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On the History of the START project (1985–1988)

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Abstract. The paper presents the history of START, an ad-hoc team created in 1985 to develop fifth-generation computers in response to the "Japanese challenge". As a new form of the organization and implementation of scientific and technical projects during the *perestroika*, START contributed to the establishment of the Institute of Informatics Systems of the Siberian Branch of the Russian Academy of Sciences (SB RAS) in 1990.

Keywords: perestroika, history of informatics, START, fifth generation computers, "Japanese challenge", post-industrial society

Introduction

Foundation of the Institute of Mathematics and Computing Center of the Siberian Branch of the USSR Academy of Sciences (SB USSR AS) in Novosibirsk in 1957 triggered interest in the problems of computer architecture. These issues were dealt with by the Department of Computer Science, headed by Eduard V. Yevreinov, Candidate of technical sciences. Together with Yuri G. Kosarev, Viktor G. Khoroshevsky, Nikolai N. Mirenkov and other scientists, Yevreinov conducted research with a view to identifying the principles of building the architecture of homogeneous computing systems (HCS) and software designed to handle large amounts of computation and automatic adjustment of problems to the elementary machines (EM) used in the network [5, With. 456]. The proposed approach turned out to be a dead end, despite optimistic forecasts. Later, Vadim Ye. Kotov, head of START, stated in his interview to the *Technology to Youth* journal that it was rash to promise to make a "parallel supercomputer" in the 1960s. As a result, the credibility of Yevreinov's team was undermined [2, p.11]. The distrust was enhanced by the failed effort of the mathematicians Yevreinov and Kosarev, and historian Vladimir A. Ustinov to perform the “machine decoding of the Mayan language” using the approach contradicting the idea of the Leningrader Yuri V. Knorozov [12]. When Kotov and his classmate Alexander S. Narin’yani became employees of the Programming Department of the Computing Center, SB USSR AS, headed by Andrei P. Ershov, they proposed another method of parallel programming - asynchronous computing. The paper was written based on the materials of the Academician A.P. Ershov Electronic Archive. Some documents have been introduced into scientific circulation for the first time.

1. START precursors

In 1962, the MEPhI undergraduates Vadim Kotov, Alexander Narin’yani and Pavel Leonov completed their pre-diploma practice in the department of Yevreinov specializing in the creation of computer technology. They became friends with the employees of the Programming Department led by Ershov. Upon graduation from the MEPhI, Kotov,

Narin'yani and Leonov were assigned to work for military organizations in Moscow but, captured by the creative atmosphere of the Programming Department, they did their best to stay in Akademgorodok and succeeded [10, p. 85–86].

Later, in Ershov's Programming Department, Kotov and Narin'yani took up the study and development of the theory of parallel computing processes. Kotov recalled: "When we started working in the department in 1963, we proposed an alternative method of parallel programming − asynchronous computing. Realizing the futility of Yevreinov's approach, Ershov agreed with our proposal after a thorough discussion. Similar approaches emerged throughout the USSR: Edward Z. Lyubimsky and Igor B. Zadykhaylo at the Institute of Applied Mechanics in Moscow, Victor I. Varshavsky in Leningrad. Later, J.B. Dennis at MIT, A. Davis at Burroughs, and many others developed a data-flow approach to asynchronous computing (though without shared memory, in contrast to our idea)" [23].

In 1971, Kotov, supervised by Ershov, defended his thesis for the candidate of physical and mathematical sciences entitled "Transformation of operator circuits into asynchronous programs". Kotov and Narin'yani obtained good results on the automatic parallelization of programs and on the development of new methods of parallel programming (asynchronous programming method) [6, 11]. Kotov was also interested in the problems of creating architectures for multiprocessor systems. In 1981, he defended his doctoral thesis "Model of asynchronous parallel computing and its linguistic and architectural implementation." Thus, the theoretical basis for further large-scale projects was laid. In 1975, the Laboratory of the Theory of Computational Processes was established with the Department of Informatics of the Computing Center, SB USSR AS. Kotov was appointed head of the laboratory. The first major work of the new team was the MARS project.

The concept of a modular asynchronous developing system (MARS) generalized the world experience in computer system architecture, which later accounted for the involvement of the Novosibirsk specialists in the development of both fundamental research and computer systems [8]. These issues were supervised by Academician Guri I. Marchuk, chairman of the Siberian Branch of the USSR Academy of Sciences (1975–1980) and director of the Computing Center, SB USSR AS; later, Deputy Chairman of the USSR Council of Ministers and Chairman of the USSR State Committee for Science and Technology (1980–1986). As early as in 1978, Vadim Kotov and Alexander Marchuk outlined and substantiated the essential principles of computing process organization: processing parallelism and access to data; decentralization of processing flows; asynchronous interaction of devices and processes; and hierarchy, modularity and specialization of components. The analysis was based on the models of asynchronous process interaction, revolutionary at the time, and architecture was seen as a natural implementation of a computing model. The concept was a far-off and keen insight, a realistic attempt to build computer architecture not basing on the capabilities of hardware, but on the needs of information processing [16].

Kotov's laboratory was developing a computing model in the form of a parallel programming language - the Core Language, later referred to as the BARS language. Hardware development began in 1981, when Yuri L. Vishnevsky and Alexander G. Marchuk proposed the architecture of the parallel processor called Mini-MARS, later MARS-M [4]. Alexander Marchuk suggested contacting the developers of Elbrus at the *ITMiVT* (Russian abbreviation for the 'Institute of Precise Mechanics and Computer Engineering'), USSR Academy of Sciences, to create together the prototype of a computer designed for numerical processing. MARS-M was assembled at a plant in Penza under the

supervision of the *ITMiVT*: three cabinets of the Elbrus-2 computer complex design. However, due to the collapse of the Soviet industry in 1989–1990, MARS-M was not brought to a working state, to say nothing of starting serial production. The MARS project developed to some extent within the framework of START in 1985 to 1989, as will be discussed below.

2. The 5th generation of computers

In the early 1980s, when the post-industrial society was forming in the West, the Soviet macroeconomics did not encourage the long-overdue modernization of all sectors of the national economy. As a result, the country was falling further and further behind the West in the technological race. Meanwhile, the *Guidelines for the Economic and Social Development of the USSR for 1981–1985 and up to 1990* considered "combining the achievements of science and technology with the advantages of socialism" the main condition for solving the problems of communist construction [31]. Aware of the urgency of the problems, Academician Guri I. Marchuk took a number of steps to provide a breakthrough in the most important areas of scientific and technological progress (the Soviet analogue of the post-industrial economy) [21, p. 104]. The state of work on high-performance computers was supervised by the Commission of the Coordinating Committee for Computer Engineering of the USSR Academy of Sciences (*KKVT*) on the problems of the architecture of large computing systems and peripheral equipment.

Thus, the meeting of the *KKVT* plenum held on April 26, 1982 discussed the problems concerning the creation and use of supercomputers. In his opening speech, Guri Marchuk informed the audience of the challenge generated by the project of the 5th generation computers prepared by the Japanese Committee for Computer Research and Development in 1979–1981 [15, p.9]. The ultimate goal of the project was introducing computers in all social spheres. It was about the realities of post-industrial society, where cybernetization of economic processes came to the fore: automation and production management, modeling of production processes, experimental data processing, long-term planning, development of the industry of accumulation and use of knowledge based on computer technologies, etc. [3].

Guri I. Marchuk spoke about the world's growing trend towards further informatization of society and urged the development of computer networks. He said that the Soviet ministries and departments had already launched a major campaign to create a preliminary project for a network of computers (to be based on *Academset*) with applications in national economy. According to him, the task of the plenum was "to initiate the research institutes of the Academy of Sciences to search for new architectural solutions for computers and new software components" [15, p. 10]. The Computing Center, Siberian Branch of the Academy of Sciences (the speaker was Vadim Kotov) and the Institute of Cybernetics, Academy of Sciences of the Ukrainian SSR (the speaker was Vladimir Mikhalevich) presented their projects of computer systems funded by the Ministry of Radio Industry. Apparently, the Soviet specialists were well aware of the global trends in the development of computer technology and its applications, and it had its effect on decision-making at the national level. However, the scale of this campaign was far behind the foreign ones both in terms of funding and degree of the state's support.

Prospects for the development of computer technology, automation of jobs for programmers and users were also discussed in the Programming Department of the

Computing Center, SB AS. An active participant of the discussion and an ardent supporter of his own approach was Kotov's fellow student and colleague, head of the Artificial Intelligence Laboratory of the Computing Center, SB USSR AS, Alexander S. Narin'yani, Candidate of physics and mathematics. At the end of 1982, he wrote a note in which he specifically substantiated the need to boost the number of non-professional computer users (instead of increasing the total capacity of the computer fleet) as a way to improve the efficiency of using computers in the national economy. The necessary condition, according to him, was the development of appropriate software. Later, bearing in mind the Japanese "great leap," Narin'yani believed that the USSR response to this challenge should differ from the strategy of Japan and the United States. While these countries focused on the simultaneous development of software and hardware, "our way should be advancing the development of the software component" [18]. Such a strategy, according to Narin'yani, could help to overcome not only the lagging of technology behind hardware, but also compensate for the gap in the total capacity of the computer fleet. By the way, Narin'yani was a consistent critic of the policy of "copying" the prototypes of both mainframes and personal computers, which he made clear in his talk in August 1985 [19].

As Kotov recalled, "in September 1983, we (Alexander Marchuk, Evgeniy Kuznetsov, Alexander Narin'yani, Enn Tyugu, Viktor Bryabrin and myself), guided by wise and fatherly Guri Ivanovich Marchuk, began the long saga of organizing START, the first in the USSR Provisional Scientific and Technical Team (in Russian, *VNTK*) with a self-explanatory name." [1]. It was an attempt to create, on the basis of the Computing Center SB AS, a structure for the development of a new generation of computers. There was still time before the April plenum of the Central Committee of the Communist Party in 1985, which announced a new policy: *perestroika* and accelerating scientific and technological progress, though some steps in this direction had been taken before. Since the development of a new generation of computers required the involvement of various departments, new organizational forms were needed.

It was supposed that one of these forms would be ad-hoc groups focused on solving promising scientific and technical problems of cross-sectoral nature and on creating and implementing new equipment, technology and materials. The decree No. 814 of August 18, 1983 of the Communist Party Central Committee and USSR Council of Ministers *On the measures to accelerate scientific and technological progress in the national economy* provided for the creation of temporary teams [22]. In January 1984, the USSR Council of Ministers adopted the resolution *On the measures to ensure the operation of temporary teams…* [26], and in April, Academician V.A. Koptyug presented to the Vice-President of the Academy of Sciences Academician E.P. Velikhov a detailed letter describing the results and prospects of research on the MARS project performed in Novosibirsk. He proposed to organize, under the auspices of the State Committee on Science and Technology (SCST), a temporary team, *VNTK*, for a period of three years to conduct research and create an experimental model of a new computer. Koptyug asked Velikhov to request that the Committee consider the case [24]. In addition, the Computing Center SB USSR AS, Computing Center of the Academy of Sciences and the Institute of Cybernetics of the Academy of Sciences of the Estonian SSR prepared materials for the SCST board *On the creation of the START Interdisciplinary Scientific and Technical Team*, dated November-December 1984 [17]. These included an analytical review on the work done abroad in the field of 5th generation computers, justification for the creation of

the *VNTK*, draft regulation on the *VNTK*, etc. We described this bureaucratic procedure in detail to show the process of taking an idea from conception to implementation.

3. START operation

Figure. The START team: E.P. Kuznetsov, V.F. Pogrebnyak, D.Ya. Levin (standing), V.E. Kotov, A.G. Marchuk, A.S. Narign'yani, E.Yu. Kandrashina. 1987

When all the formalities were completed, the SCST, led by Guri Marchuk, informed Eugene Velikhov, Vice-President of the Academy of Sciences, that the SCST was ready to organize START beginning with January 1, 1985. The project was to be supervised by the Department of Informatics, Computer Engineering and Management of the USSR Academy of Sciences and by the Siberian Branch of the USSR Academy of Sciences [25]. The team was led by Vadim Kotov. The *VNTK* included the Computing Center of the USSR Academy of Sciences (Yu. G. Evtushenko, Moscow), Computing Center of the Siberian Branch of the USSR Academy of Sciences (Vadim Kotov, Novosibirsk), Institute of Cybernetics of the Academy of Sciences of the Estonian SSR (Enn Tyugu, Tallinn,); Impulse of the USSR Ministry of Instrumentation (V.V. Rezakov, Severodonetsk), and Crystal of the USSR Ministry of Electronic Industry (N.S. Dyadenko, Kiev). The latter was charged with the development of microprocessors, storage devices, and analog microcircuits [27]. Collaborating with the *VNTK* were the design teams of the Special Design Bureaus for Computer Engineering of the SB AS and Institute of Cybernetics, Estonian SSR AS, as well as research groups from Novosibirsk University and Moscow University, a total of about 200 people [29]. START *VNTK* was completed in March 1988. The R&D results were highly appreciated by the interdepartmental commission, which noted that the project had created the basis for the further development of research on modular parallel computing systems and their intelligent software [34].

START activities included two main areas: computer architecture and intellectualization systems. In the area of system architecture research, prototypes of Mars-M conveyor computer, Mars-T multiprocessor complex (a transputer system prototype) and a series of professional Kronos 32-bit processor workstations were

developed. Mars-T used an approach initiated by Inmos, U.K., which in 1985 created a single-chip transputer-microprocessor T414 (32-bit processor, 10 million op/sec). Novosibirsk researchers believed that the direct copying of Inmos transputers was inappropriate due to the technological complexity of their application. The Kronos microprocessor and parallel computers based on it could be more versatile and adapted to domestic technology. The Kronos processor was designed according to the ideology of a compact instruction set (RISC-architecture), which made it possible to achieve high performance at low hardware costs. This instruction set supported high-level languages, primarily Modula-2 [7].

It should be noted that before the Kronos project became an integral part of START, it had its own history [28]. It was started by the head of the Laboratory of System Programming, Computing Center SB AS, Igor V. Pottosin. Back in 1983, he suggested that Dmitry N. Kuznetsov, an undergraduate of Novosibirsk State University, should implement a processor with the architecture based on the high-level languages Modula-2 and Oberon [33]. Later, the team of developers including also Alexey E. Nedorya, Evgeniy V. Tarasov, Vladimir E. Filippov and others [32], drawing on the experience of the developers of the Lilith PC (Nicholas Wirth, ETH Zurich), were able to implement a universal processor with hardware support for high-level languages. The processor was intended for designing open architecture computers: from embedded microcomputers and single-processor working stations to supermini multiprocessor computers.

As for the Modula-2 programming language, in the late 1980s it was adopted by a government decree as the basic language for the software development for on-board systems. At the same time, SOCRATES project was launched, which marked the beginning of close cooperation between Pottosin's team and Reshetnev NPO of Applied Mechanics (Krasnoyarsk-26). Cooperation between the ISI SB RAS and Applied Mechanics NPO continued until the mid-2000s. At the time, special-purpose software for the satellites created in Krasnoyarsk-26 was developed on Module-2, which ensured its reliability. In 1988, it was planned to manufacture, together with Kristall (Kyiv), an experimental 32-bit microprocessor with the Kronos command system and a capacity of 5-8 million op/sec. [30].

As for the intellectualization tools, START developed intelligent workstations and computer-interaction devices designed for non-professional users, application software packages (ASP) for modeling and mathematical programming, tools for creating knowledge bases, experimental knowledge bases and expert systems, such as:

- professional intelligent object-oriented Pirs WS as part of high-performance modules connected by Multibus-2 and an I/O machine. The WS modules were the Kronos processor, data filter, high-resolution bitmap screen controller, specialized name processor, and object memory management processor;
- micro-PRIZ system allowing for the use of automatic program synthesis with a view to organizing an effective user interface for engineering calculations. A development of this system was the NUT language and appropriate programming system. This development involved such innovations as object orientation, program synthesis, inference and a high-level multi-window interface. The system was designed to support AI tasks and build expert systems;
- SPECTRUM and MASTER programming systems able to create a convenient integrated interactive environment for the user doing a wide range of activities on a PC;

- DISO optimization program package based on modern mathematical methods, which made it possible to solve various nonlinear optimization problems and create application programs in the process of interaction with the user;

- new technology for programming intellectual tasks implemented in two systems: STEND and TCDKB (technological complex for designing knowledge bases). These systems not only allowed solving AI problems, but also contributed to the implementation of specialized software systems designed for solving such problems. The systems comprised tools for building natural language interfaces, supporting databases and knowledge bases, working with active and underdetermined data, etc. Experimental tasks covered engineering calculations and CAD systems, as well as decision-making, planning and control systems [7, 33].

START created a solid foundation, which allowed the team and management to expect interest from a number of ministries, such as the Ministry of Electronic Industry (*Minelektronprom*), Ministry of Medium Machine Building (*Minsredmash*), Ministry of General Engineering (*Minobshchemash*), and Ministry of Aviation Industry (*Minaviaprom*). The team was supposed to continue creating a set of domestic microprocessors and VLSI, supermini computers, multifunctional workstations and special-purpose control systems (on-board systems), as well as experimental samples of modular microprocessor computers with a transputer organization (up to 1 billion op/sec). The development of intellectualization tools was anticipated to lead to the integration of parallel architecture and artificial intelligence methods [7].

START contributed to the development of the element base for subsequent developments. Together with an Industrial association “Kristall”, Kyiv, three chips of the microprocessor set were developed [11]. Their use could take architectural research and development within the project to a qualitatively new level. However, the project, which was to be extended for the next five years, was discontinued. The economic and political system of the USSR began to disintegrate. As a result, the state financing of the economy stopped, and ties with the collaborators, some of which ended up in other states, were broken. Alexander G. Marchuk, highly appreciating the work done in the project, bitterly noted: “... I can’t help feeling that many of our deep concepts were not accepted by specialists; we failed to affirm our priority in technical and architectural solutions in which we were the first or among the first. Vadim Kotov said: «When working on the architecture of the Kronos processor and multiprocessor computers based on it, we took into account the level of domestic microelectronic technology, limited production capacity and slow development of new technologies. The Novosibirsk team proposed the development of the transputer approach, greater versatility of the base microprocessor and modular open architecture. This allowed creating, based on a basic set of microprocessors, a wider range of parallel computers than the INMOS transputer set afforded» [35].

Kotov, who in 1991 left to work in the United States, wrote: “I proposed the creatively revised ideas of Modular Asynchronous Evolved Systems (MARS), which formed the basis of START developments, at Hewlett-Packard Laboratories within my work on the architecture of super-large systems (Systems of Systems). This work resulted in the Service-Oriented Architecture, all levels of which, from top to bottom, are federations of independent interacting components - services hosted on a network. This is the approach I use in my current projects to build highly reliable systems for NASA”.

4. Conclusion

We should clarify that everything related to START and activities of the Coordinating Committee for Computer Science of the USSR Academy of Sciences, created on the initiative of Guri Marchuk in 1979, was an attempt by the USSR Academy of Sciences to regain its priority in the development of computer technology. At the time, the Academy was in the second rate since the national program for the development of the new types of computer technology was in the hands of the ministries (e.g., the Ryad project, or the Unified Computer System created in the USSR since the late 1960s). The umbrella organization of the *Ryad* project and head enterprise of the Council for Mutual Economic Assistance became the Research Center for Electronic Computers, established on March 18, 1968 by order No. 138 of the Minister of the Radio Industry Valery D. Kalmykov.

All this meant that there was a change of priorities in the scientific and technical policy in the field of creating computer technology in the USSR. Under the pressure of circumstances, managerial and political decisions, the mass production of computers (ES computers, *Ryad*) took a turn to copying ("redesigning") the American IBM System / 360. Though the USSR Academy of Sciences practically turned out to be aloof from the mainstream of scientific and technical policy in the field computer technology, it continued to conduct separate projects in addition to the ES program, like some branch research institutes. The USSR Academy of Sciences Coordinating Committee on Computer Science, established in 1978, took steps to coordinate the activities and promote its own ideas in the relevant research institutes. One of these projects was START, which, among other things, was a useful experience of interdepartmental cooperation within the Academy in the field of the creation of digital computing technology. The START project had the potential and to reach the level of industrial development but the new economic situation made it impossible.

Upon the completion of the START project, a number of proposals were prepared by Kotov's team for the further development of domestic computers. In particular, a plan for 1989-1993 was devised in cooperation with the interested ministries: the Ministry of Aviation Industry, Ministry of Medium Machine Building, Ministry of General Industry, and Ministry of Electronic Industry. The plan provided for the development of (a) a set of domestic microprocessors and VLSI, including a basic universal 32-bit microprocessor with the Kronos instruction system [36]; (b) a family of supermini computers, multifunctional workstations and on-board systems; and (c) experimental samples of modular multiprocessor computers with a transputer organization and a performance of over 1 billion op/sec.

These steps would have made it possible to create a domestic line of supermini-computers and minisuper-computers for the modeling, design and managing of complex objects in the interests of defense, aerospace and electronic equipment development, science and economics [35].

In the summer of 1988, Guri I. Marchuk turned to the head of the USSR Mikhail S. Gorbachev for the approval the appropriate state order and creating an inter-branch body involving the ministries interested [37]. In August and September 1988, the USSR State Planning Committee adopted a working arrangement for implementing the plan. The START Inter-branch Scientific and Technical Center [38] was to be established, and a draft state order was prepared [39]. By the resolution of the USSR Council of Ministers of October 21, 1988, the USSR Academy of Sciences and the Ministry of Electronic Industry received the appropriate work order. Even earlier, on October 17, 1987, a resolution was

adopted by the Presidium of the Siberian Branch of the USSR Academy of Sciences on the establishment of the Institute of Informatics Systems on the basis of the START Inter-branch Scientific and Technical Center. In 1990, the Institute was founded.

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