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DERMS, Federated Architecture for DER, And the Enabling Standards

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SUMMARY

Distributed Energy Management Systems (DERMS), regardless of whether this is a standalone system, integrated with the utility back-office, or subsumed into an Energy Management System (EMS) or a Distribution Management System (DMS), this capability will be needed to manage distributed energy resources (DER) at scale. There is often confusion in the marketplace with many vendors claiming DERMS capabilities, that may often represent "DERMS" being slapped onto a pre-existing product. EPRI's seminal work defined a DERMS as having four characteristics: Aggregation, Simplification, Optimization, and Translation. A DERMS, especially one that uses standards-based data integration enables flexible and sustainable architectural options for dealing with growing penetrations of DER. With standards leveraging "loosely coupled" web-services facilitates the utilities ability to focus on the function, with the "where it is" being less important. A DERMS might be a standalone system, but the functionality might be subsumed into an EMS or DMS as noted before, it might be hosted in the cloud by a third-party provider, or, and it might be deployed in a distributed fashion, to manage a microgrid or a specific feeder. This is where the federated architecture for DER (FADER) concept comes to bear. Further, work has been done to make the data exchange consistent across use cases and supporting standards. For example, the IEEE 1547 standard specifies what capabilities a smart inverter may support. The IEC standard is now fully consistent with the capabilities indicated in the IEEE standard. This enables use cases such as "bootstrapping" how a DER might show up in the DERMS in the first place, to indicate that it is ready for inclusion in a DER group, and hence, active management. These standards updates have enabled the information exchange required across several enterprise systems, that were either not done, or handled in an ad hoc way before this. This paper will explore these basic concepts, go into details into how standards such as IEC 61968-5 enable these capabilities, what research efforts are underway to advance these concepts, and the latest changes to update these standards to be consistent across the various efforts

KEYWORDS

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The DERMS Concept

At the end of 2012, the Electric Power Research Institute (EPRI) convened a workshop in Washington, D.C. This workshop included participants from across the utility industry who had been working together on the development of communication and control standards for smart inverters. This smart inverter work had been very successful and had been codified in the International Electrotechnical Commission (IEC) standard [1], and quickly adapted in Sunspec Modbus, IEEE 2030.5, and the DNP3 standards. However, although smart inverter work continues today, the focus of this workshop was to determine, “what next” for the management of distributed energy resources (DER). The highest priority need that was identified was the ability to integrate DER with grid operational systems (e.g., EMS or DMS) in a way that is practical, sustainable and extensible. Systems operators anticipated that as millions of DER began to be deployed, there was a pressing need to manage these resources in aggregate because it would be an insurmountable task to attempt to manage them individually. Hence, it was decided that the requirements for a Distributed Energy Resource Management System or *DERMS*, would need to be determined. The DERMS concept quickly gained traction and the functional requirements gathered (although they continue to be updated) and published, that prioritized the management of DER in aggregate, or groups [2].

In the management of DER, it became clear that four primary characteristics were required for a DERMS. To be sure, others have advocated for additional capabilities, but these four characteristics are the basics of a DERMS. They are:

- **Aggregation** –a DERMS should take the services of many individual DER and present them as a smaller, more manageable, number of grouped virtual resources. As noted above, the message from system operators was that they do not want to manage DER individually, especially as the amount of deployed DER increases. They want DER to be bundled together for easier management.

- **Simplification** - DERMS should handle the granular details of DER settings and present simple grid-related services. Operators don’t need or want to know the details of how to manage individual DER or what settings need to be passed. They want to ask for a capability, for example, energy dispatch, and have the DERMS handle the details of communication to the individual smart inverter on their behalf.

- **Optimization** - DERMS should optimize the use of DER within various groups to get the desired outcome at minimal cost and maximum power quality. The DERMS should pull in status and event information from the individual DER and reliably forecast the capabilities that can be called upon. If the DER is a battery, this might be as simple as indicating the state of charge. If it is wind or solar based, this becomes more complex and may rely on historical performance and weather data. Additionally, if managing a diverse group of DER, a DERMS should know how to best leverage the individual DER to get a specified outcome. This might involve equally spreading a request across all the individual DER in a group or perhaps making the request based on size, location, or type of DER.

- **Translation** - Individual DER may speak different languages depending on their type and scale. DERMS should handle these diverse languages, and present to the upstream calling entity in a cohesive way. There are several “field” protocols that might be used such as Distribution Network Protocol (DNP), Sunspec Modbus, IEC 61850, or IEEE

2030.5 (although it began life as a "behind the meter" standard it has been adapted to support DER). Open Field Message Bus (OpenFMB) could also be used, for example, if the central station is passing messages to a "DERMS in a box" that is a node in an OpenFMB network, managing a microgrid. A DERMS may need to support more than one protocol, especially if they are transitioning from a legacy standard such as DNP3, to something else.

[3]

The relationship between a DERMS, the DER, and the example enterprise systems that might "talk" to a DERMS, and their related standards are shown below. As can be seen on the right, the functional requirements developed for IEC 61850 were adopted by Sunspec Modbus, DNP3, and IEEE2030.5. OpenFMB used a hybrid CIM/61850 data model. On the enterprise side, nominally between a DERMS and other enterprise systems, the data integration is a combination of two components: IEC 61968-5:2020 standard which defines the data elements, and IEC 61968-100:2013 which defines how to do the application integration. (IEC 61968-5 was approved as an international standard in July of 2020).

To enable better understanding of IEC61968-5/IEC 61968-100 compliance, EPRI has developed a test script that includes code examples, numerous test cases, and a resource file that contains XSDs and WSDLs that can be used by developers to accelerate their understanding of the standard. This test script has been released to the Utility Communication Architecture International Users Group (UCAIUG) under an Apache 2 license so that the UCAIUG may use this as part of their CIM compliance testing regimen.

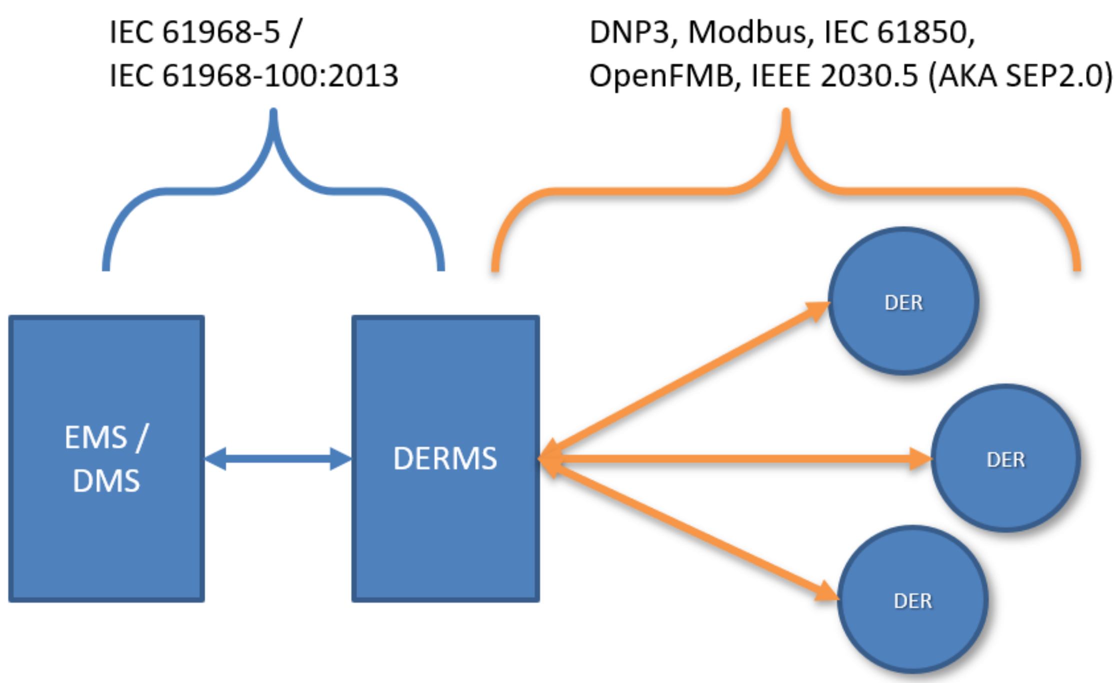

Figure 1 Conceptual DERMS Relationship and the related standards (Source : EPRI)

Although Figure 1 shows the traditional view of utility systems, where a DERMS is a standalone edge system, the use of standards-based integration based on web services enables quite a bit of architectural flexibility. These options are shown in Figure 2 below. Although a

DERMS could be a standalone edge system, DERMS capabilities could be subsumed into a distribution management system (DMS) or energy management system (EMS). A DERMS could also be hosted by a third-party provider in the cloud, or as will be shown with the Federated Architecture for DER concept, it could be fully distributed with distributed DERMS managing a feeder or a microgrid.

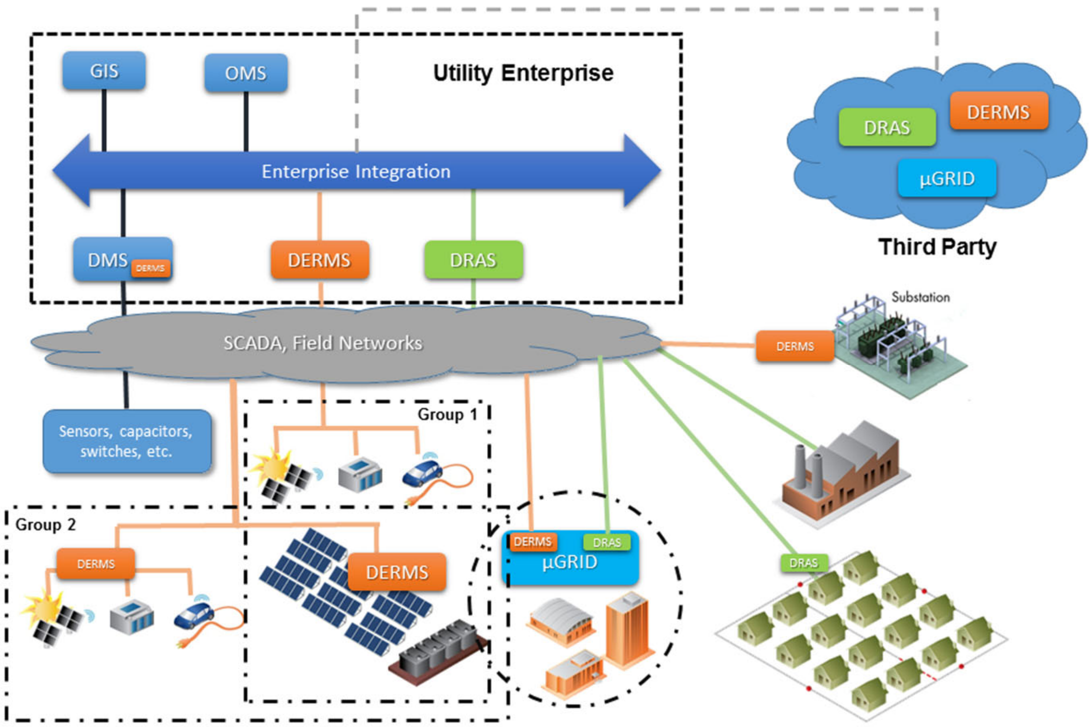

Figure 22 Architecture flexibility enabled by IEC 61968-5 (Source : EPRI)

Federated Architecture for DER

There have long been two views of how DER needs to be controlled: Centralized, with all the command and control belonging in the central data center, and distributed, with the control pushed out to where the DER is sited. However, recognizing the needs to balance the capabilities and strengths of both architecture options, EPRI developed the Federated Architecture for DER (FADER) concept. (See Figure 3 below). Federated architectures[1] combine centralized and decentralized elements and control decisions are made at the level(s) at which it is most beneficial overall. The objective of a federated DERMS architecture is to provide the highest possible autonomy to lower-level control systems thereby reducing complexity, while maintaining central awareness and optimization.

Command and control decisions in the future will need be made at many levels within the grid. The central utility will have a say but will also need to coordinate with hosting DER third parties as well as feeder and microgrid controllers. This will require lossless transformation of data across these control boundaries. IEC 61968-5/IEC61968-100 supports and enables this requirement.

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[1] *Federated Architecture, https://en.wikipedia.org/wiki/Federated_architecture*

Imagine if you will, a distributed DERMS operating a local microgrid. It recognizes and reacts to local generation/load changes by issuing commands to the DER under its control since the system has been empowered to take these local control actions as it is closest to the issue. Thereby eliminating the latency that results from sending a message to central control, waiting for a human in the loop to decide, and then, waiting for the command message to be sent to the distributed DERMS. However, central control has the broader situational awareness beyond the microgrid. By coordinating with central controls, the distributed DERMS can also meets the real time needs of the central grid. The FADER concept is illustrated in the figure below.

This is a forward-looking architecture and not yet a part of a vendor offering. However, with virtualization technologies such as Kubernetes[2] and Docker[3], the deployment and maintenance of a distributed DERMS that could support such an architecture is not far off, indeed, there are some utilities considering such an architecture on a pilot basis.

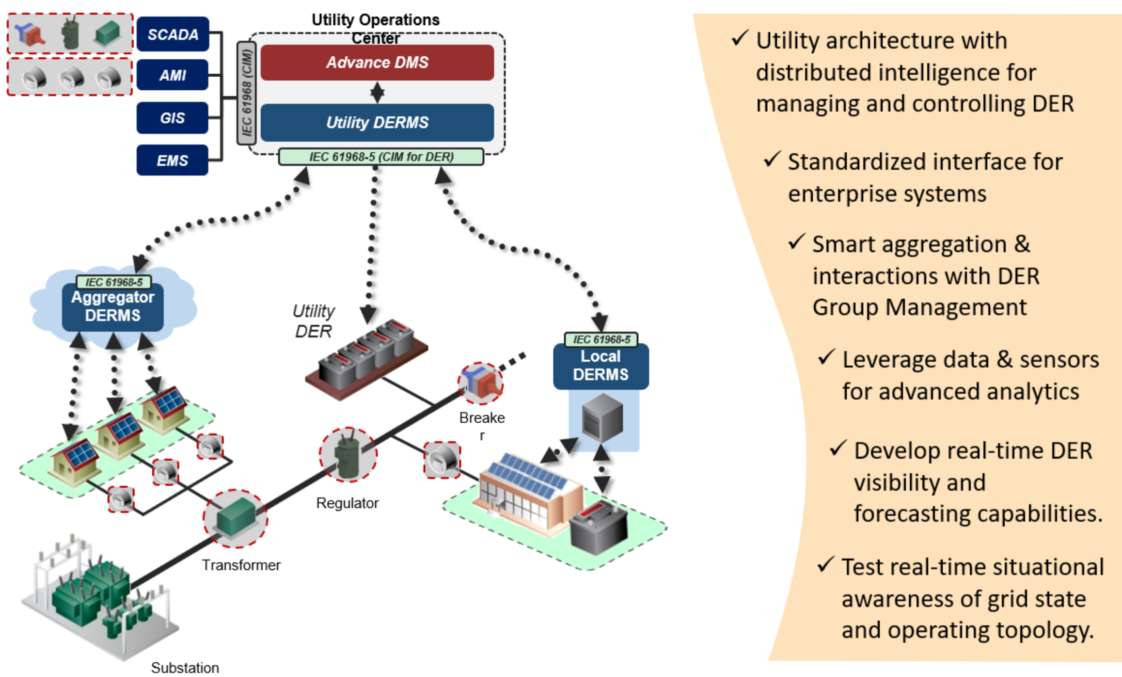

Figure 3 Federated Architecture for DER conceptual diagram (Source : EPRI)

Testing 61968-5

To facilitate adoption and understanding of the IEC 61968-5 standard, EPRI undertook the development of a test script and to provide support for the standard within its semantic test harness. Development of a test script matures the development of the underlying standard. Such an effort requires the writer to look at the standard from the lens of, "How do we create clear instructions for compliance?" If anything within the standard is ambiguous, the development of a test script will surface these issues. Indeed, the experience with developers is that they would usually rather copy and paste code than read the standard, and they will certainly write code that will pass whatever a compliance test requires, regardless of the

[2] https://kubernetes.io/
[3] https://www.docker.com/

interpretation of a standard. The benefit of this exercise is twofold: Developers get clear guidance that results in faithful and consistent interpretation of a standard, and the standards body receives feedback that help improve the clarity of new editions of the standard.

EPRI thus created a test script that could be used to provide such clarity. [4] This test script has since been granted to the Utility Communication Architecture International Users Group (UCAIUG) under an Apache 2 license so that the UCAIUG can use this resource as part of their CIM compliance and certification testing. The test script also contains a set of web service definitional language (WSDLs) and extensible schema definitions (XSDs) files that developers can use to accelerate their software development or integration work.

EPRI has also created a semantic test harness that supports each of the test cases contained within the test script and may serve the role of either sender or receiver. Additionally, users may download the equivalent set of test cases that have been developed using soapUI[4] and have soapUI take on the role of sender or receiver of the test message if the developers prefer.

[4] https://support.smartbear.com/readyapi/soapui-pro/

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