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Electricity network modeling methods

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ABSTRACT:The essence of multi-agent systems, the possibility and general principles of building multi-agent models in the electric power industry, their use for building Smart Grid are considered. One of the ways to control the power system based on the application of a multi-agent approach has been investigated. The authors give a general idea of the principle of operation of a multi-agent system (MAS) and the problems that the introduction of this technology can solve. The most recent and important achievements and developments in the field of building multi-agent systems and their areas of practical application are presented. The construction of intelligent energy systems will increase the economic efficiency of such a system by making efficient use of resources for the generation, transmission, distribution and consumption of electrical energy, as well as maintaining the optimal mode of operation of the system.

KEY WORDS: multi-agent system, smart grids, simulation, electrical grids.

I. INTRODUCTION

Modern modelling methods are based on representing any type of power equipment in the form of corresponding mathematical models. Each mathematical model of a specific equipment serves to describe the processes of a certain kind occurring in it. Also, each mathematical model describes the original object only in a certain range of boundary conditions, or with a certain accuracy. And an increase in the number of factors taken into account that affect the accuracy of the result obtained either does not give the required result, or significantly complicates the applied mathematical model.

Modelling complex electric power complexes requires combining mathematical models of individual equipment into a single system with a specific architecture. A change in the original architecture leads to a change in the formed system of equations and, ultimately, to the unsuitability of the result obtained. Taking into account the existing set of options for the configuration of the power system (or its section), depending on the possible options for operating modes, it leads to an infinite number of solutions.

As is known, when calculating the operating modes of electrical networks, the equivalent circuits of its main elements are most widely used, which reflect a number of physical processes that occur in real equipment. For example, according to Fig. 1, T- and U-shaped equivalent circuits are used for power lines.

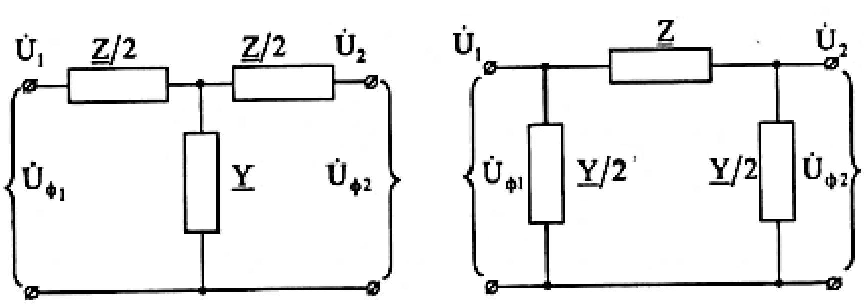

Fig. 1. Equivalent circuits of electrical network elements

The resistance of the longitudinal branch of equivalent circuits is determined by the following expression:

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$$Z = R_l + jX_l \quad (1)$$

The transverse leg conductivity is determined by the following equation

$$Y = G_l + jB_l \quad (2)$$

Typically, Y is represented as the charging power of the Qc line. Then, when using the reference values of the specific parameters of the transmission line, the values of the active resistance, inductive resistance and charging power are determined as follows:

$$R_l = R_0 L/n\ ,\ \ X_l = X_0\ L/n,\ \ Q_c/2 = q_0 nL/2 = b_0 U^2{}_n nL/2\ , \quad (3)$$

where R_0, X_0, q_0 are the specific values of the transmission line parameters, L is the length of the transmission line, n is the number of parallel circuits, U_n is the nominal voltage of the transmission line.

II. SIGNIFICANCE OF THE SYSTEM

The paper mainly focuses on how intelligent technologies can be used to build mathematical models of electrical networks. The main attention is paid to the agents of the electric power complex. The study of literature survey is presented in section III, Methodology is explained in section IV, and section Vdiscusses the future study and Conclusion.

III. LITERATURE SURVEY

Currently, the models using the agent-based concept are very few and are presented only in a few areas of the energy sector [1]. In most cases, the agents are represented by the participants of the electricity market, who are engaged in solving the problem of market liberalization [2].

This article [3] addresses the issue of modelling a local multi-carrier energy network. This problem can be considered as an extension of modelling a low voltage distribution network located at some urban or rural geographic area. But instead of using an external power flow analysis package to do the power flow calculations, as used in electric networks, in this work we integrate a multiagent algorithm to perform the task, in a concurrent way to the other simulation tasks, and not only for the electric fluid but also for a number of additional energy carriers. As the model is mainly focused in system operation, generation and load models are not developed.

In this article [4] authors study methods to find a global optimum for the local energy community or at least an acceptable approximation to it. In contrast to standard centralized control approaches, based either on expert rules or mixed integer linear optimization, we adopt an agent-based, decentralized approach that allows for incorporation of nonlinear phenomena. While studied here in small-scale systems, this approach is particularly attractive for larger systems, since with an increasing number of interacting units, the optimization problem becomes more complex and the computational effort for centralized approaches increases dramatically.

Samadi E et al.proposed a multi-agent based decentralized energy management approach in a grid-connected microgrid (MG). The MG comprises of wind and photovoltaic resources, diesel generator, electrical energy storage, and combined heat and power generations to serve electrical and thermal loads at the lower-level of energy management system (EMS). All distributed energy resources (DERs) and customers are modelled as self-interested agents who adopt reinforcement learning to optimize their behaviours and operation costs. Based on this algorithm, agents have the capability to interact with each other in a distributed manner and find the best strategy in competitive environment. At the upper-level of EMS, there is an energy management agent that gathers the information of agents of lower-level and clears the MG electrical and thermal energy market in line with predetermined goals. Utilizing energy availability from different DERs and variety of customers' consumption patterns, considering uncertainty of renewable generation and load consumption and taking into account technical constraint of DERs are the strengths of the presented framework. Performance of the proposed algorithm is investigated under different conditions of agents learning and using -greedy, soft-max and upper confidence bound methods. The simulation results verify efficacy of the proposed approach.

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Piyali D et al. studied is based on a secondary frequency control of micro-grids along with voltage control by the use of synergetic control in compliance with multi agent system. In the projected control, a voltage source control is being performed to found the micro-grid automated power supply from a renewable energy source. The plant output is being converged to a stable response in the presence of this MAS system.

Perera M.K.et al. presented an implementation of a Multi Agent System based Energy Management System for a microgrid. In addressing the emerging distributed generation concept, microgrids have been identified as a suitable platform for integration. The continuous controlling and monitoring is essential for distributed renewable sources in a microgrid platform. Multi Agent System concept provides a plug and play controlling nature to a microgrid unlike complex and conventional controlling techniques. Here a MAS is proposed with five main agents, which mainly consists of a wind agent, a solar agent, load agents and a server agent. Proposed system operation is based on the optimum supply of loads through the available renewable sources. As presented in this paper the interaction between agents in the system is simulated through Java Agent Development Environment. A microgrid test bed is implemented, in order to apply Multi Agent System operation with physically implemented agents. The main purpose of this paper is to discuss the physical implementation of a MAS for a micro grid application.

Herrera M. et al. proposed a solution for demand side management involving and agent-based architectures that was deployed in a small office. The deployment integrated an algorithm for generation and consumption balance with real-time contextual resources' priorities. The deployment's overall results, from a winter and a summer day, are presented.

IV. METHODOLOGY

In the energy industry, an agent can mean any object included in the power system, be it a power line, transformers, generators, or a consumer. The introduction of such a technology, in which each object will have its own managing agent, will create a flexible, observable and real-time controlled decentralized self-organizing system.

First of all, it is necessary to define the actions of the agent. Actions are the elements underlying the behaviour of agents: they can cause changes in the environment or in other agents. It is possible to present several models for describing the actions of agents [9]:
- global transformation of the system state (changing the modesystem operation);
- local change of the environment (shutdown of one ofparallel operating transformers with insufficient load);
- response to the impact (switching off the short circuit by relay agentsprotection);
- computing processes carried out inside the agent are necessary to perceive the received data and change its state (when the line operator disconnects the line, the line agent, receiving information from the sensors, draws appropriate conclusions and goes into standby and diagnostic mode);
- moving an agent in the environment (moving a diagnostic agent from one server to another to perform its functions).

The behaviour of agents also includes mechanisms for choosing one or another action that will be performed in accordance with the available data and the state of the agent.

This structure defines the following set of agents:

$$A_{g1} = \langle A_{gSystem}, A_{gDG}, Ag_{Line}, A_{gBus}, A_{gTrans}, A_{gDemand}, A_{gCondenser} \rangle, \quad (4)$$

where $A_{gSystem}$ is a power system agent, A_{gDG} is a distributed generation agent, A_{gLine} is a transmission line agent, A_{gBus} is a bus agent, A_{gTrans} is a transformer agent, $A_{gDemand}$ is a load agent, and $A_{gCondenser}$ is a static capacitor bank agent. Each agent has only local information, which is not sufficient to solve this problem; therefore, a certain number of agents with the distribution of their functions is required. The key point is the condition for the interaction of agents, taking into account the possibility of training [10], based on the results of which they can make a particular local decision and present the corresponding solution for the entire network. The structure of the agent training procedure is shown in Fig. 2.

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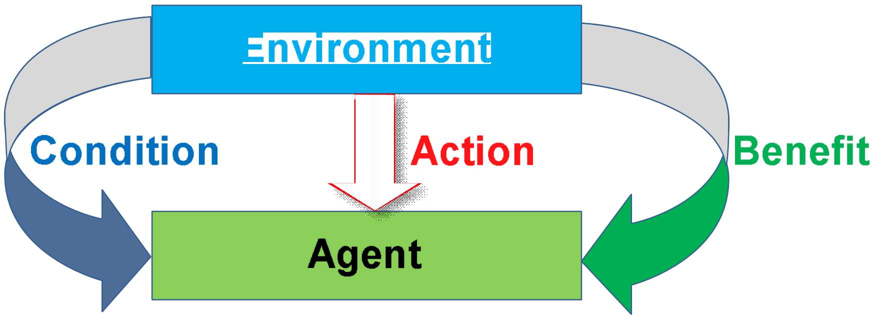

Fig. 2. Scheme of the Agent's actions in the learning process.

The learning process consists of performing steps (1) - (4) until the action is considered optimal:

(1) Assessment by the environmental agent.
(2) The agent decides on the execution of likely actions,analysing the current circumstances.
(3) The agent performs the selected action.
(4) The agent receives certain benefits for the action he performed.
(5) Go to (1).

In fig. 3 shows the structure of the agent. The input is a special device that is responsible for collecting information about the state of the environment, the output is an executive body that affects the external environment. Solver is a decision-making procedure, this block must have the ability to analyse incoming data, store information about its state and state of the environment and influence the operation of the object for which it is responsible

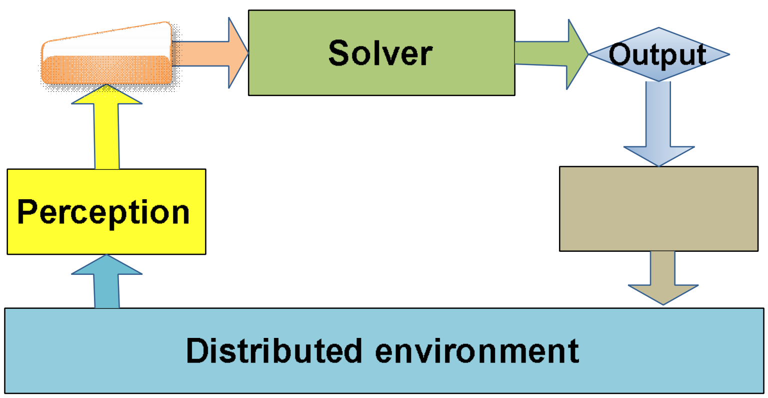

Fig. 3. Enlarged agent structure

By exchanging information with neighbouring agents, each agent can dynamically obtain information about its local area and balance the demand and supply of electricity using local information. Consequently, the systemic balance will be achieved through the contribution of each individual agent.

V.CONCLUSION AND FUTURE WORK

It should be noted that the multi-agent construction of the power system operation is currently the most promising. A multi-agent approach to the management of the power system of the future must ensure the reliable and safe operation of this power system and must not become a “weak link” in the power industry. To do this, such a system must have the ability to accept and process a large amount of information and make decisions very quickly. High automation and intelligent decision making will significantly reduce the risk of emergencies..

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REFERENCES

[1] Gilbert N. Agent-Based Models (Quantitative Applications in the Social Sciences). Sage Publications, Inc, 2007.
[2] Pipattanasomporn M., Feroze H., and Rahman S. Multi-agent systems in a distributed smart grid: Design and implementation. In Power Systems Conference and Exposition, 2009. PSCE '09. IEEE/PES, pages 1–8. 2009.
[3] Duranaa J.M., Barambones O., Kremers E., Varga L. Agent based modeling of energy networks // Energy Conversion and Management .Volume 82, June 2014, Pages 308-319.
[4] Kamal A., Elraheem A., Shikhin V., Obychaiko D. Evaluation of Operational Efficiency of Agent- Based Microgrid in Arctic Enclave // 2020 International Youth Conference on Radio Electronics, Electrical and Power Engineering (REEPE), 12-14 March 2020. Moscow, Russia.
[5]Samadi E., Badri A., Ebrahimpour R. Decentralized multi-agent based energy management of microgrid using reinforcement learning // International Journal of Electrical Power & Energy Systems. Volume 122, November 2020, 106211.
[6]Piyali D., Rashmi Ch., Abhishek Sh. Review Report on Multi-Agent System Control Analysis for Smart Grid System (January 10, 2020). Proceedings of the 5th International Conference on Computers & Management Skills (ICCM 2019) | North Eastern Regional Institute of Science & Technology (NERIST), Nirjuli, Arunachal Pradesh, India, Available at SSRN: https://ssrn.com/abstract=3517356 or http://dx.doi.org/10.2139/ssrn.3517356.
[7] Perera M.K., Disanayaka R.U.I ., Kumara E.M.C.S ., Walisundara W.M.C.S.B., Priyadarshana H.V.V., Ekanayake E.M.A.G.N.C., Hemapala K.T.M.U Multi Agent Based Energy Management System for Microgrids Multi Agent Based Energy Management System for Microgrids // 2020 IEEE 9th Power India International Conference (PIICON). 28 Feb.-1 March 2020.
[8] Herrera M., Pérez-Hernández M., Kumar A., Izquierdo J. Multi-Agent Systems and Complex Networks: Review and Applications in Systems Engineering // Special Issue "Control and Optimization of Multi-Agent Systems and Complex Networks for Systems Engineering", 8 March 2020.
[9] Makarov Ya. V. Improvement of the principles of a multi-agent approach to modelling the elements of electrical complexes and systems of the oil industry: dissertation of the candidate of technical sciences; [Place of defences: Samara State Technical University], 2016.- 139 p.
[10] Arseniev B.P., Yakovlev S.A. Integration of distributed databases. SPb .: Publishing house "Lan", 2001. - 464 p.

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