OBJECT MANAGEMENT GROUP®

DDS™

DDS – The Proven Data Connectivity Standard for IoT™

WELCOME TO THE OBJECT MANAGEMENT GROUP® (OMG®)

As an international, open membership, not-for-profit technology standards consortium, OMG Task Forces develop enterprise integration standards for a wide range of technologies and an even wider range of industries.

OMG's roots are in middleware, and one of our most widely deployed standards is the Data-Distribution Service™ standard (DDS™). DDS has already been successfully deployed in private, hybrid and public cloud systems (including so-called "fog architectures"); in mobile systems and of course general web solutions.

But today's computing infrastructure is changing dramatically to support new requirements in design and structure. This is no where more evident than in the Internet of Things (IoT), where new types of machines driven by vast, complex industrial, distributed systems, can't operate without connectivity. These new machines will transform our infrastructure into smart freeways, distributed power generation and autonomous driving cars, etc., revolutionizing the workplace and our lives for years to come.

These new IoT systems need a technology like DDS because it directly addresses real-time systems. It explicitly manages the communications "data model." Consequently, it's a "data-centric" technology. No matter what application—from financial trading platforms, to medical devices, to smart electrical grids, to exploration and production and to transportation—DDS finds the right data and then communicates it to its intended destination in a reliable, flexible, fast, and secure manner.

IoT will not only fuel innovative business strategies; it will also disrupt markets that have not been disrupted by the Internet before, bringing huge economic impacts in efficiency and competition. So if your company is just now exploring IoT and is concerned there are so many different middleware standards available, let me make this clear: DDS—as the proven data connectivity standard for IoT—will continue to parallel the groundbreaking growth of IoT in the future.

Regards,

Chairman and CEO
Object Management Group

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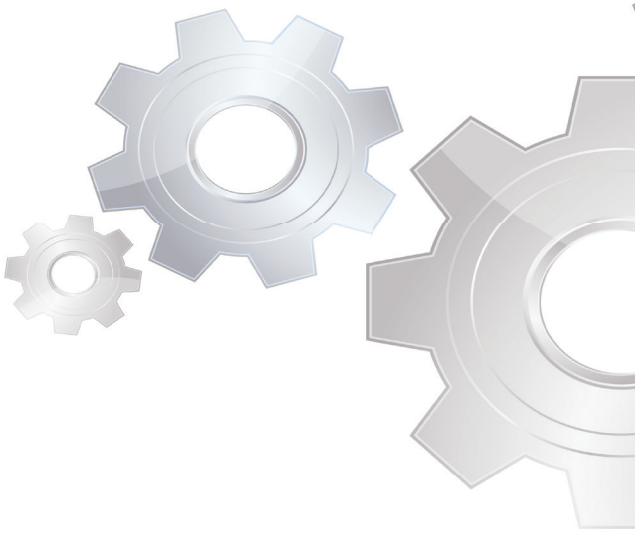


The IIoT Disruption

Gartner, the world's leading information technology research and advisory company, predicts that the Smart Machine era will be the most disruptive in the history of IT. That disruption will be led by smart, distributed infrastructure called the Industrial Internet of Things (IIoT).

While it will grow slower than the Consumer IoT, the IIoT will eventually have much larger economic impact. The IIoT will bring entirely new infrastructures to our most critical and impactful societal systems. Truly intelligent distributed machines will greatly improve function and efficiency across virtually all industries, including healthcare, transportation, energy, communications, and industrial control. The IIoT is crucial to the strategic future of most companies, even traditionally slow-moving industrial infrastructure providers. The dawn of a new age is clear.

> *"DDS is the best open middleware standard for high-throughput and real-time applications available today. From the application layer down to the wire protocol, DDS has been architected to deliver the performance and dependability that modern Internet of Things (IoT) applications need as they scale up to span the globe, and scale out to incorporate individual embedded sensors and actuators. Life-saving medical devices, global stock trading systems, international air traffic control and power generation systems are just four of the many highly-reliable business-critical applications where DDS is in use today. EMC technology and products are architected to solve these most critical problems and DDS plays an important role in providing these solutions."*
>
> - Dr. Said Tabet, Chief Architect for IOT Solutions, EMC

Unlike connecting consumer devices, the IIoT will control expensive, mission-critical systems. Thus, the requirements are very different. Reliability is often a huge challenge. The consequences of a security breach are vastly more profound for the power grid than for a home thermostat. Existing systems are already networked in some fashion, and interfacing with these legacy "brownfield" designs is a key blocking factor. Plus, unlike consumer devices that are mostly small networks, industrial plants, electrical systems or transportation grids will encompass many thousands or millions of interconnected points.

GE's CEO, Jeff Immelt, famously said that if you go to bed an industrial company, you will wake up a software and analytics company. But, software and analytics can't help industrial systems without data. True disruption requires a single data communications architecture that delivers the right data at the right time, spans sensor to cloud, interoperates between vendors, and crosses industries. That common technology will replace today's mashup of special-purpose standards and technologies with an interoperable future. Data-centric communication based on DDS offers a scalable, reliable, fast, and secure infrastructure for the hugely connected new world.

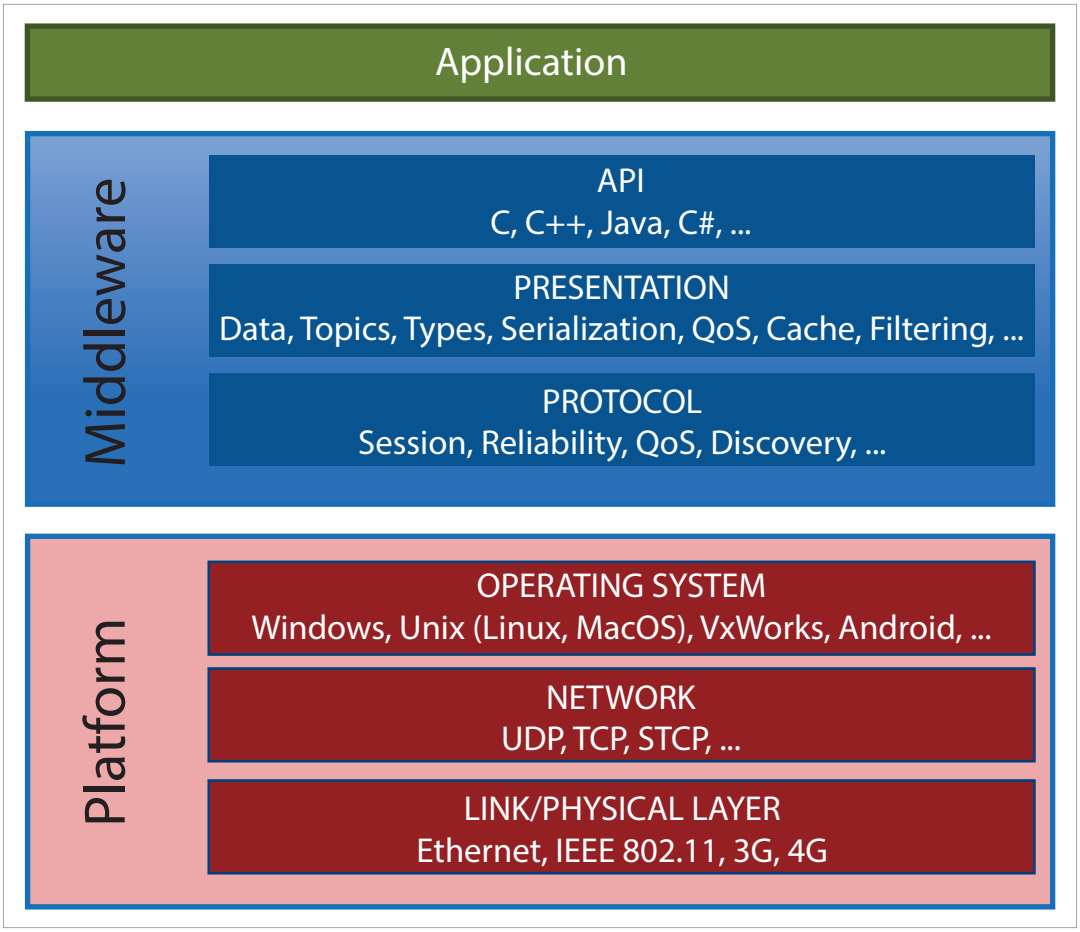
> *"DDS technologies provide a great foundation for secure dynamic distributed systems; with both publish-subscribe and RPC architectures, and too many features to list, it is a proven high-performance communications platform."*
>
> - Clark Tucker, President and CEO, Twin Oaks Computing, Inc.

What Is DDS?

THE PROVEN DATA CONNECTIVITY STANDARD FOR THE INTERNET OF THINGS

The Data-Distribution Service (DDS) is a middleware protocol and API standard for data-centric connectivity from the Object Management Group. It integrates the components of a system together, providing low-latency data connectivity, extreme reliability, advanced security, and a scalable architecture that business and mission-critical Internet of Things (IoT) applications need.

In a distributed system, middleware is the software layer that lies between the operating system and applications. It enables the various components of a system to more easily communicate and share data. It simplifies the development of distributed systems by letting software developers focus on the specific purpose of their applications rather than the mechanics of passing information between applications and systems.

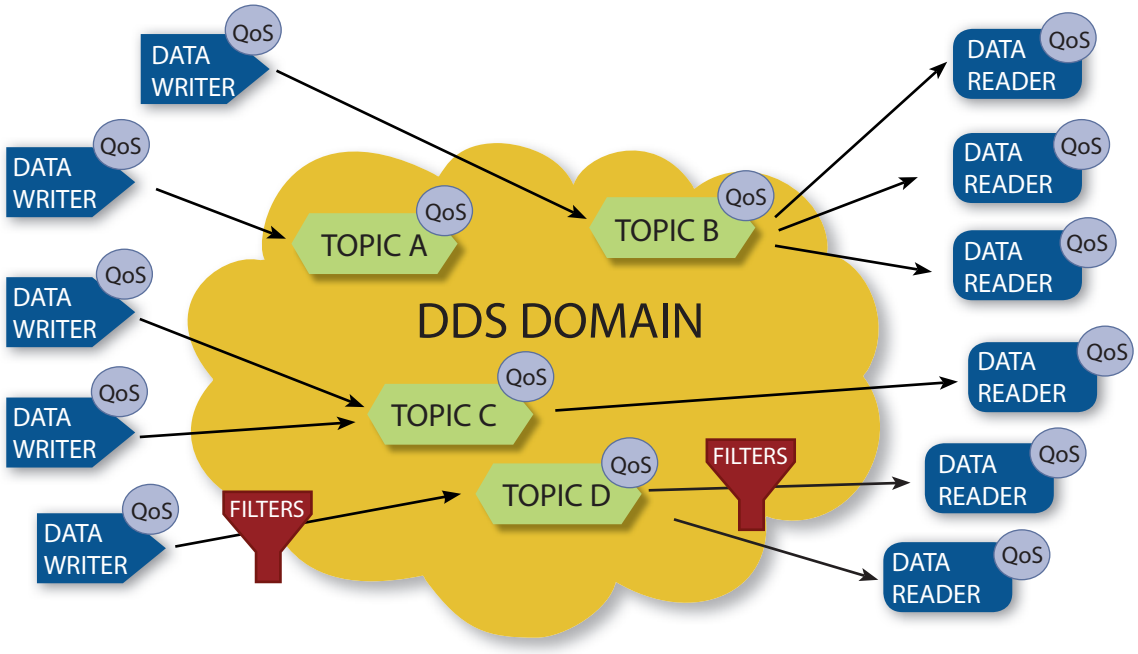


The DDS Middleware is a software layer that abstracts the Application from the details of the operating system, network transport, and low-level data formats. The same concepts and APIs are provided in different programming languages allowing applications to exchange information across of operating systems, languages, and processor architectures. Low-level details like data wire format, discovery, connections, reliability, protocols, QoS management, etc. are manage by the middleware.

DATA CENTRICITY

There are many communications middleware standards and products. DDS is uniquely data-centric, which is ideal for the Internet of Things. Most middleware works by sending information between applications and systems. Data centricity ensures that all messages include the contextual information an application needs to understand the data it receives.

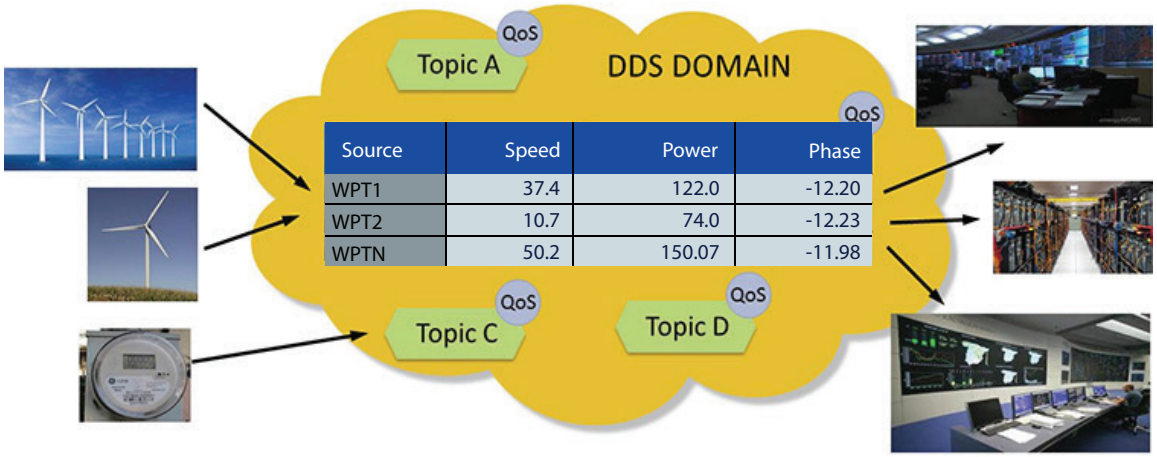
The essence of data centricity is that DDS knows what data it stores and controls how to share that data. Programmers using traditional message-centric middleware must write code that sends messages. Programmers using data-centric middleware write code that specifies how and when to share data and then directly share data values. Rather than managing all this complexity in the application code, DDS directly implements controlled, managed, secure data sharing for you.



DDS provides QoS-controlled data-sharing. Applications communicate by publishing and subscribing to Topics identified by their Topic name. Subscriptions can specify time and content filters and get only a subset of the data being published on the Topic. Different DDS Domains are completely independent from each other. There is no data-sharing across DDS domains.

GLOBAL DATA SPACE

DDS conceptually sees a local store of data called the "global data space." To the application, the global data space looks like native memory accessed via an API. You write to what looks like your local storage. In reality, DDS sends messages to update the appropriate stores on remote nodes. You read from what looks like a local store.



Inside a DDS domain the unit of information sharing is data-objects within Topics. The topic is identified by its name and the data-object by some 'Key" attributes. This is similar to how key attributes are used to identify records in a Database. This figure is conceptual. DDS communicates peer-to-peer and does not require the data to be brokered by a server or cloud.

All together, the local stores give applications the illusion of having access to the entire global data space. This is only an illusion; there is no global place where all the data lives. Each application locally stores only what it needs and only for as long as it needs it. DDS deals with data in motion; the global data space is a virtual concept that is really only a collection of local stores. Every application, in almost any language, running on any system, sees local memory in its optimal native format. The global data space shares data between embedded, mobile, and cloud applications across any transport, regardless of language or system, and with extremely low-latency.

QUALITY OF SERVICE

The behavior of data communication can be configured with flexible Quality of Service (QoS) specifications including reliability, system health (liveliness), and even security. In a real system, not every end-point needs every item in your local store. DDS is smart about sending just what it needs. If messages don't always reach their intended destinations, the middleware implements reliability where needed. When systems change, the middleware dynamically figures out where to send which data, and intelligently informs participants of the changes. If the total data size is huge, DDS intelligently filters and sends only the data each end-point really needs. When updates need to be fast, DDS sends multicast messages to update many remote applications at once. As data formats evolve, DDS keeps track of the versions used by various parts of the system and automatically translates. For security-critical applications, DDS controls access, enforces data flow paths, and encrypts data on-the-fly.

The true power of DDS emerges when you specify all of these things simultaneously, at extremely high speeds, and in a very dynamic, demanding, and unpredictable environment.

> *"MITRE is a strong supporter of standards-based solutions and approaches to foster interoperability today and evolution into the future. DDS has demonstrated its ability to play a major role in addressing distributed data distribution challenges faced by our sponsors and those they depend on in the Industrial IoT World."*
>
> - Dr. Mark Maybury, Vice President and Chief Security Officer,
> Director, NIST National Cybersecurity FFRDC, The MITRE Corporation

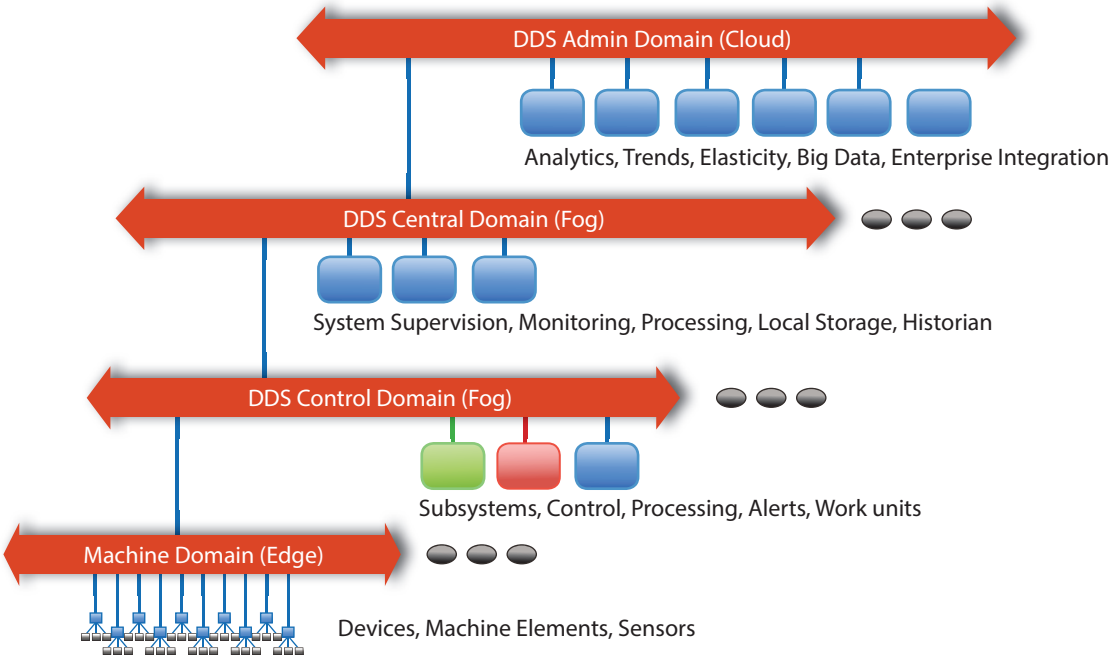
DYNAMIC DISCOVERY

DDS provides Dynamic Discovery of publishers and subscribers. Dynamic Discovery makes your DDS applications extensible. This means the application does not have to know or configure the endpoints for communications because they are automatically discovered by DDS. This can be completed at runtime and not necessarily at design or compile time, enabling real "plug-and-play" for DDS applications.

This dynamic discovery goes even further than discovering endpoints. DDS will discover if the endpoint is publishing data, subscribing to data, or both. It will discover the type of data being published or subscribed to. It will also discover the publisher's offered communication characteristics and the subscriber's requested communications characteristics. All of these attributes are taken into consideration during the dynamic discovery and matching of DDS participants.

DDS participants can be on the same machine or across a network: the application uses the same DDS API for communications. Because there is no need to know or configure IP addresses, or take into account the differences in machine architectures, adding an additional communication participant on any operating system or hardware platform becomes an easy, almost trivial, task.

SCALABLE ARCHITECTURE



DDS systems can span from Edge to Fog to Cloud. At the edge they can be used for high-speed real-time machine to machine communications. Within the intermediary system they can provide robust, reliable QoS and content-aware information flows. Integrating these systems DDS provides scalable access and distribution of information all the way to and within the cloud.

The OMG DDS architecture is designed to be scalable from small devices to the cloud and for very large systems. DDS enables the Internet of Things by scaling across thousands or millions of participants, delivering data at ultra-high speed, managing many thousands of data objects, and providing extreme availability and security. DDS simplifies distributed systems development by absorbing much of the complexity in a single, standard communications layer.

> *"The IIoT requires fast, reliable, secure communication architecture. While there are many standards in the IoT and the enterprise, none besides DDS provide the performance, reliability, and security required by first-class industrial infrastructure. RTI already has experience with 1000 applications, ranging from huge power systems to intelligent medical networks to autonomous driving. The DDS standard is proven to provide what these real-world systems need to join the intelligent, connected future."*
>
> - Dr. Stan Schneider, Chief Executive Officer, Real-Time Innovations

How Does DDS Work?

HIGH LEVEL DATA-CENTRIC INTERFACES REPLACE MESSAGE-CENTRIC PROGRAMMING

The main goal of DDS is to share the right data at the right place at the right time, even between time-decoupled publishers and consumers. DDS implements global data space by carefully replicating relevant portions of the logically shared dataspace.

THE RIGHT DATA

Not all data needs to be everywhere. Middleware should only deliver the data that consumers really need. Interest-based filtering can apply to both content and data rates. With proper implementation, DDS saves bandwidth and processing power, and minimizes overall application complexity.

As a data-centric solution, DDS can understand the schema of the shared data. This allows it to filter on content, age and/or lifecycle to provide applications with only the data they need. For example, you can send only boiler temperatures over 300 (content filter) with at most ten updates per second (rate). This efficient approach can often save 90% of the data communications overhead in many systems.

THE RIGHT PLACE

Data must be available where it is needed, to facilitate self-forming systems. DDS distributes and maintains data so it is readily available.

DDS dynamically discovers publishers and subscribers, the data types they want to share, and the related Quality-of-Service (QoS). Following a successful match, DDS enforces timely distribution according to the QoS. It implements a QoS-enforced logical channel for each data stream between each publisher-subscriber pair. A DDS subscriber can be sure that its peer publisher is actually alive and that any data produced will be delivered. This greatly simplifies application development and error handling.

THE RIGHT TIME

Real-time systems interact with the real world. Data must be available on time—the right data too late is a failure. Data differ in priority, reliability, timing, and other non-functional properties. DDS balances utilization of scarce resources to distribute data at the right time.

DDS middleware uses logical QoS policies, as set by the applications at runtime, to balance efficiency and determinism. The QoS contracts ensure these timing relationships. For example, if a subscriber requires an update every 10ms and its matched publisher does not deliver, the system declares an error, enabling remedial action. QoS policies cover many characteristics, including urgency, importance, reliability, persistence, and liveliness.

UNDERLYING TECHNICAL CONCEPTS

- Relational data modeling: DDS addresses data in a manner similar to relational databases. It can manage data by both structure related topics (using key-fields) and allow ad-hoc queries and filters on content and time so applications can extract specific data as needed.
- Pub-sub messaging: DDS uses the publish/subscribe paradigm for dynamic discovery and primary management of data-flows between relevant DDS entities, including publishers, subscribers, durability services, recording and replay-services, and connected databases. Request-reply and other patterns are built on this powerful substrate.
- Reliable multicast: The DDS standard wire protocol implements reliable multicast over plain UDP sockets, allowing systems to efficiently benefit from modern networking infrastructures.
- Lifecycle awareness: Unlike message-centric products, DDS offers explicit application support for information lifecycle awareness. For instance, it detects, communicates, and informs applications about first and last appearances of data (topic instance) updates. This facilitates timely responses to new and outdated information.
- Trigger patterns: DDS offers a variety of trigger patterns that follow updates on subscribed information. Examples include polling, callbacks (typical for GUIs), and WaitSets (similar to UNIX® 'select') to provide full application control for prioritized handling of selective trigger events.

You can find more information on DDS and how it works at **portals.omg.org/dds/.**

"Getting four complex robots with very different designs to use a common data system was challenging. The Data Distribution Service for Real-Time Systems [DDS] standard supports very flexible service parameters. We found that we could adapt the middleware to the unique needs of each robotic system."

- Terry Fong, Director of Intelligent Robotics Group, NASA Ames

Why Choose DDS?

PERFORMANCE, SCALABILITY, ROBUSTNESS, AND QOS FOR INDUSTRIAL IOT AND CONSUMER IOT

The OMG DDS standard is a perfect fit for both the Industrial Internet of Things and large-scale Consumer IoT applications. It is already well-proven in mission-critical systems in industries ranging from smart transportation to healthcare to smart energy.

IS DDS RIGHT FOR YOU?

Based on the use of DDS in thousands of applications, we can predict the need for DDS in new projects. If you answer "yes" to all of the following questions, DDS is likely to be your go-to solution.

- Do you have latency, network bandwidth/throughput, or scaling issues because you measure latency in ms or less, or you have more than 10 different applications, or you have more than a thousand data items to share?
- If your system goes offline for 5 minutes (or even 5 ms), is it a serious problem? Or, do you struggle to configure, startup, or failover to backup servers?
- Are you building a system that will take more than a year to write, last more than three years, and is expected go through multiple versions or integrate with legacy applications?

These questions help identify your critical performance, reliability, and integration needs. If you answer yes to any of these questions, you should evaluate DDS as a solution, since it offers many additional benefits.

KEY ADVANTAGES OF CHOOSING DDS

The OMG DDS middleware standard helps users reliably and securely harnesses ever-increasing amounts of device-generated data while processing the data in real-time, and acting on events as quickly as they occur. As a result, it enables smarter decisions, new services, additional revenue streams, and reduced costs. The OMG DDS middleware standard can also simplify the development, deployment, and management of IoT applications, speeding time-to-market. It provides:

- Ease of Integration: The data-centric approach used by DDS allows the definition of common and extensible data models for seamless Information Technology (IT) / Operational Technology (OT) interoperability. Its loose and anonymous data-sharing abstraction completely hides connectivity and topology details from applications.
- Performance Efficiency and Scalability: DDS implementations can achieve point-to-point latencies that are as low as 30 µsec. and throughput of several million messages per second. It uses a very efficient wire protocol, content- and time-based filtering. When properly architected, DDS-based systems can achieve near-linear scalability.
- Advanced Security: The OMG DDS Security Specification defines a comprehensive Security Model and Service Plugin Interface (SPI) architecture for compliant DDS implementations. DDS provides standardized authentication, encryption, access control and logging capabilities to enable secure data connectivity end-to-end in an IoT system.
- Open Standard: The OMG DDS middleware specification is a mature, proven standard open to participation by both vendors and users. It enables end-to-end vendor interoperability and eases IoT system development and integration through fully open, future-proof APIs with no vendor lock-in.
- QoS-Enabled: A rich set of QoS policies allows DDS to control all aspects of data distribution, such as timeliness, traffic prioritization, reliability and resource usage.
- Scalable Discovery: For large-scale dynamic systems, DDS offers automatic discovery that provides plug-and-play functionality to simplify system integration and orchestration.
- Applicability: DDS can transparently address peer-to-peer, device-to-device, device-to-cloud, and cloud-to-cloud communication. Implementations are available for embedded, mobile, web, enterprise and cloud applications.

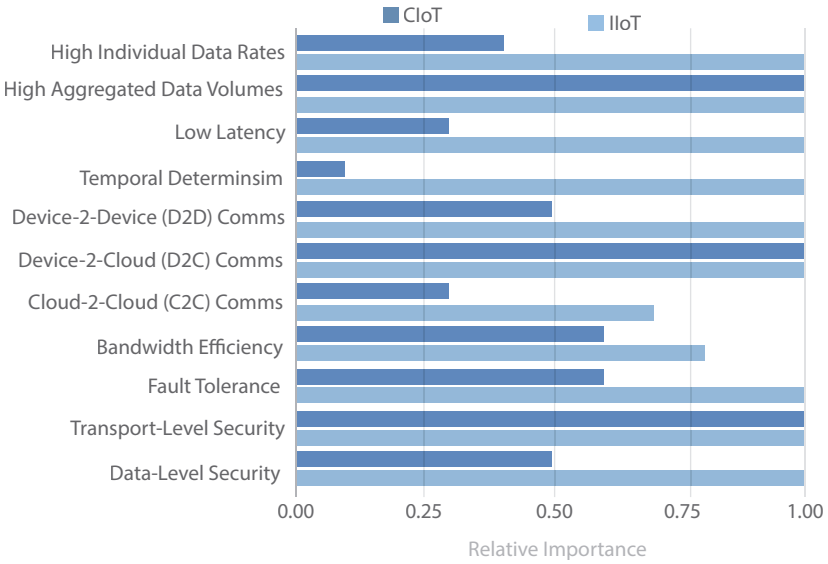
OTHER ADVANTAGES

- Programming language-, operating system-, transport- and hardware-independence
- Configurable redundancy for extremely reliable operation
- Multicast support for scalable data delivery
- Standard-wire protocol for seamless multi-vendor application interoperability
- Data selection and filtering to ensure efficient use of network and CPU resources
- Extensible data-type evolution for practical long-term architecture lifecycle
- Proven operation for mission-critical system building
- A future-proof international standard to eliminate proprietary stovepipes

How Does DDS Compare?

DIFFERENT INTERNETS OF THINGS

Applications designed for the Consumer Internet of Things and the Industrial IoT must be able to efficiently scale and securely share data. However, there are qualitative differences in system requirements for these two types of IoT applications:



Qualitative Comparison of System Requirements for Consumer and Industrial IoT Applications
Source: Cutter Journal December 2014

The Consumer and Industrial IoT share many of the same requirements. However, each requirement has a very different relative importance. For example, Industrial IoT applications must deal with high individual data rates. Single sources, such as an aircraft engine, produce high volumes of data. Consumer IoT applications don't usually deal with high individual data rates. However, all IoT applications must deal with high aggregated volumes of data.

> *"We were specifically interested in a data-sharing platform based on the Data- Distribution Service standard because of its proven performance, reliability and security."*
>
> - Fabio Cocchi S. Eiras, Project Director, ATECH – a subsidiary of Embraer Defense & Security

DIFFERENT PROTOCOLS

Several specialized messaging/data-sharing protocols are often considered for IoT applications, including:

- Message Queue Telemetry Transport (MQTT), a broker-reliant publish/subscribe messaging protocol designed to be used with TCP/IP
- Advanced Message Queuing Protocol (AMQP), which defines an efficient, binary, peer-to-peer protocol for transporting messages between two network processes (usually a client and a broker)
- Constrained Application Protocol (CoAP) is a software protocol that was designed to support the connectivity of simple low power electronic devices (e.g. wireless sensors) with Internet-based systems

The following table provides a comparison of the technologies listed above. A number of these IoT protocols were designed for simplicity and as such can support only a very limited set of use cases. DDS on the other hand, is a feature-rich standard that transparently handles much of an IoT system's data connectivity complexity, therefore, easing developer efforts.

	Transport	Paradigm	Scope	Discovery	Content Awareness	Data Centricity	Security	Data Prioritization	Fault Tolerance
AMQP	TCP/IP	Point-to-Point Message Exchange	D2D D2C C2C	No	None	Encoding	TLS	None	Impl. Specific
CoAP	UDP/IP	Request/ Reply (REST)	D2D	Yes	None	Encoding	DTLS	None	Decentralized
DDS	UDP/IP (unicast + mcast) TCP/IP	Publish/ Subscribe Request/ Reply	D2D D2C C2C	Yes	Content-Based Routing, Queries	Encoding Declaration	TLS, DTLS, DDS Security	Transport Priorities	Decentralized
MQTT	TCP/IP	Publish/ Subscribe	D2C	No	None	Undefined	TLS	None	Broker is the SPoF

TCP: Transmission Control Protocol **IP:** Internet Protocol **D2D:** Device-to-Device **D2C:** Device-to-Cloud **C2C:** Cloud-to-Cloud
TLS: Transport Layer Security **DTLS:** Datagram Transport Layer Security

Qualitative Comparison of IoT Standards

DDS: THE RIGHT CHOICE

Many real systems include devices, servers, mobile nodes, and more. They have diverse communication needs, but it's better—and easier—to use a single communication paradigm when possible. System designers should determine which of the protocols meets the primary challenge of their intended applications. Then, if possible, extend that primary choice to all aspects of the system.

For example, inter-device data use is a different use case from device data collection. Requirements for turning on your light switch (best with CoAP) are much different than the requirements for managing the generation of that power (best with DDS), monitoring the transmission lines (best with MQTT), or communicating power usage within the data center (best with AMQP).

DDS is the most versatile of these protocols. It can manage tiny devices, connect large, high-performance sensor networks and close time-critical control loops. It can also send and receive data from the cloud.

DDS communication is peer-to-peer. Elimination of message brokers and servers simplifies deployment, minimizes latency, maximizes scalability, increases reliability, and reduces cost and complexity. Using DDS does require building a data model and understanding data-centric principles. It is ideal for IoT applications that require a lasting, reliable, high-performance architecture.

DDS is the Data Connectivity Backbone for Europe's Next-Generation Air Traffic Control and Management Systems

CHALLENGE

Several independent studies from EUROCONTROL and the Federal Aviation Authority (FAA) are predicting that air traffic volumes will double by 2025. In addition to this volume increase, the Kyoto Protocol is imposing stronger regulation in terms of pollution, thus requiring more effective gate-to-gate air traffic control. Currently deployed Air Traffic Control and Management technologies are close to reaching their structural limit and are incapable of optimizing the gate-to-gate transit of aircraft. As a result, existing technologies will not be able to keep up with the predicted volume increases and will not be effective in optimizing gate-to-gate operations and thus reducing pollution and improving the overall performance of the ATM system.

SOLUTION

The CoFlight Program, headed by THALES, SELEX-SI, DSNA, ENAV and Skyguide, has developed a next generation Flight Data Processing (FDP) System, which fully in line with the Single European Sky ATM Research (SESAR) objectives, will reduce the environmental impact of aviation, improve flight cost efficiency, and optimize the airspace usage.

CoFlight has embraced open architecture principles and is built on a standard middleware infrastructure. One of the core technologies at the foundation of CoFlight is the Object Management Group's Data-Distribution Service for Real-Time Systems (DDS). Leveraging DDS has allowed the CoFlight Program to achieve these objectives.

BENEFITS

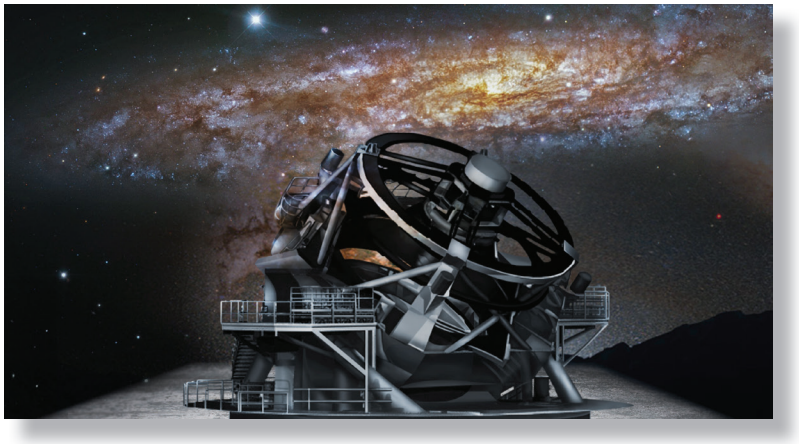
CoFlight deals with well over 6GB of flight data plans which are cached and persisted by DDS. In this use case, DDS is used as a symmetric distributed cache, providing low-latency access for flight plans to FDP servers. DDS also takes care of persisting changes to hundreds of flight data plans per second.

Along with posing some unique technical challenges, the FDP Servers are SWAL-2 (Software Assurance Level 2) components—one of the most critical elements of the entire FDP System. Thanks to its industrial strength development process, the DDS implementation used on the program was capable of providing evidence to allow the CoFlight consortium to qualify the use of DDS in SWAL-2 components.

DDS is used within CoFlight to distribute real-time updates to the Controller Working Positions (CWP)—which in some centers can add up to several hundred. The CWPs are able to customize the presentation of information available taking advantage of the advanced filtering and query capabilities available in DDS.

DDS is also used to allow different CoFlight systems, deployed within or across nations, to interoperate. In this case DDS takes care of distributing in real-time, with high reliability, efficiency, and scalability the flight-data-plans across a Wide Area Network (WAN). As EUROCAE, in the EC-133 standard, has mandated the use of DDS for exchanging flight data plans across European air traffic control centers, DDS will also be used to enable interoperability with non-CoFlight-based ATC/ATM centers.

Mission-Critical DDS Deployed in One of the World's Most Powerful Telescopes



CHALLENGE

The Large Synoptic Survey Telescope (LSST) project is an historical attempt to draw the first 3D map of the universe.

The project is organized by the Association of Universities for Research in Astronomy (AURA) and funded by the U.S. Department of Energy and the National Science Foundation with support through a public-private partnership featuring an immense collaboration of countries, companies and universities, including more than 400 scientists and engineers.

The eight-meter-wide giant telescope will sit atop the Chilean mountain of Cerro Pachón, and will work in tandem with the world's largest digital camera, weighing in at more than 6,000 pounds and snapping 3.2-gigapixel images every 20 seconds as it surveys the stars and generates 30 terabytes of data night after night for 10 years.

In the case of LSST, over 96-percent uptime over a 10-year period is required to ensure there are no risks to the $500 million program investment and no corruption of experiment data during this timeframe.

SOLUTION

The Object Management Group's Data-Distribution Service for Real-Time Systems is being used to control, monitor and regulate the data interfaces and ensuring the right data gets to the right place in real-time within the new LSST facility. DDS was chosen to process data on a colossal volume in an attempt to scale the universe generating over 30 terabytes of data 24/7.

The data that DDS is set to handle will come from the largest light-gathering source in the world. The LSST will zero in on some of the faintest objects in the sky and populate a database containing 20 billion objects. Beyond the pure science aspect of the project, scientists will also use LSST to track asteroids and determine whether they pose any impact threat to the earth.

The depth and detail of the incoming information will facilitate creation of a 3D map of the cosmos. LSST will also give scientists a better understanding of the solar system beyond Neptune, including distant objects in the Kuiper Belt and beyond.

BENEFITS

For LSST, it is critical that the applications do not handle the data. DDS was used to help simplify overall system design. Without DDS, the developed applications would have to shoulder the tasks of message interpretation & state management, and the team developing the data-sharing functionality of the system would have been three times larger.

A common characteristic of DDS applications is mission-criticality, an attribute inextricably tied to a system's intolerance for failure. Since the data-sharing infrastructure impacts all aspects of a system, its reliability, robustness and fault-tolerance become synonymous with operational success. DDS' real-time monitoring and predictive capabilities will ensure the survey does not suffer disruptions in its cosmic explorations, securing the data, its quality and the entire equally-massive investment.

DDS Powers Siemens Wind Power

CHALLENGE

Siemens Wind Power, the world's leading manufacturer of wind turbines, standardized on DDS-based messaging software for their next-generation turbines to deliver resilient, high-performance and scalable data distribution.

A wind farm may include hundreds of turbines, often installed in distant and hard-to-access locations at sea. Like all power systems, the goal of the farm is to match generation to load. A farm with hundreds of turbines must optimize that load by balancing the loading and generation across a wide geography. In a storm, the farm must decide how to take energy out of gusts to generate constant power while managing the loading and potential damage to a half-billion dollar installed asset. The wind farm thus needs to implement a highly scalable and distributed control system, where reliability and performance are critical.

Siemens identified several fundamental requirements that led them to the selection of DDS. First, the control systems within the giant turbine, itself a complex machine, required high-performance real-time networking. Second, the farms produce copious amounts of data; a farm of 500 turbines may have up to a million data points. Third, Siemens deploys wind power solutions in environments where network services may vary from fast LAN to mid-range broadband to slow wireless or satellite communications. Fourth, the entire farm must be controlled, managed, and maintained from remote monitoring stations.

SOLUTION

Siemens Wind Power uses DDS to build a scalable, high-performance operational network and integrate it with business intelligence software. DDS-based messaging software can monitor and control wind farm arrays with up to 500 wind turbines. The real-time messaging and quality of service features of DDS enable Siemens to manage turbulence through the wind farm so that performance and wear is uniform in such a highly distributed operational environment. Additionally, the ability of the standard to be integrated with other systems, including business enterprise applications, allows Siemens to remotely monitor and troubleshoot the wind farm's operations. The ability of the solution to run over a variety of different network transports helps Siemens build large farms and intelligently integrate them over multiple heterogeneous networks. In the future, the DDS system-of-systems flexibility and scalability will allow connecting multiple farms and business systems.

BENEFITS

Real-time messaging and QoS features of DDS help control large wind farms and manage dynamic effects like turbulence to optimize performance and wear. Integrating with on-shore business infrastructure allows key efficiency benefits such as predictive maintenance. Overall, the unprecedented edge-to-enterprise connectivity gives Siemens a competitive edge by combining the highest possible performance with ease of control and business systems integration.

Duke Energy Leads Standardization of a New Interoperability Framework for its Microgrid Reference Architecture

CHALLENGE

Traditional central-station power grids operate on 15-minute output update cycles that result in operators over-generating power to compensate for variation in power generation or demand. To efficiently integrate distributed energy resources, the grid needs fast-reacting intelligence at the edge.

SOLUTION

Duke Energy is committed to distributed intelligence and establishing a grid that is more simple and cost-effective to operate. The company partnered with 25 utilities, vendors, research labs and government agencies to form the Coalition of the Willing (COW-II). The goal of the Coalition is to lead the development and commercialization of a field device interoperability framework, known as the Open Field Message Bus (OpenFMB™).

This framework is a standards-based solution to reduce implementation complexity and integration costs and was formally adopted by two task forces within the Smart Grid Interoperability Panel (SGIP) and the North America Energy Standards Board (NAESB).

BENEFITS

The Coalition has demonstrated there are alternative ways to achieve enhanced microgrid operations. The microgrid test bed exhibits a diverse set of technologies that all communicate in the Data-Distribution Service (DDS), Message Queue Telemetry Transport (MQTT) or advanced message queue protocol (AMQP) open IoT pub/sub protocols, including the following assets:

1. 100-kW PV solar system with smart inverter capabilities
2. 250-kW battery energy storage system
3. 10kW solar carport with EV charging capabilities
4. 500-kW automated resistive load-bank
5. Instrumented and automated distribution grid equipment, such as reclosers, smart meters, sensors and PMUs
6. Wireless devices, supporting Wi-Fi, 4G LTE, 900 MHz RF and AMI Mesh
7. An envision room with appliances and smart breaker monitoring and control capabilities
8. An operations room with commercial application software to monitor and control the microgrid components

This project has offered a transferable test harness and validated baseline for the upcoming utility test beds at CPS Energy, Southern California Edison, EPRI, NREL, Oak Ridge Labs and other utilities and national labs that plan to implement the OpenFMB reference architecture.

Ulstein Builds Distributed Monitoring and Control with DDS

CHALLENGE

Ulstein has developed control systems for the maritime sector for decades, and are continuously seeking to improve their solutions and products to solve the demanding challenges their customers face. Their search for an improved control system platform led them towards the Data-Distribution Service. Find how their use of DDS simplifies both system architecture, development and testability.

The technical challenges Ulstein met while implementing existing middleware on a large-scale automation system forced them to think in a new direction. With about 100 integrated automation systems for ships delivered the last decade, all based on SCADA / PLC platform, Ulstein needed to change and open up their architecture. All issues regarding old versions, compatibility issues, dying support of various software platforms required a new solution. In addition Ulstein saw that the number of signals or I/Os were increasing rapidly, causing engineers to spend too much time in tuning and making SCADA platform work with all details and the risk/time in critical parts of projects during commissioning were not acceptable. The question was on how the company could reduce complexity of large-scale control systems. The Ulstein engineers were looking for a solution that would be based on open standards and open software, vendor-neutral and not bundled with hardware.

SOLUTION

Quite early in the development project one of Ulstein engineers looked at middleware options for large and safety-critical systems and discovered the DDS standard. In the beginning, Ulsten kept the middleware—they had for a while, and only implemented DDS as a replacement of their JASON implementation for controller – GUI communication. Then the company implemented DDS as the central backbone for communication between GUIs, controllers and IO Controllers with a range of fieldbus connections.

BENEFITS

Now Ulsten engineers spend less time in development and testing, as DDS tackles large numbers of signals, components and physical devices and it is proven technology with reliable support. This also enabled the company to implement a simple, vendor-neutral architecture with low-cost hardware for a large safety-critical control system. Having a standardized software solution with DDS implementation also saved Ultsen time and costs for developing their new integrated automation platform on top of the same DDS architecture. The adoption of DDS opened up an endless range of opportunities for what Ulsten can build on this platform.

The Future of DDS

DDS has proven to be an effective standard to reduce the complexity of designing and integrating large scale mission- and business-critical distributed systems across a large variety of application domains, such as Defense and Aerospace, Transportation, Telecoms, Industrial Automation, and Energy.

The rise of the Internet of Things (IoT) has given DDS even more allure. Few other standards—if any at all—are so ubiquitously applicable to address the challenges of securely, efficiently, and transparently sharing information at any scale and in very heterogeneous computing and communication environments.

As a result, in the near future we will see DDS playing an increasing role as the underlying fabric—in a sense the nervous system—of IoT applications, especially in Industrial applications, such as Smart Grids, Smart Transportation, Smart Cities and Smart Factories.

Additionally, upcoming standards such as the eXtremely Resource Constrained Environments (XRCE) DDS will expand DDS' applicability to very constrained targets, i.e. with less than 100KB of total RAM, connected by constrained networks such as LoWPANS. XRCE DDS is due to provide the most efficient way for providing connectivity to these constrained devices, such as smart sensors or smart lightbulbs, minimizing computation and communication overhead.

In summary, DDS is already a very successful standard powering an incredible number of systems. In the near future we will see an acceleration in the adoption of DDS due to the rise of the IoT. Additionally, upcoming standards such as XRCE-DDS will expand DDS' applicability to "extremely small things", thus creating by far the most applicable standard for IoT end-to-end and setting the premises for a massive adoption at a device level.

> *"PrismTech has been involved with defining and evolving the DDS standard since its very early days. This has been an amazing journey, yet only a few steps toward achieving the full potential of the standard. The acceleration in adoption and its growing role as the data-sharing standard for the IIoT have the potential for making DDS an incredible success story."*
>
> - Dr. Angelo Corsaro, Chief Technology Officer,
> ADLINK Technology Inc., Chief Technology Officer, PrismTech

DDS Vendor Listing

eProsima is a company focused on high performance middleware. The company helps design distributed systems covering all the areas impacting communications: the middleware technology to choose, the data model, the Quality of Service for the different data flows, the data links, how to test the systems, etc. For more information, please visit **www.eprosima.com**

Kongsberg Gallium develops high-performance geospatial visualization and Command and Control solutions for critical applications where it's necessary to track the locations of thousands, or even hundreds of thousands of objects in real time with a high degree of precision. For more information, please visit **www.kongsberggallium.com**

MilSOFT is the first company in Europe to achieve CMMI Level 5 and still holds this level. MilSOFT's product lines cover the areas of ICT solutions such as Network Enabled Capability, Homeland Security, Crisis/Emergency Management, Logistic Lifecycle Support & Maintenance Management, Cyber Security; and real-time applications such as C4ISR, Tactical Data Links, Image Exploitation Systems, Electronic Warfare, Cyber Security, and Embedded Solutions. For more information, please visit **dds.milsoft.com.trs**

OCI builds high performance, real-time, mission critical middleware systems and integration solutions. Its goal is to make solutions more open, scalable, reusable, interoperable, and affordable. For more information, please visit **www.ociweb.com**

PrismTech customers build system solutions for the Internet of Things, the Industrial Internet and advanced wireless communications. PrismTech's Vortex Intelligent IoT Data Sharing Platform provides an open source and commercial implementation of the Data Distribution Service (DDS). Vortex is an efficient, proven solution for mission- and business-critical real-time device, edge (Fog) and cloud IoT data sharing delivering the right information to the right place at the right time. PrismTech is a recognized leader in IoT platform technologies with recent accolades including Gartner 'Cool Vendor', Postscapes 'Must-Follow IoT Company', Sandhill 'Needle Mover', and IoT Nexus 'Power Player'. For more information, please visit **www.prismtech.com**

Real-Time Innovations provides the connectivity platform for the Industrial Internet of Things. Its RTI Connext® messaging software forms the core nervous system for smart, distributed applications. RTI Connext allows devices to intelligently share information and work together as one integrated system. RTI was named "The Most influential Industrial Internet of Things Company" in 2014 by Appinions and published in Forbes. For more information, please visit **www.rti.com**

Remedy IT is a software company specializing in developing and supporting communication middleware and component technologies. It supplies software solutions and support to many industry domains (including banking, chips manufacturing, chemical industry, traffic control, telecommunications, defense, etc.) based (whole or partly). For more information, please visit **www.remedy.nl**

Twin Oaks Computing, Inc. is a company dedicated to developing and delivering quality DDS software solutions. We build the software that collects, manages, and distributes information in a wide range of industrial, commercial, and defense industries. Our CoreDX DDS middleware technologies are integrated into real-world, mission-critical and complex information systems both here on earth and in space. For more information, please visit **www.twinoakscomputing.com**

To be listed in OMG's DDS Vendor directory go to:

dds-directory.omg.org/vendor/

DDS RESOURCE PAGE

About OMG

The Object Management Group® (OMG®) is an international, open membership, not-for-profit technology standards consortium with representatives from government, industry and academia. OMG Task Forces develop enterprise integration standards for a wide range of technologies and an even wider range of industries. OMG's modeling standards enable powerful visual design, execution and maintenance of software and other processes. Visit www.omg.org for more information.

Get involved in the DDS Platform Special Interest Group (PSIG)

If you are interested in getting involved with this group, want more information or would like to come as a guest to an upcoming meeting and obtain temporary access to the mailing list, please email an account representative at bd-team@omg.org or call + 1-781-444-0404.

Data-Distribution Service Portal

The Portal is designed as a resource hub for the DDS community and provides access to detailed information including: technical overview and benefits of using the DDS standard, use-cases, listing of companies that are building systems with DDS, directory of resources and vendors, news and events, and links to the latest DDS-related standardization work at the OMG. For more information, please visit: portals.omg.org/dds.

Want to learn more?

We are happy to discuss how OMG membership will benefit your organization! Please feel free to explore our website at www.omg.org and when you are ready, please contact bd-team@omg.org or call + 1-781-444-0404 to get started.

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