



# VEA

VEHICLE ELECTRONICS AND ARCHITECTURE

## OPEN MANAGEMENT GROUP DATA-DISTRIBUTION SERVICE (OMG-DDS) AS A DATA TRANSPORT FOR VEHICULAR INTEGRATION FOR C4ISR/EW INTEROPERABILITY (VICTORY) SERVICES

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## Report Documentation Page

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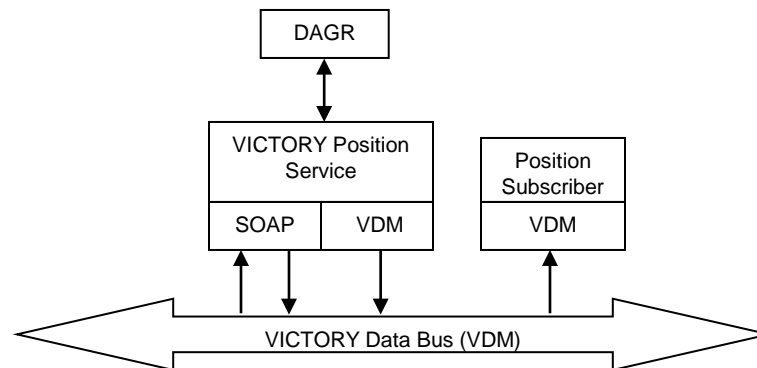
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- VICTORY is a U.S. Army initiative to improve upon current military ground vehicle electronics architecture by providing C4ISR/EW system interoperability and portability.
- VICTORY Data-Messages (VDM) are VICTORY's customized publish-subscribe (P/S) messaging solution.
- OMG-DDS is an open-standard COTS P/S messaging solution.
- Investigate replacing VDM with OMG-DDS interfaces

- The VICTORY technical approach
  - Incorporate open-standards
  - Shared services (VICTORY services)
  - Data-bus centric (VICTORY Data-Bus [VDB])
- VICTORY Standards development
  - Working groups (government, industry)
  - Adopt-adapt-author methodology
- Current scope of VICTORY
  - No real-time applications
  - No safety critical applications
  - Intra-vehicle communication (i.e. high-availability)

- VICTORY core services (Position, Orientation, Direction-of-Travel, and Time)
- Service data interface
  - Publish data to VDB using available formats or VDMs
- Service management interface
  - Monitoring/control functions available via Simple Object Access Protocol (SOAP) Remote Procedure Calls (RPC)





# Publish-Subscribe Communication Overview

- Provides loose-coupling and scalability
- P/S communication implementation
  - Centralized broker
  - Multi-broker
  - Peer-to-peer
- P/S technologies generally provide API and/or wire protocol standards
  - API standard: code portability
  - Wire protocol standard: “on-the-wire” interoperability
- Integration pattern supported by many COTS messaging technologies

# Publish-Subscribe Communication Overview

- Several COTS technologies supporting P/S:
  - Java Message Service (JMS): standard Java API, centralized or brokered topology
  - Advanced Message Queuing Protocol (AMQP): standard wire protocol, multi-brokered
  - OMG-DDS: standard API and wire protocol, peer-to-peer implementations
- OMG-DDS is a good candidate for on-vehicle COTS P/S solution
  - Data-Centric Publish Subscribe (DCPS) API standard
  - Real-Time Publish Subscribe (RTPS) wire protocol
  - Peer-to-peer implementation (middleware spawn threads in app)
  - Mechanisms for supporting real-time P/S

- Customized messaging solution supporting P/S on VDB
  - Used for services with no standard data type/protocol (e.g. Time service uses NTP/PTP not VDM)
- Provides scalability and loose-coupling
  - Internet Group Management Protocol (IGMP) to manage subscriptions
  - UDP multicast for data distribution
- Quality of Service (QoS)
  - Differentiated Service Code Point (DSCP): 6-bit field in the IP header
  - Indicates traffic priority



# VICTORY Data Message (VDM)

- Standard message features including sequence numbers, format indicators, identifiers, and timing information
- Binary header with and XML payload:

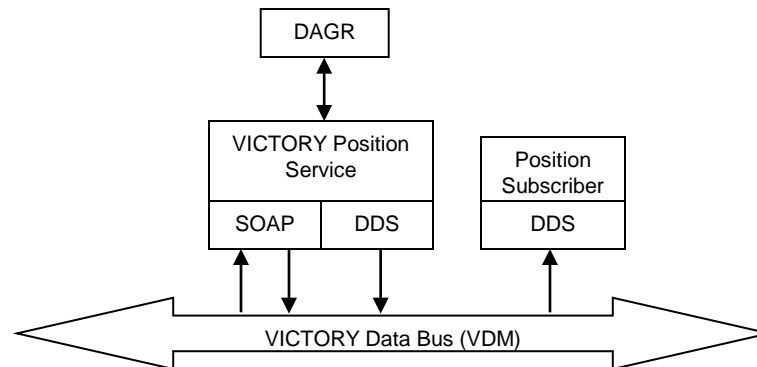
<b>16-bits</b>		<b>16-bits</b>	
<b>8-bits</b>	<b>8-bits</b>	<b>8-bits</b>	<b>8-bits</b>
VERSION			
VERSION		TIME INFO	
TIME INFO (CONTINUED)			
TIME INFO (CONTINUED)			
VDM SEQUENCE NUMBER			
INTERFACE ID			
VDM SIZE		VDM COUNT	
TYPE		OFFSET	
LENGTH		RESERVED	
		7	
		7	
TYPE		OFFSET	
LENGTH		RESERVED	
VICTORY XML PAYLOAD			

- VDM P-S Behavior (control via SOAP RPC)
  - Increase/decrease publishing frequency
  - Enable/disable publishing
  - Change multicast address and port for publishing
- TARDEC reference implementation
  - Standard POSIX libraries (e.g. sys/sockets.h)
  - C++
  - Red Hat Enterprise Linux (RHEL) on x86\_64
  - RHEL on i386.
  - Ubuntu on ARM Cortex-A8
- Good performance over high-availability network

- Open-Standard, COTS, real-time P/S, with multiple vendors.
- Extensive QoS for turning P-S behavior:
  - Deadline: The maximum time between data samples.
  - Durability: Previously published data can be stored and sent to late joining subscribers.
  - Lifespan: Specifies how long data sent by user application is considered valid.
  - Liveliness: Allows readers to detect when matching writers are no longer available.
  - Ownership: Specifies ownership of a Topic by a specific writer.
  - Reliability: Allows recovery of samples lost by the network.

# OMG-DDS Insertion into VICTORY Services

- Convert VICTORY Position Service
  - Replace VDM interface with OMG-DDS
  - Test with multiple OMG-DDS implementations (RTI Connex DDS 4.5f and PrismTech OpenSplice 6.1.1)
- Evaluate
  - Development effort
  - API completeness and conformance (i.e. vendor-specific code)
  - Interoperability



# OMG-DDS Insertion into VICTORY Services

- Convert VICTORY XML Schemas (XSD) to OMG-DDS Interface Definition Language (IDL).

```
<xsd:simpleType name="latitudeBounds_t">
  <xsd:restriction base="xsd:double">
    <xsd:minInclusive value="-90"/>
    <xsd:maxInclusive value="90"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:simpleType name="longitudeBounds_t">
  <xsd:restriction base="xsd:double">
    <xsd:maxInclusive value="180"/>
    <xsd:minExclusive value="-180"/>
  </xsd:restriction>
</xsd:simpleType>

<xsd:complexType name="absolutePosition_t">
  <xsd:sequence>
    <xsd:element name="latitude"
      type="vmt:latitudeBounds_t"/>
    <xsd:element name="longitude"
      type="vmt:longitudeBounds_t"/>
    <xsd:element name="altitude"
      type="xsd:double"/>
    <xsd:element name="mgrs" type="xsd:string"
      minOccurs="0"/>
  </xsd:sequence>
</xsd:complexType>
```



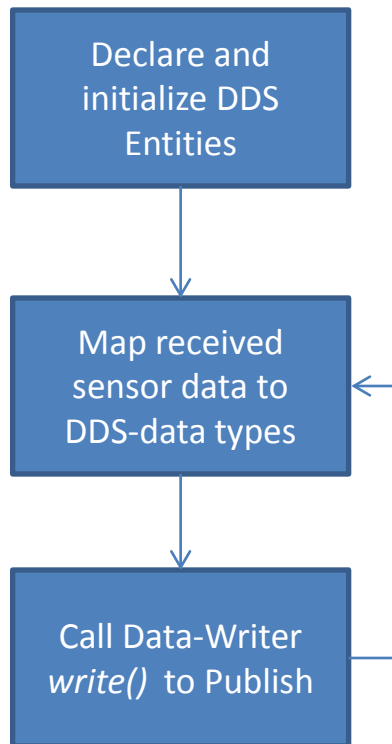
```
module VICTORY
{
  module Types
  {
    struct doubleMeasurement_t
    {
      double value;
      double uncertainty;
      boolean estimated;
      boolean valid;
    }; //@top-level false
    //
    // Military Grid Reference System
    //
    struct MgrsPos_t
    {
      string<10> gridZoneDesignator;
      long easting;
      long northing;
    }; //@top-level false

    struct AbsPos_t
    {
      doubleMeasurement_t latitude;
      doubleMeasurement_t longitude;
      doubleMeasurement_t altitude;
      boolean hasMgrs;
      MgrsPos_t mgrs;
    };
    #pragma keylist AbsPos_t
  }; //Types
}; //VICTORY
```

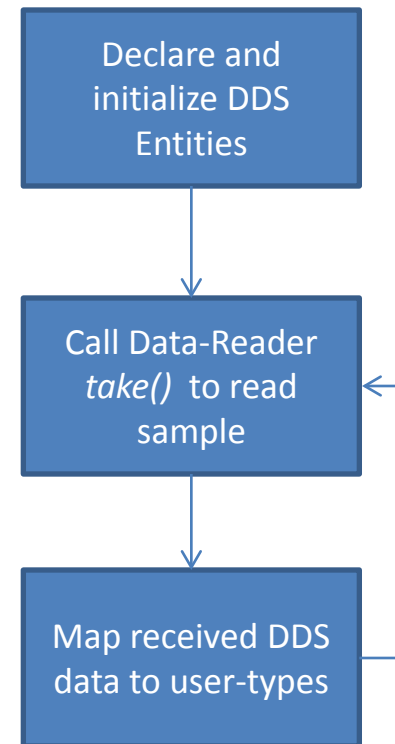
# OMG-DDS Insertion into VICTORY Services

- Modify Position Service code to use OMG-DDS interface (several days of training and ~100 lines of code)

## On Publisher (i.e. Position Service)



## On Subscriber (i.e. Position Service Client)



# OMG-DDS Insertion into VICTORY Services

Table 1: Effective QoS and Other Attributes



- Tested all combinations of RTI and PrismTech for modified Position Service and Position Service Client.
- Default OMG-DDS QoS used (VDM behavioral equivalent):

QoS & Attributes	Writer	Reader
Deadline	Infinite	Infinite
Domain ID	0	0
Durability	Volatile	Volatile
Latency Budget	0 sec	0 sec
Liveliness duration	Infinite	Infinite
Liveliness kind	Automatic	Automatic
Ownership	Shared	Shared
Reliability	Reliable	Best Effort
Topic	Position	Position
Type	AbsPos_t	AbsPos_t

- Vendor specific code changes (3 statements)
  - Casting of generic data writer to type-specific data-writer
  - User defined type-support – no native *interface* support for C++
  - Disable default vendor-specific transport setting
- Example:

```
#ifdef RTI
ddsSpecificWriter =
    VICTORY::Types::AbsPos_tDataWriter::narrow(
        ddsDataWriter );
#endif

#ifdef PRISMTECH
ddsSpecificWriter = VICTORY::Types::
    AbsPos_tDataWriter::_narrow( ddsDataWriter
    );
#endif
```





# Interoperability Results

- Applications on separate hosts worked out-of-the box
- Applications on same host required modification
  - RTI Connex DDS defaults to shared memory transport (fast)
  - Change transport to standard UDP transport:

```
#ifdef RTI  
ddsDomPartQos.transport_builtin.mask =  
    DDS_TRANSPORTBUILTIN_UDPv4;  
#endif
```

# VDM and OMG-DDS Comparison

- Features of VDM and OMG-DDS compared.

Aspect	VDM	OMG-DDS
COTS Available	No	Yes
Lines of Code	1500	100
Licensing Issues	No	Yes
Standard API	No	Yes
Standard Wire Protocol	Yes	Yes
Unbrokered Architecture	Yes	Yes

- Notable Issues:
  - VDM Development complexity
  - Licensing OMG-DDS (based on # developers, computing platform, tools, etc).

- VDM and OMG-DDS P/S solutions appear to be suitable for addressing integration problems which fall into the **current** scope of VICTORY.
- OMG-DDS is a powerful tool
  - Built on open-standards
  - Multiple vendor implementations
  - Well-supported API and wire protocol
  - May enable more capabilities on VDB
- Continue to investigate
  - VDM versus OMG-DDS cost for vehicle program
  - Performance
  - OMG-DDS advanced features and use cases
- The VICTORY Work Group should consider adopting OMG-DDS as an incremental enhancement or real-time extension should the need for more complex P/S behavior arise.