GridBox: A Cloud-based Microgrid Modeling Solution

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In the recent years, usage of renewable energy sources has substantially increased. Many households have installed solar panels or other alternatives to supplement the power received from energy providers. However, wider adoption of renewable sources is still hampered by the variability of the energy output of these sources based on the time of day or weather. Currently, excess energy produced by the consumer is often even penalized by the energy provider, which further discourages the renewable energy source adoption.

The move towards self-sustaining microgrids with energy trading can solve these problems by directing the excess energy within communities and greatly reducing the total power consumed from the energy providers. Many different energy producers can operate within the microgrid system distributing the energy to the endpoints. However, to design an effective distributed power system, a software to model, simulate and monitor the microgrid is required.

GridBox

Our software, GridBox, developed in cooperation with Sféra a. s., the industry leader in power grid information systems, offers a user-friendly toolbox for creation and modification of graph models representing microgrids and their integration with the simulation and monitoring software. These functions allow the users to easily modify the microgrid and test these changes in simulated environments.

The main tenets of GridBox are modularity and expandability. While the core of the project is the intuitive drag-and-drop user interface for microgrid modelling through web browser, it is not by far its only functionality.

Model

Our browser-based application allows the user to easily create a microgrid by inserting microgrid elements such as batteries, solar panels or households into topological (Figure 1) or topographical view (Figure 2) and connecting them into a network. All created networks are saved on the remote repository and allow simple collaboration between colleagues.

The available microgrid element and connection types are also stored in a remote repository and custom elements with specific behavior and graphics can be added by users. These elements can each have a defined set of attributes which can be modified from within the GridBox modeling interface.
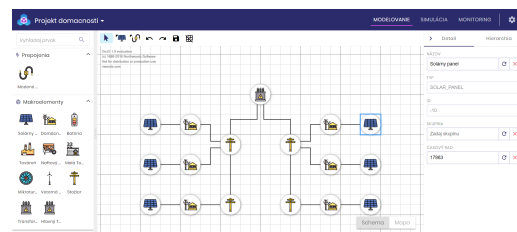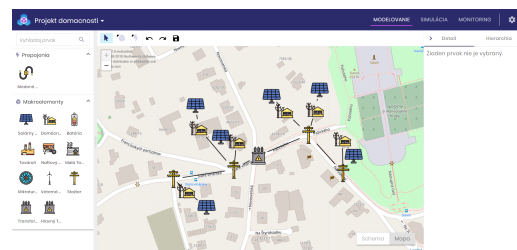

Figure 1. Schema modeling view.

Figure 2. Map modeling view.

Simulate

The networks saved in the cloud can also be used for running various simulations over the network structure. The system has a universal interface for requesting element networks along with other parameters by simulation engines, which can execute in the cloud and send the results back to the GridBox user interface for visualization (see Figures 3 and 4). The simulation results are sent back as events which can be aggregated into charts for the whole simulation interval or observed chronologically directly within the network structure in the map or the schema view.
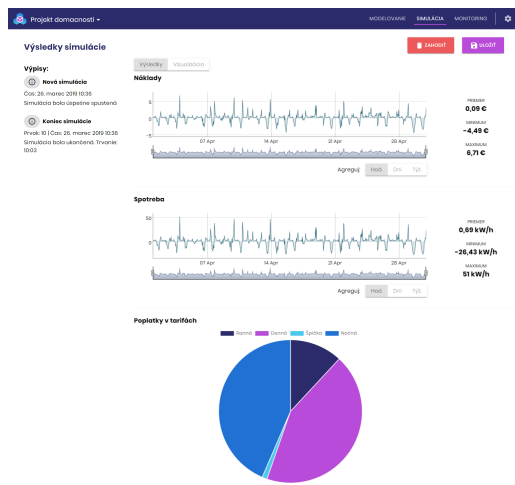

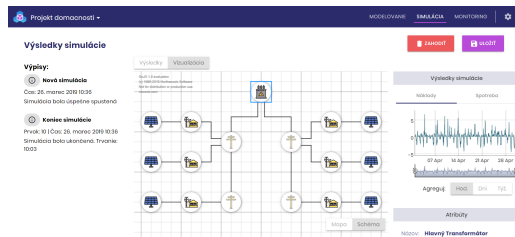*Figure 3. Simulation results view.*

Figure 4. Simulation replay view.

Monitor

The other possible use of the GridBox software is the real-time monitoring of current microgrid state. The elements of the network model can be directly linked to real-life power grid elements and show the current state of the microgrid in the visual language matching the simulation view.

Architecture

The modular architecture of GridBox is centered around the browser-based user interface built in Angular with GoJS graph library for network modeling and visualization.

The user interface is connected to the database server for storing projects and microgrid element data such as consumption time series and icons. Everything is stored as JSON objects within a NoSQL MongoDB database.

The simulation engines access the database server to retrieve the data about network structure and element types and then save the simulation results to the server. From here, the user interface retrieves them and visualizes the results.

Usage outside power industry

Even though GridBox was developed with the needs of microgrid modeling in mind, its usage is not necessarily limited to this area. Since the software is modular, the microgrid specific elements and simulation engines can easily be swapped for different endpoints adhering to the prescribed interfaces. This means that GridBox could also be useful for users in need of software for modeling and simulation of other kinds of graph structures, e.g. telecommunication and computer networks or logic and electric circuits.