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Rūsiņš Mārtiņš Freivalds

Remarkable scholar, unique teacher and great man

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Abstract The paper summarizes life, carrier, research, publications, presentations, education, teaching, and services to academic community of the remarkable scientist, teacher, and person Rūsiņš Mārtiņš Freivalds.

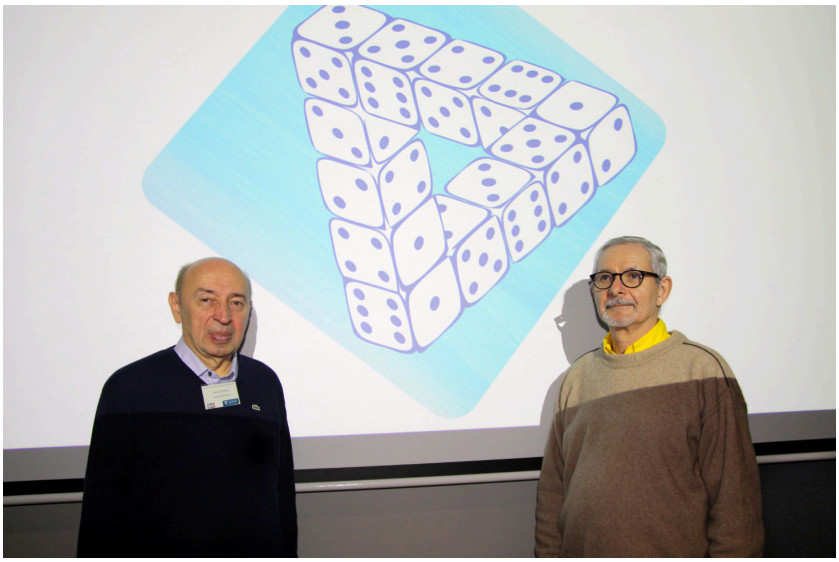
Keywords: Rūsiņš Mārtiņš Freivalds, University of Latvia, computational learning, probabilistic and quantum automata and algorithms, ultrametric automata and algorithms.

Professor Rūsiņš Freivalds was one of the nowadays already quite large family of exceptional (theoretical computer) scientists — better the scholars — and, at the same time, he belonged to a far smaller, but much more admired and loved, group of the exceptional speakers, teachers and scientific advisors. He took very much a father-like attitude to his students and he lived much for science and those having chance of doing good science.

As a scholar, Freivalds deeply loved mathematics, especially discrete one, for its usefulness and beauty and he put enormous effort to make all his students, both undergraduate and doctorate, and also people he cooperated with, to do so as well. Professor Freivalds concentrated during his so very fruitful scientific carrier, especially on transferring and using deep mathematical concepts, models, methods and results to dealing with problems in various areas of theoretical computer science. This allowed him also to see deeply what are important tasks and problems in theoretical computer science, as well as to be very inventive concerning tools to use and ways to go to deal with important and new fundamental problems.

As a teacher and speaker, he was exceptional at least in two directions. First of all, his lectures and talks were not only scientifically deep and great, but his presentations were also unusually interesting and beautiful. He usually worked exceptionally hard to make his presentations very attractive. He was one of the first, as far as I know, in the theoretical computer science community at least, who was able in useful and also nice way to utilize well and much all ways new computer presentation techniques allowed. In addition, he always tried to put things into a broader scientific context and also to make

his audience to appreciate contributions of great scientists of the past. From his talks one could feel that beauty and art were deeply embedded in his attitude to the work and presentations. He had also very special capability to introduce to students attractive, but solvable by them when working hard, problems. Students loved Freivalds and it was no wonder that at the 1st Poll in the University of Latvia he received a prize "Best Professor of all departments", in 2007.



Rūsiņš Freivalds with Cris Calude at the conference
"Unconventional Computation & Natural Computation 2015" in Auckland,
where he gave much appreciated talk. (Photo: Wai Loong Tham)

The second, and even much more unique, of Freivalds contributions as a teacher, was that he took father-like approach to his students and tried to teach them not only to choose and solve mathematically formulated problems, but also to take a broader approach to their developments. Especially, he encouraged them to appreciate art and music and to make use of their stays abroad to see and capture from new cultures what was possible. He was a master in getting much for little during his stays abroad and his students also learned that from him. He spent also large (and successful) effort to make his students to attend scientific events abroad where they could learn a lot in order to become persons with a broad view and understanding not only computer science, but also the current world.

In spite of the fact that Rūsiņš Freivalds was an extremely modest person, devoted to his research and teaching missions, he fully realized that duties of academics of such a reputation are broader — to serve academic community, his country and mankind in general.

On the university level Freivalds worked for years as Deputy Director of Computing Center, Latvian State University (1885–1990), head of the Chair of Discrete Mathematics at the Faculty of Physics and Mathematics, University of Latvia (1992–2007), and as a member of the Senate of his university (1993–1999).

On the national level Freivalds was also a member of the Expert Commission for Mathematics and Physics of the Latvian Council of Science (1993–2013) and the Full Member (since 1992) of Latvian Academy of Sciences. On the international level, he served in numerous program committees of practically all series of European theoretical computer science conferences, gave invited talks on many of them as well as during his numerous visits at academic institutions all over the world. He liked to emphasize that I was the first who brought him to these positions and that during MFCS conferences that were held annually since 1972 in Poland and Czechoslovakia he got for long time the main opportunity to meet his western colleagues. His international reputation grew up very fast and it was therefore no wonder that in 2010 he was elected to be a member of Academia Europaea as suggested by its Informatics Session Committee.

Perhaps less known is that Freivalds was, from my point of view at least, a very good tactician and diplomat well realizing what is at the given time and place possible. As perhaps his most ingenious step was that already during Andris Ambainis stay in Berkeley for his PhD Freivalds had already serious discussions with members of the Academy of Sciences about a possibility to elect Ambainis as the corresponding member of the Latvian Academy of Sciences. I would like to see that as a great idea at that time from theoretical computer science in Latvia point of view because already at that time Ambainis' scientific record was in a competitive state for such a recognition. The idea did not get through (of course) at that time, but soon (in 2003 at the age 28), after receiving his PhD in 2001 in Berkeley, Ambainis was elected as the corresponding member and 4 years later also as the full member of the Latvian Academy of Sciences.

Rūsiņš Freivalds has been also known for his love of operas and he attended opera performances wherever he could (and often with his students). During my stay in Riga in 2012 he took me to see Gaetano Donizetti opera "Anna Bolena" transmission from New York Metropolitan Opera in a movie-theater in Riga what was great and during his visit in Brno in December 2015 we went to see the Bedřich Smetana's opera "The Kiss"· This was the last but one opera performance Rūsiņš Freivalds could see (from Brno he still went to Vienna to meet his wife and attended there another opera on December 11). During the opera breaks in Brno he was discussing an idea of a paper we could work on. Perhaps also the last one he was not able to finish.

Let us now discuss, at least briefly, his research ideas and achievements.

Perhaps the common thread of all his research was to use complexity theory ideas, tools and results to get deeper insights into the problems in a variety of areas of theoretical computer science — the field he liked much as interesting and important and the field he has also broaden out much.

Main areas Freivalds worked in are: inductive inference and computational learning theory — computability and complexity approaches; complexity theory (computational, communication, size, query,...); randomized algorithms; probabilistic and quantum automata, algorithms and computations; ultrametric automata and algorithms.

Another subjects Freivalds worked on: formal languages, frequency automata, fractals representation, numbering theory, recursive functions and computability theory.

Freivalds' first internationally published paper was "Functions computable in the limit by probabilistic Turing machines" published in the "Lecture Notes in Computer Science", Springer, 1975, v. 28, p. 77–87. His last paper is "On block pumpable lan-

guages" with Ch. H. Chak, F. Stephan, H. Tan Wan Yik published in "Theoretical Computer Science" Vol. 609, Part 1, 4 January 2016, pages 272–285.

Freivalds' first great complexity result was the proof, already from 1975, that a randomized algorithm can be more efficient than any deterministic one for the same problem. More exactly, he proved that Probabilistic Turing Machines can recognize palindromes, which requires time $\Theta(n^2)$ on Deterministic Turing Machines, in time $O(n \log^2 n)$ — this Freivalds improved in 1977 to $O(n \log n)$. This result was published in the paper entitled as "Fast computations by probabilistic Turing machines" (in Russian) in "Theory of Algorithms and Programs", Riga, University of Latvia, 1975, V. 233, p. 201–205.[1] Another fundamental outcome of Freivalds along this line was the development of a new powerful method to show lower bounds for the time and space complexity of randomized algorithms.

R. Freivalds at the Best paper ceremony at the Turing-100 conference in Manchester, 2012. (Photo: S. Zariņa)

Another subject Freivalds was working on intensively for all his carrier was the inductive inference. His idea was to use again and again deep methods of classical mathematics. From a very special ones one can mention the usage of constructive ordinals to measure the complexity of inductive inference and to use Group theory in this area.

[1] Interesting enough, Freivalds' first scientific paper was "Complexity of palindromes recognition by Turing machines with an input" in journal "Algebra i Logika" 1965, Vol. 4, No. 1, p. 47–58 (in Russian)" and his first conference presentation was on the same subject at the "3rd Scientific Conference of the Novosibirsk State University" in 1964 (by the way I was in this year visiting Computer Center in Akademgorodok as one of the first foreign visitors and so we likely at least see each other there.)

Rūsiņš Freivalds had many (more than 100) co-authors. In his latest state of the developments he tried hard that each of his visits of other scientists results sooner or later also in a common paper. Here are Freivalds' most frequent co-authors. C. H. Smith (33), E. B. Kinber (17), R. Wiehagen (13), A.Ambainis (12), K. Apsitis (12), J. Barzdins (9), M. Karpinski (8). By Google Scholar, the number of citations of his papers is at least 2,889 and H-index is 26. His most cited paper (with 275 citations, as of October 28, 2016) was with Andris Ambainis: "1-way quantum finite automata: strengths, weaknesses and generalizations", published in FOCS proceedings in 1998.

R. Freivalds at the conference MFCS in Brno in 1998

Rūsiņš Freivalds got most known for his randomized algorithm (published in 1977) that could verify with arbitrarily large probability product of any two $n \times n$ matrices in $O(n^2)$ time. A naive deterministic solution has complexity $O(n^3)$ and using the fastest matrix multiplication algorithm, but very sophisticated one, one can make such testing in $O(n^{2.37})$ steps. Freivalds' extremely simple algorithm, which surely belongs to the Golden Fund of Algorithms, is nowadays presented in almost all books and lectures on algorithm designs and had huge impact on the understanding that randomness is a powerful resource.

Similar motivation has been behind many Freivalds results. To show for some computation models that randomized algorithms or automata are much better in some cases and in some senses than deterministic ones for the same problem. To prove that usually requires some ingenuity for choosing appropriate problems. Similar motivation was also behind some of his approaches to quantum tools — again to show for some computation models that their quantum versions, that use deeply quantum tools, can be in some cases and in some way, better, and significantly better, than deterministic ones or even as probabilistic ones.

Interest of Freivalds in quantum computation started after he attended, similarly as me, in 1993, FOCS conference in San Diego, where some papers were presented on quantum computing including the famous paper of Vazirani and Bernstein with the crucial result that there are universal quantum computers that can efficiently simulate all other quantum computers. Freivalds immediately realized that this area has enormous potential and he tried to make to see that also his students, including Andris Ambainis.

Prof. R. Freivalds at the opening of ICALP'2013 in Riga
(Photo: T. Grīnbergs, Media and Marketing Centre, University of Latvia)

One of the most surprising outcomes of Rūsiņš Freivalds was his introduction and exploration of ultrametric automata and algorithms. These concepts were not only practically unknown before that in theoretical computer science, but looked like from another universe. These automata and algorithms work with p-adic numbers. In spite of the fact that these automata and algorithms have properties far from any other known models of computation — for example, there is a continuum of languages recognizable by finite ultrametric automata, they are of interest as shown in a variety of papers by Rūsiņš Freivalds and his co-authors. His presentation of the basic ideas of ultrametric automata

and algorithms on the big Turing-100 conference to Turing centennial anniversary in 2012, in Manchester, brought him the prize for the best paper.

Our personal contacts started around 1980 when he was also a member of an international program committee. Since that time we met many times at MFCS, FCT, EQIS and other conferences. In 1998 he served as the chair of Randomized Computation Workshop, one of 10 workshops, at the MFCS conference in Brno, the largest conference till then in TCS in Europe with 375 participants. Very remarkable was that he brought with him, as one of the invited speakers of the workshop, Andris Ambainis — as the raising superstar — Freivalds' another correct expectations and another illustration how he tried to push his students to go up.

Professor Freivalds (left) receiving his Grand Medal of the Latvian Academy of Sciences
from newly elected president Juris Ekmanis (center)
and the outgoing president Jānis Straḍiņš

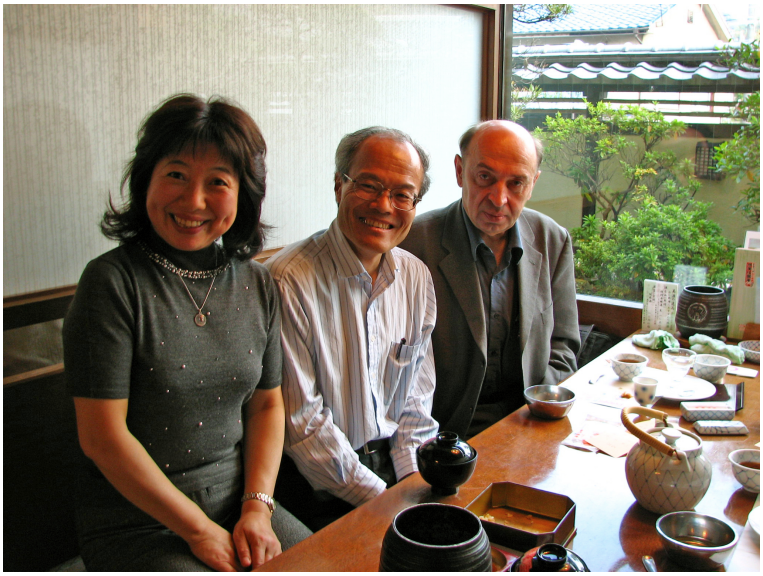
During his university study, at the Faculty of Physics and Mathematics, in his second and third year, he spent two years in Novosibirsk Academgorodok — at that time a very important center of science in Soviet Union. He also went there for his PhD with Boris Avraamovich Trakhtenbrot, the pioneer of theoretical computer science in Soviet Union and one of its great scientists.[2] He got his Ph.D. in 1971 from the S. L. Sobolev Institute of Mathematics in Novosibirsk, USSR for thesis "О полноте с точностью до кодирования систем функций конечнозначных логик" (On Completeness up to Coding for Systems of Multiple-Valued Functions).

Later he received the second, highest doctor degree at the Moscow State University (1985) nostrified in Latvia as Dr. habil. math. (1992). That allowed him to receive the

[2] Interesting enough, Freivalds did not have a common paper with Trakhtenbrot, but Freivalds co-authored a book "Teaching Fundamentals of Computers", in 1986, with academician Andrei Petrovich Ershov, another leading scientist in computing in Novosibirsk and perhaps the best known one abroad from Soviet Union at that time. (Ershov was also a big visionary and already in 1962, in a paper in the journal "Communist" he could foresee the existence of internet!) Book was soon translated also to Moldovian, Lithuanian and Azeri languages.

appointment as a Full Professor in 1985. As the next step in his professional carrier he was elected as the Corresponding Member of Latvian Academy of Sciences in 1991, and as the Full Member of Latvian Academy of Sciences in 1992.

Rūsiņš Freivalds was practically continuously heading big research projects. To name some of them: grants founded by Latvian Council of Science (1990–2016), grants for co-operative research in inductive inference for the University of Maryland and the University of Latvia, given by NSF (1992–1998) and Grant from Academy of Sweden for joint research in Computer Science for the Mälardalen University and the University of Latvia (1994–2000).



Prof. R. Freivalds in Kyoto, Japan together with
Kyoto University professor Kazuo Iwama and his wife
(Photo: S.Zariņa)

On the international level Rūsiņš Freivalds was the chair or member of international program committees of many (at least 25) conferences and workshops. Perhaps the last one of such his position was that of the Program chair for the Track of Foundations of Computer Science at SOFSEM'2016 that was held on January 23–28 in Harrachov in Czech Republic. Freivalds also organized several quantum computing workshops in Sweeden, Latvia and Czech Republic. In 2013 he was the main person behind bringing ICALP into Riga and to chair its program committeee.

Concerning already discussed Freivalds lecturing activities of importance and interest are his regular university courses: Theory of Algorithms, Advanced Problems in Algorithm Theory, Complexity of Computation, Quantum Computers; Automata, Algorithms and Formal Languages; Game Theory, Data Security and Cryptography, Linear Algebra, Mathematical Methods of Cryptography, Methods of Research in Computer Science, Main Notions of Mathematics, and others. All that also indicates his continuous effort to keep up with important developments in the related science.

Professor Freivalds had also a variety of longer terms visiting professor positions abroad. Here are some of them: Humboldt University in Berlin, Germany (1991); Electrotechnical Laboratory, Tsukuba, Japan (1993); National University Singapore, Singapore and University of Bonn, Germany (both 1994); Mälardalen University, Eskilstuna, Sweden (1996); Tsukuba Technical University, Japan (2004); Cornell University, USA (2005); Kyoto University, Kyoto, Japan (2009); Hokkaido University, Sapporo, Japan (2012).

Concerning other awards. Of special importance are four main awards from Latvian Academy of Sciences: Grand Medal (2003), Award of the LAS and GRINDEX Corporation (2003), E. Āriņš prize for a cycle of papers on "Effective Probable Algorithms" (2000), and YCL prize for his "Theory of Inductive Inference" (1976). He was appointed to be "Honorary Scientist of Latvian SSR" in 1986. He also got the University of Latvia prize for establishing a research school in TCS in Riga (2012), and his research results were included in the list of 10 top achievements of Latvian research by the Latvian Academy of of Sciences in 2012.

Rūsiņš Freivalds liked to travel and he was also much welcomed as the visitor. He liked to see new places, new cultures and to enjoy especially music in new places. He also liked to find new topics to work on and new co-authors. On the other side, he was very easy to go guest, very modest, pleasant and the one spending much effort that visits are also scientifically profitable for both sides.

TCS community will much miss Rūsiņš Mārtiņš Freivalds and never forget him.

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