Integration Profile
61850 Send Planned Schedule

Version 00.10

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1 About the Document

A **Technical Framework** represents a technical specification, which is integrated into a predefined document structure. Please note that a technical framework does not equal a new standard. It rather describes the normalised use and application of existing standards and practices to avoid interoperability issues. Integration Profiles state constraints/recommendations that define how to apply standards and good practice to realise a specific feature of a Business Function in an important interoperability fashion. The 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 framework that subdivides a technical framework into two part: volume 1 for an informative and volume 2 for a normative description. This document describes volume 2.

The document structure of the technical framework is as follows:

Volume 1:

- Business Case Overview (informative)
  - Typical use cases
  - Relevant meta-actors
  - Related standards
- 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 from the Business Function
  - Definition of transactions that are needed
  - Definition of actors that are involved
- Transactions (normative)
  - Specification of actors that shall be implemented
  - Specification of the IT standards and how options/variants shall be used

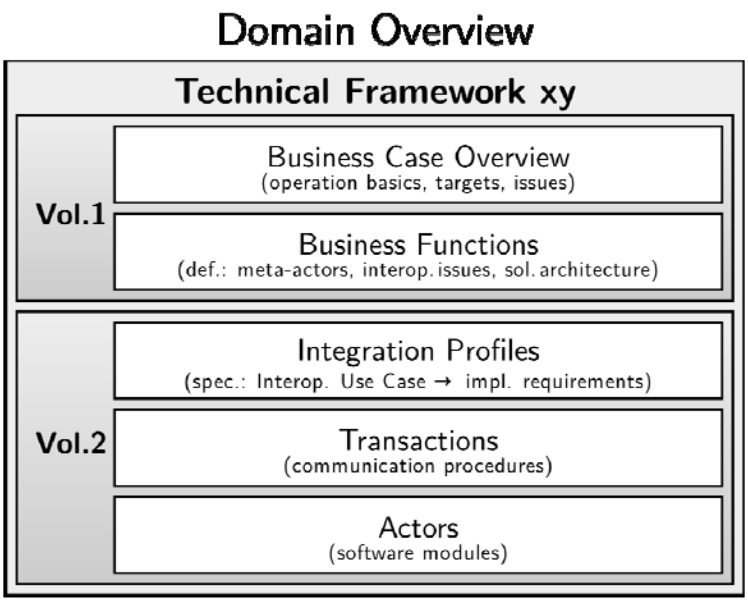


Figure 1: Structure of the Document (IES Technical Framework Template)

2 Definitions

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 feature 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 implementations outputs and response are checked against rules and patterns.

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

Interoperability Testing
is a process to check whether the system interacts effectively with foreign systems, i.e. when different vendors meet to test their interfaces against each other (e.g. Connectathon).

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
is the composition (grouping) of all the functional components (actors) that the Meta-Actor is required to integrate in order to perform all the Business Functions related to it (according to the Use Case Diagram). 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.

Transaction
is the specification of a set of messages (1..n) exchanged between at least two 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. Operational Use Cases are mentioned in the Technical Framework, but not considered by Integration Profiles because per se they do not raise interoperability problems.

3 Integration Profile: Send Planned Schedule

The profile "Send Planned Schedule" describes the interoperability issue for exchanging control information among the central Virtual Power Plant Operator (VPPOP), local Distributed Energy Unit Operators (DEUOPs) and the different Distributed Energy Unit Controllers (DEUCs) executing the contribution of the different Distributed Energy Units (DEUs) to the Virtual Power Plant (VPP). The content of the exchanged information depends on the Business Function, see the descriptions in Volume 1. The format of the exchanged information and the exchange per se are specified by the used standard series IEC 61850. The different communication relations and the used communication standard lead to the following actors-transactions relations in Figure 2 which are introduced in this Section. The concrete implementation strategy of the transactions is described in Section 4.

The following table specifies the mandatory actor grouping for the Integration Profiles defined in this document. Where possible, already defined and approved Integration Profiles from IHE are referenced. The IHE Integration Profiles can be found at http://www.ihe.net.

Table 1: Dependencies among Integration Profiles (bundling with external IPs)

Integration Profile	Depends on	Dependency Type	Purpose
61850 Send Planned Schedule (SPS)	IHE - Consistent Time	Each SPS Actor shall be grouped with the IHE Time Client Actor	To ensure consistency among timestamps
61850 Send Planned Schedule (SPS)	IHE – Audit Trail and Node Authentication	Each SPS Actor shall be grouped with IHE Secure Node or IHE Secure Application Actor	Required to manage audit trail of exchanged messages, node authentication and transport encryption
61850 Send Planned Schedule (SPS)	Set/Get 61850 Data Attribute/Object	Each SPS Actor shall transmit data attributes/objects to another actor	Transmitting the content of the LN from client to server or vice versa
61850 Send Planned Schedule (SPS)	Establish a secure connection	Client shall initiate a secure connection with the server.	Communication via a secure path
61850 Send Planned Schedule (SPS)	Check 61850 server status	Client requests the LD status of the server.	Precondition to check whether the LD is in the right state for the further transactions.

3.1 Actors/Transactions

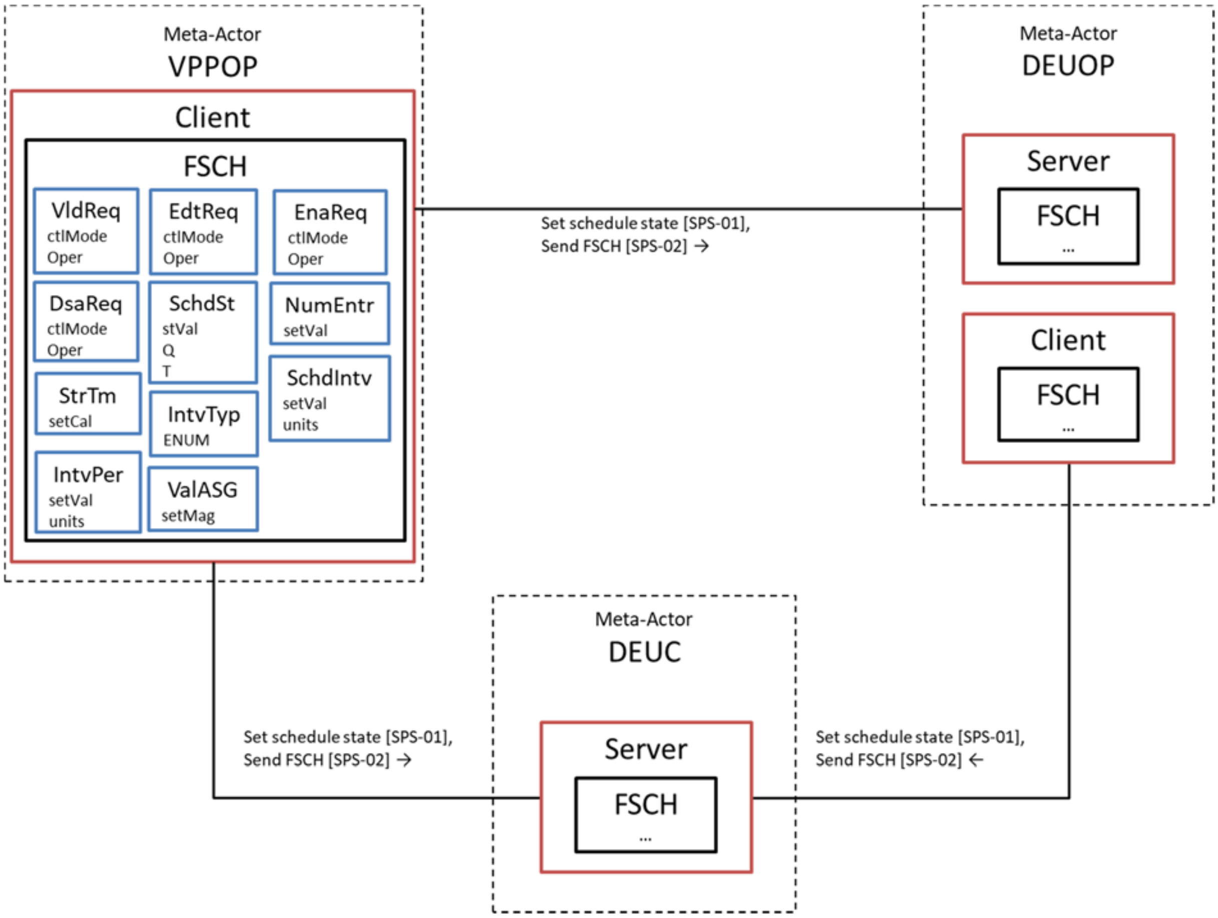


Figure 2: Actors/Transaction Diagram for Send FSCH: The dashed lines represent the grouping of actors into meta-actors.

Table 2: Transactions for Send Planned Schedule

Actors	Transaction	Optionality	Section
Client	Set schedule state [SPS-01]	R	4.1
Server	Set schedule state [SPS-01]	R	4.1
Client	Send FSCH [SPS-02]	R	4.2
Server	Send FSCH [SPS-02]	R	4.2

Hint: The DSCH was removed by the IEC 61850-7-4 (2016) and is fully replaced by the FSCH. Therefore, no transactions and profiles for the DSCH are created.

3.1.1 Actor Descriptions and Actor Profile Requirements

Some of the meta-actors/actors definitions are available in Section 3 of Volume 1.

3.1.1.1 Client

The Client is the actor that initiates a communication over a TPKT channel, being a “Transport Service on top of the TCP (IETF RFC 1006), to the Server. Either it wants to send some information, or it wants to request some information. If a TPKT channel to the Server is not already established, it initiates the connection setup with the Integration Profile “Establish a secure connection” and applies the bundled IHE ATNA Integration Profile to assure secure authorisation, encrypted data transport and adequate logging options.

3.1.1.2 Server

The Server honours the request from the Client by contributing to the connection setup, receiving the sent message, responding adequately to the received message. The Server either simple receives the sent information or response to a received request. Latter can be the execution of an internal task or replying some information to the Client via message in return.

3.1.2 Transactions

3.1.2.1 Set schedule state

The LN FSCH (functional schedule) of the standard series IEC 61850 has control data objects to change the state of the schedule. With these data objects, the schedule state shall be set to "Not ready" before new values for the schedule can be transmitted. The data objects are mapped to a SCD structure for representing the LN control unit. After establishing a secure connection via TLS 1.2, the data transmission takes place from the client (VPPOP/DEUOP) to the server (DEUC); it depends on the Integration Profiles "Establish a secure connection" and Set/Get 61850 Data Attribute/Object.

3.1.2.2 Send FSCH

After setting the schedule state to "Not ready", the data objects of the functional schedule (LN FSCH) are transmitted via the secure TLS 1.2 connection. The data objects are mapped to a SCD structure for representing the LN settings of the FSCH. The transmission is initiated by the client (VPPOP/DEUOP) that writes the data objects for the schedule in the SCD file of the server (DEUC); it depends on the Integration Profiles "Establish a secure connection" and Set/Get 61850 Data Attribute/Object.

3.2 Actor Options

Options that may be selected for each actor in this profile are listed in Table 3. Afterwards, the options are described and dependencies between options are specified.

Table 3: Actor Options for Send Asset Configurations

Actor	Role	Option	Vol. & Section
VPPOP	Aggregator	Market participant	Vol. 2, 3.2.1
	Operator (Client)	Plant Operator	Vol. 2, 3.2.2
DEUOP	Controller (Server)	DEU Controller	Vol. 2, 3.2.3
	Operator (Client)	Station Operator	Vol. 2, 3.2.4
DEUC	Controller (Server)	DEU Controller	Vol. 2, 3.2.3
DEU	Technical Unit	Producer	Vol. 2, 3.2.5
		Consumer	Vol. 2, 3.2.6
		Storage	Vol. 2, 3.2.7

3.2.1 Market participant

The VPPOP commonly acts as a market participant on the energy market, e.g. using the CIM standard series (IEC 62325) to negotiate and sell schedules (energy production cycles) and ancillary services (grid friendly flexibility). VPP focused on selling the aggregated energy volumes produced by the many assets it joins on the energy market (EX – energy exchange) is called commercial VPP (cVPP), whereas a VPP focused on selling ancillary services to the distributed grid operators (DSOs – distributed system operators) that their assets are connected to, is called technical VPP (tVPP). In practice, with today's governed energy pricing, a more or less balanced mixture of the two is the economically most viable VPP operation approach.

3.2.2 Plant Operator

The VPPOP manages many small assets and integrates them into one large virtual asset that is big enough to participate in the energy market. Every traditional plant operator is bound to the contracted grid access limits bought from the DSO. A VPP plant operator is bound to the contracted grid access limits bought per asset from the relevant DSO the asset is connected to. These limits are considerably smaller as they apply for inserting energy in the medium to low voltage distribution grids. However, the distributed connection of the many assets of a VPP to the energy grid enables the VPP operator to provide ancillary services that help the DSOs to balance their regional grid. In that case the DSO can call negotiated local schedule adjustments from the VPPOP, i.e., access flexibility that helps him in balancing his grid. The regulative alternative for DSOs, which is commonly in place as last resort measure, is selective disconnection of individual assets. Compared thereto, are ancillary service far more granular but require active cooperation of the plant operator.

3.2.3 DEU Controller

The DEU Controller (DEUC) provides the intelligent interface that converts DEU hardware into a digitally accessible IED, which can communicate with other entities. In case the DEU is integrated in a locally managed group of different assets, the DEUC communicates with the DEUOP. In case the DEU is integrated directly into a VPP, the DEUC communicates with the VPPOP. In any case, the DEUC translates messages received into control signals that make the hardware perform as intended and converts sensor signals into data objects and attributes that can be forwarded to control instances (i.e., a DEUOP and/or VPPOP). A DEUOP that is managed by a VPPOP represents the entire group of assets it manages as a single virtual DEU. Therefore, it can have the DEU Controller role alike a DEUC. The internal mechanisms to merge features and characteristics of many assets into a single representation may be complex but seen from the VPPOP the DEUOP appears alike a DEUC. However, requests from the VPPOP need more time to be answered because the DEUOP first needs to derive required requests per asset, than send these to according DEUCs and process the answers it received before it can send an answer to the VPPOP.

3.2.4 Station Controller

Alike traditional plant operators and prosumers can a DEUOP act as a local plant operator and offer ancillary services to its DSO, independent of its integration in a VPP. It does this autonomously by optimally controlling local assets it manages solely according to targets specified by its owner. In general, a DEUOP does not take part on the EX because the joint local assets are too small; this is the part of the VPPOP as aggregator. The managing actor of a micro-grid is for example such a station operator, but also every smart home/building management actor that can control how and when energy is produced and consumed by which device in the house/building. Selling energy on the EX and providing ancillary services to DSOs are more general Business Functions not only available to VPPs, and shall be specified independent of the Technical Framework on VPPs. Later, the according actors – specified somewhere else – shall be bundled to the respective VPP actors of Table 3 to prevent that VPPs require different solutions than those other entities use for identical tasks.

3.2.5 Producer

DERs occur as energy producers inserting an unknown schedule if not managed. Controlled by a DEUC the behaviour can be manged such that they at least intend to fulfil a planned schedule. In case of RES (renewable energy resources) the produced energy fluctuates due to environmental conditions (wind, clouds, temperature, season, etc.). Such energy sources can be upper bound in the amount they maximally produce, but a lower bound stating a minimum of energy produced is not always possible.

3.2.6 Consumer

Loads occur as energy consumer causing an unknown load schedule. Controlled by a DEUC the behaviour can be managed such that they intend to fulfil a planned schedule. Heavy machines that can operate at different power levels and heating devices are among others common controllable loads where a small difference in power consumption has marginal effect on the comfort of the user.

3.2.7 Storage

Energy Storages can occur as both, energy consumer and energy producer. Storage devices are commonly somehow controlled by some actor. Controlled by a DEUC they become an IED that can be integrated in a manged group of DEUs. Being designed as energy buffers their energy consumption and production can be actively varied in a wide range, making them extremely valuable balancing assets. Either as buffer for the volatile energy produced by RES, where the target is to keep the in average stored energy minimal to have maximum headroom, or as energy reserve to cover energy shortage, where the target is to keep the in average stored energy maximal to have maximum reserve.

Information Flow Process

The transmission of the planned schedule between the VPPOP or DEUOP and the DEUCs follows a sequence of single transactions between the VPPOP, DEUOP and DEUC as described above. The process flow is shown in Figure 3. The detailed description of the transactions, their data objects and common data classes can be found in the specification of the Transaction "Send FSCH" in Section 4.

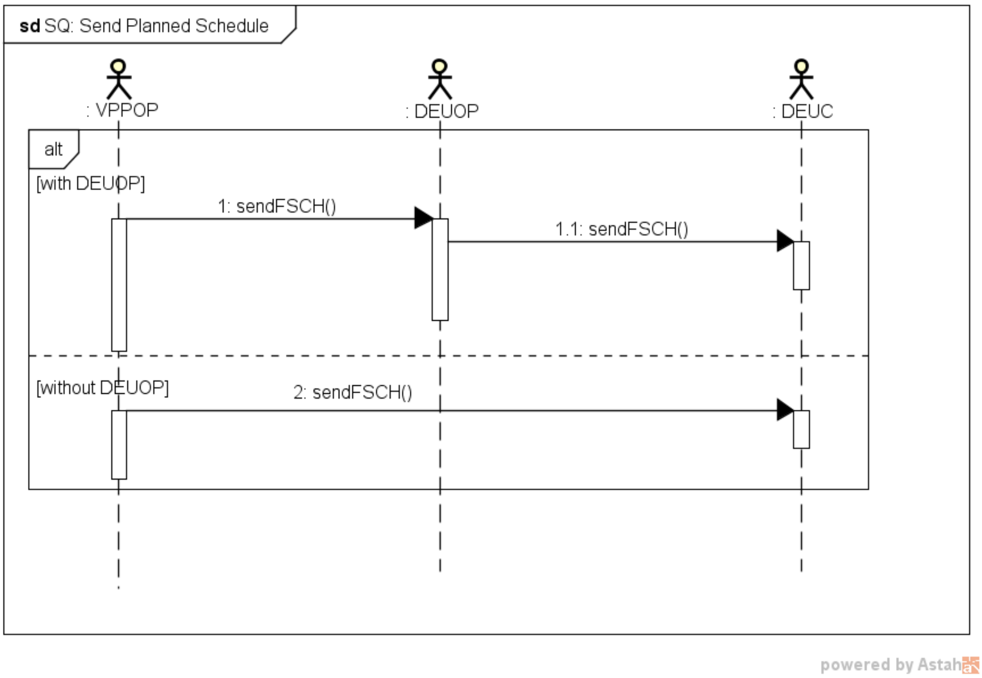


Figure 3: Sequence Diagram for "Send Planned Schedule"

3.3 Implementation Strategies

Generally, the basics of the 61850 standard series shall be applied (described in the Intro of Vol. 2). Additional details for the schedule exchange are described below.

3.3.1 State diagram for the schedule

As mentioned above, the IEC 61850 has defined the LN *functional schedule (FSCH)* for determining the process of a schedule. A schedule can be in different states as shown in Figure 4: "not ready", "validated", "ready" or "running". The state is set by the data objects VldReq, EnaReq, EdtReq, and DsaReq of the LN FSCH. The schedule can only be edited in the state "not ready", i.e. if a schedule is in state "validated", the state shall be changed to "not ready" with the data attribute EdtReq; otherwise, the schedule shall be disabled with DsaReq to reach the state "not ready". Therefore, the Booleans of the data attributes shall be set according to the schedule state that shall be reached. Before, the schedule can be activated, it shall be validated and set to the state “ready”. The activation of the schedule only depends on an external trigger or the time stamp that was set in the schedule.

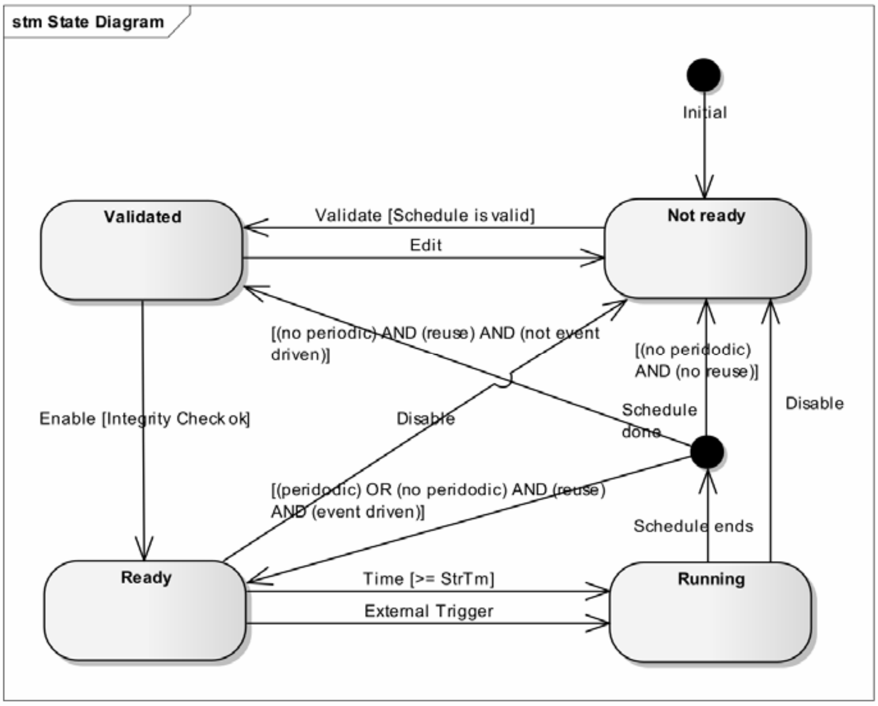


Figure 4: FSCH State Machine

3.4 Communication Requirements

The message type within the Integration Profile “Send Planned Schedule” is a Low speed message (Type 3, cf. IEC 61850-5). The message contains complex messages that shall be time-tagged. The message type should be used for slow speed auto-control functions, transmission of event records, or reading or changing set-points. In doing this, the transmission shall be less than 500 ms with TCP/IP. Thus, time-tagged schedules may belong to this type because the transmission is not time-critical for schedules which were negotiated on the Energy Exchange the previous day.

To utilize better timing GOOSE packs control information directly into Ethernet frames, skipping the TCP/IP layers. This is a different, better method that can be used within the reach of a LAN. A better implementation of the same information exchange, perfectly applicable for DEUOP – DEUC transactions.

3.5 Security Considerations

General security considerations are mentioned in the IEC 61850 basics (cf. Section 4.1.3 in the Technical Framework VPP Vol. 2).

4 Transactions

The transactions describe a concrete implementation of the interoperability issue described in the Business Function in Volume 1 of the Technical Framework which were specified through the Integration Profiles in Volume 2. The interoperability issues are described in each transaction as brief interoperability use cases which demonstrate the challenge and the actors involved of the transaction.

The IEC 61850-7-3 gives an overview on the common attribute types and the common data objects which are linked in the LN description of the 61850-4-720 part. The common data classes specify status information, measured information, control information, status settings, and analogue settings. With these data, a well-structured data exchange between substations, power plant and control centres, and DEUCs can be described. Thus, the parts IEC 61850-7-2, IEC 61850-7-420, and IEC 61850-7-3 are essential for implementing the communication mechanisms between devices from the power grid domain, especially the asset setting, schedule exchange, and measurement values.

4.1 Transaction: “Set schedule state”

4.1.1 Scope

The VPPOP/DEUOP shall change the schedule state to enable the transmission of a new schedule. Therefore, the schedule has to be in the state “not ready”. Prior the LD state of the server has to be checked; it shall have the behaviour state “on” and the health state “OK”. The LD state is requested by the VPPOP/DEUOP client and is specified in the functional Integration Profile “Check status of the server”.

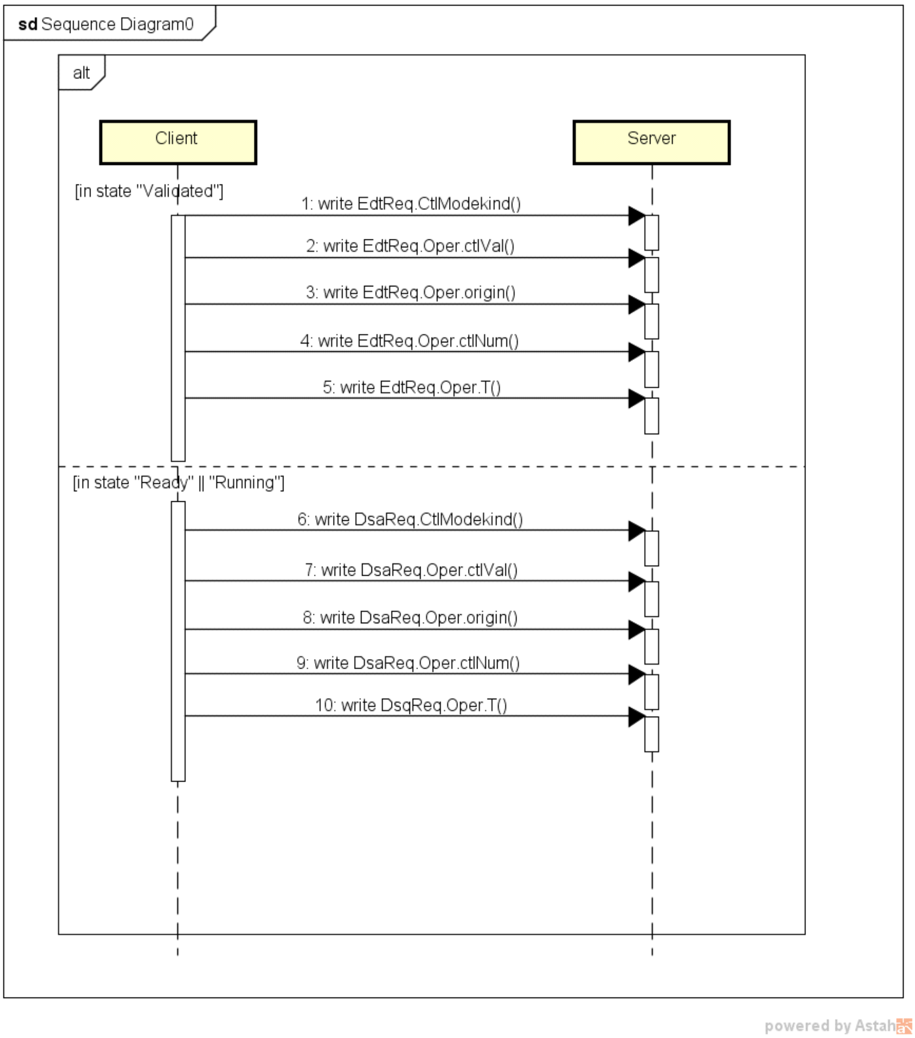
4.1.2 Actor Roles

Role	Description	Actor
Client	The client is the transaction initiator that starts and sends or requests the values of the SCD file to a receiving server actor via TCP/IP. If specified, the client uses the IHE ATNA profile to establish a secured connection before the data transmission actually starts, if it is not already in place.	The following actors may play the role of the client: VPPOP, DEUOP
Server	The server is the transaction responder that receives the values of the SCD file or the request. In case a secure connection is required, it cooperates with the client in establishing security.	The following actors may play the role of the server: DEUOP, DEUC

4.1.3 Referenced Standards

- IEC 61850-7-420 (logical nodes)
- IEC 61850-7-2 (data objects, services)
- IEC 61850-5 (protocol requirements)
- IEC 62351 – TLS 1.2

4.1.4 Interaction Diagrams



4.1.4.1 Create message

4.1.4.1.1 Triggering Event

The VPPOP/DEUOP wants to edit the schedule and has to set the schedule state to “Not ready”. Therefore, the LD has to be in the status *on* and the health state *Ok*.

4.1.4.1.2 Message Semantics

Table 4: FSCH Data Object

Logical Device	**Logical Node**	**Data Object**	**Common data class**	**Data Attribute**	**Functional Constraint**	**Description**
VPPOP / DEUOP / DEUC	FSCH	VldReq	SPC	ctlModel	CF	Specifies the control model for validate transition request, possible values are: status-only, direct-with-normal-security, sbo-with-normal-security, direct-with-enhanced-security, sbo-with-enhanced-security

		EnaReq	SPC	ctlModel	CF	Specifies the control model for enable transition request, possible values are: status-only, direct-with-normal-security, sbo-with-normal-security, direct-with-enhanced-security, sbo-with-enhanced-security
		EdtReq	SPC	ctlModel	CF	Specifies the control model for edit transition request, possible values are: status-only, direct-with-normal-security, sbo-with-normal-security, direct-with-enhanced-security, sbo-with-enhanced-security
		DsaReq	SPC	ctlModel	CF	Specifies the control model for disable transition request, possible values are: status-only, direct-with-normal-security, sbo-with-normal-security, direct-with-enhanced-security, sbo-with-enhanced-security

The content of the SCD file to set the state of the schedule includes:

```
<LNodeType InClass="FSCH" id="FSCH" desc="Schedule">
        <DO name="VldReq" type="SPC"/>
        <DO name="EnaReq" type="SPC"/>
        <DO name="EdtReq" type="SPC"/>
        <DO name="DsaReq" type="SPC"/>
</LNodeTyoe>
<DOType cdc="TSG" id="SPC">
        <DA name="ctlModel" bType="Enum" type="CtlModelKind" fc="CF" dchg="true"/>
        <DA name="ctlVal" bType="BOOLEAN" type="BOOLEAN"/>
        <DA name="origin" bType="Originator" type="Originator" fc="ST" />
        <DA name="ctlNum" bType="INT8U" type="INT8U" fc="ST" />
        <DA name="T" bType="TimeStamp" type="TimeStamp" fc="ST" />
</DOType>
<EnumType id="CtlModelKind">
        <EnumVal ord="0">status-only</EnumVal>
        <EnumVal ord="1">direct-with-normal-security</EnumVal>
        <EnumVal ord="2">sbo-with-normal-security</EnumVal>
        <EnumVal ord="3">direct-with-enhanced-security</EnumVal>
        <EnumVal ord="4">sbo-with-enhanced-security</EnumVal>
</EnumType>
```

4.1.4.1.3 Expected Actions

The VPPOP/DEUOP has created the SCD file for setting the schedule state to “Not ready”.

4.1.4.2 Establish Secure Connection

A secure connection between client and server is established by the functional Integration Profile “Establish a secure connection”.

4.1.4.3 Transmit Message

The Client writes the values of its SCD file to the SCD file of the Server via the secure TCP/IP connection that was established in the step 4.1.4.2. The data transmission is specified in the functional Integration Profile Set/Get 61850 Data Attribute/Object.

4.1.5 Security Considerations

General security considerations are mentioned in the IEC 61850 basics (cf. Section 4.1.3 in the Technical Framework VPP Vol. 2).

4.2 Transaction: "Send FSCH"

4.2.1 Scope

After the participation on the energy market and the coordination with the DSO according to the planned schedules, the VPPOP creates functional schedules for its DEUs and sends them to the DEUOPs or directly to the DEUCs. The DEUOPs manage different DEUs and is responsible to execute the schedules in the operative mode, i.e. the DEUOP creates single functional schedules for the different DEUs and sends them to the DEUCs. The interoperability issue is the direct schedule exchange between VPPOP and DEUOP, VPPOP and DEUC, and DEUOP and DEUC via a secure connection. Before, the transaction of the schedule can be executed, the VPPOP/DEUOP has to create the SCD file which will be transferred to the DEUOP/DEUC.

Hint: The DSCH was removed by the IEC 61850-7-4 (2016) and is fully replaced by the FSCH. Therefore, no transactions and profiles for the DSCH are created.

4.2.2 Actor Roles

Table 5: Actor Roles for Send FSCH

Role	Description	Actor
Client	The client is the transaction initiator that starts and sends or requests the values of the SCD file to a receiving server actor via TCP/IP. If specified, the client uses the IHE ATNA profile to establish a secured connection before the data transmission actually starts, if it is not already in place.	The following actors may play the role of the client: VPPOP, DEUOP
Server	The server is the transaction responder that receives the values of the SCD file or the request. In case a secure connection is required, it cooperates with the client in establishing security.	The following actors may play the role of the server: DEUOP, DEUC

4.2.3 Referenced Standards

- IEC 61850-7-420 (logical nodes)
- IEC 61850-7-2 (data objects, services)
- IEC 61850-5 (protocol requirements)
- IEC 62351 – TLS 1.2

4.2.4 Interaction Diagrams

The interactions are depicted as sequence diagram. For the transaction "Send FSCH", the sequence diagram includes the transaction "*Set schedule state*" (as precondition) and the functional Integration Profile Set/get 61850 Data Attribute/Object to transmit the values.

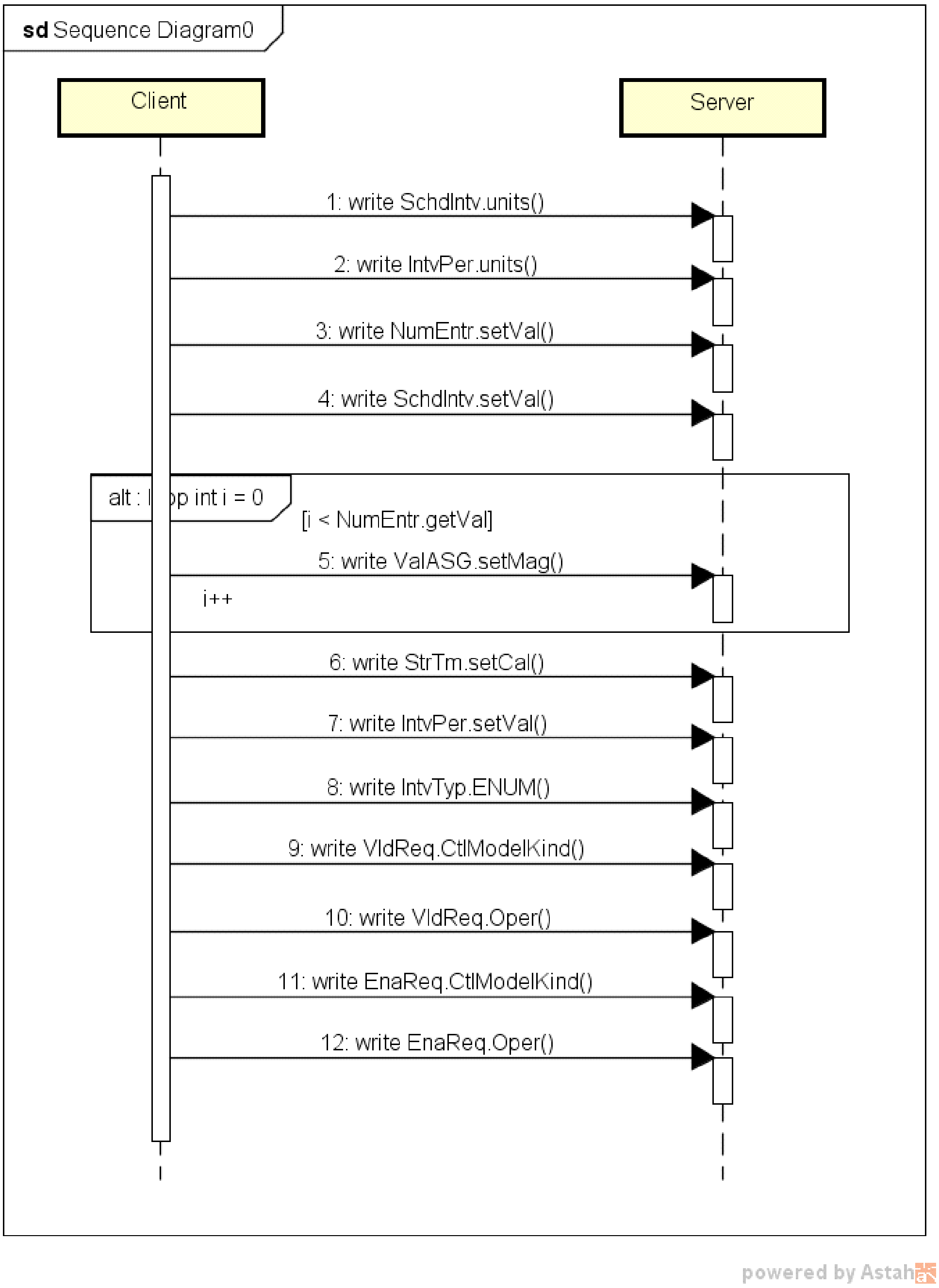


Figure 5: Data flow for Send FSCH

4.2.4.1 Create the message

4.2.4.1.1 Trigger Events

The VPPOP triggers the transmission of the schedule including the FSCH LN to the respective DEUOP/DEUC; otherwise, the DEUOP triggers the transmission to the DEUC. Therefore, the LD has to be in the health state *Ok* and the schedule state of the LD has to be *not ready* (cf. Section 3.3) for changing the schedule values in the next step (cf. Section 4.2.4.1.2).

4.2.4.1.2 Message Semantics

If the preconditions in the triggering event are fulfilled, the schedule can be edited by changing the following data objects of the LN FSCH. The values of the SCD file from the LN are transmitted.
The schedule needs the following data objects from the FSCH (IEC 61850-7-420):

Table 6: FSCH Data Objects

Logical Device	**Logical Node**	**Data Object**	**Common data class**	**Data Attribute**	**Functional Constraint**	**Description**
VPPOP / DEUOP / DEUC	FSCH	SchdSt	INS	stVal	ST	State of this schedule
				Q	ST	Quality of schedule state
				T	ST	Timestamp of schedule state
		NumEntr	ING	setVal	SP	The number of schedule entries that are valid out of the instantiated ValASG. It shall be > 0.
		SchdIntv	ING	setVal	SP	The schedule interval duration
				units	CF	Eg.: sec, min, h, d
		ValASG	ASG	setMag	SP	The ASG scheduled values (current value output as MV (FC: Measured Value))
		StrTm	TSG	setCal	SP	Start time of the schedule in calendar time
		IntvPer	ING	setVal	SP	Interval period
				units	CF	Eg.: sec, min, h, d
		IntvTyp	ENG	ENUM	SP	Interval type

Notes:

FSCH: Functional schedule
ING: Integer status setting
ASG: Analogue setting
TSG: Time setting group
SP: setting point
EX: extended

Based on the LNs, a SCD file is generated with the IEC 61850 Substation Configuration Tool (SCT) by the H+S Hard- & Software Technologie GmbH & Co. KG. The SCD file shall content at least the following structure:


```
<?xml version="1.0" encoding="UTF-8"?>
<SCL xmlns="http://www.iec.ch/61850/2003/SCL" xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" version="2007" revision="B">
	<Header id="" version="1" revision="1" toolID="Notepad++">
		<History>
			<Hitem version="0" revision="1" when="2017-09-25 11:45:55" who="Schicklgruber" what="Initial creation
of model" why="Initial version"/>
		</History>
	</Header>
	<Substation name="SUBSTATION">
		<VoltageLevel name="VOLTAGELEVEL">
			<Bay name="BAY"/>
		</VoltageLevel>
	</Substation>
	<Communication>
		<SubNetwork name="NETWORK" type="8-MMS">
			<BitRate unit="b/s" multiplier="M">100</BitRate>
			<ConnectedAP iedName="OPENMUCIED" apName="AP1">
				<Address>
					<P type="IP">10.0.0.1</P>
					<P type="IP-SUBNET">255.0.0.0</P>
					<P type="IP-GATEWAY">0.0.0.0</P>
				</Address>
			</ConnectedAP>
		</SubNetwork>
	</Communication>
	<IED name="OPENMUCIED">
		<Services>
```

```xml
				<DynAssociation max="5"/>
				<GetDirectory/>
				<GetDataObjectDefinition/>
				<DataObjectDirectory/>
				<GetDataSetValue/>
				<DataSetDirectory/>
				<ConfDataSet max="20" maxAttributes="250" modify="true"/>
				<DynDataSet max="20" maxAttributes="250"/>
				<ReadWrite/>
				<ConfReportControl bufConf="true" bufMode="both" max="15"/>
				<GetCBValues/>
				<ReportSettings bufTime="Dyn" cbName="Conf" datSet="Dyn" intgPd="Dyn" optFields="Dyn" owner="true" resvTms="true" rptID="Dyn" trgOps="Dyn"/>
				<GSESettings appID="Conf" cbName="Conf" datSet="Conf"/>
				<GOOSE max="50"/>
				<ConfLNs fixLnInst="false" fixPrefix="false"/>
				<TimeSyncProt c37_238="true" other="false" sntp="true"/>
			</Services>
			<AccessPoint name="AP1">
				<Server>
					<Authentication/>
					<LDevice inst="LD1">
						<LN0 lnType="LLN0" lnClass="LLN0" inst=""/>
						<LN lnClass="LPHD" inst="1" lnType="LPHD"/>
						<LN prefix="Normal_" lnClass="FSCH" inst="1" lnType="FSCH"/>
					</LDevice>
				</Server>
			</AccessPoint>
		</IED>
		<DataTypeTemplates>

			<LNodeType lnClass="FSCH" id="FSCH" desc="Schedule">
				<DO name="SchdSt" type="ENS_ScheduleStateKind"/>
				<DO name="NumEntr" type="ING"/>
				<DO name="SchdIntv" type="ING"/>
				<DO name="ValASG" type="ASG"/>
				<DO name="StrTm" type="TSG"/>
				<DO name =”IntvPer” type =”ING”/>
				<DO name =”IntvTyp” type =”ENG”/>
			</LNodeType>
			<DOType cdc="ING" id="ING">
				<DA name="setVal" bType="INT32" dchg="true" fc="SP"/>
				<DA name="units" bType="Unit" dchg="true" fc="CF"/>
			</DOType>
			<DOType cdc="ENG" id="ENG">
				<DA name="setVal" bType="Enum" type="CalcIntervalKind" dchg="true" fc="SP"/>
			</DOType>
			<DOType cdc="ASG" id="ASG">
				<DA name="setMag" bType="Struct" type="AnalogueValue" dchg="true" fc="SP"/>
			</DOType>
			<DOType cdc="TSG" id="TSG">
				<DA name="setCal" bType="Struct" type="CalendarTime" fc="SP" dchg="true"/>
			</DOType>

			<EnumType id="ScheduleStateKind">
				<EnumVal ord="1">Not ready</EnumVal>
				<EnumVal ord="2">Validated</EnumVal>
				<EnumVal ord="3">Ready</EnumVal>
				<EnumVal ord="4">Running</EnumVal>
			</EnumType>
			<EnumType id="CalcIntervalKind">
				<EnumVal ord="1">MS</EnumVal>
				<EnumVal ord="2">PER_CYCLE</EnumVal>
				<EnumVal ord="3">CYCLE</EnumVal>
				<EnumVal ord="4">DAY</EnumVal>
				<EnumVal ord="4">WEEK</EnumVal>
				<EnumVal ord="4">MONTH</EnumVal>
				<EnumVal ord="4">YEAR</EnumVal>
				<EnumVal ord="4">EXTERNAL</EnumVal>
			</EnumType>

			<DAType id="AnalogueValue">
				<BDA name="f" bType="FLOAT32"/>
			</DAType>
			<DAType id="CalendarTime">
				<BDA name="occ" bType="INT16U"/>
				<BDA name="occType" bType="Enum" type="OccurrenceKind"/>
				<BDA name="occPer" bType="Enum" type="PeriodKind"/>
				<BDA name="weekDay" bType="Enum" type="WeekdayKind"/>
				<BDA name="month" bType="Enum" type="MonthKind"/>
				<BDA name="day" bType="INT8U"/>
				<BDA name="hr" bType="INT8U"/>
				<BDA name="mn" bType="INT8U"/>
			</DAType>
		</DataTypeTemplates>
</SCL>
```

4.2.4.1.3 Expected Actions

The SCD content for the schedule is created by the VPPOP/DEUOP client.

4.2.4.2 Establish Secure Connection

A secure connection between client and server is established by the functional Integration Profile "Establish a secure connection".

4.2.4.3 Transmit Message

The client writes the values to the SCD file of the server via the secure TCP/IP connection that was established in the step 4.2.4.2. The data transmission is specified in the functional Integration Profile Set/Get 61850 Data Attribute/Object.

4.2.4.4 Validate LN FSCH

The VPPOP/DEUOP client received a SCD file containing the functional schedule.

4.2.4.4.1 Trigger Events

The DEUOP/DEUC server received a message containing a schedule from the VPPOP.

4.2.4.4.2 Message Semantics

The SCD file described in Section 4.2.4.1.2 was transmitted and the same LN structure like in Table 6 shall result.

4.2.4.4.3 Expected Actions

The client got the LN FSCH data.

4.2.5 Security Considerations

For a secure transmission, a connection via TLS 2 (Transport Layer Security 2) is mandatory (cf. **Fehler! Verweisquelle konnte nicht gefunden werden.**). Aspects for authentication/authorization and logging as described the IHE ATNA Profile shall also be considered for this transaction: http://wiki.ihe.net/index.php/Audit_Trail_and_Node_Authentication. The logging should contain parameters of the transmitter, receiver, time-stamp, and status of the transmission (successful or failing). Additional, reasons for the incorrect message transmission can be defined. A concrete schema for the logging still has to be defined. The logging and the schema are specified in the Functional Integration Profile "Audit Trail Event".

5 Abbreviations

ATNA	Audit Trail and Node Authentication
CDC	Common Data Classes
CIM	Common Information Model
cVPP	commercial VPP
DER	Distributed Energy Resource
DEU	Distributed Energy Unit
DEUC	Distributed Energy Unit Controller
DEUOP	Distributed Energy Unit Operator
DO	Data Objects
DSCH	LN: DER energy and / or ancillary service schedule
DSO	Distributed system operator
FFG	Austria Research Promotion Agency
FSCH	LN: Functional Schedule
GOOSE	Generic Object Oriented Substation Events
IEC	International Electrotechnical Commission
IES	Integrating the Energy System
IETF	Internet Engineering Task Force
IHE	Integrating the Healthcare
IP	Integration Profile
ISO	International Organization for Standardization
IT	Information Technology
LAN	Local Area Network
LD	Logical Device
LN	Logical Node
MMS	Manufacturing Message Specification
SCD	Substation Configuration Description
SCL	Substation Configuration description Language
SCSM	Specific Communication Service Mapping
SGAM	Smart Grid Architecture Model
SO	System Operator
SPS	Send Planned Schedule
TCP/IP	Transmission Control Protocol/Internet Protocol
TLS	Transport Layer Security
TPKT	Transport Packet
tVPP	technical VPP
UCMR	Use Case Management Repository
VPP	Virtual Power Plant
VPPOP	VPP Operator

6 References

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

[2] IEC, “IEC 61850-7-4 Edition 2.0 - Communication networks and systems for power utility automation - Part 7-4: Basic communication structure - Compatible logical node classes and data object classes.” 2016.

[3] IEC, “IEC 61850-8-1: Communication networks and systems in substations - Part 8-1: Specific Communication Service Mapping (SCSM) - Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3.” 2004.

[4] ISO/IEC 88241: 1999, Information technology – Abstract Syntax Notation One (ASN. 1) ITU X.690 (07/2002), Information technology

[5] RFC 5246: The Transport Layer Security (TLS) Protocol Version 1.2 – Communication security over the Internet

[6] IEC 62351: Power systems management and associated information exchange - Data and communications security

[7] IEC 61850-5: Communication requirements for functions and device models.

[8] M. Janssen, C. Andersen, C. Brunner, J. Dall: „Modelling of DER schedules using IEC 61850“ in “20th International Conference on Electricity Distribution” 2009.