

## Building Distributed LVC Simulations with Data Distribution Service (DDS)

Paul Tingey  
Senior Field Application Engineer

### Agenda

- An Overview of DDS
  - DDS Principles
- Differences between DDS and HLA/DIS
- Using DDS in MS&T Systems
  - A DDS to HLA demo system
- Conclusions



## RTI in the Industrial IoT

- RTI is the largest connectivity middleware vendor
- 1350+ designs, many real-world programs across industries
- Full DDS, tools, services, support, secure and certified versions
- ~200 people



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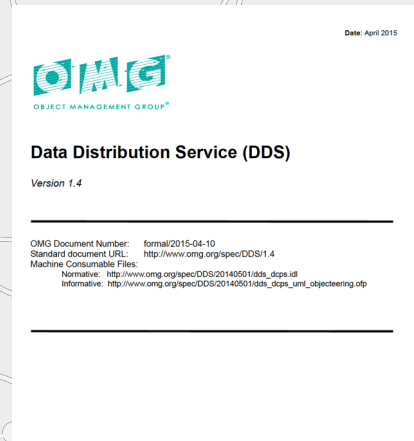
## An Overview of Data Distribution Service (DDS)



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## OMG Data Distribution Service

- First version of the DDS standard was released in 2004
- Most recent version (v1.4) was released in April 2015
- “Data-Centric Publish-Subscribe model for distributed application communication and integration”



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## What is the Data Distribution Service ?

- DDS is an **open-standard** managed by the Object Management Group® (OMG)
- DDS is at the heart of many **OA** initiatives in A&D
- DDS is a connectivity framework technology for **real-time systems** that allows interoperability of **any CPU, language, and operating system**
- Operates a **Publish-Subscribe** paradigm, enables location transparency and is decentralized and dynamically scalable
- DDS takes a **Data-Centric** approach that simplifies connectivity management and improves scalability and code reuse while also reducing development cycle times



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## What is the Data Distribution Service ?

- DDS is **TRL 9** technology used widely in the “**L**” parts of **LVC** systems
- DDS was originally designed for mission critical systems
- DDS is ideally suited to applications that are required to share large amounts of data in a fast, secure, scalable and reliable way
- Because it’s an open standard it’s been adopted in numerous defense related projects (especially for the MOD and DOD)
- It’s widespread use in military systems has led to strong interest in the simulation and training market

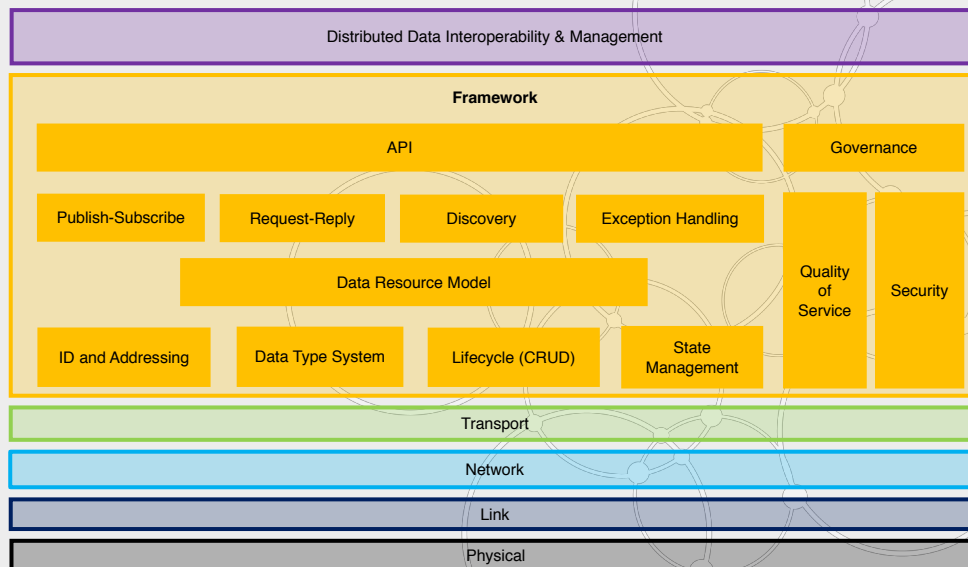


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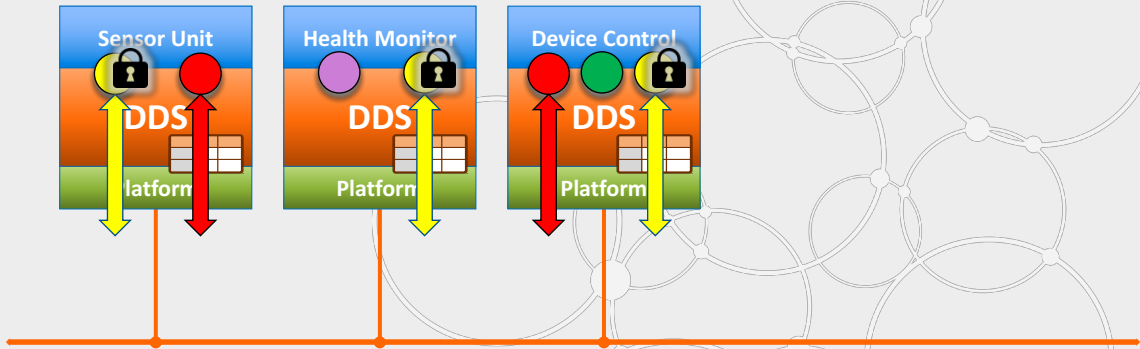
## Connectivity Framework Layer

Connectivity Framework Functions



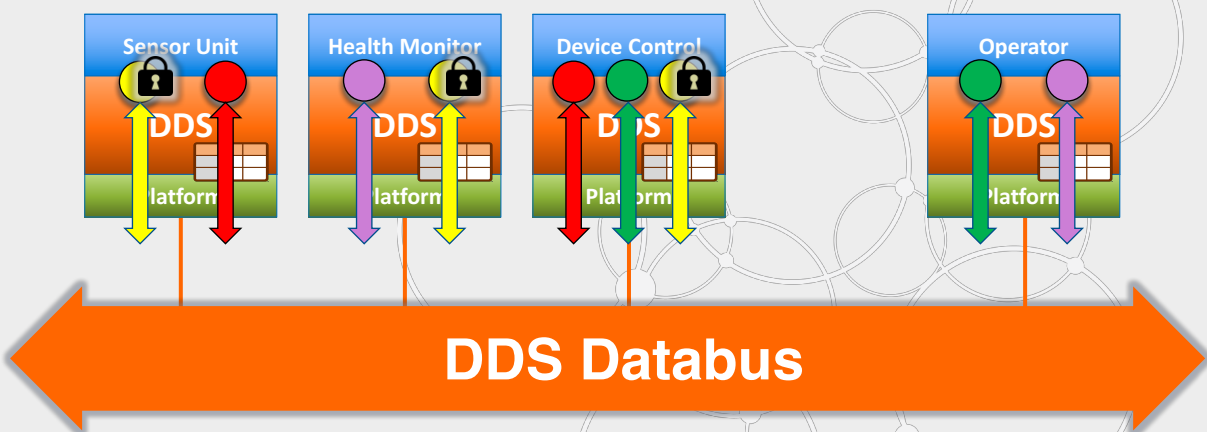
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### Connection via the DDS Databus...



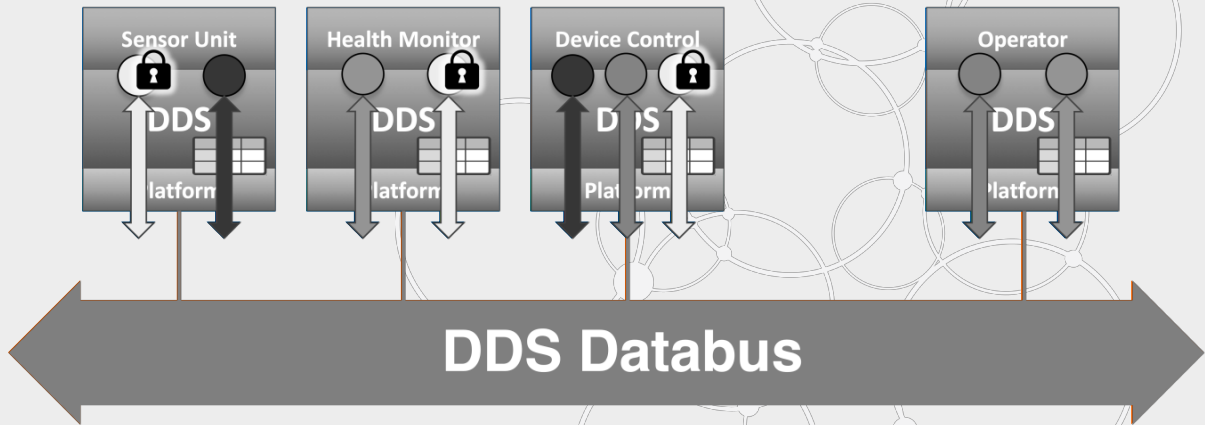
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### Connection via the DDS Databus...



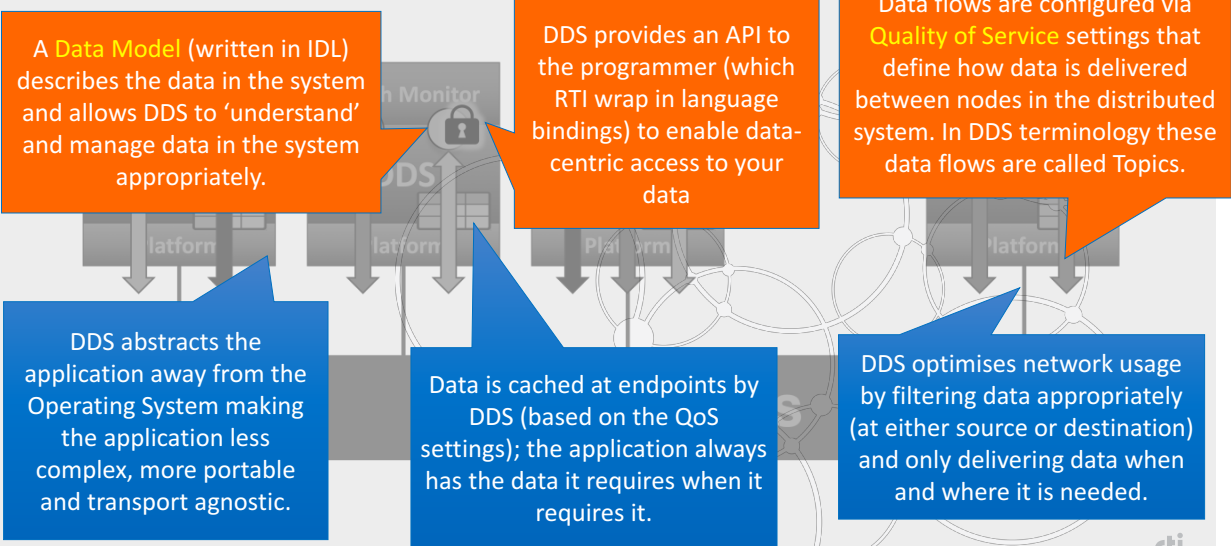
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## Connection via the DDS Databus...



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## Connection via the DDS Databus...



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## About Data Centricity

**Data Centricity Definition**

- The interface *is* the data.
- The infrastructure understands that data.
- The system manages the data and imposes rules on how applications exchange data.

```
SELECT * FROM ShapeData
WHERE color='RED' AND shapsize > 10;
```

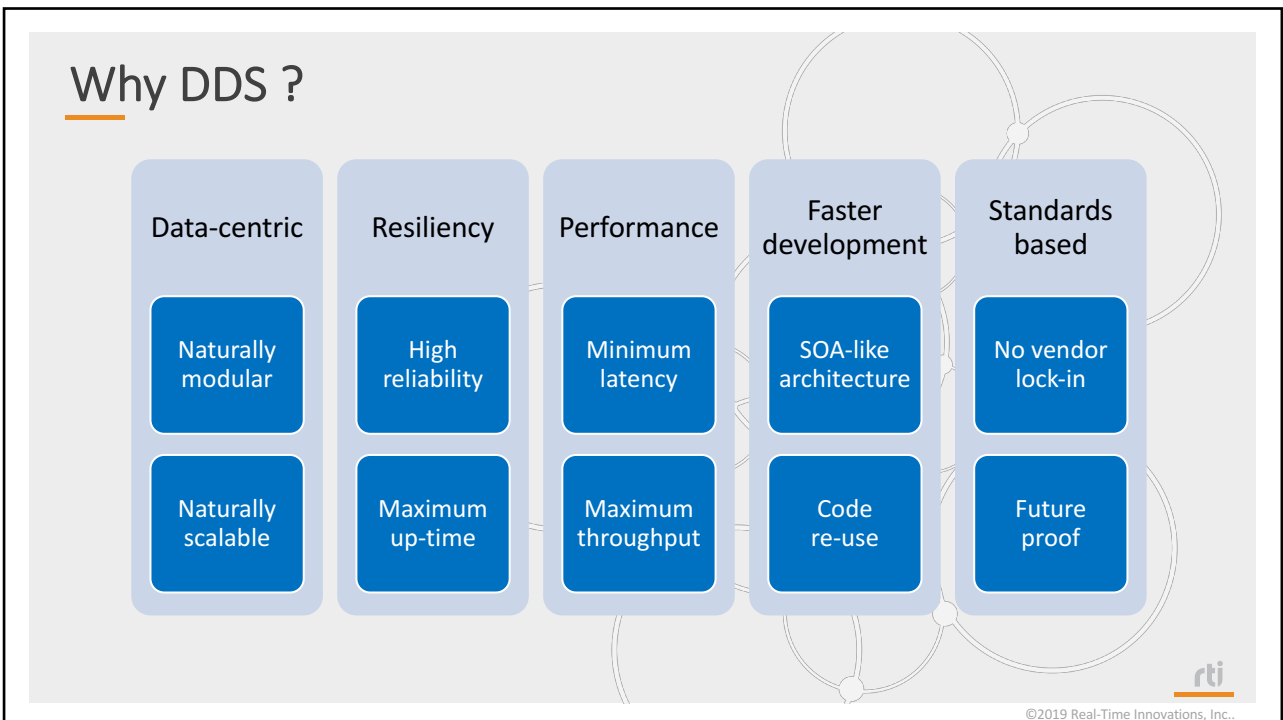
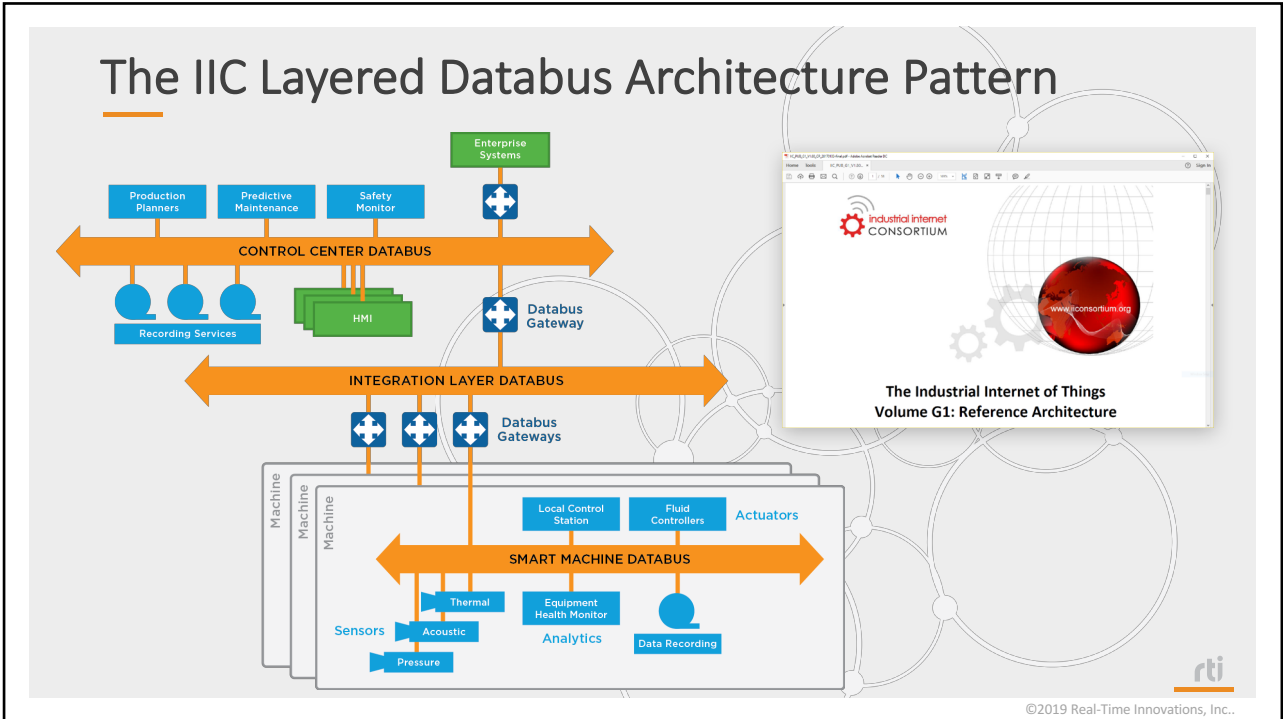
```
cft = create_contentfilteredtopic_with_filter(
    "MyFiltered_topic", ShapeData_topic,
    "(color MATCH 'RED') AND (shapsize > 10)", ... );
```

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## DDS Security Plugins

- Based on OMG DDS Security spec
- Built-In Plugins
  - Little to no change required to DDS applications
- Optional SDK available to customize plugin behavior
- Runs over any transport
  - Does not require TCP or IP
  - Secure Multicast for scalability, low latency
- Completely decentralized
  - High performance and scalability
  - No single point-of-failure

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## Differences between DDS and HLA/DIS



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### DDS & HLA/DIS Differences

- Interoperability Wire Protocol
  - DDS has a standard Interoperability protocol (RTPS)
  - DIS has a standard wire protocol (IEEE-1278)
  - HLA has no wire protocol
- API
  - DDS has standard APIs (DDS-DCPS)
  - DIS has no standard for consistent APIs
  - HLA has a “Run-Time Infrastructure” API
- Real-Time Quality of Service
  - DDS has comprehensive support for more than 20 QoS policies
  - HLA/DIS have no real support for QoS (only area of interest, some reliability and rate-reduction)



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## DDS & HLA/DIS Differences

- Presence & Discovery Services
  - DDS supports full presence, discovery and introspection of all participants, entities, types, QoS
  - HLA has limited support: Declaration Management and Disconnect notifications
- Simulation Services
  - DDS does not offer services specific to simulation
    - Although Time and Federation can be modeled in DDS
  - HLA supports simulation services:
    - Federation, Time, and Ownership Management



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## DDS & HLA (non-functional) Differences

- Performance
  - DDS implementations have been benchmarked to have 40 usec one-way latency in standard Gbit Ethernet and throughput (for 256 B messages) close to the theoretical maximum of 1 Gbit/sec
  - HLA one-way latencies range from 300 usec to 30 msec and throughputs (for 256 B messages) on the order of 60 Mbit/sec
- Scalability
  - DDS implementations have benchmarked scalability up to 4000 participants (processes) with minimal degradation in throughput
- Applicability & Adoption
  - DDS is broadly applicable to real-time systems and is in use in many markets beyond simulation and A&D
  - HLA has more limited applicability limited to the simulation domain



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## Using DDS in Modeling, Simulation & Training Systems



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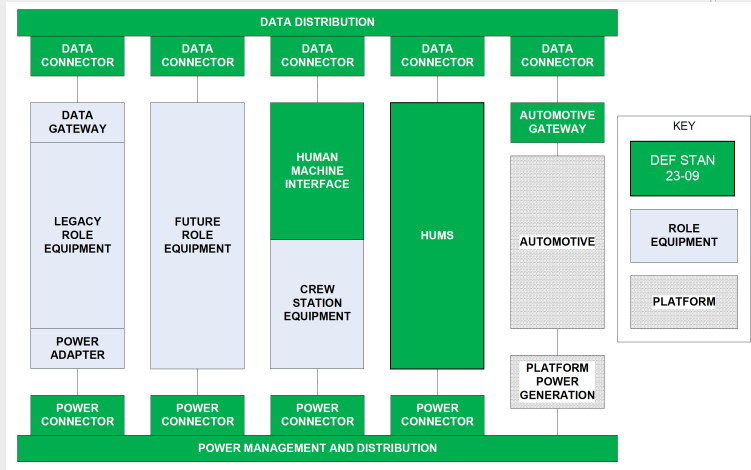
### Why use DDS within distributed LVC simulations?

- 1) Take advantage of increased DDS performance
  - Superior DDS performance (e.g. versus HLA) translates into better simulation performance
- 2) Take advantage of DDS Security in new distributed simulations
  - Secure training and simulations over WAN and Cloud
  - Role based access allows for joint exercises between Coalition forces
- 3) Enables leveraging/integration of existing system software
  - Hundreds of A&D systems (Land, Sea and Air) are already being built using DDS
- 4) Enables leveraging of recorded mission data
  - Recorded data from actual mission execution could be combined with simulation data and be used for training



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## UK MOD General Vehicle Architecture



GVA Interfaces and Boundaries (taken from Def-Stan 23-09)

- GVA mandates standards for common interfaces
  - Electronic
  - Power
  - Mechanical



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## US Navy Zumwalt DDG-1000

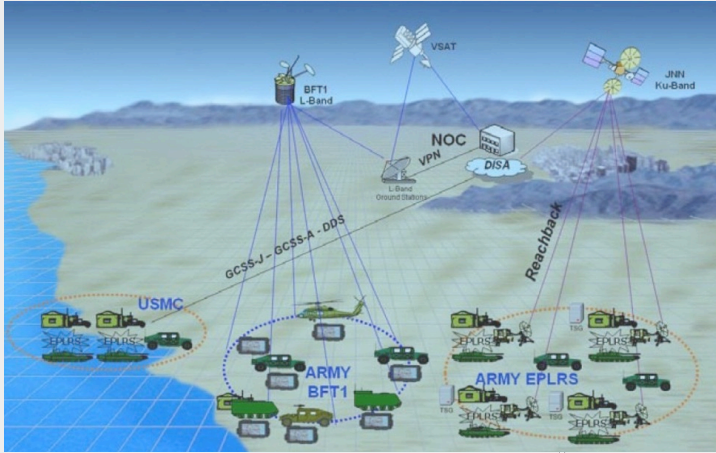


- Raytheon uses RTI middleware to control the Zumwalt Class Destroyer (DDG-1000)
- RTI DDS coordinates and manages complex, diverse onboard hardware and software systems
- RTI connects hundreds of computers, thousands of applications, and more than 10 million publish-subscribe pairs



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## Blue Force Tracker (JBC-P)

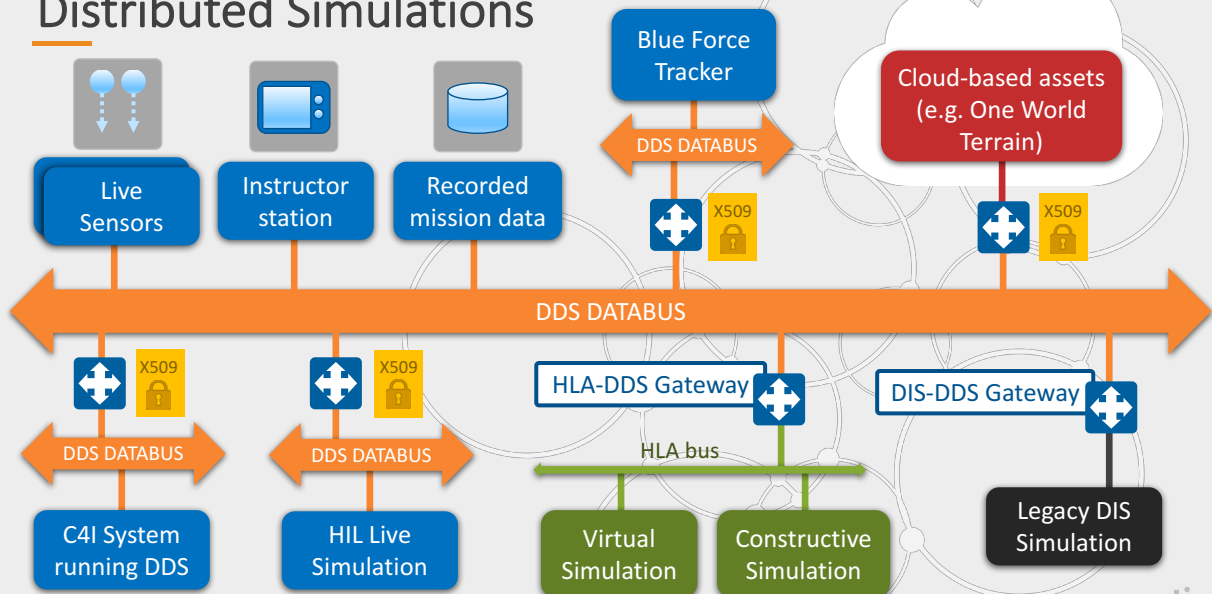


- The US Army's “Blue Force Tracker” collects tracking information vehicles and other assets over a wide area.
  - Able to track 250,000+ assets in real-time
  - Created to replace a less performant, proprietary system
- The DDS-based system analyzes all the tracks in a private cloud.

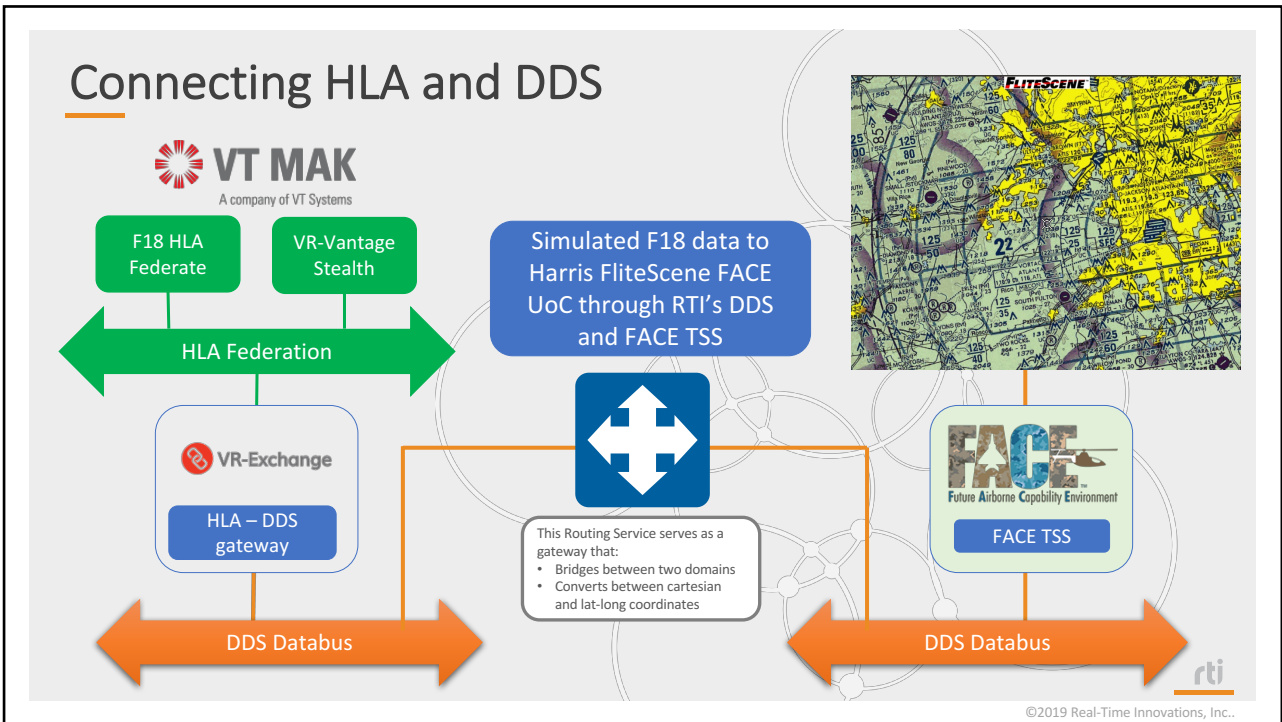


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## Distributed Simulations



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## simpleBaseEntity visualization

RTI Administration Console

DDS Logical View

type filter text

- FACE\_DM\_CHANGEVIEW
- FACE\_DM\_DISABLEOVERLAY
- FACE\_DM\_ENABLEOVERLAY
- FACE\_DM\_SETMAPSTATE
- FACE\_DM\_UPDATEWNSHIPLOCA
- FACE\_DM\_UPDATEWNSHIPMOV
- Domain 1
  - simpleBaseEntity\_topic
  - simpleDetonationInteraction\_topic
  - simpleFireInteraction\_topic
- Domain 2

Physical View

type filter text

- System
  - face-id
  - FliteScene: -557797922
  - FliteScene Test: Test: 9176
  - nova
  - RTI Connect Broker for VR-Link: 6300
  - VTMak\_to\_FliteScene: 13664
  - nova.rti.com

Time Chart 2

Value

Time

Sample Inspector

type filter text on field names

Field	Value	Type
SampleData		
entityId (Key)	1:2648:1	string<255>
entityType	1:2:225:19:0:0	string<255>
markingText	MAK:VRLink-	string<255>
location		simpleOM:Spa...
x	647822.8516334814	double
y	-523965.358012241	double
z	3577207.6591899665	double
velocity		simpleOM:Spa...
x	918.935546875	double
y	292.24334716796875	double
z	255.73509216308594	double
acceleration		simpleOM:Spa...
x	37.20399371962031	double
y	-49.25521469116211	double
z	-78.67522430419922	double
rotationalVelocity		simpleOM:Spa...
x	0.0	double
y	0.04472136124968529	double
z	0.0894427249937057	double
orientation		simpleOM:Ta...
psi	-2.7055406440173373	double
theta	-0.20812503593233876	double
phi	0.8810260131785002	double
deadReckoningAlgori	DRAlgorithm_DRM_RVV (4)	simpleOM:DRAL
damageState	DamageNone (0)	simpleOM:Dam...
forced	Forcefriendly (1)	simpleOM:Forc...
frozen	false	boolean
SampleInfo		SampleInfo

Inspecting instance from Domain 1: simpleBaseEntity\_topic

rti

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## Conclusions

- DDS is a mature standard from OMG
  - Focuses on efficient data-distribution for real-time and high-performance systems
  - Mandated and Deployed worldwide in Military systems and other Demanding real-time applications
  - Platform neutral, with a Portable API and Interoperable Wire Protocol
  - Deployed DDS Security Specification
- DDS is an ideal platform for integration of training systems
  - Superior performance
  - Granular data security with pluggable architecture for customized protocols
  - Flexible & Evolvable Type System
  - Highly Tunable via Quality of Service (QoS)
  - Can easily integrate and reuse system software and mission data
- DDS could be used in combination with HLA/DIS types as a data-dictionary
  - Would leverage existing simulation object models plus DDS benefits



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## Thank You

