Technical Framework
Virtual Power Plant

Vol. 2

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Disclaimer

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Table of Content

1 About the Document

A **Technical Framework** represents a stack of information and technical specifications integrated into the predefined document structure shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**. Please note that a technical framework does not equal a new standard or standards family. It rather describes the normalised use and application of existing standards and practices to avoid interoperability issues. Integration Profiles are implementable specifications describing how to use established standards to meet specific application needs. They state implementation constraints and recommendations that define how to apply standards and good practice to realise specific features and functionalities required for a Business Function in an interoperable fashion.

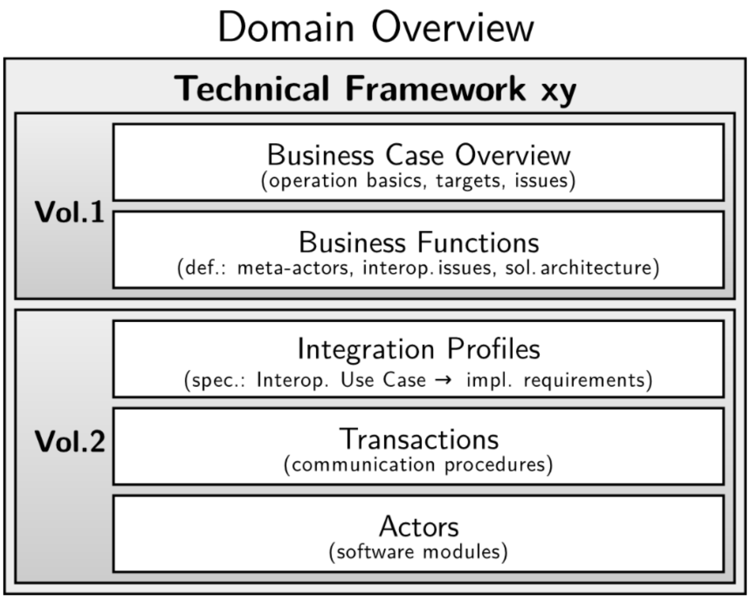

Figure 1: Structure of the Document (IES Technical Framework Template)

A technical framework is embedded in a business domain overview, which is accessible from the project homepage at http://www.iesaustria.at. The concept is based on the IHE technical frameworks[1], which comprise two parts. IES specifies volume 1 to be entirely informative, presenting the big picture, i.e., business case and business functions, and volume 2 to cover all the normative and technical specifications, i.e., the integration profiles.

[1] IHE: Integrating the Healthcare Enterprise [https://www.ihe.net/resources/technical_frameworks/]

The document structure of a technical framework is as follows:

Volume 1:

- Business Case Overview (informative)
  - Typical meta-use-cases (application variants)
  - Relevant meta-actors (business roles)
  - Related standards (overview)
- Business Functions (informative)
  - Describe the interoperability issues with the IEC 62559 Use Case Methodology
  - Use Case diagrams

Volume 2:

- Integration Profiles (informative and normative)
  - Technical solution for a specific interoperability issue (operational/functional)
  - Definition of transactions that are needed and may cause interoperability issues
  - Definition of the actors that are involved in above transactions
- Transactions (normative)
  - Procedures and protocols required for interoperable cooperation
  - Specification of the actors that shall be implemented
  - Specification of the IT standards and how options/variants shall be used
- Actors (optional, informative, may have been specified before)
  - Implementation examples/options to realise the actors that perform transactions
  - Software tools/stacks/platforms that can be used
  - Reference implementation(s)

This document comprises Volume 2 of the Technical Framework on interoperability issues in Virtual Power Plant (VPP) business cases. It provides the collection of all VPP related Integration Profiles released and included at the date this document was published ([Publish Date]).

2 Definitions

Definition of terms frequently used with IES Documents.

Actor
is a functional software component of a system that executes transactions with other actors as defined in an Integration Profile.

Business Case
is the economic viable application of an idea or technology.

Business Function
is a specific functionality that is required to be realised for a Business Case to work.

Conformance Testing
is a standalone process to ensure that the implementation conforms to specified standards and profiles, i.e. the implementation's outputs and responses are checked against patterns and rules.

Functional Integration Profile
is the specification of a single feature taken from a standard to be used in Integration Profiles.

Integration Profile (operational)
is the specification required to realise a part of a Business Function (or combination thereof related to a single task) in an interoperable fashion (normalised).

Interoperability [ITU-T Y.101, ITU-T M.60]
is the ability of two or more systems or applications (i.e., products and services from different suppliers) to exchange information and to mutually use the information that has been exchanged.

Interoperability Testing [ITU-T Z.450]
is testing to assess the ability of two or more systems to exchange information and to make mutual use of the information that has been exchanged.

Interoperability Use Case
is a part of a Business Function that relies on data exchange between different actors according to an Integration Profile (i.e. where interoperability is required).

Meta-Actor
joins functional components (actors) in order to fulfil all the functionalities required for a Business Function (IHE grouping). For the Use Case description, it could be a human operator, but typically it is a software component embedded in some device that provides an interface to some communication infrastructure.

Technical Framework
is the hierarchy of documents that introduce, define and specify how to implement functionalities and features such that interoperability is achieved.

Transaction
is the specification of a set of messages (1..n) exchanged between a pair of actors that realise the Use Case specific information exchange (in one or both directions, in a strict or loose order) as specified by an Integration Profile.

Operational Use Case

is a part of a Business Function that describes an activity not involving any data exchange between actors. This kind of use cases are mentioned in the IES Technical Framework, but not considered in Integration Profiles because per se they do not raise interoperability problems.

3 IEC 61850 Integration Profiles

In Volume 2, Integration Profiles are defined and exemplary implementation options are provided by Transactions (aka Solution Building Blocks). Integration Profiles are normative descriptions of features and specifics (Architecture Building Block Specifications) that need to be implemented in order to realise the respective Business Function (Architecture Building Block) in an interoperable manner. Commonly, where convenient, the name of the Integration Profile shall somehow reflect the name of the Business Function for ease of association.

To avoid multiple specification of basic features a technology provides, we start with Functional Integration Profiles. These normatively specify how a general feature shall be implemented, independent of any Business Function. They represent functions a technology provides on the same level as Transactions – the lowest level Solution Building Blocks. For example, a file transfer may be normatively specified independent of the file type, e.g., use the FTP protocol, which would never work for a Business Function that requires a specific file type to be interoperable. In consequence, Functional Integration Profiles cannot be tested on interoperability on their own, only conformity checks may be specified and executed based on the specification of Functional Integration Profiles. Hence, to implement and test Functional Integration Profiles they shall be grouped/bundled with common (operational) Integration Profiles, always.

At this point, all operational Integration Profiles for the VPP are listed and linked to separate documents for the concrete specification. Basics for the implementation of the standards series IEC 61850 are shown in Section 4.

3.1 Send Asset Configurations

A DEUC shares its asset configurations with an operation unit (VPPOP or DEUOP).

3.2 Send Planned Schedule

An operation unit (VPPOP or DEUOP) transmits a functional schedule to a DEUC.

3.3 Get Measured Values

A DEUC supplies measured values to an operation unit (VPPOP or DEUOP).

4 IEC 61850 basics

Main aspects of the implementation strategy for the IEC 61850 standard series are described to understand the data structure and the protocols used to transmit the information.

The IEC 61850 Ed. 2.0 standard series describes a concept how intelligent electronic devices (IEDs) of power grids can be virtually represented as logical devices (LDs) composed of logical nodes (LNs) with data objects (DOs) that split-up into data attributes (DAs). IEDs can communicate with each other. Date objects and attributes can be read and written remotely once a connection between two IEDs is established and the individually required configuration of the participating LDs is known. Data exchange can be requested (get, write) or is triggered via events (send). For example, a group of data attributes can be automatically sent to one or more predefined remote IEDs whenever something changed locally.

The composition of a logical device is the data structure that represents the IED in the virtual world. The structure is sketched in Figure 2. The possible composition of logical nodes, i.e., the mandatorily and optionally contained data objects and attributes, is specified by IEC 61850 and provides the basis for a normalised use. The access to individual data objects and attributes shall always be individually specified, i.e., only IEDs granted the right to read or write a specified data object/attribute are able to do so. This right can be even restricted to specific conditions.

The 61850 standard series defines the information model used for exchanging information between instances of logical devices (LDs) and/or logical nodes (LNs). The model uses a strict hierarchy as indicated above and shown in Figure 2 and Figure 3**Fehler! Verweisquelle konnte nicht gefunden werden.**. A LD can be composed out of one or more LNs, where each LN represents a certain in IEC 61850 defined information element with dedicated functionalities. The LN itself is based on data objects that can be used in different LNs. Every data object can hold one or more data attributes, each of a defined data type. The common data classes are the bases of the data objects and group common data attributes. The bases of this hierarchy are the standard data types, e.g., integer, float, complex, time, quality, etc.

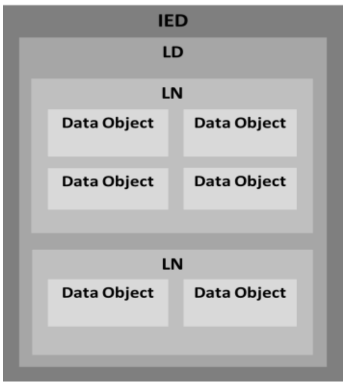

Figure 2: Data Structure in IEC 61850

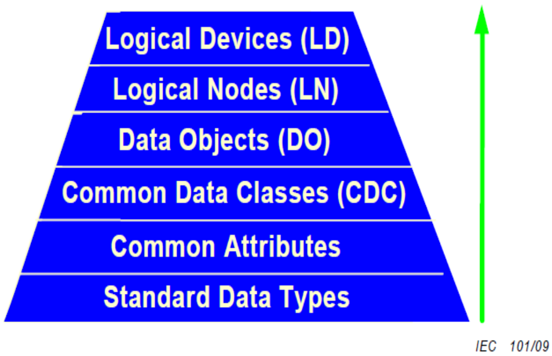

Figure 3: Information model hierarchy[2]

[2] IEC, "IEC 61850-7-420 -Communication networks and systems for power utility automation - Part 7-420: Basic communication structure - Distributed energy resources logical nodes." 2009.

The outermost component represented by the information model is the IED; it describes a device incorporating one or more data interfaces with the capability of receiving or sending data from or to other components (i.e., other IEDs). The IED is represented by an LD that contains various LNs to model the functionalities the IED offers. LDs are not specified by the IEC 61850 standard series because manufacturers shall be free to compose their devices with their own set of functions, which are mapped by the LN data structure that describes the LD. Each LN's data structure is composed from data objects based on the specified common data classes and data attributes. Data attributes can have different functional constraints with different triggering options and access rights management. These types are defined in IEC 61850-7-2 and shall be considered in the description of the transactions because they determine access rights and other rules to obey.

4.1 Composing required components

In this Technical Framework, the IEDs are VPPOP, DEUOP and DEUC. The 61850-7-420 standard mentions the following LD for these IEDs: VPPOP is a DER plant operator, a DEUOP is a DER Plant Controller and a DEUC is the Controller of one DEU entity/asset (Technical Unit – TE). The part IEC 61850-7-2 and 61850-7-42 of the standard series describe all functions of the LNs for these three LDs. Each LD contains the LNs LLN0 and LPHD to provide physical information about the IED; these are shown in Table 1**Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 1: LLN0 and LPHD content for VPPOP, DEUOP and DEUC

Logical Node	Data Object	Data Attribute	Common data class	Functional Constraint	Description
LLN0	Beh	EnumType	ENS	STs	The current status of the logical device. Its behaviour can be: on, on-blocked, test, test/blocked, or off.
LPHD	PhyNam	vendor	DPL	DC	Vendor Name of the physical device.
		cdcName	DPL	EX	Name of the physical device. Details are written in IEC 61850-7-1.
		cdcNs	DPL	EX	Name space of the physical device. Details are written in IEC 61850-7-1.
	PhyHealth	EnumType	ENS	ST	The current health status of the device. Its status can be: Ok, Warning, or Alarm.
	Proxy	stVal	SPS	ST	Indicates if the LN is a proxy, i.e. stVal is only a Boolean.
		q	SPS	ST	Quality of the proxy
		t	SPS	ST	TimeStamp of the proxy

Figure 4**Fehler! Verweisquelle konnte nicht gefunden werden.** shows a typical grouping of LNs to LDs. Please note that this graph makes no claims of being complete nor specifying a normative architecture and is therefore an informative example. It can be derived from the figure that the LD DER Unit Controller consists of the LNs DRCT, DRCS, DRCC, FSEQ, and MMXU. These logical nodes are normatively named according to IEC 61850-7-420 where a detailed specification on the contained data objects can be found. Partially, these logical nodes are used in the transactions of this Technical Framework.

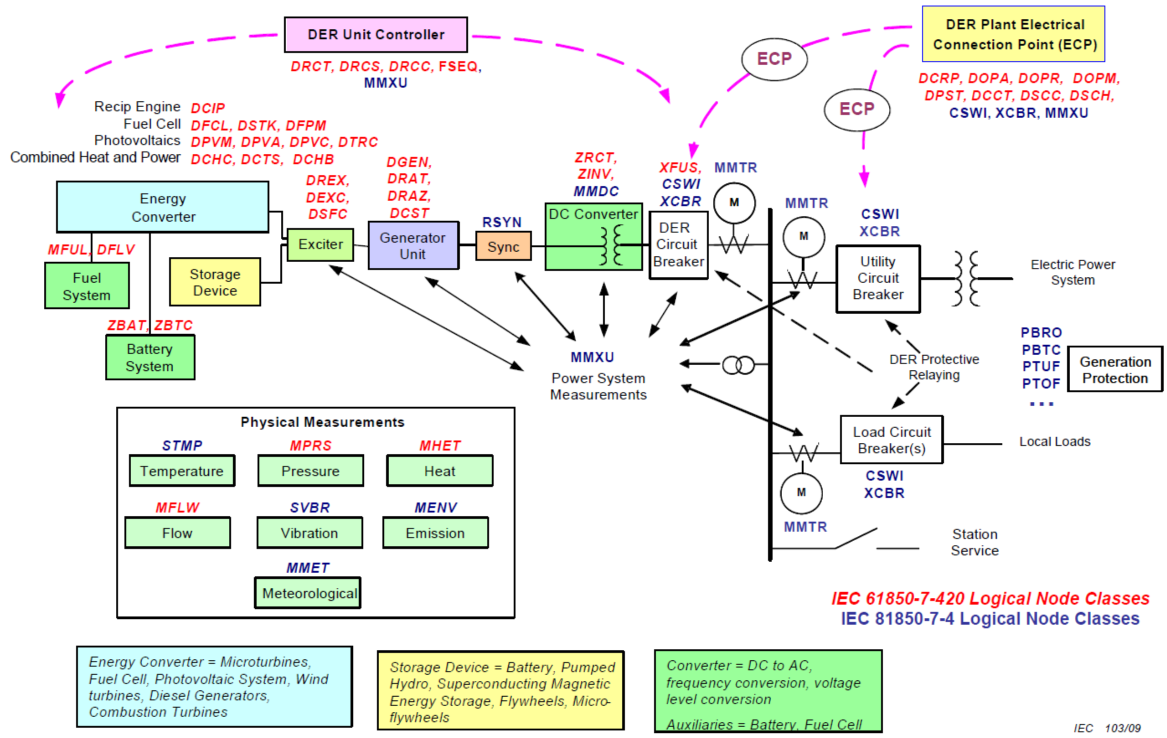

Figure 4: Conceptual organisation of DER logical devices and logical nodes (Source: [2])

After modelling the data structure with LNs, this information can be stored in an XML file using the Substation Configuration Language (SCL) explained in IEC 61850-6. The SCL supports the standardized design of IED functionalities. The XML files can be exchanged easily between projects and tools can handle the SCL files for different purposes to enable interoperability mandatory parts or common functionalities shall never be skipped. Next to the features represented by LNs, the SCL file handles the data flow and describes the communication path by describing the IP address of connected IEDs. So, the type of the SCL file is a SCD (Substation Configuration Description) file. The SCD file is used to describe a complete substation in detail. It contains substation, communication, IED and data type template sections. Additionally, the file types ICD and IID in the IEC 61850-7-X standards are applied. The ICD (IED Capability Description) defines a complete capability of an IED with an optional communication section. The IID (Instantiated IED Description) defines the configuration of one IED for a project. In the Technical Framework only the SCD files are considered to describe functions with a complete specification about the content, communication, and data type templates.

4.1.1.1 Structure of the SCD file

As mentioned above, the data structure given by the LNs of an IED can be stored in an SCD file. SCD files have the following structure:

- Header: with schema information about the file
- Substation section: describes the functional structure and its relation to primary devices
- Communication section: describes the connection between the IED access points to the respective subnetwork and includes also properties of the access points
- IED section: contains the description of supported communication services, access points and the IED's LDs, LNs, and their data objects and attributes
- Data type template section: contains the declaration of all types used in the SCD file; LN types, DO types, attributes, enumerations, etc.

4.1.2 Access Management

The data flow is bound/limited by the functional constraints of data attributes. In IEC 61850-7-3, an explanation of the functional constraints for the data attributes is given. In IEC 61850-8-1, an order for transmitting data attributes is recommended. So, the order is not mandatory; however, it specifies an operational feasible order that prevents some serious hazards. Therefore, this ordering shall be considered mandatory. Furthermore, the IEC 61850-8-1 describes the mapping of LNs and data objects according to Manufacturing Message Specification (MMS) to enable data exchange over an ISO/IEC 8802-3 Local Area Network (LAN) connecting the IEDs.

Notes:

- LLN0: The Logical Node Zero is used to address common issues of logical devices. For instance, it includes information about the LD's health and current operation mode.
- LPHD: The Logical Node Physical Device is used to present common issues of physical devices alike location, inventory ID and maintenance interval.
- FSCH: The LN FSCH defines a functional schedule.
- MMXU: The LN MMXU defines measured values for currents, voltages, powers, impedances, etc.
- DRCT: The LN of the DER controller defines the characteristics and capabilities of a DER unit or an aggregation thereof.
- DRCS: The LN of the DER controller status
- DRCC: The LN of the DER controller characteristics

4.1.3 Security Considerations

All data exchange shall be done with symmetric encryption (IEC 62351 – TLS 1.2), i.e. actors (alias communication partners) shall securely exchange a secret key (e.g. VHPready proposes the Diffie-Hellmann-Algorithm), which shall be used to encrypt and decrypt all information exchanged.
Further security considerations:

- Authentication of communication partners
- Protecting message integrity
- Preventing Replay-Attacks
- Logging message exchange and errors

These security considerations are addressed by bundling in the IHE Audit Trail and Node Authentication (ATNA) Profile. All VPP actors shall be either grouped with a Secure Node or a Secure Application Actor as defined by IHE. Furthermore, all VPP actors shall be grouped with a Time Client Actor as defined in IHE Consistent Time (CT) profile.

The IHE ATNA profile describes a structure for logging transactions between actors. This is mandatory to get an interoperable logging semantic.

4.1.4 Further information

The complete documentation of the Business Function and the information collection about the IEC 61850 can be found on the project website (https://mahara-mr.technikum-wien.at/group/integrating-the-energy-systems/usecases) where also further information about the implementation process is provided.

Note: The test procedure is not part of the Technical Framework. For the IES project, an adopted Gazelle test platform is used. The Gazelle helps to manage the test cases and to check whether the transactions implemented by vendors work. Further information about the test procedure can be found at: http://iesaustria.at.

5 Abbreviations

ATNA	Audit Trail and Node Authentication
CT	Consistent Time
DER	Distributed Energy Resource
DEU	Distributed Energy Unit
DEUC	Distributed Energy Unit Controller
DEUOP	Distributed Energy Unit Operator
DSO	Distributed system operator
EEX	Energy Exchange
e-Sens	Electronic Simple European Networked Services
FFG	Austria Research Promotion Agency
GPL	General Public License
IEC	International Electrotechnical Commission
IES	Integrating the Energy System
ISO	International Organization for Standardization
IT	Information Technology
LAN	Local Area Network
MMS	Manufacturing Message Specification
SO	System Operator
TCP/IP	Transmission Control Protocol/Internet Protocol
TLS	Transport Layer Security
UCMR	Use Case Management Repository
VPP	Virtual Power Plant
VPPOP	VPP Operator

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