Study Committee D2

Information systems and Telecommunication

Paper 10613_2022

EMPLOYING THE DIGITAL PLATFORM FOR INTELLIGENT CONTROL OF DISTRIBUTED ENERGY RESOURCES

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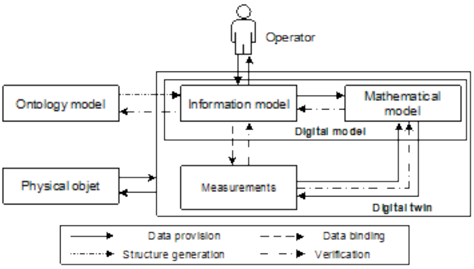
Motivation

- The development and modernization of DER control systems require large capital and time costs. One of the possible ways reduce them is to create a digital platform organized as a software constructor. This approach is being implemented in the Russian digital Platform for the management of distributed energy systems – the ∀Platform
- General information about the ∀Platform was presented at the 48th CIGRE 2020 Paris Session. This report is a follow-up study that describes a practical use case of the ∀Platform



Ontological approach

- The use of the ontological approach makes it possible to ensure the unity of information environment for the digital twin through a qualitative description of the semantics of the interaction between elements of the control system and ensuring the compatibility of standards for different subject areas.
- **Figure 1 – Digital twin architecture.** A structural diagram explaining the relationship between ontological and information models, the digital twin of a physical object in the context of the ontological approach.

- The ontology is used as part of the Platform for the implementation of the following tasks:

  1) generation of classes for the programming languages (Go, Python, etc.) to transfer data between system components. Their generation from a single source allows us to guarantee a unified description format and the absence of problems in interaction, even if the services are written in different programming languages.

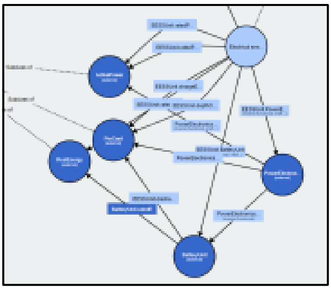
  2) code generation for working with configuration data: both at the level of individual microservices (loading and validating individual configuration files) and for the system as a whole (validating a set of configuration files)

  3) formation of the structure of the master database

  4) ensuring the integration of external systems using a data-centric approach

  5) automation of the formation of documentation for software components.
- The use of ontology as a basis for information support reduces the cost of describing the software architecture and ensures the interoperability of heterogeneous components. As a result, it allows to reduce time-to-market and ensure compliance with different information models.
- The Application Developer gets acquainted with the information support of the Platform using a graphical representation of the ontology **(Figure 2 in English (a) and Russian (b)).**

a)



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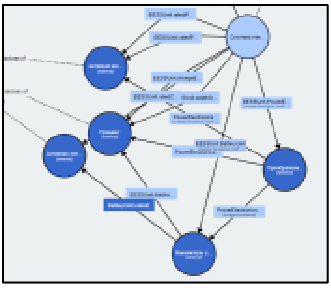

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Platform application deployment process

- The following stakeholders are involved in the EMS deployment process: energy prosumers, platform maintainers, platform developers, application developers, equipment manufacturers.
- The process of creating an EMS based on the Platform includes the following steps:

  A. Selection of The Configuration Required for The Application.

  B. Configuring and Deploying Software Components on Hardware.

  C. Configuring a Connection to The Cloud.

  D. Digital Twin Formation

  The energy prosumer, together with the Platform maintainers, perform the following operations:

  1) Entering information about controlled equipment into the database.

  2) Ensuring the data collection from devices and/or automated systems.

  3) Selection of forecasting algorithms and training of load and generation machine learning forecasting models.

  4) Setting up and determining the sufficiency of mathematical models to form the required control system.

  5) Connection the required datasets of measurements to mathematical models. As a result, a prototype of a digital twin is formed.

  6) Connecting the digital twin to operational data and analyzing its adequacy.

  7) Acceptance tests of the digital twin and its calibration (if necessary)

  As a result, the list of platform and application components of the control system is specified.

  E. Deploying and Configuring Missing Components

  F. Implementation of Information Protection Measures

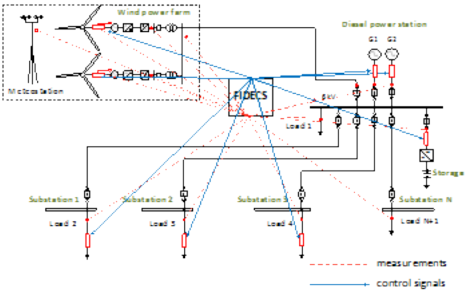
  G. Field Testing of the Deployed Control System

  H. User Training

- To ensure convenient work while developing applications, the application developer has at his disposal documentation for microservices, SDK, and a technical portal for interacting with the Platform developer.

Use case – object description

- Figure 3 – Microgrid single-line diagram



- **The microgrid includes:**

  1) Wind farm with two wind turbines with a rated power of 2x225 kW

  2) Diesel power plant with two diesel generators with a rated power of 2x320 kW

  3) Energy storage systems based on a redox battery with a rated power of 250 kW and energy capacity of 1000 kWh

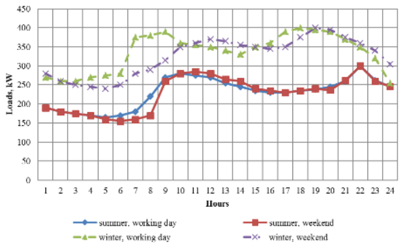
- The use of the intelligent control system allows to:

  1) maximize the capacity factor of wind turbines;

  2) select the optimal operating mode of diesel generators (the choice of the composition of the included units and the optimal distribution of the load between the generating sources), which ensures the minimum fuel consumption and units' maintenance ;

  3) maintain the operation of the microgrid with fully stopped diesel generators.

- The daily load profiles of the microgrid are presented in the figure below (figure 4)



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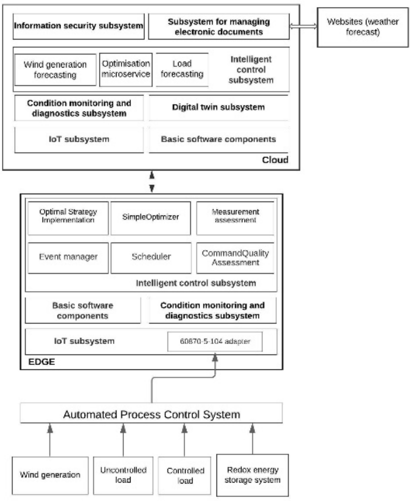
Microgrid control system architecture

- **Figure 5 – Microgrid control system architecture.**



- The microgrid control system architecture includes the following layers:

✓ **Cloud layer** (monitoring and diagnostics; renewables generation and load forecasting; formation of an optimal strategy for managing the electrical equipment; graphic user interface (GUI))

✓ **EDGE layer** (equipment control using simple algorithms; implementation of the DER optimal management strategy obtained from the Cloud; graphic user interface (GUI); interaction with the automated process control system)

- **Figure 6 - The external view of a set of software-hardware "A-EDGE"** on which the control scheme is implemented

Software components

- The microgrid control system includes the following Platform components:

  1) IEC 60870-5-104 adapter

  2) Load forecaster

  3) Wind forecaster

  4) Optimization microservice

  5) Event manager

  6) Scheduler

  7) SimpleOptimizer

  8) Optimal strategy implementation microservice

  9) Measurement assessment

  10) Modules for monitoring the quality of commands and control signals

  11) Basic software components

Graphical user interface (GUI)

- **Figure 7 – Screenshot of the graphic user interface (GUI).** Screenshot of the graphic user interface is shown in the figure below.

Conclusion

- The proposed approach makes it possible to ensure the readiness of the information structure of the ∀Platform for expansion as IoT technologies develop and the observability of control objects increases

- The presented platform solution allows to provide flexibility while configuring the control system for any facility (industrial enterprise or building)

- The proposed solution reduces the cost of creating a control system, reduces the time-to-market for applications, and ensures correct integration with external systems / data providers.