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Interoperability & Standardization: a Roadmap for Success

White Paper

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Introduction

In recent years, Advanced Metering Infrastructure (AMI) has emerged as a pivotal component for Distribution System Operators (DSOs) seeking to optimize their operations and bolster network stability. The advent of AMI allows DSOs to create a resilient and scalable AMI grid while maintaining a cost-effective approach. Achieving this goal depends on the DSO's capacity to integrate systems and devices from different vendors. This ability enables DSOs to merge devices, systems, and services from different vendors and will not only enhance operational efficiency but also increase the flexibility of the supply chain.

For DSOs the Low Voltage (LV) grid is becoming a complex asset to tackle and monitor. The growing complexity of the grid with the integration of Electric Vehicles (EVs), the rising number of power chargers, and the inclusion of Distributed Energy Resources (DERs) represents a challenge for DSOs worldwide. Moreover, with the increasing pressure from regulatory entities to digitalize the LV grid and focus on sustainability, DSOs now find themselves compelled to accelerate their roll-out activities in a complex socio-economic landscape. In this fast-evolving environment, with a multitude of players and X-Tier suppliers offering diverse products and services, DSOs are advocating for plug-and-play solutions. This push aims to reduce the costs associated with the integration of multi-vendor solutions and also to lower lifecycle cost by enabling interchangeability of devices in the field.

The need for interoperability is not limited to vertical integration (e.g. smart meters, gas and heat meters and management systems), but also extends to horizontal integration (e.g. multi-vendor smart meters). Consequently, interoperability became the prominent solution to meet DSOs' expectations on the aforementioned topics.

From the perspective of manufacturers and suppliers, interoperability may be seen as double-edged sword. On one hand, a potential opportunity to reach a broader customer base, on the other, a constant risk that could undermine competitive advantage through a perceived lack of differentiation.

For manufacturers, interoperability offers the prospect of enhancing operational efficiency, typically achieved through standardization. Notably, DLMS/COSEM (as commonly referred to as DLMS specifications) is one of the most promising standards for Smart Metering, enabling suppliers to standardize their designs and production lines, thus reducing manufacturing costs. The strength of standardization and interoperability encourages their ability not to limit manufacturers from differentiation but to serve as a foundation for incorporating new and unique features.

In fact, interoperability for utilities encourages innovation from manufacturers rather than limiting their differential factors.

Market Fragmentation and the Need for Interoperability

Within the modern landscape of AMI, several factors are hindering the realization of effective interoperability.

Vendor-Specific Ecosystems

Nowadays, each vendor has its own ecosystem including meters, IoT devices gateways, Application Programming Interfaces (APIs) and Head-End Systems (HES). This leads to several clear disadvantages such as: increased operation costs due to the existence of multiple tools, increased maintenance complexity as support is needed for the different tools, and increased deployment costs.

Data Management Complexity

One of the most critical challenges with this type of deployment is the complexity associated with managing data collected from various sensors, in this case smart electricity meters, gas meters, heat meters and other LV devices. Moreover, the presence of diverse presentation and application standards from each vendor results in data structured in different ways. This disparity drives integration costs and introduces complex technical challenges when creating management tools, generating reports or accessing data.

Multiplicity of Communication Technologies

Manufacturers frequently adopt multiple communication technologies such as Meters&More, PRIME, Wi-SUN, G3 and others. This complicates the process of data collection from the meters and leads to higher infrastructure costs, primarily due to the lack of multi-protocol data concentrators in the market. Hence, having multiple communication technologies (excluding point-to-point cellular technologies) in the same LV grid domain means having multiple devices to aggregate each protocol. The challenges outlined above often force DSOs to embrace a vendor-lock framework to navigate these complexities.

Vendor-lock is defined as the inability

to integrate devices from other companies into the current infrastructure due to proprietary protocols or multiple data structures. Vendor-lock is one of the most unfavorable scenarios for any company as it severely restricts negotiating power, often narrowing down the offering of products and services to only a few suppliers. Thus, this increases the risks associated with the supply chain, including delays, price reviews and volume constraints. To mitigate the risk of vendor-lock and alleviate the costs associated with technology diversity, interoperability and standardization emerge as key factors to address the aforementioned challenges.

The Role of Standardization and Compatibility in AMI

In the realm of AMI, an abundance of communication technologies are available for connecting IoT devices to networks. Three main categories of IoT networking technologies are widely used for smart metering applications – Power Line Communication (PLC), Cellular (from 3GPP) and various Radio Frequency (RF) technologies. Each of these technologies serve as the conduits for the exchange of information between IoT devices, but they all have their own characteristics that make them appropriate for certain scenarios. Their functionality can be categorized within the OSI (Open Systems Interconnection) model layers:

Lower OSI Layers (1-4)

The lower layers define how data is managed throughout the network, from the transmission medium (PLC or RF) to frame routing and management (including segmentation, error checking and flow control).

Upper OSI Layers (5-7)

These upper layers focus on structured data, emphasizing application-specific aspects. They encompass data models, encryption, and connection management.

To summarize, lower layers focus on bits, frames and how these are transmitted in a network, while upper layers focus on the meaning of the data for the end applications.

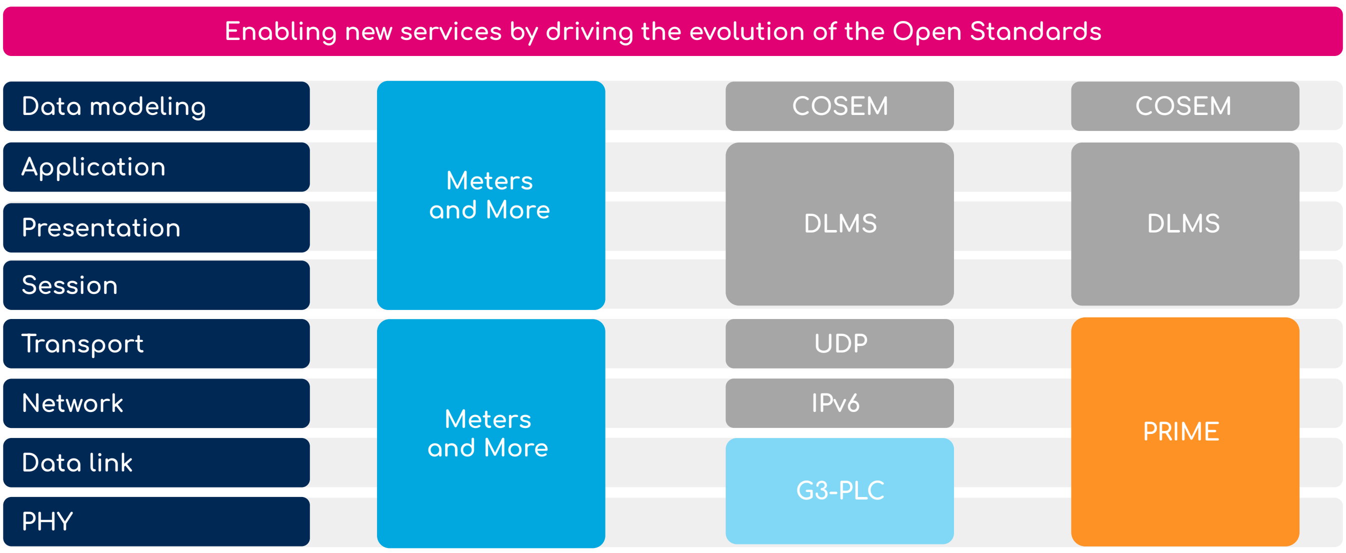
7. Application layer	Human-computer interaction layer, where applications can access the network services
6. Presentation layer	Ensures that data is in a usable format and is where data encryptions occurs
5. Session layer	Maintains connections and is responsible for controlling ports and sessions
4. Transport layer	Transmits data using transmission protocols including TCP and UDP
3. Network layer	Decides which physical path the data will take
2. Data link layer	Decides the format of data on the network
1. Physical layer	Transmits raw bit streams over the physical medium

Each layer within this framework can use several protocols and standards depending on the environment and the application. For instance, standardization efforts such as IEEE802.15.4 at the physical and data link layers govern open communication standards for low-power RF communications, while G3-PLC serves as a PLC protocol for layer 1.

On the other hand, upper layers rely on data and security protocols such as DLMS specifications, which standardizes the data model for energy smart meters.

In general, there are two levels of standardization: one at lower layers and another at upper layers. These levels can operate independently of each other, allowing for diverse combinations of technology. This also means that a device may adhere to a standard for lower layers, such as IEEE 802.15.4, while implementing a custom data model.

Some associations advocate a full stack of protocols for all layers, such as Hybrid G3-PLC, PRIME, Wi-SUN, Meters&More, and others. Although each stack uses different protocols and standards, the most recent releases (PRIME and Hybrid G3-PLC) share a common thread in utilizing DLMS specifications for upper layers.



Interoperability and Standardization: Driving Efficiency in AMI

Interoperability is the ability of different devices to communicate and it can occur at both network and data model level.

The lack of interoperability at the network level can lead to higher hardware costs due to the lack of multi-protocol concentrators. However, the lack of interoperability at the data level will result in much higher integration and operation costs.

DLMS specifications define the transport and application layer with a set of standard object-oriented messages. These specifications are maintained by the DLMS User Association and are communication media independent so they can work over different lower layers specifications (RF, PLC).

However, the use of DLMS specifications do not automatically guarantee interoperability with other devices implementing the DLMS specifications. This led the DLMS UA to developed Generic Companion Profiles which ensure the highest level of interoperability and compatibility.

DLMS UA Generic Companion Profiles (GCP's) are a precise selection of features and functionalities specified in the DLMS UA Core Specifications, tailored to meet the requirements of various use cases. By aggregating multiple use cases and parameterizing and configuring the core functionalities, a specific application can be developed for devices or services within a particular industry, Smart Metering for instance. These generic companion profiles serve as standardized guidelines and specifications, allowing devices from different manufacturers to communicate and behave in the same way independently of their origin. By implementing these profiles, utilities and device implementers can ensure smooth integration and enhanced functionality, ultimately benefiting end-users.

The release of core specifications alongside companion profiles underscores the importance of organizations like DLMS UA, that play a key role in promoting interoperability, and also providing certification services to validate compliance and compatibility to the specifications.

Elevating Interoperability; Data Exchange Security

In the broader context of interoperability, data security emerges as an essential component.

The quest for interoperability typically encompasses two distinct layers of data security: securing communication protocols and reinforcing data exchange processes, especially during critical processes such as device commissioning and decommissioning.

It is not merely about enabling devices to connect to specific networks since it extends to safeguarding the entire lifecycle of data exchange.

As we progress towards a more interconnected future, where devices communicate and interact, a holistic approach to interoperability must consider not only the interchangeability of devices but also the robustness of data security mechanisms.

Acknowledging this imperative, organizations like DLMS UA are taking proactive measures to secure data exchange, demonstrating a steadfast commitment in the promotion of interoperability.

DLMS UA has already taken significant strides in fortifying data security and is now focusing on standardizing the commissioning and decommissioning processes in device data exchange. This holistic approach ensures not only the security but also the standardization of data exchange, contributing to the establishment of a resilient and efficient ecosystem for interconnected devices.

The Impact of Interoperability & Interchangeability

A DSO responsible for replacing a defective meter in the field due to the expiration of the previous supply contract and the introduction of a more innovative product faces several critical considerations:

Communication Technology Compatibility

Ensure that the new meter aligns with the communication technology supported by the IoT platform, considering factors like PLC & RF compatibility. For example, if there are only devices within the network that support PLC, meters that communicate via the same technology are required.

Upper OSI Layer Compatibility (Layers 5-7)

Verify that the data exchange format matches the existing infrastructure. The main standard for energy metering is DLMS that defines the transport and application layer with a set of standard object-oriented messages, and that is adopted by the IEC in the 62056 series of standards.

Lower OSI Layer Compatibility (Layers 1-4)

Confirm that the information exchanged adheres to a protocol recognizable by the communication platform, considering protocols like Hybrid G3-PLC and Wi-SUN.

If these criteria are met, the DSO can efficiently replace the malfunctioning meter. By ensuring the new meter uses the same communication media and integrating the protocols and standards from the previous meter, the transition occurs smoothly. However, in practice, achieving complete interchangeability is not always straightforward.

Interchangeability is the ability to physically swap one device for another while maintaining the same functionality without altering existing systems. It plays a key role in real-world scenarios which are more intricate than this idealized interoperability model suggests.

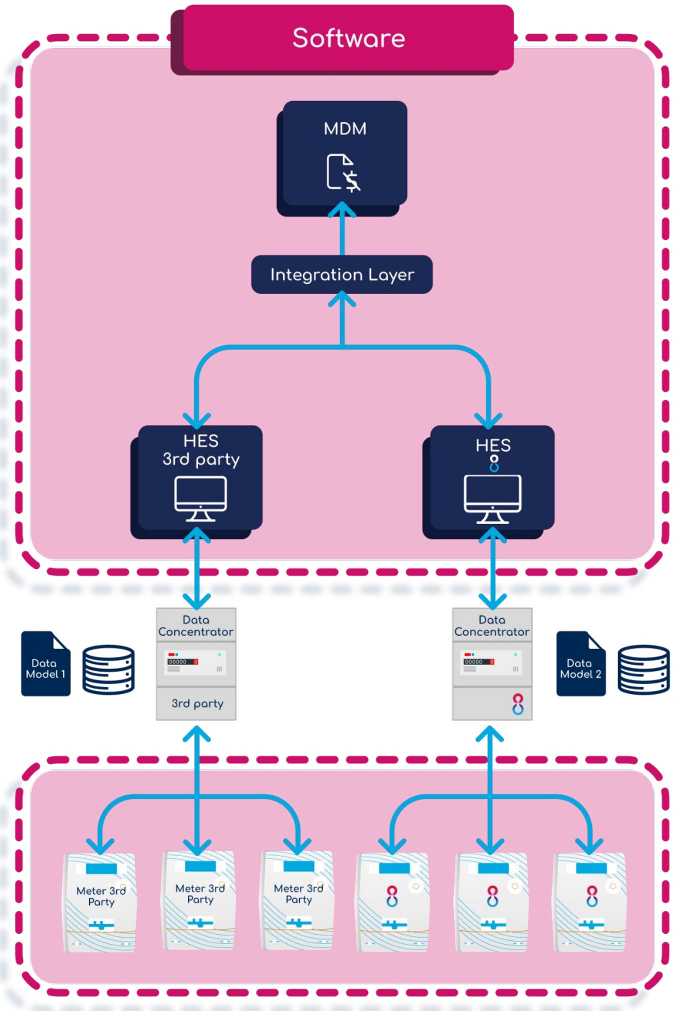
Even in a fully interoperable environment, achieving perfect integration and uniformity among meter solutions is a challenging endeavor for DSOs. In practice, many DSOs resort to the vendor-lock framework mentioned earlier or opt to integrate new meters into entirely new infrastructures to avoid communication compatibility issues with existing infrastructure.

Frequently, the resulting configuration resembles the one illustrated in **FIGURE 1**.

In this configuration, each meter has its own data concentrator and management system. Additionally, other systems or applications may rely on the data collected by these meters. This complexity requires the implementation of an expensive integration layer to facilitate communication between the different systems, applications, and databases. Moreover, despite having the same lower OSI layers, as each meter has its own orders, every time a new type of meter is integrated, an integration step with the central systems is required, further escalating costs.

While this approach entails several limitations at the device level, requiring careful consideration of hardware compatibility with different IT infrastructures, it does provide DSOs with greater flexibility in managing existing situations, including those resulting from acquisitions.

FIGURE 1 - Non-Interoperable Scenario



Achieving Interoperability with DLMS UA Specifications

In contrast, an alternative approach becomes feasible when all devices are certified to be DLMS compliant and compatible and assume the same lower OSI layers. This interoperable approach, as illustrated in **FIGURE 2**, substantially reduces costs.

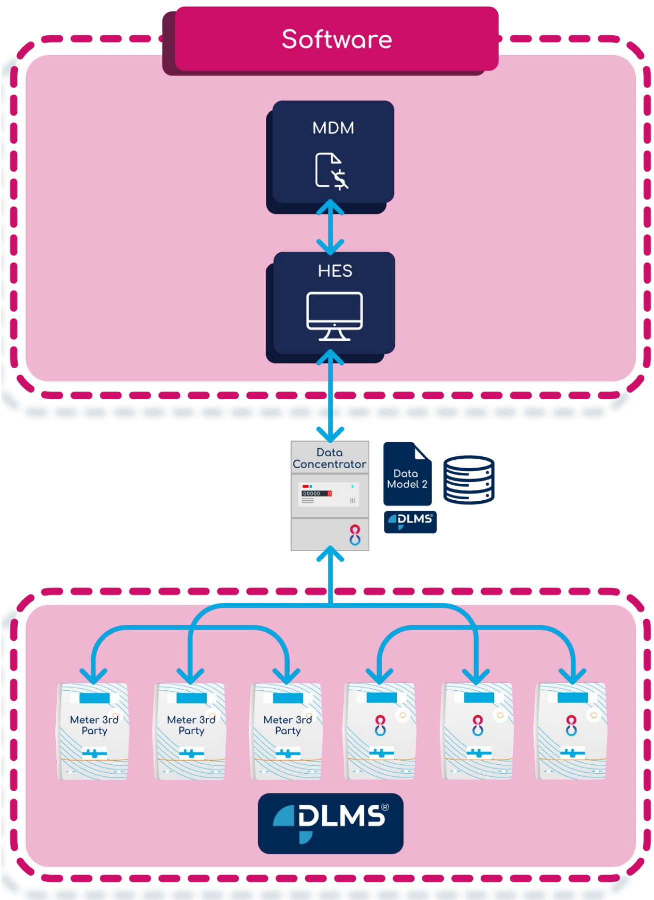
Since all the meters have the same DLMS commands, no additional development is necessary for the central systems. In this configuration, the central system often adopts an all-in-one design, capable of managing any DLMS-compatible device, without additional customization.

However, a light integration step may be required to configure the central system according to the available DLMS commands on the new meter.

It is worth noting that not all the DLMS-compatible meters have the same commands. These will vary based on the manufacturer's specification, requirements and any additional differentiating features.

Additionally, in this interoperable approach, applications, and related systems $[S_0,S_1,...,S_N]$ can work independently from the central system. If designed correctly, these systems integrate easily with the structure of DLMS messages. Furthermore, this approach also enables future use cases such as multi-utility integration, where heat, water and gas meters use the same DLMS specifications. A simple addition of a new S_k system or application facilitates data management from each sub-meter category.

FIGURE 2 - Interoperable Scenario



While there is a perceived risk that standardization could impose limits on innovation, it is crucial to recognize that standards do not prohibit manufacturers from enhancing their products with additional features to foster innovation and differentiation.

Therefore, manufacturers are encouraged to proactively leverage standards as a basis and then incorporate new functionalities and address emerging use cases.

This approach not only aligns with the evolving needs of DSOs but also opens doors to innovation and market differentiation.

Conclusions

In conclusion, the dynamic landscape of Advanced Metering Infrastructure (AMI) presents both opportunities and challenges for Distribution System Operators (DSOs). As **DSOs strive** to **optimize their operations, enhance network stability, and adapt to the complexities of the Low Voltage (LV) grid**, the importance of interoperability and standardization has never been more evident.

The **proliferation of technologies, vendors,** and **standards** within the Smart Metering market has brought forth **operational complexities, vendor-specific ecosystems, and data management challenges**. While the growing diversity of communication technologies has introduced opportunities, it has also given rise to higher infrastructure costs and hindered continuous data exchange. In response to these challenges, DSOs have at times found themselves locked into proprietary frameworks, limiting their flexibility, and negotiating power.

To navigate this intricate landscape, **interoperability and standardization** have **emerged as key strategies.** Standardization and compatibility across communication technologies and data models play a pivotal role in **ensuring the smooth operation of AMI systems.** This not only **minimizes costs** but also **maximizes efficiency,** positioning DSOs to **meet** evolving **regulatory requirements** and **industry best practices.**

As DSOs chart their course in this ever-evolving ecosystem, it is crucial to consider factors such as device certification, future-proofing strategies, vendor collaboration, and robust data security and privacy measures. These elements collectively contribute to the successful implementation and operation of AMI solutions. In practice, DSOs often find themselves striking a balance between standardized approaches and the need to adapt to specific situations and evolving technologies. **Flexibility and adaptability remain key** assets **in optimizing** utility costs and processes throughout **the entire AMI lifecycle**. By embracing interoperability and standardization, DSOs can not only meet current challenges but also position themselves to thrive in the exciting and rapidly evolving world of smart metering and grid management.

The journey toward an optimized, resilient, and sustainable LV grid continues, and interoperability and standardization are the guiding lights illuminating the path forward.

Embrace interoperability and standardization for a thriving grid

Gridspertise

Gridspertise offers grid intelligent devices, end-to-end cloud-edge platform solutions, and services to accelerate the digital transformation of electricity distribution grids across three main areas: metering and grid edge digitalization, network infrastructure digitalization, field operation digitalization.

The Company's portfolio is designed as an open ecosystem, easy to integrate with Distribution System Operators' existing infrastructure, combining intelligent and automated grid central level as well as on the edge. The company was set-up in 2021 as a carve-out of Enel's twenty-year-long experience in developing, testing, and scaling up digital technologies to transform legacy distribution networks into smart grids.

Gridspertise is today jointly controlled by the Enel Group and the leading global alternative investment manager CVC Capital Partners.

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