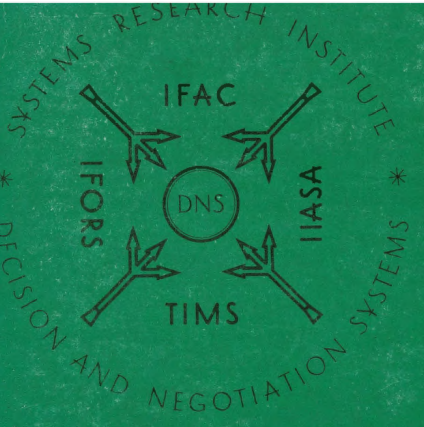

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SUPPORT SYSTEMS FOR DECISION AND NEGOTIATION PROCESSES

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MULTILEVEL POLYHIERARCHICAL MODEL FOR ORGANIZATIONAL DECISION SUPPORT IMPLEMENTED ON IBM PC TYPE PACKAGE DIANA-9

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Abstract: The study on the methodology of computer-aided DIAgnostic ANAlysis and design of management systems (DIANA) has been carried on at the Systems Research Institute for many years. The most significant element of this methodology is a formal model of a plant under investigation. Computer implementation of such a model, has turned out to be a very difficult problem. The paper presents an attempt at solving it.

Keywords: Information systems, models, CAD, CASE, organizations, diagnostic analysis.

1. Introduction

Recently computers have found wide use in creative processes and the developlment of such applications is very rapid. Not long ago this field was dominated by a piece of paper, pen and the functioning of human brain. The development mentioned is due to combination of two factors: theoretical studies on artificial intelligence, carried on for many years, have yielded significant results and the crucial qualitative change in the computer technology has occurred. Design is one of creative processes, which can be supported by the use of a computer. This application resulted in so called computer-aided design. The most interesting new direction in this areas is the so called CASE approach (Computer-Aided Systems Engineering).

A natural consequence of the development discussed was the occurrence of a new approach known under the general name - expert

systems. Due to this approach, it has been possible to combine the deep expert knowledge, but - very often - being less prone to formalization, with enormous capabilities of data storage and processing offered by modern computers. The advent of microcomputers has been vital to the development of this approach. Microcomputers make it possible not only to enlarge the number of users, but also - owing to a user friendly software - to open the way for direct use of computers by persons who are not specialists in the areas of the computer science (e.g.experts in other areas).

At the Systems Research Institute studies in this field have been carried on for many years. They are concerned with complex management systems. The studies carried out have resulted in a methodology of computer - aided DIAgnostic ANAlysis and design of management systems [1]. Consecutive variants of this methodology (called *DIANA* 1 to 7) were implemented on large computers and tested on distinct real - life plants [2]. An experience gained has made it possible to work out a new microcomputer generation of the methodology considered, intended for microcomputers of IBM PC XT type (DIANA-8) [3] and for IBM PC AT or PS/2 (DIANA-9) [4].

The most significant element of this methodology is a formal model of a plant under investigation [5]. In first variants of this methodology this model is given in the form of a network of information connections. The nodes of this network represent elementary operations of a management system under consideration, arcs represent receivers and suppliers of the outcomes of these operations. Computer implementation of such a model, being in fact a plant under design [6], has turned out to be very difficult problem. The paper presents an attempt at solving it, described - from necessity - in brief.

2. Network of information connections versus microcomputer data base

At first it should be noted that the network dimensionality, even quite high as compared to capabilities of microcomputers

(medium - scale plants have about 20 000 nodes and 100 000 arcs), is not the main obstacle to construction of a computer package under consideration. The fundamental problem consists in the fact that such a network has a complex hierarchical - spatial structure. This fact seems to be straightforward and obvious now, however, it was not understood immediately. Its only evidence was in the form of unexpected and unforeseeable responses of a system under investigation.

Under significant simplifications made, a model of the network considered can be described as follows:

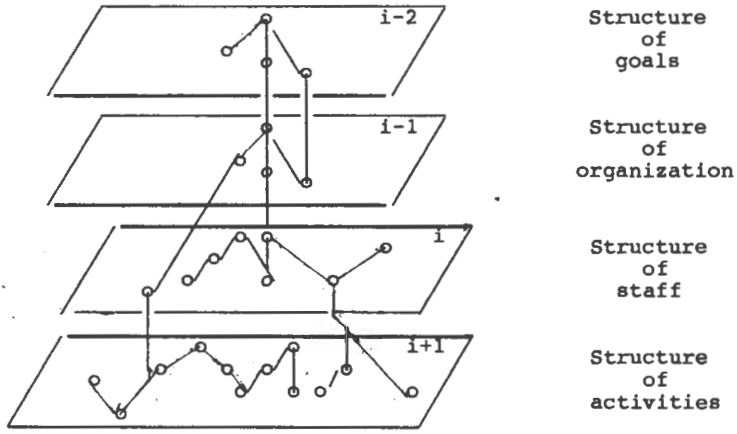


Fig.1. Network of information connections

(i+1) the lowest lewel:the network of elementary operations having its own hierarchical structure (task, subtask etc.);

(i) the medium level: the network of persons interacting with each other in order of accomplish operations that are performed by these persons, in other words these connections result from the network of the lowest lewel.This network has its own hierarchical structure (subordinates and superiors);

(i-1) the higher level : the network of organizational units interacting with each other according to connections among persons who work at these units. This level has own

hierarchical structure (sections, departments, divisions, etc.).

(i-2) the highest level: consists of the goals (and resources) with their own connections among organization units (the hierarchical structure is a result of units structure).

It is worth noting that in the process of modelling notions of the highest or lowest level depend upon the case considered and are to be defined, e.g. relations among organizational units and operations performed by them.

For this reason no one of existing and commercially available Data Base Management Systems developed for microcomputers of IBM PC/XT/AT type cannot be used for the purpose of constructing such a model. The decision to implement this system on a microcomputer of such a type is due to the fact that they are widespread in Poland. Therefore, it has been necessary to work out a new Data Base Management System.

Author's results concerning the so called Q - algebra [7] form the theoretical basis of the approach discussed. Making use of this algebra, a polyhierarchical formal model of the information network has been constructed [8]. An experience in the field of the so called post-relation systems of Data Base Management, gained by western outstanding software companies, has been also utilized.

As a result a general - purpose Data Base Management System, called MIDAS, has been constructed. It has been applied in a DIANA-9 computer package.

3. Realization of the diagnosis process

The first function of the DIANA methodology is to determine result of DIAgnostic ANAlysis (the name DIANA is an acronym). The spatial network, described above, is tested by means of special algorithms used for identification of deficiences.

The DIANA-9 package consists of 64 diagnosis programs. Some of them are used to detected:

- *"blind alley"*
- *"doubled operation"*
- *"bottle-neck"*
- *non-uniform load*
- *source of delays*
- *source of errors*
- *lack of time synchronization*
- *faulty test control function*
- *faulty coordinating function*
- *disfunction situation*
- *hidden human conflicts*
- *ability to perform elementary operations* etc.

Results of the diagnosis process are used by experts to improve of a plant under investigation. Their proposal are verified ed on the model (spatial network) by means of diagnostic programs. This process can be repeated so many times as it is needed to receive satisfactory results (it is a iterative process). Only the final result is implemented on a real plant. In such a way it is possible to accomplish the organizatonal decision support. The same procedure can be used for a new plant too. It should be mentioned that the *DIANA-9* package has special programs of computer-aided design.

4. Realization of the design process

Due to flexibility of the *DIANA-9* package, the design process can be accomplished autonomously (independently) at any of the mentioned levels. When all the necessary data are entered into the data base, the design process can be realized for the whole plant.In every case, the design procedure is the same and comprises the following operations:

(I) at every level (or for the whole plant; Fig. 2) nodes-germs

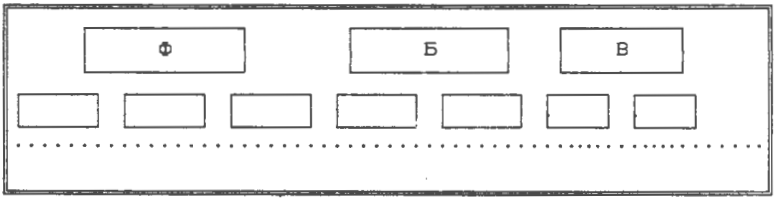


Fig. 2. Initial structure.

are determined, i.e. those elements of the whole plant or of the network associated with a given level that are the most specific for aggregates under design,e.g. operations corresponding to given tasks or personnel working at a given organizational unit (Fig.3).

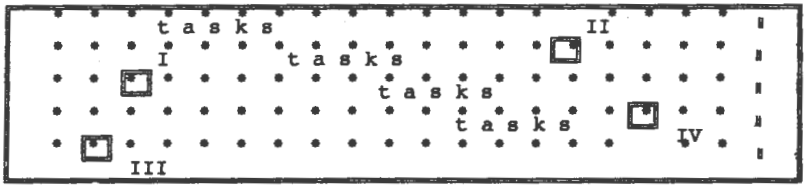
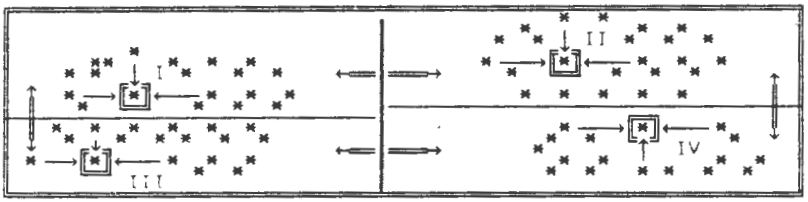


Fig. 3. "Structure without structure" (germs are to be defined). (II) appropriate algorithms of cluster-analysis type are used to optimize a given performance index (depending upon the design process level) choosing the tasks that are related to germs most closely; (see Fig. 4)



(——→ - strong connections; ⟹ - measure of dispertion)

Fig. 4. Design process (transfer of tasks to germs).

Next steps of design: accomplished by means of algorithms for cluster-analysis. In the example investigated space is partitioned into on four parts (Fig. 5).

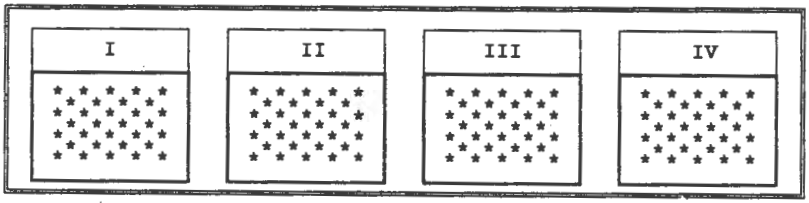


Fig. 5. Result of the first step of design.

(III) computerized evaluation of a resulting variant of the structure under design is carried out. As a result of this evaluation is to be verified by experts;

(IV) if a result obtained variant is unsatisfactory, then the process is repeated.

It should be noted that for every generated variant of a system, a computerized diagnostic analysis is carried on, whose results are used to improve a system under design.

5. Concluding remarks

The *DIANA-9* computer package, worked-out at the Systems Research Institute, is characterized by some features being convenient from the users's point of view:

(i) user friendly software - due to comprehensive menu with many commands available, persons without professional training can make use of it;

(ii) the data base under consideration is divided into two parts (as far as users are concerned). In the first one data on a plant under investigation are stored. Every one has the access to them. They are entered prior to the design process. The second one is a short "photography" of the first one. Hence some a much of design variants can be worked out in parallel.

(iii) in order to have the possibility of extending experience gained from the analysis of generated variants of a system under design, a block of statistical analysis has been constructed.

Recently, the *DIANA-9* package is tested on a real - life plant and results that have been obtained yet are rather optimistic.

6. References

[1] E. Michalewski, J.Ostrowski, M. Stankiewicz : Computer-aided diagnosis and design of plant organization; AMPS-COMPCONTROL'85,Budapest 1985.

[2] E.Michalewski, J.Ostrowski, M.Stankiewicz: The concept of a software tool for analysis and simulation of decision and information flow in large-scale organization; The First IASTED Symposium, Lille 1983.

[3] E.Michalewski E.: Application of a microcomputer package DIANA - 8 for design of computerised management systems, Symp. Information Systems Design II-ISD, Gdańsk 1990.

[4] E.Michalewski: Computer - Aided Advisor for organization management based on the package DIANA-9. Int.Sem.Operation. and Systems Research of the Transition to Advanced Market Economies, Bratislava 1990.

[5] E.Michalewski: Some aspects of computer diagnostic analysis of the management systems; "Control and Cybernetics", vol.4 No 3 - 4, 1975.

[6] E.Michalewski: Computer Consultant to a Designer of Complex Management System, International Conference - Systems Engineering II, Coventry 1982.

[7] E.Michalewski: Application of Q-algebra for simulation of large-scale management systems, Systems Science VI, Prace Naukowe PW, nr 9, Wrocław 1979.

[8] E. Michalewski: Polyhierarchical dynamic model of a large-scale management system; Prace Naukowe ICT PW, Nr 3, Wrocław 1978.