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THE MODEL BALANCING PARALLEL PROCESSING OF PFOTO-VIDEOFRAMES IN COMPUTING CLUSTER FOR UAV

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In solving some problems that are common to the system of operating UAVs, for example, parallel processing tasks of photo and videoframes, it seems appropriate the operative design of the computing cluster for UAV. The computing cluster for UAV is characterized by a dynamic structure (field) telecommunication system. This circumstance makes it necessary for management purposes, to synthesize the model of such cluster what allows, on the one hand, to calculate the effective plan for the organization of the computation process, and on the other hand - to spend on these calculations the minimum resources (particularly - time). It is proposed this classic problem of the model synthesis in terms of "cost - performance" in the case of computing cluster for UAV to solve by using s (linear) V.Leontyev's model

Keywords: cluster, UAV, distribution of resources, balancing, V.Leontyev's model

Introduction

Computing cluster for the user is presented as a single resource, which is carried by a related set of computer systems (complete computers), that own all resources necessary for their full operation, including processors, memory, input/output subsystem, etc. (Fig.1). Computing clusters for UAVs are loosely coupled systems based on the use of widespread and relatively cheap information and telecommunication technologies, the corresponding software and hardware.

A feature of the computing cluster for the solutions of UAVs functional problems is rapid changes, sometimes even in the decision process of the separate general problem, the topology of the telecommunication system that implies the corresponding variations of the parameters used for planning (parallel) computing process.

An effective plan for the organization of the computational process in the computer cluster of the UAV consists in alignment (balancing) of load in order to optimize the use of resources. This is expected to increase the amount of data storages, performance, reliability and availability of data.

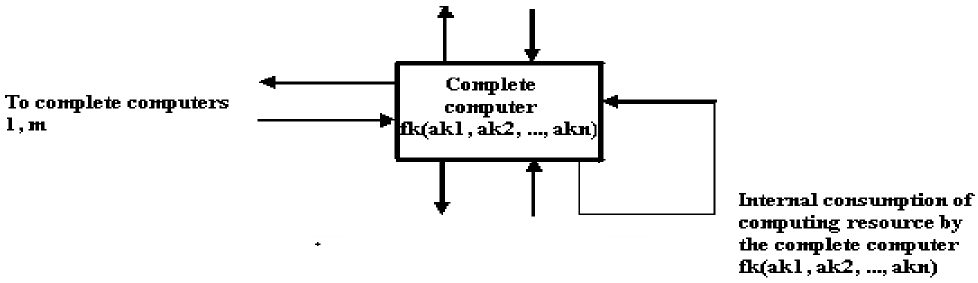

Fig.1. The complete computer in the computer cluster of UAV

The figure emphasizes the fact that the actual computing cluster resource for UAVs is defined as the performance itself fulls computers and the telecommunication component.

Planning (parallel) applied problem solving using the available single computational cluster resource associated with the distribution of computing resources on the full computer of cluster in providing solutions of common problem. The quick changeability of field communication system topology, even in the process to solve a separate general problem, leads to the necessity to set up operatively the parameters of the model to plan the performance process of UAVs functional tasks, which include the task of processing streams of photo-, videoframes,. In [1] there is proposed the method to distribute the computing cluster resources with using the standard algorithms of mathematical programming realizing planning model, synthesized based on the classical Leontyev's model considered in [2]. In this paper we propose a linear structure of balancing model for UAVs cluster, for which the parameters, in its turn, are identified on the basis of factor analysis.

The statement of the problem for the balancing of parallel processing of photo- videoframes in cluster systems

The applied problem of (operative) processing photo, video frame by means of a computing cluster for UAVs (eg, parallel execution of procedures of photos' zoom in *JPEG*, which received from UAV) requires for its decision n kinds of computing resource, produced in n nodes of cluster; while the maximum amount of resource that has been produced in i-th node (complete computer) for the needs solving an arbitrary applied problem, is known and represented by the matrix of $V_{1 \cdot n}$. The amount of required resource for solving current problem is represented by the matrix of $R_{1 \cdot n}$.

Each complete computer $CC_i \big| i = \overline{1,n}$ generates the function of $f_i(a_{i1}, a_{i2}, ..., a_{ij}, ..., a_{in})$, associating the intensities of resources' producing in $CC_j \big| j = \overline{1,n}$ with the amount of generated computing resource in *CC*; for the entire cluster we have $F_{1 \cdot n}$.

It is given the intensity of (technological) producing process of computational resource, which we denote $X = [x_i]_{1 \cdot n}$, where $x_i \big| i = \overline{1,n}$ is the intensity of (technological) producing process of computational resource in *CC* (the total amount of required computing resource of i-th kind, which is produced for the period of problem solving, is equal to $E \cdot X^T$). Here E is the auxiliary identity matrix, the introduction of which is also due to need to conciliate the dimensions of computing resource values.

We introduce the following assumptions:

1) each $CC_i \big| i=\overline{1,n}$ is producing only one, inherent for this *CC*, computing resource;

2) each type of computing resource is produced by only one $CC_i \big| i=\overline{1,n}$ from *CC* of cluster;

3) each $CC_i \big| i=\overline{1,n}$ has a single for the cluster technology of computing resource conversion.

It is necessary to determine an effective plan for the organization computing processes (or verify the absence thereof) on the cost allocation of computing *CC* resources for solving the applied problem.

The mathematical model of the problem

The model of distributed computing resource takes the form:

$$(E-A)\cdot X^T - R^T = 0 \qquad (1)$$

$$A \geq 0 \qquad (2)$$

We consider two cases for the additional assumptions. In first case additionally there are introduced the following assumptions:

1) functions generated by each complete computer $CC_i \big| i=\overline{1,n}$, are additive:

$$f_i(\{a_{ij} \big| j=\overline{1,n}\}) = \sum_{j=1}^{n} f_{ij}(a_{ij});$$

2) function of $f_{ij}(a_{ij})$ is linear with respect a_{ij} and is represented using a matrix of (technological) coefficients $A_{nxn} = [a_{ij}]$: $f_{ij}(a_{ij}) = a_{ij} \cdot x_j$, where a_{ij} is the ratio of resource cost of CC_i in producing the resource in CC_j. The ratio of a_{ij} takes into account the costs of *i*-th resource directly on producing the resource unit of *j*, and also the costs, associated with (tele) communications.

In second case the model assumptions are introduced:

1) functions generated by each complete computer of $CC_i \big| i=\overline{1,n}$, are additive with the nonlinear dependence of the variables of $a_{ij}, x_j \big| j=\overline{1,n}$: :

$$f_i(\{a_{ij}, x_j \big| j=\overline{1,n}\}) = \sum_{j=1}^{n} f_{ij}(a_{ij}, x_j);$$

2) function of $f_{ij}(a_{ij}, x_j)$ is represented with using the matrix of (technological) coefficients of $A_{nxn} = [a_{ij}]$: $f_{ij}(a_{ij}) = a_{ij} \cdot x_j$

In its structure this model is similar to V.Leontyev's model of interbranch balance [6].

The identification of the parameters for model of (1) - (2) it is proposed to carry out by the method of principal components.

Researching the model

The model was studied using the tools [3] (in particular, used utility of fmincon) hypothetical example of UAVs computing cluster (see fig. 2). In first case of the model there are given the intensities of computing resource produced in CC of cluster in form: X_1 = 78,096*10^9 *op/s*, X_2 =71,788*10^9 *op/s*, X_3 = 76,812*10^9 *op/s*, X_4 = 14,320*10^9 *op/s*, X_5 = 213,436*10^9 *op/s*.

The values of A matrix are obtained by the method of principal components, as follows:

$$A = \begin{Vmatrix} 0{,}1158 & 0{,}2944 & 0{,}2818 & 0{,}4565 & 0{,}0925 \\ 0{,}2607 & 0{,}1134 & 0{,}2641 & 0{,}4526 & 0{,}0774 \\ 0{,}2751 & 0{,}2910 & 0{,}1153 & 0{,}4558 & 0{,}0893 \\ 0{,}0050 & 0{,}0295 & 0{,}0098 & 0{,}1009 & 0{,}0451 \\ 0{,}5765 & 0{,}5702 & 0{,}5752 & 0{,}5141 & 0{,}3558 \end{Vmatrix}$$

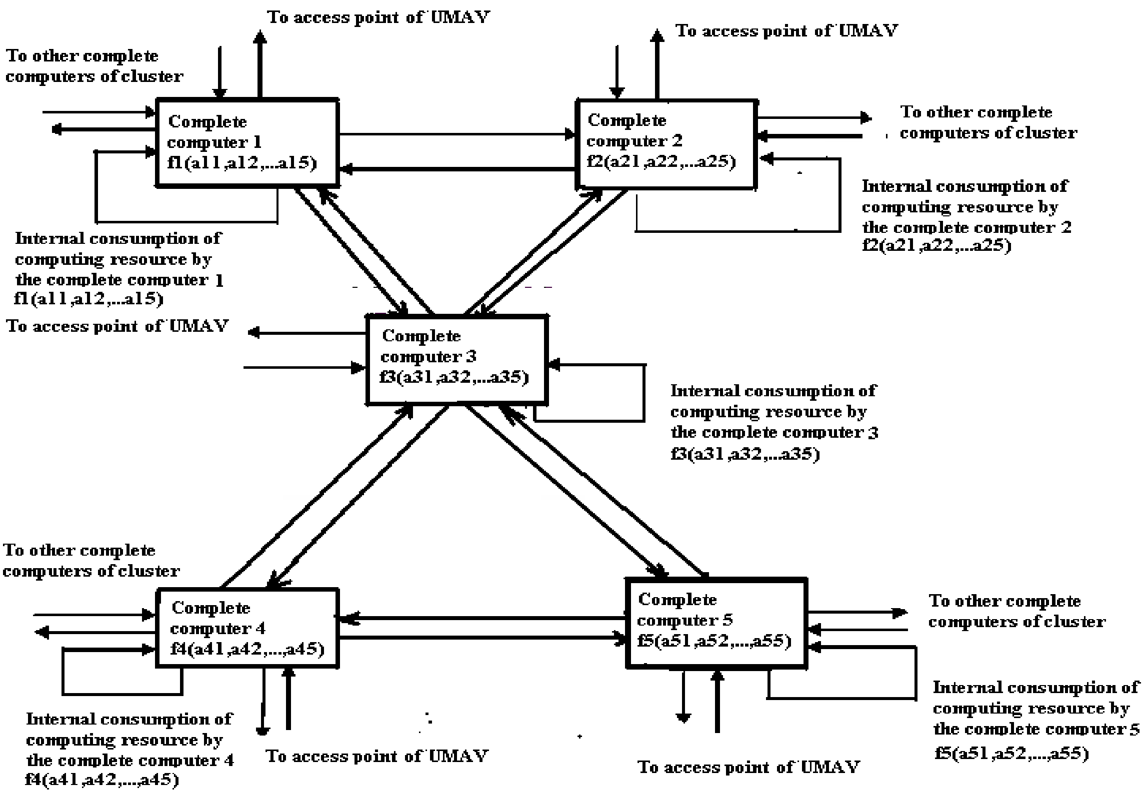

Fig. 2. Fully connected cluster with five complete computers

Conclusion

The proposed in the article model of balanced computing cluster of UAVs allows calculate as part of the management system by the cluster, an effective plan for the organization computing processes at a minimum costs of time resources for these calculations. The proposed model also allows to evaluate the (hidden) structure and parameters of the telecommunication system of the computing cluster of UAV.

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