



## Grzegorz Rozenberg

Professor G. Rozenberg received his Master and Engineer degree in computer science in 1965 from the Technical University of Warsaw, Poland. In 1968 he obtained Ph.D. in mathematics at the Polish Academy of Sciences, Warsaw. Since then he has held full time positions at the Polish Academy of Sciences, Utrecht University, The Netherlands, State University of New York at Buffalo, U.S.A., and University of Antwerp, Belgium. Since 1979 he has been a professor at the Department of Computer Science of Leiden University, The Netherlands, and an adjunct professor at the University of Colorado at Boulder, U.S.A.

Professor Rozenberg was the President of the European Association for Theoretical Computer Science (EATCS), 1985-1994, and he is currently the chairman of the Steering Committee for International Conferences on Theory and Applications of Petri Nets. He has published about 300 papers, edited about 30 books, and written 3 books. He is the editor of the Bulletin of the EATCS, the editor of the series Advances in Petri Nets (Springer-Verlag), and a co-editor of the Monographs in Theoretical Computer Science (Springer-Verlag). He has been a member of the program committees for practically all major conferences on theoretical computer science in Europe. He is also involved in a number of externally funded research projects on both national and international levels.

He is a foreign member of the Finnish Academy of Sciences and Letters, a member of Academia Europaea, and he holds a honorary doctorate of the University of Turku, Finland.

## The Magic of Theory and The Theory of Magic

I will recall here, and reflect upon, the places I have been, the events that I have witnessed or participated in, and the people that I have met. I will not

discuss (in any depth) my ideas about science, or technical aspects of my scientific work, since they are explicitly or implicitly visible in my papers and books.

## Warsaw, Poland

I have received my basic education in Warsaw, Poland. The high school I attended had (as usual) bad teachers and good teachers; as a matter of fact the bad teachers were in the majority. I have always had a bad memory and this has determined many choices in my life, like, e.g., the choice of topics I did like in school and those that I didn't. For example, we had a bad teacher of chemistry, and moreover it seemed to me then that the main aim of the chemistry classes was to memorize difficult names of molecules and compounds. Thus, I did not like chemistry at all. On the other hand, we had a fantastic teacher of mathematics, and at a very early stage I realized that you don't have to remember things in mathematics because you can deduce "everything". Thus mathematics has become one of my most favorite topics. I also did like very much literature and poetry. I wrote poetry during the high school and during my studies – most of it is lost by now.

Some of the books that I had been reading when I was in school, were books that were not available in Poland after the war, for example westerns. The way to get these books and to read them was very memorable. You could borrow such a book (or a hand written copy of it) for a specific period of time, and then you had to rewrite it by hand. You had to return the book to the owner, but in this way you were in a possession of the manuscript that you could read several times, and moreover you could exchange it with other boys for their manuscripts. I surely rewrote many books during my school times.

I had two passions during the school. One of them was playing cards, and the other one was fencing.

Playing poker was very popular after the war in Warsaw. You had to pay with cash, or with some of your valuable possessions (like pocket knife, or a key ring). I remember that I could not concentrate on a poker game, because when I would get five cards into my hands, I would start thinking about various arrangements of the cards so that something "unusual" would happen. This must have been very annoying to my co-players, and so I was excluded from playing poker. However, I have been inventing some nice tricks with cards, and at some point I started to show them to my friends. Then I regained their respect because I could do something that none of them could. I remember being very proud of this.

Already at the beginning of the high school I was accepted into a fencing club. Fencing became my most favourite sport. One should know that in the '50s and in the '60s Poland was one of the very top countries in the world as far as fencing was concerned. I had been lucky to get into the hands of a trainer, a Hungarian by origin, who was also the trainer of the national team. He was very encouraging towards me, and so I must have been really good. I remember that one of the unpleasant consequences of becoming a student, after the high

school, was the choice between studying and fencing, which I had to make if I wanted to be good in either of the two. Fencing was very useful for me because I have often walked in Warsaw in the evening with a stick in my hand, which I could use to defend myself if attacked by some thugs. As a matter of fact, this has happened several times, and I could defend myself quite well.

Yet another passion of mine was dancing, which was quite natural because it has also involved the footwork which is so important in fencing. Later, during my studies, I was working in a jazz club and in a student club, where dancing was the main activity; dancing jazz or rock and roll was considered very cool then.

I decided to study electronics because it looked to me like a very nice way of combining physics and mathematics on the one hand and the technology on the other. At that time, the word “electronics” was synonymous with the most modern technology. The study of electronics was very popular and so the entry exams were very competitive – only one in ten candidates has been admitted. The entry exam was really hard.

A big part of the study of electronics was very interesting, but there were a lot of classes, especially in the first half of the studies, that were totally useless in any sense, and taught by totally unintelligent teachers. I did however enjoy many classes – the mathematics and physics programmes were very good, and I liked very much information theory, design of electronic lamps and transistors, electronic circuit design, analogue computing, and all kinds of laboratories.

The Soviet Union was the biggest pirate in the market of translation of books – they were translating many books published in the West without any permission whatsoever. That must have been awful from all legal points of view, however it was wonderful for Polish students and scientists. We could buy translations of all kinds of scientific books published in the West and this was the only access to these books we had. I still remember the joy of buying such books (and starting to read them in the bookstore already). Obviously we never knew that producing these books by Soviet Union was illegal – it was axiomatic that everything that Soviet Union did was legal and admirable.

I have been a big lover of theater and during the studies I even organised a Society of Student Fans of Theater – I remember that quite many times we, the students from the society, were in the big majority in theater. There were many terrific actors in Warsaw, and very often a performance, of even a classic play, was a symbolic protest against the system – the audience always knew that!

What was really great during these years in Poland were jokes. Jokes formed a natural survival tool in the system of total arrogance and stupidity. It was quite dangerous to tell good jokes – but one always knew with whom one could exchange them. As a matter of fact, the best jokes were the political ones – here is one. “The biggest factory in the world was built in one of the communist countries. Many visitors are coming to see it. A very proud mayor of the city where the factory was located is driving one of the important visitors to the factory. When they arrive at the entrance gate, the mayor says: “This is the biggest factory in the world, it employs about 15000 people”. Because of the

noise of a passing truck, the visitor has not heard the end of the sentence, and so he asks “How many people work there?” The mayor says “Oh! you mean work”, and then he adds “May be two or three”. This is an example of a beautiful abstraction: the communist system has destroyed the work ethics – factors other than the quality of your work were determining your position, your salary was the same whether you really worked or you were pretending that you work.

Students could do the army service in such a way that (for a number of years) one day a week was spent (in uniforms) at army barracks in Warsaw. Also one or two summers were spent in some army unit in a country. There were exams taken each semester, and failing them was really dangerous because this could mean the regular army service after the studies. My relationship with the army was simple and symmetric: we hated each other! I often had nightmares that I will have to do the service after my studies. Fortunately, this has not happened, which (at least partially) was due to the fact that I had to give private lessons (mostly mathematics) to the military that were following (were forced to follow) some evening classes in order to get some kind of certificates. It was a clear blackmail, but I accepted this as the best way out for me from the awkward situation that I was in. As a matter of fact, being a good student in science has helped me in a number of ways. I was giving private lessons in mathematics and physics already in high school – this provided me with a nice way of earning money; this continued also during my later studies. It also saved me from the army service. Moreover, during studies I could do assignments (also optional) quickly and well, and so I was allowed to skip some of the exercise classes which were scheduled for each week. In this way I could collect free days which I was then using for visiting my girl friend Maja (now my wife) who lived in a different city.

I chose to specialize in “mathematical machines” – this is how computers were called then in Poland, and it was a very good choice indeed. I was in love with all the stuff that we were learning, especially the engineering aspects of computer architecture. I did not like programming so much because totally stupid paper-punching mistakes made programmes totally unusable. I still remember spending a lot of time with paper punchers (using Hollerith code) for correcting mistakes.

I wrote my master thesis on the theory of algorithms (for the engineers!) – it looked very challenging for me then. My advisor, the director of the Institute for Mathematical Machines, was very fond of my thesis and was showing it to many people (even when it was not completed yet). Somehow in this way I got into contact with Andrzej Ehrenfeucht who worked then at the Mathematical Institute of the Polish Academy of Sciences. This has changed my life in many ways.

In 1964 I was offered a position at the Institute of Mathematics of the Polish Academy of Sciences, IMPAS, in the group of Mathematical Logic headed by A. Mostowski. I had been also offered a position in the Electronics Department of the Technical University – my advisor wanted to keep me there. I chose the offer from the Mathematical Institute, because, especially through my contacts with Andrzej, I had discovered the **MAGIC OF THEORY**.

Mostowski was a very kind man of very good manners. He always had time whenever I wanted to talk to him. I still remember the interview when he offered me a job. Looking through the papers he said at some point: “I see that you will be the youngest member of the Institute”, he paused and then he continued “but this problem will resolve itself with time”. Other members of the group were Andrzej Ehrenfeucht, Grzegorzcyk and Zdzislaw Pawlak. I had a lot of contacts with Andrzej and Zdzislaw, and much less with Grzegorzcyk. The years in the Institute were very exciting for me. It was great to see famous people like Kuratowski, Mostowski, Łoś, and Sierpinski around. But the main reason for my excitement was the fact that I was coached by Andrzej and Zdzislaw who were always there to talk to me. Andrzej a real virtuoso of theory, and Zdzislaw, a real master of capturing the essence of various applications and translating them into elegant models.

Several books and papers influenced me very much at the beginning of my scientific development. The books were: “Abelian categories” by P. Freyd and “Computability and Unsolvability” by M. Davis. The papers were “Finite automata and their decision problems” by M. Rabin and D. Scott, “Linear automaton transformations” by A. Nerode, “Formal properties of grammars” by N. Chomsky, “The algebraic theory of context-free languages” by N. Chomsky and M.P. Schützenberger, and “On formal properties of simple phrase structure grammars” by Y. Bar-Hillel, M. Perlis, and E. Shamir. Especially the last three papers had a lasting effect on me: I became a “grammar man” and remain so until today. The Mathematical Institute had a wonderful library (where the wife of Mostowski was the main librarian) – I found the above books and papers in our library. Later I got my own copy of M. Davis’ book – I do not remember how I got it, but it was then one of my cherished possessions.

I had already discovered automata theory during the last year of my study and together with a friend of mine, Pawel Kerntopf (who was an assistant professor), we organized a seminar on automata theory at the electronics department. Some of the very good students joined it, together with some young members of the scientific staff. I had been working in parallel on category theory and automata theory. The paper by Rabin and Scott had led me to consider multitape automata. Through my work on axioms for the category of relations I got into contact with Eilenberg. I was very impressed when I met him, and I was very proud to learn that he was also working on the axioms for the category of relations with a considerable overlap with my work. I remember that he was very encouraging towards me then.

Working at IMPAS gave me an opportunity to meet some well-known scientists. Thus, e.g., I met Solomon Marcus, who was visiting Pawlak in Warsaw. We talked about contextual grammars, which he started to develop then – by now the theory of contextual grammars is well recognised in linguistics and formal language theory. As a matter of fact, many years later, in the mid-90’s, I have worked quite intensively with Gheorge Păun, Arto Salomaa, and Andrzej Ehrenfeucht on the theory of contextual grammars. When Marcus was in Poland I took him to the city of Lodz, where Maja lived. I offered Marcus a number of

possibilities to spend an evening together with Maja and her parents. He explicitly asked me to take him to see an operetta, which I did. During the play I had been quite worried that Marcus did not understand the songs - everything was in Polish. When I told him (after the show) about my worries, he told me that this is exactly what he wanted. He was writing a book on the mathematical theory of theater, and this particular evening he was just conducting an experiment: how much can one get from a play without understanding the language!

Nowadays I am working on DNA computing which also involves the planning of experiments. It looks like I may have some talent for doing this. If so, then the roots of this talent may lie in my Warsaw times. At some point I was convinced that my phone was bugged by the police. In order to check whether it was so, I had decided not to pay my telephone bills for some time. Usually, if one would not pay the bills even for a short period of time, the telephone would be cut off. Since the police were apparently interested in listening to my conversations, my phone was not disconnected - this experiment had confirmed my conjecture that the phone was bugged!

Marcus invited me to Bucharest to present my results in formal language theory. I was very happy to go there to continue our discussions on contextual grammars, and other topics. I went by train. The first border to be crossed was the border between Poland and Soviet Union - it certainly did not look like the border between two countries belonging to the same political block. It looked much more like an entrance to a concentration camp with all kinds of grotesque fortifications. I had been working on my lecture for Bucharest, when the Russian border police entered my compartment. They asked for the passport and other travel documents that I had for this trip. They certainly did not like my face. I had a book by S. Ginsburg on context-free languages on the seat next to me. The Russian officer (apparently the head of the trio that have entered my compartment) took the book and noticed the word "New York" on the first page. He asked then why do I have "This American Book". I have explained to him that I am going to Bucharest to give a lecture and that this is a mathematical book that I was using for preparing my lecture. "Aha!" he said, and asked immediately "do you have more of this type of American propaganda with you?" Even though I have answered in the negative, he went through all my luggage with amazing precision. He took away every single piece of paper I had (including all material for my lecture), each time asking me whether I need this specific piece. Each time I had answered "yes", and each time he would say "Aha!" and confiscate this piece of evidence! It is a pity that this scene was not filmed, it certainly looked like a grotesque ritual. After he took everything I had, the trio has disappeared - I was very relieved because they gave me back my passport. My first thought was to go back right away to Warsaw, however, I was afraid to leave the train: I could be arrested. I had been quite tense during this incident. I forgot to say that there was one more passenger in my compartment. He was working at a technical university somewhere in Soviet Union. We had talked quite a lot before the train came to the Russian border and so there was some "bond" between us. When I looked at him after the Russians left he was

totally pale. Then, after the train left the station, he has asked me how could I be so careless and not to hide the book by Ginsburg. He then showed me that he had on him an American book on calculus strapped by his trousers' belt to his back under the shirt. When I saw this, I had an attack of hysterical laughing, and very soon we were both laughing like crazy for some time. I was again in a good shape. After I had returned to Warsaw, I reported the incident to J. Łoś who was the director of IMPAS. He wanted to make all kinds of official protests and actions, but I have asked him not to do anything because, after all, it was such a minor incident in the ocean of idiocies happening all the time.

## Utrecht, The Netherlands

We (i.e., my wife, my 7 months old son, and myself) left Poland in 1969 – this was the first real opportunity for us to leave. I had an offer from the Mathematical Institute of the University of Utrecht for a visiting position – this was very important for me then. One other reason to go to Holland was that I met a wonderful Dutch couple – André and Rita, and so I felt that I have already friends there (which was psychologically very important to us). Henk Barendregt (today the “world champion” in lambda calculus and functional programming) was very instrumental in getting the offer from Utrecht. I was “appended” to the group of Dirk van Dalen, but Dirk made it very clear from the beginning that I am an independent “singleton” group. The support by Dirk and by A. van der Sluis was very important for me.

Shortly after my arrival, Dirk gave me his paper on context-sensitive Lindenmayer systems (L systems). I read the paper with great interest, and right away got interested in L systems. Dirk introduced me to Aristid Lindenmayer, and from the moment we met we began our scientific cooperation. We became very good friends and this friendship has extended to our families. Aristid's wife Jane, an artist, is a wonderful person. Their home was in a village very close (biking distance) to ours and we have often visited each other. We have had endless scientific discussions with Aristid – only a small part of these discussions has been reflected in our papers. Through my work with Aristid I have discovered the excitement of interdisciplinary work. Working with Aristid was a real pleasure – I have learned from him that elegant abstractions from the things we observe in nature may be as beautiful as nature itself. Although he was a biologist he was in constant search for formal theories. This reminds me of the following story. Together with Aristid we had organized a conference on “Formal Languages, Automata and Development”. Stan Ulam, a very famous mathematician, was one of our invited guests. He told the following joke. Two scientists arrive in the evening to a city for a conference. They learn that in the morning there is quite an official opening, and they are supposed to wear shirt and tie. They try to find a laundry to wash their shirts, but it is quite late and it looks like all laundries are closed. They are already quite desperate, when they notice a big lighted window with signs “Laundry”. They enter the place quite happy, put the shirts on the counter and ask the man behind the counter to

wash them. But the man says: this is not a laundry, we just sell signs. This was quite a subtle comment by Stan on the use of theory.

In the first two years of my stay in Utrecht, I had given/organized many lectures on theoretical computer science and organized many seminars covering quite a broad scope of theoretical computer science. The seminars and lectures were national events – Holland is a small country and traveling to lectures/seminars at other universities (cities) is quite usual. The support by the department allowed me to invite many outstanding speakers from various European countries and from the US. In this way I met e.g., Maurice Nivat, Mike Harrison and, most importantly, Arto Salomaa.

With Arto we had a special bond from the moment that we have met. Since then we have written very many papers, written and edited many books, organized many conferences, and talked to each other an uncountable number of hours. Our scientific cooperation is natural in the sense that just being together leads to doing research and writing papers. It is amazing how, when being together, we always run out of time before even reaching many of the topics we have planned to cover. As a matter of fact, when I met Arto for the first time at the Schiphol airport to bring him to Utrecht, we were so much engaged in a conversation that I drove to Amsterdam rather than to my home in Utrecht !! Arto has a photographic memory. If I want to recall an event from the past, I mention it to Arto, he switches on his internal video (as we say), and then he can tell all the details of the event. Since I have very bad memory, we have already agreed that Arto will write my memoirs! Our families are very close. The hospitality of his wife Kaarina made my stays at their country farm, Rauhala, unforgettable. Kaarina is a real cat lover, and I became good friend also with her cats. Through my stays at Rauhala with the “best sauna in the world”, I have learned the pleasures of the Finnish sauna, and I am a (very proud) holder of sauna records for foreigners. I am also a good friend with Arto’s children, daughter Kirsti and son Kai. Kai is by today a very good scientist; as a matter of fact I have been a co-author of Kai’s first published paper. His wife Suning is a chemist and I hope to cooperate with her on molecular computing.

Also Mostowski, Pawlak and Eilenberg have visited me in Utrecht. Eilenberg was a collector of some kind of figurines – particularly valuable were those from Indonesia. Because of the historic ties of Holland with Indonesia, there were many sources of these figurines in Holland, especially in Utrecht. So we have visited quite a number of rather unusual places and people in Utrecht during his stay.

I have also met Joost Engelfriet, he was attending some of my seminars in Utrecht. We then started our cooperation, and have written many joint papers since then. When I settled in Leiden, Joost joined my group. He is technically very strong – I remember that many years ago I told Joost that I like to work with him because “usually I give him a lemma and then he returns a theorem”.

When I arrived in Utrecht, there was already a group of researchers working on L systems. Besides Dirk and Aristid it included also Jan van Leeuwen and Paul Doucet, both from the Mathematical Institute. Paul wrote his Ph.D. thesis

on the theory of L systems, but left science afterwards. Jan I believe was still a student when I arrived. He is an example of a prominent scientist who was a major contributor to the theory of L systems, and later became a leading figure of theoretical computer science. Another such example is Mogens Nielsen from Aarhus, Denmark. I remember to be very much impressed by his English, especially his pronunciation. I met him many times during my visits to Aarhus (when Arto stayed there for two years) and we are good friends now. I met him, as well as Sven Skyum from Aarhus and Arto, also at one of the famous Oberwolfach meetings (on formal language theory). We all then wrote a very widely referenced paper on L systems, also very unusual because its second part was published before the first! Mogens made major contributions to formal language theory and by today he is one of the top researchers in concurrency.

Also in Oberwolfach I met many researchers who at that time were leaders in theoretical computer science in Germany, for instance, Günter Hotz and Wilfried Brauer. I became good friends with Wilfried and his wife Ute.

Shortly after arriving in Holland, I have visited Technion in Haifa, Israel, where I met Shimon Even and Azaria Paz. We became good friends and the friendship extended to our families. I was amazed to learn during a visit by Shimon and his wife Tamar to Holland, that Shimon is a very good car mechanic. With Azaria and his wife Erela we still maintain very close contacts; as a matter of fact their daughter Sharon was adopted by me. A couple of times Maja has accompanied me to a conference just because Erela was also coming there.

## **Buffalo, U.S.A.**

In January 1971 I went to Buffalo, New York, U.S.A. to work in the Department of Computer Science – I have been invited by Gabor Herman. The encounter with the legendary bad winter weather was quite remarkable. I bought a used Ford Mustang very soon after our arrival, and on the first ride home the snow “got loose”. First I heard on the car radio that “the visibility is approaching zero; please find a safe parking place”, and then indeed within minutes I could not see “anything” – fortunately I was then close to our apartment building and made it just on time. Our apartment building was quite close to my office which was really important in the winter. In the coffee room of our department we had a kettle with very hot water available all the time. Whenever one could not open the frozen car doors one would use the kettle to pour the hot water over the slot of the frozen drivers door, and get inside the car in this way. Then, however, quite often the door would not close properly, and so one had to keep the door locked using a rope fixed to the drivers seat! – driving in the winter in Buffalo required some ingenuity.

Gabor was a very intense researcher, who was then totally devoted to L systems. Together with three Ph.D. students, we had in Buffalo a very active group developing the theory of L systems. At some point we have decided to write a book on L systems. This was certainly a good decision because the book brought many gifted researchers to L systems. We had regular weekly “book

meetings” with our three Ph.D. students going through (the many versions of) the manuscript. Two of our Ph.D. students were Chinese and one was British. Gabor came to Great Britain from Hungary when he was a young boy. His English was very good and he was a very conscientious writer. Very often during our book meetings, Gabor would have long arguments with Adrian Walker (our British student) about the placing of commas in the text. Gabor would cite all kinds of rules about the commas, while Adrian would simply say that a comma does or does not fit in a given place. I usually supported Adrian because British was his mother tongue and then he “simply knew” where to put commas. One time the discussion became very animated and Gabor insisted on his “comma decisions”. I proposed then that we place at the end of the book an “Epilogue on Commas” – it would consist of lines of commas and the following comment: “The above commas were removed/added by Adrian Walker from/to the original manuscript of the book”. Everybody laughed, and the COMMA PROBLEM has been resolved forever.

The stay in Buffalo was my first American adventure. I quickly learned that my American colleagues work much harder than my Dutch colleagues. It was quite usual to stay at your office late at night; often a group of “night workers” would drive together around the midnight to have coffee and doughnuts at one of the “breakfast places” opened 24 hours a day. I also learned that the best graduate students were Chinese – as a matter of fact my first Ph.D. student in Buffalo was K.P. Lee, a very clever and nice person.

Buffalo was not a nice city. As a matter of fact the biggest asset of Buffalo was its proximity to Toronto. We drove there quite often – I have family there, and the city is very nice – it was then relatively safe. Buffalo was quite a crime city. Maja worked at a research institute in downtown Buffalo. At some point the institute built a new garage, which was two blocks away. We were quite shocked when Maja got a letter from the administration of the institute asking employees not to walk to the institute from the garage, but rather to use shuttle busses – the crime downtown was the reason.

I have driven an uncountable number of times to Niagara Falls – almost every visitor we had wanted to see the falls. At some point I was certainly qualified to be an official guide for the Niagara Falls.

Rohit Parikh was in the Mathematics Department which was on the same campus. He is a very fast thinker, but also a very fast talker and extremely fast writer (on the blackboard). He was also a supplier for us of a very good yoghurt (cultured on special bacteria from India). I have enjoyed very much his company. Tony Ralston was the chair of our department – he was very active and visible in many professional organizations such as AFIP and IEEE. We often had discussions about the nature and the future of computer science. It is amazing how computer science of today differs from the predictions of then. In particular, Tony was convinced that discrete mathematics is “the only” kind of mathematics needed for computer science – this opinion was shared by most of computer scientists then. It suffices to have a look today at neural networks, or computer graphics to see that this prediction has not been confirmed.

Also from the scientific point of view the proximity to Canada was a big asset of Buffalo. In this way I have met Derrick Wood who was at McMaster University in Hamilton, and Andy Szilard from the University of Western Ontario in London, Ontario (the REAL London, as they say there). I have written a number of papers with Derrick. By now he has moved to Hong Kong.

During my stay in Buffalo I was invited by Seymour Ginsburg to Los Angeles – Seymour was at the University of Southern California. There was some kind of a “rule” in the U.S. at that time, that if you wanted to join the top of formal language theorists in the U.S., then you had to be “initiated” by Seymour. I was thus very pleased by the invitation and moved for six weeks (or two months) to Los Angeles. Working with Seymour was a very interesting experience for me, to see the way he approached research and the way he wrote papers was very instructive. The following story says a lot about addictions. I was a passionate pipe smoker – I was preparing tobacco mixtures myself, and was “insmoking” new pipes also for my friends. As a matter of fact I have even written a book on pipe smoking (“The art and science of pipe smoking”). This is one of the two books that I have written and never published (I quit smoking in 1979, and there was a real danger that finishing the manuscript then could lead me back to pipe smoking). Anyhow, even when I was smoking I had this theory that if I have a pause in smoking (say one month) on regular bases, then my organism will clean up all the negative effects of smoking, whatever they were. The stay in LA coincided with one of my non-smoking periods. We were working with Seymour on control languages for TOL systems. The work was going well but we could not get a real theorem. I decided then to shorten the nonsmoking period and drove to a very good shop with pipes and tobacco in Westwood where I bought a pouch of really good “Turkish Melange”. We had “the theorem” next day.

## Antwerp, Belgium

Shortly after coming back from Buffalo to Utrecht, I received an offer from the mathematics department of the Antwerp University (UIA) in Antwerp, Belgium to build up computer science there. The offer was attractive, but I did not want to cut the academic ties with Utrecht. Thus, for the first two years I was one day a week in Antwerp (and the rest in Utrecht), and later I was one day a week in Utrecht and the rest in Antwerp.

Antwerp is a beautiful city and I enjoyed being there very much. My hotel was next to the famous cathedral in the centre of the city, with an abundance of excellent restaurants and coffee shops. The food in Antwerp was superior – Belgians really know how to enjoy life. I was quite happy there. I had 3 Ph.D. students there, all very good – two of them, Dirk Vermeir and Dirk Janssens, are university professors now. With Dirk Vermeir we worked on the L systems of finite index – his Ph.D. thesis is a definitive treatment of this topic. The following happening was the beginning of my friendship with Dirk Vermeir. Shortly after he began work on his Ph.D. under my supervision, we were having lunch together with a number of faculty members in the university restaurant. At some point

Dirk asked me about my age. Turning my answer into a joke I said “sixty” (I was then about 34 years old). Then Dirk said very politely and in a good faith “You certainly do not look older than fifty years old”. This was the beginning of our friendship, and I have not been making this kind of joke since then! With Dirk Janssens we worked out the theory of node-label controlled (NLC) graph grammars. I consider the theory of NLC grammars, generalized later by Joost Engelfriet, George Leih and Emo Welzl, to NCE graph grammars, to be an important part of the theory of graph grammars.

During the Antwerp days I have also worked on two-level grammars introduced by van Wijngaarden. I remember that van Wijngaarden visited (unannounced) my seminar on 2-level grammars at UIA. I had been mainly interested in the theoretical aspects, and in particular in the descriptive mechanism behind them. This led to the formulation of cooperating grammar systems. Many years later I learned that they have been reinvented with a different underlying motivation and that there was a great interest in them. As a matter of fact I resumed the work on the theory of cooperating grammar systems in 1995, mainly in cooperation with Gheorge Păun and Arto.

Even when my main job was in Antwerp I lived in Bilthoven – a small village close to Utrecht (the reason was that it is very close to the academic hospital where Maja works). This meant a lot of driving, about 2 hours one way on the main Benelux highway with a lot of wet (rain or snow) days per year – this was the negative aspect of working in Antwerp.

As a matter of fact I’ve been car driving a lot in my life. I’ve seen enormous number of driving accidents and that makes me an alert driver. Since I am “mentally absent” when doing science or magic, I have a rule that I never think of (or discuss) science or magic when driving. A colleague of mine said that, since I spend so many hours driving a car, I may miss in this way an opportunity of proving nice results. “It may be true” I replied “that there is a chance that I miss in this way some very good results. But the chance, that I would not be able to write them up is much bigger.” The usefulness of this rule was confirmed when Mathias Jantzen from Hamburg was visiting me a long time ago. He is interested in magic, and when we were driving to my home in Bilthoven, he has asked me a question about (some technical aspect of) magic. Somehow I forgot my rule, and got into discussion with him. Within few minutes we had a small accident, bumping (fortunately “softly”) into a car in front of us that slowed down very suddenly. This was a pointed reminder about my rule, and I have obeyed it very strictly ever since.

## Leiden, The Netherlands

In 1979 I accepted a professorship in theoretical computer science at Leiden University in Holland. This became the last station in my search for a place to settle.

Leiden University is very old, with very rich traditions and well known all over the world. Unfortunately computer science was somewhat lost within the

mathematics department. The situation is quite different now. In recent years we have recruited some (very) young professors, and by today we have a really dynamic department of quite a broad scope and independent from the mathematics department, although we cooperate in various matters (both mathematics and computer science belong to the quite large Faculty of Mathematics and Natural Sciences).

I have a very nice group in Leiden: Joost Engelfriet, Jetty Kleijn and Hendrik Jan Hoogetboom. This is the tenured staff; then we also have a number of Ph.D. students – five of them at present. I have written about Joost already; I may add here that he is an excellent teacher. Jetty and Hendrik Jan are both worth their weights in gold. They are very much responsible for the nice functioning of our group. Jetty is an expert in formal language theory and in concurrency. She works more now on concurrency, especially Petri Nets and trace theory. Also, she is very skillful in combining her scientific career, teaching and administrative duties, and family life. Hendrik Jan likes to work on problems of combinatorial nature. He is an expert in formal language theory and trace theory, and in the last two years he has joined the DNA Computing crowd. All three, Jetty, Joost and Hendrik Jan were also my Ph.D. students – this is quite unusual, but I believe that this creates a special bond between us. Together with our efficient secretary Marloes, we form a nice and efficient group. Since I call my Ph.D.’s my children, we really form a family.

A propos Ph.D. students: I still do not have a universal algorithm for guiding them. Some of my Ph.D.’s wrote their theses with very little guidance (interference ?) from me (as a matter of fact I wrote my thesis totally on my own). With other students I’ve worked very intensely, writing many papers together. And then there were Ph.D. students “in-between”. Typically I like to give to the beginning Ph.D. student a hand-written manuscript about a specific technical topic. Such a manuscript is only a rough outline of some (“initial”) results and then I suggest that a student starts from this manuscript and works towards a paper. A big majority of beginning Ph.D. students know very little about writing papers, and so my initial coaching consists of enforcing many iterations of the first paper they write. This takes much of my time, but I always hope that this is a good investment – and usually the papers they write later require much less corrections.

I have been very healthy until about 1987 when I started to have serious back problems. They were first sporadic and located only at the lower back, but then with time the pain periods became longer and I got also neck problems, and carpal tunnel problem in both wrists. All of these have greatly influenced my functioning in recent years. Particularly unpleasant are periods when I cannot write. However I think that I manage this problem quite well: I read medical literature and even develop my own exercises. I am quite proud of it as this also supports my contention that “all that I have, I got on my own”. In connection with my pain problems I have invented the following definition of optimists and pessimists among people with chronic pain (I am an optimist). When there is a bad period, an optimist is taking it well since he/she looks already forward to

a good period that will follow. When there is a good period, a pessimist does not enjoy it because he/she knows already that a bad period will be coming. My doctors like this description very much. During bad periods, my group in Leiden is tremendously helpful and so I function well at the university – our secretary Marloes became literally my right hand (which is interesting because she is left handed). Maja (who is herself a medical doctor) takes care of me very well. I do accept invitations also for longer trips because Maja goes with me and she enjoys traveling very much. Traveling is very important because one learns so much about “the rest of the world” and gets a better perspective on one’s own environment. For example I remember the course on Petri Nets that took place in Campina Grande in Brasil in 1996. There were students that traveled about 5000 km one way – 4 days by busses. And they were very enthusiastic, “eating up” every word uttered by the lecturers. It is then difficult to understand when a student from Leiden does not go to an interesting lecture in Amsterdam because it is too far (30 km).

The technological advances can quite soon solve my problems with writing. Already now there exists software that transcribes spoken dictation into a text on the computer screen. I have purchased one produced by Dragon Systems called “Naturally Speaking” (NS for short), however by mistake they have delivered the British English rather than American English version. The distributor in Holland has acknowledged the mistake, and because it takes a long time before they can deliver another version, I was given the British English version in the meantime, just to get acquainted with the software. My dutch-polish accent trained in the U.S. for so many years has little in common with the British pronunciation and this showed quite strongly in my use of the software. First I thought that I would be able to use NS to write this contribution. However I gave up after some most unexpected mistranslations. Here is an example of what has happened several times. I have dictated: “I have entered the Technical University of Warsaw in 1959” and NS wrote: “I have entered the technical uterus to war so 9059”. Another time, when I was training NS to better recognize my voice, Maja has entered the room. I said then “I am dictating this text for my lovely wife”, and NS wrote “I am dictating this text for my laughing wife” which was pretty good but a bit funny. I then trained NS to distinguish my “lovely” from “laughing”, and after a short while NS translated my sentence into “I am dictating this text for my salary wife”. Maja said then “This is certainly correct”! Clearly the root of these mistranslations is that NS ALWAYS “says something”, even if it does not “understand” what has been said. I see this sort of situation quite often with people, and this often leads to problems.

## **Boulder, U.S.A.**

My first trip to Boulder was in 1971 (from Buffalo) – to visit Andrzej Ehrenfeucht. Since then I have traveled to Boulder two or three times each year. Hence, the Boulder track was (and still is) interleaving with the rest of my life. As I have already written Andrzej has changed my life in many ways. He was the first

one to show me the magic of theory so that I have switched from the engineering part of computer science to theory. Then through our collaboration for about 30 years, I have learned a lot from him both about science and about life in general. He knows so much about so many interesting matters, like, e.g., dinosaurs, geology, history of science, butterflies, spiders, ... We have written together more than a hundred papers, and still each new one is an exciting adventure. Just being together with Andrzej and his life partner Pat Baggett is wonderful.

Boulder is a beautiful place and it became my second home. A wonderful aspect of Boulder is its big distance from Leiden. It was definitely much better some time ago when fax and e-mail had not been in (such a) use yet. It was easier then to protect myself there from all “unscientific contacts”. But even today being in Boulder allows me to distance myself from the daily stream of events in Leiden, and to reflect (in peace) about various matters of life, science and magic. I must have been a monk in my previous life because I really like long retreats (although I miss my family during longer stays in Boulder). Also, I have a very good medical care there – with quite many health problems haunting me in the recent years, this is a very important aspect of my life in Boulder.

After so many years of commuting to Boulder, I must be by now a part time American. Boulder is my second home – I always stay in the same apartment in the University Club. One of the benefits of staying at the University Club is a possibility of meeting interesting scientists that stay there while visiting one of the departments. In this way I met, e.g., Paul Erdős and had interesting discussions with him.

I have many friends in Boulder – some from the university and some from outside the university. I cherish very much my friendship with Mycielski and Malitz families – Jan Mycielski and Jerry Malitz professors at the department of mathematics. Also Mike Lightner and Linda Lundbeck are very close friends. Mike is a professor of electrical engineering and computer science and also a very serious musician. Linda is a professional musician. They both play recorders and specialize in old music. From time to time we have an “M and M” evening (of Music and Magic) – they play music and I perform magic.

Lloyd Fosdick who essentially created the computer science department in Boulder is a very good friend. He is retired now and lives in Turkey. It is a pity, because I miss very enjoyable dinners we used to have with him and his wife Riki. I also enjoy my “regular” dinners with Hal Gabow. With Mike Main we have worked together on graph grammars, and I have worked now for several years already with Skip Ellis on Computer Supported Collaborative Work (CSCW). I enjoy working with Skip also because through him I keep in touch with important developments in the applied aspects of computer science.

I have also very good friends outside the university. Many years ago I was “adopted” by the Verdoner family – Otto has Dutch roots and Daisy has Greek roots. They are wonderful people and I enjoy very much to be an uncle magician for their two sons.

## EATCS

I have devoted a big part of my life to service for the computer science community. My involvement with the European Association for Theoretical Computer Science (EATCS) falls under the cliché of the exemplary military career: “from soldier to general”. I became an EATCS member quite early, then I was a Treasurer, the editor of the “EATCS Bulletin”, one of the editors of the “EATCS Monograph Series”, a Vice-President, and the President. One certainly has to be motivated to devote as much time as I did (and am still doing) serving the community. Without this work my list of publications would certainly be much longer. My main motivation is rooted in my Warsaw time, where the feeling of isolation (implying “not belonging to the community”) was very frustrating. Thus, bringing together scientists from various countries and various disciplines of science is for me a noble cause, certainly worth devoting a considerable part of my life.

The responsibilities of the EATCS President are perceived differently by different people. The following story is really true. During the ICALP (the annual conference of EATCS) in Madrid in 1991, I was chatting with a group of friends in a break between lectures. A young man approached our group and asked “are you professor Rozenberg, the EATCS president?”. I answered “yes” and then he said: “It is already the second day when there is no toilet paper in the men’s toilet on this floor. Could you do something about it”, and this was not a joke. I certainly arranged for more toilet paper!

I have benefited from my EATCS work. First of all, there is an enormous satisfaction of doing something useful for so many people. Then, I’ve met in this way many interesting people. Also, I have gained a very good understanding of the nature of the community of scientists working in theoretical computer science (TCS). I certainly understand quite well the differences between the “cultures” of scientists from different countries. This helps me a lot in understanding the problems of creating the European Community.

I have also cooperated a lot with my American colleagues working for SIGACT. I think that the main difference between the American and European TCS scene lies in the “heterogeneity” of Europeans. While in the US it is quite typical to have just a few “fashionable” trends (with a small number of “gurus”) followed by “everybody”, it is difficult to see how, e.g., British could influence French not to do formal language theory (which is beautifully developed in France) because it is not anymore fashionable in Great Britain! In my opinion, this diversity is the strongest guarantee of health of TCS in Europe.

I think that, in general, the advice of doing something (e.g. within EATCS) because “Americans do it” is not very valuable (in the same way as SIGACT doing something just because Europeans do it would not be valuable either). I remember well that when I was the EATCS Treasurer, my American friends were giving me a lot of advice on how to run EATCS finances; in the meantime SIGACT went broke a couple of times, while EATCS finances were very healthy.

As a matter of fact, my general advice is: do not follow too much advice from someone else!! It leads very easily to the loss of originality – it is often better to

make a mistake and to learn from it. This reminds me the following real story. The first car that I bought in Holland in 1970 was a quite old Volkswagen Beetle. It still had a choke and I often had difficulties in starting it. A good friend from the US, a mathematician, was staying in Holland for a couple of years then, and he was a very skillful car mechanic. He was often giving me a demonstration of the use of choke. He was trying to teach me how the sound of the motor (reacting to the pulling or the pushing of the choke bar) was guiding the use of the choke. We concluded that my hearing is somewhat impaired, and so I do not hear “the subtleties”. At some point I had to bring my car to a garage for a total overhaul. When I was in the garage to pick up my car, a conversation with the car mechanic (who took care of my car) somehow led to the choke in my car. He told me then (and showed me) that the choke in my car was disconnected by the previous owner, the choke bar was just “hanging there” not connected to anything!

EATCS Monograph Series (recently splitted into Monographs and Texts) is an important and successful activity of EATCS. It has perhaps the most friendly editors–publisher team. Wilfried Brauer, Arto Salomaa and myself are the editors, and Dr. Hans Wössner and Mrs. Ingeborg Mayer are responsible for this series on behalf of Springer Verlag. Once a year, for at least twelve years already, we meet in my home for a day discussing all the matters pertinent for the series. Through these years I have developed a recipe for the *Monograph Soup* which is our traditional lunch (as a matter of fact this recipe is coauthored by Maja). For the evening dinner we are often joined by Wilfried’s wife Ute and Maja.

## DADARA

I have a wonderful family. I owe a lot to my parents who I really admire – my father died in 1996, my mother is still alive. One reads and hears a lot about heros, one sees them in movies, however I’ve never met one except for my mother. She is a real hero – one could certainly write a book about her life. I have known my wife Maja since 1962; we were married in 1967. She is a wonderful life partner and my life without her would certainly be much less satisfying (difficult for me to imagine). She has created for us a wonderful nest, no wonder that Maja in Finnish means “a cozy home”. Then I have two brothers of choice, Andrzej and Arto. It is difficult to imagine better brothers (an interesting aspect of this brotherhood is that Andrzej and Arto have never met).

My son Daniel is very special to me both emotionally and intellectually. He is an artist, very well known internationally. He was born with a pencil in his hand (Maja always says that this was painful!). We never had a problem of finding something interesting for Daniel to do “because he is bored” – he was always either drawing or reading a book. I remember that when we were in Buffalo and Daniel was in a kindergarten, he was often bringing home all kind of words and expressions that we did not know. At some point we realized that these were Japanese words that he was picking up during lunches with a Japanese girl from

the kindergarten and her mother! In this way his talent for foreign languages manifested itself for the first time. By today he knows six or seven languages.

Daniel was not very much impressed by the fact that I was a university professor and perhaps a known scientist. But I had his respect as demonstrated by the following story. Once I came home from my office early in the afternoon and found Daniel and his school friend Ferdie in the hall of our house (Daniel was 14 years old then). Daniel introduced his friend to me, and I went directly to the kitchen to have a glass of water. Since the door was open, I could hear the following conversation. Ferdie: "What is your father's occupation?", Daniel: "He is a university professor", then he paused for about 5 seconds and added "but he is not stupid, he is a very good magician". This story has become well known among my friends – professors and magicians.

Daniel began his professional career, under the name DADARA, as a cartoonist. His cartoons, almost always without titles, were amazing. He has a wonderful sense of humor and a very good (drawing) hand: in few strokes of a pencil he can make a deep comment about the life around us. He is a very prolific artist – he drew thousands of cartoons which made him well known. For example, he was a cartoonist for an established Italian monthly "Linus" (it was nice for me to see his name listed in Linus with cartoonists such as Gary Larsen and Altan), and he became well known in Italy. Once, after giving a lecture in Italy, I went for a dinner with a group of professors. At some point during the dinner I have heard the name "DADARA" mentioned by two Italian colleagues (in their conversation in Italian) sitting to the right of me – I did not know them. I then interrupted their conversation and said "I know DADARA". They continued their conversation in Italian, so I have asked my Italian friend sitting to my left what they said. He told me that their comment was that I was bragging. Hence, a couple of minutes later, I again interrupted their conversation and said: "DADARA is my son". They were laughing and continued their conversation. When I asked my friend what was their comment now, he told me that one of them said that I am drunk. I found this very nice (I do not drink alcohol at all), and did not interfere with their conversation anymore.

I am fascinated by DADARA's creativity – it is amazing to see what kind of visions he has in his head! I have always liked a company of creative people, and the fact that he is my son adds an extra dimension to my admiration of his art. He is an example of a wonderful genetic mutation: neither Maja nor I have any talent for drawing or painting, this is also true for our families, and then we get such a talented son.

DADARA does not like labels – since everybody called him a cartoonist, he has switched to painting, and very soon everybody admired his paintings. Several years ago DADARA was designing flyers for all kinds of big events in Amsterdam. His flyers became very popular (collector items) and the press pronounced him "the king of flyers". Since he does not like labels – he quit designing flyers for quite a long time. This drive for change, the evolution of style, is very characteristic for DADARA. While at the beginning I was worried (although I never said it) that he abandons a style that is so nice, now I am looking forward

to the changes that surely lead to pieces of art that are even more beautiful and more intriguing. Quite often I found out that a painting by DADARA expresses a feeling (an emotion) that I had “inside me” for a long time but could not express.

DADARA lives in DADALAND which is in his head and which also contains the art that he has created. Also his beautiful atelier in Amsterdam, where each small detail was thought of and created by him, is a material extension of DADALAND.

I think that analyzing why an artist (or a scientist) is so creative does not make much sense – it is simply in his/her brain. Observing DADARA supports this point of view. In the time (not much) that is not used for science or magic (or mundane matters of functioning), I study the paintings by Hieronimus Bosch – the Dutch painter living at the end of the 15th and the beginning of the 16th century. I like Bosch paintings very much, and I have been planning already that after I retire I will travel visiting “all” museums where they have his original paintings. For me, Bosch is the pure genius much ahead of his time. He is the real father of surrealism. I remember visiting once the museum of Salvatore Dali in Figuera, Spain. There I have seen sketches by Dali from his young years, when he was “training his hand for the paintings to come”. Many of these sketches were simply figures from paintings by Bosch. Although we know very little about Bosch (we even don’t know when he died!), there is an abundance of theories explaining why Bosch was so original and creative. For me they do not make much sense. There is a simple explanation: he had all of these fascinating and intricate scenes in his head – the Boschland.

## The Golden Triangle Plus

I have done research in various areas of TCS. At some point my research has converged to three areas – I like this combination very much and so I call it a golden triangle. The areas are: 1) formal language and automata theory, 2) the theory of graph transformations, 3) concurrency. Let me comment on each of them.

### 1) Formal language and automata theory (FLAT).

This area forms the backbone of TCS in the sense that many other areas have their roots in it, and it is perhaps the best developed and the most mature area of TCS. The Handbook of Formal Languages (in 3 volumes) published by Springer Verlag in 1997, which we have edited with Arto, demonstrates an amazing richness and scope of FLAT.

Although I have worked on various problems in FLAT already in Poland, my first big FLAT adventure was the theory of Lindenmayer systems (L systems). The theory of L systems is a beautiful research area – it is full of Perfect Research Problems, i.e., problems that are elegant, very easy to state and very challenging to solve. Moreover many problems in L systems are very well motivated. The theory of L systems is quite special to me, since through scientific collaboration

I've met interesting people, many of whom are (were) my very good friends. First of all, Aristid Lindenmayer himself – as I have mentioned already, through my work with Aristid I have discovered the pleasures of interdisciplinary research. Then, Arto Salomaa – I have written about him already. Arto must be the best “producer” of brilliant Ph.D.'s within FLAT – the group of his Ph.D.'s includes T. Harju, J. Honkala, J. Karhumäki, J. Kari, L. Kari, M. Linna, V. Niemi, M. Penttonen, and K. Ruohonen. I have profited from the quality of this group, as I have collaborated with some of them. I was an “official opponent” for Juhani's Ph.D. thesis defense – I am quite proud of this because he is by today one of the leading researchers in FLAT, and he could certainly be my official opponent today! Juhani is also an ornithologist – he disappears for about a month (I think in June) in Finnish forests where he rings owls. A long time ago during one of his visits in Holland he gave me some pictures (taken by him) of young owls in their nests – the pictures were beautiful and I've fallen in love with owls. I started to collect “everything” about owls: books, figurines, the real stuffed owls, ... By today I am an owl lover and have a collection of more than 1000 owls. One of the attractions of owls for me is that they look to me like “the magicians of nature”.

Arto has introduced me to Hermann Maurer in 1974 during the ICALP (International Colloquium on Automata, Languages and Programming) in Saarbrücken. He is one of the most talented people that I have met: he has been active and very successful in many disciplines of computer science ranging from very theoretic to very applied. His Hyper-G (Hyperwave) is acknowledged to be one of the most important WWW systems. Hermann is producing at the end of each year a report on his activities during the given year and sends it to his friends. Together with Maja we always look forward to these reports and enjoy reading them enormously. My visits to Hermann, first in Karlsruhe and then in Graz, were always very memorable; we had excellent time with his wife Ushi and children Stephan and Claudia. We have written together a number of papers in FLAT.

In recent years I have cooperated a lot with Gheorge Păun mostly on topics from FLAT and DNA Computing. Gheorge is very gifted and extremely efficient researcher – he is certainly one of the stars of FLAT and DNA Computing. Somehow he reminds me myself when I was still in Poland: total involvement in science gives you some encapsulation against all that happens around you. Gheorge is one of former students of Solomon Marcus. The list of former students of Marcus working now in TCS is very impressive – it includes Cris Calude, Lila Kari, Alexandru Mateescu, and Gheorge, all very well known now. I am a friend with all of them, and have written papers with Lila, Alexandru and Gheorge. I was an “official opponent” of Lila for her Ph.D. thesis defense. She is a very talented researcher – already one of the most visible scientists in DNA computing. I certainly have some affinity with Romanians. As a matter of fact I remember that Sheila Greibach told me, when I met her for the first time, that she thought that I am Romanian.

## 2) The theory of graph transformations.

Graphs are “everywhere” in computer science, and graph transformation is one of the important paradigms of computer science spread throughout many of its disciplines. Graph grammars (where one rewrites graphs rather than strings as is the case in classical FLAT) originated already in the 60’s, motivated by considerations about pattern recognition, compiler construction and data type specification. Since then the list of areas which have interacted with the development of graph grammars has grown considerably, and methods for transforming (sets of) graphs other than grammatical are investigated now.

My interest in graph grammars begun around 1973 when I met Hartmut Ehrig from Berlin. Hartmut was one of the pioneers of graph grammars and his enthusiasm about graph grammars was quite contagious. We became good friends and together we have organized quite a lot of activities in the area of graph grammars. Hartmut is a very serious scientist and very reliable in both scientific and organizational matters. Through Hartmut I met Hans Jörg Krewowski who was then his Ph.D. student. Since then we have collaborated and become good friends. Together with Manfred Nagl and Hartmut we organized the first workshop on graph grammars, it initiated a series of workshops which form the focus of research in the area of graph transformations. Manfred was responsible for important applications of graph grammars, and the three of them (Hans Jörg, Hartmut and Manfred) have greatly contributed to the development of graph grammars in Europe. My first big adventure in graph grammars was the theory of node-label controlled (NLC) graph grammars which we have developed in Antwerp with Dirk Janssens. The theory of NLC grammars generalized later by Joost Engelfriet, George Leih and Emo Welzl to edNCE graph grammars (graph grammars with neighbourhood controlled embedding and dynamic edge relabeling) became an important part of the theory of graph grammars. With Dirk we have also developed a theory of graph grammars modeling massive parallelism as represented, e.g., by actor systems. Dirk has later generalized actor grammars to the so called EMS systems which became one of the main models of concurrency within the framework of graph transformations. During one of my trips to Graz to visit Hermann Maurer I met Emo Welzl. We started our cooperation even before we met, through Hermann: we have written a paper on picture languages which became quite popular. With Emo we worked on NLC grammars. He came in 1983 for a year to Leiden where he was a post doc in my group. We became very good friends (he is also a good friend of my son Daniel), I have “adopted him”, and by now he is one of my kids. We have worked out together the theory of boundary NLC grammars. Emo is now a professor at the well known ETH in Zurich – he is one of the young stars of TCS in Europe.

For many years now we have been developing with Andrzej the theory of 2-structures which forms a useful framework for considering decompositions and transformations of graph-like structures. Tero Harju has joined us quite early in this research and so most of the theory has been developed by the three of us (although Tero never met Andrzej). Tero is one of these brilliant Ph.D.’s of Arto. He is a wonderful research partner not only because he is a good mathematician

but also because he has a very good sense of humor. We certainly laugh a lot when we work together. Unfortunately he is quite addicted to cigarette smoking. However, he never smokes inside his own or someone else's house. He goes outside and paces around smoking. My neighbours call him "a walking chimney". One says that Finns do not talk much (Arto is an exception) – but we have spent countless hours with Tero talking about so many things.

### 3) Concurrency.

In 1976 I have attended the "Advanced Course on Petri Nets" which took place in Hamburg, Germany (West Germany then). The course has been an important event in my life as there I've fallen in love with Petri Nets and in this way I discovered the larger area of concurrency. During this course I met Carl Adam Petri and have been very impressed with his way of thinking about concurrency. I also met there Antoni Mazurkiewicz from Warsaw and P.S. Thiagarajan, or simply Thiagu for his friends, from the group of Petri at GMD in Schloss Birlinghoven near Bonn. Although I have remembered Antoni Mazurkiewicz from my Warsaw times, we never had any contact there. We have spent many hours together in Hamburg and became very good friends since then. Later I also met his wife, Violetta who is a professor of linguistics at Warsaw University. She is also a world class astrologer – it must be that astrologers and magicians understand each other very well, because we became very good friends. The friendship extended to our families during the one year stay of Antoni in Leiden (for the academic year 1985–1986). Antoni introduced me to his theory of traces, known worldwide as the theory of "Mazurkiewicz traces". It is a very elegant and fruitful way of thinking about concurrency. My group in Leiden has a lot of expertise in traces – Hendrik Jan Hoogeboom and Jetty Kleijn are the real experts in both syntactic and semantic aspects of trace theory.

Thiagu was the real expert on Petri Nets at GMD. He "had nets in his blood" and in particular was a real master of counterexamples. You gave him a conjecture about nets, and if it did not hold then there was a big chance that Thiagu would find a counterexample. Thiagu has also a wonderful sense of humor and always knows a lot of gossip – we have exchanged many jokes and gossip. He is certainly a very stimulating research partner and a very lively friend to have around.

It was really for Petri, Antoni and Thiagu that I have fallen in love with Petri Nets and trace theory. Through the years together with Thiagu, Wolfgang Reisig, Hartman Genrich, Kurt Jensen and many others we have built up a real community of researchers in Petri Nets centered around the European Workshop on Application and Theory of Petri Nets promoted later to the International Conference on Application and Theory of Petri Nets (ICATPN). This became a very well functioning community composed of users, practical designers and theoreticians of concurrent systems. As with EATCS, I have invested a lot of time and energy in the Petri Nets community (I am the chairman of the Steering Committee for ICATPN). It was certainly worth it.

From 1983 until 1993 I had been involved in the Dutch project on concurrency, initially known as LPC (Landelijk Project Concurrency) and then as

REX (Research and Education in Concurrent Systems). This project was based on the cooperation of the group of Jaco de Bakker from Amsterdam, the group of Willem Paul de Roever from Eindhoven, and my group from Leiden. The cooperation was very successful, and the project has certainly contributed to the progress of research on concurrent systems in Europe. With Jaco I have cooperated also in a number of other activities – I find him to be a very professional colleague, and look forward to some future activities where we will cooperate.

4) Plus.

I have also worked (and published papers) on interesting topics from outside the golden triangle. In particular for several years already I work in two new areas that I find interesting

– CSCW (Computer Supported Cooperative Work).

This is a very applied area that can use some good theory, which is not there yet. I have worked here with Skip Ellis, one of the leaders of CSCW and with Andrzej. One can apply here some known models like Petri Nets (modelling Workflow Systems), but clearly new models describing protocols of structured cooperation are needed.

– DNA Computing.

This is a beautiful area. It is often traced back to some remarks of R. Feynman on computing with molecules, but there are really two founders of the area. One is Tom Head who already in his paper from 1987 presented a theory of computing based on the use of restriction enzymes. This work was theoretical and not supported by experiments then. The other one is Len Adleman who published in 1994 a paper in “Science” where he outlines a method for solving the Hamiltonian Path Problem based on the Watson Crick complementarity principle for DNA molecules. He also gave “a proof of the principle” by implementing his method in the laboratory (for a small graph). This is a fascinating area: the fact that you can actually compute with molecules is very exciting, independently of whether or not one can beat NP-complete problems. Although some techniques of formal language theory can be applicable in this area (after all DNA molecules are “double strings”) it is becoming clear that new models are needed. A characteristic feature of this area is its interdisciplinary character – something I love from the time of my work on L-systems. At the workshops on DNA Computing one meets biologists, chemists, physicists, engineers, mathematicians, computer scientists, ... I am now quite involved in DNA Computing and this is already rewarding: I have learned a lot in recent years about genetics. It is a pity that Aristid Lindenmayer is not anymore with us – he cannot witness the formation of yet another area of computing motivated by nature.

My optimism about the future of DNA Computing is also supported by the fact that my new collaborators, Hans Kusters and Paul Savelkoul from Amsterdam, and Paul Hooykaas, Kees Libbenga and Herman Spaink from Leiden, are very enthusiastic about this area of research. They are all biologists, except for Paul Savelkoul who is a medical microbiologist. We have now formed

in Leiden the Leiden Centre for Natural Computing where we have three research programs: molecular computing, evolutionary algorithms and neural computing. I am the director of the molecular computing program, Thomas Bäck and Joost Kok are the directors of the evolutionary algorithms program, and Joost Kok is the director of the neural Computing program. Thomas and Joost are my colleagues from the Leiden Centre for Advanced Computer Science – they are prominent researchers in their research areas. The biology department participates in the molecular computing program. The future of computing in Leiden looks very natural indeed.

### **Magic**

Magic is a way of living in the same way that science or music is – you go to bed with an idea of an illusion, and you may wake up with a solution. It is certainly very creative and, as in science, you invent your own material where you sometimes build on the work of others. As a matter of fact there is a great similarity between magic and science. Magic teaches you that things do not have to be the way they seem to be at the first glance. The blue deck of cards turns out to be red, or a card that you have seen in the deck is actually not there. **DO NOT ACCEPT THINGS ON THEIR FACE VALUE: QUESTION EVERYTHING** (your senses may be deceptive, your thinking may be deceptive). But this is really one of the main rules of researchers in science! Another common feature of scientists and magicians is that you make friends very easily. You go somewhere, give a lecture to a group of scientists (or have an “individual” session with a scientist), a discussion follows, and very soon you have new friends – you go to a restaurant together, and between the dishes you use the napkins to scribble some scientific ideas. In the same way, you go somewhere, you give a show (or you have an individual presentation for a magician), a discussion follows, and very soon you have new friends – you go to a restaurant together, and between the dishes you use free spots on the table cloth to demonstrate some ideas on cards and coins. One of the advantages of my involvement in magic is that in this way I have an access to a totally different community of people, which is very interesting. Many of my good friends are magicians.

Magic is a performing art, and modern magic is not so old, it dates back to the last century. Many performing artists consider magic to be the Queen of performing arts, because so many branches of performing arts do contain an element of illusion. If you go to a theater and the lights go down, the curtain goes up, and you see a decoration which represents, e.g., a house in Paris, then if the play is good, you forget that this is a decoration – you simply are in Paris! (but this is an illusion). Illusion is the essence of magic: when magician comes, illusion is there, and when he leaves, illusion disappears.

Magic is divided in categories, and close up magic is what the name says: there is no distance between the magician and a spectator, you see everything done just under your nose, there is nothing to hide. Thus, many magicians consider close up magic to be the Queen of magic. A close up magician may use different media to invoke illusions: playing cards, coins, rope, timbles, ... (I use playing cards because I love them). There is a great similarity between close up magic

and mathematics: good illusions are “compact” and elegant. If your building up for the climax is too diffused and “illogical”, then you will not catch (control) the attention span of a spectator. If your magic is elegant, then this elevates the senses of a spectator to a different level of perception – it is not anymore the level of “solving a puzzle”. And then, the most beautiful effects are unexpected, just like in mathematics. Paul Harris, one of the giants of modern close up magic, calls magic “the art of astonishment” and that’s what it is.

Up to about ten years ago I was keeping my magic and my science lives separated. Then I have realized that performing at scientific workshops and conferences which I attend gives me more opportunities to perform for bigger audiences (because of the chronic lack of time I would not have such opportunities otherwise). And so I do quite a lot of “table hopping” (moving from table to table to perform) at conferences now. As a matter of fact this mixing of disciplines goes also the other way around. I have been a couple of times in New Zealand which is a beautiful country. It has some very good magicians, and already during my first stay there I became a sort of “honorary member” of one of the magic societies there. I am a very good friend with some of the very good magicians there like Alan Watson and his magic family and Ken Ring. Anyhow, when I was there in 1997, they learned that I was lecturing in New Zealand on DNA Computing and so before my show (“Story telling with playing cards”) they asked me to explain what the DNA Computing was. Hence, before the start of my show I gave about 20 minutes lecture on DNA Computing for magicians, and (judging from the response) it was successful!

One of the problems that a magician may encounter is the attitude of some spectators. Some of them will sit there very, very tense, watching every move of your hands, ready for “catching you”. I like to explain (at the beginning of a performance) that such an attitude makes no sense. One should relax and enjoy, because there is nothing there to catch you on – illusions have no explanation. If, by any chance, one will catch a glimpse of “something” (technical), then this particular effect was not an illusion! This logical argument relaxes my spectators, also scientists. I remember that when I gave this explanation to Mike Rabin, Mike called this the “Rozenberg Principle”: an event observed disappears!

As I wrote already, my stays in Boulder are wonderful because I am there much more the master of my time, and in particular I have much more time for magic (late nights are often taken by magic). I have been very lucky by finding there a group of friends which are very good magicians: Gene Gordon, Bob Larue, David Neighbours and Lamont Ream (David and Lamont are among world top magicians). Together with Gene and David, often joined by Bob, we have regular card sessions in my apartment (we often joke that the University Club will become really famous in the history of magic!), and with Lamont we have magic sessions in his apartment in Longmont. With Bob and his wife Mel we are now also family friends – we hope to have them visit in Holland soon.

The symbiosis of science and magic in my life has also some frustrating aspects. If I get very involved in science for a longer stretch of time (e.g., writing a paper), then quite often at the end of such a period I get worried that I have

been “out of magic” for “so long”, and there I have so much to do. The same holds the other way around. So these frustrations control for me the interleaving of science and magic. As a matter of fact, one of the biggest frustrations I had, happened many years ago. I was admitted then to a magic class coached by Tomy Wonder, that was meeting about once a month. Unfortunately, because of my traveling in service of science (conferences, lectures, etc.) I missed most of the classes. I lost a unique chance because he was a wonderful coach, and by today he is one of the most famous magicians in the world.

As a magician, one can ponder over questions that are not totally rational. For example, was magic predestined for me? Nobody knows, but I wonder: the maiden name of my mother is Zauberman (meaning magician) and the name of my wife is Maja, which means “illusion” in Hindu (I certainly did not know it when marrying Maja). Anyhow all my magician friends are very jealous that I am married to illusion!

There is quite a lot of literature on the **THEORY OF MAGIC**. The aim of it is mostly to provide some guidelines, some principles that enhance the performance of a magician. It is mostly concerned with things like perception of events by a spectator, or the psychology of a spectator, or the aims and the strategy of a performance. The difference with TCS is that the theory of magic stays rather close to its applications (in a performance). In TCS we abstract from a phenomenon in information processing and formulate some notions, which then lead to other notions, and so we have “an iterative build up” of a theory that can end up quite far from the initial application (motivation) area. In the theory of magic you stay really close to the application area. This is the way I see the difference. Anyhow, I am really NOT interested in the theory of magic – in magic my interest lies in the heart of applications: the performance.

I have a wonderful family, I have written many papers, I have shuffled many decks of cards. Life has been good to me.