Review of the NCD 43 (2023), 59–68

Irina Krayneva
A. Ershov Institute of Informatics Systems Siberian Branch, Novosibirsk, Russia
Merik Meriste
Tallinn University of Technology, Tallinn, Estonia
Killu Sanborn
Oxford Finance LLC, San Diego, CA, USA

ENN TYUGU: SOCIAL AND PROFESSIONAL BACKGROUND

Abstract. Our paper is dedicated to an Estonian scientist in Computer Science and Engineering, Enn Tyugu (1935–2020). The narration combines two approaches: social (national) and professional. The social context of Tyugu's biography included the World War II, deportation, Cold War, loss and restoration independence of Estonia. Adaptation to these events formed the so-called "soviet subjectivity" as the external loyalty of the Soviet citizen to the politics and ideology of the state, a cover for their "personal core" and private life. External loyalty, ability and perseverance allowed E. Tyugu to acquire a very high level of professional competence. He participated in programmer projects in the interests of the national economy; his contacts with colleagues from the leading scientific centers of the USSR helped to maintain the theoretical level of research in several areas of programming theory, to enter the academic community as one of the pioneers of informatics in Estonia.

1. Introduction

The object of our research is the scientific biography of the Estonian programmer Enn Tyugu (1935–2020), an expert in automatic software synthesis, high-level language implementation, knowledge-based systems development and other areas of Computer Science and Computer Engineering. This biographical sketch encompasses several

stages in Tyugu's scientific career. However, given the historical context of his life, we cannot limit ourselves to his competencies. In 1941, when Enn was 6 years old, his family was deported to Russia. His parents died before the end of the war, and he stayed with his older brother. In 1946 he miraculously returned to Estonia, got a university degree, and went on to become a prominent scientist [29]. We hope that the story of the person who, like many of his compatriots [6], managed to overcome the absence of freedom and deprivation when forced to accept the rules of other people's game, will be informative and educational.

Having received proper education, Tyugu joined the stratum of scientific workers - a community vital for an industrial society, as noted by sociologists and futurologists. Their role stemmed from the technological determinism typical of the Soviet society, technocracy, and absolutization of scientism, [14, 31, p. 43]. From the perspective of social anthropology, these trends formed the image of a "technocratic man", armed with knowledge and capable of modifying nature and society on the basis of scientific and rational approaches [14].

The community of those involved in software development formed in the era of the Cold War and Big Science. Computer development in the USSR in the fifties was yet another major Soviet project, on a par with the atomic project, albeit on a lesser scale [11]. Theorists and practitioners of computer science saw the need to usecomputers not only for military and scientific purposes, but also for planning, control, and production automation (that is, non-arithmetic uses of computers) [10, pp. 213–274]. Tyugu's career in computer science began in the field of industrial automation and CAD.

This story is based on the memories of Tyugu published in Estonian [22], his scientific papers, materials from the Academician A.P. Ershov Electronic Archive [1], and works on the history of Estonia [4, 7, 19, 24, 32]. The paper outlines Tyugu's childhood and youth, university years, emerging interest in Cybernetics and Computer Science, successful scientific and academic career in the USSR, active social position in the early years of *Perestroika* and Estonia's renewed independence, and his return to Big Science.

2. The Beginning of the Story

Enn Tyugu was born in the family of telegraph workers. His father, Harald Tyugu (1891-1942), and his mother, Elfride Nael (1899-1945), were probably among the first representatives of the national scientific and technical intelligentsia in Estonia. Enn's memories of his early childhood were happy and calm; his nanny and elder brother Ants took good care of him. The family had an apartment in Tallinn and a summerhouse in the suburbs of Haabersti.

The situation changed in 1940, when Estonia, an independent parliamentary republic since February 1918, was annexed to the Soviet Union according to a secret supplementary protocol of the Molotov-Ribbentrop Pact of 1939 [25]. Tyugu recalled: "That winter (1940) there was trouble in the air. My parents were fluent in German and Russian. Their speaking foreign languages, something that had not happened before, irritated me. Now I realize that they did not want to discuss the unpleasant events occurring in Estonia and other places with me around" [22, p. 27].

By the summer of 1941, Estonia was completely sovietized. The process was accompanied by arrests, executions and deportations of citizens: like in the other two Baltic republics, it was the elite that got prosecuted: local and national-level politicians, prominent figures in economy and finance, military officers, active members of the Kaitseliit (Estonian Self-Defense Union), and wealthy peasants. According to the White Book, over 53,000 people were repressed in Estonia in June 1941 [32, p.14].

Tyugu's family was deported to the town of Urzhum in the Kirov Oblast, Bashkiria. Harald Tyugu died on March, 17, 1942, in the Sosva division of the North-Urals camp (Sevurallag) in the Sverdlovskaya Oblast: the high mortality of prisoners is Sevurallag, especially in 1941-1942, was the result of harsh working (logging) and living unsanitary conditions, as well as poor nutrition. Enn's older brother Ants (1921-1996) worked in a logging camp on the River Vyatka; Enn went to the kindergarten. He got his first lessons of Russian by learning poems for the New Year party. On September 1, 1942, Enn started school. Russian was difficult for him, while mathematics was easy. In April 1945, his mother died of sepsis. In the spring of 1946, Enn, thanks to the help of his aunt, returned to Tallinn. In 1953 he graduated from Tallinn secondary school, where he excelled in math. This must have affected his choice of the university – the Tallinn Polytechnic Institute, where he majored in engineering (1953-1958).

At that time, the national economy of the Estonian Soviet Socialist Republic (ESSR) was heavily invested in accordance with the Action Plans (*Pyatiletkas*). Per capita investment into the Estonian economy exceeded the average for the USSR by around 30% in 1940-1950 and by 17% in 1951-1955. In the 1960s through the 1990s, despite the general standoff with the West, Estonia had more extensive economic connections with other countries (particularly Finland) than any other Soviet Republic, especially with regard to Computer Science [8, 17].

In the late 1950s and early 1960s, computing sciences got a boost in the Soviet Baltic as part of the campaign for scientific and technological modernization and rehabilitation of cybernetics. A number of cybernetics research institutes – basically computer science centers - sprang up within the Soviet Academy of Sciences, including the one in Tallinn in 1960 [4]. Computer science specialists for the Baltic republics were trained in the Leningrad Polytechnic Institute, Moscow Energy Institute, and in Novosibirsk, Kyiv and Minsk. Tyugu was selected to participate in this program [15, 25].

After graduating from the Tallinn Polytechnic Institute in 1958, Tyugu worked as a designer-engineer at the Tallinn Excavator Factory, where he designed a mud pump and contributed to the creation of a multi-bucket excavator, which has been widely used ever since in land improvement. It was then that he got interested in cybernetics. In 1959, he took a two-year course in computer engineering at the Leningrad Polytechnic Institute, which defined his future life and scientific career. He was grateful to Professor Alexander Voldek (1911-1977), an outstanding Estonian scientist, electrical engineer, Doctor of Technical Sciences (1957), Academician of the Estonian Academy of Sciences (1969). From 1950 through 1961, Voldek worked in Tallinn and in Leningrad. Being well aware of the importance of production management automation and computational mathematics, he helped some students from Estonia to get a relevant education in Leningrad and Moscow. Tyugu combined his studies with the work at the Tallinn Electrical Engineering Institute (TEEI) (1959-1976), where he grew from a staff researcher to the department head [29].

3. An Invisible College of Programmeres

In the early 1960s, the TEEI developed the STEM (Specialized Technological Electronic Machine) microcomputer and its software [2], which symbolized the transition from universal to special-purpose computers. STEMs were used to calculate the cutting conditions and time standards for metal-cutting machines and to optimize the cutting speed and tool life under multiple nonlinear and discrete restrictions. Extremely reliable for the time, STEMs were installed at the Kirov Factory in Leningrad; similar computers were built for other major factories in the USSR [24]. In 1967, the design

received the State Award of the Estonian SSR. A year before, Tyugu, who participated in the development of STEM software, defended his thesis for the degree of the Candidate of Technical Sciences, *Calculating Technological Parameters on Computers*. His supervisor was Georgiy Goranskiy (1912-1999), director of the Institute of Technical Cybernetics of the Belorussian SSR Academy of Sciences (Minsk, 1965-1970). The results of the research were also published in the monograph [21] and certificate of invention [3]. Interestingly, the PDP-11 emerged in the 1970s, i.e. five years after the STEMs were installed at the Kirov Factory [22, p. 79].

In 1970-1971, Tyugu became a researcher and enrolled for the Doctorate studies at the Programming Department of the Computing Center in Novosibirsk Akademgorodok, Siberian Branch, USSR Academy of Sciences. His scientific consultant was head of the department Andrei Ershov [1, f. 328, l. 106]. Tyugu appreciated communication with his colleagues, such as Vadim Kotov and Alexander Narinyani, who explained to him how parallel programming methods could be applied in his work. At that time, Tyugu participated in high-ranking national and international conferences. In particular, he presented the paper *A system of modular programming for the Minsk-22 computer* [1, f.553, l. 6] at the Second All-Union Programming Conference (VKP-2) held in Novosibirsk in 1970 and gave a talk based on the same material at the IFIP-71 Congress in Ljubljana in Yugoslavia [26]. The Computing Center gave a truly royal gift to Tyugu: he was included in the Soviet delegation to the Congress though the number of people allowed to participate in the Congress was strictly limited [1, f. 437, l. 26].

In 1973, in Leningrad, Tyugu defended his Doctorate thesis in theoretical cybernetics, entitled *Application of computational models in CAD software*, dedicated to the revolutionary interdisciplinary area of CAD application – machine design. Tyugu developed computational models for representing objects and processes described by engineers in machine design. In addition, he developed a module programming system (MPS) for the Minsk-22 second-generation computers, which, however, raised certain issues. One of them was that Minsk-22 had no operating system. Besides, the MPS was designed for programming big problems on low-speed performance machines with limited RAM, so the MPS had limited capabilities. However, it contained utilities necessary to build translators from the languages closer to the engineering language than any universal programming language. Ershov appreciated the thesis highly, noting its theoretical and practical importance [1, f. 119, ll. 317–318].

In 1979, when Tyugu was still affiliated with Ershov's department, he was invited to participate in a legendary event – scientific pilgrimage to Urgench, the native city of Al-Khorezmi [28]. In addition, Ershov, vice-chairman of the IFIP-1980 Programming committee and head of the Software Section, ensured the USSR was properly represented at the Congress. Vadim Kotov and Enn Tyugu were invited speakers. In the same year, Tyugu became a member of the Bureau [1, f. 260, l. 80] and head of the KOSMO Workgroup on Program Synthesis. KOSMO is the Russian abbreviation for the Commission on System Mathematical Support, established by the Coordinating Committee on Computing Machines, USSR Academy of Sciences, and headed by Ershov. Moreover, Tyugu was a member of the Committee on the Distribution and Use of Computing Machines in the USSR Academy of Sciences [1, f. 260, l. 52]. In 1981, Tyugu was elected a Corresponding Member of the Academy of Sciences of the Estonian SSR and in 1985 he became a full member of the Academy and Secretary Academician of the Department of Informatics and Mechanics (1985-1991).

In 1976-1986, Tyugu headed the Software Laboratory at the Institute of Cybernetics in Tallinn. The research program of the laboratory focused on programming automation problems with applications to engineering calculations. Tyugu suggested an approach to

developing instrumental systems for packaged applications based on automation program synthesis. This approach, later known as "semantic computing networks" and "conceptual programming," allowed an integration of various software suites into a single system. It was implemented in the PRIZ program (Russian abbreviation for Program for Solving Engineering Problems) [16].

In the late 1970s, Tyugu contributed to the development of the Science and Technology Program in Computer Science at the Estonian Academy of Sciences [20]. This work brought together the efforts of about 200 Estonian specialists in such areas as CAD software for computer-aided process control, software development for small computers, automated programming, control and malfunction analysis of digital circuits, development of magnetic component core memory, etc. CAD based on informal descriptions was developed further, and automated program synthesis was Tyugu's domain. In his talk given at KOSMO in March 1982, he drew attention to the low level of technology at Estonian research institutes. At the time, the only powerful computer in Estonia was ES-1052 with 8Mb RAM and 700,000 op/sec. It was one of the first mainframes, designed under the COMECON international program for the development of compatible IBM System/360-based computers (Unified Computer System) [1, f. 275, ll. 11–26]. Nevertheless, Estonian programmers managed to adapt PRIZ to incorporate it in the Unified Computer System software [9]. The technological backwardness was offset by extensive scientific contacts and experience exchange. In 1984 Tyugu reported at KOSMO the theoretical results on proof theory and its varied applications to mathematics and computer science [1, f. 269, ll. 105–106].

From 1985 to 1988, the team led by Tyugu participated in START, a Soviet project aimed at creating the fifth generation computers. The idea born in Japan was picked up in the USSR, which at the time copied American computers on a large-scale: the Soviet Academy of Sciences strived to restore its positions in computer development [1, f. 602, ll. 1–3]. Participation in this project provided the Estonian team with good financial support, which they used to develop their own smart software environments [18, 23]. Their core was structural program synthesis implemented earlier on old mainframe computers – a particular method of logic programming accepted as the fundamental paradigm for the future generation of software development. Before starting this project, Tyugu working on PRIZ had gained positive experience in practical program synthesis [9]. Since the logic background of this approach was intuitionist propositional calculus, it was referred to as propositional logic programming. Another software paradigm was merging several knowledge representation forms in a single system. This approach enabled the creation of a smart programming environment, the New Utopist (NUT), where traditional programming tools like the C language were combined with object-oriented and logic programming facilities [30].

In the end of the 1960s, Tyugu suggested organizing winter software schools in Viljandi with a view to bringing together the engineers from computer factories in Minsk, Zagorsk, Kyiv, and Kazan and the masterminds of programming from the Lebedev Institute of Precision Mechanics and Computer Engineering, Keldysh Institute of Applied Mathematics, Glushkov Institute of Cybernetics, Joint Institute for Nuclear Research in Dubna, to name just a few. The scope of the topics discussed at the schools included the automata theory, artificial intelligence, image recognition, information transfer, and creation of asynchronous electronic devices and systems. In this way, Tyugu definitely became one of the leaders in Computer Science in Estonia and in the USSR. He successfully used his academic status in research, organization and social areas.

4. Science and Politics

During the *Perestroika* (1985-1991), Tyugu was actively involved in Estonian political life. In 1989-1991, he was a deputy from Estonia at the Congress of the USSR People's Deputies. Together with other Estonian deputies, he advocated the rescindment and condemnation of the secret protocols of the Molotov-Ribbentrop Pact. On August 20, 1991, the Supreme Soviet of Estonia declared its independence, legally reinstalling the Estonian Republic. This resolution was followed by the restoration of diplomatic relationships and recognition of the Estonian Republic by many of the world's states. In 1996, Tyugu ran for presidency of Estonia although he was a professor at the Royal Institute of Technology in Sweden. He believed that "the role of the president is to find balance, compromise and moderation" (in these very words one of the presidents of the Estonian Republic Kersti Kaljulaid formulated her goal) [12].

Having not received enough votes, he continued his work as a researcher and coordinator with the Royal Institute of Technology (1992-2000). While working abroad, Tyugu maintained a close connection with his Estonian colleagues through joint research projects [29]. In 2000, he returned to Estonia. Then Estonian universities were eager to employ young researchers, which involved dismissing the old professor-level staff as they were possible candidates for senior positions in public universities. Tyugu, however, managed to retain the position of Research Professor at the Institute of Cybernetics of Tallinn University of Technology (TUT) almost until his retirement in 2016.

As one of the forefathers of Estonian computer science, Tyugu continued working as a faculty member at TUT for decades. He supervised 29 Master's and Doctoral theses; his students are dispersed across the world. He was Professor of Estonian Business School and Researcher-Counselor of the Co-operative NATO Cyber Defense Centre of Excellence (2008–2010). Tyugu published six monographs and over two hundred scientific articles.

In 2001-2016 he participated in several R&D projects, two of which he led himself. The project *Extendable visual specification language and its supporting environment* (2003-2005) focused on applied research in formal languages and their software support aimed at the development of a new generation of high-productivity tools, basic structures and semantics of specification and visual languages [5]. The project *Logic-based methods of distributed applications composition* (2006-2009) developed instruments with precise logical semantic for the automatic composition of distributed application designed for the structural synthesis of linear logic algorithms. This work made it possible to unify specification and control of web services and grid computing.

Also, Tyugu gave an insight into the history of informatics in the Baltic Republics [24, 25, 27]. The pluses, according to him, were as follows: mathematics was taught well in high school; the scientists knew each other personally and had good contacts with top researchers in the Soviet Union. The minuses were poor hardware and a lack of experts and international contacts, although the latter did not concern Tyugu, who, directly or indirectly, was actively involved in international cooperation through Ershov's team until the early 1990s.

Another of Tyugu's diverse interests was management. Similarly to Frederick P. Brooks, who, in his famous book *The Mythical Man-Month. Essays on Software Engineering* (1975), looked into the organizational problems inside the teams of software developers, Tyugu turned to the issue of communication between customers and developers. His idea was that during the discussion of a project some information essential for the project but nonessential for its developers or customers is inevitably lost. Tyugu proposed a simple model – a "dipole" – that helped to identify the

customer's and developer's view of the problems of information system development and thus to avoid misunderstanding [33]. The participants of software development projects actively discussed and further developed this idea in the 1990s and in the 2000s.

Tyugu was twice awarded with the National Science Prize (in 1967 and in 1987). In 2001, he received the Order of the White Star, 3rd Class. Along with such masterminds of informatics as Boris Tamm, Iaan Penjam, Merik Meriste, Juhan Pruuden, Tyugu was one of the founders of informatics in Estonia, a country which has now become the leader in IT applications in the Baltic region.

He always led an active lifestyle. While in Novosibirsk, he was fond of hunting, rafting with friends along the stormy Siberian rivers. Later, he took up yachting and enjoyed tennis, mountain and cross-country skiing. He found great pleasure in reading, especially thanks to his impressive knowledge of languages.

5. Conclusion

We would like to conclude our story with the following observations. Estonians, as a rule, are calm, good-natured, substantial and business-like. This is what Enn Tyugu was, judging by his autobiography. As a child, he suffered a serious trauma: lost his parents, home, and motherland. However, even if there is bitterness in his memories, it is well-concealed. The very form of the memories written in several acts, like a play, and their name, *Life as a Show*, moves the losses and bitterness into the background, both structurally and stylistically, and creates the illusion of distance between the main character and events of his life. However, the details provided by the author and the skills he acquired in his childhood prove that the experience was deep-rooted. He managed to put what Nature had given him to the best possible use and was persistent in pursuing his goals.

After the Second World War, life in the Baltic Republics went back to normal, but the memory of the past remained. As soon as an opportunity to regain independence appeared, the Baltic Republics seized it. When Estonia faced urgent problems crucial for its independence, Tyugu became a parliamentary deputy and even ran for president. When this period was over, he returned to science.

Computer Science and Computer Engineering originated in the Baltic republics during the Cold War. The border position of the region gave them some preferences: they became a sort of a showcase for the Soviet Union, and as such received large investments and high quality education. As for Enn Tyugu, it is obvious that he, with his ability for mathematics and inquisitive mind, understood the prospects of cybernetics and advanced through the ranks. The creation of the Institute of Cybernetics in Estonia was dictated by the rapid development of the chemical and energy industries (oil shale mining), where automation and controls played an important role. It was the automation of software engineering with applications to engineering calculations in mechanical engineering where Tyugu gained his first programming experience. Despite the modest possibilities of computing technology in Estonia, he managed to gain significant theoretical knowledge by communicating with programmers and scientists from the leading academic centers in the USSR. Soon, he became a member of the academic elite, both as a scientist and organizer of science. In the 1980s, the team led by Tyugu joined START, a project to create fifth generation computers. The high-level tools for creating smart software developed under this project allowed the development of convenient user programs with a friendly interface. Later, in 2003 Estonian programmers participated in the creation of the Skype program, which provided text, voice and video communication over the Internet between computers. As a member of

the Estonian Academy of Sciences, Tyugu was an important figure in Estonia and abroad. Today, Estonia, with its 1,500,000 citizens as the only important resource, is a leader in the European Union in terms of the pace of innovation. It looks into the future with confidence, and Enn Tyugu has undoubtedly contributed to it.

We thank Irina Adrianova for their help with preparing this paper.

I. Kraineva participated in this research within the topic «Creation and maintenance of information resources focused on supporting science and education» within the framework of the State Research Project «Problems of data processing and analysis, modeling of complex systems, methodology and support of science and education in computer science and programming» of the Basic Research Program in the Russian Federation on long-term period (2021–2030) (FWNU-2022-0006).

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cora@iis.nsk.su
merik.meriste@taltech.ee
Ksanborn@oxfordfinance.com