WHITEPAPER

How To Gain Visibility and Collaborative Control over Distributed Energy Resources (DERs)

INTRODUCING A STANDARDS-BASED, DATA-CENTRIC APPROACH
FOR UTILITIES TO CREATE AN INTEROPERABLE ECOSYSTEM OF DERS

EXECUTIVE SUMMARY

The energy sector is undergoing an unstoppable disruption in traditional power generation sources and processes. For over a century, the industry has owned energy generation plants. Now, power generation from Distributed Energy Resources (DER) sourced from solar, wind, natural gas and water are increasingly supplementing (and even replacing) these power plants. Hundreds, thousands, and even millions of DER endpoints are entering the market and connecting to the grid.

Many utilities view this as a welcome new business model and opportunity. DERs have the potential to demonstrably affect the economics of power production; research from Navigant predicts a 12% compound annual growth for DERs from 2015 to 2024.[1]

In addition to the economic impact, DERs also upend the monolithic "hub and spoke" operations model that utilities have used for over a century. DERs are highly decentralized and consist of an extremely large number of endpoints, ranging in size from individual homes to large scale wind farms.

Today, the vast majority of DERs are grid-connected but for the most part, are not owned by the utilities. This is a sea change for the energy industry: The ownership and power is, literally, shifting. Even utilities that have not yet incorporated DERs must prepare for their impact. As the numbers increase, so too does the need to monitor and control these grid assets. In addition, there is a growing opportunity and need for regional coordination of the assets.

Incorporating DERs into the grid requires a new level of integration of new and legacy equipment. Utilities need a technical solution that integrates dynamic, dispersed DERs and provides secure interoperability to legacy systems without disrupting them.

This paper discusses how utilities can use data-centricity and a software databus to mesh the old with the new. This approach is based on the well-established Data Distribution Service™ (DDS) set of standards, which is used by industrial companies to solve problems exactly like the challenges that DERs present in the era of the Industrial Internet of Things (IIoT).

INCORPORATING DATA THAT PLAYS BY DIFFERENT RULES

Changes are occurring on the traditional electric grid. One change that is rapidly gathering steam is the emergence of DERs. A DER is any resource on the grid that produces electricity and doesn't fit the formal NERC definition of the Bulk Electric System (BES).[2]

DERs are becoming a more persistent and increasingly urgent topic with external policy makers and consumers. This sense of urgency is based on multiple factors, including:

- Local and global interest in clean, renewable energy production
- Improved economics for renewable energy sources, which are often more cost effective than fossil fueled generation
- The demand for increasing transparency for energy consumption data by technology-savvy consumers
- A shift in economics due to rising costs of traditional power generation (fuel costs, etc.)

These factors are making DERs more attractive and inevitable, yet there are hurdles to widespread adoption.

One major consideration is that the majority of DERs are not owned by utilities. They contribute energy to the grid, but the utility has limited ability to see or control these individual power generation sources. DERs are proliferating at a rate that no one can accurately predict. Therefore, it's difficult for utilities to predict the impact on their operations.

As in any industry, there are forward-thinking companies that are boldly embracing new business models and approaches. There are also utilities that continue to take a wait-and-see attitude toward DERs. Regardless of how utilities are individually approaching DERs, one thing is clear: The industry is rapidly moving beyond questions of "if" to "how."

Integrating data provided from DERs into decades-old legacy systems presents numerous technical challenges. As shown in Table 1, DERs are largely incompatible with traditional utility systems and processes. If utilities can manage or neutralize these differences, all of the necessary information can be visible. Gaining visibility is the first step to convert DER data into actionable information.

Legacy Utility Systems and Processes	Third-party DERs
Data* sources are owned and controlled by the utility	Data sources are owned and controlled by the third party (e.g., campus, landowner)
Data is collected from a known number of endpoints	Data is generated by a number of endpoints that is exponentially larger than the number of traditional endpoints
The type and volume of data is predictable	The type and volume of data is dynamic and unpredictable
All data is presented in a consistent format that utility systems can understand	Third party applications speak different languages, run on different platforms and transport mechanisms, use different versions of operating systems
Information is secure	Security of information is unknown
** Note: for the purpose of this whitepaper, the term "data" is used interchangeably with "information."*	

Table 1: Data from Legacy System and DERs Operate by Different Rules

USING AN INDUSTRIAL STANDARD TO CREATE A "PLUG-AND-PLAY" (PNP) DER ECOSYSTEM

As described above, and in terms of volume of discrete endpoints, DERs already outnumber traditional energy-generation sources. These endpoints are also likely to be incompatible with traditional systems in terms of protocol, platforms, operating systems and more. In short, they simply don't have the characteristics to act like traditional utilities systems and fit neatly into the traditional hub-and-spoke model.

Utilities can't afford a lengthy hand-holding process to connect and integrate each new DER that connects to the grid. PnP functionality — such as users experience when purchasing a new mobile phone today (very automatic) — will be necessary. Further, instead of working with individual DERs, utilities should look at developing a holistic collection of DERs as an ecosystem. An ecosystem is usually characterized by diversity. It is also dynamic, constantly growing and changing. This certainly fits the characteristics of DERs.

For utilities, the technical challenge is to create an ecosystem of DERs that can easily interoperate with traditional systems and processes. With PnP capabilities, utilities can onboard new DERs automatically and at scale. The data generated from the DERs — such as energy produced, frequency, voltage, etc. — can then be collected, analyzed and utilized by traditional systems.

This requires a new communications framework to handle the flow of data between the expanded ecosystem and legacy systems. This data-centric framework - new to utilities - is based on DDS, the highly-reliable industry standard that manages communications of disparate, high-volume endpoints that define the Industrial Internet of Things (IIoT).

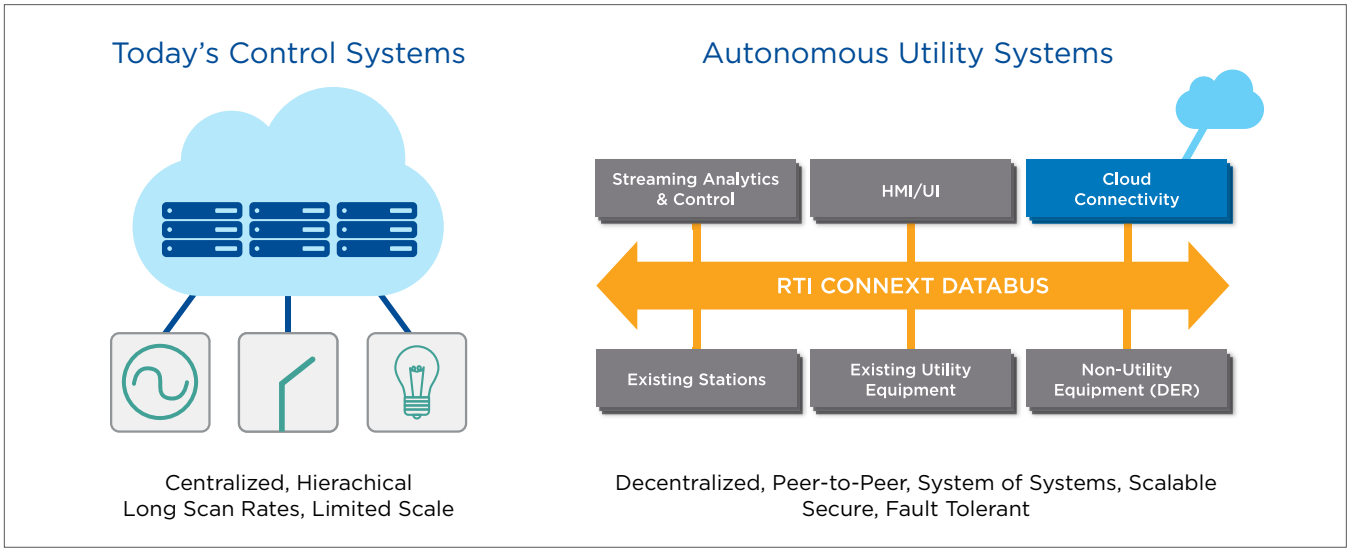

Figure 1: Architectural comparison of traditional vs. autonomous utility systems. The databus is the structure that enables disparate DERs to work together as an integrated ecosystem. The databus enables independent DERs to function as a secure, scalable and cohesive ecosystem.

Developed by the Object Management Group®, DDS is widely deployed across multiple industries under the IIoT. DDS provides a proven way to manage high volumes of data for industrial applications, through an open integration data-centric framework for software applications. It is proven and used in thousands of deployed use cases, ranging from robotics in healthcare to autonomous vehicles. With its heritage in reliability and security, combining intelligent software with DDS serves as both a control bus and edge-to-cloud connectivity framework.

THE BENEFITS OF DATA-CENTRICITY AND THE SOFTWARE DATABUS

As illustrated in Figure 1, a data-centric communications architecture connects DERs to the databus, not to each other, using a publish/subscribe process. The data is gathered from the different DER (both utility owned and not) and shared on the connected DDS databus. In turn, databuses can be layered and data can be routed while fully secured, to the appropriate databus. [See 'Prioritizing Data' section below.] From there, it is available on utility owned/run computers for analysis. The DDS architecture protects the legacy systems from externally-generated data, through a series of publish/subscribe rules and security protocols. It also protects the utility from an overload of data. In a data-centric model, data and services aren't tightly coupled to a specific device, setting the stage for a decoupled, PnP architecture. DDS is not dependent on servers or brokers — it is a true distributed system with no single points of failure.

The easiest way to understand a databus is to compare it to a database. A database is a repository in which data is stored (short- or long-term) and from which data can be extracted. In contrast, a databus is a shared space for data in motion (rather than standing/stale data). The databus distributes data in motion from device, machine and applications based on opt-in, authorized communications. The data serves as the interface between devices but isn't necessarily stored anywhere. Messages do not need to be sent through brokers to access or process that data. In the databus structure, information from the utility's database/historian is attached and leveraged.

Because all data and services are available on the databus, the only information needed by the application is the domain ID, the topic (or service) name, and the key that identifies the specific data object (or service instantiation). Applications are not expected to connect to any servers or specific nodes. They just send their request to the databus, which takes care of 1) discovering applications that are connected to it and 2) securely getting information to the right place(s).

In a complex, data-intensive DER ecosystem, this means that data discovery is automatic. Data and services can flow to multiple locations. Applications can join, leave or change locations and IP addresses, and so on. The databus automatically manages the correct flows.

With a databus, utilities can accomplish a number of tasks:

- Offer plug-and-play functionality for each DER
- Seamlessly operate with multiple protocols (e.g., Modbus, DNP3.0, GOOSE) and support any language, device or transport type
- Provide interoperability with any hardware, software, operating system or network
- Create a true peer-to-peer publish/subscribe network
- Secure individual data as well as work with the network-layer security (e.g., TLS)
- Perform language/measurement conversions automatically (such as Fahrenheit and Celsius temperature)
- Enable scalability through automatic discovery for new third-party data streams

INTEROPERABILITY WITH LEGACY SYSTEMS

When considering adding DER power sources, the highest imperative is safeguarding existing operations. This encompasses multiple non-negotiable requirements, including:

- Non-disruption of existing operations
- DDS installation/operation on the actual legacy equipment or a small gateway, with no dependence on hardware, software, language, protocol, network, etc.
- Minimal (if any) risk of exposing existing systems to security breaches through backdoor communications or data hijacking
- No risk of flooding or overwhelming existing systems with too much or unnecessary data

As shown in Figure 2, the databus accommodates those requirements, enabling designers to utilize legacy, current and future equipment/devices. There's no need to rip and replace existing systems.

HANDLING VOLUME

A significant benefit of the databus is its scalability to accommodate changes in size/scale. Three attributes of the databus make rapidly escalating volume manageable:

- The databus is infinitely scalable
- There is no single point of failure
- It connects applications to data, not to each other

The databus eliminates the need to send messages through brokers or other intermediaries, providing a very clean and efficient way of handling high-volume information flow.

PRIORITIZING DATA

The DDS databus is more than a pipeline for collecting data from a myriad of disparate sources. It also embeds intelligence to identify and prioritize data on a very fine-grained basis. Without the ability to differentiate and prioritize, the cost of handling fast-growing, fast-moving data streams becomes astronomical. Scalability becomes cost-prohibitive.

The DDS databus provides efficient filtering based on virtually any set of criteria, such as high priority and low priority data, thresholds and priorities. However, filtering and prioritizing

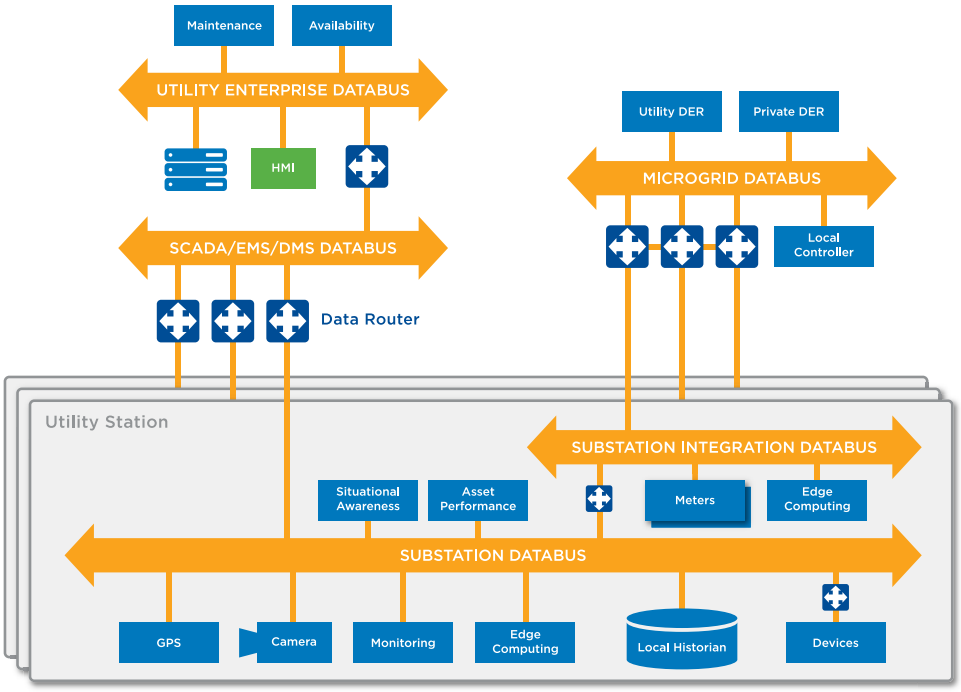

Figure 2: The data-centric databus manages data from DERs and legacy utility systems. It can link to other databuses in a layered architecture pattern to accommodate information demands throughout the utility's operations.

data is not going to be a static or fixed requirement. The need for information can change in the moments before or after a power failure.

Efficient data filtering and prioritization uses bandwidth more efficiently. Instead of investing in bandwidth that doesn't get used, the databus has the ability to balance the flow of data using filtering. For example, the utility can define rules to limit traffic to only necessary or critical data. It can add policies for peak volumes.

SAFEGUARDING AND SECURING EXISTING SYSTEMS

Bandwidth and security have a lot in common: adding more of either one is usually expensive but not always more effective. In the case of security, a lot of layers and mechanisms add management complexity, which translates to increased operational costs. Complexity can also introduce unintentional, exploitable gaps.

Extending the existing networks and security models that protect centralized legacy systems today to new/future DERs is impractical. The scale (and corresponding cost and complexity) is simply too large. The DDS databus is designed for highly distributed, high-volume, highly diverse environments. Because the databus deals with data, not applications, it's possible to apply fine-grained security at the data level. For example, if the data is confidential, it can be encrypted, authenticated and checked for data integrity, whereas non-confidential data may only need authentication.

SCENARIO: A HIGH-PROFILE, HIGH-STAKES MANDATE FOR CHANGE

An electric utility is faced with a mandate to shift to clean energy. The economics make renewables attractive, and policy makers have updated a previous mandate on carbon-free emissions. The new mandate calls for an accelerated timetable from ten to five years.

The challenge is to identify an approach that doesn't derail programs related to keeping the lights on, which means a response that:

- Meets the accelerated timetable
- Doesn't in any way adversely affect the legacy infrastructure
- Doesn't require an investment that takes away from other high priority projects
- Is built on proven technologies

The solution involves using a DDS databus to create an ecosystem of DERs that allows the utility to:

- Gain knowledge with a standard-based approach that puts the utility ahead of competitors and future issues
- Proactively protect the grid while enhancing grid resilience
- Reduce escalating demands on already-strained operational resources
- Accelerate development time through a standard-based, proven approach

By using a DDS databus, the utility can:

- Move from 'after the fact', reactionary operations to optimized and well-orchestrated data management
- For both the utility and the DER owner, DER would be available for "solid state control" of the grid

- Incorporate data/controllability from new IIoT type devices — even behind the customer's meter — securely, with tremendous data "fidelity"
- Communicate and optimize across devices and platforms without the need for "rip and replace"
- Avoid vendor lock-in through adoption of DDS, an open standard solution that enables full interoperability, plugable security and maintenance of other Quality of Service (QOS) functions
- Fully deploy and promote the PnP scenarios needed in utility operations

CONCLUSION

A year from now, the number of DERs will have grown. That's a given. However, the rate of growth for each utility's coverage area is unknown. The types of endpoints are also unknown. By implementing a DDS databus connectivity framework, utility companies can incorporate new functionality into their legacy operations — one that delivers secure, interoperable information flow, at scale. It provides utilities with the ability to create an ecosystem out of unowned DERs. Utilities can create this ecosystem without changing their legacy systems; DERs can plug into this platform without changing their systems.

What every utility gains by putting a standards-based databus in place today is easy response today and preparedness for whatever comes tomorrow. The databus is a forward-looking platform that assumes growth. It allows utilities to start with a goal of visibility and move rapidly toward more strategic, multi-faceted use of a broader DER-based ecosystem.

Through this data-centric approach, utilities will have a wealth of information they didn't have previously about these unowned DERs. This data can be incorporated into the analytics for long term planning. It can add immeasurably to accurate modeling and studies. With this real world data, utilities are in a position to have more fruitful discussions with policy makers, potential partners, the public and others. In this way, the utility leaders will demonstrate that knowledge truly is power.

[1] https://www.ourenergypolicy.org/wp-content/uploads/2017/03/Navigant-Research_Maximizing-the-Locational-Value-of-DERs.pdf
[2] NERC | Distributed Energy Resources Task Force Report | February 2017; https://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/Distributed_Energy_Resources_Report.pdf

ABOUT RTI CONNEXT DDS

RTI Connext DDS is the software connectivity framework for mission-critical applications. Based on the DDS standard, Connext DDS enables electric utilities to create a limitless ecosystem of grid-connected DER endpoints. To traditional systems and processes, this information source — even with its vast volume and diversity — works as a single manageable system.

RTI accelerates development with tested, validated, production-ready offerings for the utility market. Working with RTI offloads IT development teams and reduces maintenance costs. The following ROI metrics are based on actual RTI customer projects:

- Approximately 50 percent reduction in initial development costs
- Approximately 70 percent reduction in annual maintenance costs

For more information on how a DDS databus would work in your environment, please contact info@rti.com.

ABOUT RTI

Real-Time Innovations (RTI) is the largest software framework provider for smart machines and real-world systems. The company's RTI Connext® product enables intelligent architecture by sharing information in real time, making large applications work together as one.

With over 1,500 deployments, RTI software runs the largest power plants in North America, connects perception to control in vehicles, coordinates combat management on US Navy ships, drives a new generation of medical robotics, controls hyperloop and flying cars, and provides 24/7 medical intelligence for hospital patients and emergency victims.

RTI is the best in the world at connecting intelligent, distributed systems. These systems improve medical care, make our roads safer, improve energy use, and protect our freedom.

RTI is the leading vendor of products compliant with the Object Management Group® (OMG) Data Distribution Service™ (DDS) standard. RTI is privately held and headquartered in Sunnyvale, California with regional headquarters in Spain and Singapore.

Download a free 30-day trial of the latest, fully-functional Connext DDS software today: https://www.rti.com/downloads.

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