English

Smart API SEAS

The use of Smart API in the energy sector

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1. Challenges of control due to the transformation of energy networks

There are several notable trends taking place in the energy market today. These include for instance the shift away from oil as an energy source especially in transportation, the steadily increasing number of various electric appliances and devices at homes and offices, and the decreasing prices of distributed energy production technologies such as solar panels.

In the past years, overall energy demand has increased and shifted especially towards electricity as the form of consuming energy. Electric vehicles will be a further major shift from other forms of distributing energy towards electricity, with heavily fluctuating demand and usage patterns different from what the distribution networks were originally designed for. At the same time energy production must increasingly rely on renewable sources whose production is weather dependent and hard to predict. This potentially leads into a noteworthy disparity between electricity production and consumption which makes balancing the networks increasingly difficult.

The majority of the changes lead towards a system where central energy production facilities - dams, nuclear power plants, etc - must co-exist with a myriad of smaller, less reliable systems in the same network. At the same time capacity demand for them will show a significantly higher fluctuation.

Because proper operation of the electrical network is based on the balance between production and consumption, this poses a great challenge for the management of the network. To properly cope with the problem, new IT systems are needed for electricity production and distribution. Developing the Smart API technology started by finding a communication system that helps in solving exactly that problem.

For an electricity network to be properly balanced, real-time and predictive measurement and control capabilities are needed in a wide-spead management system. This necessarily involves handling the issue of controlling and large volume of distributed consumption and production points which can simultaneously act as an energy producer and/or consumer, hence the term "prosumer".

While remotely controlling and coordinating the electrical loads of homes, office buildings and industrial premises has been possible for decades already, such controls are not yet widely enough adopted to confront the challenges of new electrical networks. A key reason for this is that such adoption is still too expensive in high volume. The process is costly because it involves

- Finding each party that acts as the gatekeeper to some resource (the "finding problem")
- Receiving the security clearance for accessing the resource (the "access problem")
- Learning the details of the mostly proprietary access method (the "compatibility problem")
- Implementing the technical compatibility to each remote system (the "implementation problem")
- Managing the monetary compensation for the access and ensuring compliance to commitments (the "compensation problem")

To solve these problems, technology is needed to offer automated access to each measurement point and load to lower the cost of control for the service provider. Smart API has been designed as such a solution and addresses each of the core problems listed above.

The solution comprises

- An infrastructure that helps energy market participants find each other and communicate with each other
- A flexible datamodeling framework which allows for a common data format for coordinated network balancing while enabling data extensions critical for each business

- A core set of standard messages and methods for the most common network monitoring and control tasks called **SEAS, the Smart Energy API Standard**.

2. Smart API as a solution for energy network balancing

2.1. Mapping and abstracting the energy network

The changing structure of energy networks is one of the main drivers of smarter electricity distribution, the Smart Grid. As the old tree-like, hierarchical structure of energy networks is broken and energy production becomes a mesh of distributed, small generation units, it becomes increasingly important to understand the relationships of various entities. Who is connected where, who manages and is responsible for which part, what is the effect of performing some action on different participants?

Such relationships are links between the entities. They form networks, or graphs, of relations that need to be processed to understand the state of the system at any given moment. And for that purpose we need to be able to represent data in graph format, a type of a map of IT systems. With the use of such graphs, energy companies can in a distributed fashion create control maps that offer exact means on what loads and where need to be controlled in order to find balance.

Smart API models data in what is called linked semantic data. With this data format it is possible to describe the relationships between systems with high accuracy. The model fits directly into the other key technology, the Internet of Things, which is the technical platform for making low cost, high volume connections to a heterogeneous environment found in energy networks. The important feature of Smart API is that it allows parties that have not previously participated in energy network balancing, for example manufacturers of heating and cooling devices for buildings, to flexibly enter the control market.

In addition to modeling and mapping, one must be able to control. In control, the linked data used by Smart API has a key distinction in defining what is called a context, a more precise definition of what the data actually means. To understand why the context in control applications is so important, let's first explore what it actually means to make automatic control of a large volume of distributed resources.

1. First, in a distributed environment there are likely to be many different suppliers using different technologies and each having their own ways of representing and transmitting data

2. Second, to be cost effective, control needs automation, which in turn required various kinds of computing algorithms. The algorithms must be able to receive data in a common style and in a common meaning to make their calculations correct.

So in a nutshell we are looking at multiple sources of heterogeneous data combined with the requirement of very accurate, mission critical calculation. Contexts are meant to help in interpreting data so that one uniform meaning can be found. So if manufacturer A says what they mean by some energy reading and similarly manufacturer B says what they mean by it, numbers can be converted between those two interpretations.

Further, the semantics of linked data let us define things that are abstract and act as combinations of other things. This point brings us to the second key topic in control applications: risk.

While it is technically possible to micromanage the consumption in an electric network even by switching individual lamps remotely, why would an energy company - or any third party service provider - really bother with such small loads? They usually don't and the idea is that market mechanisms create an opportunity for smaller players, load aggregators, to do the micromanagement and then sell that capability as a bundle, a "portfolio" of controllable loads and energy sources.

The actual business value of control systems comes from controlling large masses that in aggregate offer sufficient adjustment capacity to be worthwhile for a business. Simple math shows that such volumes need to be so large that micromanaging individual entities makes no business sense. If the smallest amount to trade is a megawatt and the controlled power of a single entity is a kilowatt, even the smallest adjustment requires a thousand targets at minimum. The loss in customer satisfaction and reputation due to failing in the management is huge compared to the benefit of controlling an individual entity.

So who is willing to take the risk of control? The answer is "it depends". In some cases it will be the energy company directly, in some cases it will be a smaller aggregator, in some cases the consumers themselves through automation systems. To make all the "it depends" options fit together, we need a way to describe the capabilities at each level and instead of just direct commands, means to set targets to each layer of control. These targets are the abstractions of control. And this is why abstractions are an integral feature of linked data in Smart API.

2.2. Solving high volume problems

So, finally, how do we go about in solving the problem of doing high volume control at low cost? The response to that is Smart API Services.

The core of Smart API Services is a set of directory and security services, that act as orchestrators of networks. Much like the domain name service of the Internet, Seas API Services do not handle the data itself but just act as the supporting layer that makes the operation easier. Smart API connections themselves are peer-to-peer.

There are four core services in Smart API Services

- Smart API Find
- Smart API Talk
- Smart API Secure
- Smart API Transact

Each Smart API node registers itself to Smart API Find directory which maintains a map of management relationships. You can consider Smart API Find as kind of a "phone book" of Smart API parties. It knows who is who and how to contact that party. As the name implies, its purpose is to solve the "finding" problem.

Once a party to connect to is found, a secure connection must be established. Smart API Secure helps in this. It contains methods for authentication, authorization policies, cryptographic key management, etc. With the help of Smart API Secure, two systems can negotiate access rights and automatically open access to trusted parties. This service is therefore useful in solving the "access problem".

Once access is granted, the communicating parties must understand each other during the data exchange. Smart API Talk is for this purpose. It hosts all the data definitions, or ontologies, offers tools for defining and expanding them, converts data, and has tools for automatic software code generation. In essence, it helps in actually implementing common data exchange, i.e. solves the "implementation problem".

Finally, once the data exchange completes, it can be recorded in the ledger of Smart API Transact service. Smart API Transact can be used to securely prove that parties have sent and received data or performed some other action as agreed on. Sophisticated cryptography is used to create a proof of each action, resulting in a database that can be used as a basis of payments, thus solving the "compensation problem".

2.3. Smart Energy API Standard

Smart Energy API Standard, or "SEAS", is a set of common definitions for the most common network balancing actitivies needed in a network. While energy networks do differ in structure and type of clientele, their balancing activities still follow a fairly similar pattern. This involves agreeing on responsibilities, monitoring consumption, and issuing control commands. The data needed for such activities can therefore be standardized to a large extent and this is what SEAS is for.

SEAS includes predefined data definitions for

- Setting targets and objectives
- Retrieving time-series of data
- Issuing direct control commands
- Bookkeeping promises and how well they have been held

With this set of activities, it is straightforward to implement demand response automation. In practice, software engineers have ready-made classes that can be embedded into IT systems for easy communication. For information on how these actually work in practice, the technical documentation at http://www.smart-api.io/seas will show all the details.

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