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CLUSTERING & HIGH AVAILABILITY OF NEUROPROCESSOR SYSTEM
CLUSTERING (High Availability Systems)
RESTORABILITY OF NEUROPROCESSOR SYSTEMS DATA HANDLINGS

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The set-theoretic model of a clustering is researched and "high readiness" a restorability of neuroprocessor cluster systems pipeline, vectorial, pipeline vectorial and vectorial pipeline data handling structures on the basis of the modern domestic microset of NM 640X is evaluated

Keywords: cluster, clustering methods, set-theoretic model, equivalence classes, "high readiness" restorability, faultlessness, probability. probability of trouble-free operation

Introduction.

Building of a level of readiness assumes suppression in certain limits of influence of failures and failures by means of monitoring aids and error correction or an equipment room and program redundance of implementation of different options of fault-tolerant architecture [1,2]. The main task of creation of "systems of high readiness" (High Availability Systems) is lowering of down time of the system which minimization requires different strategy and technology [2,3]. Authors offer conceptual model of the set-theoretic clustering implementing system of any of possible structures and raising at the expense of natural reservation a restorability of cluster neuroprocessor systems.

Mathematical methods of cluster analysis

With development of computer networks by clusters began to call two and more computers (servers or workstations), connected in a single system special program and hardware. Such clusters can be considered as the heterogeneous computing system with distributed memory and distributed control. The machines clustered together in this way, can redistribute very quickly in case of a failure of one processor operation on other processors both in a cluster, and between clusters. Thus the organized systems with rather high level of multisequencing provide the following properties: resource sharing, high readiness, high throughput, restorability, convenience of system maintenance and extensibility in case of rather low expenses.

The important section of the theory of recognition methods of a clustering or automatic classification, a taxonomy, self-training, training without the teacher make, the groups solving problems of partition of object groups on equivalence classes in case of the given character spaces or matrixes of likeness of objects. In case of what, the principles according to which objects integrate in one cluster, are usually "internal affair" of certain algorithm of a clustering. The user, knowing these principles, can interpret in certain limits results of each specific method.

Therefore the main objective of a clustering is considered first of all as the task of search of partitions of selection of character descriptions of objects $X = \{x_1, x_2, \dots, x_m\}, x_i = \{x_{i1}, x_{i2}, \dots, x_{in}\}$; $I(S_1), I(S_2), \dots, I(S_m), I(S) = (x_1(S), x_2(S), \dots, x_n(S))$, (1)

where by partition $K = \{K_1, K_2, \dots, K_l\}$ of selection on $X = \{x_1, x_2, \dots, x_m\}$ groups s arbitrary set of not being crossed subsets of a set of X covering all objects of selection: $K_i \subseteq X, i = 1,2, \dots, l, \bigcup_{i=1}^{l} K_i = X, K_i \cap K_j = \emptyset, i \neq j$. arbitrary set of not being crossed subsets of a set of X covering all objects of selection F(K) of partition K. Then the task of a clustering will consist in finding of partition of K *, delivering an extremum to criterion. $F(K): F(K^*) = \underset{K \in \{K\}}{extr} F(K)$. Methods of a clustering differ with criteria:

1. Amount of interclass dispersions or amount of squares of errors.
2. Analysis of scattering matrixes.
3. Method of "k-intra group averages".
4. Forel's method - movements of hyperspheres of the fixed radius to "condensation" of objects.

Each of the given methods has the merits and demerits. In operation it is offered to use the set-theoretical approach, allowing the initial program of processing to break into non-overlapping sets for the solution of the task (1).

Set-theoretic model.

For the solution of the task of partition we will enter concept of equality of clusters of CLl and CLk of some PR (j) program of information processing: CLl = CLk which is understood further as equality of lengths of the specified clusters of CLl = CLk and their coincidence to within the Mki (k) =MKi command (l), PR(j) = <by mki,="" mk1...="" mkj="">, i.e.

| CLl | = | CLk | l, k = 1, N

CLl = CLk = {

MKi(k)=MKi (l), i=1, |CLl ||. (2)

For separation of clusters and their representation it is offered to use set-theoretic model at the heart of which the concept of equivalence [4] lies. Thus expression (1) is criterion of a quality of partition.

In operation is shown that the entered cluster design of KSw□S of information processing is the equivalence relation, meeting conditions of reflexivity, symmetry and transitivity.</by>

Really, any arbitrary cluster of processing of the CL l information, fitting (2), is executed parallely to itself, i.e. CL l KS w CL l. Thus the condition of a reflectiveness of any cluster of CL l PR (j) of information processing is fair.

If the cluster of information processing of CL l is equal to a cluster of CLk and is therefore parallel to this cluster, then the cluster of processing of CL k is equal to a cluster of processing of CL l and, therefore, at the same time in time with it can be executed, i.e.$CL_l, CL_k \in PR^{(j)} : CL_l \; KS_w CL_k \Rightarrow CL_k \; KS_w CL_l$. (3)

In other words the condition of symmetry of any two clusters CL_l, $CL_k \in PR^{(j)}$ is satisfied by information processing.

If the cluster of information processing of CL_l равен is equal to a cluster of processing of CL_k, and the cluster of CL_k, in turn, is equal to CL_q, then the cluster of processing of CL_l s equal and is therefore parallel to a cluster of processing of CL_q, i.e.

$CL_l, CL_k, CL_q \in PR^{(j)} E KS_w : CL_l KS_w CL_k$, $CL_k KS_w CL_q - \Rightarrow CL_l KS_w CL_q$. (4)

Thus the condition of transitivity of two arbitrary clusters of CL_l, $CL_q \in PR^{(j)}$ information processing is fair.

Therefore the statement that the relation of a cluster design of processing of KS_w is the equivalence relation is fair.

Really, the relation of a cluster design of KS_w information processing specifies that any two CLl randomly taken a cluster and CL_l и CL_k fitting, can be executed at the same time on different processor modules under control of the commands, belonging to the specified clusters:

$CL_l, CL_k \in PR^{(j)} : CL_l \; KS_w \; CL_k$ (5).

Thus the entered relation of a cluster design of information processing of KS_w by determination puts set of independent and unequal clusters of which number is equal to number of equivalence classes of L, and multiplicity (CL l) q is defined an equivalence class order | to a l | in compliance to program of information processing of PR (j) some j-oh: $|\mathbf{a}_l|$:

$\forall j=1,N \; PR^{(j)Sw} \Rightarrow \{ (CL_l)^q \}, \forall q=1,|\mathbf{a}_l|; \forall l=1,L$ (6)

Each equivalence class has the representative in a type of the subprogramme of CL l, having number of macro instructions, equal to a |CL l program order. Expression (5) is the solution of the task of cluster analysis since sets required partition of the initial PR (j) program on clusters.

Cluster representation of neuroprocessor systems

As a result of the solution of the task (6) the following candidate solutions in the form of productional model of knowledge on which it is possible to construct expert system of a variation of different structures of processing are possible.

1 . The number of equivalence classes is equal to L and the order of each class is equal to al unit = 1. Then j -algorithm of information represents a tuple from the L clusters: $A^{(j)\;Sw} \Rightarrow \{CL_1\} = <CL_1, CL_2, .., CL_l, .., CL_L>$, (7)
ach of which is the representative of the equivalence class and provides with input information the subsequent CLl+1 a cluster. Having taken number of processor modules equal to L and having assigned each lst to the module a klaskter corresponding to it, we will receive NPS implementation conveyor-based (fig. 1) for example, on the basis of NM 640X [8] neuroprocesssor.

Further key parameters of a received processing pipeline of information are defined: number of modules of processing of L, volume of a random access memory (Memory) of |CL |, productivity as time of a cycle of the pipeline – T0, idle time-Tpr time, etc. [5-7].

2 . The number of equivalence classes of L is equal to unit and the class |al order | is equal to q. Then j-mu corresponds to algorithm of processing of A (j) of information a set of q of absolutely identical clusters $A^{(j)\;Sk} \Rightarrow \{(CL)^q\}$. Thus, if output information of each cluster Thus, if output information of each cluster CL_i, $\forall i = 1,q$ is input for everyone subsequent CL_{i+1}, then we have a cluster design conveyor-based with number of clusters equal q, each of which functions on commands of a cluster of CL.

If input information is required at the same time for all clusters, then, assigning q of processor modules to information processing, we receive NPS implementation of vectorial or parallel type $A^{(j)\;Sм} \Rightarrow (CL_1) = <CL_1><CL_1>...<CL_1>$, in which all q of processor modules function on the same cluster CL_1.

Further similarly key parameters of received cluster vectorial design of information processing are defined: number of modules of processing - L, the volume of a random access memory -|CL|, productivity –T_0, down time - $T_{пр}$ and etc.

3. The number of equivalence classes is equal to L and the order p each l-go of a class is equal $|\mathbf{a}_l|$. This case is the general and assumes the relations not only between clusters in a class, but also between clusters of different classes.

Let information exchange between representatives of classes CL_l, $\forall l=1,L$ it is carried out sequentially. If clusters in lst class exchange sequentially, then, assigning number of processor modules $N_0 = L * \boldsymbol{\Sigma}_{l=1} |\mathbf{a}_l|$ let's receive known pipeline structure. If subprogrammes in lst class require information at the same time, then, assigning number of processor modules the equal $N_0 = L * \mathbf{max} |\mathbf{a}_l|, \forall l=1,L$, let's receive pipeline and vectorial structure of data handling.

If clusters in 1st class communicate sequentially, we have vekorno-pipeline structure of information processing. The specified structures are special cases more the general – cluster array structure of processing.

Further for each received structure of information processing key parameters are defined: number of modules of processing - L, the volume of a random access memory of |CL |, productivity as cycle time – T0, down time - Tpr, etc.

Thus, introduction of a clustering allowed to parallelize the processing program according to (6) and depending on researched algorithms of information processing of PR (j) and to receive cluster designs of processing: pipeline, vectorial [5], or new, earlier not studied, structures of the organization of neuroprocessor systems: pipeline and vectorial, vectorial and pipeline, etc. [5-7]. As a result the hardware redundance is entered into neuroprocessor system in the form of separate neuroprocessor modules and by that there is a possibility of increase of faultlessness, a restorability and readiness of cluster neuroprocessor systems.

ASSESSMENT OF HIGH READINESS OF CLUSTER NEUROPROCESSOR SYSTEMS

As it is known [1,2,9,10], high readiness is defined by reliability as which understand property of computing equipment to execute the functions laid to it, saving the operational indexes during the given period according to the specification.

Quality and speed of restoration of equipment is defined not only maintainability, but also the organization of service of maintenance and perfection of automation of neuroprocessor data handling system.

For finding of indexes of high readiness (restorability) use a random variable — runtime of operations on maintenance. This value depending on the purpose of accumulation of statistical data can be time of repair (restoration) of the NPS equipment after origin of failures and failure, time of technical training of equipment taking into account and without time of restoration or runtime of regulated operations.

Operational index of maintainability of the NPS equipment is the probability of restoration of $p_в(t)$ of equipment for the preset time as probability of that won't exceed time of restoration of $t_в$ set for these purposes of time of t: $p_в(t) = P\{t_в <= t\}$.

By determination of this probability it is clear that it can represent a distribution function of runtime of operations on NPS equipment restoration.

The considerable part of electronic circuits is constructed in such a way that the failure at least one of the NPS elements carries to a failure of all system as a whole. Such connection of elements from the point of view of reliability is called as sequential (main). If all elements in serial connection work independent, the probability of trouble-free operation of the diagram NPS from N elements for a period of t is on a formula $p(t)=p_1(t)p_2(t)...p_i(t)...p_N(t) = \Pi_{i=1}^{N}p_i(t)$.

In some cases electronic circuits are arranged so that the failure of one of elements doesn't lead to a diagram failure as a whole. In this case say that such diagrams have the functional reservation. However when it isn't possible normal methods to achieve high reliability of equipment, it is necessary to resort to reservation which can be realized at a stage of constructioning or in use equipment by установки two, three same neuroprocessors.

Reservation in "physical" sense is characterized by a parallel coupling of neuroprocessors in which only the failure of all elements leads to a connection failure as a whole. In this connection from k of elements along with a basic element there is (k-1) of reserve elements. Each of which can be put into operation or disconnected in case of a failure. Reserve circuits in which all elements at the same time participate in operation can be generally created, and the failure of one or several neuroprocessors doesn't break operability of a circuit. Thus probability of a failure of a parallel coupling $Q(t)=q_1(t)q_2(t)...q_i(t)...q_k(t)=\Pi_{i=1}^{k}[1 — p_i(t)]$,

where $q_i(t)$ - is the probability of a failure of i-th neuroprocessor parallel coupling.

Then the probability of trouble-free operation of a parallel coupling of neuroprocessors is equal $P(t)=1- \Pi_{i=1}^{k}[1—p_i(t)]$. (8)

This formula shows that with increase in number of reserve circuits reliability of all NPS increases.

For research of the most rational (best) method of reliability augmentation we will enter and we will consider the following ratios. Let NPS consist of N sequentially connected elements and for the purpose of reliability augmentation m is reserved by reserve circuits. The redundant system isn't serviced (the refused circuits isn't under repair). The relation of quantity of reserve circuits to number of the mains is called as redundary rate. For the cases of reservation shown in figures number of reserve circuits of m matches redundary rate. Generally redundary rate can be and fractional number.

The probability of trouble-free operation in case of the general reservation (a reserve loaded) is from a condition that the failure of all system including one main and m of reserve circuits, will occur after independent from each other will refuse all (m+1) of parallel circuits. Then probability of a failure $Q_{общ}$ (t) of system is equal: $Q_{общ}(t)=Q_1(t)Q_2(t)..Q_j(t)...Q_{m+1}(t)= \Pi_{j=1}^{m+1} Q_j(t)$,

and the probability of trouble-free operation Pобщ (t) of system is:

$$P_{общ}(t)=1—Q_{общ}(t)= 1—\Pi_{j=1}^{m+1} Q_j(t)=1—\Pi_{j=1}^{m+1} [1—\Pi_{i=1}^{N}p_i(t)] \quad (9)$$

where $Q_j(t)$— is probability of a failure during t j-th of a reserve circuit; pi(t) - probability of trouble-free operation during t i-th of an element of a circuit (the main or reserve).

If all (m+1) of circuits in a parallel coupling are equally safe, the probability of trouble-free operation is defined

$$P_{общ}(t)=1 — [1 — \Pi_{i=1}^{N} p_i(t)]^{m+1}. \quad (10)$$

The probability of trouble-free operation in case of inherent redundancy is defined from a condition that NPS consists of N sequentially connected links, and each link (m+1) parallely connected elements, and failures of elements in a link — events independent and therefore the probability is defined:

$$P_{разд}(t)=\Pi_{i=1}^{N}p_{iзв}(t)=\Pi_{i=1}^{N}[1-q_{iзв}(t)]=\Pi_{i=1}^{N}[1-\Pi_{j=1}^{m+1}q_{ij}(t)]=\Pi_{i=1}^{N}\{1-\Pi_{j=1}^{m+1}[1-p_j(t)]\}, \quad (11)$$

Where $p_{iзв}(t)$, $q_{iзв}(t)$ — is the probability of trouble-free operation and failure of i-th of a link of connection respectively; and pij(t), qij(t) — probability of trouble-free operation and a failure in i-th a link of j-th of an element (the main or reserve) respectively.

If all (m+1) of circuits in a parallel coupling are equally safe, the probability of trouble-free operation is defined:

$$P_{разд}(t) = \Pi_{i=1}^{N}\{1 — [1 — p_i(t)]^{m+1} \}. \quad (12)$$

Comparing of formulas (10) and (12) allows to set that for all pi (t), N and m values (excepting a trivial case, when pi (t) =0 and N =1) values $P_{общ}(t) < P_{разд}(t)$.

Example. Let the equipment of neuroprocessor system consist of ten neuroprocessors, each of which has probability of trouble-free operation during tp(t) = 0.8. There are two reserve circuits. In case of the general reservation Робщ(t)= $1 — (1— 0.8^{10})^3$ = 0.27, and in case of inherent redundancy Рразд(t) = $[1—(1—0.8^3)^{10}]$=0.92. It visually testifies to the considerable efficiency of inherent redundancy in comparison with the general.

Conclusion. The offered technique of a clustering allows to parallelize the processing program according to (6) and depending on researched algorithms of information processing of PR (j) and to receive cluster designs of processing: pipeline, vectorial, or new, earlier not studied, structures of the organization of neuroprocessor systems: pipeline and vectorial, vectorial and pipeline, etc. on the basis of a domestic microset of NM 640X. As a result the hardware redundance is entered into neuroprocessor system in the form of separate neuroprocessor modules and by that there is a possibility of increase of faultlessness, a restorability and high readiness of cluster neuroprocessor systems at the expense of received general and inherent redundancy.

In case of the general reservation the failure of any of elements of a working circuit causes of switching on entirely a reserve circuit while in case of inherent redundancy the failure of one of elements causes of switching on of only one element that leads to increase of high readiness of cluster neuroprocessor systems.

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CLUSTERING AND RECOVERABILITY NEUROPROCESSOR OF DATA PRICESSING SYSTEMS

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Investigate teoretic-set model of clustering and pricing of recoverability of neuroprocessor pipeline systems studied, vector, pipeline - vector and vector – pipeline structures based data set of the modern domestic mikro sets NM 640X.

Key words: cluster, methods of the clustering, set – theoretic model, classes of the equivalence, recoverability, reliability, probability of reliable performance.

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