

Introduction

DDS overview

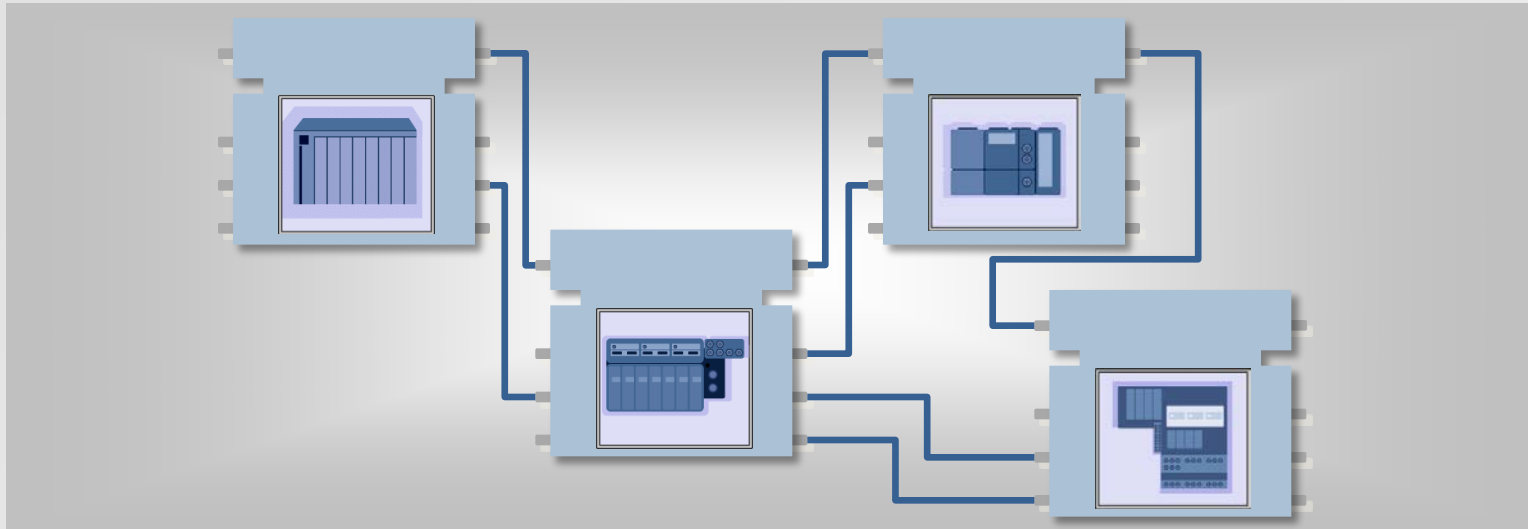
Control comm.

DDS mapping

4DIAC Implement.

Summary

Designing High Performance IEC61499 Applications on Top of DDS



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Industrial communications

- Complex
- Different solutions at the different layers
 - Fieldbus at bottom layers: Profibus, CAN, ...
 - Ethernet, Wi-Fi at top layers

Middleware solutions

- CORBA: Common Object Request Broker Architecture
- OPC: Object Linking and Embedding for Process Control
- Web Services
- DDS: Data Distribution Service

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Properties

- ❑ Middleware specification by the OMG
 - ❑ Object Management Group
- ❑ Publisher/Subscriber paradigm
 - ❑ Versus Client/Server, e.g. CORBA
- ❑ Guarantee Real-Time constraints
- ❑ Quality of Service control
- ❑ Open solutions
 - ❑ RTI Connex, OpenSplice, OpenDDS
- ❑ Programming languages
 - ❑ C, C++, Java
- ❑ Operating Systems
 - ❑ Windows, VxWorks, QNX, Lynx, ...
- ❑ Data defined using IDL (Interface Definition Language)
 - ❑ Instead of exchanging messages



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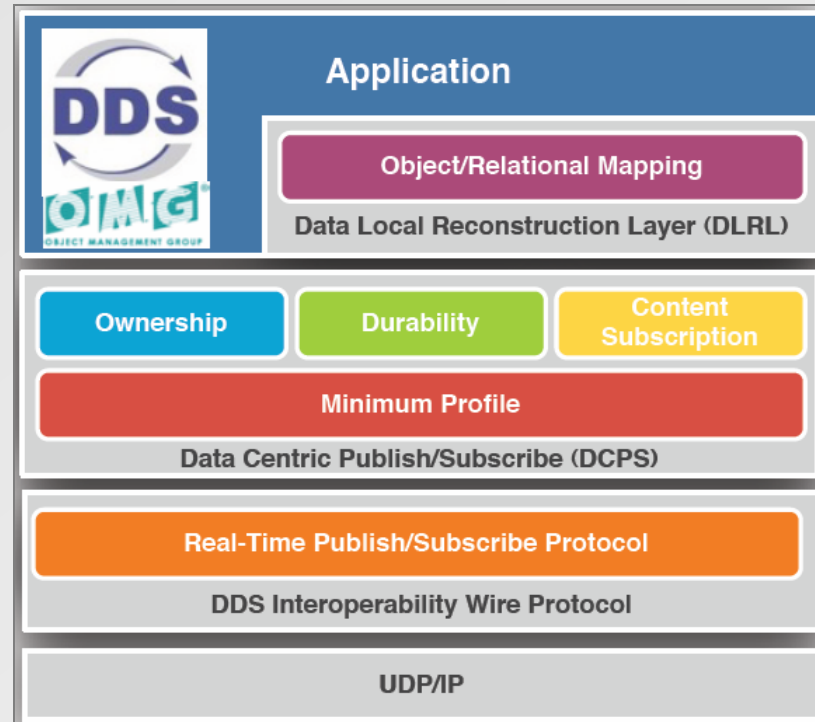
Summary

DDS v1.2 API Standard

- ❑ Language Independent, OS and HW architecture independent
- ❑ **DCPS**: Standard API for Data-Centric, Topic-Based, Real-Time Publish/Subscribe
- ❑ **DLRL**: Standard API for creating Object Views out of collection of Topics

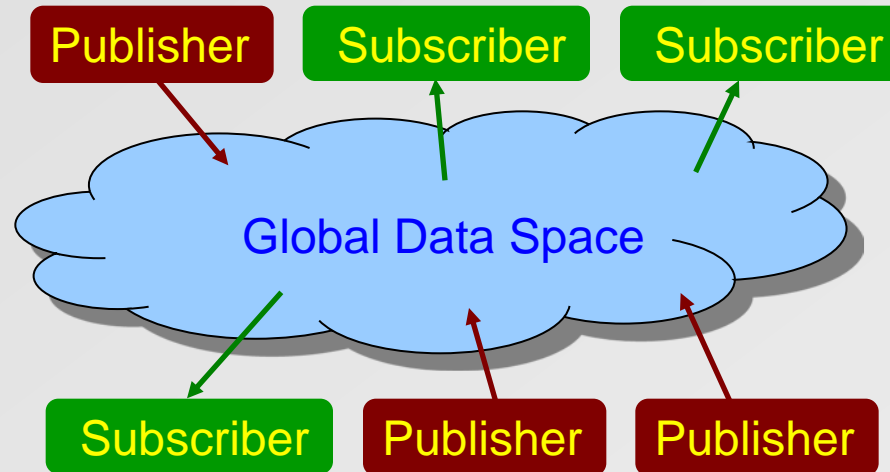
❑ DDSI/RTPS v2.1 Wire Protocol Standard

- ❑ Standard wire protocol allowing interoperability between different implementations of the DDS standard



Virtual Global Data Space

- ❑ Many to many communication
- ❑ Decoupled in time, space and synchronization



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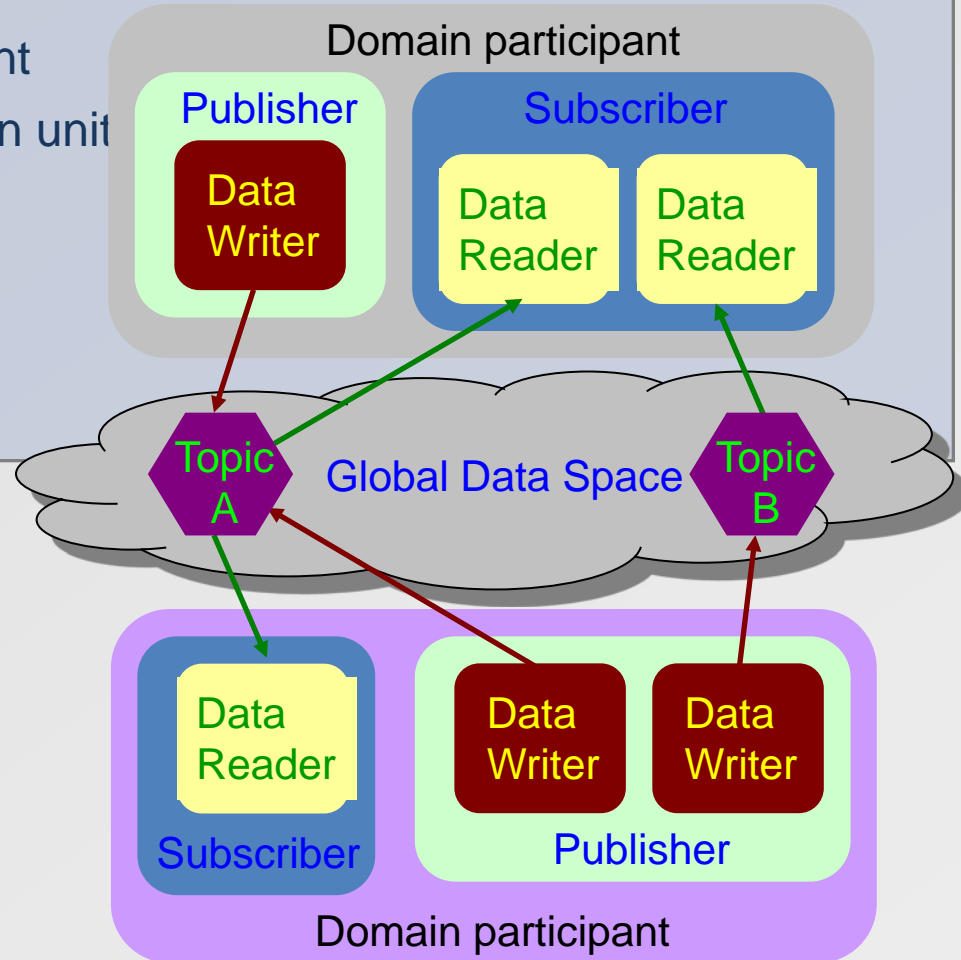
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Entities

- ❑ **Domain:** context
- ❑ Domain participant
- ❑ **Topic:** information unit
- ❑ Data Writer
- ❑ Data Reader
- ❑ Publisher
- ❑ Subscriber



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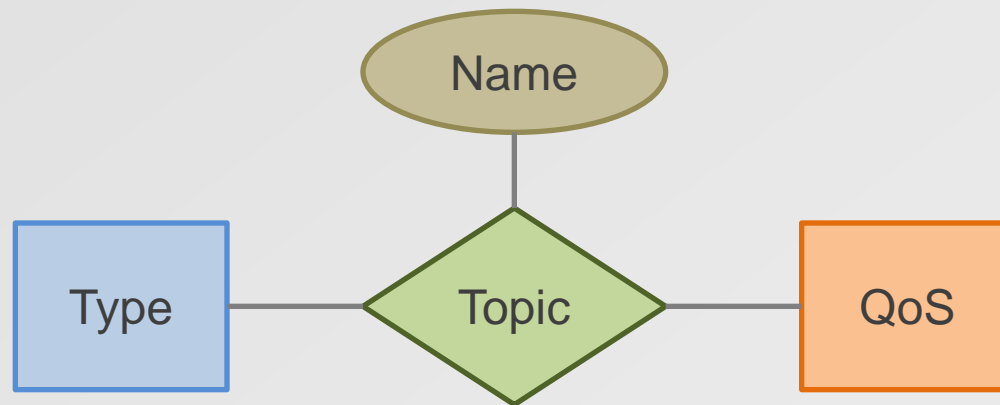
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Topic

- ❑ **Unit of information atomically exchanged** between Publishers and Subscribers
- ❑ An **association between a unique name, a type and a QoS setting**



A DDS Topic Type is described by an IDL Structure containing an arbitrary number for fields

DDS Domains and Partitions

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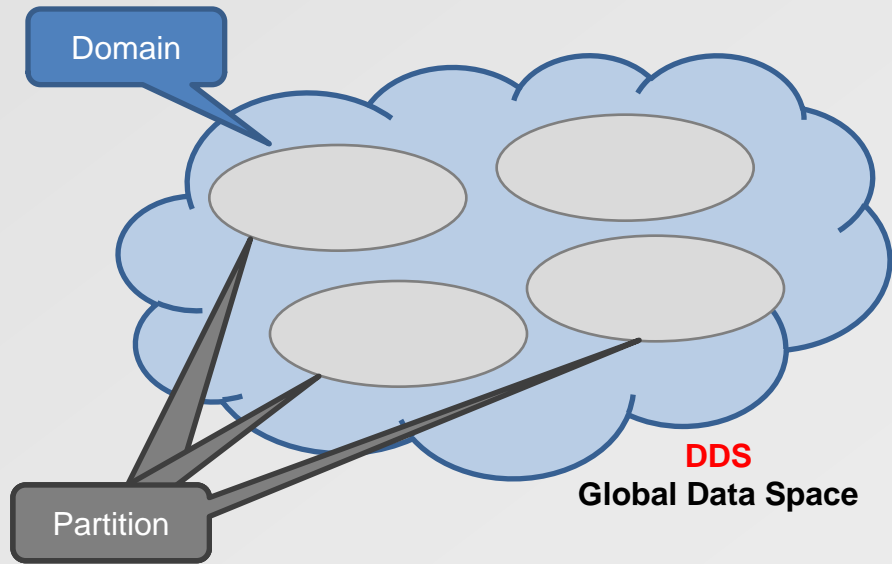
Summary

Domain

- ❑ A Domain is one instance of the DDS Global Data Space
- ❑ DDS entities always belong to a specific domain

Partition

- ❑ A partition is a scoping mechanism provided by DDS to organize a domain



DDS provides three main mechanism for exchanging information with the application

- ❑ **Polling:** The application polls from time to time for new data or status changes. The interval might depend on the kind of applications as well as data
- ❑ **WaitSets:** The application registers a WaitSet with DDS and waits (i.e. is suspended) until one of the specified events has happened
- ❑ **Listeners:** The application registers a listener with a specific DDS entity to be notified when relevant events occur, such as state changes

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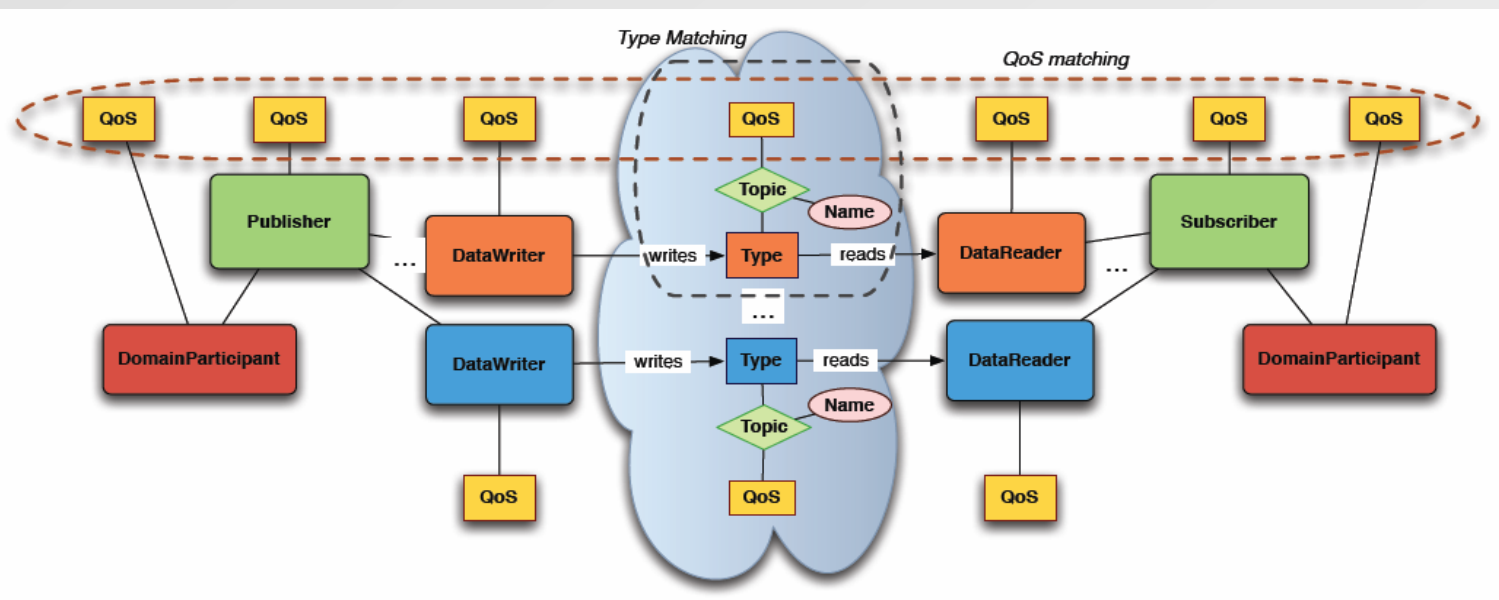
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QoS-Policies

- ❑ QoS-Policies are used to control relevant properties of OpenSplice DDS entities, such as:
 - Temporal Properties, Priority, Durability, Availability, ...
- ❑ Some QoS-Policies are matched based on a **Request vs. Offered Model** thus QoS-enforcement
- ❑ Publications and Subscriptions match only if the declared vs. requested QoS are compatible



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QoS Policies

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QoS Policy	Applicability	RxO	Modifiable	
DURABILITY	T, DR, DW	Y	N	Data Availability
DURABILITY SERVICE	T, DW	N	N	
LIFESPAN	T, DW	N/A	Y	
HISTORY	T, DR, DW	N	N	Data Delivery
PRESENTATION	P, S	Y	N	
RELIABILITY	T, DR, DW	Y	N	
PARTITION	P, S	N	Y	
DESTINATION ORDER	T, DR, DW	Y	N	
OWNERSHIP	T, DR, DW	Y	N	
OWNERSHIP STRENGTH	DW	N/A	Y	
DEADLINE	T, DR, DW	Y	Y	Data Timeliness
LATENCY BUDGET	T, DR, DW	Y	Y	
TRANSPORT PRIORITY	T, DW	N/A	Y	
TIME BASED FILTER	DR	N/A	Y	Resources
RESOURCE LIMITS	T, DR, DW	N	N	
USER_DATA	DP, DR, DW	N	Y	Configuration
TOPIC_DATA	T	N	Y	
GROUP_DATA	P, S	N	Y	

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Communication types

- ❑ Non-Real-Time communications: ERP, MES, SCADA, ...
 - ❑ Configuration and monitoring
 - ❑ Parameterization
 - ❑ Diagnostics
- ❑ Cyclical Process communications
 - ❑ Real-time process data transfer
- ❑ Acyclic Process communications
 - ❑ Real-time alarms and events

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	Services			
	Aperiodic Alarms & Events	Periodic Sampled Measures	Request/No Response	Request / Response
Topics	1	1	1	2
Distribution	Many to many	Many to many	One to one	One to one
Deadline	-	Period	-	-
Destination Order	Source	Source	Reception	Source
Durability	Persistent / Transient	Volatile	Volatile / Transient	Volatile / Transient
History	Keep N	Keep last	Keep N	Keep N
Latency Budget	Estimated urgency	33-50% of Period	-	-
Lifespan	App. dependent	Period	-	-
Liveliness	Automatic	Manual by topic	Automatic	Automatic
Ownership	Shared / Exclusive	Shared	Shared	Exclusive
Reliability	Reliable	Best effort	Reliable	Reliable
Transport Priority	Highest	High	Low	Lowest

Mapping into DDS topics

Messages exchanged and mapping into DDS topics

	Services			
	Acyclic Events	Cyclic Variables	Request /No Response	Request / Response
Paradigm	Publish / Subscribe		Client / Server	
Topics (per variable)	1	1	1	2
Distribution	Many to one	Many to many	One to one	One to one
Content Filtered	No	Yes	Yes	Yes

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DDS SIFBs

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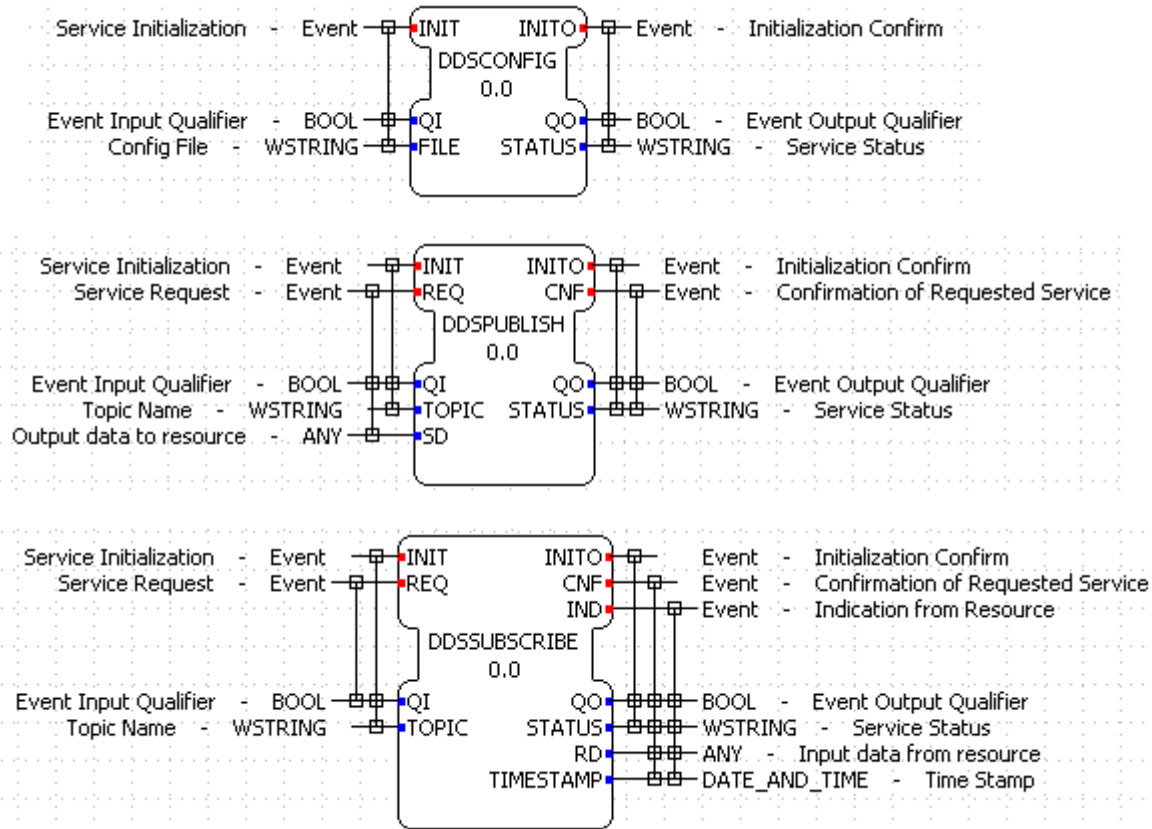
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DDS Entities Configuration XML File

```
<?xml version="1.0" encoding="UTF-8"?>
<DDSEntities Name="TestDDS" Comment="Test DDS entities" >
  <Identification ApplicationDomain="FORTE" Description="DDS entities model for FORTE" />
  <VersionInfo Organization="GCIS DISA ETSI" Version="0.0" Author="FPG" Date="2013-04-10" Remarks="Test FORTE with DDS" />
  <Domain Id="0" QoS_Library="FORTEQoSLibrary" QoS_Profile="Aperiodic">
    <Topic Name="StrDDSdat" Type="TTSTRING" QoS_Profile="Aperiodic" />
    <Topic Name="WordDDSdat" Type="TTWORD" QoS_Profile="Aperiodic" />
  </Domain>
</DDSEntities>
```

```
public:
  typedef enum
  {
    TTNUL,
    TTBYTE,
    TTWORD,
    TTDWORD,
    TTBUFFER,
    TTSTRING
  } TopicTypes;
```

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DDS QoS Configuration XML File (USER_QOS_PROFILES.xml)

```

<?xml version="1.0" encoding="UTF-8"?>
<dds>
  <!-- ===== -->
  <!-- Init - FORTEQoSLibrary Library -->
  <!-- ===== -->
  <qos_library name="FORTEQoSLibrary">
    <!-- ===== -->
    <!-- Init - FORTEQoSLibrary Library - Aperiodic Profile -->
    <!-- ===== -->
    <qos_profile name="Aperiodic">
      <participant_qos>
        <participant_name>
          <name>FORTE QoS (Aperiodic)</name>
        </participant_name>
      </participant_qos>

      <datareader_qos>
        <destination_order>
          <kind>BY_SOURCE_TIMESTAMP_DESTINATIONORDER_QOS</kind>
        </destination_order>
        <durability>
          <kind>TRANSIENT_DURABILITY_QOS</kind>
        </durability>
        <liveliness>
          <kind>AUTOMATIC_LIVELINESS_QOS</kind>
        </liveliness>
        <ownership>
          <kind>SHARED_OWNERSHIP_QOS</kind>
        </ownership>
        <reliability>
          <kind>RELIABLE_RELIABILITY_QOS</kind>
        </reliability>
        <history>
          <kind>KEEP_LAST_HISTORY_QOS</kind>
          <depth>1</depth>
        </history>
        <protocol>
      </datareader_qos>

      <datawriter_qos>
    </qos_profile>
    <!-- ===== -->
    <!-- End - FORTEQoSLibrary Library - Aperiodic Profile -->
    <!-- ===== -->
  
```

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DDS Test Application

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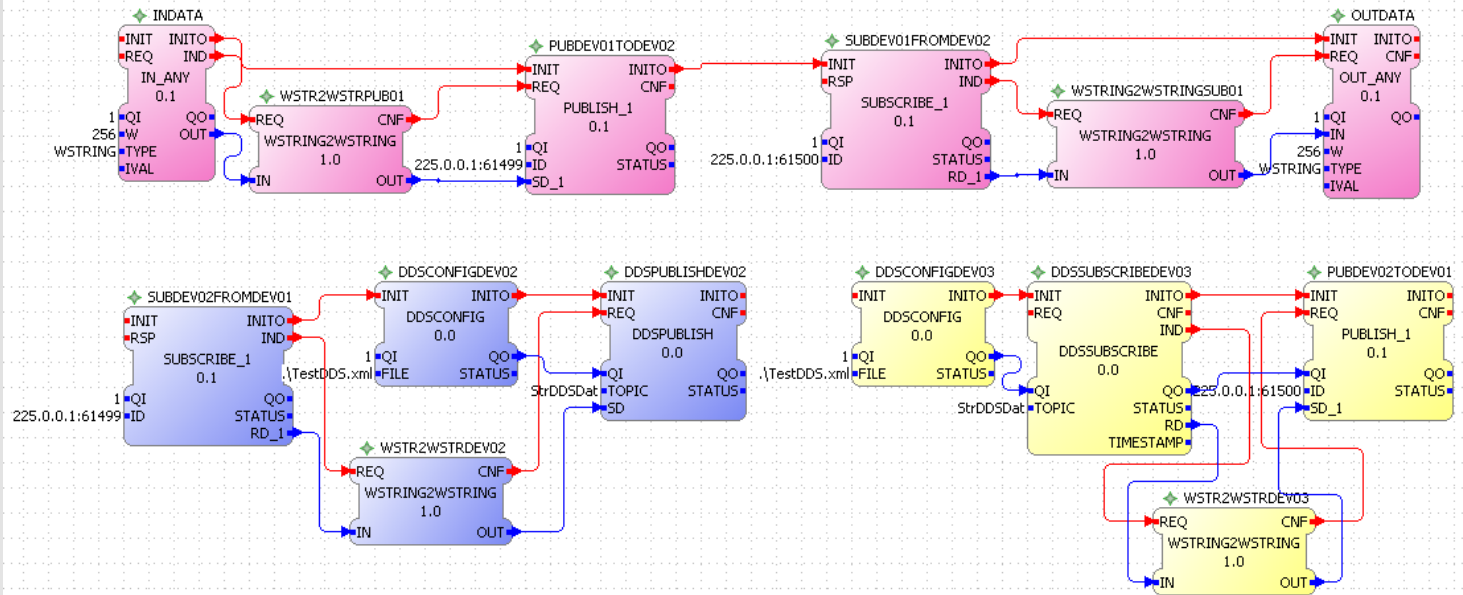
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DDS Test System

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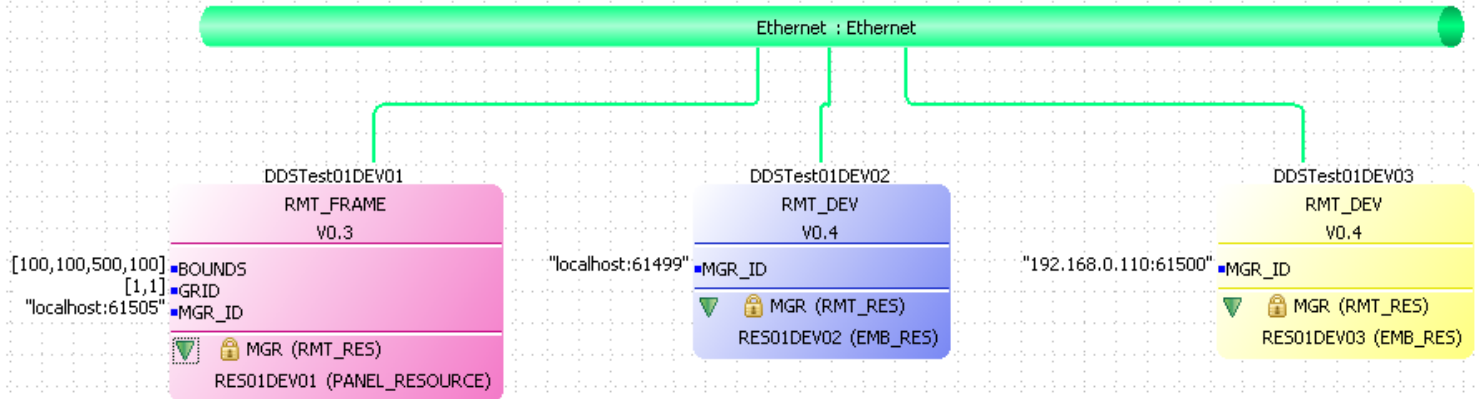
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● Summary

- ❑ Middleware backbone: OMG DDS
 - ❑ Adequate for Real-Time environments
 - ❑ Some non-RT services adapt better to Client/Server
 - ❑ Avoid critical and non-critical interferences
 - ❑ Main services in Industrial automation identified
 - ❑ Mapping
 - ❑ Topics
 - ❑ QoS parameters
- ❑ 4DIAC-FORTE Implementation by SIFBs
- ❑ Future Work
 - ❑ Analyze performance

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