From technologies to algorithms through the prism of algorithm analysis

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Abstract. In anticipation of the predicted transition from the technology economy to the algorithm economy, the article is devoted to the analysis of algorithms as an object of intellectual activity of universities registered for the period from 2010 to the present. The selection of information about algorithms and their statistical processing is carried out automatically by the collector_stat program developed by the authors of the article. This article is based on the results of the National Supercomputer Forum (NSCF-2019) and the materials of the joint Fund for electronic resources "Science and education".

1. Introduction
In the post-industrial economy, technology is developing rapidly and goods are changing rapidly. Therefore, we need to accelerate the digital design of new products. For this purpose, high-performance computing is used, which is the basis of the digitalization of the economy [1]. Digitalization of the economy allows full-scale design to be replaced by digital, mathematical (simulation) modeling [2]. Today, the digitalization index of the Russian economy has reached 0.36. It continues to grow, but it is still small for the tasks set. The digitalization index indicates that Russia counts almost 8 times less per unit of production than it is on average around the world [3]. The objects of research are Russian universities-developers of algorithms. The subject of research is algorithms developed by universities. Research methods are methods of statistics, logic, expertise, and content analysis.

2. Purpose of research
The aim of the research is to analyze algorithms as objects of intellectual activity (REID). Evaluation of REID in the form of algorithms allows to indirectly assess the country's readiness to move from economy to economy algorithms, object relations which is not a thing, not a program, and algorithm [1].

The results of intellectual activity in accordance with the types of human activity are divided into works of science, works of art, works of literature. Starting from the opposite, we say that algorithms are neither works of literature nor works of art, therefore, they are works of science [4]:

[1]...

[2]...

[3]...

[4]...
Sorted works of science in the form of algorithms made up 2.5% of the total volume of the Ofemnio database [5, 6]. Figure 2 shows an approximation of the graph of changes in the number of registered algorithms from 2010 to the present. Viewer of approximating curve of graphic - exponent:

Figure 1. Type classification of intellectual activity results.

Figure 2. Distribution of algorithms by year.

Thus, there is an exponential increase in the number of registered algorithms. 115 authors participated in the development of the sorted number of algorithms; their personalization by the number of algorithms is shown in figure 3:

Figure 3. Distribution of algorithms by authors.
17 science cities of the country are recorded (figure 4), from which the algorithms were received:

![The geography of the registered algorithms](image)

**Figure 4.** Distribution of algorithmus across science cities.

Analysis of data on algorithms confirms that the most active developers of algorithms are universities and academic institutions. The chart below shows the most active universities in the field of algorithm development.

| Distribution of algorithms by developer organizations |
|-------------------------------------------------------|
| 1. Omsk state technical University                      |
| 2. Tomsk state University                                |
| 3. Bashkir state University                              |
| 4. Siberian state University of railway transport        |
| 5. Sobolev Institute of mathematics of the Siberian branch of the Russian Academy of Sciences |
| 6. Military Academy of the military defense of the Armed Forces of the Russian Federation named after Marshal of Soviet Union A. M. Vasilevsky |
| 7. Volga state University of telecommunications and Informatics |
| 8. Siberian state automobile and road University (SibADI) |

**Figure 5.** Distribution of algorithms by developer organizations.

As for works of science, algorithms are classified according to scientific directions in accordance with the State category of scientific and technical information (GRNTI).
Figure 6. Distribution of algorithms by scientific directions (headings of GRNTI).

The diagram shows the multiplicity of fields of science for which algorithms have been developed, including areas of academic science and the industrial sector, in particular the oil and gas industry, which has run out of "lungs" oil and gas. Consequently, there is a demand for simulation modeling of mining at depths in order to assess seismic activity and prevent emergencies [7]. The chart States that the first place in the quantitative distribution is occupied by the scientific direction of GENERAL AND COMPLEX PROBLEMS OF NATURAL AND EXACT SCIENCES, as the most significant area of interest of universities.

The specific classification of algorithms by form-functional feature allows you to determine what percentage of algorithms are transformed into programs:

Figure 7. The distribution of algorithms on a functional basis.

We note that 96% of algorithms have a software implementation in the form of various forms of software:

- the program
- the software package
- a software module
- program library
- database
• software system,

with the following quantitative distribution, putting the "program" form in the first place as the most replicated:

![Distribution of algorithms by implementation forms](image)

**Figure 8.** Quantitative distribution of algorithms by type of implementation.

The variety of algorithm implementations combined with the concept of "software" allows us to apply the analysis of the following software and technical characteristics to them:

• the type of computer;
• OS type and version;
• workbench,

which are shown in figures 9, 10, 11:

![The allocation algorithms for the types of computers](image)

**Figure 9.** Quantitative distribution of algorithms by computer types.

![Distribution of algorithms by operating system types and versions](image)

**Figure 10.** Quantitative distribution of algorithms by operating system types and versions.
Figure 11. Distribution of algorithms by tools.

As the diagrams show, computers running on the Intel platform with the Windows operating system installed are mainly used for developing algorithms.

The variety of programming languages shown in figure 11 characterizes the transformation of algorithms into software that is currently designed to digitalize the technology economy.

In addition, "clean" algorithms are recorded, in the amount of 4%, as groundwork for the transition to the future economy of algorithms. Thus, the initial readiness of the country to transition from the economy of technologies to the economy of algorithms is confirmed.

In order to make the transition from the economy of technologies to the economy of algorithms, the Federal target program "Education" added the subprogram "Preschool education". This subroutine provides solutions to such tasks as:

- training and retraining of teachers and educators of pre-school education institutions in order to provide pre-school children with programming and algorithmization;
- organization of the learning process for algorithmization and programming of children from preschool age.

An illustrative example is the training of programming for 6000 preschool children aged 5 years and older in Surgut [7, 8] and existing examples of partnership between preschool institutions and leading universities in the country.

3. Conclusion

Thus, the analysis of the algorithms demonstrated:

- exponential growth in the number of algorithms over the past 10 years;
- variety of scientific directions of algorithm development with the advantage of the scientific direction GENERAL and COMPLEX PROBLEMS of NATURAL and EXACT SCIENCES, as an area of increased interest of universities;
- improving the system of professional development of teachers of preschool educational institutions in order to teach children algorithmization and programming;
• rearrangement of traditimization and programming training starting from preschool age, as confirmed by numerous examples from life.

Thus, the route map of the transition from the economy of technologies to the economy of algorithms has been launched and demonstrates its first results.

4. Confirmation
Algorithms and programs that implement them are publicly available on the portal of the United Fund for electronic resources "Science and education", in the public database Ofernio: http://www.ofernio.ru/program/ofapis_bd/index.html.

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