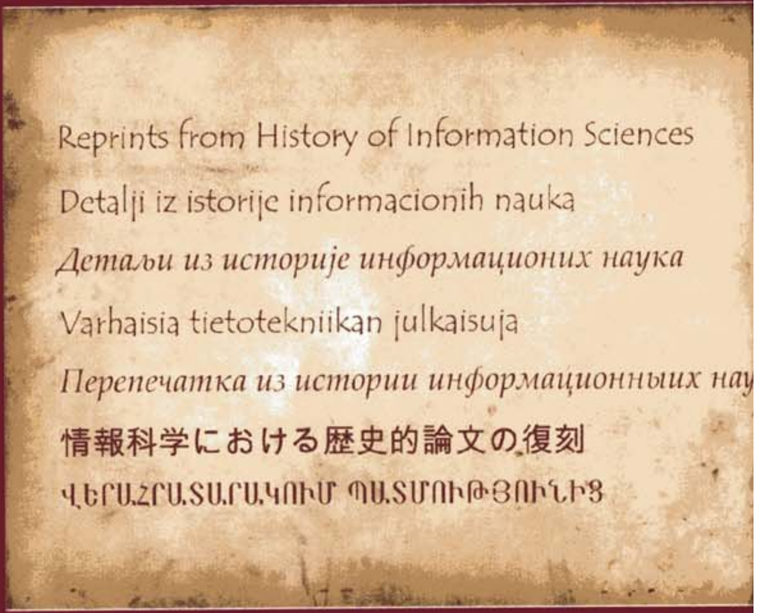
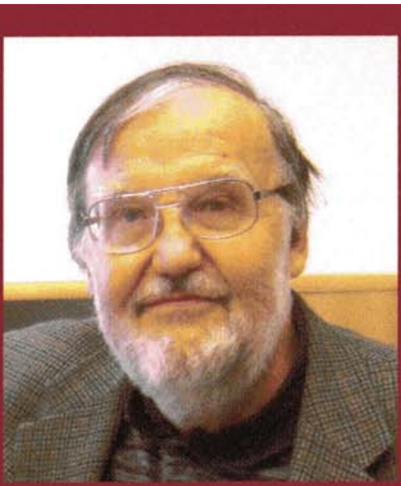
Reprints from the Early Days of Information Sciences

Interview with Arto Salomaa


Reprints from History of Information Sciences
Detalji iz istorije informacionih nauka
Детаљи из историје информационих наука
Varhaisia tietotekniikan julkaisuja
Перепечатка из истории информационных нау
情報科学における歴史的論文の復刻
ՎԵՐԱՀՐԱՏԱՐԱԿՈՒՄ ՊԱՏՄՈՒԹՅՈՒՆԻՑ

Edited by Radomir S. Stanković and Jaakko T. Astola



Born in Turku, Finland, June 6, 1934.
Elementary, high school and studies in Turku. MA, University of Turku, 1954.
Graduate studies at the University of California, Berkeley, 1956-1957.
Ph. Lic., University of Helsinki, 1959.
Ph. D., University of Turku, 1960.
Assistant, instructor and docent, University of Turku, 1957--1965.
Professor of Applied Mathematics, University of Oulu, 1965.
Professor of Mathematics, University of Turku, 1966-1998.
Research Professor at the Academy of Finland, 1975--1980.
Research Professor at the Academy of Finland, 1989-1994.
Academy Professor at the Academy of Finland, 1995-1999.
Ph. D. h.c. Åbo Akademi 1988.
Ph. D. h.c., University of Oulu 1989.
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Ph. D. h.c. in mathematics, University of Bucharest, Romania, 1992.
Doktor-Ingenieur Ehren halber (h.c.), TU Magdeburg, Germany, 1992.
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Doctor Honoris Causa, TU Graz, 1999.

Academician,
One of the Twelve Fellows in
the Academy of Finland, 2001

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Reprints from the Early Days of Information Sciences

Interview with Arto Salomaa

Excerpt from

Reprints from The Early Days of Information Sciences
On the Contributions of Arto Salomaa to Multiple-Valued Logic

TICSP Series #50, 2009 ISBN 987-952-15-2290-1 ISSN 1456-2774

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Interview with Arto Salomaa
Radomir S. Stankovic, Jaakko T. Astola, (eds.)

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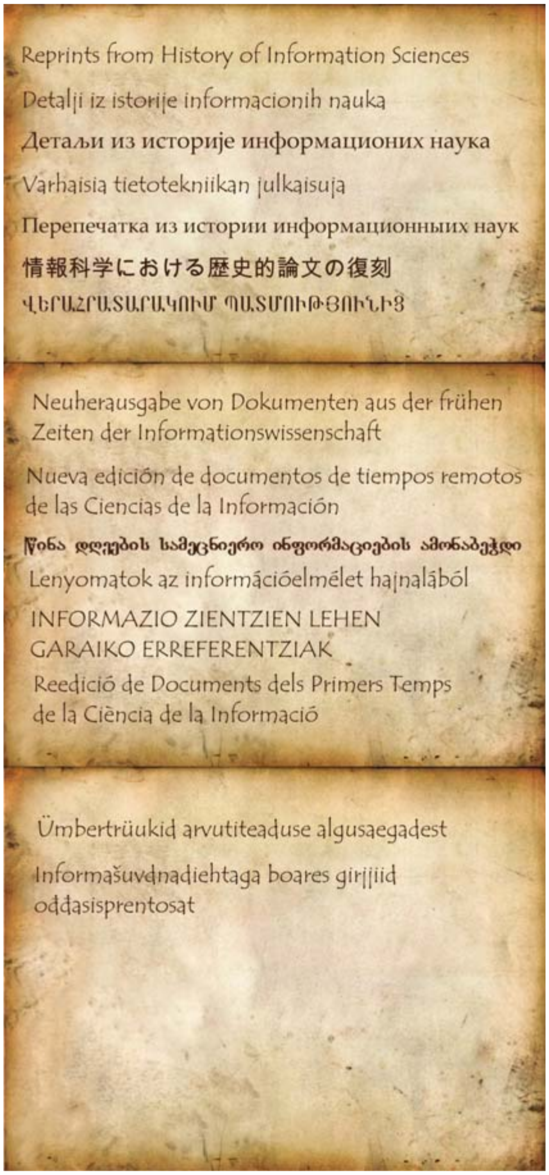
Notice

This book contains several reprints of pages selected from several books by Arto Salomaa or books dedicated to him. They contain interesting historical information about Arto Salomaa and the research community in general. We did not want to rephrase or rewrite the original statements, since we believe that the way they were presented originally, has a particular value for the reader.

We kindly ask for these reprints not to be viewed simply as graphic illustrations from previous publications, but to be read as a part of the presentations in this book.



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Neuherausgabe von Dokumenten aus der frühen
Zeiten der Informationswissenschaft

Nueva edición de documentos de tiempos remotos
de las Ciencias de la Información

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Lenyomatok az információelmélet hajnalából

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GARAIKO ERREFERENTZIAK

Reedició de Documents dels Primers Temps
de la Ciència de la Informació

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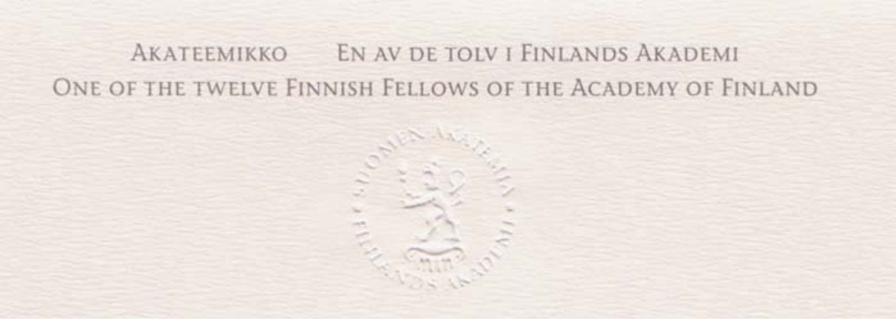
Interview with Arto Salomaa

The interview conducted by Radomir S. Stanković in the office
of Arto Salomaa, B-6035
Turku Centre for Computer Science (TUCS)
Joukahaisenkatu 3-5 B
20520 Turku
Finland

A look from the door of the office of Prof. Salomaa, B-0635 in ICS Building of TUCS



AKATEEMIKKO EN AV DE TOLV I FINLANDS AKADEMI
ONE OF THE TWELVE FINNISH FELLOWS OF THE ACADEMY OF FINLAND

Memorandum of letters used by members of the Finnish Academy

To simply explain who is Arto Salomaa it is sufficient to say *One of the Twelve* as stated in the memorandum of the letters used by members of the Finnish Academy.

The biography of Arto Salomaa has been published many times at different occasions, as for instance, when he was accepted as a member of one of four Academia, some round birthdays, etc. Therefore, instead of writing yet another formal one, we will provide several photos and excerpts from books written by Prof. Salomaa or devoted to him. These photos should illustrate the main principles accepted and appreciated by Prof. Salomaa in his life and work. Photos were taken while talking with Prof. Salomaa about his numerous books. They were taken without any pretensions except to be some simple reminders of particular details he presented, however, later we realized that they can tell much more than that.

For details in biography of Prof. Salomaa and concrete data, we refer to

Juhani Karhumäki, "A short biography of Arto Salomaa", *Information and Computation,* Vol. 151, 1999, 2-4,

and to the web site of Prof. Salomaa

http://vanha.math.utu.fi/staff/asalomaa/

prepared in the very same excellent and clear way as his numerous

publications.

Interview

We would like to ask about your work in Multiple Valued Logic, *since this would be the main subject of this issue of Reprints devoted to a part of your work.*

Recently I have not really done anything except, there is one thing, I don't know if you know about this, this is a recent book, it appeared in 2006, here I wrote an article about Moisil and Many-Valued Logic and it has some of my recollections. This is the only thing I've really published about this after what I've said in 1964/65.

We would like to reprint this paper in Ajatus, *the first paper from 1959 and maybe we also could take a look in this.*

This was actually my first publication.

This is *why it is so interesting.*

Then my PhD thesis was about Sheffer functions and the main theorem appeared also In the *Journal of Symbolic Logic* in 1960.

You were very active as a reviewer for the Journal of Symbolic

Logic. That is true, however, only in early days, but not

anymore.

Let me maybe first start with a classical question. Everyone knows who you are in science, but it is very interesting to see how you view yourself in this perspective, because you have so many different interests, including sauna, on your web pages there are photos of your family, and so on. What you would say now about, what is your main?

It is very difficult to say what the main is, because there are so different things in many years, but I have really always liked the things I'm doing at the moment, and I have written many books. In another interview, not so long ago, Christian Calude asked me what I liked, and I would say I like my first book, "Theory of Automata" the most, and it was quite long, 7 seven years after my PhD, but it was the first book. The publisher was very bad, this Pergamon Press, there were all kind of scandals, they screwed up things enormously, but I still like the book. And I think that for things that are in the book still nothing much has changed from these days, it is very mathematical, so it stays the same.

Exactly as you say in one title: "Theory is Forever".

THE

JOURNAL

OF

SYMBOLIC LOGIC

A THEOREM CONCERNING THE COMPOSITION OF FUNCTIONS OF SEVERAL VARIABLES RANGING OVER A FINITE SET

BY

ARTO SALOMAA

REPRINTED FROM VOLUME 25, NUMBER 3, SEPTEMBER 1960
Copyright 1962 by the Association for Symbolic Logic, Inc.
Printed in The Netherlands

Yes, this was one book that was published for my birthday, so that was not my invention, the title.

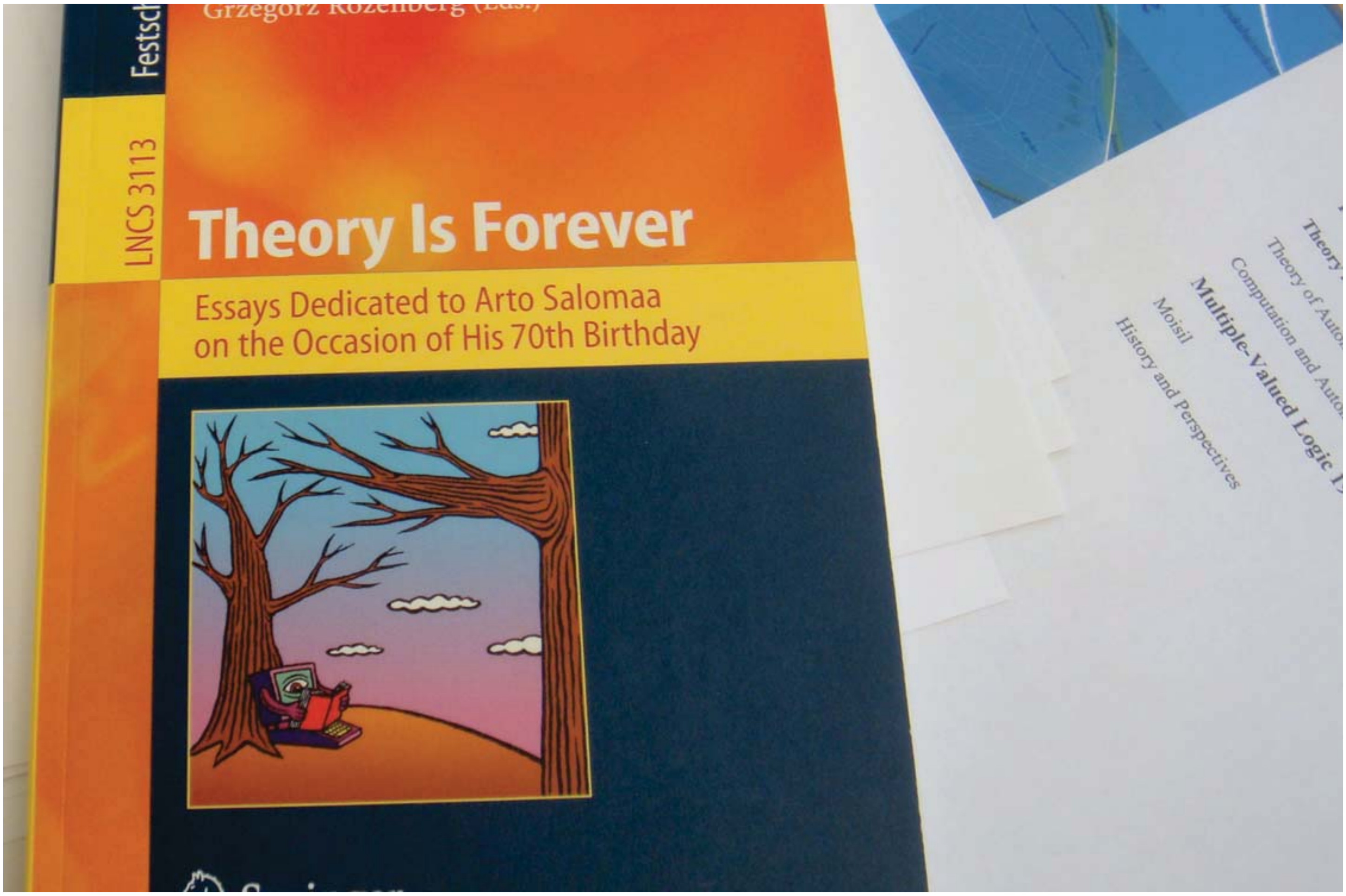
May I ask you about your name - Arto Kustaa Salomaa. Who gave you the name, maybe your father?

Yes, so in the first place my last name, of course, comes from my father and his original name was Grönholm, which is a Swedish name and means Green Island. When he was very young, something like 15, in that time there was a movement in Finland to translate names into Finnish, and Salomaa is quite common name in Finland. There are many Salomaas and they are not related to me. Then Arto, it is very easy to say, is the Finnish form of German Arthur or English Arthur. Arthur Schopenhauer was my father's favorite philosopher and he wanted me to have this name. And Kustaa is from Gustav Swedish name, and there are kings in Sweden with this name Gustav and I got name Kustaa just because in Finland we have The Name Days, and today (March 17) is the day of Kerttu, that is the women's name, and I was born on June 6, which is Kustaa's Day, so this is the explanation of the name.

Can you tell us something about the place where you were born, and early days, how it looked in the primary school at that time, maybe you remember your teachers or friends?

Yes, I was born in Turku, and basically spent my whole life here, I've been 10 years abroad. I was born here and my childhood was here, and of course childhood was at the time of war, and these were very rough times. I was pretty much alone, because my brother was in the front and my father was also involved in war activities, and my mother and sister were also engaged. My sister was actually 15 years older than me, so she was with me, but she had to work until late in the evening, so I was just hanging around with boys and this was my first contact with cryptography, because the boys gangs were using this coding and I was very good in breaking codes and doing things like this. I was also interested in mathematical problems in that time.

For instance, one problem when there are leagues of football teams, for example, n teams, and how many games teams play against each other. Of course I didn't know anything about Pascal's triangle or binomial coefficients, but I was able to invent the rule for this and the boys did not believe this rule and they came up with the counter example, and they took, actually fourteen existing Finnish teams and they took actual games. There were 90 games and my formula gave 91, 7 times 13. But when we carefully looked through the list, one game was missing, They had two Turku teams and the game between them was missing, so my formula was correct.
And then, of course, the elementary school of that time was for one or two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Theory Is Forever
Essays Dedicated to Arto Salomaa
on the Occasion of His 70th Birthday
Theory
Theory of Auto
Computation and Auto
Multiple-Valued Logic
Moisil
History and Perspectives

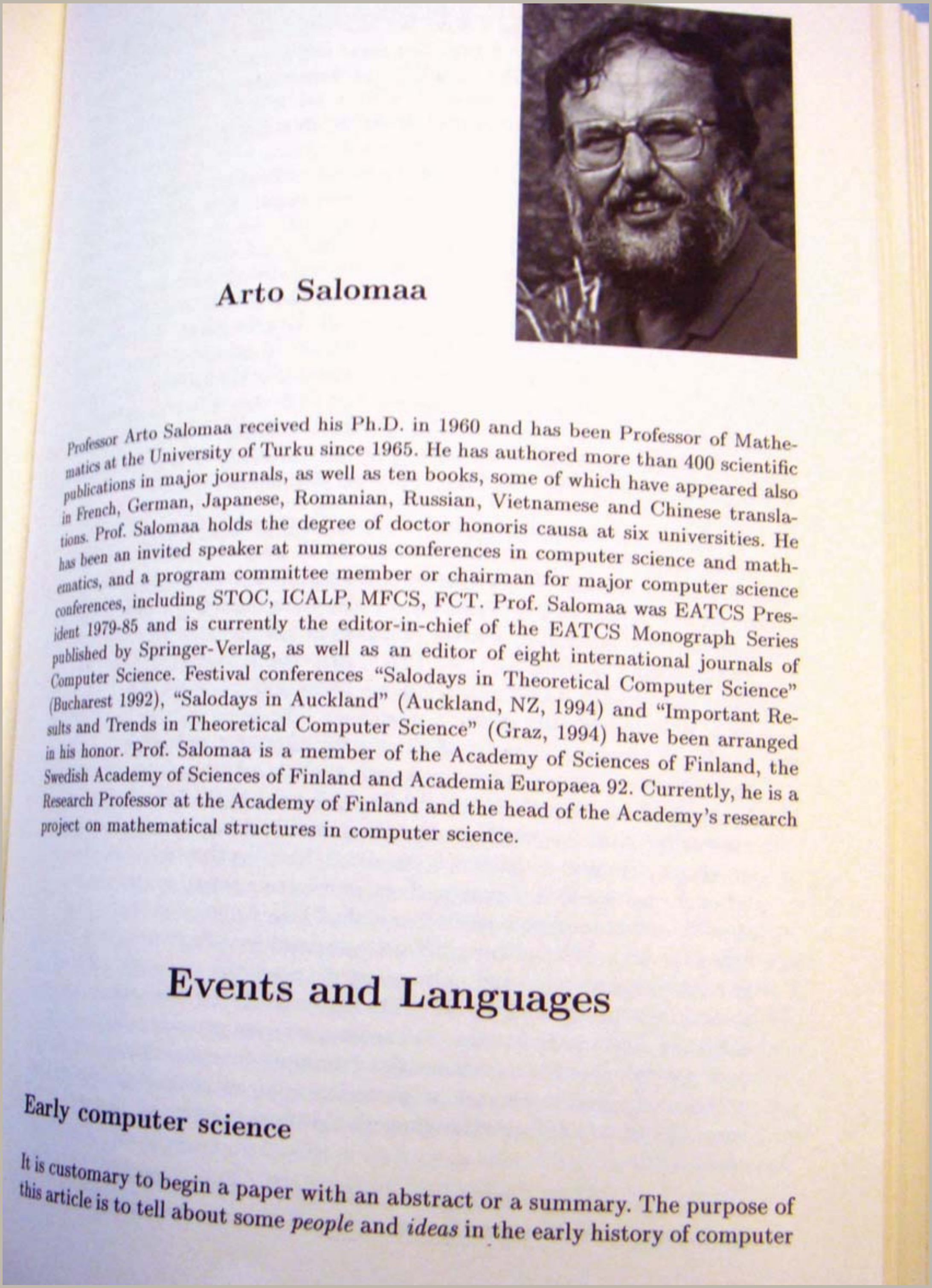
hours per day, and there was bombing going on in Turku. Sometimes, some of the activities were taking place in Naantali, the place not far from Turku and the danger of bombing was not so high. After elementary school, I went to classical lyceum, and five years after the end of the war nothing much was available. People usually say that people were much satisfied in that time when there was nothing available. Of course I had some good teachers, for example, my math teacher in classical lyceum was very good, and also I liked Latin very much, and now when I have time I still read some Latin and so forth. In fact, it was by kind of accident that I haven't studied Latin, so I started the mathematic studies and I was the first years in Turku and I found my research field, Formal languages and Automata Theory, when I was in Berkeley.

What was the profession of your father?

He was a Professor of Philosophy in Turku.

What was the problem with books and text books of that time, because it was postwar era, no media available, how you got literature to study?

I would say that the math curricula of that time was very classical, it was basically analysis, and a bit of algebra, and these books existed in Finnish. But the modern books, I knew them only when I went to Berkeley.



Arto Salomaa

Professor Arto Salomaa received his Ph.D. in 1960 and has been Professor of Mathematics at the University of Turku since 1965. He has authored more than 400 scientific publications in major journals, as well as ten books, some of which have appeared also in French, German, Japanese, Romanian, Russian, Vietnamese and Chinese translations. Prof. Salomaa holds the degree of doctor honoris causa at six universities. He has been an invited speaker at numerous conferences in computer science and mathematics, and a program committee member or chairman for major computer science conferences, including STOC, ICALP, MFCS, FCT. Prof. Salomaa was EATCS President 1979-85 and is currently the editor-in-chief of the EATCS Monograph Series published by Springer-Verlag, as well as an editor of eight international journals of Computer Science. Festival conferences "Salodays in Theoretical Computer Science" (Bucharest 1992), "Salodays in Auckland" (Auckland, NZ, 1994) and "Important Results and Trends in Theoretical Computer Science" (Graz, 1994) have been arranged in his honor. Prof. Salomaa is a member of the Academy of Sciences of Finland, the Swedish Academy of Sciences of Finland and Academia Europaea 92. Currently, he is a Research Professor at the Academy of Finland and the head of the Academy's research project on mathematical structures in computer science.

Events and Languages

Early computer science

It is customary to begin a paper with an abstract or a summary. The purpose of this article is to tell about some *people* and *ideas* in the early history of computer

How have you selected Berkeley?

This was more accidentally, there was a system of scholarships and grants. Finland was the only country that paid its debts to United States after the First World war. And at some stage, around 1950, it was decided that from that point on, all the further payments will be used for cultural exchange. So scholars came to Finland and there were grants for Finnish students to study in United States and this was graduate studies, so I have already had my master degree when I applied this. And I really think it was kind of accident, I knew the name of Tarski, who was in Berkeley, and I had listed three universities, and the Committee chose Berkeley, so 1 went there. So the Tarski's name was my choice why I've put Berkeley.

Then you said you have met John Myhill

Yes, John Myhill was one of the founding fathers of Automata Theory and I attended his seminar. On that seminar there was a new book called "Automata Studies" and we went through this book. My own work on this seminar was about self-re producing machines and in that time it was not much known in biology or anything. For instance, it was a controversial thing whether machines could at all reproduce themselves, because there were all kind of arguments in articles that if you self-reproduce yourself, you have to be more than what a machine can be. Von Neumann was the great name and my work was more or less to do in detail what Von Neumann's paper was. My work there was never published, this was kind of very detailed constructions of instructions for the machine. Parts for the machine were randomly provided in plane, and the machine was moving around and collecting the parts. It was like Theory of Turing Machines.

Maybe in that time there were thoughts - can machines think?

Yes, the artificial intelligence was also forming, there were all kinds of questions what is possible for machines and what is not. If I compare the situation then and now, the differences are that in late fifties and early sixties, people were very optimistic with machines translations, that it is a very easy thing to translate from one language to another, but this was very difficult. And people were thinking that machines could never play good chess, now it turns to be the entirely opposite.

So, there have been some different opinions then and now? How do you predict the future of machines nowadays, they will put us into slavery?

I don't think so; I am not into science fiction. Of course this is more political question, like some search engines as Google, if they get too much power or one gets information only from them, it is not so good. But, I think, once you use your own judgment, it is a very good source to find information.

Do you think they have changed the way of learning or thinking of people, because now we can find data and information everywhere.

Well, I think the learning is certainly totally different now, and this is of course problem for teachers, because if you have to write an essay, it is so easy to copy from internet and it is very difficult for teachers to find this. But, I think, in general this is a great asset, these new things.

You said that in your childhood there were your sister and your friends, but now kids are growing near electronic media and after some years they start reading, does it also employ their way of learning?

It certainly does, because some of my friends think that reading becomes obsolete at some stage. But still, books are nicer to read than from the machines.

What do you think after writing so many books, do you think it would be possible to change something in the way of writing, to approach maybe classical books to electronic media presentations?

I think it is going very much towards electronic media. I have been involved in one electronic journal called the *Journal of Universal Computer Science.* It brings also printed volumes, but these volumes are going mainly to libraries. The publishing in general and the editing job now is much easier than before. It is the same this peer reviewing, but earlier I had to make many copies and mail an article and ask the person if he wants to review and ask to send it back, but now I can just email the file, otherwise I would have to make copies, etc. Also now I can just send the file and if he does want to review, he will act as a referee and if disagrees, then I can ask someone else in the same way just by forwarding the message. But how would be the publishing in general, I think the journals will still exist, because people want to see the paper, not only at the screen. Maybe the more finalized version can be printed, and in these electronic journals one can still change the contents.

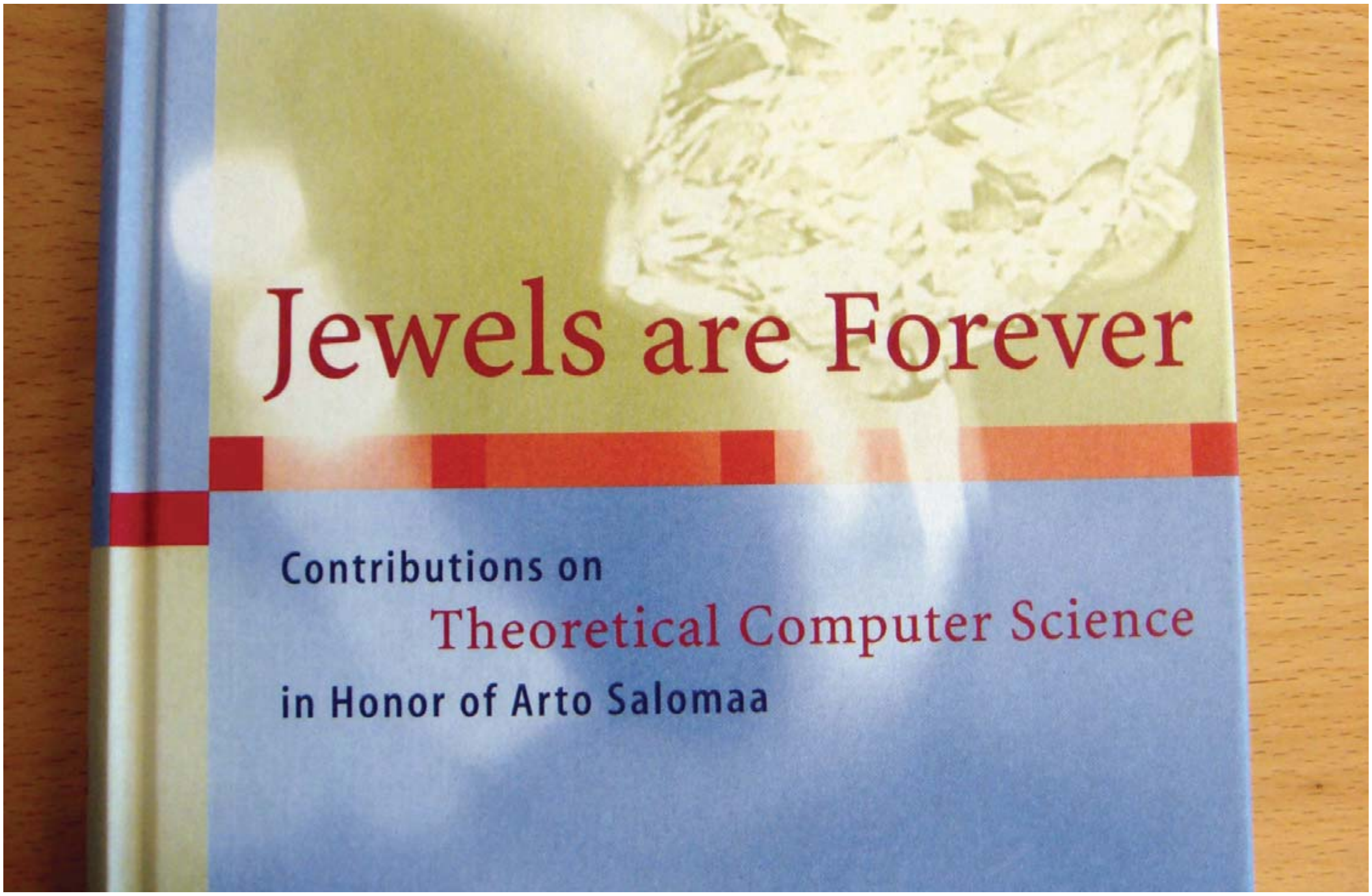
What do you think about the quality printing? Would you like to see your books in a good quality printing or maybe cheaper that would be easier accessible?

I think this electronic means have certainly improved the quality, now it is much easier to write papers than before. For example, the LaTex is a very good tool and so on. I like when a book appears in good quality and usually the publishers do that and then they can charge.

I am an Editor of this series of books, and these are nice books, and for one such book the publisher can charge 100 euros.

How do you remember your colleagues and Professors from Berkeley, especially John Myhill, as a person I mean?

John Myhill was a very difficult person, he had several nervous breakdowns and sometimes he had to spend months in sanatorium and so forth, and I was never so close with him. But, his lectures were very impressive, because he was full of new ideas, but he was kind of out of this world. I have told many times this story, it is a true story. We were waiting for him to come to a lecture, and when he didn't come we went to search him around and he was in another room and he had already written the blackboard half full without noticing that there was no audience. Tarski was, of course, entirely different, he was very socializing, and was kind of a Man of the World, always dressed very elegantly and so forth. I took some courses from him. There were many other people, like Roger Lyndon and Robert McNaughton were there at that time, later they became very well known in this field.


Jewels are Forever

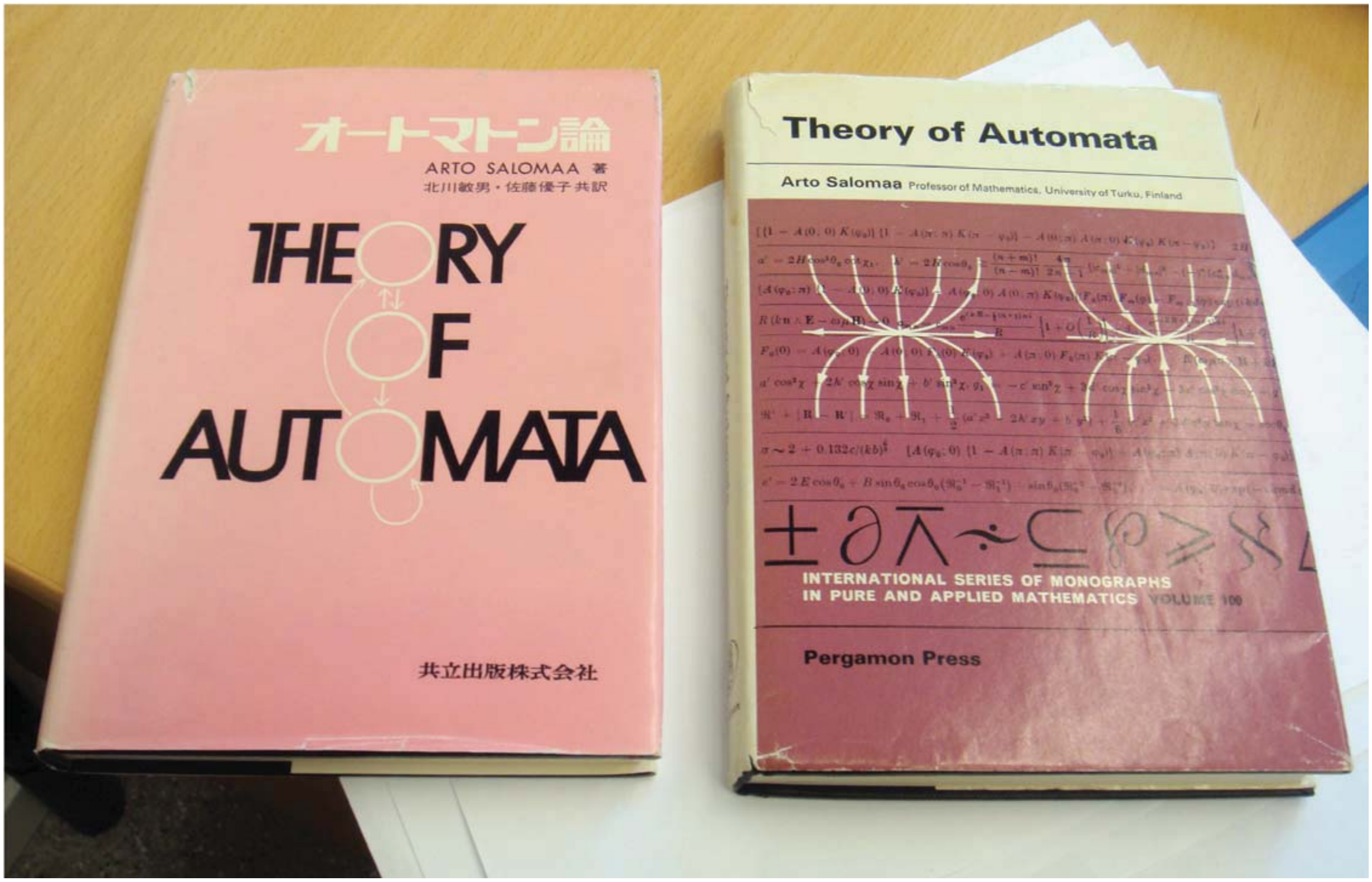
Contributions on
Theoretical Computer Science
in Honor of Arto Salomaa

In this book on the occasion of your 70th birthday it is written that you are one of the most influential researchers in the Theoretical Computer Science. Of course, there are many directions, but which one would you maybe select, where you went deeper?

Certainly Automata and Formal Languages, these two subjects. Sometimes you speak separately on Lindenmayer systems, because it is kind of biological, but it's much more Formal Language theory. 1 have also written two books about Formal Power Series, and it is also kind of another extension of Formal Languages because it's not power series in the sense of classical mathematics but in non-commuting variables, it is like words where letters do not commute. The other field I have been working or teaching much is Cryptography, and I have written a book about cryptography, but I'm not saying that I made any significant contribution to it, except maybe I was the first one to teach cryptography in Finland and so many of these practical people, in Nokia for instance, they are my students.

You actually started teaching cryptography when playing with kids.

It is true, but there was a time gap, this was in mid forties, but then I came back to cryptography only in late seventies, when there was this idea of Public-Key Cryptography, very nice mathematically, very challenging and interesting mathematically. I gave here in Turku first lectures, I think in 1982.


オートマトン論
ARTO SALOMAA 著
北川敏男・佐藤優子 共訳
THEORY OF AUTOMATA
共立出版株式会社
Theory of Automata
Arto Salomaa Professor of Mathematics, University of Turku, Finland
INTERNATIONAL SERIES OF MONOGRAPHS IN PURE AND APPLIED MATHEMATICS VOLUME 100
Pergamon Press

And then the book appeared in 1990.

Yes, the book appeared in 1990.

Here in your book could be found that William Stanley Jevons actually provided first idea about this one way function in cryptography. Do you have any comment about this, maybe like this problem of factoring product of two large numbers?

This is the key issue in this, but I'm not aware of any significant progress in this. Of course, if some fast algorithm will be invented, this would mean that RSA will become very vulnerable and a lot of these security things, computers, are using RSA in some form.

It appeared this Shor algorithm related to the quantum computing. Is this a problem for this area or still not?

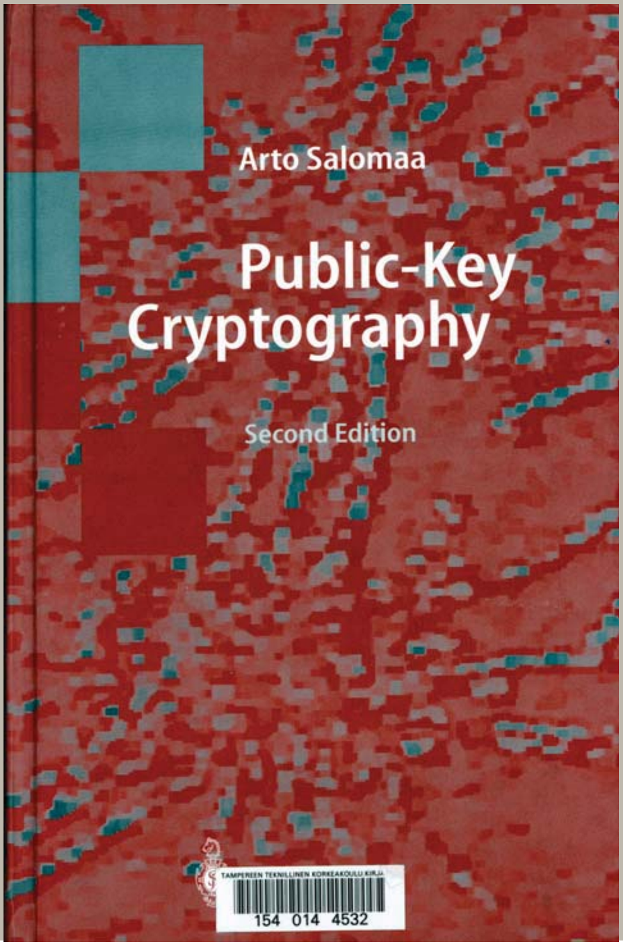
Not yet as far as I know, because the quantum computers are still developing, so I don't think they still do some real big stuff.

You started speaking about your Professorship in mathematics in Turku, you taught also cryptography and some other courses?

I can say that I have been teaching here in Turku, since I came back from Berkeley, in 1957. And I have been teaching any kinds of courses, from differential equations, calculus, number theory, algebra. Now I've just noticed that also I gave a course in game theory in 1965, and I've noticed that I still have my lectures from this course and I've talked about this "Nash Equilibrium", you know this now Nash became very famous, he won Nobel Prize and there is this movie "Beautiful Mind" which is about him. It was a pretty new thing in 1965 this "Nash Equilibrium", so I talked a bit about this in my lectures.

Does it mean that you like teaching or how do you feel teaching compared to research?

Especially when I was younger I surely liked teaching. I also like very much to guide PhD students. I have really wonderful PhD students, much better than myself. They are all different and you need to have a different approach to



Arto Salomaa

Public-Key Cryptography

Second Edition

TAMPEREEN TEKNILLINEN KORKEAKOULU KIRJ
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every of them. Like, some students work entirely alone, and some you have to see once or twice a week. So it very much depends on the person.

In one period, you also studied in Helsinki?

I have never studied in Helsinki University, but it was kind of formal reason that I took one exam or degree. I have master degree here in Turku, and then doctor degree in Turku, but it was kind of formal requirement that I have this intermediate degree, licentiate degree as called in Finland, so I had this in Helsinki. I never actually studied there; I only took this degree there.

Then you went to Western Ontario in Canada?

1 was there for two years and I wrote this book "Theory of Automata" and it was a very nice period, it was developing a University and very nice colleagues.

How did you get contact to go to Western Ontario?

Actually, they have approached me, because Robert McNaughton, whom I've mentioned earlier, we were together in Berkeley, he had given lectures in a summer school in London, Ontario, and he had mentioned about my work on Axiom System for Regular Expressions and that is how they knew me. So, they contacted me, actually by phone, it sounded like a nice opportunity and I went there.

Kai Salomaa?

Kai Salomaa, yes he is my son. He is not actually there, but he is in Canada. He is in Queens University, Kingston. He was, of course, a small boy when I was visiting there, but actually I get regular contact with London and I have visited it almost every year, including last fall. Now, of course I have additional motivation, because my son is in Canada, and I want to visit him. But always when I visit Canada, I spent couple of weeks in London, because still there are actually many professors, my former PhD students, there are two who came from here, Turku Center for Computer Science, Lucian Hie and Lila Kari, they are both professors there now.

Then you went to Aarhus, Denmark?

Yes, in between I was five years in Finland, and then I was a Visiting Professor in Aarhus for two years. There I had also very nice time, that was kind of beginning time of Lindenmayer systems, this biological thing. I had some students in Aarhus, so we did some work there.

Then you also published this Mathematical Theory of L-Systems?

This was a bit later; it was actually written in late seventies, when I came back to Finland. I was together with Grzegorz Rozenberg, who is, really I can say, my best friend and we keep in daily contact, even now we phone each other every day.

Then in 1999, in a conference in Prague, you had a joint invited talk?

Yes, we actually started to talk and we practiced very much, saying the same things together and we both gave some parts of the talk after that.

That's really impressive, that you have so many co-authors, somewhere I have found over 50. And also all these students, associates, you said very close friends, for example Derick Wood or Hermann Maurer.

We all work in the so called MSW group and we work together.

How this group started?

It started so that Hermann Maurer invited me to Graz, he had also earlier worked with Derick Wood, and we started writing papers together and it was a very nice collaboration. It was always starting in the following way, that two of us start together and wrote the paper and the third one checked it, so this happened in all places. Derick Wood was in Canada, and Hermann was originally in Karlsruhe, Germany, but Maurer came to Graz, Austria, and I was here.

This huge group of your associates are from Romania, and they came here.

Yes, actually Moisil I knew a little bit, we have talked few times in the early sixties. I met him in a big math congress that is held every four years, and it was in 1962 in Stockholm. After that he came to Helsinki and I met him there. He had done work on mathematic logic, but then there was practically nothing in between, but only after the revolution in Romania. So first Lila Kari came here and then after that I had very close cooperation with Gheorghe Paun and Alexandru Mateescu, who died unfortunately few years ago. So these are the closest Romanians. And then of course, I had Romanian PhD students here, Valeria Mihalache and Lucian Hie here in Turku. Lucian Hie is now a Professor in London, Ontario.

And with Professor Mateescu you wrote a chapter in a handbook about languages something that is very interesting for me to ask. There is a table of languages, how they develop, and in one place you are mentioning Serbo-Croatian language, Bulgarian language, Macedonian language. Is it just because it belongs to the same family of Indo-European languages?

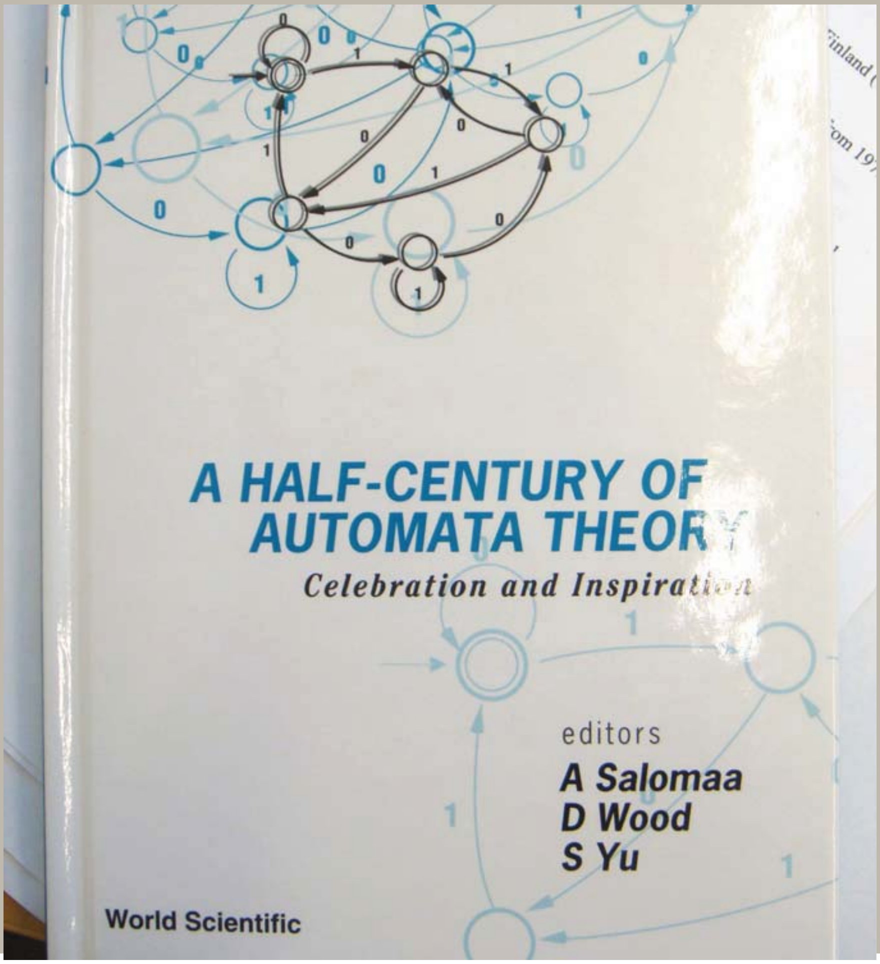
I think this refers to this table; this is more or less the table that appeared in some linguistic thing, it was in *Scientific American* or something similar. This is basically where we did not do any more details, this is just kind of introduction from language point of view, and this is more or less also from *Scientific American.*

Was it so that it was one Prototype language, proto-language, and that all other languages developed from it?

This is how it is viewed in Indo-European languages, so our original contribution here in this chapter starts from this *Formal Language Theory,* it is more under this telegraphic survey.

Your *book on Formal Languages, published in 1973, was referred in 1991 among the 100 most cited texts, and it is really impressive and after that appeared this Handbook on Formal Languages.*

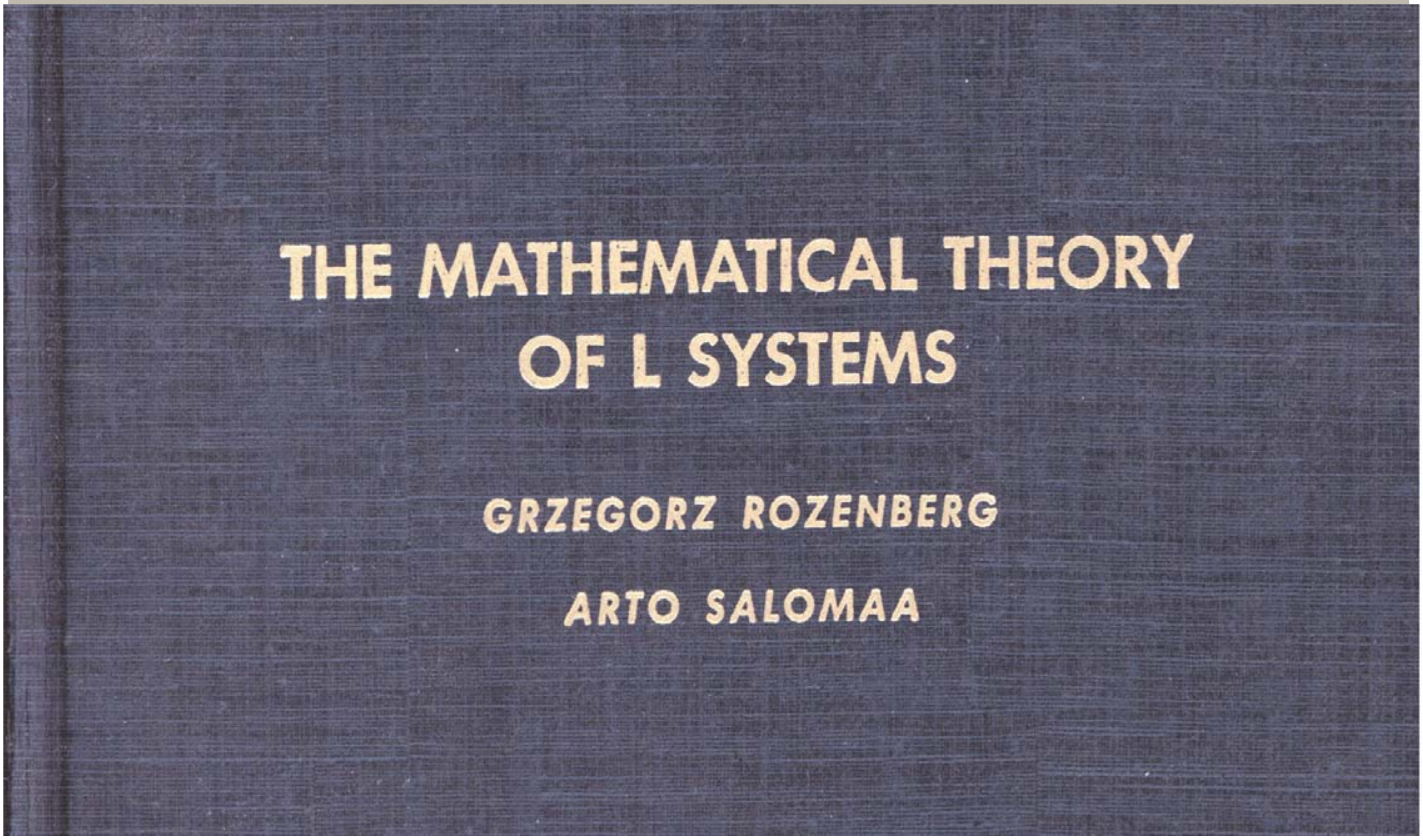
Yes, but this is entirely different thing. Like we say here, in some parts of


A HALF-CENTURY OF
AUTOMATA THEORY
Celebration and Inspiration
editors
A Salomaa
D Wood
S Yu
World Scientific

introduction, in that time, in 1973, one could really write about formal languages in a single volume and still bring the topic to the area of recent topics. But now, in nineties when the Handbook was compiled, this book has 51 authors. It was impossible to conceive such one book, and that's why we wanted to make this Handbook. I think that I have written some articles, like two articles with Mateescu and couple of others and also one with Lila Kari and Rozenberg about Lindenmayer systems.

Then about the origins of the Formal Language Theory, you wrote pretty much about this story of origins in combinatorics, computability theory, etc, What is you opinion on this now about these origins?

My opinion about origins has not changed. I have been mostly interested in these aspects that are kind of mathematical aspects, dealing with Automata Theory and combinatorics of words rather than these linguistic origins. These linguistic origins, for instance, the linguistic people they kind of emphasize different things, which, of course, have also led to very interesting mathematical formal problems. But, as regards the origins in general, 1 still think that formal languages came from many sources.



Emil Post, Axel Thue, Alan Turing, including Chomsky?

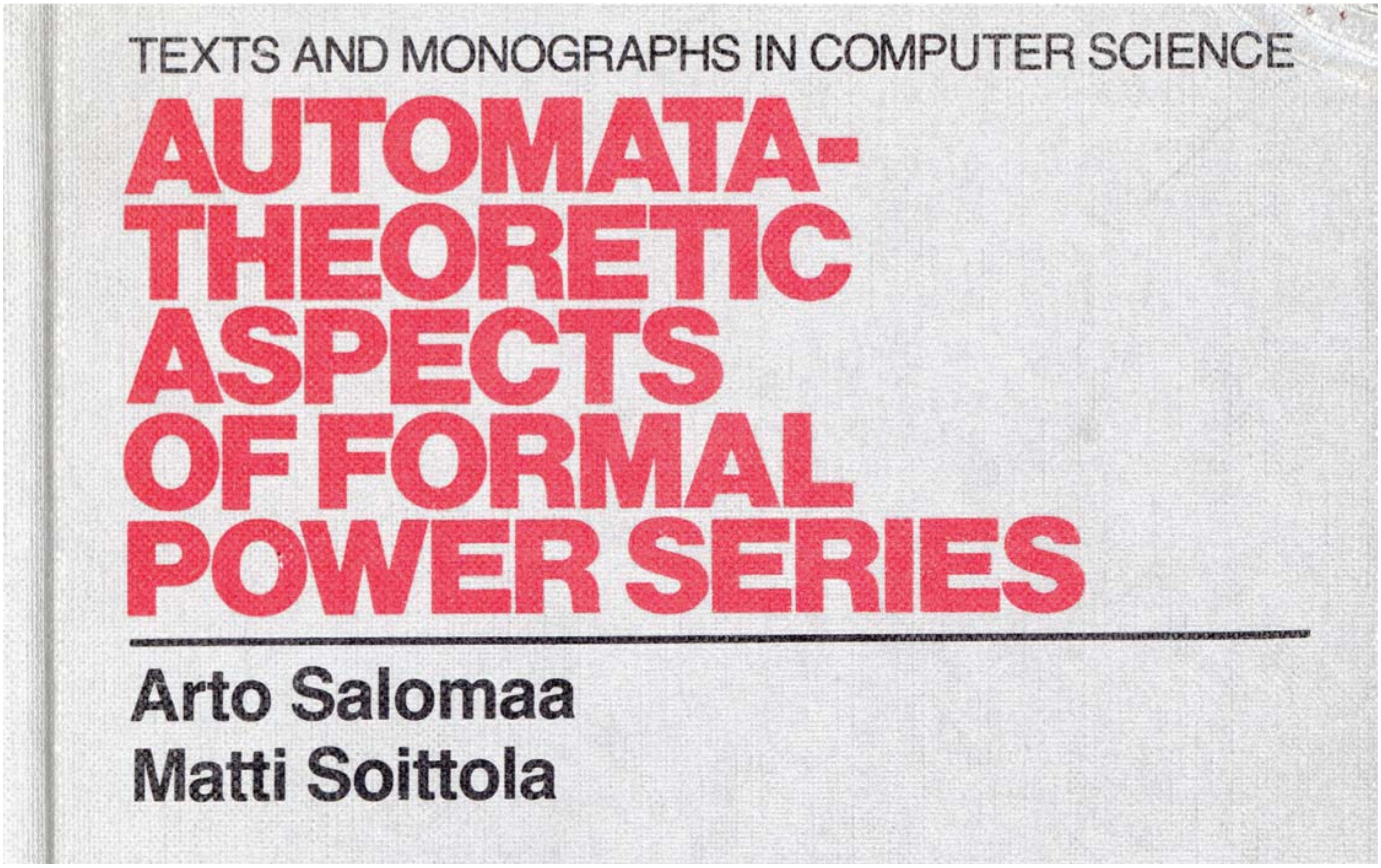
Chomsky is a bit different than the other three, from Post and Turing they are more of this my type of origins.

But it is also interesting that Emil Post had just one paper about multiple-valued logic, he started the same as you, and you also had several papers. Is it the normal way of development, starting from multi-valued logic?

No, it is very accidental.

But besides these Formal languages you are also interested in the Turku dialect?

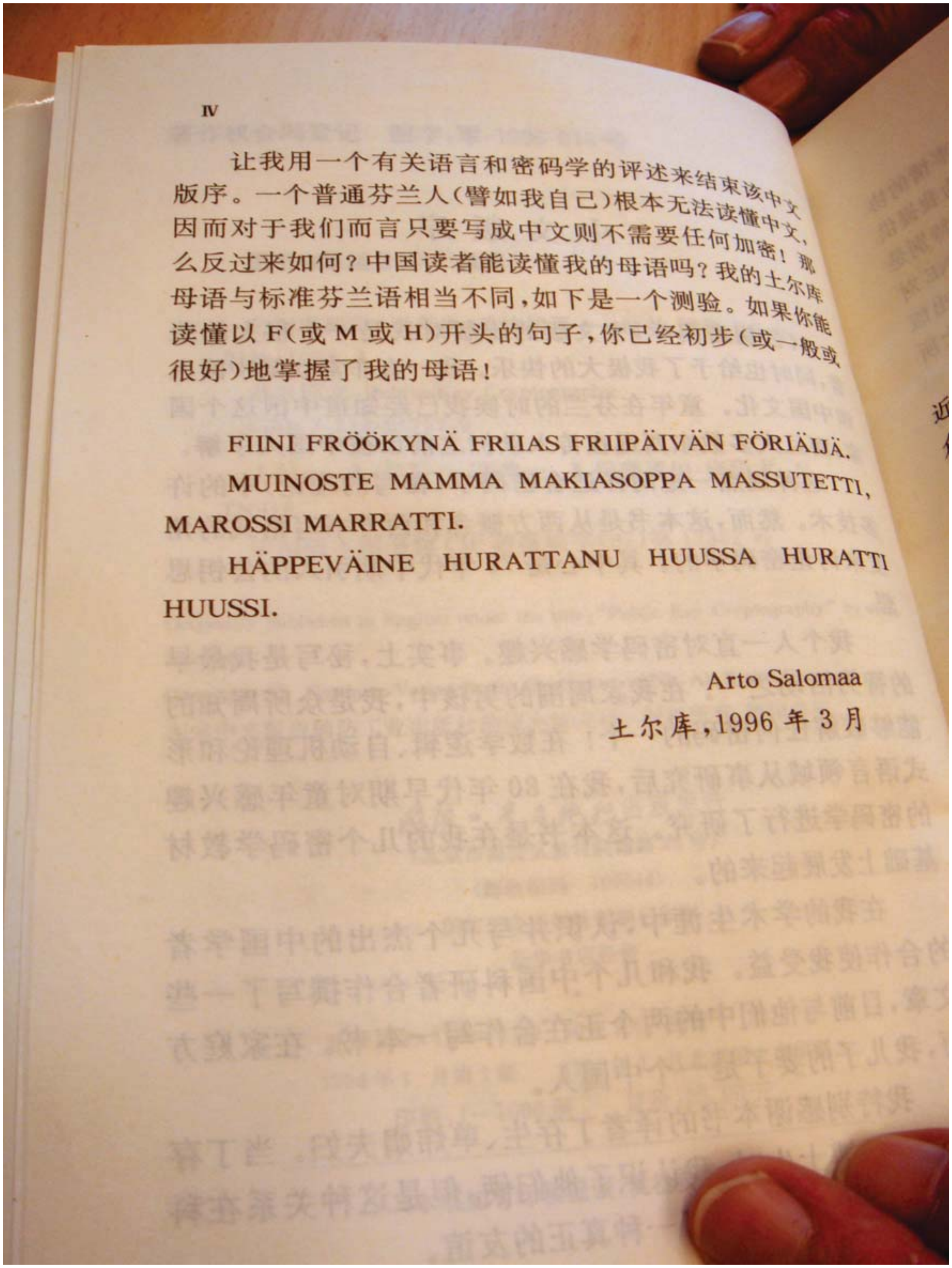
Well, to some extent, yes, surely. But I have not done anything formal about this or anything in writing about this, but in translations of my cryptography book, I have mentioned some examples of this Turku dialect. This is the Chinese translation of



TEXTS AND MONOGRAPHS IN COMPUTER SCIENCE

AUTOMATA-THEORETIC ASPECTS OF FORMAL POWER SERIES

Arto Salomaa
Matti Soittola



IV

让我用一个有关语言和密码学的评述来结束该中文版序。一个普通芬兰人（譬如我自己）根本无法读懂中文，因而对于我们而言只要写成中文则不需要任何加密！那么反过来如何？中国读者能读懂我的母语吗？我的土尔库母语与标准芬兰语相当不同，如下是一个测验。如果你能读懂以 F（或 M 或 H）开头的句子，你已经初步（或一般或很好）地掌握了我的母语！

FIINI FRÖÖKYNÄ FRIIAS FRIIPÄIVÄN FÖRIÄIJÄ.

MUINOSTE MAMMA MAKIASOPPA MASSUTETTI, MAROSSI MARRATTI.

HÄPPEVÄINE HURATTANU HUUSSA HURATTI HUUSSI.

Arto Salomaa

土尔库，1996 年 3 月

Cryptography Book, I think here my point is that if your language is Chinese, you don't need any cryptography because this is already a cryptography, and then I say that I ask whether the Chinese people could read these phrases in Finnish. Jaakko Astola would surely understand that. This last sentence is very good, you really have to know Turku language to understand this.

Another interesting question is, since you have so many associates, so many students, and you work with them in a different manner, maybe sauna was the place to meet them?

Yes, some of them yes, but the point is that some people don't want to come to sauna. Some Finns make this mistake, they kind of force people to come and my usual attitude is that, ok if you don't want to come to paradise that's up to you. I have never forced anybody to come to sauna, but certainly I've met some of them, like MSW group, we spoke about three-sauna-problems. Because, I have an idea that the veins in your brain open when you are in sauna. And then, if a problem is difficult, like Sherlock Holmes spoke of three-pipe-problems, we spoke of three-sauna-problems and that you have to go three times to sauna to solve this problem.

Salosauna is?

Salosauna is my sauna, I had it since 1975, it's about 50 km from Turku, it's very old building so we bought this, Salosauna was already built around 1870, so it's an old wooden building.

There is a song about it by Herman Maurer?

There is a song, but it's about people who came on the conference, it's not actually about Salosauna. Oh, he has also written about Salosauna, so you are right, it's actually in this book I have. So this is Hermann Maurer's poem, he has written several things about Salousauna, both in English and German.

And your paper "What computer scientists should know about sauna"?

Yes, this appears in this Bulletin, actually several times. It is also available in the net, and it's also in German translation, somebody translated into German and it was originally in English.

Have you ever met any Serbian Professor?

I have certainly met, like there was this Oberwolfach Conference in earlier times. I remember especially there was one Serbian, who was very good in drawing, but I don't remember his name. He drew a picture of me that was very good.

And you became a Doctor Honoris Causa of six Universities?

Yes, actually of seven. It was six, but I think Graz was the latest.

What is your cooperation with those Universities? Do you have some cooperation in teaching or giving lectures?

The first one was the Swedish University in Turku, and of course I had some colleagues there, then University of Oulu also in Finland, my former student is a Professor of Math there and I have been there. In all of these Universities I have some contact and in Bucharest, Szeged in Hungary, then Magdeburg in Germany, there I also knew people. I have visited University of Latvia in Riga. I think in all of them there has been some cooperation, more or less. Like, just yesterday I got an invitation to State University of Latvia, they have some celebration, they could be 90 or 100 years old and they invited me, but I'm not planning to go, because I don't travel so much these days anymore.

known result about regular sets (over free monoids) to regular sets over arbitrary monoids, there must be a reason, mathematical or otherwise, for doing so.

I have written about sauna elsewhere (for instance, see [19]), so I do not discuss here matters such as what is a sauna and what is a good sauna. Instead, I will let some of my friends and colleagues speak. During his visits, Hermann Maurer has written me so many poems that I could edit a book of sauna poetry by him. First a passage about sauna in general.

> Salosauna, once again
> heightens joy and heightens pain.
> Underlines what maybe counts
> what this life in truth amounts.
> Through this sauna's windowpane
> past some sunshine, wind and rain,
> our hearts and eyes and ears
> cut through all the passing years:
> see the friendships that stay strong,
> newborn faces, happy song.
> Memories taste sad and sweet
> as they rise in sauna's heat.

Then some lines of Hermann describing difficult problems:

> Als Arbeitsaufenthalt ersonnen
> hat es mit Sauna gleich begonnen.
> Wir schwitzten, dachten, tranken viel
> vergassen aber nicht das Ziel:
> Erweiterung der Theorie
> wir wollen ganz erforschen sie!
> Wir haben also nachgedacht
> ob das, was uns so Kummer macht:
> die Dichte endlich Systeme
> sich lösen lässt durch Theoreme
> die ohne Sauna schwer zu finden
> und Wert sind, dass wir sie verkünden.
> Nun, das Problem, es scheint nicht leicht,
> 's hat eine Sitzung nicht gereicht,
> sodass die Lösung wir mit Sorgen
> verschieben mussten bis auf morgen.

Nobody can be more convincing than Werner Kuich:

> Salosauna, Finnische Freunde, Ruhiges Rauhala
> Allzulange entbehrt.
> Kaarina, die kundige Köchin,
> und Arto, den Allgewaltigen
> sowie Salosauna,

grüsst Werner aus Wien
der deutsche Dichter.

Wer diese "letzten Sieben" überlebt hat,
der kann wahrlich sagen,
dass ihm nichts Saunamässiges mehr fremd ist.

Azaria Paz is also in a poetic mood:

Salosauna
What a sauna
With the flora and the fauna
Naveh shalom
And the sky above

And so is Bolgani Rozenberg ("löyly" is the Finnish word for sauna heat and "supikoira" is a raccoon dog):

When you come to Tarzan nest
You get sauna at its best
Where you can admire
Löyly and birch wood on fire
A lot of flora and fauna
Can be seen from Salosauna
But with Bolgani and nice weather
You can see two supikoiras together

Most of the time Bolgani is very practical:

> This time Bolgani was flown into sauna! It took some 50 minutes from the moment that the plane landed until the moment that Bolgani has entered Salosauna. We had three sittings. The EATCS Monograph matters were settled already in the first break between sittings – real Salosauna efficiency .... This was the most responsible day in Bolgani's life: I had to take care of fire going in three locations in the sauna building and in the living room of Salosauna Administration Building (= Rauhala). In heating Salosauna I've applied the ESP (Energy Saving Principle): the heat should be so good that for the next two days one can still use the Salosauna in optimal conditions. It looks like I've succeeded. In fact, the family room in the sauna building was so hot that we were going from it into the sauna room just to cool down.

Derick Wood was always good in enumeration problems:

Fifty thousand buckets of water,
Thirty thousand logs,
Five thousand bottles,
Two thousand candles,

Two thousand matches,
One thousand newspapers,
One thousand birch twigs,
One radio, and
One salosauna
make one thousand salosauna sittings.

I conclude with the lines of Andy Szilard:

In the heat
when friends meet
it's a real treat
even though they burn their meat

as well as with those of Andy's former teacher of English, the late Ron Bates ("kiuas" is the Finnish word for sauna stove):

The kiuas is there,
The marriage of water and stone,
And fire, this is where
We come to be one.

References

[1] A. Aho and J. Ullman, The theory of languages. *Math. Systems Theory* 2 (1968) 97–126.

[2] R.V. Book, Problems in formal language theory. *Proc. 4th Princeton Conf. on Inform. Sciences and Systems* (1970) 253–256.

[3] N. Chomsky, On certain formal properties of grammars. *Information and Control* 2 (1959) 137–167.

[4] M. Davis, *Computability and Unsolvability.* McGraw-Hill (1958).

[5] F. Dejean and M.P. Schützenberger, On a question of Eggan. *Information and Control* 9 (1966) 23–25.

[6] S. Ginsburg, *An Introduction to Mathematical Machine Theory.* Addison-Wesley (1962).

[7] S. Ginsburg and E. Spanier, Finite-turn pushdown automata. *J. SIAM Control* 4 (1966) 429–453.

[8] V.M. Glushkov, Abstraktnaja teorija avtomatov. *Uspehi Mat. Nauk* 16 (1961) 3–62.

[9] S. Greibach and S. Ginsburg, Multitape AFA. *J. Assoc. Comput. Mach.* 19 (1972) 193–221.

[10] S. Greibach and J. Hopcroft, Scattered context grammars. *J. Comput. Syst. Sci.* 3 (1969) 233–247.

[11] M.A. Harrison, *Introduction to Formal Language Theory.* Addison-Wesley (1978).

[12] N.E. Kobrinskij and B.A. Trakhtenbrot, *Vvedenie b teoriju konechnykh avtomatov.* Gosud. izd. Fiz.-Mat. Lit., Moscow (1962).

[13] G. Rozenberg, Decision problems for quasi-uniform events. *Bull. Acad. Polon. Sci.* XV (1967) 745–752.

[14] G. Rozenberg and A. Salomaa (ed.), *The Book of L.* Springer-Verlag (1985).

[15] G. Rozenberg and A. Salomaa (ed.), *Handbook of Formal Languages*, I–III. Springer-Verlag (1997).

[16] A. Salomaa, A theorem concerning the composition of functions of several variables ranging over a finite set. *Journal of Symbolic Logic* 25 (1960) 203–208.

[17] A. Salomaa, *Theory of Automata*. Pergamon Press (1969).

[18] A. Salomaa, *Formal Languages*. Academic Press (1973).

[19] A. Salomaa, What computer scientists should know about sauna. *EATCS Bull.* 15 (1981) 8–21, and 35 (1988) 15–26.

[20] C.E. Shannon and J. McCarthy (ed.), *Automata Studies*. Princeton Univ. Press, Princeton (1956).

[21] D. Wood, Bibliography 23. Formal language theory and automata theory. *Computing Reviews* 11 (1970) 417–430.

Then you became a Member of four Academia; it is Finnish Academy, Swedish Academy in Finland, Hungarian Academy, then Academia Europaea?

Actually two in Finland, they are Swedish speaking Academy in Finland, then Academy of Sciences in Finland.

You are very active there?

I am not really very active; I very seldom go to these meetings. Like, these two Academies in Finland, they meet in Helsinki and I usually don't go there, very seldom.

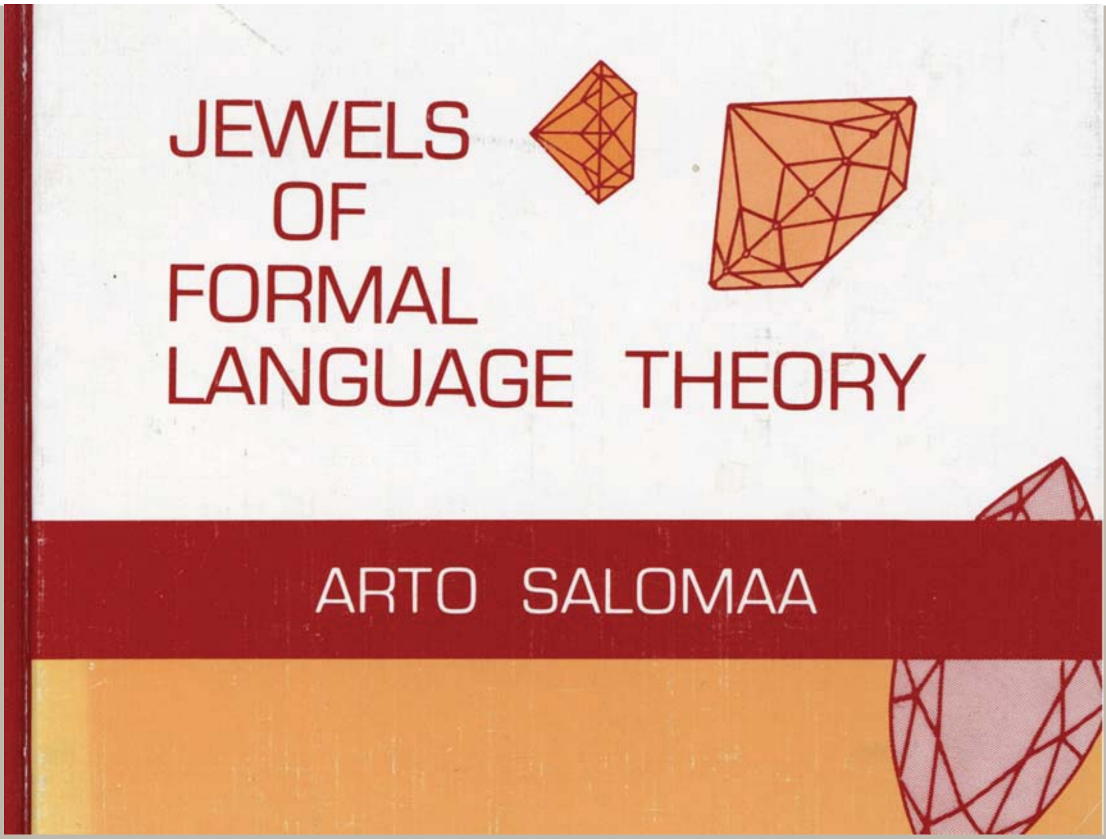
And about this European Association for Theoretical Computer Science, you have been there a president and chairing it, etc. What you can tell us more about this Association?

This was kind of small at the beginning and I was somehow involved in it from really early stages. And then it started to develop and it became almost equally big as the corresponding association in America. It used to have these main activities, so it has this Bulletin which they publish; I had my Formal Languages column there for decades and it publishes other things, like reports from the conferences, announcements of the conferences and this *Theoretical Computer Science* journal used to be also the journal of this Association. But I don't really know what exact relations are now, maybe it is not advertised that much anymore, this Association. Then also we had this book series which were initiated by this Academy.

You have been very active in this Nevanlinna Institute and also jury for the Godel Prize. What are your memories about this?

I was a member when it started, about 10 years, but it seems very long time ago now, now it's something like that my job finished there in early nineties. But it was first kind of Institute common to all Universities in Finland; it was in Mathematics and Computer Science. Its activities included, for instance, and this is still true, they give prize for the best Doctoral dissertation in Mathematics in Finland each year. Some of my students have also got this prize from the Nevanlinna Institute. The Gödel Prize is kind of common between this EATCS and the corresponding American organization. I was there and there are some rules how many years you serve there. I have served there many years as the rules say and at least once, one year I was Chairman in this. It selects what is called Gödel Prize for the best article in Theoretical Computer Science within the last five years also.

You said Mathematics and Computer Science; are they different or maybe they are combined areas? How do you feel about this?



They are certainly combined areas; it is very difficult to say what about Automata Theory and Mathematics, it is very close to Semirings Theory and it is very mathematical and this Formal Power Series is of course very mathematical. This of course concerns Theoretical Computer Science and Computer Science in general.

You have selected very interesting titles for your books, one was "Theory of Automata", then "Computation and Automata" and then it was this "Jewels of Formal Language Theory". It is a very interesting title.

This Jewels was kind of, actually the other two you have mentioned they were kind of general research, but this Jewels was intended to present mathematically beautiful things in Formal Languages. The model for this book was this Russian Khinchin's book "Three Pearls of Number Theory" so I had this as a starting point for this Jewels book.

You have mentioned Russian authors and it's mainly Soviet time. Was there any influence of Soviet time to Finland, especially science in Finland? Where they completely independent?

Yes, certainly. In my case there was no, but this can vary from field to field, like there was some definite cooperation in certain technical areas. Of course, I had some Russian colleagues who visited me here and so forth. My main contacts were not in Russia.

How about the way of studying or life of a student here in Finland and maybe States? Was it so different?

Maybe not anymore now so different. But in my time it was very different, because in that time students were really on their own, there was very little guidance and Professors were very big bosses and you couldn't see them much. It was very different from when I went from here to Berkeley, to see that famous persons, like Tarski, were available for an ordinary student like me.

How could you see Finland and science in Finland now in the world perspective, because we all know Finland is one of the highest tech countries?

Well, it is very difficult to say in general for Science, but I think in my area, Theoretical Computer Science, Finland is very good and there are my students and there are also a lot of other people. And if you relate this to the number of people in the country, I would say that only Israel is maybe equally good in Theoretical Computer Science as Finland. Otherwise, Finland is superior if you take the number of people in the population in the country.

How do you feel, how it happened that Finland is so highly developed after so terrible time, World War in Europe? After Second World War, you had very hard time, is it mentality of people?

I think one reason was, that there were few instances in history where a small country like Finland, was able to defend itself from a vastly superior power like when Finland was in the Winter War and in the Second World War Finland was never occupied by foreign troops, and this makes Finns kind of proud and maybe people didn't want to leave the country. This is of course one explanation. The other explanation would be that in sauna veins open, but this is very difficult to say.

Turku was a former capital in some period. And is it Turku capital in science and how are the relations between Turku and Helsinki, Turku and Tampere?

I think they are good, of course I can say that Helsinki now has bigger Institute and definitely much more people, it is also capital in science, there is no question about it, but I think relations are good, and also with Tampere relations are very good. I personally have very good relations with both Technical Universities and former Rector Timo Lepistö, who is now late, he died unfortunately early, we were very close personal friends and I have visited Tampere quite often. Even now I have good contacts there with both schools, Technical University and University of Tampere. But these are smaller places, but if you ask for capital, then you have to say it is Helsinki.

I would like to ask you more about this Many-Valued Logic, because it is my field of interest. Once you have written that the interpretation of the values could be very important for practical application. But how to think about it, what could be the interpretation, do you have your own opinion?

Well I have not been thinking about this so much lately. Of course, the interpretation could be different kind of probabilities, but I think that basically some meta language level things start to be two valued after all. My work in many-valued logic and my own contributions were not in these interpretations, but this could be considered as purely combinatorial topic that is this Composition Theory of Functions over finite sets, truth-values are from finite sets and using this compositions, you can get any function. This can be stated as strictly mathematical topic without any reference to many-valued truth values. But I was also involved, this was a second part of my thesis, I wrote something about axiomatisation of logic, but it was never published. Of course, later, there were many works done on this.

Since you analyze the history of many-valued logic and origins? Do you see the perspective of this area, maybe from engineering point of view, concrete applications?

I know there are many people working in this area and many things have been done since I was interested in this. Certainly, there are applications, but I am not so much aware of them, so it is difficult to say, but certainly the engineers have been working on this.

And about this DNA computing?

DNA computing is entirely different thing, so that was the field I've got interested, because it is very nice from the Formal Language point of view, because it brought entirely new problem areas. It is also very nice in these steps that it could bring something entirely new, because you have this massive parallelism, once you make this DNA soup, then you can encode all possibilities, and then all these complementarities and the combination forms, you get kind of computation really in this sense. This really could lead to something, but it is also difficult to compare which one is more promising, the quantum computing or DNA, but really no striking applications have been shown yet. It is kind of, how should I say, I do not believe either one would ever substitute normal computers. In some problem areas, I can visualize they can be very useful, especially Quantum computing could be very useful in cryptography. And DNA computing also if one can really take care of this massive parallelism in laboratory.

About these regularities that are described by using the L-systems, you also mentioned the Sierpinski triangle, are they really appearing in nature, are they *natural that should be mapped into mathematics or they are more mathematical and then we suddenly discover something in nature that matches them?*

Well, it's both ways, so one speaks much about this general term Natural computing, so it is computing model by nature, like genetic algorithms to one can look as algorithms that started in nature. We look what happens in nature, and then perhaps we can bring this to our own computing devices. So, this is a really very very promising approach.

And about these regularities and automata - do you think that automata are very good models to describe a lot of different phenomena or how would you say? Automata they are more mathematical models for many phenomena?

They have been used really, like this text editing and many things like this. Now there is very much advanced theoretical work done on this complexity of basic automata operations, these regular operations. For instance, if you search certain texts, certain subtext, then really automata are very helpful, but it is certainly not everywhere, so you have to look what kind of problems come up and then decide.

What would be the vision for the development of Formal languages in the future?

There is of course this, that I would like to call the French School, that are very much in this combinatorics on words and This kind of mathematical aspects of words. Then, there are these various linguistic approaches that are good topics for natural languages. Now there are all kinds of families that are bigger than context-free languages, like one that we studied that are good for natural languages. There are recent things like these biological things like this slicing that we have done in DNA computing, and there are many areas, so I cannot say which one will be most important in future. The only thing I can say for sure is that this French School, this mathematical topic are important, because mathematics will always be there, but how important are other things will depend on whether they really bring something significant to this.

Do you think that you, somehow, always support this mathematical approach to Formal Languages? Does it mean that mathematics is an essential thing in this area?

Yes, certainly, of course.

And there is *this binary Logic, Multi-valued logic, Fuzzy Logic? What do you think about this Fuzzy Logic, because it is close to computing with words?*

Yes, there are all kinds of claims that Japanese have made all kinds of equipment using Fuzzy Logic. I don't know so much about this, but there was one doctoral student here in Turku who moved latter to Lappeenranta working in this area and then I had to know a little bit of this. I think that certainly one can not ignore this topic, it is very promising approach, because I think that life is not this black and white, but there are different shades of gray and similar things in all kinds of situations, for instance if it is cold or not in this room, etc. For all kinds of regulating devices, you need this Fuzzy Logic for sure.

Would you like to visit East Euorpe one day, maybe Serbia, I would like to invite you?

I would like certainly, however, as I said, I travel very little these days. My health is otherwise ok, but I have very bad knees, so I'm using stick when I walk outside. The only trip I like to go is that I usually go once a year to Canada, and occasionally something else. But, very few trips abroad these days.

There is another interesting question. Your son is working in your field. How does it feel to perate with your own son in the same field? Is it easy?

It is, of course, very easy, but we have not cooperated very much, but we had some joint publications. But mainly, in all of these publications, there is not a single publication where are just two of us, there is always somebody else. My Chinese friend Sheng Yu is in many of these.

You have visited China?

I have not visited China, but also I have contact, because my son is married to a Chinese.

And about translations of your books, they have been translated in many languages. How do you feel, is translation always very close to the original or not so similar?

Except for German I cannot tell, for example for Chinese and Japanese I cannot tell at all, then I think also Romanian and Vietnamese, they have been really translated into languages that are not familiar to me. And there is this German translation of Formal Languages that is very good. And there is also French translation of one of my books that is also ok. Then Russian translations, I know and I can read a little bit of Russian but I cannot really tell is it good or not. There is this DNA computing in Russian translation, and it is probably very good, because these are very good people who translate.

You probably receive many letters from your former students all around the world?

Yes, especially now e-mails, I get quite.

How is it to work with someone and become a friend at the same time? Does it simplify the scientific work or when you are friends you cannot fight that much and argue on some topics or does it just helps?

It certainly helps, so I would say that my best friends are really people with whom I have worked very much. So it certainly helps and I would say that good cooperation is something where you don't count how much work each of you does, but everybody tries its best. This was always the case for this MSW group, we never counted we should do equally, and everybody tries to do as much as possible. There are also different types of people, like some people do not like to write things up, so I like to write things up. It is very often, when we have certain results, then I write the paper up, and I produce the final results.

How about mathematical proofs? Do you like to prove your theories or you just come up with some theorem, and you know that it's correct and you don't like to write a complete proof or do you prefer to do that?

Of course, if you publish it, you should write a proof and you should write it in reasonable big details. When I write a proof, I usually do so, this is my style of writing. I also provide some intuitive application. There are also other styles, that are strictly formal, that say this is this, and this is this and it can go several pages, and one doesn't really know what is happening. Some people think this is not good, but I think it is good that I always like explanations, like now we do this because we try to get this at the end and so forth.

And about examples in writing?

Examples I like really much. I liked very much, with this Romanian, my very good friend, Alexandru Mateescu, who died 3 years ago. We were different in this sense, I always when we came up to a new thing, and then he started to generalize it to get algebraic generalizations, and I wanted to have specific examples to see where it leads to.

What is the topic that you maybe would like to say, and that I would ask, and I didn't ask about? Maybe some things considering work with students, after so many years of experience?

There are of course many things, one thing I would like to say is a personal thing, I like classical music very much. I usually say that if you have a very beautiful mathematical results, this is something like Beethoven quartetto or something like this. Mathematics can be really very beautiful and this is what I also like to say, that mathematics is a great fun. If you really have some problem and you are really making some progress and prove it, then there is no other thing that I would like to do more. Like I want to watch football and my favorite example is that there was a World Cup Final in football, it was between Germany and Argentine in 1990, and at the same time I had a really a very nice thing to write. Then finally I watched the final, but immediately I came to this that was interesting.

Are you playing some instrument?

I'm not playing myself. This is also when I compare music and mathematics, it is that you can really enjoy in music without being professional, but I doubt whether you could really enjoy mathematical beauty without being, at least to some extent, professional.

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