Accelerate the Solution of Problems of Digital Signal Processing Technology Based INTEL CILK PLUS

M. Musaev[1], I. Khujayarov[2] and A. Buriboev[3*]

[1] Professor, Department of Computer system,
Tashkent University of Information Technologies
Tashkent, Uzbekistan

[2] Research scholar, Department of Information Technologies,
Samarkand branch of Tashkent University of Information Technologies
Samarkand, Uzbekistan

[3] Research scholar, Department of Information Technologies,
Samarkand branch of Tashkent University of Information Technologies
Samarkand, Uzbekistan

[*]*Corresponding author's email: wolfsonabror [AT] gmail.com*

ABSTRACT — ***In this paper we considered the steps of the method of accelerated digital signal processing algorithms with modern software tools parallel processing. Compared the experimental data, obtained during the processing of parallelizing OpenMP technology and Cilk Plus. As a hardware implementation architecture are analyzed multi-core processors.***

Keywords — Intel Cilk Plus, Basic Interface for Parallelism, Basic Linear Algebra Communication Subprograms

1. INTRODUCTION

The main requirement for methods and algorithms for digital signal processing (DSP) is to increase computing speed. Signal processing in the spectral region using numerical methods, - Fourier analysis and processing of the signal spectrum. One way to improve the processing speed of the problems with DSP algorithms is the use of parallel processing. To enable the parallel execution of more tasks need to efficiently integrate two or more cores on a single microprocessor. Such a multi-core configuration on a single chip provides a higher exchange rate between the nuclei, than when using an external bus, switches, etc. in multiprocessor systems. Multi-core architecture provides two or more full-featured set of resources to improve the performance of each processor. Principles of operation of multicore processors consists of parallelism. As a result, the core of the parallel operation requires the parallel distribution of information flow. All this requires the creation of optimal DSP algorithms, which are based on software developed parallel processing[1,2].

2. MAIN PART

Parallelism in problems of signal processing is carried out in three stages[3]:
1) The use of parallelism based on mathematical methods. At this stage, developed a mathematical model decomposition whole problem into independent components.
2) The use of algorithmic parallelism on stage. This step creates the algorithms based on mathematical models, which must also comply with the laws of parallelism.
3) Application-level parallelism of the processor. At this stage the software implementation of the distribution of the computational load in multi-core processors using a single programming language in which you can develop parallelized programs (eg, C ++, C #, Java), special software tools and libraries (OpenMP, Intel Click Plus, etc.).

In the spectral methods of digital signal processing formula both direct and inverse transformation are the product of vector samples of the input signal by a matrix of basis functions[4,5]. In the algorithms of Fourier analysis basis functions are of the form a local basis (Haar, Daubechies wavelets) and integral bases (Fourier and Hadamard). Getting the spectral values of the signals generated by multiplying a vector by a matrix. The general formula of multiplying a vector by a matrix is as follows:

$$c_j = \sum_{i=0}^{2^n-1} f_j * k_{i,j} \quad j = 0 \div 2^n - 1, \quad 2^n = N \quad (1)$$

where –c_j the spectral coefficients; - $k_{i,j}$ Elements of the basis functions; - f_i Samples of the input signal; N-the size of the transformation matrix. According to the formula (1) CPU executes calculating without flow separation. This formula means consistent signal processing. Multiplication of a vector by a matrix can be performed in parallel by dividing the flow in the lines. The number of threads (m) may be $m = 0..2^n - 1.$ to facilitate the distribution of flow between the processor and the subsequent ordering of the results generally the number of threads is divided into two groups with numbers $0 \div N/2 - 1; \quad N/2 \div N - 1.$ If two groups, the two streams are formed in the form of:

$$M_j(L_j : H_j) = \left[\begin{array}{l} L_j = \sum_{i=0}^{N/2-1} f_j k_{i,j} \ \ here\ i = 0.....N/2 - 1; \quad j = 0..N - 1; \\ \mathrm{H_j} = \sum_{N/2}^{N-1} f_j k_{i,j} \ \ here \quad i = N/2.....N - 1; \quad j = 0..N - 1; \end{array} \right]$$

where L_j and H_j - flow matrix vector multiplication.

As an example, two core processor, where the first core of this stream - L_j the second core of this stream - H_j. Thus, when the matrix multiplication of the vector formed parallel streams consisting of the input signal and reports the elements (rows) of the matrix.

Nowadays created software tools, including special libraries, which provide parallel processing on multicore processors. For example, communication libraries and interfaces (BIP (Basic Interface for Parallelism), BLACS (Basic Linear Algebra Communication Subprograms), KeLP (Kernel Lattice Parallelism)), parallel languages and special extension of C ++ (Intel Cilk Plus), special application packages (IPP (Intel Integrated Performance Primitives), MKL (Math Kernel Library), TBB (Intel Threading Building Blocks)), automation of parallel funds and other special technology and software (OpenMP, Visual Parallel Studio) and software packages. (OpenMP, Visual Parallel Studio) and software packages. Using the formula (2) in the calculation of the spectrum of the input signal increases the degree of parallelism and faster processing.

When using the software parallelization for multi-core processors, the programmer has the possibility at high-level languages and specific directives above standard threading libraries to form a separate thread for each of the processor cores. On the basis of formulas (1) and (2) form the data flow and use technology Intel Cilk Plus.

Intel Cilk Plus - extension languages C and C ++, which simplifies the development of applications for parallel tasks and data in shared memory systems. Provides an effective and safe concurrency type "fork-join" (operation of generation - spawn, hotspots, dispatching system performance);

Provides a vector parallelism (vectorization of operations with sections of arrays and elemental functions);

- Intel Cilk Plus is supported compilers:
- Intel (starting with version 12);
- GCC (since version 4.7);
- compatible with Microsoft Visual Studio.

In Intel Cilk Plus preserves the semantics of sequential programs. Program can be executed in serial or in parallel mode. Parallel execution is possible if it allows the target platform (sufficient number of core).

A programmer using Intel Cilk Plus must think about what should be parallelized. This is one of the differences from the OpenMP-programming. Balancing engaged in runtime - system. Balancing is performed by the capture operation. Scheduling algorithm such that the efficiency of as high rules.

Structure Intel cilk plus. Keywords (of 3):

-Cilk_spawn-causing the problem;

-Cilk_for-parallelization of loops;

-Cilk_sync – Synchronization

Key words cilk_spawn denotes the point of generation. At this point, a new task that you can continue the data stream captured or another (parallel) flow. Key words cilk_for loop parallelization. The program is used in place of a header cycle parameter:

Cilk_for (int k = 0; k = N; ++ k) { loop body } at the end of the cycle, a barrier synchronization - program execution continues only after all iterations.

Hotspots (gearboxes). Gearboxes - "parallel" global variables to avoid races for data and locks. Effective management gearbox ensures system performance Cilk - programs.

Element (vector function). Element provides vectoring function of math functions. Arguments elemental functions - vectors of values. Returns the result vector, conformal vector argument.

3. EXPERIMENTAL FEATURE ANALYSIS

A comparative analysis of the run-time DSP algorithms for sequential formulas (1) and parallel (2) processing on a dual core processor (Figure 1). This Figure shows the values of one input signal when using different basic systems. This figure makes it possible to select the optimum base processing. Bases are shown as: - Fourier transform (F), discrete cosine transform (DCT), the Haar basis (H), the basis Hadamard (A), wavelet basis (V).

Below: the first column indicates the execution in milliseconds (ms) in the normal sequential method of computing the spectrum C_j for N = 2048. The second column is a calculation time in parallel with the process with OpenMP. The third column indicate the computation time for a parallel fashion with technology Intel Cilk Plus.

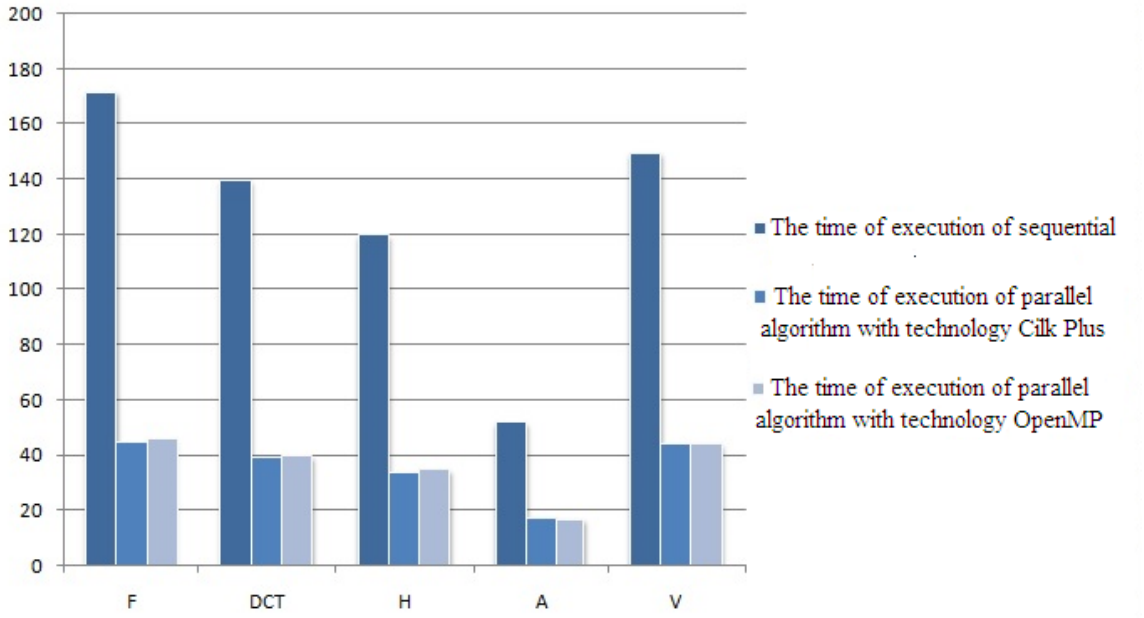

Figure - 1. Graph presenting the results of the experiment.

Based on the results of the experiment can be seen that the time spent on computation using technologies Intel Click Plus and OpenMP has an insignificant difference. You can also note the ease of use, scaling principle of programming, depending on the computer system cores Intel Cilk Plus, unfortunately OpenMP these functions are not supported at the appropriate level.

We estimate the acceleration factor of the results of parallel processing in accordance with the known laws of Amdahl. This ratio is determined by the formula

$$K = \frac{T_s + T_p}{T_s + \frac{T_p}{M}} \qquad (3)$$

where T_s - the execution of the algorithm in a consistent manner; T_p - Time algorithm circuiting switch parallel form; M - The number of cores.

Basis transformation		F	DCT	H	A	V
The acceleration factor	Cilk Plus	3,84	3,53	3,5	2,96	3,38
	OpenMP	3,73	3,51	3,42	3,06	3,36

Analysis of the results using (3) shows that the different basic systems acceleration factor in the average value of 3 to 3.8 ie the processing speed can be increased by more than 3 times when N = 2048. The results of this study show that the use of two-stage method of parallelization in problems of DSP enables significant acceleration of the process of processing the input signals.

4. CONCLUSIONS

Summarizing discussed in this article are parallel computations when solving DSP, can be briefly summarized the main conclusions obtained by:

- The true parallelism is truly simultaneous execution of multiple software threads. Most modern multi-core processors - are processor with multiple instruction stream and multiple data streams;
- To receive the maximum benefit from a parallel program must take into account the restrictions on the timing of

individual subtasks, their information interaction, load balancing between processor; cores;
- For vector-matrix calculations typical DSP algorithms is to repeat the same action for different elements of vectors and matrices, indicating the presence of data parallelism, so the parallelization of such operations is reduced, as a rule, to the separation vector and matrix elements between the processor cores;
- Parallelization of tasks using Intel Cilk Plus technology enables scaling architecture of multicore processors parallel software.

5. REFERENCES

[1] Musaev M.M., Rahmatov F.A. "The method of interpolation and compression for DSP", Journal of ICEIC, pp. 151-154, 2008.
[2] Musaev M.M., Rahmatov F.A. Algebraic model representation of signals and its implementation on DSP. Journal of ICAICT, IEEE, doi:10.1109/2010.934636, pp 239-242, 2010.
[3] Khujayorov I.Sh., Berdanov U.A. Parallel solutions of tasks of digital signal processing. International Conference "Actual problems of development of info-communications and information-oriented society", Tashkent, pp. 173-176, 2012.
[4] John G. Proakis, Dimitris Manolakis: Digital Signal Processing: Principles, Algorithms and Applications, 4th edition, Pearson, USA, 2006.
[5] Dag Stranneby, William Walker. Digital Signal Processing and Applications, 2nd edition, Elsevier, 2004.