Multi Leveled Hierarchical Approach for Monitoring and Management Information Systems Construction

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Abstract – **Dynamic of complex technical systems state is shaped in this working out. On this basis a model of two leveled hierarchical system for active power controlling in an energy system is proposed. Conclusions are made regarding the advantages of multi leveled management.**

Keywords – **Supervisory Control and Data Acquisition (SCADA), automatic management, hierarchical system.**

I. INTRODUCTION

Supervisory Control and Data Acquisition systems (SCADA) [1,2] in some important production sectors, such as production and distribution of electricity, transport management, etc., are crucial for their correct and reliable functioning.

Electric power system represents a complex corporative structure with varied equipment, enormous number of sub-systems and complex connections between them. Its management is impossible without quick and due decisions minded the high requirements for reliability and safety of functioning, because any failures in the energy system could have serious economic and social outcomes. All this requires development and improvement of new approaches for organization and management of the energy system.

In this paper, based on the established objective function, a model of two leveled hierarchical system for active power controlling in energy system is proposed. Conclusions are made regarding the advantages of multi leveled approach to information systems for monitoring and management.

II. MODEL OF DYNAMIC OF COMPLEX TECHNICAL SYSTEMS STATUS

Each complex technical system could be represented as a combination of n interacting in between sub-systems. Each state x_i of sub-system i is examined as a point in the vector space X_i. Let $X_0 \in X_i$ is a closed area of the space, where p. x_i is moving in the process of system functioning, i.e. X_0 is an area of the admissible working regimes, then $x_i \in X_0$ for $i \in [1, n]$ expresses the current state of the system.

Let $u(t) \in U$ and $v(t) \in V$ are respectively the entrance impacts and the exist signals of the system, which represent a function of time t.

The system transition from one state $x_i(t_1)$ into another $x_i(t_2)$ for $t_2 > t_1$ determines its dynamic. It could be realized under internal managing signals influence, as well as in consequence of internal disturbances.

Let in the initial moment t_0 the system is in state: $x_i(t_0) \in X_0$.

If the system state modification is a result an external signal influence, then it is described with the equation:

$$x_i(t) = F[t, t_0, x_i(t_0), u(t)], \qquad (1)$$

where F is the operator of the transition and it is determined in accordance with the specific case.

The signal

$$v(t) = F[t, x_i(t), u(t)] \qquad (2)$$

is set up at the system exit.

Depending on the specific task for management, functional dependency F is defined and equation (2) is calculated on condition that dependency (1) is performed. The problem could be solved by one – computer configuration on the basis of so called full interlocking or on the basis of multi-leveled hierarchical computer system. In the case of a hierarchical system, each higher management level is performed by radial connections with controlled systems of one type. The number of systems of higher level depends on the target functions complexity and the controlled systems. Each more complicated production process requires due decisions coordinated with other processes. The more complicated the target for management is the more information the managing body has to cover and process with the necessary precision and quick operation

III. TWO LEVELED SYSTEM FOR ACTIVE POWER CONTROLLING IN THE ENERGY SYSTEM

A classical example of multi leveled hierarchical system is the problem for active power controlling in the energy system.

The system is divided into n interacting in between sub-systems (areas) [2]. The borders of the respective areas are chosen in a way so that each of the sub-systems represent a separate company or entity (Fig. 1). Each area includes a row of generating stations and a great diversity of users. As far as only the exchange of electric power between areas is examined in this instance, we accept that each area is described with the following parameters: C_i - full loading in area i ; X_i - active power, generated by elements in area i ;

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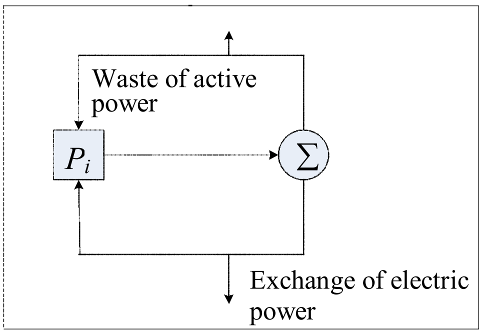

Fig. 1. Sub-system i

Y_i - wastage of active power in area i; U_i - exchange of power through the energy lines, connecting area i with the other areas.

In case of back load, the wastages in area i depend on the power, generated in the area itself, as well as on the exchange of power, i.e. $Y_i = F(X_i, U_i)$

The equation determining power balance could be written in the following mode:

$$F(X_i, U_i) + C_i - U_i + X_i = 0 \qquad (3)$$

n equations of this type could be compared. Apart from that, the exchange of power between the areas has to be balanced, i.e.

$$U_1 + U_2 + ..U_n = 0 \qquad (4)$$

Equation (2) describes the sub-processes and equation (4) describes their interaction.

On this basis the task for active power tracking in the united energy system is brought to definition of the power X_i and the volume of exchanges U_i, where the wastage of power Y_i is minimal.

The full wastage of power is:

$$Y = \sum_{i=1}^{n} F_i(X_i, U_i) \qquad (5)$$

Then the optimal controlling of active power is brought to

$$Y = \sum_{i=1}^{n} F_i(X_i, U_i) \to \min \qquad (6)$$

provided, the variables $X = (X_1,....X_n)$ and $U = (U_1,....U_n)$ answer the balance equations (3) and (4).

Task (6) could be worked out with the help of two leveled system, possessing organizational hierarchy. In this case, except for the central managing computer, each area has its own computer for working out the task for controlling. This organization is shown in Figure 2.

A question arises how the task for minimization to be distributed between the computers of different areas and the central computer.

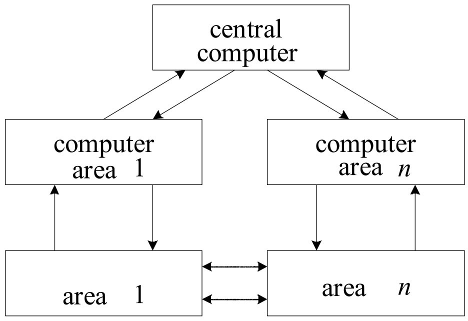

Fig. 2. Two leveled system

An approach based on the so called principle for interactions forecast can be used for this purpose. This method is composed of the following.

The computer for *i*-area solves the task for minimization of $F_i(X_i, U_i^*)$ regarding X_i in the performance of condition (4), as value U_i^* is set by the central computer. The task of the central computer is determination of the supporting exchange level, i.e. U_1^*, ..., U_n^*.

If the exchange is performed at this condition, the local minimum will be at the same time global. When the difference between the supporting exchange level (defined by the central computer) and the real exchange come beyond the borders of the instructed limits, the new supporting exchange is determined through an iteration process between the central computer and different areas computers.

IV. CONCLUSION

In this paper, the objective function of the dispatching system for active power controlling in the energy system is defined. It is shown that it can be optimized by two leveled hierarchical management. Thus the system is less sensitive on changes of external influences such as changing conditions in one area causes changes in only one of solving (local) tasks.

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