

OpenSplice DDS for IIoT Systems

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Innovation shapes the vision.

Hard work brings it to life.

Determination turns it into success."

— ZettaScale Technology

About ZettaScale

ZettaScale's mission is to bring to every connected human and machine the unconstrained freedom to communicate, compute and store — anywhere, at any scale, efficiently and securely. We strive for excellence as engineers and humans -- we firmly believe that we can't separate "the engineer" from "the human". As such we embrace and promote the Seven Knightly Virtues of Courage, Justice, Mercy, Generosity, Faith, Nobility and Hope.



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OpenSplice DDS is part of the ZettaScale DDS offering - it is a fully featured DDS implementation targeted for enterprise platforms and devices. It is designed for interoperability across the broader ZettaScale DDS product portfolio. The OpenSplice DDS product offering is made of the Core offering and a set of commercially available add-ons and extra features. The OpenSplice DDS Core is a full implementation of the Object Management Group (OMG) Data Distribution Service for Real-time Systems (henceforth DDS) rev1.4 standard (DCPS profiles) and the OMG-DDSI-RTPS v2.3 interoperable wire-protocol.

1. Introduction

Since the emergence of the Industrial Internet and the Industrial Internet of Things (IIoT) as major technology trends in the early 2010s, there has been extensive discussion about the technologies, protocols and standards used to build connected industrial systems. Much of this discussion has focused on the communication and messaging technologies that address the integration challenges of an increasingly connected industrial and business-critical application landscape.

Rather than relying on a single “silver bullet” protocol, real-world IIoT systems typically employ a combination of technologies, with different protocols providing different capabilities at different layers of the system architecture. This reflects both the need to integrate existing and legacy technologies and the practical reality that different parts of an industrial system have different communication, performance, interoperability and operational requirements.

This paper provides an architectural perspective on the role of the Object Management Group (OMG) Data Distribution Service (DDS) standard in IIoT systems. It examines how DDS can be used to provide machine-to-machine (M2M) real-time data sharing and integration across complex industrial environments.



2. IIoT and the Industrial Internet

The IIoT is an important part of the wider IoT that targets industrial and business critical systems composed of thousands of sensor enabled devices connected over real-time M2M networks. The Industrial Internet can be viewed as the connection of machine sensors and actuators to local processing and to the Internet. In many cases this involves onward connection to other important networks of machines and people that can independently generate value. The IIoT represents a convergence between machines, low cost embedded sensing technologies, advanced analytics software and Internet connectivity.

The growing proliferation of smart connected intelligent devices is driving the Industrial Internet. This in turn is enabling business to harness the ever-increasing amounts of device generated data, process the data in real-time and act on events as quickly as they occur to drive smarter decisions, enable new services, create new revenue streams and reduce costs.

Computerized machine and process control in a distributed environment is nothing new although historically these systems have relied on centralized management systems. However, with the availability of both centralized and edge-based or distributed information management systems combined with the ability to integrate the capabilities of a number of previously autonomous devices using IP network technologies, this is driving a whole world of new opportunities for industrial devices to collaborate and coordinate their activities, to improve efficiency, support new process models and enable businesses to generate value.

This revolution is naturally driving the need for much tighter integration between Information Technologies (IT) and Operational Technologies (OT). To do this as efficiently as possible the use of both existing and potential new standards to facilitate much greater levels of interoperability between systems and systems-of-systems will be required otherwise integration costs will balloon.

Other key factors for the successful implementation of this new generation of IIoT systems will include the use of Internet connectivity, local data access, the support for distributed information processing combined with advanced analytics, advanced network management and an end-to-end approach to security.

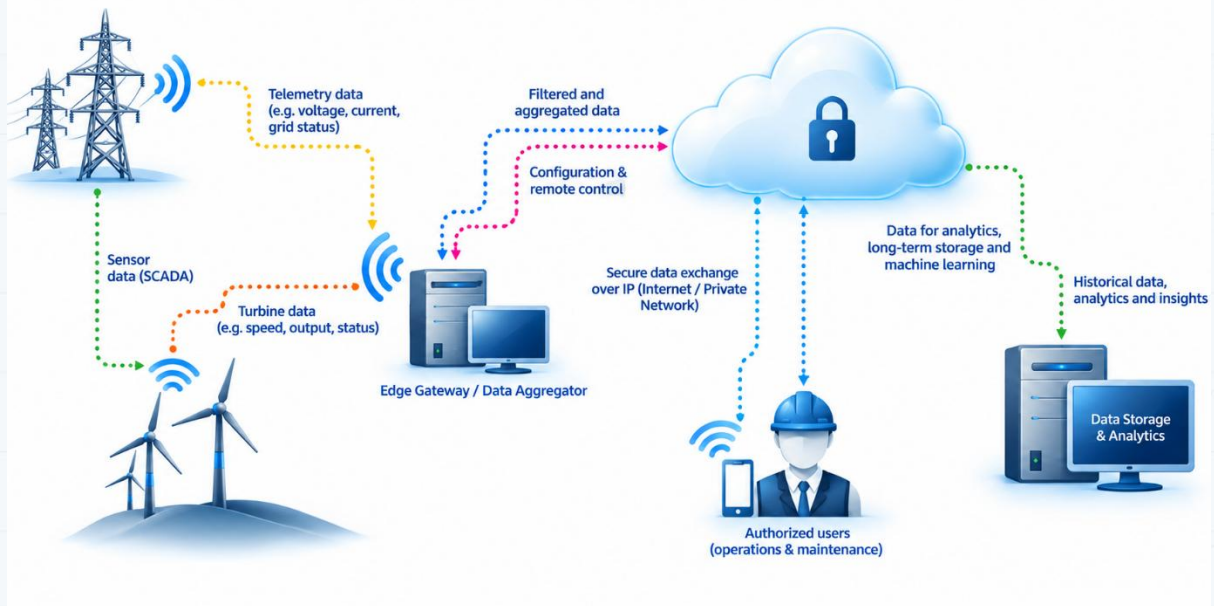


Figure 1 – Access to Real-time Information is Critical in IIoT

In IIoT application domains such as smart power grids or other types of large scale utility management system the integration of the different operational systems has traditionally been via back office centralized management infrastructure. Traditional utilities technologies and their data are often siloed and based on proprietary hardware from different vendors, using many different protocols, software and telecommunication technologies to make the data available to the centralized information systems.

The next generation of industrial systems will need to adopt new approaches to the integration of distributed devices and equipment from many different manufacturers to realize operational benefits. In the power sector for example, existing systems that were designed to support a small number of large generation facilities will be faced with the need to integrate an increasing number of distributed energy resources (DERs), such as wind, solar and electricity storage into existing power generation and distribution networks.

The IIoT offers the potential for industry to move from siloed, single function and proprietary centralized managed systems to new multi-function distributed systems with fully integrated co-ordination with the centralized systems.

3. IIoT Real-time Data Integration Challenge

In order to leverage the expected benefits that the IIoT will deliver to industry, particularly to the operational efficiency of systems, IIoT software architectures must be designed that can leverage the large volumes of actionable data from both the new generation of smart machines / devices and legacy equipment.



This will require a layered architecture, built using a range of software, network and telecommunication technologies. The heterogeneity of devices, machines and systems already deployed using different software stacks and a plethora of communication protocols, will require the use of new interoperable technologies and an architecture that can support the unification of the legacy protocols. This can be achieved by the means of a new generation of sophisticated protocol bridges that can translate device data produced in different formats into a unified representation that can be processed by the distributed control systems. The resulting data / decisions produced as the output of this analysis can be shared in real-time across device Local Area Networks (LANs) and the centralized control systems.

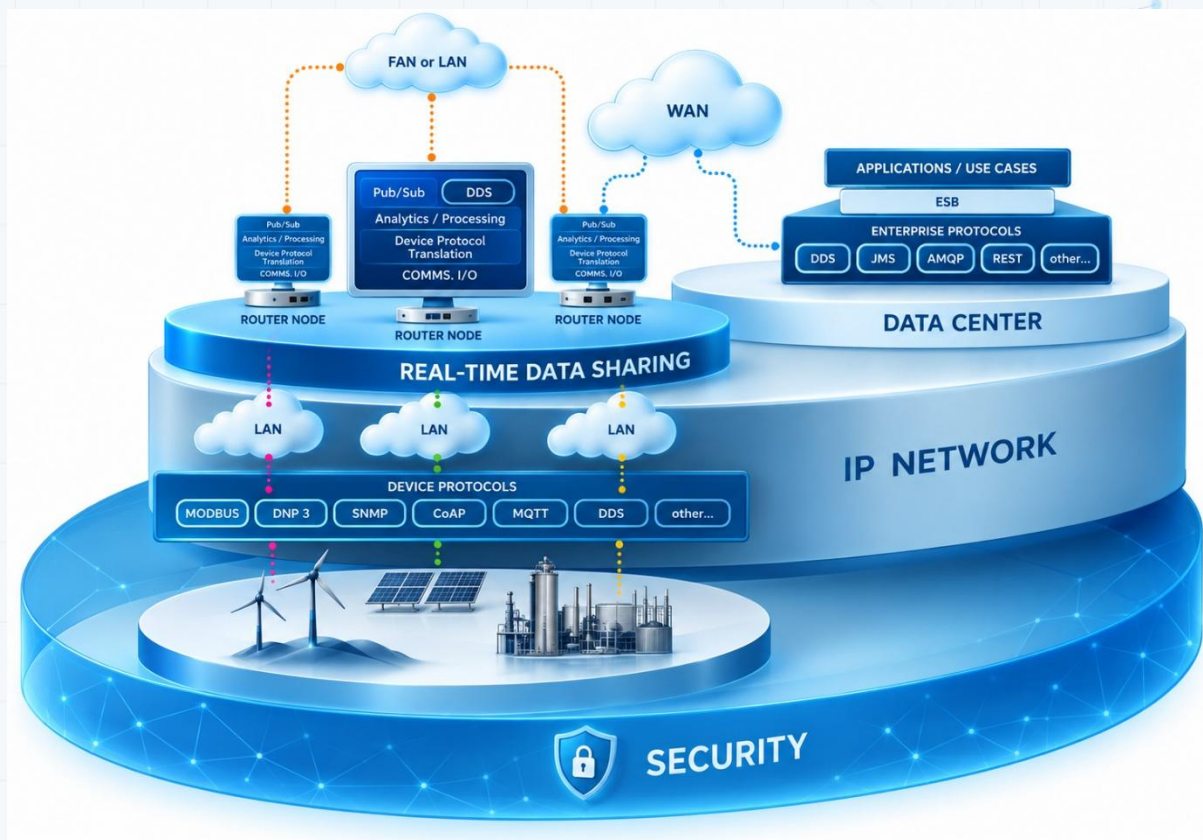


Figure 2 – Layered IIoT System Architecture

DDS implementations, including ZettaScale's OpenSplice DDS Intelligent Data Sharing platform, are already being used very successfully in this scenario to provide a high-performance, resilient, secure and interoperable real-time data-sharing layer. DDS can be used to unify M2M co-ordination for the edge device networks while at the same time making important real-time data available to the centralized systems, as well as feeding centralized control decisions back down to the devices. The ability to process data at the edge and share control decisions in real-time across device networks that were previously isolated from each other, in a coordinated way, is where the real value of the IIoT is being gained and DDS is a key enabler of this capability. As illustrated in Figure 2, DDS can also be



used to send and receive data from the actual devices themselves and in this case no protocol translation is required at the router nodes and data can be shared directly with other nodes, reducing communication latency and improving system responsiveness and performance.

At the highest level of the architecture are the data centers hosting the centralized information management systems. These systems use a different set of enterprise computing and software technologies to support the applications running at this layer. In order to leverage the new flows of real-time device data propagated upwards from the equipment, the centralized systems need to connect into the real-time information feeds from the layers below. In most cases this requires connectivity over a Wide Area Network (WAN). Protocol translation is typically required again to share data from the DDS real-time data feeds and forward the information to the applications using an Enterprise Service Bus (ESB) for processing and possibly offline storage. Centralized control decisions will also flow back down to device networks via the DDS real-time data sharing layer. If the applications are already using DDS as part of their enterprise infrastructure then no protocol translation will be required and additional performance benefits realized.

4. Why DDS for IIoT Systems?

DDS was originally developed for aerospace and defense applications and has been used successfully for many years in large scale, real-time distributed systems. In recent years it has been used in other commercial application domains such as power grid management, industrial automation, transportation management, smart cities and healthcare.

DDS is based on a data centric publish and subscribe model and enables large numbers of distributed applications to share information with each other asynchronously and in real-time.

DDS provides a comprehensive Quality of Service (QoS) framework that allows applications to control important characteristics of data communication, including reliability, durability, resource usage, deadlines, liveliness and ordering. These policies allow applications to tailor data-delivery behavior to the requirements of the system.

The rich set of QoS provided by DDS enables users to tune the communication behavior of the system intelligently to meet specific requirements. These include being able to specify how long data is available for future use, whether data exchanges are reliable or best effort, the ordering of data presented to an application and whether the data is exchanged as part of a wider transactional context.

DDS also provides mechanisms for efficiently managing and distributing large numbers of related data streams. Content-based filtering and QoS policies allow applications to receive the data they require while reducing unnecessary data processing and network traffic. DDS's data-centric model also supports the distribution of current data state to applications as required by the system.



The DDS standard defines the Data-Centric Publish-Subscribe (DCPS) layer together with APIs and programming-language mappings. OpenSplice DDS provides support for multiple programming languages, enabling applications to use standardized DDS APIs across different development environments.

The DDS standard also defines a wire protocol, the DDS Interoperability Wire Protocol, referred to as DDSI. DDSI was designed for real-time systems and is a binary protocol with a very efficient and compact encoding that enables different DDS implementations to interoperate with each other, helping to reduce system integration and costs, as well as preventing vendor “lock in”.

DDS also supports automatic “Discovery” that allows DDS nodes to declare the information that they can provide or what data they would like to receive. Once discovered, publishers and subscribers can communicate directly without requiring a centralized message broker. This significantly simplifies the process of configuring systems with many devices exchanging data. It also enables Industrial Internet systems to evolve more easily by providing plug-and-play support for devices joining the network at a point in the future. This capability can have significant benefits for large complex IIoT projects, enabling the systems to evolve dynamically and efficiently and minimizing integration costs.

In order to build a trusted IIoT system DDS provides a standardized security architecture that allows applications to protect their communications, manage authentication and access control to resources in systems that may consist of thousands of devices, supporting the integrity and confidentiality of data in the system.

5. OpenSplice DDS: The State of the Art in Data Sharing and Integration

Zettascale's OpenSplice DDS is based on the DDS standard and supports the real-time data-sharing requirements of complex IIoT systems.

OpenSplice DDS enables applications to securely share real-time data across a variety of platforms and network environments. This includes data sharing between devices (device-to-device) on the same LAN and data sharing between devices and cloud-based data centers (device-to-cloud). OpenSplice DDS supports interoperable data sharing across a broad range of computing and application environments, including server, embedded, web and mobile platforms.

OpenSplice DDS also includes a suite of development and diagnostic tools that helps IIoT system developers design, develop, test, debug, tune, monitor and manage DDS-based systems and systems of systems.

OpenSplice DDS provides standardized DDS APIs and development tools that enable applications across edge-based OT and enterprise IT environments to exchange and



integrate real-time data. Its open DDS architecture supports integration with a broad range of application frameworks, analytics systems and other enterprise technologies.

6. Conclusion

The deployment of both centralized and edge-based distributed management systems is opening up a whole new world of opportunities for improved efficiency, new business models and value creation for industrial systems. This in turn is driving the need for a tighter integration between IT and OT. Implementations of the DDS standard are being used successfully to provide a unified integration and real-time data sharing layer between the device networks, distributed processing nodes and centralized information management systems.

ZettaScale's OpenSplice DDS is an advanced suite of technologies based on the DDS standard providing device-to-device and device-to-cloud support for IIoT systems requiring high-performance, secure, reliable and interoperable real-time data sharing.



Notices

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References and For More Information

For further information regarding OpenSplice DDS, please e-mail: contact@zettascale.tech or visit: www.zettascale.tech



OpenSplice DDS

DATA-CENTRIC MIDDLEWARE FOR MISSION-CRITICAL SYSTEMS



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