `encode_datawriter_submessage,` places them in the same RTPS message and then transforms the RTPS Message containing all the resulting `SecureSubMsg` submessages using `encode_rtps_message.`

The steps followed to decode the message are the reverse ones.

Note that the DataWriter entities that are sending the submessages and/or the DataReader entities that are the destination of the different Submessages may be different. In this situation each call to `encode_serialized_data(), encode_datawriter_submessage(),`

decode_datawriter_submessage(), and encode_serialized_data(), shall receive the proper DatawriterCryptoHandle and DatareaderCryptoHandle handles.

8.8.8.3 Encoding/decoding of multiple reader messages on an RTPS message

The figure below illustrates the functionality of the security plugins in the situation where the intended RTPS message contains multiple DataReader RTPS submessages from the same DataReader or from multiple DataReader entities. These include AckNack and NackFrag RTPS Submessages as defined in 7.3.1.

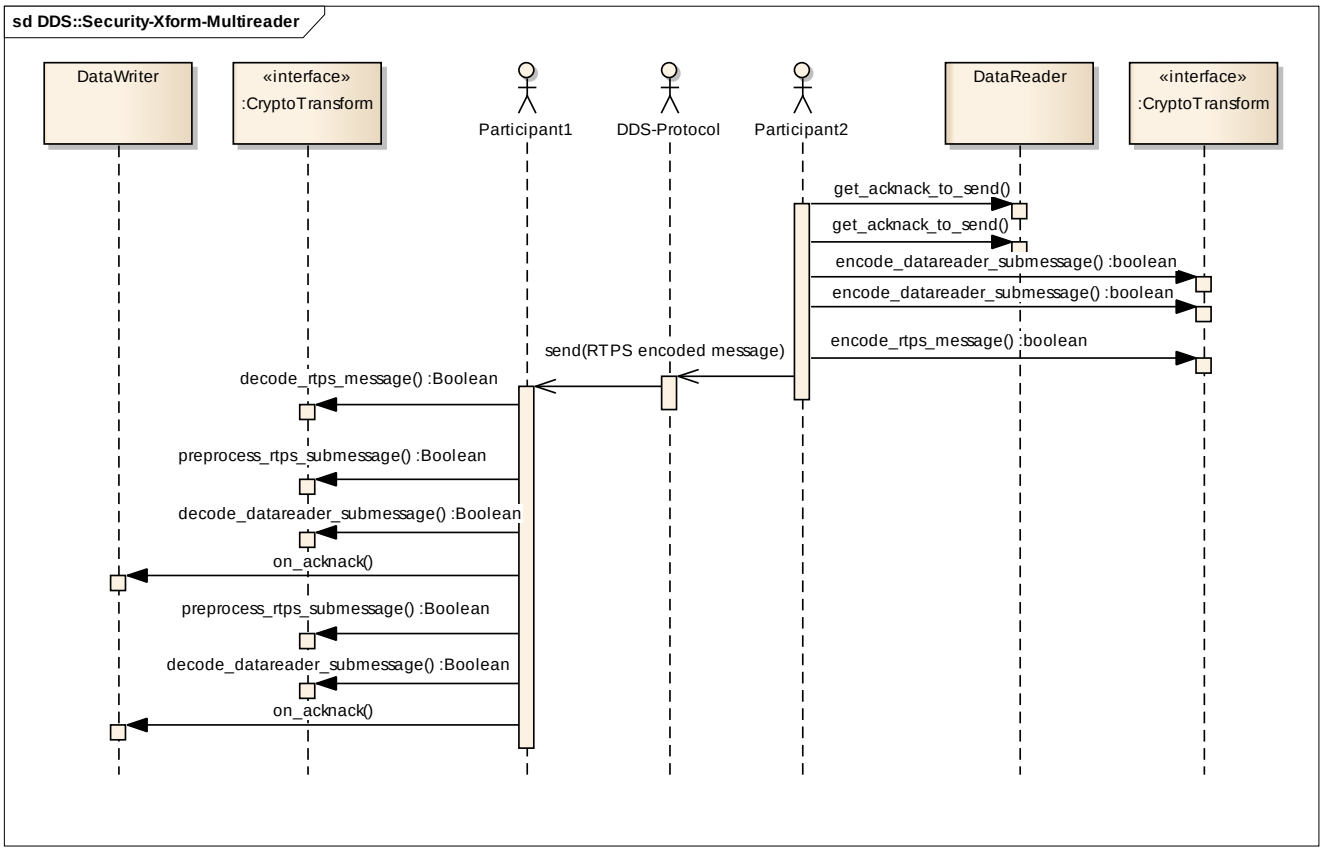


Figure 33 -- Cryptographic CryptoTransform plugin sequence diagram for encoding/decoding multiple DataReader submessages

1. This step is notional; the specific mechanism depends on the DDS Implementation. Participant2 realizes it is time to send an AckNack or NackFrag submessage from DataReader to a remote DataWriter.

2. Participant2 constructs the AckNack (or any other DataReader RTPS Submessage) and calls the operation encode_datareader_submessage. This operation creates an RTPS SecureSubMsg that protects the original Submessage potentially encrypting it, adding a MAC and/or digital signature. This operation shall receive as parameter the DatareaderCryptoHandle of the DataReader that sends the submessage and a list of DatawriterCryptoHandle handles of all the DataWriter entities to which the Submessage will be sent.

3. Step 2 may be repeated multiple times constructing various SecureSubMsg submessages from different DataReader RTPS Submessages. Different submessages may

originate on different DataReader entities and/or be destined for different DataWriter entities. On each case the encode_datareader_submessage operation shall receive the DatareaderCryptoHandle and list of DatawriterCryptoHandle that correspond to the source and destinations of that particular Submessage.

4. Participant2 constructs the RTPS Message that contains the SecureSubMsg submessages obtained as a result of the previous steps. It shall then call encode_rtps_message to transform the "original" RTPS Message into another "encoded" RTPS Message containing a single SecureSubMsg with the MultiSubmsgFlag (see 7.3.6.2) set to true.

5. Participant2 sends the "encoded" RTPS Message to Participant1 (and any other destination DomainParticipant).

6. Participant1 receives the "encoded" RTPS Message. The DDS implementation parses the message and detects a RTPS SecureSubMsg with the MultiSubmsgFlag (see 7.3.6.2) set to true. This indicates it shall call the decode_rtps_message() to transform the "encoded" RTPS Message into an RTPS Message that decodes the RTPS SecureSubMsg and proceed to parse that instead.

7. Participant1 encounters parses the RTPS Message resulting from the previous step and encounters a RTPS SecureSubMsg with the MultiSubmsgFlag (see 7.3.6.2) set to false. This indicates it shall call prepare_rtps_submessage to determine whether this is a DataWriter submessage or a DataReader submessage and obtain the DatawriterCryptoHandle and DatareaderCryptoHandle handles it needs to decode the message. This function determines it is a DataReader submessage.

8. Participant1 calls decode_datareader_submessage passing in the RTPS SecureSubMsg and obtains the original AckNack (or proper DataReader Submessage) submessage that was the input to the encode_datareader_submessage() on the DataReader side (Participant2). This operation takes as arguments the DatawriterCryptoHandle and DatareaderCryptoHandle obtained in the previous step.

9. This step is notional; the specific mechanism depends on the DDS Implementation. Participant1 realizes it is time to notify the DataReader of the Acknowledgment, negative acknowledgment or whatever the DataReader Submessage indicated.

10. Each SecureSubMsg encountered within the RTPS Message having the MultiSubmsgFlag (see 7.3.6.2) set to false is processed in this same way. The operation prepare_rtps_submessage is first invoked and it indicates it is a DataReader submessage Participant1 shall call decode_datareader_submessage() on the submessage.

8.8.8.4 Encoding/decoding of reader and writer messages on an RTPS message

The figure below illustrates the functionality of the security plugins with regards to encoding the data, Submessages and RTPS messages in the situation where the intended RTPS message contains multiple RTPS Submessages which can represent a mix of different kinds of DataWriter and DataReader submessages such as Data, Heartbeat, Gap, AckNack, NackFrag and any other RTPS Submessage as defined in 7.3.1.

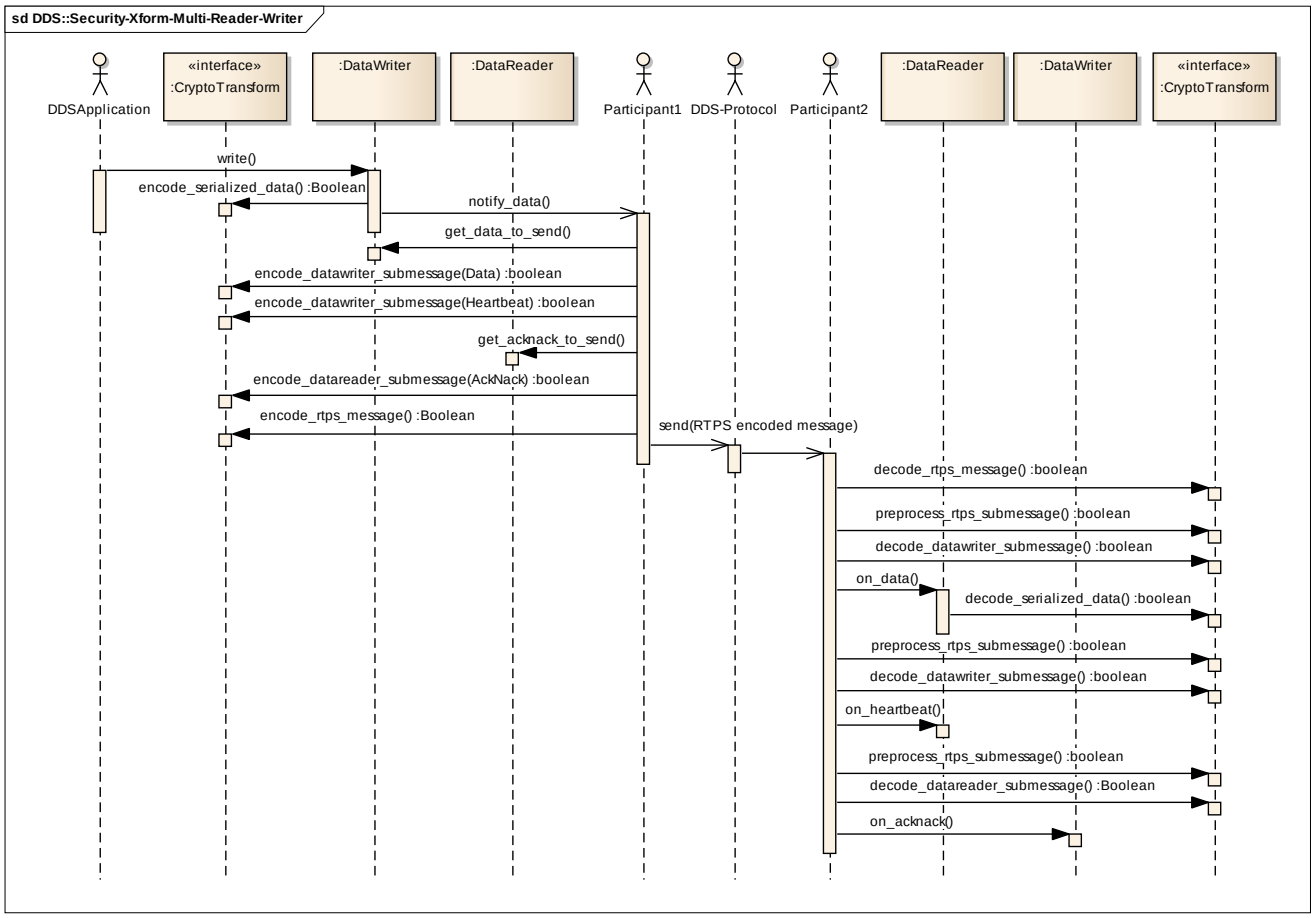


Figure 34 – Cryptographic CryptoTransform plugin sequence diagram for encoding/decoding multiple DataWriter and DataReader submessages

1. The application writes data using a `DataWriter` belonging to Participant1. The DDS implementation serializes the data.

2. The `DataWriter` in Participant1 constructs the `SerializedData` RTPS submessage element and calls the operation `encode_serialized_data`. This operation creates a RTPS `SecData` that protects the `SerializedData` potentially encrypting it, adding a MAC and/or digital signature.

3. This step is notional; the specific mechanism depends on the DDS Implementation. Participant1 realizes it is time to send the data written by the `DataWriter` to a remote `DataReader`.

4. Participant1 constructs the RTPS `Data` Submessage that it will send to the `DataReader` and calls the operation `encode_datawriter_submessage` to transform the original `Data` submessage to a `SecureSubMsg`.

5. This step is notional. The specifics will depend on the DDS Implementation. Participant1 decides it needs to send a `Heartbeat` submessage along with the `Data` submessage. It constructs the RTPS `Heartbeat` submessage and calls the operation `encode_datawriter_submessage()` to transform the original `Heartbeat` submessage to a `SecureSubMsg`.

6. This step is notional. The specific mechanism depends on the DDS Implementation. Participant1 decides it also wants to include an RTPS `AckNack` submessage from a DataReader that also belongs to Participant1 into the same RTPS Message because it is destined to the same Participant2.

7. Participant1 constructs the RTPS `AckNack` submessage and calls `encode_datareader_submessage` to transform the original `AckNack` submessage to a `SecureSubMsg`.

8. Participant1 constructs the RTPS Message that contains the `SecureSubMsg` submessages obtained as a result of the previous steps. It shall then call `encode_rtps_message`. To transform the "original" RTPS Message into another "encoded" RTPS Message containing a single `SecureSubMsg` with the `MultiSubmsgFlag` (see 7.3.6.2) set to `true`.

9. Participant1 sends the "encoded" RTPS `Message` to Participant2 (and any other destination DomainParticipant).

10. Participant2 receives the "encoded" RTPS Message. Participant2 parses the message and detects a RTPS `SecureSubMsg` with the `MultiSubmsgFlag` (see 7.3.6.2) set to `true`. This indicates it shall call the `decode_rtps_message` to transform the "encoded" RTPS Message into an RTPS Message that decodes the RTPS `SecureSubMsg` and proceed to parse that instead.

11. Participant2 parses the RTPS Message resulting from the previous step and encounters a RTPS `SecureSubMsg` with the `MultiSubmsgFlag` (see 7.3.6.2) set to `false`. This indicates it shall call `prepare_rtps_submessage` to determine whether this is a `DataWriter` submessage or a `DataReader` submessage and obtain the `DatawriterCryptoHandle` and `DatareaderCryptoHandle` handles it needs to decode the message. This function determines it is a `DataWriter` submessage.

12. Participant1 calls the operation `decode_datawriter_submessage` passing in the RTPS `SecureSubMsg` and obtains the original `Data` submessage that was the input to the `encode_datarwriter_submessage` on Participant1. This operation takes as arguments the `DatawriterCryptoHandle` and `DatareaderCryptoHandle` obtained in the previous step.

13. This step is notional; the specific mechanism depends on the DDS Implementation. The Participant2 realizes it is time to notify the `DataReader` of the arrival of data.

14. Participant2 calls `decode_serialized_data` passing in the RTPS `SecuredPayload` and obtains the original `SerializedData` submessage element was the input to the `encode_serialized_data` on the Participant1 side. This operation takes as arguments the `DatawriterCryptoHandle` and `DatareaderCryptoHandle` obtained in the step 11.

15. Step 11 is repeated. It is again determined that the next `SecureSubMsg` is a `DataWriter` submessage and the proper `DatawriterCryptoHandle` and `DatareaderCryptoHandle` handles are retrieved.

16. Step 12 is repeated, Participant2 calls `decode_datawriter_submessage` passing in the RTPS `SecureSubMsg` and it transforms it into the original `Heartbeat` submessage.
17. This step is notional; the specific mechanism depends on the DDS Implementation. Participant2 notifies DataReader of the `Heartbeat`.
18. Step 11 is repeated. It is determined that the next `SecureSubMsg` is a `DataReader` submessage and the proper `DatawriterCryptoHandle` and `DatareaderCryptoHandle` handles are retrieved.
19. Participant2 calls `decode_datareader_submessage` passing in the RTPS `SecureSubMsg` and obtains the original `AckNack` submessage that was the input to the `encode_datareader_submessage` on Participant1. This operation takes as arguments the `DatawriterCryptoHandle` and `DatareaderCryptoHandle` obtained in the previous step.
20. This step is notional; the specific mechanism depends on the DDS Implementation. Participant2 notifies `DataWriter` of the `AckNack`.

9 Builtin Plugins

9.1 Introduction

This specification defines the behavior and implementation of at least one builtin plugin for each kind of plugin. The builtin plugins provide out-of-the-box interoperability between implementations of this specification.

The builtin plugins are summarized in the table below:

Table 28 – Summary of the Builtin Plugins

SPI	*Plugin Name*	*Description*
Authentication	DDS:Auth:PKI-RSA/DSA-DH	Uses PKI with a pre-configured shared Certificate Authority. RSA or DSA and Diffie-Hellman for authentication and key exchange.
AccessControl	DDS:Access:PKI-Signed-XML-Permissions	Permissions document signed by shared Certificate Authority
Cryptography	DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH	AES128 for encryption (in counter mode) SHA1 and SHA256 for digest HMAC-SHA1 and HMAC-256 for MAC
DataTagging	DDS:Tagging:DDS_Discovery	Send Tags via Endpoint Discovery
Logging	DDS:Logging:DDS_LogTopic	Logs security events to a dedicated DDS Log Topic

9.2 Requirements and Priorities (Non-Normative)

The selection of the builtin plugins was driven by several functional, as well as, non-functional requirements, as described below.

Most DDS users surveyed consider the following functional requirements as essential elements of a secure DDS middleware:

- Authentication of applications (DDS Domain Participants) joining a DDS Domain
- Access control of applications subscribing to specific data at the Domain and Topic level
- Message integrity and authentication
- Encryption of a data sample using different encryption keys for different Topics

In addition to these essential needs, many users also required that secure DDS middleware should provide for:

- Sending digitally signed data samples
- Sending data securely over multicast
- Tagging data
- Integrating with open standard security plugins

Other functional requirements which are considered useful but less common were:

- Access control to certain samples within a Topic but not others, with access rights being granted according to the data-sample contents or the data-sample key.
- Access control to certain attributes within a data sample but not others, such that certain DataReader entities can only observe a subset of the attributes as defined by their permissions.
- Permissions that control which QoS might be used by a specific DDS Entity: DomainParticipant, Publisher, DataWriter, Subscriber, or DataReader.

The primary non-functional requirements that informed the selection of the builtin plugins are:

- Performance and Scalability
- Robustness and Availability
- Fit to the DDS Data-Centric Information Model
- Leverage and reuse of existing security infrastructure and technologies
- Ease of use while supporting common application requirements

9.2.1 Performance and Scalability

DDS is commonly deployed in systems that demand high performance and need to scale to large numbers of processes and computers. Different applications vary greatly in the number of processes, Topics, and/or data-objects belonging to each Topic.

The policy enforcement/decision points as well as the transformations (cipher, decipher, hash) performed by the plugins should not adversely degrade system performance and scalability beyond what is tolerable and strictly needed. In practice this means several things for the builtin plugins:

- The use of Asymmetric Key Cryptography shall be limited to the discovery, authentication, session and shared-secret establishment phase (i.e., when a Participant discovers another Participant, a DataReader and matching DataWriter). To the extent possible it shall not be used in the critical path of data distribution.
- The use of ciphers, HMACs, or digital signatures shall be selectable on a per stream (Topic) basis. In case of encryption, symmetric ciphers should be used for the application data.
- It shall be possible to provide integrity via HMAC techniques without also requiring the data to be ciphered.
- Multicast shall be supported even for ciphered data.

9.2.2 Robustness and Availability

DDS is deployed in mission-critical systems, which must continue to operate 24/7 despite partial system malfunction. DDS also operates in fielded environments where specific components or systems may be subject to accidental failure or active attack. DDS provides a highly robust infrastructure due to the way the communication model and protocols are defined as they can be (and commonly are) implemented in a peer-to-peer fashion without any centralized services. For this reason, many DDS implementations have no single points of failure.

The builtin plugins should not negate these desirable properties present in the underlying DDS middleware infrastructure.

In practice, this means that:

- Centralized policy decision points or services should be avoided.
- The individual DDS DomainParticipant components should be self-contained and have what they need to operate securely even in the presence of system partitions.
- Multi-party key agreement protocols shall be avoided because they can be easily disrupted by disrupting just one party.
- Security tokens and keys should be compartmentalized as much as possible such that compromise of an application component is contained to that component itself. For example, selection of a system-wide secret key for the whole Domain or even for a Topic should be avoided.

9.2.3 Fitness to the DDS Data-Centric Model

Application developers that use DDS think in terms of the data-centric elements that DDS provides. That is, they think first and foremost about the Domains (global data spaces) the application must join and the Topics that the application needs to read and write. Therefore, the builtin plugins should offer the possibility to control access with this level of granularity.

Users of DDS also think about the data objects (keyed instances) they read and write, the ability to dispose instances, filter by content, set QoS, and so forth. While it may be useful to offer ways to provide access controls to this as well, it was considered of lesser priority and potentially conflicting with the goal of ease of configurability and maintainability.

The semantics of DDS communications require that individual samples can be consumed independently of each other. Depending on the QoS policy settings samples written by a single DataWriter may be received and processed out of order relative to the order sent, or may be received with intermediate gaps resulting from best-effort communication (if selected), or may be filtered by content, time, or history, etc. For this reason, any encryption and/or digital signature applied to a sample should be able to be processed in isolation, without requiring the receiver to maintain a specific context reconstructed from previous samples.

9.2.4 Leverage and Reuse of Existing Security Infrastructure and Technologies

To the extent possible, it is desirable that the builtin plugins leverage and reuse existing IA technology and tools. This not only reduces the barrier of entry for implementers of the specification, but also more importantly enhances the quality of the result by allowing the use of proven, peer-reviewed, and/or already certified approaches. The builtin plugins leverage existing standards and tools for PKI,

ciphers, hashing and digital signing. To the extent possible, ideas and approaches from existing protocols for key management and secure multicast are also leveraged, although where appropriate they have been adapted to the data-centric communications model of DDS and the DDS-RTPS wire protocol.

9.2.5 Ease-of-Use while Supporting Common Application Requirements

It is anticipated that specialized applications may need to develop their own security plugins to either integrate existing security infrastructure or meet specialized requirements. Therefore the primary consumers of the builtin plugins will be users who want to secure their systems but not have complex needs or significant legacy components. Under these conditions, ease-of-use is essential. A security infrastructure that is too hard to configure or too complex to understand or maintain is less likely to be used, or may be used wrongly, resulting in systems that are less secure overall.

The builtin plugins balance rich functionality and ease-of-use, providing for the most common use cases, in a manner that is easy to understand and use correctly.

9.3 Builtin Authentication: DDS:Auth:PKI-RSA/DSA-DH

This builtin authentication plugin is referred to as the “DDS:Auth:PKI-RSA/DSA-DH”.

The DDS:Auth:PKI-RSA/DSA-DH plugin implements authentication using a trusted `Certificate Authority` (CA). It performs mutual authentication between discovered participants using the Digital Signature Algorithm (DSA) [11] and establishes a shared secret using Diffie-Hellman (D-H) Key Agreement Method [12].

The CA could be an existing one. Or a new one could be created for the purpose of deploying applications on a DDS `Domain`. The nature or manner in which the CA is selected is not important because the way it is used enforces a shared recognition by all participating applications.

Prior to a `DomainParticipant` being enabled the DDS:Auth:PKI-RSA/DSA-DH plugin associated with the `DomainParticipant` must be configured with three things:

1. The `X.509 Certificate` that defines the `Shared CA`. This certificate contains the 2048-bit RSA `Public Key` of the CA.
2. The 2048-bit `RSA Private Key` of the `DomainParticipant`.
3. An `X.509 Certificate` that chains up to the `Shared CA` , that binds the 2048-bit `RSA Public Key of the DomainParticipant` to the `Distinguished Name` (subject name) for the `DomainParticipant` and any intermediate CA certificates required to build the chain.

9.3.1 Configuration

The specific format of the root CA certificate, the private key of the `DomainParticipant`, and the certificate for the `DomainParticipant` are not dictated by this specification. Implementations may use standard formats for certificates and keys and configure them using an API, an extended QoS Policy, or some other implementation-specific mechanism.

Leaving the details of the DDS:Auth:PKI-RSA/DSA-DH plugin configuration unspecified does not affect interoperability and might be required to accommodate different security concerns and

platforms. For example, some platforms may provide specialized secure storage for holding private keys, others may not support a file system, etc.

`DomainParticipant` entities should use Certificate Revocation Lists (CRLs) and/or OCSP to check for revoked certificates.

9.3.2 DDS:Auth:PKI-RSA/DSA-DH Types

This sub clause specifies the content and format of the `Credential` and `Token` objects used by the DDS:Auth:PKI-RSA/DSA-DH plugin.

`Credential` and `Token` attributes left unspecified in this specification shall be understood to not have any required values in this specification. These attributes shall be handled according to the following rules:

- Plugin implementations may place data in these attributes as long as they also include a property attribute that allows the implementation to unambiguously detect the presence and interpret these attributes.
- Attributes that are not understood shall be ignored.
- `Property` and `BinaryProperty` names shall comply with the rules defined in 7.2.1 and 7.2.2, respectively.

The content of the `Handle` objects is not specified as it represents references to internal state that is only understood by the plugin itself. The DDS Implementation only needs to hold a reference to the retuned `Handle` objects returned by the plugin operations and pass these `Handle` references to other operations.

9.3.2.1 DDS:Auth:PKI-RSA/DSA-DH IdentityCredential

The DDS:Auth:PKI-RSA/DSA-DH plugin shall set the attributes of the `IdentityCredential` objects as specified in the table below.

Table 29 – IdentityCredential class for the builtin Authentication plugin

Attribute name	*Attribute value*
class_id	"DDS:Auth:X.509-PEM"
binary_value1	Octet sequence containing the characters in the PEM-encoded X.509 certificate for the `DomainParticipant` signed by the shared Certificate Authority.
binary_value2	Octet sequence containing the characters in the PEM-encoded RSA Private Key associated with the Public Key, which was signed in the certificate contained in the ***binary_value1*** attribute.

9.3.2.2 DDS:Auth:PKI-RSA/DSA-DH IdentityToken

The DDS:Auth:PKI-RSA/DSA-DH plugin shall set the attributes of the `IdentityToken` object as specified in the table below:

Table 30 – IdentityToken class for the builtin Authentication plugin

Attribute name	*Attribute value*
class_id	"DDS:Auth:X.509-PEM-SHA256"
binary_value1	Octet sequence containing the SHA256 hash of the ***binary_value1*** attribute of the `IdentityCredential`. The SHA256 hash shall be encoded in binary therefore the sequence shall contain exactly 32 octets.

9.3.2.3 DDS:Auth:PKI-RSA/DSA-DH HandshakeMessageToken

The DDS:Auth:PKI-RSA/DSA-DH plugin uses several `HandshakeMessageToken` object formats:

- `HandshakeRequestMessageToken` objects
- `HandshakeReplyMessgeToken` objects
- `HandshakeFinalMessageToken` objects

9.3.2.3.1 HandshakeRequestMessageToken objects

The attributes in `HandshakeRequestMessageToken` objects shall be set as specified in the table below. References to the `DomainParticipant` within the table refer to the `DomainParticipant` that is sending the message that embeds the `HandshakeRequestMessageToken`.

Table 31 – HandshakeRequestMessageToken for the builtin Authentication plugin

Attribute name	*Attribute value*
class_id	The string can be set to either "DDS:Auth:ChallengeReq:DSA-DH" or "DDS:Auth:ChallengeReq:PKI-RSA". Both values shall be supported.
properties	There shall be 2 properties: (1) A property with ***name*** set to "`dds.sec.identity`" and ***value*** set to string containing the elements of the ***value*** attribute of the `IdentityCredential`, one character per element. Note that the octets in the `IdentityCredential` ***value*** were defined to hold characters resulting from a PEM encoding (9.3.2.1) so the value of the property is precisely those characters. (2) A property with ***name*** set to "`dds.sec.permissions`" and ***value*** set to the contents of the ***binary_value1*** attribute of the `PersimissionsCredential` of the `DomainParticipant`. Note that the octets in the `PermissionsCredential` ***binary_value1*** were defined to hold characters resulting from a PEM encoding (9.4.2.1) so the value of the property is precisely those characters. Plugin implementations may add extra properties as long as the names comply the rules defined in 7.2.1 Plugin implementations shall ignore any properties they do not understand.
binary_value1	The value of this octet sequence shall be set to a NONCE whose first 10 octets are set to match the ascii encoding of the string:

	"CHALLENGE:"

9.3.2.3.2 HandshakeReplyMessageToken

The attributes in the `HandshakeReplyMessageToken` objects are set as specified in the table below. References to the `DomainParticipant` within the table refer to the `DomainParticipant` that is sending the message that embeds the `HandshakeReplyMessageToken`.

Table 32 – HandshakeReplyMessageToken for the builtin Authentication plugin

Attribute name	*Attribute value*
class_id	The string can be set to either "DDS:Auth:ChallengeRep:DSA-DH" or "DDS:Auth:ChallengeRep:PKI-RSA". Both values shall be supported.
properties	There shall be 2 properties set the same way as for the `HandshakeRequestMessageToken` except that they correspond to the `DomainParticipant` that is sending the `HandshakeRequestMessageToken`. Plugin implementations may add extra properties as long as the names comply the rules defined in 7.4.3.5. Plugin implementations shall ignore any properties they do not understand.
binary_value1	The value of this octet sequence shall be set to a NONCE whose first 10 octets are set to match those in the string: "CHALLENGE:"
binary_value2	The value of this octet sequence shall be set to the result of signing the SHA-256 hash of the ***binary_value1*** attribute of the corresponding previously-received `HandshakeRequestMessageToken` object with the private key associated with the `DomainParticipant` that creates the `HandshakeReplyMessageToken` object.

9.3.2.3.3 HandshakeFinalMessageToken

`HandshakeFinalMessageToken` objects are used to finish an authentication handshake and communicate a `SharedSecret`. The `SharedSecret` shall be a **256-bit random number** generated using a cryptographically-strong random number generator. Each created `HandshakeFinalMessageToken` shall have associated a unique `SharedSecret`.

The attributes in the `HandshakeFinalMessageToken` objects shall be set as specified in the table below.

Table 33 – HandshakeFinalMessageToken for the builtin Authentication plugin

Attribute name	*Attribute value*
class_id	The string shall be set to either "DDS:Auth:ChallengeFin:DSA-DH" or "DDS:Auth:ChallengeFin:PKI-RSA". Both values shall be supported.
binary_value1	Shall be set to the result of encrypting the `SharedSecret` with the Public Key of the remote `DomainParticipant` that is the destination of the `HandshakeFinalMessageToken`.
binary_value2	The bytes in this octet sequence shall be set to the result of signing

	the SHA-256 hash of the concatenation of the ***binary_value1*** attribute of the corresponding previously-received `HandshakeReplyMessageToken` object and the ***binary_value1*** in the `HandshakeFinalMessageToken`. This signature shall use the private key associated with the `DomainParticipant` that creates the `HandshakeFinalMessageToken` object.

9.3.3 DDS:Auth:PKI-RSA/DSA-DH plugin behavior

The table below describes the actions that the DDS:Auth:PKI-RSA/DSA-DH plugin performs when each of the plugin operations is invoked.

Table 34 – Actions undertaken by the operations of the bultin Authentication plugin

`validate_local_identity`	This operation shall receive the ***participant_key*** associated with the local `DomainParticipant` whose identity is being validated. This operation shall receive the ***identity_credential*** containing an the `IdentityCredential` object with the contents described in 9.3.2.1. The operation shall verify the validity of the ***identity_credential*** using the configured CA. The operation shall check a CRL and/or an OCSP (RFC 2560) responder. This includes checking the expiration date of the certificate. If the above check fails the operation shall return VALIDATION_FAILED. The operation shall fill the ***handle*** with an implementation-dependent reference that allows the implementation to retrieve at least the following information: 1. The private key associated with the ***identity_credential*** 2. The public key associated with the ***identity_credential***. 3. The ***participant_key.*** The operation shall return the 16-byte ***effective_participant_key*** computed as follows: • The first bit (bit 0) shall be set to 1. • The 47 bits following the first bit (bits 1 to 47) shall be set to the 47 first bits of the SHA-256 hash of the SubjectName appearing on the ***identity_credential*** • The following 48 bits (bits 48 to 96) shall be set to the first 48 bits of the SHA-256 hash of the ***candidate_participant_key*** • The remaining 32 bits (bits 97 to 127) shall be set identical to

	the corresponding bits in the ***candidate_participant_key*** If successful, the operation shall return VALIDATION_OK.
`get_identity_token`	The operation shall receive the ***handle*** corresponding to the one returned by a successful previous call to ***validate_local_identity.*** If the above condition is not met the operation shall return the exception DDS_SecurityException_PreconditionError. This operation shall return an `IdentityToken` object with the content specified in 9.3.2.2.
`set_permissions_credential_and_token`	This operation shall store the `PermissionsCredentialToken` and the `PermissionsToken` internally to the plugin and associate them with the `DomainPartipant` represented by the IdentityHandle.
`validate_remote_identity`	The operation shall receive the `IdentityToken` of the remote participant in the argument ***remote_identity_token***. The contents of the `IdentityToken` shall identical to what would be returned by a call to `get_identity_token` on the `Authentication` plugin of the remote `DomainParticipant` associated with the ***remote_participant_key.*** The operation shall compare lexicographically the ***remote_participant_key*** with the participant key obtained from the ***local_identity_handle***. If the ***remote_participant_key*** > ***local participant_key***, the operation shall return VALIDATION_PENDING_HANDSHAKE_REQUEST. If the ***remote_participant_key*** < ***local participant_key***, the operation shall return VALIDATION_PENDING_HANDSHAKE_MESSAGE. In both scenarios the ***remote_identity_handle*** shall be filled with a referece to internal plugin information that identifies the remote participant and associates it to the ***remote_identity_token*** and any additional information requied for the challenge protocol.

`begin_handshake_request`	The operation shall receive the ***initiator_identity_handle*** corresponding to the ***local_identity_handle*** of a previous invocation to the ***validate_remote_identity*** operation that returned VALIDATION_PENDING_HANDSHAKE_REQUEST. The operation shall also receive the ***replier_identity_handle*** corresponding to the ***remote_identity_handle*** returned by that same invocation to the ***validate_remote_identity*** operation. The operation shall return the ***handshake_message*** containing a `HandshakeRequestMessageToken` object with contents as defined in 9.3.2.3.1. The operation shall fill the ***handshake_handle*** with an implementation-dependent reference that allows the implementation to retrieve at least the following information: 1. The ***local_identity_handle*** 2. The ***remote_identity_handle*** 3. The value attribute of the ***handshake_message*** returned. The operation shall return VALIDATION_PENDING_HANDSHAKE_MESSAGE.
`begin_handshake_reply`	The operation shall receive the ***replier_identity_handle*** corresponding to ***local_identity_handle*** of a previous invocation to the ***validate_remote_identity*** operation that returned VALIDATION_PENDING_CHALLENGE_MESSAGE. The operation shall also receive the ***initiator_identity_handle*** corresponding to the ***remote_identity_handle*** returned by that same invocation to the `validate_remote_identity` operation. If any of the above conditons is not met the operation shall return the exception DDS_SecurityException_PreconditionError. The operation shall verify the validity of the `IdentityCredential` contained in the property named "`dds.sec.`identity" found in the ***handshake_message_in*** `HandshakeMessageToken`. This verification shall be done using the locally configured CA in the same manner as the `validate_local_identity` operation. If the ***handshake_message_in*** does not contain the aforementioned property or the verification fails then the operation shall fail und return ValidationResult_Fail. The operation shall verify that the first bit of the ***participant_key*** is set to 1 and that the following 47 bits match the first 47 bits of

	the SHA-256 hash of the SubjectName appearing in the `IdentityCredential`. If this verification fails the operation shall fail und return ValidationResult_Fail. The operation shall fill the ***handshake_message_out*** with a `HandshakeReplyMessageToken` object with the content specified in 9.3.2.3.2. The operation shall fill the ***handshake_handle*** with an implementation-dependent reference that allows the implementation to retrieve at least the following information: 1. The ***replier_identity_handle*** 2. The ***initiator_identity_handle*** 3. The value attribute of the ***challenge_message*** returned 4. The property with name "dds.sec.permissions" found within the ***handshake_message_in*** if present The operation shall return VALIDATION_PENDING_CHALLENGE_MESSAGE.

`process_handshake`
 	
on a ***handshake_handle***
 	
created by
 	
`begin_handshake_request`
	The operation shall be called with the ***handshake_handle*** returned by a previous call to ***begin_handshake_request*** that returned VALIDATION_PENDING_CHALLENGE_MESSAGE.
	
	The ***handshake_message_in*** shall correspond to a `HandshakeReplyMessageToken` object received as a reply to the ***handshake_message*** `HandshakeRequestMessageToken` object associated with the ***handshake_handle***.
	
	If any of the above conditons is not met, the operation shall return the exception DDS_SecurityException_PreconditionError.
	
	The operation shall verify that the contents of the ***handshake_message_in*** correspond to a `HandshakeReplyMessageToken` as described in 9.3.2.3.2.
	
	The operation shall verify the validity of the `IdentityCredential` contained in the property named "`dds.sec.`identity" found in the ***handshake_message_in*** `HandshakeMessageToken`. This verification shall be done using the locally configured CA in the same manner as the ***validate_local_identity*** operation.
	
	If the ***handshake_message_in*** does not contain the aforementioned property or the verification fails, then the operation shall fail und return ValidationResult_Fail.
	
	The operation shall decrypt the contents of the ***binary_value2*** using the Public Key of the remote participant associated with the

	handshake_handle. The operation shall verify that the result of this decryption correspond the SHA256 of the ***binary_value1*** attribute in the `HandshakeRequestMessageToken` associated with the ***handshake_handle***. If the specified verification on the ***binary_value2*** does not succeed, the operation shall return VALIDATION_FAILED. If the specified verification on the ***binary_value2*** succeeds, then the operation shall generate a 256-bit random number to be used as a `SharedSecret` using a cryptographycally-strong random number generator. The operation shall create a `HandshakeFinalMessageToken` object with an associated `SharedSecret` as described in 9.3.2.3.3. The operation shall fill the ***handshake_message_out*** with the created `HandshakeFinalMessageToken` object. The operation shall store the ***value*** of property with ***name*** "`dds.sec.`permissions" found within the ***handshake_message_in***, if present and associate it with the ***handshake_handle*** as the `PermissionsCertificate` of remote `DomainParticipant`. The operation shall save the `SharedSecret` in the ***hansdhake_handle*** and return VALIDATION_OK_WITH_FINAL_MESSAGE.

`process_handshake`
 	
on a ***handshake_handle***
 	
created by
 	
`begin_handshake_reply`
	The operation shall be called with the ***handshake_handle*** returned by a previous call to ***begin_handshake_reply*** that retuned VALIDATION_PENDING_HANDSHAKE_MESSAGE.
	
	The ***handshake_message_in*** shall correspond to the one received as a reply to the ***handshake_message_out*** associated with the ***handshake_handle***.
	
	If any of the above conditions is not met, the operation shall return the exception DDS_SecurityException_PreconditionError.
	
	The operation shall verify that the contents of the ***handshake_message_in*** correspond to a `HandshakeFinalMessageToken` object as described in 9.3.2.3.3.
	
	The contents of the ***handshake_message_in binary_value1*** attribute shall be decrypted with the Private Key of the local participant associated with the ***handshake_handle***. The result shall be saved as the SharedSecret and be associated with the ***hansdhake_handle.***
	
	The contents of the ***handshake_message_***in ***binary_value2*** attribute shall be decrypted with the public key of the remote

	participant and the operation shall verify that it contains the expected SHA-256 hash as described in 9.3.2.3.3. If the specified verification on the ***binary_value2*** does not succeed the operation shall return VALIDATION_FAIL If specified verification on the ***binary_value2*** succeeds, then the operation shall return VALIDATION_OK.
`get_shared_secret`	This operation shall be called with the ***handshake_handle*** that was previously used to call either ***process_handshake*** and for which the aforementioned operation returned VALIDATION_OK_WITH_FINAL_MESSAGE or VALIDATION_OK. If the above conditon is not met, the operation shall return the exception DDS_SecurityException_PreconditionError. The operation shall return a `SharedSecretHandle` that is internally associated with the SharedSecret stablished as part of the handshake. On failure the operation shall return nil.
`get_peer_permissions_credential_token`	This operation shall be called with the ***handshake_handle*** that was previously used to call either ***process_handshake*** and for which the aforementioned operation returned VALIDATION_OK_WITH_FINAL_MESSAGE or VALIDATION_OK. If the above conditon is not met, the operation shall return the exception DDS_SecurityException_PreconditionError. The operation shall return the `PermissionsCredentialToken` of the peer `DomainParticipant` associated with the ***handshake_handle***. If the `DomainParticipant` initiated the handshake, then the peer `PermissionsCredentialToken` was received in the `HandshakeReplyMessageToken`, otherwise it was received in the `HandshakeRequestMessageToken`. In both cases the `PermissionsCredentialToken` appeared as the value of the property named "`dds.sec.permissions`". On failure the operation shall return nil.
`set_listener`	This operation shall save a reference to the listener object and associate it with the specified `IdentityHandle`.
`return_identity_token`	This operation shall behave as specified in 8.3.2.9.13.

`return_peer_permissions_credential_token`	This operation shall behave as specified in 8.3.2.9.14.
`return_handshake_handle`	This operation shall behave as specified in 8.3.2.9.15.
`return_identity_handle`	This operation shall behave as specified in 8.3.2.9.16.
`return_sharedsecret_handle`	This operation shall behave as specified in 8.3.2.9.17.

9.3.4 DDS:Auth:PKI-RSA/DSA-DH plugin authentication protocol

The operations the Secure DDS implementation executes on the `Authentication` plugin combined with the behavior of the DDS:Auth:PKI-RSA/DSA-DH result in an efficient 3-message protocol that performs mutual authentication and establishes a shared secret.

The rest of this sub clause describes the resulting protocol.

The authentication protocol is symmetric, that is there are no client and server roles. But only one `DomainParticipant` should initiate the protocol. To determine which of the two `DomainParticipant` entities shall initiate the protocol, each `DomainParticipant` compares its own GUID with that of the other DomainParticipant. The `DomainParticipant` with the lower GUID (using lexicographical order) initiates the protocol.

9.3.4.1 Terms and notation

The table below summarizes the terms used in the description of the protocol

Table 35 – Terms used in the description of the builtin authentication protocol

Term	*Meaning*
Participant_A	The `DomainParticipant` that initiates the handshake protocol. It calls `begin_handshake_request`, sends the `HandshakeRequestMessageToken`, receives the `HandshakeReplyMessageToken`, and sends the `HandshakeFinalMessageToken`) .
Participant_B	The DomainParticipant that does not initiate the handshake protocol. It calls `begin_handshake_reply`, receives the `HandshakeRequestMessageToken` , sends the `HandshakeReplyMessageToken`, and receives the `HandshakeFinalMessageToken`).
PubK_A	The Public Key of Participant_A
PubK_B	The Public Key of Participant_B
PrivK_A	The Private Key of Participant_A

PrivK_B	The Private Key of Participant_B
Cert_A	The `IdentityCertificate` (signed by the shared CA) of Participant A. It contains PubK_A.
Cert_B	The `IdentityCertificate` (signed by the shared CA) of Participant B. It contains PubK_B.
Challenge_A	The challenge created by Participant_A by calling `begin_handshake_request` on the `Authentication` plugin.
Challenge_B	The challenge created by Participant_B by calling `begin_handshake_reply` on the `Authentication` plugin.
SharedSecret	A cryptographically strong random number generated with the purpose of establishing a shared secret between Participant_A and Participant_B

The table below summarizes the notation and transformation functions used in the description of the protocol:

Table 36 – Notation of the operations/transformations used in the description of the builtin authentication protocol

Function / notation	*meaning*
Sign(data)	Signs the 'data' argument using the Private Key.
Encrypt(PubK, data).	Encrypts the data using the public key PubK.
Hash(data)	Hashes the 'data' argument using SHA-256.
data1 # data2	The symbol '#' is used to indicate byte concatenation.

9.3.4.2 Protocol description

The table below describes the resulting 3-way protocol that establishes authentication and a shared secret between Participant_A and Participant_B.

Table 37 – Description of built-in authentication protocol

Participant A	Participant B
Is configured with PrivK_A , Cert_A (and thus PubK_A) Generates a random challenge_A and sends: `HandshakeRequestMessageToken: (Cert_A, Challenge_A)`	Is configured with PrivK_B, Cert_B (and thus PubK_B)
	Receives `HandshakeRequestMessageToken` containing Cert_A, Challenge_A Verifies Cert_A with the configured CA Generates a random Challenge_B and sends:

	HandshakeReplyMessageToken: (Cert_B, Sign(Challenge_A), Challenge_B)
Receives HandshakeReplyMessageToken Verifies Cert_B with the configured CA Verifies Sign(challenge_A) against PubK_B Generates SharedSecret and encrypts it using PubK_B, resulting on: Encrypt(PubK_B, SharedSecret) Hashes Challenge_B concatenated with the previously encrypted SharedSecret Signs the hash. Sends: HandshakeFinalMessageToken: (Encrypt(PubK_B, SharedSecret), Sign(Hash(Challenge_B # Encrypt(PubK_B, SharedSecret))))	
	Receives HandshakeFinalMessageToken Verifies the signature over the hash, that is verifies Sign(Hash(Challenge_B # Encrypt(PubK_B, SharedSecret)))) against PubK_A Decrypts the SharedSecret using PrivK_B.

9.4 Builtin Access Control: DDS:Access:PKI-Signed-XML-Permissions

This builtin AccessControl plugin is referred to as the “DDS:Access:PKI-Signed-XML-Permissions” plugin.

The DDS:Access:PKI-Signed-XML-Permissions implements the `AccessControl` plugin API using a permissions document signed by a shared Certificate Authority (CA).

The shared CA could be an existing one (including the same CA used for the `Authentication` plugin), or a new one could be created for the purpose of assigning permissions to the applications on a DDS Domain. The nature or manner in which the CA is selected is not important because the way it is used enforces a shared recognition by all participating applications.

Each `DomainParticipant` has an associated instance of the DDS:Access:PKI-Signed-XML-Permissions plugin.

9.4.1 Configuration

The DDS:Access:PKI-Signed-XML-Permissions plugin is configured with three documents:

- The Permissions CA certificate
- The Domain governance signed by the Permissions CA
- The DomainParticipant permissions signed by the Permissions CA

9.4.1.1 Permissions CA Certificate

This is a self-signed x.509 certificate that contains the Public Key of the CA that will be used to sign the Domain Governance and Domain Permissions document.

The way the Permissions CA certificate is provided to the plugins is not specified. It may be done in an implementation-dependent way. The fact that this is not specified does not affect interoperability.

9.4.1.2 Domain Governance Document

The domain governance document is an XML document that specifies how the domain should be secured.

The document specifies which DDS domain IDs shall be protected and the details of the protection. Specifically this document configures the following aspects that apply to the whole domain:

- Whether the discovery information should be protected and the kind of protection: only message authentication codes (MACs) or encryption followed by MAC.
- Whether the whole RTPS message should be protected and the kind of protection. This is in addition to any protection that may occur for individual submessages and for submessage data payloads.
- Whether the liveliness messages should be protected.
- Whether a discovered DomainParticipants that cannot authenticate or fail the authentication should be allowed to join the domain and see any discovery data that are configured as ‘unprotected’ and any Topics that are configured as ‘unprotected’.
- Whether any discovered DomainParticipant that authenticates successfully should be allowed to join the domain and see the discovery data without checking the access control policies.

In addition, the domain governance document specifies how the information on specific Topics within the domain should be treated. Specifically:

- Whether the discovery information on specific Topics should be sent using the secure (protected) discovery writers or using the regular (unprotected) discovery writers.

- Whether read access to the Topic should be open to all or restricted to the DomainParticipants that have the proper permissions.
- Whether write access to the Topic should be open to all or restricted to the DomainParticipants that have the proper permissions.
- Whether the metadata information sent on the Topic (sequence numbers, heartbeats, key hashes, gaps, acknowledgment messages, etc.) should be protected and the kind of protection (MAC or Encrypt+MAC).
- Whether the payload data sent on the Topic (serialized application level data) should be protected and the kind of protection (MAC or Encrypt+MAC).

9.4.1.2.1 Protection Kinds

The domain governance document provides a means for the application to configure the kinds of cryptographic transformation applied to the complete RTPS Message, certain RTPS SubMessages, and the SerializedPayload RTPS submessage element that appears within the `Data` and `DataFrag` submessages.

The configuration allows specification of three protection levels: NONE, SIGN, ENCRYPT.

NONE indicates no cryptographic transformation is applied.

- When referring to the whole RTPS message, it means that the `encode_rtps message` operation on the `CryptoTransform` interface shall either not be called, or if it is called it shall behave as a No-Op by returning the same cleartext bytes that were its input. In other words it shall not enclose the RTPS message inside the `SecureSubMsg`.
- When referring to a concrete RTPS `SubMessage` originating on a `DataWriter` (`Data`, `DataFrag`, `Gap`, `Heartbeat`) it means that the `encode_datawriter_submessage` operation on the `CryptoTransform` interface shall either not be called, or if it is called it shall behave as a No-Op by returning the same cleartext bytes that were its input. In other words it shall not envelope the submessage inside a `SecureSubMsg`.
- When referring to a concrete RTPS `SubMessage` originating on a `DataReader` (`AckNack`, `NackFrag`) it means that the `encode_datareader_submessage` operation on the `CryptoTransform` interface shall either not be called, or if it is called it shall behave as a No-Op by returning the same cleartext bytes that were its input. In other words it shall not enclose the submessage inside a `SecureSubMsg`.
- When referring to a concrete `SerializedPayload` sub message element inside the `DataWriter` `Data` and `DataFrag` submessages, it means that the encode_serialized_data operation on the `CryptoTransform` interface shall either not be called, or if it is called it shall behave as a No-Op by returning the same cleartext bytes that were its input. In other words it shall not enclose the `SerializedData` submessage element inside a `SecuredPayload` submessage element.

SIGN indicates the cryptographic transformation shall be purely a hash-based message authentication code (HMAC), that is, no encryption is performed.

- When referring to the whole RTPS message, it means that the `encode_rtps message` operation on the `CryptoTransform` interface shall be called and its return shall be enclosed inside a `SecureSubMsg`. The `encode_rtps message` operation shall only sign the message

using the HMAC algorithm. Therefore the resulting `CryptoTransformIdentifier` for the `SecureSubMsg` shall be either HMAC_SHA1 or HMAC_SHA256.

- When referring to a concrete RTPS `SubMessage` originating on a `DataWriter` (`Data`, `DataFrag`, `Gap`, `Heartbeat`), it means that the `encode_datawriter_submessage` operation on the `CryptoTransform` interface shall be called and its return shall be enclosed inside a `SecureSubMsg`. The `encode_datawriter_submessage` operation shall only sign the message using the HMAC algorithm. Therefore the resulting `CryptoTransformIdentifier` for the `SecureSubMsg` shall be either HMAC_SHA1 or HMAC_SHA256.
- When referring to a concrete RTPS `SubMessage` originating on a `DataReader` (`AckNack`, `NackFrag`), it means that the `encode_datareader_submessage` operation on the `CryptoTransform` interface it means that the `encode_datareader_submessage` operation on the `CryptoTransform` interface shall be called and its return shall be enclosed inside a `SecureSubMsg`. The `encode_datareader_submessage` operation shall only sign the message using the HMAC algorithm. Therefore the resulting `CryptoTransformIdentifier` for the `SecureSubMsg` shall be either HMAC_SHA1 or HMAC_SHA256.
- When referring to a concrete `SerializedPayload` sub message element inside the `DataWriter` `Data` and `DataFrag` submessages, it means that the `encode_serialized_data` operation on the `CryptoTransform` interface shall be called and its return shall be enclosed inside a `SecureData` submessage element. The `encode_serialized_data` operation shall only sign the message using the HMAC algorithm. Therefore, the resulting `CryptoTransformIdentifier` for the `SecureData` shall be either HMAC_SHA1 or HMAC_SHA256.

ENCRYPT indicates the cryptographic transformation shall be an encryption followed by a hash-based message authentication code (HMAC) computed on the ciphertext, also known as Encrypt-then-MAC.

- When referring to the whole RTPS message, it means that the `encode_rtps message` operation on the `CryptoTransform` interface shall be called and its return shall be enclosed inside a `SecureSubMsg`. The `encode_rtps message` operation shall first encrypt the RTPS message, prepend the `SecureSubMsg` headers and then compute the HMAC over the result. Therefore the resulting `CryptoTransformIdentifier` for the `SecureSubMsg` shall be either AES128_HMAC_SHA1 or AES256_HMAC_SHA256.
- When referring to a concrete RTPS `SubMessage` originating on a `DataWriter` (`Data`, `DataFrag`, `Gap`, `Heartbeat`), it means that the `encode_datawriter_submessage` operation on the `CryptoTransform` interface shall be called and its return shall be enclosed inside a `SecureSubMsg`. The `encode_datawriter_submessage` operation shall first encrypt the RTPS message, prepend the `SecureSubMsg` headers and then compute the HMAC over the result. Therefore the resulting `CryptoTransformIdentifier` for the `SecureSubMsg` shall be either AES128_HMAC_SHA1 or AES256_HMAC_SHA256.
- When referring to a concrete RTPS Sub Messages originating on a `DataReader` (`AckNack`, `NackFrag`), it means that the `encode_datareader_submessage` operation on the `CryptoTransform` interface shall be called and its return shall be enclosed inside a `SecureSubMsg`. The `encode_datareader_submessage` operation shall first encrypt the

RTPS message, prepend the SecureSubMsg headers, and then compute the HMAC over the result. Therefore the resulting CryptoTransformIdentifier for the SecureSubMsg shall be either HMAC_SHA1 or HMAC_SHA256.

- When referring to a concrete SerializedPayload sub message element inside the DataWriter Data and DataFrag submessages, it means that the encode_serialized_data operation on the CryptoTransform interface shall be called and its return shall be enclosed inside a SecureData submessage element. The encode_serialized_data operation shall first encrypt the RTPS message, prepend the SecureData headers and then compute the HMAC over the result. Therefore the resulting CryptoTransformIdentifier for the SecureData shall be either HMAC_SHA1 or HMAC_SHA256.

9.4.1.2.2 Domain Governance document format

The format of this document defined using the following XSD:

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
    elementFormDefault="qualified" attributeFormDefault="unqualified">

    <xs:element name="dds" type="DomainAccessRulesNode" />

    <xs:complexType name="DomainAccessRulesNode">
        <xs:sequence minOccurs="1" maxOccurs="1">
            <xs:element name="domain_access_rules"
                        type="DomainAccessRules" />
        </xs:sequence>
    </xs:complexType>

    <xs:complexType name="DomainAccessRules">
        <xs:sequence minOccurs="1" maxOccurs="unbounded">
            <xs:element name="domain_rule" type="DomainRule" />
        </xs:sequence>
    </xs:complexType>

    <xs:complexType name="DomainRule">
        <xs:sequence minOccurs="1" maxOccurs="1">
            <xs:element name="domain_id" type="xs:string" />
            <xs:element name="allow_unauthenticated_join"
                        type="BooleanKind" />
            <xs:element name="enable_join_access_control"
                        type="BooleanKind" />
            <xs:element name="discovery_protection_kind"
                        type="ProtectionKind" />
            <xs:element name="liveliness_protection_kind"
                        type="ProtectionKind" />
            <xs:element name="rtps_protection_kind"
                       type="ProtectionKind" />
            <xs:element name="topic_access_rules"
                        type="TopicAccessRules" />
        </xs:sequence>
    </xs:complexType>
```

```
    <xs:simpleType name="ProtectionKind">
        <xs:restriction base="xs:string">
            <xs:enumeration value="ENCRYPT" />
            <xs:enumeration value="SIGN" />
            <xs:enumeration value="NONE" />
        </xs:restriction>
    </xs:simpleType>
    <xs:simpleType name="BooleanKind">
        <xs:restriction base="xs:string">
            <xs:enumeration value="TRUE" />
            <xs:enumeration value="FALSE" />
        </xs:restriction>
    </xs:simpleType>

    <xs:complexType name="TopicAccessRules">
        <xs:sequence minOccurs="1" maxOccurs="unbounded">
            <xs:element name="topic_rule" type="TopicRule" />
        </xs:sequence>
    </xs:complexType>

    <xs:complexType name="TopicRule">
        <xs:sequence minOccurs="1" maxOccurs="1">
            <xs:element name="topic_expression" type="TopicExpression" />
            <xs:element name="enable_discovery_protection"
                        type="BooleanKind" />
            <xs:element name="enable_read_access_control"
                        type="BooleanKind" />
            <xs:element name="enable_write_access_control"
                        type="BooleanKind" />
            <xs:element name="metadata_protection_kind"
                        type="ProtectionKind" />
            <xs:element name="data_protection_kind"
                        type="ProtectionKind" />
        </xs:sequence>
    </xs:complexType>


    <xs:simpleType name="TopicExpression">
        <xs:restriction base="xs:string" />
    </xs:simpleType>

</xs:schema>
```

9.4.1.2.3 Domain Access Rules Section

The XML domain governance document is delimited by the `<dds>` XML element tag and contains a single domain access rules Section delimited by the `<domain_access_rules>` XML element tag.

The domain access rules Section contains a set of domain rules each delimited by the `<domain_rule>` XML element tag.

9.4.1.2.4 Domain Rules

Each domain rule appears within the domain access rules Section delimited by the `<domain_rule>` XML element tag.

Each domain rule contains the following elements and sections:

1. Domain id element
2. Discovery Protection Kind element
3. Liveliness Protection Kind element
4. Allow Unauthenticated Join element
5. Enable Join Access Control element
6. Topic Access Rules Section, containing topic rules

The contents and delimiters of each Section are described below.

The domain rules shall be evaluated in the same order as they appear in the document. A rule only applies to a particular `DomainParticipant` if the domain Section matches the DDS domain_id to which the `DomainParticipant` belongs. If multiple rules match, the first rule that matches is the only one that applies.

9.4.1.2.4.1 Domain Id element

This element is delimited by the XML element <**domain_id**>.

The value in this element identifies the DDS `domain_id` to which the rule applies.

9.4.1.2.4.2 Allow Unauthenticated Join element

This element is delimited by the XML element <**allow_unauthenticated_join**>.

This element may take the binary values TRUE or FALSE.

If the value is set to FALSE, the `ParticipantSecurityAttributes` returned by the `get_participant_sec_attributes` operation on the `AccessControl` shall have the ***allow_unauthenticated_participants*** member set to FALSE.

If the value is set to TRUE, the `ParticipantSecurityAttributes` returned by the `get_participant_sec_attributes` operation on the `AccessControl` shall have the ***allow_unauthenticated_participants*** member set to TRUE.

9.4.1.2.4.3 Enable Join Access Control element

This element is delimited by the XML element <**enable_join_access_control**>.

This element may take the binary values TRUE or FALSE.

If the value is set to FALSE, the `ParticipantSecurityAttributes` returned by the `get_participant_sec_attributes` operation on the `AccessControl` shall have the ***is_access_protected*** member set to FALSE.

If the value is set to TRUE, the `ParticipantSecurityAttributes` returned by the `get_participant_sec_attributes` operation on the `AccessControl` shall have the ***is_access_protected*** member set to TRUE.

9.4.1.2.4.4 Discovery Protection Kind element

This element is delimited by the XML element <**discovery_protection_kind**>.

The discovery protection element specifies the protection kind (see 9.4.1.2.1) used for the secure builtin `DataWriter` and `DataReader` entities used for discovery: ***SEDPbuiltinPublicationsSecureWriter***, ***SEDPbuiltinSubscriptionsSecureWriter,*** ***SEDPbuiltinPublicationsSecureReader***, ***SEDPbuiltinSubscriptionsSecureReader***.

The discovery protection kind element may take three possible values: NONE, SIGN, or ENCRYPT. The resulting behavior for the aforementioned builtin discovery secure entities shall be as specified in 9.4.1.2.1 with regards to the RTPS SubMessages.

The builtin endpoints shall never apply cryptographic transformations to the `SecuredPayload` submessage element.

9.4.1.2.4.5 Liveliness Protection Kind element

This element is delimited by the XML element <**liveliness_protection_kind**>.

The liveliness protection element specifies the protection kind (see 9.4.1.2.1) used for builtin `DataWriter` and `DataReader` associated with the ***ParticipantMessageSecure*** builtin Topic (see 7.4.2): ***BuiltinParticipantMessageSecureWriter*** and ***BuiltinParticipantMessageSecureWriter.***

The discovery protection kind element may take three possible values: NONE, SIGN, or ENCRYPT. The resulting behavior for the aforementioned builtin secure entities shall be as specified in 9.4.1.2.1.

9.4.1.2.4.6 RTPS Protection Kind element

This element is delimited by the XML element <**rtps_protection_kind**>.

The liveliness protection element specifies the protection kind (see 9.4.1.2.1) used for the whole RTPS message.

The discovery protection kind element may take three possible values: NONE, SIGN, or ENCRYPT. The resulting behavior for the RTPS message cryptographic transformation shall be as specified in 9.4.1.2.1.

9.4.1.2.4.7 Topic Access Rules Section

This element is delimited by the XML element <**topic_access_rules**> and contains a sequence of topic rule elements.

9.4.1.2.5 Topic Rule Section

This element is delimited by the XML element <**topic_rules**> and appears within the domain rule Section.

Each topic rule Section contains the following elements:

1. Topic expression
2. Enable Discovery protection
3. Enable Read Access Control element
4. Enable Write Access Control element
5. Metadata protection Kind

6. Data protection Kind

The contents and delimiters of each Section are described below.

The topic expression element within the rules selects a set of Topic names. The rule applies to apply to any DataReader or DataWriter associated with a Topic whose name matches the Topic expression name.

The topic access rules shall be evaluated in the same order as they appear within the **<topic_access_rules>** Section. If multiple rules match the first rule that matches is the only one that applies.

9.4.1.2.5.1 Topic expression element

This element is delimited by the XML element **<topic_expression>**.

The `value` in this element identifies the set of DDS `Topic` names to which the rule applies. The rule will apply to any DataReader or DataWriter associated with a Topic whose name matches the value.

9.4.1.2.5.2 Enable Discovery protection element

This element is delimited by the XML element **<enable_discovery_protection>**.

This element may take the binary values TRUE or FALSE.

The setting controls the contents of the `EndpointSecurityAttributes` returned by the `AccessControl::get_endpoint_sec_attributes` operation on any DataWriter or DataReader entity whose associated Topic name matches the rule's topic expression. Specifically the ***is_discovery_protected*** attribute in the `EndpointSecurityAttributes` shall be set to the binary value specified in the "enable discovery protection" element.

9.4.1.2.5.3 Enable Read Access Control element

This element is delimited by the XML element **<enable_read_access_control>**.

This element may take the binary values TRUE or FALSE.

The setting shall control the contents of the `EndpointSecurityAttributes` returned by the `AccessControl::get_endpoint_sec_attributes` operation on any DataWriter entity whose associated Topic name matches the rule's topic expression. Specifically the ***is_access_protected*** attribute in the `EndpointSecurityAttributes` shall be set to the binary value specified in the "enable read access protection" element.

In addition, this element shall control the `AccessControl::check_create_datareader` operation on any DataReader entity whose associated Topic name matches the rule's topic expression. Specifically:

- If the value of "enable_read_access_control" element is FALSE, the operation `check_create_datareader` shall return TRUE without further checking the Permissions document.
- If the value of "enable_read_access_control" element is TRUE, the operation `check_create_datareader` shall return a value according to what is specified in the Permissions document, see 9.4.1.3.

9.4.1.2.5.4 Enable Write Access Control element

This element is delimited by the XML element **<enable_write_access_control>**.

This element may take the binary values TRUE or FALSE.

The setting controls the contents of the `EndpointSecurityAttributes` returned by the `AccessControl::get_endpoint_sec_attributes` operation on any DataReader entity whose associated Topic name matches the rule's topic expression. Specifically the ***is_access_protected*** attribute in the `EndpointSecurityAttributes` shall be set to the binary value specified in the "enable write access protection" element.

In addition, this element shall control the `AccessControl::check_create_datawriter` operation on any DataWriter entity whose associated Topic name matches the rule's topic expression. Specifically:

- If the value of "enable_write_access_control" element is FALSE, the operation `check_create_datawriter` shall return TRUE without further checking the Permissions document.
- If the value of "enable_write_access_control" element is TRUE, the operation `check_create_datareader` shall return a value according to what is specified in the Permissions document, see 9.4.1.3.

9.4.1.2.5.5 Metadata Protection Kind element

This element is delimited by the XML element <**metadata_protection_kind**>.

This element may take the binary values TRUE or FALSE.

The setting of this element shall specify the protection kind (see 9.4.1.2.1) used for the RTPS `SubMessages` sent by any `DataWriter` and `DataReader` whose associated `Topic` name matches the rule's topic expression.

The setting of this element shall also control the contents of the `EndpointSecurityAttributes` returned by the `AccessControl::get_endpoint_sec_attributes` operation on any `DataWriter` or `DataReader` entity whose associated Topic name matches the rule's topic expression. Specifically the ***is_submessage_protected*** attribute in the `EndpointSecurityAttributes` shall be set to the binary value specified in the "data protection kind" element.

9.4.1.2.5.6 Data Protection Kind element

This element is delimited by the XML element <**data_protection_kind**>.

This element may take the binary values TRUE or FALSE.

The setting of this element shall specify the protection kind (see 9.4.1.2.1) used for the RTPS `SerializedPayload` submessage element sent by any `DataWriter` whose associated Topic name matches the rule's topic expression.

The setting shall control the contents of the `EndpointSecurityAttributes` returned by the `AccessControl::get_endpoint_sec_attributes` operation on any `DataWriter` entity whose associated `Topic` name matches the rule's topic expression. Specifically the ***is_payload_protected*** attribute in the `EndpointSecurityAttributes` shall be set to the binary value specified in the "data protection kind" element.

9.4.1.2.6 Example Domain Governance document (non normative)

Following is an example permissions document that is written according to the XSD described in the previous sections.

```
<?xml version="1.0" encoding="utf-16"?>
<dds xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:noNamespaceSchemaLocation="omg_shared_ca_domain_governance.xsd">
    <domain_access_rules>
        <domain_rule>
            <domain_id>0</domain_id>
            <allow_unauthenticated_participants>FALSE
                </allow_unauthenticated_participants>
            <enable_join_access_control>TRUE
                </enable_join_access_control>
            <rtps_protection_kind>SIGN
                </rtps_protection_kind>
            <discovery_protection_kind>ENCRYPT
                </discovery_protection_kind>
            <liveliness_protection_kind>SIGN
                </liveliness_protection_kind>
            <topic_access_rules>
                <topic_rule>
                    <topic_expression>Square*
                      </topic_expression>
                    <enable_discovery_protection>TRUE
                      </enable_discovery_protection>
                    <enable_read_access_control>TRUE
                      </enable_read_access_control>
                    <enable_write_access_control>TRUE
                      </enable_write_access_control>
                    <metadata_protection_kind>ENCRYPT
                      </metadata_protection_kind>
                    <data_protection_kind>ENCRYPT
                      </data_protection_kind>
                </topic_rule>

                <topic_rule>
                    <topic_expression>Circle</topic_expression>
                    <enable_discovery_protection>TRUE
                      </enable_discovery_protection>
                    <enable_read_access_control>FALSE
                      </enable_read_access_control>
                    <enable_write_access_control>TRUE
                      </enable_write_access_control>
                    <metadata_protection_kind>ENCRYPT
                      </metadata_protection_kind>
                    <data_protection_kind>ENCRYPT
                      </data_protection_kind>
                </topic_rule>

                <topic_rule>
                    <topic_expression>Triangle
                      </topic_expression>
```

```
                    <enable_discovery_protection>FALSE
                      </enable_discovery_protection>
                    <enable_read_access_control>FALSE
                      </enable_read_access_control>
                    <enable_write_access_control>TRUE
                      </enable_write_access_control>
                    <metadata_protection_kind>NONE
                      </metadata_protection_kind>
                    <data_protection_kind>NONE
                      </data_protection_kind>
                </topic_rule>

                <topic_rule>
                    <topic_expression>*</topic_expression>
                    <enable_discovery_protection>TRUE
                      </enable_discovery_protection>
                    <enable_read_access_control>TRUE
                      </enable_read_access_control>
                    <enable_write_access_control>TRUE
                      </enable_write_access_control>
                    <metadata_protection_kind>ENCRYPT
                      </metadata_protection_kind>
                    <data_protection_kind>ENCRYPT
                      </data_protection_kind>
                </topic_rule>
            </topic_access_rules>
        </domain_rule>

    </domain_access_rules>
</dds>
```

9.4.1.3 DomainParticipant permissions document

The permissions document is an XML document containing the permissions of the domain participant and binding them to the distinguished name of the `DomainParticipant` as defined in the DDS:Auth:PKI-RSA/DSA-DH authentication plugin.

The format of this document defined using the following XSD.

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
           elementFormDefault="qualified"
           attributeFormDefault="unqualified">

    <xs:element name="permissions" type="Permissions"/>

    <xs:complexType name="Permissions">
        <xs:sequence minOccurs="1" maxOccurs="unbounded">
            <xs:element name="grant" type="Grant" />
         </xs:sequence>
    </xs:complexType>
```

```
<xs:complexType name="Grant">
    <xs:sequence minOccurs="1" maxOccurs="1">
        <xs:element name="subject_name" type="xs:string" />
        <xs:element name="validity" type="Validity" />
        <xs:sequence minOccurs="1" maxOccurs="unbounded">
            <xs:choice minOccurs="1" maxOccurs="1">
                <xs:element name="allow_rule" minOccurs="0"
                            type="Rule" />
                <xs:element name="deny_rule" minOccurs="0"
                            type="Rule" />
            </xs:choice>
        </xs:sequence>
        <xs:element name="default" type="DefaultAction"/>
    </xs:sequence>
    <xs:attribute name="name" type="xs:string" use="required"/>
</xs:complexType>

<xs:complexType name="Validity">
    <xs:sequence minOccurs="1" maxOccurs="1">
        <xs:element name="not_before" type="xs:string" />
        <xs:element name="not_after" type="xs:string" />
    </xs:sequence>
</xs:complexType>

<xs:complexType name="Rule">
    <xs:sequence minOccurs="1" maxOccurs="1">
        <xs:element name="domain_id" type="xs:string" />
        <xs:sequence minOccurs="1" maxOccurs="unbounded">
            <xs:element name="publish" type="Criteria" />
        </xs:sequence>
        <xs:sequence minOccurs="0" maxOccurs="unbounded">
            <xs:element name="subscribe" type="Criteria" />
        </xs:sequence>
        <xs:sequence minOccurs="0" maxOccurs="unbounded">
            <xs:element name="relay" type="Criteria" />
        </xs:sequence>
    </xs:sequence>
</xs:complexType>



<xs:complexType name="Criteria">
    <xs:sequence minOccurs="1" maxOccurs="unbounded">
        <xs:choice minOccurs="0" maxOccurs="unbounded">
            <xs:element name="topic" minOccurs="0"
                        type="TopicExpression"/>
            <xs:element name="partition" minOccurs="0"
                        type="PartitionExpression"/>
            <xs:element name="data_tags" minOccurs="0"
                        type="DataTags"/>
        </xs:choice>
    </xs:sequence>
</xs:complexType>
```

```
    <xs:simpleType name="TopicExpression">
        <xs:restriction base="xs:string"/>
    </xs:simpleType>

    <xs:simpleType name="PartitionExpression">
        <xs:restriction base="xs:string"/>
    </xs:simpleType>


    <xs:complexType name="DataTags">
        <xs:sequence minOccurs="1" maxOccurs="unbounded">
            <xs:element name="tag" type="TagNameValuePair"/>
        </xs:sequence>
    </xs:complexType>
    <xs:complexType name="TagNameValuePair">
        <xs:sequence minOccurs="1" maxOccurs="unbounded">
            <xs:element name="name" type="xs:string"/>
            <xs:element name="value" type="xs:string"/>
        </xs:sequence>
    </xs:complexType>

    <xs:simpleType name="DefaultAction">
        <xs:restriction base="xs:string">
            <xs:enumeration value="ALLOW"/>
            <xs:enumeration value="DENY"/>
        </xs:restriction>
    </xs:simpleType>

</xs:schema>
```

9.4.1.3.1 Permissions Section

The XML permissions document contains a permissions Section. This is the portion of the XML document delimited by the `<permissions>` XML element tag.

The permissions Section contains a set of grant sections.

9.4.1.3.2 Grant Section

The grant sections appear within the permissions Section delimited by the `<grant>` XML element tag.

Each grant Section contains three sections:

1. Subject name Section (subject_name element)
2. Validity Section (validity element)
3. Rules Section (allow, deny and default elements)

The contents and delimiters of each Section are described below.

9.4.1.3.2.1 Subject name Section

This Section is delimited by the XML element <**subject_name**>.

The subject name Section identifies the DomainParticipant to which the permissions apply. Each subject name can only appear in a single <permissions> Section within the XML Permissions document.

The contents of the **<subject_name>** element shall be the x.509 subject name for the `DomainParticipant` as is given in its Authorization Certificate. A permissions Section with a subject name that does not match the subject name given in the corresponding Authorization certificate shall be ignored.

The x.509 subject name is a set of name-value pairs. The format of x.509 subject name shall use a single string containing the sequence of names-value pairs. Each name shall be separated from the corresponding value by the '=' character and each pair shall be separated from the next by the forward slash character '/'. This representation is the same used by openssl package to print subject names.

For example:

```
<subject_name>/C=US/ST=CA/L=Sunnyvale/O=ACME Inc./OU=CTO Office/CN=DDS
Shapes Demo/emailAddress=cto@acme.com</subject_name>
```

9.4.1.3.2.2 Validity Section

This Section is delimited by the XML element <validity>. The contents of this element reflect the valid dates for the permissions. It contains both the starting date and the end date in GMT formatted as YYYYMMDDHH.

A permissions Section with a validity date that falls outside the current date at which the permissions are being evaluated shall be ignored.

9.4.1.3.2.3 Rules Section

This Section contains the permissions assigned to the `DomainParticipant`. It is described as a set of rules.

The rules are applied in the same order that appear in the document. If the criteria for the rule matches the `domain_id` join and/or publish or subscribe operation that is being attempted then the allow or deny decision is applied. If the criteria for a rule does not match the operation being attempted the evaluation shall proceed to the next rule. If all rules have been examined without a match then the decision specified by the "default" rule is applied. The default rule, if present, must appear after all allow and deny rules. If the default rule is not present the implied default decision is DENY.

The matching criteria for the rules specifies the `domain_id`, topics (published and subscribed), the partitions (published and subscribed), and the data-tags associated with the DataWriter and DataReader.

9.4.1.3.2.3.1 Format of the allow rules

Allow rules appear inside the **<allow_rule>** XML Element. Each rule contains the domain IDs to which the rule applies, and the topic names that are allowed to be published and subscribed within those domains.

9.4.1.3.2.3.1.1 Domain Id Section

This Section is delimited by the XML element <domain_id>. The contents of this element shall be an expression defining the set of DDS Domain Id values to which the allow rule applies. The expression syntax and matching shall use the syntax and rules of the POSIX fnmatch() function as specified in POSIX 1003.2-1992, Section B.6 [38].

For example:

```
<domain_id>0</domain_id>
```

9.4.1.3.2.3.1.2 Publish Section

This Section defines the Topic names that the rule allows to be published.

The publish Section shall be delimited by the **<publish>** XML Element.

The topic names appear in the Section delimited by the **<topics>** XML element. Topic names may be given explicitly or by means of Topic name expressions. The Topic name expression syntax and matching shall use the syntax and rules of the POSIX fnmatch() function as specified in POSIX 1003.2-1992, Section B.6 [38].

The publish Section may also include one or more sections delimited by the **<partitions>** XML Element. The **<partition>** XML Elements contain the DDS Partition names where it is allowed to publish the specified Topic names. Partition names may be given explicitly or by means of Partition name expressions. The Partition name expression syntax and matching shall use the syntax and rules of the POSIX fnmatch() function as specified in POSIX 1003.2-1992, Section B.6 [38]. If there is no <partitions> Section then the rule allows publishing on any partition.

The publish Section may also include one or more sections delimited by the **<data_tags>** XML Element. The **<data_tags>** XML Elements contain a set of tags that shall be associated with the DataWriter that publishes the data on the Topic names allowed by the rule.

Example1:

```
<publish>
    <topic>Circle1</topic>
</publish>
```

Example2:

```
<publish>
    <topic>Square</topic>
    <partition>A_partition</partition>
</publish>
```

Example3:

```
<publish>
    <topic>Cir*</topic>
    <data_tags>
        <tag>
             <name>aTagName1</name>
            <value>aTagValue1</value>
        </tag>
    </data_tags>
</publish>
```

9.4.1.3.2.3.1.3 Subscribe Section

This Section defines the Topic names that the rule allows to be subscribed.

The publish Section shall be delimited by the **<subscribe>** XML Element.

The topic names appear in the Section delimited by the **<topics>** XML element. Topic names may be given explicitly or by means of Topic name expressions. The Topic name expression syntax and matching shall use the syntax and rules of the POSIX fnmatch() function as specified in POSIX 1003.2-1992, Section B.6 [38].

The subscribe Section may also include one or more sections delimited by the **<partitions>** XML Element. The **<partition>** XML Elements contain the DDS Partition names where it is allowed to subscribe to the specified Topic names. Partition names may be given explicitly or by means of Partition name expressions. The Partition name expression syntax and matching shall use the syntax and rules of the POSIX fnmatch() function as specified in POSIX 1003.2-1992, Section B.6 [38]. If there is no <partitions> Section then the rule allows subscribing on any partition.

The subscribe Section may also include one or more sections delimited by the **<data_tags>** XML Element. The **<data_tags>** XML Elements contain a set of tags that shall be associated with the DataReader that subscribes the data on the Topic names allowed by the rule.

Example1:
```
<subscribe>
    <topic>Circle1</topic>
</subscribe>
```

Example2:
```
<subscribe>
    <topic>Square</topic>
    <partition>A_partition</partition>
</subscribe>
```

Example3:
```
<subscribe>
    <topic>Cir*</topic>
    <data_tags>
        <tag>
             <name>aTagName1</name>
            <value>aTagValue1</value>
        </tag>
    </data_tags>
</subscribe>
```

9.4.1.3.2.3.1.4 Example allow rule

```
    <allow_rule>
            <domain_id>0</domain_id>
            <publish>
                <topic>Cir*</topic>
                <data_tags>
                    <tag>
                        <name>aTagName1</name>
                        <value>aTagValue1</value>
                    </tag>
```

```
            </data_tags>
        </publish>
        <subscribe>
            <topic>Sq*</topic>
            <data_tags>
                <tag>
                    <name>aTagName1</name>
                    <value>aTagValue1</value>
                </tag>
                <tag>
                    <name>aTagName2</name>
                    <value>aTagValue2</value>
                </tag>
            </data_tags>
        </subscribe>
        <subscribe>
            <topic>Triangle</topic>
            <partition>P*</partition>
        </subscribe>
    </allow_rule>
```

9.4.1.3.2.3.2 Format for deny rules

Deny rules appear inside the **<deny_rule>** XML Element. Each rule contains the domain IDs to which the rule applies, and the topic names that are denied to be published and subscribed within those domains.

Deny rules have the same format as the allow rules. The only difference is how they are interpreted. If the criteria in the deny rule matches the operation being performed then the decision is to deny the operation.

9.4.1.3.2.3.2.1 Example deny rule

```
    <deny_rule>
            <domain_id>0</domain_id>
            <publish>
                <topic>Circle1</topic>
            </publish>
            <publish>
                <topic>Square</topic>
                <partition>A_partition</partition>
            </publish>
            <subscribe>
                <topic>Square1</topic>
            </subscribe>
            <subscribe>
                <topic>Tr*</topic>
                <partition>P1*</partition>
            </subscribe>

    </deny_rule>
```

9.4.1.4 DomainParticipant example permissions document (non normative)

Following is an example permissions document that is written according to the XSD described in the previous sections.

```
<?xml version="1.0" encoding="utf-16"?>

<permissions xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:noNamespaceSchemaLocation="omg_shared_ca_permissions.xsd">

    <grant name="ShapesPermission">
        <subject_name>/C=US/ST=CA/L=Sunnyvale/O=ACME Inc./OU=CTO
Office/CN=DDS Shapes Demo/emailAddress=cto@acme.com</subject_name>

        <validity>
            <!-- Format is YYYYMMDDHH in GMT -->
            <not_before>2013060113</not_before>
            <not_after>2014060113</not_after>
        </validity>

        <deny_rule>
            <domain_id>0</domain_id>
            <publish>
                <topic>Circle1</topic>
            </publish>
            <publish>
                <topic>Square</topic>
                <partition>A_partition</partition>
            </publish>
            <subscribe>
                <topic>Square1</topic>
            </subscribe>
            <subscribe>
                <topic>Tr*</topic>
                <partition>P1*</partition>
            </subscribe>
        </deny_rule>

        <allow_rule>
            <domain_id>0</domain_id>
            <publish>
                <topic>Cir*</topic>
                <data_tags>
                    <tag>
                        <name>aTagName1</name>
                        <value>aTagValue1</value>
                    </tag>
                </data_tags>
            </publish>
            <subscribe>
                <topic>Sq*</topic>
                <data_tags>
                    <tag>
                        <name>aTagName1</name>
```

```
                        <value>aTagValue1</value>
                    </tag>
                    <tag>
                        <name>aTagName2</name>
                        <value>aTagValue2</value>
                    </tag>
                </data_tags>
            </subscribe>
            <subscribe>
                <topic>Triangle</topic>
                <partition>P*</partition>
            </subscribe>
            <relay>
                <topic>*</topic>
                <partition>aPartitionName</partition>
            </relay>
        </allow_rule>

        <default>DENY</default>
    </grant>
</permissions>
```

9.4.2 DDS:Access:PKI-Signed-XML-Permissions Types

This sub clause specifies the content and format of the `Credential` and `Token` objects used by the DDS:Access:PKI-Signed-XML-Permissions plugin.

9.4.2.1 DDS:Access:PKI-Signed-XML-Permissions PermissionsCredential

The DDS:Access:PKI-Signed-XML-Permissions plugin shall set the attributes of the `PermissionsCredential` objects as specified in the table below:

Table 38 – PermissionsCredential class for the builtin AccessControl plugin

Attribute name	*Attribute value*
class_id	"DDS:Access:PKI-Signed-XML-Permissions"
binary_value1	Octet sequence containing the characters in the PEM-encoded PKCS#7 signature of the ***XML permissions document*** (see 9.4.1.3) of the `DomainParticipant` signed by the shared Permissions Authority. The PKCS#7 signature shall have the content-type ***signed data*** as defined in the PKCS#7 specification [37]. The content-type ***signed data*** is used so that the PKCS#7 embeds the permissions document.

9.4.2.2 DDS:Access:PKI-Signed-XML-Permissions PermissionsCredentialToken

The DDS:Access:PKI-Signed-XML-Permissions plugin shall set the attributes of the `PermissionsCredentialToken` objects identically to the `PermissionsCredential` object.

9.4.2.3 DDS:Access:PKI-Signed-XML-Permissions PermissionsToken

The DDS:Access:PKI-Signed-XML-Permissions plugin shall set the attributes of the `PermissionsToken` object as specified in the table below:

Table 39 PermissionsToken class for the builtin AccessControl plugin

Attribute name	*Attribute value*
class_id	"DDS:Access:PKI-Signed-XML-Permissions"
binary_value1	Octet sequence containing the SHA256 hash of the ***binary_value1*** attribute of the `PermissionsCredential`. The SHA256 hash is encoded in binary therefore the sequence shall contain exactly 32 octets.

9.4.3 DDS:Access:PKI-Signed-XML-Permissions plugin behavior

The DDS:Access:PKI-Signed-XML-Permissions shall be initialized to have access to the Permissions CA 2048-bit RSA public key. As this is a builtin plugin the mechanism for initialization is implementation dependent.

The table below describes the actions that the DDS:Access:PKI-Signed-XML-Permissions plugin performs when each of the plugin operations is invoked.

Table 40 – Actions undertaken by the operations of the bultin AccessControl plugin

`check_create_participant`	This operation shall use the ***permissions_handle*** to retrieve the cached Permissions Section. The operation shall verify that the Permissions Section allows creating a `DomainParticipant` in the specified ***domain_id***.
`check_create_datawriter`	This operation shall use the ***permissions_handle*** to retrieve the cached Permissions Section. The operation shall verify that the Permissions Section allows publishing the `Topic` with specified ***topic_name*** on the specified domain_id.
`check_create_datareader`	This operation shall use the ***permissions_handle*** to retrieve the cached Permissions Section. The operation shall verify that the Permissions Section allows subscribing to the `Topic` with specified ***topic_name*** on the specified ***domain_id***.
`check_create_topic`	This operation shall use the ***permissions_handle*** to retrieve the cached Permissions Section. The operation shall verify that the Permissions Section allows publishing or subscribing to the `Topic` with specified ***topic_name*** on the specified ***domain_id***.

`check_local_datawriter_register_instance`	This operation shall return TRUE.
`check_local_datawriter_dispose_instance`	This operation shall return TRUE.
`check_remote_participant`	This operation shall use the ***permissions_handle*** to retrieve the cached Permissions Section. The operation shall verify that the Permissions Section allows creating a `DomainParticipant` in the specified ***domain_id***.
`check_remote_datawriter`	This operation shall use the ***permissions_handle*** to retrieve the cached Permissions Section. The operation will verify that the Permissions Section allows publishing a the `Topic` with specified ***topic_name*** on the specified ***domain_id***.
`check_remote_datareader`	This operation will use the ***permissions_handle*** to retrieve the cached Permissions Section. The operation will verify that the Permissions Section allows subscribing to the `Topic` with specified ***topic_name*** on the specified ***domain_id***. If the permissions Section specifies that the DomainParticipant can 'subscribe' to the Topic the operation shall return TRUE and also set the 'allow_relay_only' output parameter to FALSE. If the permissions Section specifies that the DomainParticipant can 'relay' the Topic the operation shall return TRUE and also set the 'allow_relay_only' output parameter to TRUE. Otherwise the operation shall return FALSE.
`check_remote_topic`	This operation will use the ***permissions_handle*** to retrieve the cached Permissions Section. The operation will verify that the Permissions Section allows publishing or subscribing to the `Topic` with specified ***topic_name*** on the specified ***domain_id***.
`check_local_datawriter_match`	This operation shall return TRUE.
`check_local_datareader_match`	This operation shall return TRUE.

`check_remote_datawriter_register_instance`	This operation shall return TRUE.
`check_remote_datawriter_dispose_instance`	This operation shall return TRUE.
`get_permissions_token`	This operation shall return the `PermissionsToken` formatted as described in 9.4.2.3.
`get_permissions_credential_token`	This operation shall return the `PermissionsToken` formatted as described in 9.4.2.2
`set_listener`	This operation shall save a reference to the listener object and associate it with the specified `PermissionsHandle`.
`return_permissions_token`	This operation shall behave as specified in 8.4.2.7.20
`return_permissions_credential_token`	This operation shall behave as specified in 8.4.2.7.21
`validate_local_permissions`	This operation shall invoke the operation `get_identity_token` on the ***auth_plugin*** that is passed as a parameter to obtain the `IdentityCredential` associated with the `IdentityHandle` and get the subject name of the certificate given to the `DomainParticipant`. The operation shall receive the `PermissionsCredential` formatted as described in 9.4.2.1. The operation shall check the subject name in the PKCS7 documents and determine that it matches the one from the `IdentityCredential`. The operation shall verify the digital signature of the PKCS7 document by the configured Permissions CA. If all of these succeed the operation shall cache the Permissions (see 9.4.1.3.1) from the certificate and return an opaque handle that the plugin can use to refer to the saved information. Otherwise the operation shall return an error.
`validate_remote_permissions`	This operation shall invoke the operation `get_identity_token` on the ***auth_plugin*** passing the ***remote_identity_handle*** to retrieve the `IdentityToken` for the remote `DomainParticipant`. The operation shall receive the `PermissionsToken` which shall contain the PKCS7 digitally-signed permissions document.

	The operation shall check the subject name in the PKCS7 documents and determine that it matches the one from the `IdentityToken` of the remote `DomainParticipant`. The operation shall verify the digital signature of the PKCS7 document by the configured Permissions CA. If all of these succeed the operation shall cache the Permission Section from the `PermissionsToken` and return an opaque handle that the plugin can use to refer to the saved information. Otherwise the operation shall return an error.

9.5 Builtin Crypto: DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH

The builtin `Cryptographic` plugin is referred to as “DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH” plugin.

DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH provides data encryption services using Advanced Encryption Standard (AES) in counter (CTR) mode. It supports two AES key sizes: 128 bits and 256 bits. It also provides hash-based message authentication (HMAC) services with two different hashing functions: SHA256 and SHA1.

The approach followed is conceptually similar to that used for SRTP [20]. However it has been enhanced to be able to support additional scenarios, such as the presence of services like a DDS persistence service or a data relay service, which are present in DDS-RTPS systems and not supported by SRTP.

The algorithm used for data confidentiality is AES in CTR mode. While AES is a block cipher, the use of counter mode effectively turns it into a stream cipher. It generates key-stream blocks that are XORed with the plaintext blocks to get the ciphertext. Since the XOR operation is symmetric the decryption operation is exactly the same. It is called counter mode because the key-stream blocks are generated encrypting successive values of a "counter" with the key. This mode of operation requires the SessionKey to be kept secret, however the counter does not need to be protected and can be any function that creates a sequence that does not repeat in a long time, in particular it can be a simple incrementing integer.

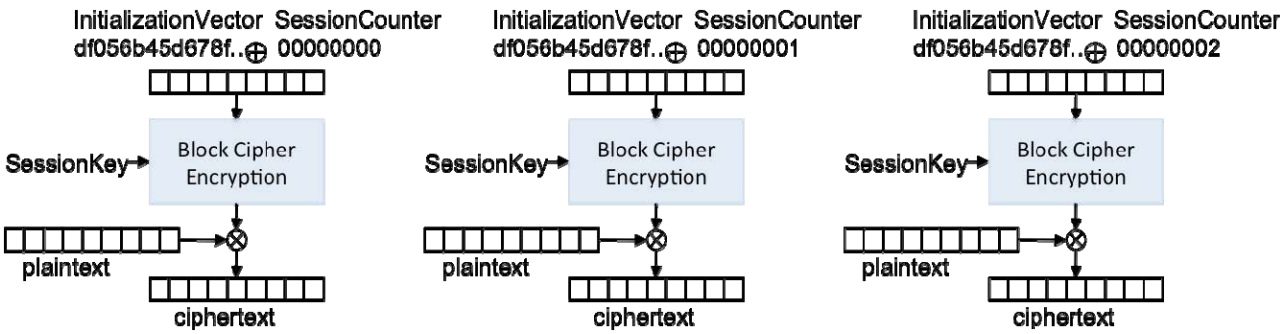


Figure 35 – User of AES encryption in counter-mode

The use of counter mode allows decryption of blocks in arbitrary order. All that is needed to decrypt a block are the SessionKey and the counter. This is very important for DDS because a `DataReader` may not receive all the samples written by a matched `DataWriter`. The use of DDS `ContentFilteredTopics` as well as DDS QoS policies such as `History` (with KEEP_LAST kind), `Reliability` (with BEST_EFFORTS kind), `Lifespan`, and `TimeBasedFilter`, among others, can result in a `DataReader` receiving a subset of the samples written by a `DataWriter`.

The DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH plugin is also used to compute a Hash-based Message Authentication Code (HMAC). The plugin supports two hashing algorithms to use with HMAC-SHA256 and HMAC-SHA1. HMAC is defined by IETF RFC 2014 [27]. HMAC keys must be at least as long as the block size of the underlying hash algorithm. The MAC may be computed over the entire RTPS message, which can include multiple submessages, encrypted using different AES keys or may be over particular submessages.

9.5.1 Configuration

The configuration of the DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH plugin is not dictated by this specification and therefore is implementation specific. Implementations may provide, for example, an API, an extended QoS Policy, or some other mechanism. The requirement is that the different modes of operation should all be supported and configurable.

9.5.2 DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH Types

The `Cryptographic` plugin defines a set of generic data types to be used to initialize the plugin and to externalize the properties and material that must be shared with the applications that need to decode the cipher material, verify signatures, etc.

Each plugin implementation defines the contents of these types in a manner appropriate for the algorithms it uses. All “Handle” types are local opaque handles that are only understood by the local plugin object that creates them. The remaining types shall be fully specified so that independent implementations of DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH can interoperate.

9.5.2.1 DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH CryptoToken

The DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH plugin shall set the attributes of the `CryptoToken` object as specified in the table below:

Table 41 – CryptoToken class for the builtin AccessControl plugin

Attribute name	*Attribute value*
class_id	“DDS:Crypto:AES-CTR-HMAC”
binary_value1	A sequence of octets containing the result of encrypting the Extended CDR encapsulation of the `KeyMaterial_AES_CTR_HMAC` structure whose IDL is defined below. The encryption is performed using the key **KxKey** derived from the SharedSecret as described in 9.5.2.1.2.
binary_value2	A sequence of octets containing the HMAC of the ***binary_value1*** attribute. The HMAC uses the MAC key **KxMacKey** derived from the SharedSecret as described in 9.5.2.1.2.

9.5.2.1.1 KeyMaterial_AES_CTR_HMAC structure

The contents and serialization of the `KeyMaterial_AES_CTR_HMAC` structure are described by the Extended IDL below:

```
enum CipherKind {
   NONE   = 0,
   AES128 = 1,
   AES256 = 2
};
enum HashKind {
   NONE     = 0,
   SHA1     = 1,
   SHA256   = 2
};

struct KeyMaterial_AES_CTR_HMAC {
    CipherKind cipher_kind;
    HashKind  hash_kind;
    long  master_key_id;

    sequence<octet, 32>  master_key;
    sequence<octet, 32>  initilization_vector;
    sequence<octet, 32>  hmac_key_id;
}; //@Extensibility EXTENSIBLE_EXTENSIBILITY
```

9.5.2.1.2 Key material used by the BuiltinParticipantVolatileMessageSecureWriter and BuiltinParticipantVolatileMessageSecureReader

The KxKey and KxMacKey are derived from the `SharedSecret` using the formulas:

```
KxKey :=

  HMACsha256(SharedSecret, Challenge_A # Challenge_B # KxCookie)

KxMacKey :=

  HMACsha256(SharedSecret, Challenge_A # Challenge_B # KxMacCookie)
```

In the above formula the terms used shall have the meaning described in the table below:

Table 42 – Terms used in KxKey and KxMacKey derivation formula for the builtin Cryptographic plugin

Term	*Meaning*
Challenge_A	The challenge that was sent in the value attribute of the `HandshakeRequestMessageToken` as part of the Authentication protocol
Challenge_B	The challenge that was sent in the value attribute of the `HandshakeReplyMessageToken` as part of the Authentication protocol
SharedSecret	The shared secret that was sent in the value attribute of the `HandshakeFinalMessageToken` as part of the Authentication protocol.

	Note that the value attribute contained the `SharedSecret` encrypted with the Public Key of the remote `DomainParticipant` that was the destination of the `HandshakeFinalMessageToken`. The `SharedSecret` used here refers to the un-encrypted value.
KxKeyCookie	The 16 bytes in the string “key exchange key”
KxMacKeyCookie	The 16 bytes in the string “key exchange mac”
data1 # data2 # data3	The symbol ‘#’ is used to indicate byte concatenation
HMACsha256(key, data)	Computes the hash-based message authentication code on ‘data’ using the key specified as first argument and a SHA256 hash as defined in [27].

9.5.2.2 DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH CryptoTransformIdentifier

The DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH shall set the `CryptoTransformIdentifier` attributes as specified in the table below:

Table 43 – CryptoTransformIdentifier class for the builtin Cryptographic plugin

Attribute	*Value*
`transformation_kind_id`	Set to one of the following values: #define HMAC_SHA1 { 0x00, 0x00, 0x01, 0x00} #define HMAC_SHA256 { 0x00, 0x00, 0x01, 0x01} #define AES128_HMAC_SHA1 { 0x00, 0x00, 0x02, 0x00} #define AES256_HMAC_SHA256 { 0x00, 0x00, 0x02, 0x01} The value HMAC_SHA1 indicates the transformation performed leaves the plaintext unencrypted and appends an HMAC using SHA1. The value HMAC_SHA256 indicates the transformation performed leaves the plaintext unencrypted and appends an HMAC using SHA256. The value AES-128_HMAC_SHA1 indicates the transformation performed first encrypts the cleartext using AES with 128-bit key and the resulting cipher text is appended with the HMAC computed over the ciphertext using SHA1. The value AES-256_HMAC_SHA256 indicates the transformation performed first encrypts the cleartext using AES with 256-bit key and the resulting cipher text is appended with the HMAC computed over the ciphertext using SHA256.
`transformation_key_id`	This is set to a different value each time the key used for encryption or HMAC changes. The algorithm used should avoid repeating the values for the same CryptoHandle performing the encryption.

9.5.2.3 DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH SecureDataHeader

The DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH `CryptoTransform` interface has several operations that transform clear text into cipher text. The cipher-text created by these "encode" operations contains a `SecureDataHeader` that is interpreted by the corresponding "decode" operations on the receiving size. The `SecureDataHeader` structure is described by the Extended IDL below:

```
@Extensibility(FINAL_EXTENSIBILITY)
struct SecureDataHeader_AES_CTR_HMAC {
    CryptoTranformIdentifier transform_id;
    long session_id;
    long session_counter;
};
```

9.5.3 DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH plugin behavior

This plugin implements three interfaces: `CryptoKeyFactory`, `CryptoKeyExchange`, and `CryptoTransform`. Each is described separately.

9.5.3.1 CryptoKeyFactory for DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH

The table below describes the actions that the DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH when each of the `CryptoKeyFactory` plugin operations is invoked.

Table 44 – Actions undertaken by the operations of the bultin Cryptographic CryptoKeyFactory plugin

`register_local_participant`	This operation shall create a new `KeyMaterial_AES_CTR_HMAC` object and return a handle that can the plugin can use to access the created object. We will refer to this object by the name: `ParticipantKeyMaterial`. The `CipherKind` and `HashKind` for the `ParticipantKeyMaterial` object shall be configurable but the configuration mechanism is not specified.
`register_matched_remote_participant`	This operation shall associate the `SharedSecret` received as an argument with the local and remote `ParticipantCryptoHandle.` This operation shall create a new `KeyMaterial_AES_CTR_HMAC` object and associate it with the local and remote `ParticipantCryptoHandle` pair. We will refer to this object by the name: `Participant2ParticipantKeyMaterial`. The `CipherKind` for the `Participant2ParticipantKeyMaterial` object shall be NONE. The HashKind shall be configurable but the configuration mechanism is not specified. The `Participant2ParticipantKeyMaterial` shall be used

	when the local participant needs to produce a MAC that can only be verified by that one matched remote participant. This operation also creates the **KxKey** and the **KxMacKey** that derive from the `SharedSecret` passed as a parameter and associate them with the local and remote `ParticipantCryptoHandle` pair. We will refer to these keys as `Participant2ParticipantKxKey` and `Participant2ParticipantKxMacKey`, respectively.
`register_local_datawriter`	This operation shall create a new `KeyMaterial_AES_CTR_HMAC` object and returns a handle that can the plugin can use to access the created object. We will refer to this object by the name: `WriterKeyMaterial`. The `CipherKind` and `HashKind` for the `WriterKeyMaterial` object shall be configurable but the configuration mechanism is not specified.
`register_matched_remote_datareader`	This operation shall create a new `KeyMaterial_AES_CTR_HMAC` object and associate it with the local `DatawriterCryptoHandle` and remote `DatareaderCryptoHandle` pair. We will refer to this object by the name: `Writer2ReaderKeyMaterial`. The `CipherKind` for the `Writer2ReaderKeyMaterial` object shall be NONE. The `HashKind` shall be configurable but the configuration mechanism is not specified. The `Writer2ReaderKeyMaterial` shall be used when the local `DataWriter` needs to produce a MAC that can only be verified by that one matched remote `DataReader`.
`register_local_datareader`	This operation shall create a new `KeyMaterial_AES_CTR_HMAC` object and return a handle that can the plugin can use to access the created object. We will refer to this object by the name: `ReaderKeyMaterial`. The `CipherKind` and `HashKind` for the `ReaderKeyMaterial` object shall be configurable but the configuration mechanism is not specified. It is possible for the configuration to result in both `CipherKind` and `HashKind` having the value NONE.
`register_matched_remote_datawriter`	This operation shall create a new `KeyMaterial_AES_CTR_HMAC` object and associate it with the local `DatareaderCryptoHandle` and remote `DatawriterCryptoHandle` pair. We will refer to this object by the name: `Reader2WriterKeyMaterial`. The `CipherKind` for the `Reader2WriterKeyMaterial` object shall be NONE. The HashKind shall be configurable but the configuration mechanism is not specified. The `Reader2WriterKeyMaterial` shall be used when the local

	DataReader needs to produce a MAC that can only be verified by that one matched remote DataWriter.
unregister_participant	Releases any resources allocated on the corresponding call to register_local_participant, or register_matched_remote_participant.
unregister_datawriter	Releases any resources allocated on the corresponding call to register_local_datawriter, or register_matched_remote_datawriter.
unregister_datareader	Releases any resources allocated on the corresponding call to register_local_datareader, or register_matched_remote_datareader.

9.5.3.2 CryptoKeyExchange for DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH

The table below describes the actions that the DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH when each of the CryptoKeyExchange plugin operations is invoked.

Table 45 – Actions undertaken by the operations of the bultin Cryptographic CryptoKeyExchange plugin

create_local_participant_crypto_tokens	Creates two DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH CryptoToken objects and returns both in the output sequence. The first CryptoToken contains the ParticipantKeyMaterial created on the call to register_local_participant. The second CryptoToken contains the Participant2ParticipantKeyMaterial created on the call to register_matched_remote_participant for the remote_participant_crypto. Both CryptoToken objects use the Participant2ParticipantKxKey and Participant2ParticipantKxMacKey.
set_remote_participant_crypto_tokens	Shall receive the sequence of two CryptoToken objects that was created by the corresponding call to create_local_participant_crypto_tokens on the remote side. The operation uses the Participant2ParticipantKxKey and Participant2ParticipantKxMacKey associated with the local and remote ParticipantCryptoHandle pair to verify and decode the two tokens and associates the obtained keys with the CryptoHandle pair. The decoded keys shall be referred as RemoteParticipantKeyMaterial and RemoteParticipant2ParticipantKeyMaterial, respectively.
create_local_datawriter_crypto_tokens	Creates two DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH CryptoToken objects and returns both in the output sequence. The first CryptoToken contains the DatawriterKeyMaterial created on the call to register_local_datawriter.

	The second CryptoToken contains the Writer2ReaderKeyMaterial created on the call to register_matched_remote_datareader for the remote_datareader_crypto. Both CryptoToken objects use the Participant2ParticipantKxKey and Participant2ParticipantKxMacKey.
set_remote_datawriter_crypto_tokens	Shall receive the sequence of two CryptoToken objects that was created by the corresponding call to create_local_datawriter_crypto_tokens on the remote side. The operation uses the Participant2ParticipantKxKey and Participant2ParticipantKxMacKey associated with the local and remote ParticipantCryptoHandle pair to verify and decode the two tokens and associates the obtained keys with the CryptoHandle pair. The decoded keys shall be referred as RemoteDatawriterKeyMaterial and RemoteWriter2ReaderKeyMaterial, respectively.
create_local_datareader_crypto_tokens	Creates two DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH CryptoToken objects and returns both in the output sequence. The first CryptoToken contains the DatareaderKeyMaterial created on the call to register_local_datareader. The second CryptoToken contains the Reader2WriterKeyMaterial created on the call to register_matched_remote_datawriter for the remote_datawriter_crypto. Both CryptoToken objects use the Participant2ParticipantKxKey and Participant2ParticipantKxMacKey.
set_remote_datareader_crypto_tokens	Shall receive the sequence of two CryptoToken objects that was created by the corresponding call to create_local_datareader_crypto_tokens on the remote side. The operation uses the Participant2ParticipantKxKey and Participant2ParticipantKxMacKey associated with the local and remote ParticipantCryptoHandle pair to verify and decode the two tokens and associates the obtained keys with the CryptoHandle pair. The decoded keys shall be referred as RemoteDatareaderKeyMaterial and RemoteReader2WriterKeyMaterial, respectively.
return_crypto_tokens	Releases the resources associated with the CryptoToken objects in the sequence.

9.5.3.3 CryptoKeyTransform for DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH

9.5.3.3.1 Overview

The table below describes the actions that the DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH when each of the `CryptoKeyTransform` plugin operations is invoked.

Table 46 – Actions undertaken by the operations of the bultin Cryptographic CryptoKeyTransform plugin

`encode_serialized_data`	Uses the `WriterKeyMaterial` associated with the `sending_datawriter_crypto` to encrypt and sign the input SerializedData RTPS SubmessageElement transforming into a RTPS SecureData SubmessageElement containing the EncodeOperationOutputData that is the result of the encrypting and signing operations. This operation shall always set the additional_digests attribute in the EncodeOperationOutputData to the empty sequence.
`encode_datawriter_submessage`	Uses the `WriterKeyMaterial` associated with the `sending_datawriter_crypto` and the `Writer2ReaderKeyMaterial` associated with the `sending_datawriter_crypto` and each of the `receiving_datareader_crypto` handles to transform the input RTPS Submessage into a RTPS SecureSubMessage containing the EncodeOperationOutputData that is the result of the encrypting and signing operations. The ciphertext shall be computed using the `WriterKeyMaterial` associated with the `sending_datawriter_crypto.` Depending on the configuration the operation may compute and set the common_digest or the additional_digests attributes. If computed, the common_digest shall be computed using the `WriterKeyMaterial` associated with the `sending_datawriter_crypto.` If computed, the additional_digests shall be computed using the `Writer2ReaderKeyMaterial` associated with the pair composed of the `sending_datawriter_crypto` and each of the corresponding `receiving_datareader_crypto`.
`encode_datareader_submessage`	Uses the `ReaderKeyMaterial` associated with the `sending_datareader_crypto` and the `Reader2WriterKeyMaterial` associated with the `sending_datareader_crypto` and each of the `receiving_datareader_crypto` handles to transform the input RTPS Submessage into a RTPS SecureSubMessage containing the EncodeOperationOutputData that is the result of the encrypting and signing operations. The ciphertext shall be computed using the `ReaderKeyMaterial` associated with the `sending_datareader_crypto.` Depending on the configuration the operation may compute and set the

	common_digest or the additional_digests. If computed, the common_digest shall be computed using the `ReaderKeyMaterial` associated with the `sending_datareader_crypto.` If computed, the additional_digests shall be computed using the `Reader2WriterKeyMaterial` associated with the pair composed of the `sending_datareader_crypto` and each of the corresponding `receiving_datawriter_crypto`.
`encode_rtps_message`	Uses the `ParticipantKeyMaterial` associated with the `sending_participant_crypto` and the `Participant2ParticipantKeyMaterial` associated with the `sending_participant_crypto` and each of the `receiving_articipant_crypto` handles to transform the input RTPS Message into a RTPS Message that contains a single RTPS SecureSubMessage. The SecureSubMessage contains the EncodeOperationOutputData that is the result of the encrypting and signing operations. The ciphertext shall be computed using the `ParticipantKeyMaterial` associated with the `sending_participant_crypto.` Depending on the configuration the operation may compute and set the common_digest or the additional_digests. If computed, the common_digest shall be computed using the `ParticipantKeyMaterial` associated with the `sending_participant_crypto.` If computed, the additional_digests shall be computed using the `Participant2ParticipantKeyMaterial` associated with the pair composed of the `sending_participant_crypto` and each of the corresponding `receiving_participant_crypto`.
`decode_rtps_message`	Examines the `CryptoTranformIdentifier` to determine the transform_kind_id is one of the recognized kinds. If the kind is not recognized, the operation shall fail with an exception. Uses source and destination DomainParticipant GUIDs in the RTPS Header to locate the sending_participant_crypto and receiving_participant_crypto. Then looks whether the transform_key_id attribute in the `CryptoTranformIdentifier` is associated with those ParticipantCryptoHandles. If the association is not found the operation shall fail with and exception. Uses the `RemoteParticipantKeyMaterial` and the `RemoteParticipant2ParticopantKeyMaterial` associated with the retrieved ParticipantCryptoHandles to verify and decrypt the RTPS SubMessage that follows the RTPS Header. If the verification or decryption fails the operation shall fail with and exception. If the `RemoteParticipantKeyMaterial` specified a hash_kind different from NONE, then the operation shall check that the received

	SecureSubMessage contains a common_digest and use it to verify the SecureSubMessage. If the common_digest is missing or the verification fails the operation shall fail with an exception. If the `RemoteParticopant2ParticipantKeyMaterial` specified a hash_kind different from NONE, then the operation shall check that the received SecureSubMessage contains an additional_digest element with a transformation_id it that is associated with local and remote ParticipantCryptoHandles. If the additional_digest is missing or the verification fails the operation shall fail with an exception. Upon success the returned RTPS Message shall match the input to the encode_rtps_message operation on the DomainParticipant that sent the message.
`preprocess_secure_submsg`	Examines the RTPS SecureSubmessage to: 1. Determine whether the `CryptoTranformIdentifier` the transform_kind_id matches one of the recognized kinds. 2. Classify the RTPS Submessage as a Writer or Reader Submessage. 3. Retrieve the DatawriterCryptoHandle and DataReaderCryptoHandle handles associated with the `CryptoTranformIdentifier` the transform_key_id.
`decode_datawriter_submessage`	Uses the `RemoteDatawriterKeyMaterial` and the `RemoteDatawriter2DatareaderKeyMaterial` associated with the CryptoHandles returned by the preprocess_secure_submessage to verify and decrypt the RTPS SubMessage If the verification or decryption fails the operation shall fail with and exception. If the `RemoteDatawriterKeyMaterial` specified a hash_kind different from NONE, then the operation shall check that the received SecureSubMessage contains a common_digest and use it to verify the SecureSubMessage. If the common_digest is missing or the verification fails the operation shall fail with an exception. If the `RemoteDatawriter2DatareaderKeyMaterial` specified a hash_kind different from NONE, then the operation shall check that the received SecureSubMessage contains an additional_digest element with a transformation_id it that is associated with local and remote CryptoHandles. If the additional_digest is missing or the verification fails the operation shall fail with an exception. Upon success the returned RTPS SubMessage shall match the input to the encode_datawriter_message operation on the DomainParticipant that sent the message.
`decode_datareader_submessage`	Uses the `RemoteDatareaderKeyMaterial` and the `RemoteDatareader2DatawriterKeyMaterial` associated with the CryptoHandles returned by the preprocess_secure_submessage to verify and decrypt the RTPS SubMessage If the verification or decryption fails the operation shall fail with and exception.

	If the `RemoteDatareaderKeyMaterial` specified a hash_kind different from NONE, then the operation shall check that the received SecureSubMessage contains a common_digest and use it to verify the SecureSubMessage. If the common_digest is missing or the verification fails the operation shall fail with an exception. If the `RemoteDatareader2DatawriterKeyMaterial` specified a hash_kind different from NONE, then the operation shall check that the received SecureSubMessage contains an additional_digest element with a transformation_id it that is associated with local and remote CryptoHandles. If the additional_digest is missing or the verification fails the operation shall fail with an exception. Upon success the returned RTPS SubMessage shall match the input to the encode_datareader_message operation on the DomainParticipant that sent the message.
`decode_serialized_data`	Uses writerGUID and the readerGUID in the RTPS SubMessage to locate the sending_datawriter_crypto and receiving_datareader_crypto. Then looks whether the transform_key_id attribute in the `CryptoTranformIdentifier` in the SecureData SubmessageElement is associated with those CryptoHandles. If the association is not found the operation shall fail with and exception. Uses the `RemoteDatawriterKeyMaterial` associated with the retrieved CryptoHandles to verify and decrypt the RTPS SecureData SubmessageElement. If the verification or decryption fails the operation shall fail with and exception. If the `RemoteDatawriterKeyMaterial` specified a hash_kind different from NONE, then the operation shall check that the received SecureData SubmessageElement contains a common_digest and use it to verify the SecureSubMessage. If the common_digest is missing or the verification fails the operation shall fail with an exception.

9.5.3.3.2 Encode/decode operation virtual machine

The logical operation of the DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH is described in terms of a virtual machine as it performs the encrypt message digest operations. This is not intended to mandate implementations should follow this approach literally, simply that the observable results for any plaintext are the same as the virtual machine described here.

For any given cryptographic session the operation of the DDS:Crypto:AES-CTR-HMAC-RSA/DSA-DH transforms plaintext into ciphertext can be described in terms of a virtual machine that maintains the following state:

Table 47 – Terms used in Key Computation and cryptographic transformations formulas for the builtin cryptographic plugin

State variable	*Type*	*Meaning*
MasterKey	128 bit array for AES128	The master key from which session salts, session keys and

	256 bit array for AES256	session hash keys are derived.
MasterSalt	128 bit array for AES128 256 bit array for AES256	A random vector used in connection with the MasterKey to create the SessionKey.
MasterHMACSalt	128 bit array for AES128 256 bit array for AES256	A random vector used in connection with the MasterKey to create the SessionHashKey.
MasterSessionSalt	128 bit array for AES128	A random vector used to salt the derivation of the SessionSalt from the MasterKey and the SessionId.
MasterKeyId	32 bit integer	A random number associated with the master key when it is first created used to tag the ciphertext to ensure the correct key is being used during decryption. It may be used also for the purposes of re-keying.
SessionId	32 bit array	An incrementing counter used to create the current SessionKey, SessionSalt, and SessionHMACKey from the MasterKey and Master salts. The SessionId is changed each time a new SessionKey is needed and then used to derive the new SessionKey and SessionSalt from the MasterKey. Knowledge of the MasterKey, MasterSalt, MasterHMACSalt, and the SessionId is sufficient to create the SessionKey, SessionSalt, and SessionHMACKey.
SessionSalt	128 bit array	A vector constructed from the MasterKey, MasterSessionSalt and SessionId used in connection with the session counter to construct the input

		to the Block Cipher.
SessionKey	128 bit array for AES128 256 bit array for AES256	The current key used for creating the ciphertext. It is constructed from the MasterKey, MasterSalt, and SessionId.
SessionHMACKey	128 bit array for AES128 256 bit array for AES256	The current key used to compute the HMAC performed by the compute_digest operation.
session_block_counter	64 bit integer	A counter that counts the number of blocks that have been ciphered with the current SessionKey.
max_blocks_per_session	64 bit integer	A configurable property that limits the number of blocks that can be ciphered with the same SessionKey. If the session_block_counter exceeds this value a new SessionKey, SessionSalt, and SessionHMACKey are computed and the session_block_counter is reset to zero.

All the key material with a name that starts with "Master" corresponds to the `KeyMaterial_AES_CTR_HMAC` objects that were created by the `CryptoKeyFactory` operations. This key material is not used directly to encrypt or compute MAC of the plaintext. Rather it is used to create "Session" Key material by means of the algorithms described below. This has the benefit that the 'session' keys used to secure the date stream data can be modified as needed to maintain the security if the stream without having to perform explicit rekey and key-exchange operations.

Note that by deriving the SessionHMACKey from the same MasterKey as the SessionKey we are limiting the potential deployment scenarios in that if an application needs to receive data and validate the digest to ensure it has not been tampered with, it has to also be given the key necessary to understand the data. This may be too strong a requirement for applications such as the Persistence Service, or a logging or forwarding service that need to simply forward data but may not have the right privileges to understand its contents. To avoid this situation it would be necessary to separate the digest of the data from the digest of the RTPS Submessage so that it becomes possible to give access to the keys necessary to verify complete submessage integrity to a service without simultaneously giving access to the keys necessary to verify data integrity and understand the data itself.

9.5.3.3.3 Computation of Session Keys and Salts

The SessionKey, SessionSalt, and SessionHMACKey are computed from the MasterKey, MasterSalt and the SessionId:

```
SessionSalt := HMAC(MasterKey,"SessionSalt" + MasterSessionSalt + SessionId)
Truncated to 128 bits

SessionKey := HMAC(MasterKey,"SessionKey" + MasterSalt + SessionId)

SessionHMACKey := HMAC(MasterKey,"SessionHMACKey" + MasterHMACSalt + SessionId)
```

In the above expressions the symbol '+' indicates concatenation.

9.5.3.3.4 Computation of ciphertext from plaintext

The ciphertext is computed from the plain text the SessionSalt as the NONCE for CTR mode.

The encryption transforms the plaintext input into ciphertext by performing an encryption operation using the AES algorithm in counter mode using the SessionKeys associated with the specified KeyHandle. The encryption transformation is described in detail in the sections that follow.

The encryption operation increments the session counter associated with the KeyHandle by one for each encrypted block.

This operation may change the session key. This decision should be taken at the beginning as all ciphertext returned by an invocation of the operation must be encrypted with the same session key. If a new session key is changed the SessionId must be changed in correspondence and session counter is reset accordingly.

The resulting ciphertext is enclosed inside a `SecureDataHeader` that indicates the sessionId and stating value for the counter.

The resulting block of bytes from the "encode" operations (encode_serialized_data, encode_datawriter_submessage, encode_datareader_submessage, and encode_rtps_message) is the Extended CDR encoding of the IDL for the `EncodeOperationOutputData` below:

```
struct DigestResult {
    SecureDataHeader_AES_CTR_HMAC digest_header;
    sequence<octet>  digest;
}; //@Extensibility FINAL_EXTENSIBILITY


struct  EncodeOperationOutputData {
    SecureDataHeader_AES_CTR_HMAC secure_data_header;
    sequence<octet>  ciphertext;
    sequence<octet>  common_digest;
    sequence<Digest> additional_digests;
}; //@Extensibility FINAL_EXTENSIBILITY
```

9.5.3.3.5 Computation of plaintext from ciphertext

The decrypt operation first checks that the `CryptoTransformIdentifier` attribute in the `SecureDataHeader_AES_CTR_HMAC` has the proper `transformation_kind_id` and also uses the `CryptoTransformIdentifier` `transformation_key_id` to locate `MasterKey`

and MasterSalt. In case of a re-key the CryptographicSessionHandle may be associated with multiple MasterKeyId and this parameter allows selection of the correct one. If the MasterKeyId is not found associated with the CryptographicSessionHandle the operation shall fail.

The session_id attribute within the SecureDataHeader_AES_CTR_HMAC is used to obtain the proper SessionSalt and SessionKey. Note that this only requires a re-computation if it has changed from the previously received SessionId for that CryptographicSessionHandle.

Given the SessionSalt and SessionKey the transformation performed to recover the plaintext from the ciphertext is identical to the one performed to go plaintext to ciphertext.

9.5.3.3.6 Computation of the message digest

The message digest is computed on the secure_data_header and the ciphertext.

There are two types of digests that may appear.

- The first stored in the common_digest uses the KeyMaterial described in the secure_data_header. This digest may be verified by all the receivers of the EncodeOperationOutputData.
- The second type, stored in the additional_digests contains digests that use different SecureDataHeader_AES_CTR_HMAC which appear explicitly in the DigestResult digest_header. These digests use keys that are only shared with some of the receivers of the EncodeOperationOutputData. In general each receiver will only have the keys necessary to verify one of these additional_digests. The key material for these digest is derived from the RemoteParticipant2ParticipantKeyMaterial, the RemoteWriter2ReaderKeyMaterial, or the RemoteReader2WriterKeyMaterial.

Depending on the selected algorithm the digest is computed as an HMAC-SHA256 or HMAC-SHA1.

9.6 Builtin Logging Plugin

The builtin Logging Plugin is known as the DDS:Logging:DDS_LogTopic.

The DDS:Logging:DDS_LogTopic implements logging by publishing information to a DDS Topic BuiltinLoggingTopic defined below.

The BuiltinLoggingTopic shall have the Topic name “DDS:Security:LogTopic”.

The BuiltinLoggingTopic shall have the Type BuiltinLoggingType defined in the IDL below:

```
enum BuiltinLoggingLogLevel {
   FATAL_LEVEL,
   SEVERE_LEVEL,
   ERROR_LEVEL,
   WARNING_LEVEL,
   NOTICE_LEVEL,
   INFO_LEVEL,
   DEBUG_LEVEL,
   TRACE_LEVEL
};
```

```
struct BuiltinLoggingType {
   BuiltinTopicKey_t source_guid;
   long log_level;
   string message;
   string category;
};
```

Knowledge of the `BuiltinLoggingTopic` shall be builtin into the DDS:Auth:PKI-RSA/DSA-DH `AccessControl` plugin and it shall be treated according to the folowing topic rule:

```
<topic_rule>
    <topic_expression> DDS:Security:LogTopic</topic_expression>
    <enable_discovery_protection>FALSE</enable_discovery_protection>
    <enable_read_access_control>TRUE</enable_read_access_control>
    <enable_write_access_control>FALSE</enable_write_access_control>
    <metadata_protection_kind>SIGN</metadata_protection_kind>
    <data_protection_kind>ENCRYPT</data_protection_kind>
</topic_rule>
```

The above rule means implies that any `DomainParticipant` with permission necessary to join the DDS `Domain` shall be allowed to write the `BuiltinLoggingTopic` but in order to read the `BuiltinLoggingTopic` the `DomainParticipant` needs to have a grant for the `BuiltinLoggingTopic` in its permissions document.

9.6.1 DDS:Logging:DDS_LogTopic plugin behavior

The table below describes the actions that the DDS:Logging:DDS_LogTopic plugin performs when each of the plugin operations is invoked.

Table 48 – Actions undertaken by the operations of the bultin Logging plugin

`set_log_options`	Controls the configurtion of the plugin. The LogOptions parameter shall be used to take the actions described below: If the ***distribute*** parameter is set to TRUE, the DDS:Logging:DDS_LogTopic shall create a `DataWriter` to send the `BuiltinLoggingTopic` if it is FALSE, it shall not. The plugin shall open a file with the name indicated in the ***log_file*** parameter. The plugin shall remember the value of the ***log_level*** so that it can be used during the `log` operation.
`log`	This operation shall check if logging was enabled by a prior call to `enable_logging` and if not it shall return without performing any action. If logging was enabled, it shall behave as described below: The operation shall compare the value of the the ***log_level*** parameter with the value saved during the `set_log_options` operation.

	If the ***log_level*** parameter value is greater than the one saved by the `set_log_options` operation, the operation shall return without performing any action. If the ***log_level*** parameter value is less than or equal to the one saved, the `log` operation shall perform two actions: • It shall append a string representation of the parameters passed to the log operation to the end of the file opened by the `set_log_options` operation. • If the value of the ***distribute*** option was set on the call to `set_log_options`, the plugin shall fill an object of type `BuiltinLoggingType` with the values passed as arguments to the `log` operation and publish it using the `DataWriter` associated with the `BuiltinLoggingTopic` created by the `set_log_options` operation.
`enable_logging`	This operation shall save the fact that logging was enabled such that the information can be used by the `log` operation.

10 Plugin Language Bindings

10.1 Introduction

Clause 8 defines the plugin interfaces in a programming-language independent manner using UML. Using the terminology of the DDS specification this UML definition could be considered a Platform Independent Model (PIM) for the plugin interfaces. The mapping to each specific programming languages platform could therefore be considered a Platform Specific Model (PSM) for that programming language.

The mapping of the plugin interfaces to specific programming languages is defined by first defining the interfaces using OMG-IDL version 3.5 with the additional syntax defined in the DDS-XTYPES specification and subsequently applying the IDL to language mapping to the target language.

IDL Types lacking the DDS-XTYPES `@Entensibility` annotation shall be interpreted as having the extensibility kind EXTENSIBLE_EXTENSIBILITY. This matches the DDS-XTYPES specification implied extensibility of un-annotated types.

For consistency with the DDS specification, the DDS security specification defines language bindings to each of the language PSMs specified for DDS, namely:

- C as derived from the IDL to C mapping
- C++ classic, as derived from the IDL to C++ mapping
- Java classic, as derived from the IDL to Java mapping
- C++ modern, aligned with the DDS-STDC++ specification, this is derived from the IDL to C++11 mapping
- Java modern with the DDS-JAVA5+ specification

10.2 IDL representation of the plugin interfaces

For consistency in the resulting APIs, the mapping from the plugin interfaces defined in clause 8 and the OMG IDL follows the same PIM to PSM mapping rules as the OMG DDS specification (see sub clause 7.2.2 of the DDS specification version 1.2 [1]). A relevant subset of these rules is repeated here. In this rules “PIM” refers to the UML description of the interfaces in clause 8 and PSM refers to the OMG-IDL description of the interfaces that appears in the associated file: **dds_security.idl**

- The PIM to PSM mapping maps the UML interfaces and classes into IDL interfaces. Plain data types are mapped into structures.
- ‘Out’ parameters in the PIM are conventionally mapped to ‘inout’ parameters in the PSM in order to minimize the memory allocation performed by the Service and allow for more efficient implementations. The intended meaning is that the caller of such an operation should provide an object to serve as a “container” and that the operation will then “fill in” the state of that objects appropriately.

The resulting IDL representation of the plugin interfaces appears in the file **dds_security.idl** which shall be considered part of the DDS Security specification.

10.3 C language representation of the plugin interfaces

The C language representation of the plugin interfaces shall be obtained applying the IDL to C mapping [5] to the **dds_security.idl** file.

10.4 C++ classic representation of the plugin interfaces

The C++ classic (without the use of the C++ standard library) language representation of the plugin interfaces shall be obtained using the IDL2C++ mapping [7] to the **dds_security.idl** file.

10.5 Java classic

The Java classic language representation of the plugin interfaces shall be obtained using the IDL2Java mapping [6] to the **dds_security.idl** file.

10.6 C++11 representation of the plugin interfaces

This representation is aligned with the DDS-STDC++ PSM.

The C++ classic language representation of the plugin interfaces shall be obtained using the IDL2C++11 mapping [8] to the **dds_security.idl** file with the following exceptions:

1. The IDL module DDS shall be mapped to the C++ namespace **dds** so it matches the namespace used by the DDS-STD-C++ PSM.
2. The mapping shall not use any C++11-only feature of the language or the library (e.g., move constructors, noexcept, override, std::array).
3. Arrays shall map to the dds::core::array template defined in the DDS-STD-C++ PSM.
4. The enumerations shall map to the dds::core::safe_enum template defined in the DDS-STD-C++ PSM.
5. The IDL DynamicData native type shall be mapped to the C++ type dds::code::xtypes::DynamicData defined in the DDS-STDC++ PSM.

10.7 Java modern aligned with the DDS-JAVA5+ PSM

The Java classic language representation of the plugin interfaces shall be obtained using the IDL2Java mapping [6] to the **dds_security.idl** file with the following exceptions:

1. The IDL module DDS shall be mapped to the Java namespace **org.omg.dds** so it matches the namespace used by the DDS-JAVA5+ PSM.
2. The IDL DynamicData native type shall be mapped to the type org.omg.dds.type.dynamic.DynamicData defined in the DDS-JAVA5+ PSM.

Annex A - References

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