Industry recommendation

Conditional Grid Connections

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Introduction

This document aims to describe an industry recommendation for IT communication between Distribution System Operators (DSO) and customers with conditional grid connections[1] in Sweden. The document also describes the industry-wide evaluation process that forms the basis of the recommendation. As an appendix, experiences from a Proof-Of-Concept implementation of the proposed OpenADR protocol are described to give those organizations that want to integrate their systems insights on how that might work in practice.

The end goal is to promote an industry standard to serve as guidance for how communication between DSO and customer can be managed within the scope of conditional grid connections.

The industry recommendation stems from the idea that it becomes easier and more efficient for market participants to introduce conditional agreements if the same IT communication protocol is used in the market. However, the industry recommendation is voluntary and does not entail any mandatory requirements for the actors to use the proposed data protocol.

Contents

[1] Also called ”non-firm grid connection” or “flexible grid connection”

Background

Conditional electricity grid agreements enable earlier connection of customer facilities to locations in the grid where there is currently a shortage of capacity. There is great potential in being able to connect, for example, charging stations while the electricity grid is reinforced. Other types of customer facilities may also be considered for conditional grid connection agreements.

If there is a need to reduce the power consumption or production of a customer facility with an active conditional agreement, the DSO must be able to communicate an *activation request signal* with the customer in an automated manner. The exchange of information must therefore be system to system in accordance with a defined communication protocol.

As many DSOs may introduce conditional agreements in the coming years, there is a risk that different protocols will be introduced on the market. This would be inefficient for customers, e.g. charging point operators that have charging stations operating under conditional agreements with multiple grid owners. This would lead to increased administrative burden and complexity as well as increased costs for setting up different types of communication solutions.

The introduction of conditional agreements in the industry would therefore be facilitated if all actors use the same communication protocol for the exchange of information between grid owner and customer.

Prerequisites for an industry recommendation

Swedenergy (Energiföretagen Sverige) initiated an effort 2022 to identify which existing data protocols are currently used for activation request signal in other countries and then evaluate which of these would be best suited to introduce as a Swedish industry standard. The work has been carried out by a specially appointed working group with the support of a reference group. In both groups there are experts in the field from both DSOs and customers (charging point operators (CPOs)).

Conditional grid agreement in this context refer to limitation of subscription/withdrawal rights for the customer (compare with dispatch limitation in ACER's draft framework for demand flexibility).

ACER:s definition: "Dispatch limitation (Swedish "abonnemangsbegränsning") means a congestion management product whereby a service provider offers to limit the use of the firm connection capacity of a service providing unit or group prior to the determination of its dispatch, i.e. prior to closure of the day-ahead market."

- Conditional grid agreement is an example of dispatch limitation.

The activation request signal is to be used when the DSO wants to communicate a limitation of the power output (or input in case of a production site) to the customer. The basic principle for the communication between the DSO and the customer is that the DSO sends an activation request signal to the customer – who decreases the electricity output/input for its resource. This means that the limitation of electric power does not take place instantaneously but is carried out with a certain time delay. This principle is based on the fact that DSO does not have the prerequisites, the tools or the knowledge about *how* the customer's resource "behind the meter" should be adapted to limit the power output/input. Therefore, it is the customer who should be responsible for the actual execution of this task.

The following prerequisites have been guiding:

- The recommendation should refer to an open and internationally viable and used communication protocol.
- Since the details of the information content are not yet fully known and considering how quickly developments are taking place in this area, the communication protocol should be flexible and adaptable to future needs.
- The recommendation, and the communication protocol that is proposed, must not affect or inhibit competition between the market actors. This refers to both existing and new actors.
- The recommendation primarily applies to charging stations, but it should be viable for other types of flexibility resources (both consumption and production).
- In case the flexibility resource is a charging station: limiting the electrical output will affect the customer charging their vehicle. Therefore, the customer perspective is important when it comes to the exchange of information between the actors. For example, the information exchange should enable the CPO to inform their customer about ongoing and forecasted limitations at their charging stations.
- The security of information exchange between actors and IT system communications must be ensured.
- The information exchange involves two actors: the DSO and the customer with conditional grid connection. In some cases, however, another actor can act as an agent for the customer, for example in the case of charging infrastructure; an aggregator or payment service provider representing the CPO.
- This recommendation is introduced to make it easier for market participants here and now. But given the rapid development in technology, communication and regulations, not least at EU level, the conditions may change in the longer term. If, for example, there are new standards and/or regulations on the market in the future, this recommendation may need to be updated, or discontinued if it is no longer needed.

Evaluation of potential data protocols

Four potential data protocols were identified for evaluation:

- OSCP https://www.openchargealliance.org/protocols/oscp-20/
- OpenADR (IEC 62746-10-1) https://www.openadr.org/
- IEEE 2030.5-2018 https://standards.ieee.org/ieee/2030.5/5897/
- IEC 61850-7-420 https://webstore.iec.ch/publication/34384

In an initial evaluation, the working group concluded that both OSCP and OpenADR meet the basic needs for activation request signal and that these data protocols would work to be introduced as industry standards. However, the working group agreed that IEEE 2030.5-2018 and IEC 61850-7-420 did not fulfill the requirements.

Based on a more in-depth evaluation the working and reference groups propose that OpenADR should be recommended as the industry standard. The following conclusions and judgments were decisive:

- OpenADR is considered to be a more future-proof protocol than OSCP.
- OpenADR is the data protocol used by most actors from an international perspective.
- OpenADR has support for several different use cases and can be used for both forecast and real-time control polling. OpenADR also supports other types of flexibility services.
- OpenADR is an established IEC standard.
- The evaluation was based on OpenADR 2.0b, which is the current version used by many actors internationally. However, this version is a few years old and it is met with some criticism that it is not fully updated in accordance with modern IT development. The OpenADR Alliance has recently finalized a 3.0 version which will be easier to implement. This is based on the usage of JSON and a real RESTful API. This new version should be very flexible as the business logic is removed from the initial VTN and VEN implementations. OpenADR 3.0 is not meant to replace 2.0 but rather adds a simpler implementation where it is appropriate.

Proof-of-Concept to verify OpenADR

In January 2023, a broader market referral was then carried out where various market participants could submit their views on the proposal to choose OpenADR as an industry recommendation. The responses received showed that a majority supported the proposal.

To further test communication via OpenADR 2.0b, the working group organized a Proof-of-Concept (PoC) with E.ON in the role of DSO and Vattenfall in the role of customer/CPO (see appendix below).

Industry recommendation

Based on the experience gained from the evaluation process, Proof-of-Concept, as well as interest and positive feedback from industry actors, **the recommendation is to adopt OpenADR as a standard communication protocol for conditional grid agreements**. The recommendation is voluntary and does not entail any mandatory requirements for the actors to use the proposed data protocol.

Next steps

For actors getting started with OpenADR, it's recommended to focus on the latest 3.0 specification since this should be the most future-proof version and require the least amount of development and maintenance efforts. More information about 3.0 can be found here: https://www.openadr.org/openadr-3-0

For those looking to work with OpenADR 2.0b, OpenLEADR is a great way to learn more about OpenADR and quickly get to testable implementations of both DSO and CPO functionality.

Ideally, all DSOs should use same or similar parameters for OpenADR to avoid customers having to manage e.g. multiple signal names or types for their setup. The appendix gives pointers and suggestions on this, but the details may change if iterations are needed.

Connecting customers/CPOs can do the following:

- Visit the OpenADR alliance web site for further reading and support.
- Explore different ways to implement a client, which could be by building from scratch, using OpenLEADR or similar library/application, or sourcing a hardware solution.
- Discuss with their DSO the practical and technical implications of the conditional agreement, as well as suitable ways to handle integration.
- Implement the OpenADR client solution decided upon to perform testing internally and together with the DSO.

Appendix: Example of a real-world use case and PoC

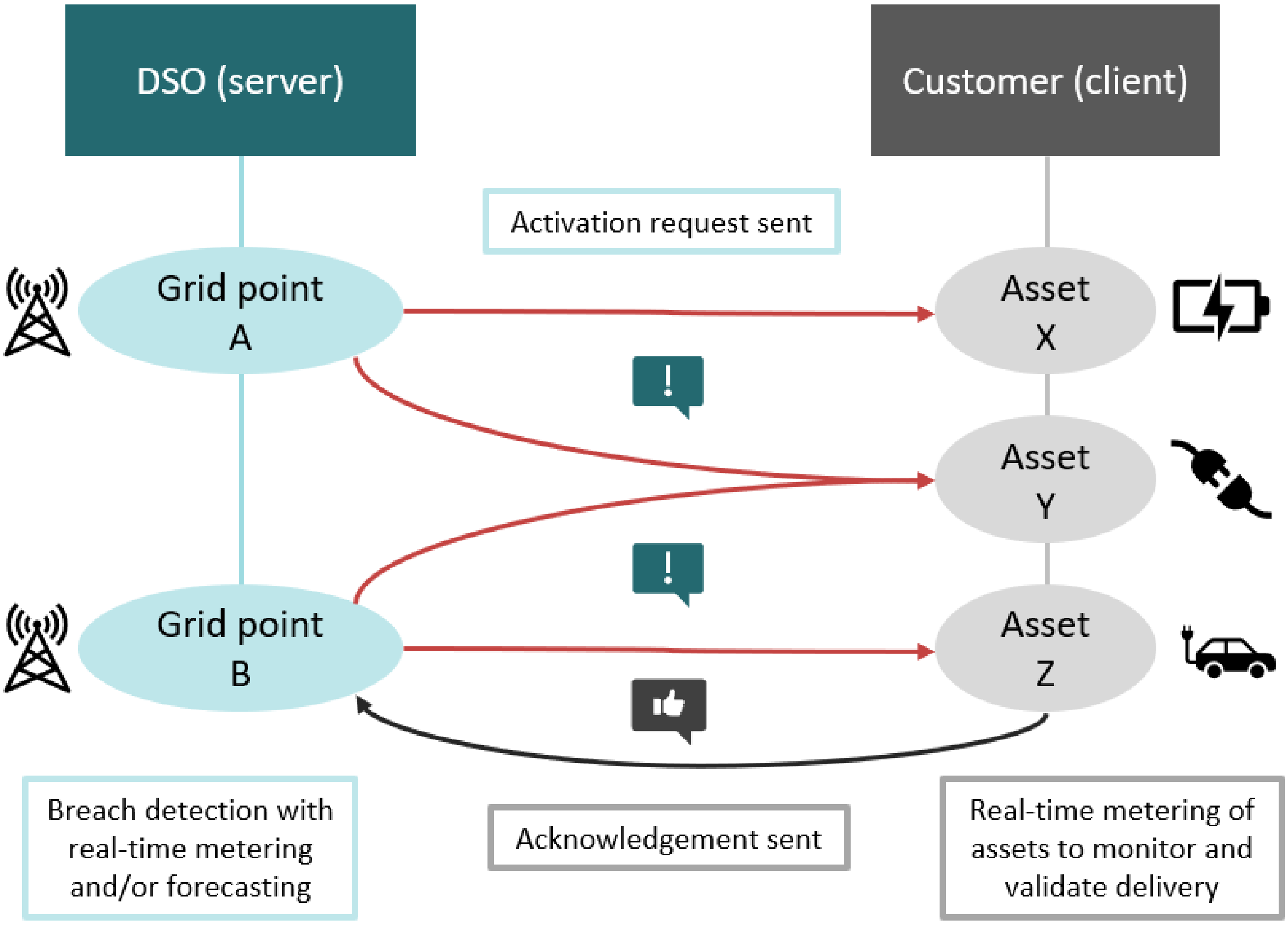
During 2022, Vattenfall and E.ON cooperated to develop system support for managing conditional connections. An existing platform for flexibility services called E.ON SWITCH was used, to also enable interoperability with local flexibility markets. SWITCH is a web application that provides systems and interfaces between actors such as grid owners, consumers, producers, and aggregators.

At the time of development (early 2022) no obvious standard was found to use as basis for the communication between DSO and customer, so proprietary API endpoints were created where connecting clients could fetch the requests generated by the system. As part of the work on evaluating potential communication protocols, SWITCH could be used for proof-of-concept testing to further standardization on a national level.

Use case description (general)

- The DSO identifies a congestion issue in a grid area that puts a hard limit on available power for customers that wants to connect one or multiple assets.
- The customer assets could be EV chargers, energy storage etc. To allow connection ahead of grid reinforcements, the DSO and customer negotiates an agreement that specifies conditional reduction of asset consumption or production.
- During nominal grid operation the typical subscription level apply.
- In case of a detected level breach affecting the grid, requests will be sent to the customer for temporarily reducing asset power limit to a lower level (for allowed consumption or production).
- The whole flow is automated by using real-time data for grid observation and triggering requests, as well as for validating customer compliance.
- DSO and customer systems are integrated to manage configuration of assets and automated communication between actors.
- The customer is responsible for making sure that the request content is handled correctly, i.e. that relevant software and hardware performs any operations necessary to comply with DSO limits.

Information exchange overview



SWITCH specific prerequisites

- Each substation (or grid point) can have one or multiple connected assets, and each asset can be connected to one or multiple substations
- Every request specifies a 15-minute delivery period, e.g. 13:00-13:15, and a triggered grid limit breach may result in one or multiple requests
- In each request, an asset delivery limit for maximum power is specified that the customer must adhere to for the duration of the delivery period
- Asset delivery limit is configured by the DSO according to the conditional agreement and is a static value
- The customer is required to send an acknowledgement to confirm that they've received the request, within a configured timespan (default of 5 minutes)
- Real-time readings sent to SWITCH must comply with rules such as timestamps in UTC format and allowed frequencies of momentaneous and average values
- Validation of compliance is done based on readings which must on average be below the asset limit for the delivery period

- Customers need to integrate with SWITCH API endpoints to continually check for new requests, send acknowledgements, and deliver real-time meter readings. This is necessary to be able to perform asset control and be compliant with the DSO conditional agreement.

Standardization efforts

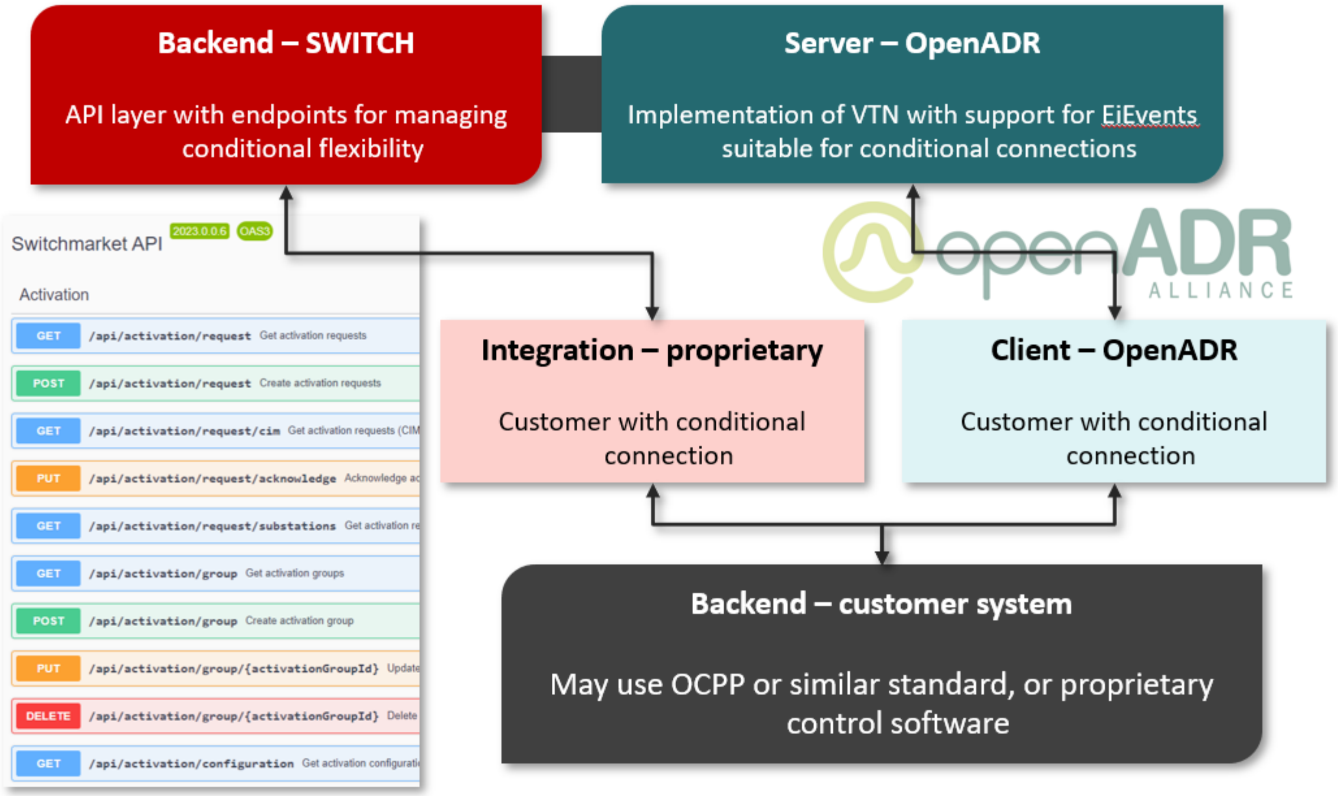
As part of the PoC, E.ON has implemented an OpenADR server (VTN or Virtual Top Node) which connecting clients (VENs or Virtual End Nodes) can poll for event signals. The events should closely match the general use case of conditional activation requests as well as the specific SWITCH requirements.

The OpenADR 2.0b specification is extensive and provides ample support for the server-client exchange needed for conditional connections. It doesn't include RESTful API communication with JSON files (the most common web standard) but rather uses XML. For some developers, a quick path to a working VEN can be either using the OpenLEADR python library, or the EPRI desktop application.

The current implementation in SWITCH works as follows:

- Customers that want to integrate using OpenADR gets access to SWITCH and can setup their own VEN configuration with one or multiple assets
- Using a predefined URL, clients can connect their VEN to the SWITCH VTN
- Registration process is handled according to the OpenADR specification
- VENs can poll the VTN for new events using HTTP pull
- Any request that involves at least one asset configured for a VEN will result in a created OpenADR event with signal name LOAD_DISPATCH and signal type SETPOINT
- Information about start time, duration and asset delivery limit is included in the event XML payload
- VENs can use oadrResponse to acknowledge the event signal
- Real-time data can be sent either as OpenADR reports (TELEMETRY_USAGE) or using the proprietary API endpoint for readings
- More details and code samples, as well as contact information to the SWITCH team can be found on docs.switchmarket.se

To encourage OpenADR adoption, the proprietary API endpoints for conditional activation requests are scheduled to be removed from SWITCH by the end of Q2 2024. After that, only OpenADR integrations will be used for conditional connections. This should provide enough time for iterating the current VTN implementation (if necessary) and allow API customers to migrate to OpenADR.



High-level overview of VTN implementation and PoC setup

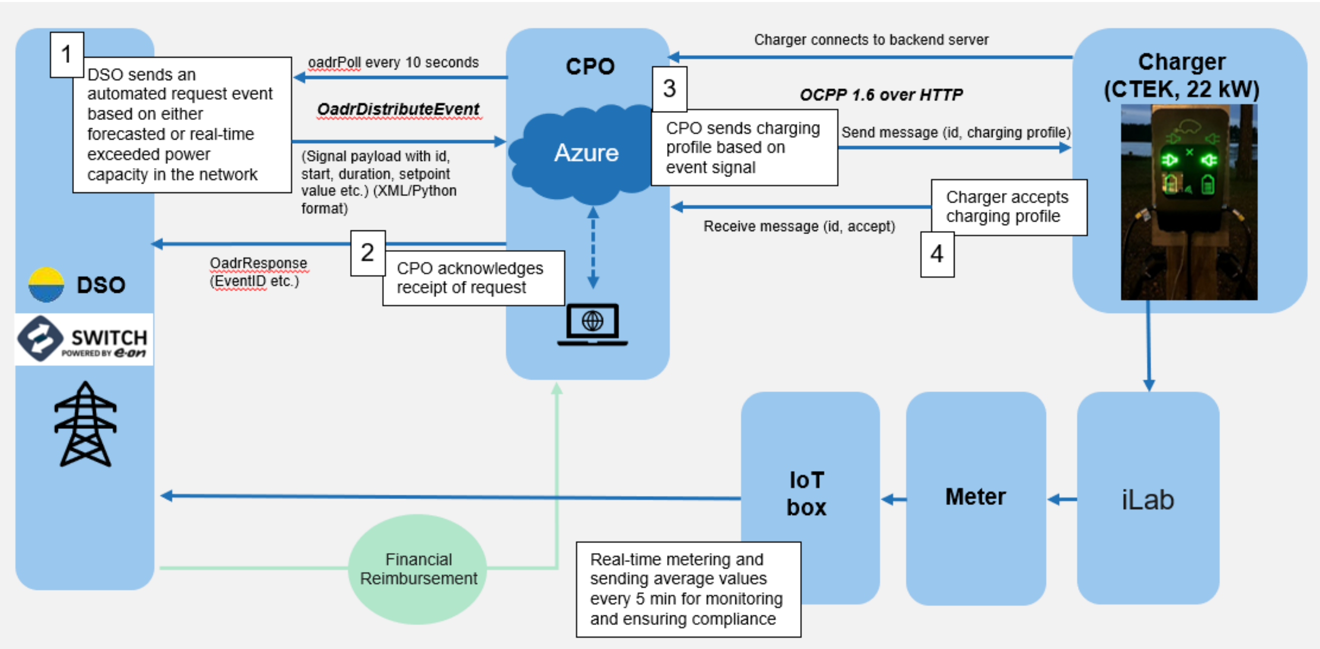
Testing – results and learnings

As part of a PoC for OpenADR development and communication, Vattenfall R&D participated with a VEN connecting to the SWITCH VTN. OpenLEADR was used due to library resources being readily available and since the existing backend codebase was in Python. The first steps involved Vattenfall understanding the use case for conditional requests in relation to OpenADR, sourcing a client certificate and registering the VEN. Some notes from this first phase:

- Even though more or less complete VEN implementations can be found on Github, troubleshooting still requires some amount of familiarity with the OpenADR specification
- Acquiring a suitable certificate could present a hurdle for some organizations if they are not allowed to purchase a basic one themselves (e.g. because of internal security or administrative constraints)
- SWITCH does not currently issue certificates for VENs, but basic SSL can be purchased for around 140 SEK per year
- With a simple setup (e.g. OpenLEADR), development time needed to have a working and registered VEN should be less than a week or as little as a few hours depending on starting conditions of the integrating organization

The next phase included verifying that a triggered request in SWITCH generated an OpenADR event, checking that the VEN polling picked up the event correctly, and that the response was sent and received. This flow could be confirmed and worked as expected.

It's worth noting that using the signal type SETPOINT is not strictly analogous with the asset delivery limit from the proprietary SWITCH request, since it specifies a fixed level rather than a maximum. This may be improved by using a custom signal type that only communicates the maximum allowed power level without any further conditions. However, introducing a new signal type would require careful alignment to ensure that all affected actors agree on the benefits. Regardless, the general use case is still supported by the current VTN implementation in SWITCH.



Setup overview for the PoC

In the third and final phase event signals were forwarded to the backend system controlling a single EV charging point, a CTEK 22 kW charger located in Älvkarleby close to Uppsala. Normal power level when charging was around 8-9 kW and a limit of 5 kW was configured for testing sessions. Events were mapped onto charging profiles by the CPO system and sent to the connected charger. Real-time average readings for power, voltage and current were posted to the SWITCH API every 5 minutes for delivery validation, since the OpenADR reporting functionality was not yet ready for testing.

- During the test, 4 requests were created and published as events on the SWITCH VTN server covering a period of 1 hour while an EV was charging
- All events were received by the Vattenfall VEN with responses sent and received
- A charging profile for current that corresponded to the 5 kW limit was generated and forwarded to the charger using OCPP 1.6 protocol
- The charger reduced the current and power to adhere to the delivery limit, which could be verified with posted real-time data (see image below)

Real-time power metering from the charging point during testing

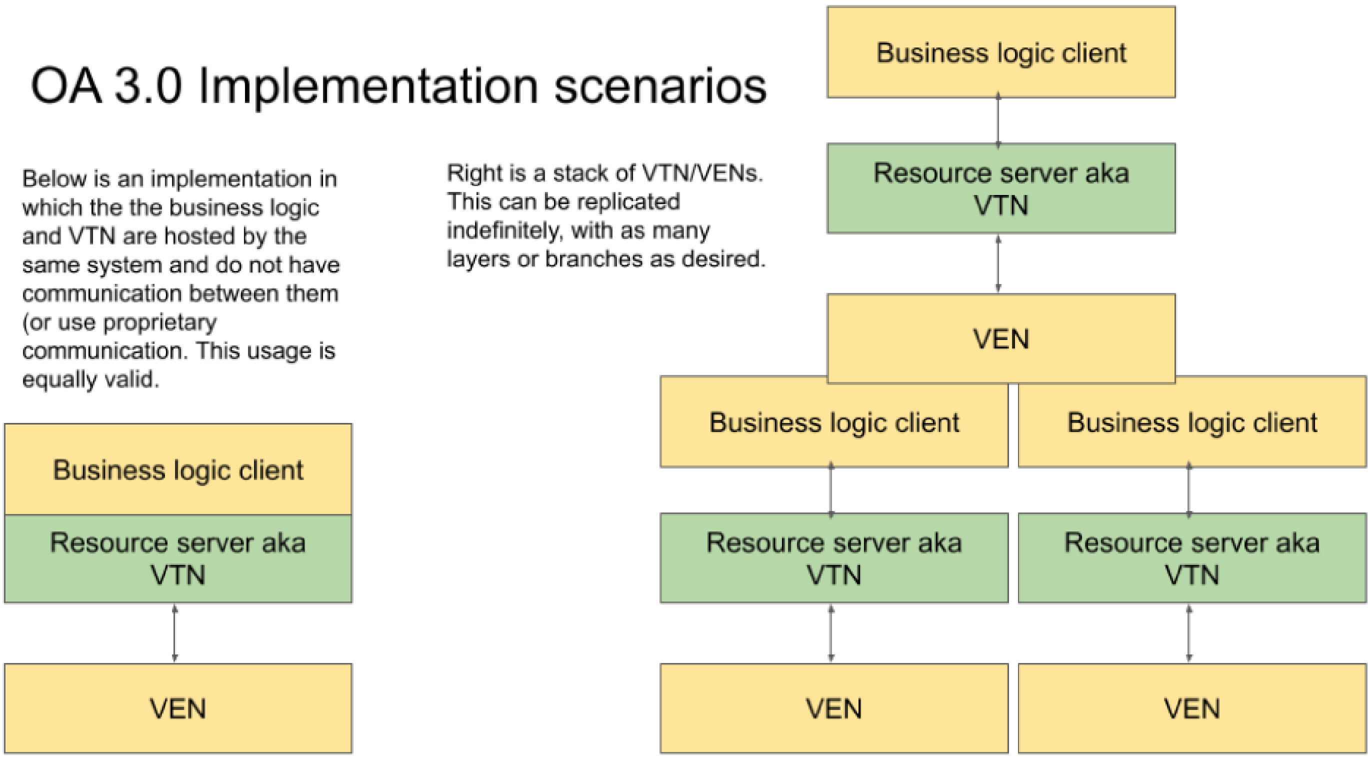
In summary, the proof-of-concept demonstrated how OpenADR could be used to handle DSO to CPO communication for controlling EV charging infrastructure via OCPP or similar.

Conclusions and further development

Even though there's still some potential improvements to be made, the test setup of SWITCH VTN and Vattenfall VEN is functional. Working with OpenADR has been reasonably straight-forward but somewhat time-consuming on the server side. Building a VTN from scratch to work with an existing backend is unlikely to be necessary for more than a few actors, such as larger DSOs. For smaller DSOs, using a third-party solution might be more efficient.

VENs are less complicated to build or setup, and there are multiple open source options available. While nothing definitive can be said about development time and cost, these factors should work to reduce the effort needed for customers especially.

Preliminary reading of the newly released guides and specifications for the latest OpenADR 3.0 version indicate that it will be a more modern and flexible way to implement a VTN/VEN, separate from but working together with any business logic needed. OpenADR 3.0 will not be compatible with 2.0b but VTNs are expected to support both for full certification from the alliance. SWITCH will aim to fully support 3.0 by implementing a VTN in the existing backend, since a fully REST-based solution with JSON files is much more aligned with common web API usage than SOAP/XML.



Example structures from OpenADR 3.0 guide