DDSI TCP/IP PSM

*Version 1.0*

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Preface

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**Courier - 10 pt. Bold:** Programming language elements.

Helvetica/Arial - 10 pt: Exceptions

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

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# Scope

This specification extends the existing DDSI v1.2 Platform Independent and Specific Model (PIM/PSM) with support for the TCP/IP transport protocol.

# Conformance

The entire specification represents a single conformance point.

# Normative References

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

List of normative references.

* **[DDS]** Data Distribution Service for Real-Time Systems Specification, version 1.2 (OMG document formal/2007-01-01)
* **[DDSI]** The Data Distribution Service Interoperability Wire Protocol, version 2.1 (OMG Document formal//2009-01-05)

# Terms and Definitions

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

DDS: Data Distribution Service

DDSI: Data Distribution Service Interoperability Wire Protocol

DP : Domain Participant

DR: Data Reader

DW: Data Writer

IP: Internet Protocol

TCP: Transmission Control Protocol

TLS : Transport Level Security

# Symbols

N.A.

# Additional Information

## Changes to Adopted OMG Specifications [optional]

N.A.

## Acknowledgments

The following companies submitted this specification:

1. ADLINK Inc.

The following people contributed to this specification:

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# 

# TCP/IP DDSI PSM

This section provides the normative specification for extending the DDSI v2.1 with support for the TCP/IP transport protocol.

## Assumptions of the existing DDSI PIM/PSM

The DDSI v2.1 specification assumes a message oriented best effort transport. As such, it relies on the underlying transport for identifying message boundaries and message sizes and enhances the transport with reliable communication. This specification provides a series of additions and amendments to the DDSI v1.2 specification that allow for efficient implementation of DDSI over TCP/IP.

## Message Boundaries

A new Submessage is introduced by this specification to allow the definition of a message size. This Submessage is defined as follows:

1 2 3

0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1

+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

| MSG\_LEN |X|X|X|X|X|X|0|E| octetsToNextHeader |

+---------------+---------------+-------------------------------+

| Message-Length |

+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

Where MSG\_LEN shall be added to the SubmessageKind enumeration defined in the Section 9.4.5.1.1 of the DDSI v2.1 with a value of 0x18.

This Submessage, when present, shall always be the first Submessage after the message header.

## Data Exchange Protocol

The DDSI v2.1 protocol relies on heartbeats and acks/nacks to implement ordered reliable communication over a best effort transport. Since TCP/IP provides ordered and reliable data exchange, this specification relaxes some of the requirement for interoperability specified by the DDSI v2.1 to fully take advantage of the TCP/IP reliable communication.

Specifically, the following section in the DDSI v2.1 should be amended as described below:

|  |  |
| --- | --- |
| **Current DDSI v2.1** | **Amended DDSI v2.1** |
| **8.4.2.2.3 Writers must send periodic HEARTBEAT Messages (reliable only)**  A ***Writer*** must periodically inform each matching reliable ***Reader*** of the availability of a data sample by sending a periodic HEARTBEAT Message that includes the sequence number of the available sample. If no samples are available, no HEARTBEAT Message needs to be sent.  For strict reliable communication, the ***Writer*** must continue to send HEARTBEAT Messages to a ***Reader*** until the ***Reader*** has either acknowledged receiving all available samples or has disappeared. In all other cases, the number of HEARTBEAT Messages sent can be implementation specific and may be finite.  **8.4.2.3.4 Readers can only send an ACKNACK Message in response to a HEARTBEAT Message**  In steady state, an ACKNACK Message can only be sent as a response to a HEARTBEAT Message from a ***Writer***. ACKNACK Messages can be sent from a ***Reader*** when it first discovers a ***Writer*** as an optimization. ***Writers*** are not required to respond to these pre-emptive ACKNACK Messages. | **8.4.2.2.3 Writers may send periodic HEARTBEAT Messages (reliable only)**  A ***Writer*** may periodically inform each matching reliable ***Reader*** of the availability of a data sample by sending a periodic HEARTBEAT Message that includes the sequence number of the available sample. If no samples are available, no HEARTBEAT Message needs to be sent.  For strict reliable communication, the ***Writer*** may continue to send HEARTBEAT Messages to a ***Reader*** until the ***Reader*** has either acknowledged receiving all available samples or has disappeared. In all other cases, the number of HEARTBEAT Messages sent can be implementation specific and may be finite.  **8.4.2.3.4 In steady state Readers shall only send an ACKNACK Message in response to a HEARTBEAT Message**  In steady state, an ACKNACK Message shall only be sent as a response to a HEARTBEAT Message from a ***Writer***. Otherwise, ACKNACK Messages may be sent from a ***Reader*** when it first discovers a ***Writer*** or when it recovers from exhaustion of its resource limits and needs to retrieve the samples discarded. |

These amendments to the DDSI v2.1 specification make it possible to have reliable communication over TCP/IP without inducing the overhead of exchanging ACK/NACK nor having to send periodic HEARTBEATS.

## Discovery Protocol

### Extended Locator Types

Support for TCP/IP locators can be added to the DDSI v2.1 specification by extending the Locator\_t definition of Table 9.4 on page 153 with the following kinds:

#define LOCATOR\_KIND\_UDPv4 0x01

#define LOCATOR\_KIND\_UDPv6 0x02

#define LOCATOR\_KIND\_TCPv4 0x04

#define LOCATOR\_KIND\_TCPv6 0x08

This definition allow locator kinds to be composed via the “or operator” to define a locator to represent both a UDP as well as a TCP endpoint. This clearly allows to support multiple endpoints in a very space efficient manner.

### Locators

#### Discovery Locators

The SPDP ports defined in Table 9.8 on page 178 for UDP unicast communication are also used for TCP communication since it is perfectly legal to have an UDP and a TCP socket bound on the same port.

#### User Data Locators

The unicast ports defined in Table 9.9 on page 179 for UDP unicast communication are also used for TCP communication since it is perfectly legal to have an UDP and a TCP socket bound on the same port.

#### Default Discovery Locator

A default discovery locator cannot be defined for TCP/IP. As such DDS implementation compliant with this specification should provide vendor specific mechanisms of specifying a bootstrap endpoint over which the discovery protocol can be initiated.

Implementations may decide to transitively forward discovered information, or may provide federated discovery services. However all of this is out the scope of this specification and is considered as implementation detail. The only requirement imposed by this specification is for DDS implementations allow the specification of a locator over which discovery information for this node will be advertised.

#### Exposing and Selecting Locators

When using a TCP/IP transport the rules for exposing locators are quite important to guide the connection establishment and management. Given a node with K network interfaces and a remote discovery locator the problem that implementations have to address is which interfaces should be exposed to the remote node. This specification uses the following simple rule:

1. For each network interfaces associated with this domain participant determine whether the address is private or public [RFC 1918].
2. If the remote discovery locator is a public address then only send the locators representing public addresses if any. If no public address is available for this participant no locator will be provided as part of the discovery message. Otherwise, if the remote discovery locator is a private address only include as part of the discovery message any public address and the private address on the same subnet. Notice that this simple rule allows the forwarding of private and public locators to hosts on the same subnet and only public addresses to hosts that are accessible only through publicly routable addresses.

In the next Session we describe how connections are established and managed.

## Connection Management

This specification allows a DDS-RTPS runtime to use one or more TCP/IP connections to exchange data between matching readers and writers. As described below, a connection may be opened by either side, likewise a connection can be reused to communicate with the connecting peer. A new Submessage, the EntityID is used to advertise entities that are bound to a specific connection and rules are provided on how these can be migrated.

A participant shall be listening for incoming DDSI-RTPS traffic on any connection. As consequence, a participant can always send back DDSI-RTPS traffic on an incoming connection and be assured that it will be processed.

### ****EntityId****

#### ****Purpose****

The Submessage indicates that the concerned entity (GUID(context.sourceGuidPrefix, entityId)) shall be reachable using the connection on which the EntityId Submessage was received. If the Submessage contains

ENTITYID\_PARTICIPANT (000001c1), it holds for all entities owned by the participant.

#### ****Behavior****

When (1) a DDSI-RTPS Entity is discovered through the SEDP protocol, or (2) a DDSI-RTPS Entity is updated through the SEDP protocol, all local DDSI-RTPS Entities matching the discovered DDSI-RTPS entity must send an EntityId Submessage to the discovered DDSI-RTPS entity using a connection on which they will listen for messages from the remote DDSI-RTPS Entity.

The DDSI-RTPS protocol shall always, and only, use the most recent connection for which an EntityId Submessage was received to communicate with the given entity, even if the same EntityId Submessage was previously received on another connection. Non-participant EntityId Submessages always take precedence over participant EntityId Submessages, even when received earlier.

#### The EntityId Submessage has the following wire representation:

|  |
| --- |
| 0...2...........8...............16.............24...............32  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  | ENTITY\_ID |X|X|X|X|X|X|X|E|. octetsToNextHeader |  +---------------+---------------+---------------+---------------+  | EntityId entityId |  +---------------+---------------+---------------+---------------+ |

ENTITY\_ID = 0x19

### ****Connection Multiplicity****

This specification supports both communication over a single TCP/IP connection for both discovery and data as well as the use of multiple connections. The problem of concurrent connections being established by two peers is addressed by ensuring that when detecting mutual connections, then the peer with smaller GUID will close its connection and reuse the connection from the peer with higher GUID prefix.

Multiple connections are supported through a combination of EntityId Submessage, on the TCP/IP *client*, and the standard DDSI-RTPS mechanism already specified for selecting locators and establishing communication between matching entities.

In other terms, EntityId Submessages can be used to advertise entities across multiple connections. Likewise, locators can be exploited to set-up multiple connections. The combination of the two mechanisms provides a flexible framework to support interoperable communication across multiple TCP/IP connections.

## NAT Considerations

This RFC addresses the problem of communication between nodes that are behind a NAT and node exposing public IP addresses. The problem of having nodes behind NAT communicating with each other can be solved by using other protocols, such as STUN [IETF RFC 5389], to configure the discovery information.

## Security

This specification allows for the DDS Security standard to be run unchanged. Additionally, it allows for TLS to be transparently used to secure TCP/IP based DDS communication.

## Compliance with the RFP

This submission addresses all the mandatory requirements of the RFP along with a series of optional requirements. The full coverage is provided in the table below.

|  |  |  |
| --- | --- | --- |
| RFP Req. # | Mandatory Requirement | Comment |
| 6.5.1.1 | *Proposals shall provide a PSM, derived from the DDSI-RTPS PIM, targeting TCP .* | The submission reuses entirely the DDSI-RTPS PIM and only adds two new submessages to support TCP/IP. |
| 6.5.1.2 | *The proposed PSM shall implement the DDSI-RTPS PIM in its entirety.* | .As the submission extends the DDSI-RTPS PIM it fully implements it. |
| 6.5.1.3 | *The proposed PSM shall not introduce dependencies on other communication middleware technologies..* | The submission only uses TCP/IP and DDSI-RTPS. |
| 6.5.1.4 | *Proposals shall reuse the sub messages defined in the DDSI-RTPS PIM.* | The submission reuses all messages defined in the DDSI-RTSP PIM. |
| 6.5.1.5 | *The proposed PSM shall not change or extend the DDS API.* | The submission does not define any API. |
| 6.5.2.1 | *The proposed PSM shall support deployments where participants behaving as a client and a server communicate directly over TCP without interviening NATs.* | The submission supports this use case simply leveraging locators and regular discovery and connection establishment. |
| 6.5.2.2 | *The proposed PSM shall support deployments where the participant behaving as a client is behind a NAT.* | The proposal supports this as a client can expose no locators and the server can reuse incoming connections for all communications. |
| 6.5.2.3 | *The proposed PSM shall support deployments where the participant behaving as a server is behind a NAT.* | In the context of the current submission the role of the client or server depends only on who can connect to who. Thus, this use case is trivially supported by locators configuration. |
| 6.5.2.4 | *The proposed PSM shall support deployments where the participants behaving as a client and a server are both behind a NAT.* | In the context of the current submission the role of the client or server depends only on who can connect to who. Thus, this use case is trivially supported by locators configuration |
| 6.5.2.5 | *The proposed PSM shall support deployments where participants need to communicate using UDP with some applications and TCP with other applications.* | The submission does not prevent implementations from supporting communication on UDP/IP and TCP/IP with different peers or even the same peers. Additionally, the same messages can be sent to peers regardless of the transport used. |
| 6.5.2.6 | *The proposed PSM shall address deployments where participants can communicate using both UDP and TCP.* | The submission does not prevent implementations from supporting communication on UDP/IP and TCP/IP with different peers or even the same peers. Additionally, the same messages can be sent to peers regardless of the transport used. |
| 6.5.3.1 | *The proposed PSM shall support communication over a single TCP connection.* | The submission does support communication on single as well as on multiple TCP/IP connections. |
| 6.5.3.2 | *The proposed PSM shall specify the behavior when multiple peers attempt to establish connections with one another.* | The submission resolves concurrent connections between peers by imposing an ordering based on GUIDPrefix. In other terms the peer with the smaller GUIDPrefix will close the connection when detecting a double connection. |
| 6.5.3.3 | *The proposed PSM shall support discovery and data traffic to/from multiple participants over a TCP connection* | The submission supports this use case and further extends its to TCP/IP connection and disconnnections through the EntityId Submessage. |
| 6.5.3.4 | *The proposed PSM shall specify a mechanism to handle TCP connection drops without affecting DDS communications.* | The submission decouples the DDS session from the TCP/IP connections. Thus the DDSI end-points will retain status as long as the lease won’t expire. Additinally, the EntityId Submessage and the amended sematic on the ACKNACK addresses the effective re-establishment of reliability. |
|  |  |  |

|  |  |  |
| --- | --- | --- |
| RFP Req. # | Non Mandatory Requirement | Comment |
| 6.6.1.1 | *The proposed PSM may provide security extensions compatible with [DDS- SECURITY].* | The DDS Security specification can be used as-is on this PSM. |
| 6.6.2.1 | *The proposed PSM may support communication over different TCP connections (e.g., different connections for sending user data and sending discovery data).* | Different connections are supported and the EntityId Submessage is used to advertise the connection to be used for given participant/Reader/Writer. |
| 6.6.2.2 | *The proposed PSM may support communication over different TCP connections through load balancers.* | This is trivially supported by the current submissions as all traffic can run on a single connection. This is the most transparent manner of dealing with TCP/IP load-balancer. |
| 6.6.2.3s | *The proposed PSM may provide a mechanism to exchange discovery and data traffic to/from multiple participants sharing TCP connections created by participants in the same process* | Different participants are supported behind a single connections, in general **k>=1** participants on a given process can be allocated across **n>=1** TCP/IP connections. |