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Using of Optimization techniques for development of functionally integrated systems of relay protection and automation

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The use of modern information technologies for implementing the functions of PACS creates the environment and necessitates the creation of new principles of development of PACS to ensure their effective use at all stages of the life cycle and to improve their technical excellence and reliability. IEC 61850 allows to apply specialized industrial computers (SIC) for implementing the functions of PACS. An important difference between the SIC's and a conventional IED`s should be the possibility of flexible configuration, integration and optimization of the functions of PACS. Unlike conventional industrial computers the SIC should have an operation system that provides an information model of the protected object and performs the information exchange between PACS functions situated as in one SIC and so in different SIC`s. The configuration of the communication interfaces for data transfer between the SIC`s should be performed by the operating system automatically.

Development of functionally integrated PACS on the proposed technical platform will raise the level of their technical excellence, above all, by solving the problem of automatic adaptation of the composition of functions to changing conditions in the power system and automatic optimization the architecture of functional interaction with changes in the composition of technical means of PACS because of malfunctions possible during operation. Thus, the main task is to achieve the necessary intellectual level of the PACS algorithms, criteria and methods of optimization and ensure reliability of operation by the way of software development. The quality of the software determines the duration of the life cycle of the PACS. The SIC should provide the required level of reliability and software compatibility even after hardware upgrading or replacement. Functionally integrated PACS with flexible functional structure will have feature of automatic self-tuning and self-organization. Self-tuning means the automatic calculation of tuning parameters in accordance to requirements of sensitivity and selectivity of the protection. Self-organization means automatic selection from the knowledge base required composition of PACS functions for all elements of the primary equipment as well as their subsequent automatic distribution into the SIC`s and adjustment of information exchange between the SIC`s. Self-tuning and self-organization of PACS is performed in coordination with the monitoring data of the primary equipment and information and communication infrastructure. This allows to perform automatic reconfiguration of the functional structure of PACS and to provide the required level of reliability of PACS because the composition of the protected equipment could change or failure of components of PACS could occur during operation. The basic principles of optimization techniques for development of PACS with flexible functional structure are as follows. At first stage, the

required composition of PACS functions is determined for each element of the primary equipment. The required composition of functions is determined by using of the reasoner and the Knowledge Base that formed on the basis of regulatory technical documents regulating the rules for implementing of PACS. At the second stage, the optimal distribution of PACS functions into the SIC`s is performed. To do this, for each function the set of parameters is assigned. These parameters define the conditions of distribution PACS functions to the SIC. These parameters are, for example, the appointment of the function (main or backup protection), the required level of functional reliability, computational requirement, amount of the input and output signals and other. Furthermore, as optimization parameters are used the reserves of computing power and reserves of informational load of communication interfaces of the SIC`s. It is necessary for the optimal management of the functional structure of PACS during the whole lifetime. It allows to take into account possible scenarios of malfunctions of hardware units of PACS as well as need of changes in PACS functionality associated with long-term plans of development of electric power systems.

At the project phase of PACS for determining the initial functional structure it assumes that each PACS function is situated in separate SIC. At the operation phase as the initial functional structure is used the existing distribution of functions to the SIC`s. Then the value of minimizing goal function is calculated. The goal function integrates some kinds of distribution weights of the SIC`s. The value of the goal function is a sum of the values of weights of combining the PACS functions with different appointments and with different requirements for reliability in one device, the values of weights of reserves of computing power , the amount of used SIC`s and the values of weights of reserves of informational load of communication interfaces. The implementation of optimization techniques based on the use of genetic algorithms. Changing parameters of the optimization techniques are the so-called "coordinates" of PACS functions determining their placement in a particular SIC. Then, according to certain rules is performed the synthesis of the structure of local area network that provides the necessary information exchange between the SIC`s.

This article describes key decisions on the use of optimization techniques to develop a functionally integrated PACS with flexible functional structure and conceptual architecture of PACS with self-tuning and self-organizing features. It describes how to create an ontology of PACS with using of Web Ontology Language (OWL DL 2.0). It contains the description of the optimization techniques for the determination of the functional structure of PACS using ontology and the developed optimality criteria and restrictions. It shows the differences in the application of optimization techniques at the project phase and at the operational phase of PACS. It describes the results of applying the optimization techniques by the example of the development of a functionally integrated PACS of substation.