Преглед НЦД 14 (2009), 53–60

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CREATION AND SCIENTIFIC INTERPRETATION OF ACAD. ERSHOV'S ELECTRONIC ARCHIVE

Academician Andrei Ershov (April 19, 1931 – December 8, 1988) belongs to the generation of first Russian programmers. He is justly regarded as the creator of the Siberian School of Informatics. Upon graduating from the Moscow State University in 1954, he began his career in the Computing Center of the Academy of Sciences of the USSR. In 1961, he moved to Siberia, where Akademgorodok, the new scientific center, was being built. His substantial contribution to the establishment of informatics as a new branch of science and a new social phenomenon is universally acknowledged, both nationally and worldwide. Andrei Ershov paid a lot of attention to international scientific collaboration. He was a member of the IFIP Algol Working Group from the day of its creation in 1962. In 1974 Ershov was awarded the title of Honorary Member of the British Computer Society along with C. Strachey, E. Dijkstra, H. Hopper, and others. In 1980 he was given an IFIP Silver Core for organizing IFIP Congresses.

In 2000, creation of the electronic version of Andrei Ershov's archive began. The archive is stored in the Institute of Informatics Systems of the Siberian Branch of the Russian Academy of Sciences (IIS SB RAS). The project was initially supported by Microsoft Research and is carried on by joint efforts of IIS employees and xTech, a Russian IT company. It is supported by grants from RFBR and RHF; the Novosibirsk IT companies UniPro and Atapy Software also contributed to the project.

I. Ershov's Archive – a collection of authentic sources on the history of science

The Ershov Archive contains over 550 thick stationery folders holding vast materials on the history of the national informatics and programming as seen through the prism of Andrei's life. The bulk of the archive is formed by textual sources: drafts and manuscripts of Ershov's monographs and articles, project reports, reviews of graduation works of students, Candidate and Doctor of Sciences dissertations, business and personal correspondence, etc. Chronologically, the archive embraces the period between 1947 and 1989. The earliest documents date back to Andrei's school years; the most recent entries, which were addressed to Andrei Ershov and added to the archive after his death in 1988, are from 1989.

Andrei Ershov used the chronological-thematic principle for organizing his archive. He personally formed, annotated and dated each folder. As a rule, the documents have handwritten marks, which Andrei used to register the reception of a document. There are

marks reflecting the movement of the document through bureaucratic instances. Some of the incoming letters have three dates – the dates the letter was written, received and answered. If a document was compiled outside Ershov's office, it got a special marking: "GAN" for the Hotel of the Academy of Science, "Tu-154", "Uzkoye Resort", etc. Scientific manuscripts were provided with chronologies allowing us to trace the stages of work.

The electronic version of Ershov archive virtually identically represents the structure set by the original archive, however, the electronic version is even more comprehensive. For even fuller coverage, documents saved in Andrei's family were added along with the documents found during additional search. The work is continued at the moment.

All documents in the electronic archive are distributed by topics reflecting the chief stages and events in the life of Academician Andrei Ershov. Inside each topic, documents are divided into logically bound groups, which in turn may be divided into sub-groups. Each document is given a brief comment. Navigation is intuitive and implemented through standard browser tools. Having chosen a document, a user can see a screen with relatively full information about the document: its name, date of creation, information about its author and address (if it is a letter, a memo, etc), and, naturally, the document itself can be viewed as a digital image. Reading some interesting documents may be difficult if they are in a foreign language or unintelligible handwriting; in this case, the document is supplemented with its textual representation.

The search system allows forming a set group of documents and extracting it from the pool for studying it as a list. The list can be sorted alphabetically or chronologically. There is a total of 28 topics in the archive, within which documents are divided into groups and subgroups with common topics.

II. Software tools for creation of electronic archives and museums

The tools applied in the project were developed by xTech Company; they consist of a number of special applications and an automated information system (AIS), which supports chief technological processes of creation of the electronic archive:

- input of factual materials (graphic representations of documents, pictures of items, textual descriptions, sound files, etc.) into the database – thus creating the virtual museum (archive, library, …) fund;
- description of items: museum items, archive documents, persons, organizations, etc, i.e. creating item id cards.
- structuring the objects in a the virtual museum, linking objects (exhibition items, persons, and organizations) – i.e. cataloguing thematic and object collections;
- creating virtual exhibitions and expos both in the Internet and on various media including CD and DVD – i.e. publishing objects;
- information support of exhibitions, thematic shows, press releases, and other events in the museum (mailing info- and newsletters, invitations, publishing analytic and other essential materials in the Internet, etc.)

The automated information system is built within three-level client-server architecture as a Web application. All interaction with the virtual archive and museum (administration, data manipulation and publication, etc.) is performed through the Web browser. The system supports various representations of documents – graphic, hypertext, or abstract-based, along with working with documents in different languages. Above that, the AIS makes it possible to organize work of a large group of operators connected with creation of the virtual fund, its description and structuring.

The system is implemented on the basis of Microsoft technologies using automated text recognition tools by Atapy Software. It consists of two relatively independent subsystems, the so called Front-end and Back-end.

The Front-end is a website providing public access to the electronic archive and virtual museum. The current address of its English version is http://ershov.iis.nsk.su/english/.

The Back-end is a software subsystem for filling the database with various data, managing its content, linking its objects and data actualization.

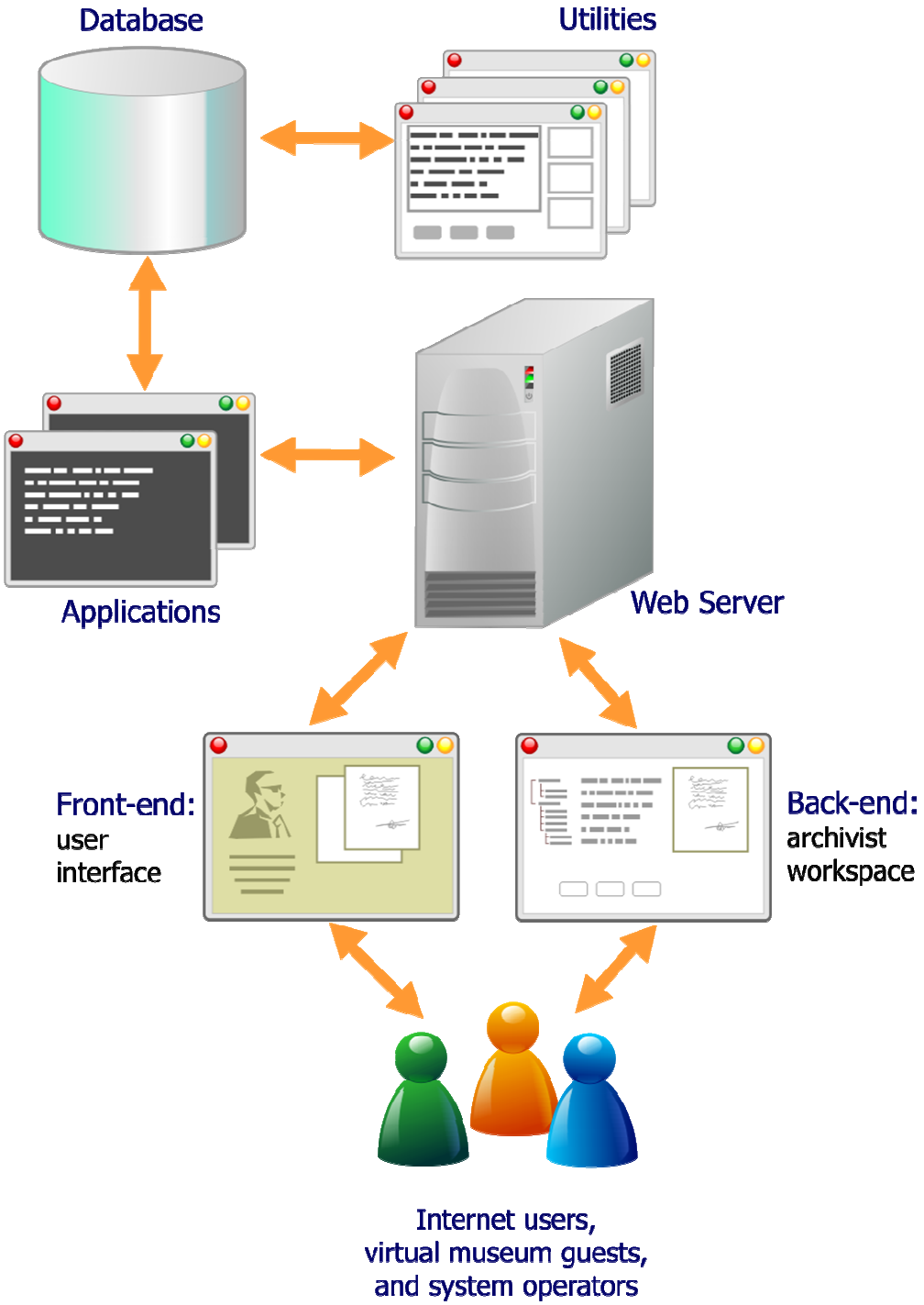

Fig.1. Structure of AIS Software

The developed software provides stable function and incessant access to the archive. It turned out to be a reliable and convenient tool for the organization and support of electronic museums and archives.

III. Stages of the scientific interpretation of the Ershov Archive

Creation of the electronic version of the archive took several years. During this period, researchers gained valuable experience, based on the sources contained in the archive. Today's archive is a massive collection of over 100 000 documents. As the electronic version is filled, and the documents systematized by topic and groups are studied, the archive is gradually being introduced to the scientific community.

At the initial stage of the research the publications were mostly descriptive in nature, since their goal was to announce the archive as an information resource. Only the most representative documents and materials were published in the scientific world[1].

As the electronic archive was filled, and new data sources were explored, the publications became more analytical. A part of the publications was devoted to specific parts of Ershov's scientific biography and projects he led. The researchers attempted to make a kind of a cross-section of the social information contained in the archive[2].

In the spring of 2006, to commemorate Ershov's 75th Anniversary, the research group published a book called "Andrei Petrovich Ershov – a Scientist and a Person". The book consists of the most interesting archive documents as well as a number of articles based on the archive materials.

At the first international conference on Perspectives of Soviet and Russian Computing organized by IFIP and Petrozavodsk State University (SORUCOM.2006) researchers from the IIS SB RAS presented talks devoted both to Ershov's Archive and his scientific school[3].

Using the archive materials, researchers compiled the complete bibliography of Ershov's scientific works: his lifetime publications and later editions, scientific and travel reports, public speeches, along with unpublished texts whose full manuscripts or theses have been preserved in the archive[4].

Research of the archive is in progress now. Currently, the researchers are compiling Andrei Ershov's biographic chronicle and his science & research biography.

IV. Academician Ershov siberian school in informatics as a Scientific-and-educational phenomenon

Special attention should be paid to the phenomenon of the Siberian (or Novosibirsk) scientific school in informatics and programming created by academician A.P. Ershov. The

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[1] Kraineva I., Cheremnykh N. A. Ershov's personal archive in Internet. *Otechestvennye arkhivy* 5 (2001), 53–55

[2] Kraineva I. "Programming, the second literacy": following A.P. Ershov's talk at the 3rd IFIP and UNESCO World Conference on Computers in Education in June 25–30, 1981. http://ershov.iis.nsk.su/russian/second_literacy/pred.html, April 15, 2004

[3] Gorodniaia L., Kraineva I. "Shkolnitsa" application package for automatizaton of school education process. In *Proceedings of the first international conference on Perspectives of Soviet and Russian Computing: SORUCOM 2006*. Part 2, Petrozavodsk, June 3–7, 2006, pp. 12–18

[4] http://ershov.iis.nsk.su/ershov/russian/scient.html

archive documents allow us to make some observations on peculiarity of its formation and development.

Let us note that scientific schools take their special position among various social forms of scientific communities. A vast bibliography devoted to investigations of this phenomenon was studied and generalized by N.A. Kupershtokh[5]. This essay can be supplemented with Internet-publications[6] on this topic. In addition, we would like to note a new work by E.Z. Mirskaya[7], a well-known researcher of a social phenomenon of a scientific school, where she presented its sociological analysis, features and functions in the development of science, as well as the lifecycle of a scientific school.

When investigating a scientific school, we can follow its evolution from a theoretical approach to practical one related to the governmental solution to support financially the leading scientific schools. The notion of a scientific school is not strictly determined. In[8] it is treated as a relatively small scientific team united not only by a research topic and organizational issues, but a common system of views, ideas, interests and traditions, developed in time and passed to younger researchers. In this context, it is important to have a clear view of a particular school.

Scientific schools in informatics and programming appeared in the 1950[ties]. Their first chroniclers were programmers themselves and A. Ershov was among them. Two preprints on the history of computer science in the USSR[9], prepared in cooperation with his co-author M.R. Shura-Bura, are still topical. Only 150 their copies were printed, so they immediately became a bibliographical rarity.

The first detailed description of scientific achievements of A. Ershov and his school was given by his friend and closest colleague I.V. Pottosin. On his initiative, 2 collections of papers and documents devoted to the history of the Novosibirsk school of programming have been prepared[10]. They presented various materials: analysis of completed projects and the history of their development and deployment, memoirs about persons and events from 1950-80ties, when Andrei Ershov headed the programming department, first in the Institute of Mathematics and later in the Computing Center of the Siberian Branch of AS.

The Ershov school of programming can be regarded as a research school differing from others. It is common for a scientific school that mature specialists work together with the beginners. But the programming department headed by Ershov was formed of researchers of almost the same age, and this was not an obstacle for their work. The first big project, a

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[5] Kupershtokh N. A. Scientific schools in Russia and Siberia: research problems // Philosophy of Science, Novosibirsk, 2 (25) (2005), 93–106. Available at the site of the Branch of SPSL SB RAS: http://www.prometeus.nsc.ru/science/schools/docs/scisch.ssi

[6] Questionnaire of a scientific school. Belarus President Academy of management // http://www.pacademy.edu.by. Scientific schools of the Perm' State University. Deviatkova L.I. Academician Rem Viktorovich Khokhlov — rector of the Moscow State University. Book fragments // http://www.phys.msu.su.

[7] Mirskaya E.Z. Scientific schools: history, problems and perspectives // Science of science and new trends in the development of science in Russia. — Moscow. — 2005. — pp. 244–265.

[8] Leading scientific schools in Russia. Vol. 1. — M.: «Janus-K». — 1998.

[9] Ershov A.P., Shura-Bura M.R. The early development of programming in the USSR// A History of Computing in the Twentieth Century: A Collection of Essays. — New York a.o., 1980. — pp. 137–196.

[10] Pottosin I. Andrei Ershov: life and creative work// A. Ershov. Selected papers. — Novosibirsk, 1994. — pp. 5–29. The early development of the Novosibirsk programming school. The Mosaic. — Novosibirsk, 2001. — 194 pp.; Novosibirsk programming school. Roll call of generations. — Novosibirsk, 2004— 242 pp. http://www.iis.nsk.su.

system for automatic programming ALPHA, was completed only one year later than two other similar projects supervised by more experienced scientists, doctors of science Shura-Bura (AC-2) and Lavrov (AC-1). In a short time A. Ershov, who approved himself a good organizer, became a formal and ideological leader of the programmer community of the USSR.

Another specific feature of Ershov's school is commitment to scientific and human values and traditions, their preservation and augmentation. A. Ershov often emphasized the role of prominent persons in formation of the next generation. In his lecture at the methodological seminar of the Computing Center, Ershov told that "when reading biographies of outstanding scientists, one should not be afraid of admiration for these persons. Those who are able to admire success or achievement of other people are free of many hangups" [11]. He repeatedly put special attention to scientific and moral influence exerted on him by outstanding scientists, like M.V. Keldysh, M.A. Lavrentyev, S.A. Lebedev, and others. Among his teachers, Ershov put A.A. Lyapunov in a special place and admired his "absolute disinterest in strengthening his authority by external means … combined with no less absolute firmness of his principles" [12].

One of the basic features of a scientific school is not only a bright leader but also existence of several generations – bearers of an "initial impetus". In twenty years, A. Ershov was a supervisor of 39 PhDs. Later at least one third of them defended their doctor theses, continued research work in Russia and abroad and founded their own schools. The kernel of Ershov's school was the basis for establishing a separate institute in 1990 – the Institute of Informatics Systems of SB RAS. His scientific heritage still has influence on the development of informatics and programming.

Works by A. Ershov gave impetus to the development of theoretical programming. In the end of 1976, he came to the idea of mixed computations. He defined a notion of mixed computations as a fundamental principle of system programming. Various aspects of mixed computations, from theoretical and even philosophical to purely practical, have been developed in papers by his colleagues and disciples, such as M.A. Bulyonkov, V.E. Itkin (Novosibirsk), B.N. Ostrovsky (Barnaul), V.K. Sabelfeld (Russia-Germany), G. Barzdins (Latvia), and others. In 1997, a laboratory for mixed computations was organized in IIS and headed by Dr. M.A. Bulyonkov, Ershov's disciple.

A. Ershov is one of the founders of applying graph theory to programming. His early works, where graph-theoretical methods were used in solutions of problems of programming[13], are regarded as classical. A. Ershov considered a graph to be the main construction for a programmer which possesses a huge inexhaustible descriptive power comparable to complexity of programming problems. In IIS, research in graph applications in programming is supervised by Prof. Kasyanov. In particular, work is performed on analysis and systematizing graph-theoretical algorithms and methods, an "encyclopedia" of graph algorithms for programmers has been prepared and its English edition is to be published.

Academician Ershov put forward a concept of provable programming and justified the fundamental importance of the development of program (and system) verification. In 1988, he wrote that "the fundamental possibility was found of making programming provable and

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[11] http://ershov.iis.nsk.su/archive/eaimage.asp?fileid=223938

[12] Ershov A. The teacher // Essays on informatics history in Russia. — Novosibirsk, 1998. — p.194.

[13] Ershov A. On programming of arithmetic operations // DAN USSR — 1958. — V. 118, № 3. — pp. 427–430; Reduction of the memory allocation problem to the graph coloring problem. // DAN USSR. — 1962. — 142(4) — pp. 785–787.

provide a program with a conformance certificate according to the purposes of its creation. Program verification is the main method for making such certificates" [14].. Only 15 years later, a famous English scientist Hoar confirmed the importance of provable programming problems and proposed the basic method of program verification. Recently, the development of methods and tools for program and system verification is the main research topic of the IIS laboratory of theoretical programming headed by Dr. V.A. Nepomniaschy. Researchers of this laboratory essentially contribute to formation of the next generation of scientists in the Institute – one third of PhDs and one doctor of science, who defended their theses for 15 years of the IIS lifetime, are from this laboratory.

Programming system development, as well as the related theoretical research, is substantially based on all previous results obtained in this area by Ershov and his department (like optimizing compilers Alpha for M-220 computer, Alpha-6 for BESM-6, etc.). In 1990-ties, the IIS laboratory of system programming (headed by Prof. I.V. Pottosin and now by Dr. V.I. Shelekhov) created a system SOKRAT intended to support efficient and reliable programs for embedded computers. Program analysis methods, such as data flow analysis and program transformation, are now under development within the framework of the predicate programming project.

One more specific feature of the Siberian school of programming is a high social responsibility, which is called a civil position. Having better knowledge of the future prospects and changes in our society due to computer invasion in our everyday life, A. Ershov became an active supporter of the idea to teach informatics and programming at school. He proposed a course of lectures "Foundations of informatics and computer science" and composed the first textbook for schoolchildren. Andrei belonged to those scientists who formed not only methods for teaching informatics at school but the multistage methodology for propagating computer literacy in the country. The main research directions in school informatics, shaped in 1980-ties, are still actual. We can mention writing textbooks and manuals in programming and informatics, establishment of a system of early professional training for schoolchildren, development of information systems supporting informatics as a school subject, as well as social and organizational activity aimed at promoting school informatics.

A. Ershov believed that a scientific school should contribute to activity of the world scientific community, and this tradition is maintained in the IIS. In May 1991, the 1st International conference "Perspectives of System Informatics" (PSI) was held. Now it is a triennial event that is always considered to be an important and fruitful scientific meeting. The conference is dedicated to the memory of A. Ershov and his outstanding contribution to the development of informatics. Thus, in 1996, PSI was timed to Ershov's 75th anniversary. It was intended to present and discuss the advanced research directions in informatics, such as theoretical computer science, programming methodology and new information technologies. Another aim of the conference was to improve contacts and exchange ideas between researchers from the East and West. Papers submitted to PSI are reviewed by three experts and, as a result, only high-level talks are selected. Usually, one-third of all the participants are foreign guests. Conference proceedings are published by Springer-Verlag, series "Lecture Notes in Computer Science".

The lifecycle of a scientific school directly depends on its capability to perform innovative and educational activity. In this respect, the Siberian school of programming is at

[14] Ershov A. Introduction// Nepomniaschy V., Riakin O. Applied methods of program verification. — Moscow, 1988.

the stage when knowledge industry and reproduction of research personnel are governed by new social conditions. At present, the IIS researchers actively participate in teaching students of the mechanics-and-mathematics department and information technology department of the Novosibirsk State University. The IIS laboratories is a training base for students: every year more than 70 senior students make their diploma studies under supervision of the IIS researchers. There are many post-graduate students in our institute, as well as the dissertation council in “Software for computers, complexes and networks”.

The authors are grateful to the IIS researchers, namely, Dr. V.A. Nepomniaschy, Prof. I.B. Virbitskaite, Prof. V.N. Kasyanov, Dr. V.I. Shelekhov. Dr. M.A. Bulyonkov. Dr. F.A. Murzin, and N.F. Voronko, for information and documents used in writing this paper.

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