ON THE PROBLEM OF THE EFFICIENCY OF A MULTIPROCESSOR COMPUTING SYSTEM WHEN SOLVING ONE CLASS OF THE PROBLEM

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In this paper, this problem is considered. There is a difference mesh of dimension *M*; the problem computational time using a single-processor system is determined by the value of *t*. This parameter is not determinative. Here it is essential to increase the size of the grid, and more than one that can be processed in the memory of one processor. This procedure is crucial for a more detailed computation, or for obtaining some new effects of the researched processes. In this case, it is necessary to study the features of the computations in the conditions of this class of problems based on using the InfiniBand network interface in multiprocessor computing systems.

The purpose of this paper is to study the features of the InfiniBand network interface in multiprocessor computing systems in solving problems related to the computing area expansion.

At the same time it is necessary to solve the following problems:

1. Identify the basic regularities regarding the time of the problem computation from the change of computing area of a multiprocessor computing system constructed, using the InfiniBand network interface. It is necessary to derive the main analytical relations that determine the dependence of the problem solution time based on the parameters of the multiprocessor computing system.

2. To study the variant of a hypothetical computer with unlimited memory and conduct its comparative analysis with a real multiprocessor computing system. At the same time, derive analytical relations that determine the peculiarities of computing for such a computer. Perform a comparative analysis of the functioning of a real multiprocessor system and a hypothetical computer with unlimited memory in order to determine the main factors that affect the efficiency of parallelizing the real computing system.

3. Run the simulation phase of the main time characteristics of the solvable problem by a multiprocessor computing system based on the InfiniBand network interface. Identify the main regularities of the problem solving time depending on the computing area expansion.

The studies carried out are aimed at further development of the approach highlighted by the authors in [1-3] and relates to the developed multiprocessor computing system [4].

Consequently, the problem of expanding the computing area by increasing the number of nodes in the cluster system is considered. At the same time, we assume that the computing area is evenly distributed among the nodes of the cluster system. The main analytical relationships for determining the efficiency of such a multiprocessor computing system is derived in [5]. Under such conditions it is defined T_{ex} is the time of boundary data interchange among nodes of a cluster, sec. Note that if the iteration computational time depends only on the processor power, the time of the boundary data interchange is determined by the size of the difference grid, the number of nodes of the cluster system and the bandwidth of the computing network. Consequently, the value T_{ex} can be determined by the following ratio:

$$T_{ex} = \frac{m \cdot N \cdot \sqrt{\frac{S}{\pi}}}{k \cdot d \cdot V_p} . \quad (1)$$

The m value can be equal to units for one-way boundary data interchange or for two for two-way, V_p is the throughput of the network interface port (Gbit/sec), N is the number of nodes in the multiprocessor computing system, S is the total volume of the multiprocessor computing system, k is the number of channels of computer networks simultaneously (number of computing networks), d is half-duplex ($d = 1$) or duplex ($d = 2$) mode of the cluster system's computing network.

In this class of problems, all computations are performed on the basis of the difference grid. In addition, for the analysis of the efficiency of the multiprocessor computing system, the most important parameter will be one iteration (T_{it}) computation relative to the computing area. Then, in a multiprocessor application, the total time of one iteration will be determined on the basis of the following relationship:

$$T_{it} = T_c^N + T_{ex} \; . \quad (2)$$

Here T_C^N is one iteration computation time when using N computing nodes, sec.

Obviously, for a case when $N = 1$, it is obtained that

$$T_{it} = T_c^1 . \quad (3)$$

Here T_c^1 is the time of one iteration for one-processor computing system.

Analysis of the ratio (1, 2) shows that an increase in the field of computing by N the problem computational times increases as $N^{3/2}$ with some coefficient that depends on node RAM volume, the bandwidth capacity of the cluster network and the character of the data interchange among computing nodes , i.e.:

$$T_{it} = T_c^N + N^{3/2} \cdot f(m,R,V). \quad (4)$$

The analysis of the ratio (4) demonstrates the perspective of the use of modern communication technologies, such as InfiniBand, as well as multi-core computing platforms.

Based on our research background, let us consider the case of a hypothetical computer with an unlimited amount of memory. Thus, taking into account the relation (3), we obtain:

$$T_c^1(S) = \frac{S_i}{V_c} . \quad (5)$$

In relation (5), the total computational scope of a hypothetical computer can be filed as follows:

$$S_i = i \cdot R \,, \tag{6}$$

here, i is the coefficient that determinesthe change in the computing area of a hypothetical computer.

The analysis of relations (5), (6) illustrates that with an increase in the total volume of computations by N times, the computational time of problems grows linearly with some coefficient, which depends on the computational capabilities of those processors used in the system.

In accordance with the above ratios, computing experiments were carried out for a computer platform equipped with an *Intel E*8400 3 *GHz* processor. Here, as the initial one, the corresponding characteristics of the class of problems solved by the very cluster system were adopted. The simulation results are presented as graphical dependencies (Figure 1).

As it can be seen from Figure 1, one iteration computational time with the increase in the computing area of the multiprocessor system varies according to nonlinear dependence (curve 1, T_{it}). This dependence shows that with an increase in the computing area by N times, the computational time of the problem increases as $N^{3/2}$ with some coefficients depending on the RAM amount of the cluster node, the network interface bandwidth, and the nature of the data interchange among the computing nodes. At the same time, one iteration computational time of for a hypothetical computer with unlimited memory, as expected, increases linearly (line 2, T_{id}). The inclination angle of such a line is determined by the characteristics of the computer platform used in the system. The simulation results represented the following general trend.

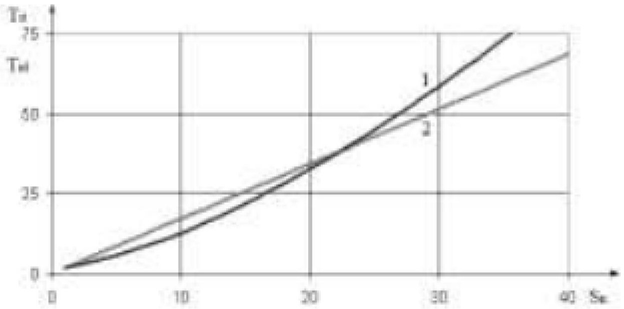

Figure 1 - Curves of the time dependence of the calculation of one iteration on the size of the computing area of the multiprocessor system

It is obvious that in the case, when $S_n < S_{id}$, the computational time of the multiprocessor computing system becomes less than computation time of the ideal computer. This is due to the increase in the number of processors of the multiprocessor system. On the other hand, when $S_n > S_{id}$, due to the significant impact of the time boundary data interchange on the total time of solving the problem, with the background of expanding the computing scope, the time of solving the problem for a real multiprocessor computing system will significantly increase compared to the ideal computer. It becomes apparent that the promising mode of using the multiprocessor computing system is a case, when $S_n < S_{id}$. A highlight of the mode peculiarities of such a work of the multiprocessor computing system and the authors' further research is devoted.

Consequently, on the basis of the conducted researches it is possible to note the following:

1. The basic regularities concerning the problem computational time are revealed, depending on the change of the computation domain of the multiprocessor computing system. It is shown that with total number of computations increasing by *N* times the problem computation time grows as *N* in the power of one and a half.

2. The main analytical relations are obtained, which determine the problem solving time dependence on the basic parameters of the multiprocessor computing system. Such correlations have shown that the problem computation time increases according to the nonlinear law with some coefficient, depending on the RAM volume of the node of the computing systems, the cluster network bandwidth and the nature of the data interchange among the computing nodes.

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