HUNGARIAN PIONEERS OF THE INFORMATION AGE

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The electronic computer has been in existence only about fifty years, yet the annual sales of personal computers in 1996 exceeded seventy million units. Webs cover the whole globe. We can no longer imagine our life and work without computers, microprocessors, networks, without the information superhighway. This is a success story in which Hungarians had and have an important role. We can find them at many important milestones on the road of computers and computing. In this article I will concentrate on those who have been working in the United States.

The age of information could not have been reached without computers, which regardless of their size, speed, power and cost, all follow the concept defined by **John von Neumann (Neumann János,** 1903–1957) who was not only the "father" of the modern computer but also one of the greatest mathematicians of the twentieth century and the inventor of game theory. He published a book on this theory in 1944. Fifty years later another Hungarian, **John G. Harsanyi (Harsányi János,** 1920–) received the Nobel prize in economics "for his pioneering analysis of equilibria in the theory of non-cooperative games."

John Kemeny (Kemény János, 1928–1992), Einstein's former research assistant, the president of the Dartmouth College for twelve years and chairman of President Carter's Commission on the Three Mile Island nuclear accident, is the coauthor of BASIC, the world's most popular programming language, which can be found in each personal computer. The Esperanto of computers made available programming and computer applications to the masses. He envisioned and helped to make real in many cases the man – machine interaction and networking of computers, thus e-mail, teleconferencing, the Internet, which have led us to the new information galaxy. Charles Simonyi at Microsoft has helped to develop many important Microsoft software products, from Word, through Excel, to Windows.

It is hard to imagine desktops or laptops, supercomputers or even a modern washing machine without microprocessors, the products of Intel, which is the world's leading manufacturer of computer chips. Its annual earnings in 1996 exceeded $ 5.2 billion on sales of $ 20.8 billion. **Andy Grove (Gróf András,** 1938–) the former student of the Technical University of Budapest left Hungary in 1956, earned his Ph. D. from the University of California at Berkeley, co-founded Intel

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and served as its chief executive officer during the past five years. According to *Fortune* (February 17, 1997) "Intel is the only manufacturer that can afford the gargantuan plants required to make millions of microprocessors." And: "He [Grove] may be the best manager in the world."

As one can see from the above list, Hungarians had and have a key role both in the fields of hardware and software. They achieved their results mainly in the United States. This does not mean that there are no others living and working in Hungary, who contributed significantly to computing and its applications. Those who are working in Hungary have contributed more to software and to applications than to hardware developments. The Hungarian Academy of Sciences has several different research centers in this field. Maybe the most well known is SZTAKI (Számítástechnikai Automatizálási Kutató Intézet).

Two widely known software products – the results of recent development – are Recognita and ArchiCAD. Recognita was originally developed at SZKI (Számítástechnikai Koordinációs Intézet) is a document recognition software with artificial intelligence functions, which is used by many companies producing document scanners (among others by Hewlett Packard, IBM, and Ricoh.). ArchiCAD, a computer aided design program for architects, was developed both for the Apple and for the Windows platform. In sells well all over the world. The software house, Graphisoft has an office in California, another one in Tokyo, not to mention the list of their European presence.

There is a long list of names and institutions that have had a pioneering role in Hungary in the field of computing and automation, and space permits only the mention of a few. At the Measurement Research Center of the Hungarian Academy of Sciences Dr. Rezső Tarján headed a department where a successful group worked on different memory and storage systems, as well as delay lines. They had close contact with Dr. László Kozma, professor of the Technical University of Budapest and Dr. László Kalmár, who was working in Szeged at the József Attila Tudományegyetem. Tarján has published a significant number of articles and books. László Kalmár (1905–1976) established a center at his university, where he worked on the problems of programmability and automata. His important "product" was the Szegedi Katica (Ladybird from Szeged), which was programmable and could be used to modell different sensors. The first Hungarian made programmable digital computer, M3 was developed by the Cybernetic Research Team of the Hungarian Academy of Sciences during the 1950s. The Central Physical Research Institute of the Academy played a leading role not only in research but in the low volume production of digital compatible computers as well. Their products were the more reliable computers manufactured in those days in the COMECON countries.

As for the future of computing, CNN (cellular neutral network) is a superprocessor which can have a key role in parallel processing, as for example in the case of image processing. Dr. Tamás Roska, who is the member of the Hungarian

Academy of Sciences from SZTAKI, is working on CNN with Prof. L. O. Chua, who has a laboratory in Berkeley. As a result of Prof. Roska's research the CNN Universal Machine and Supercomputer can combine the 'neural' analog array computation and the logical (digital) one and can be used – among many others – to imitate some functional asymmetries of the human brain.

As Isaac Asimov noted: "A saying circulated among us [who worked on the atomic bomb] that two intelligent species live on earth: humans and Hungarians." The previously mentioned pioneers of the information age belong to the second group, those who have had an essential role in our "new age." We hope there will be many other who will follow them on both sides of the Atlantic Ocean.

Neumann János – John von Neumann (1903–1957)

> In much of 1867–1913, Budapest sped forward economically faster than anywhere else in Europe, – Norman Macrae, the past editor of The Economist, wrote enthusiastically. – The booming Budapest of 1903, into which Johnny [von Neumann] was born, was about to produce one of the most glittering single generations of scientists, writers, artists, musicians, and useful expatriate millionaires to come from one small community. Budapest surfed into the 20th century on a wave of music and operetta down the blue Danube, as an industrializing city that 'still of violets in the spring', pulsing with mental vigor in its six hundred coffehouses and its brilliant elitist schools. One was asked why Hungary in this generation had brought forth so many geniuses. Nobel laureate **Eugene P. Wigner** replied that he did not understand the question. Hungary in that time had produced only one genius, Johnny von Neumann.

He could have been a Nobel laureate in mathematics. But as Theodore von Kármán noted in The Wind and Beyond: "There is no Nobel prize in mathematics, possibly because Alfred Nobel could not forgive his mistress for running off with a mathematician."

Edward Teller characterizes Neumann's mathematical talent jokingly:

1. *Johnny can prove any statement.*
2. *Anything Johnny proves is right.*

In the late 1920s in Max Born's physics department in Göttingen Bohr, Fermi, Heisenberg, Oppenheimer, Pauli, Schrödinger, Teller, Wigner gave each other the key and quantum mechanics was born. Atomic spectra were explained by Heisenberg with the help of infinite columns of numbers indicating the observable dipole momenta associated with each spectral line. Schrödinger described light emission by the vibration of an electron field. Schrödinger disliked

Heisenberg's abstract algebra, Heisenberg considered Schrödinger's electron jelly to be disgusting. But both theories gave identical results! The old Hilbert asked his assistant Neumann to clarify the situation. The twenty-six year old Neumann gave Hilbert a note in which he proved that both were right. Neumann had given quantum mechanics an interpretation that is accepted now worldwide by physicists and by mathematicians. The era of the constructive coexistence of mathematics and quantum mechanics had begun, and *The Mathematical Foundation of Quantum Mechanics* by Johann von Neumann became its classical text book.

Sensing the changing political climate in Germany, Neumann accepted the invitation from Princeton University and in 1930 sailed to America. For him the practicality of the American people was attractive. In contrast to the reservations of Einstein, Wigner and Béla Bartók for Neumann America was *love at first sight,* and Johann von Neumann became Johnny.

At Princeton he soon became one of the leading personalities of the newly established *Institute for Advanced Studies* and enjoyed high respect. The Neumanns missed the relaxed atmosphere of the European cafés and seminars, so they organized regular parties, not only as social events but as brainstorming meetings for scientists.

Neumann became a citizen of the United States in 1937, and as a good American he learned to play poker and drive a car. To tell the truth, he was a poor player and an equally poor driver because his attention was usually devoted to more exciting topics. He published a paper on the mathematical theory of poker from which his *game theory* developed. Years later the superpowers' game of the Cold War directed Harsányi's attention towards game theory and eventually led to a Nobel prize in economics in 1994. The press release of the Royal Swedish Academy of Sciences stated, "John G. Harsanyi showed how games of incomplete information can be analyzed, thereby providing a theoretical foundation for a lively field of research which focuses on strategic situations where different agents don't know each others' objectives."

Another important input for von Neumann came from another direction. A military test ground was developed at Aberdeen in Maryland (Aberdeen Proving Ground, established in 1917, is the oldest army testing ground). There **Theodore von Kármán** constructed the first supersonic wind tunnel. Kármán was interested in aerodynamics, in vortices, which became relevant for supersonic flight. But the equations of aerodynamics were highly nonlinear, for solving them the power of conventional mathematical analysis was insufficient. Kármán asked for the help of his Hungarian friend in 1937. Neumann started working enthusiastically for the military, he was made lieutenant of the United States Army. He elaborated artillery tables, studied explosions and shock waves. To calculate non-linear shock waves, Neumann needed machines. In Los Alamos only the electromechanical punch card machines of International Business Machines (IBM) were available, developed originally for the census in 1890. The multiplication of two ten-digit numbers takes about five minutes for a human and took about fifteen seconds for these calculators. The speed of the calculation was low because of the inertia of the mechanical relays.

The turning point in the history of computation was August 7, 1944, when John von Neumann visited Philadelphia and saw ENIAC (Electronic Numerical Integrator and Computer) constructed by J. Eckert. Neumann was impressed by the ENIAC *imitating the human brain with its 17.000 electron tubes.*

In the case of calculating a new differential equation, the rewiring of ENIAC required a quarter of an hour, followed by the computation time of three seconds. This made the machine inefficient. Neumann got the idea in late August 1944 that not only the initial data but even the program can be input to the computer and stored electronically in the memory. Then *the central processing unit* executes the operations one after the other, according to the stored program. This has become the "von Neumann computer" now in use worldwide.

In his famous book *The Man and the Computer* John Kemeny recalled one of Neumann's most interesting lectures about his proposals for the new computers.

> In 1946 I had the privilege of listening to a lecture at Los Alamos by the great Hungarian-born mathematician John von Neumann. I was at that time assigned by the United States Army to work at the Los Alamos computation center. Von Neumann was one of the chief consultants to this computer operation. He must have concluded that even though the work we were doing was useful, with modern technology it should be possible to design computers that would make life a great deal easier. Although I do not have notes on his 1946 lecture, I have never forgotten some of his main points.
> Von Neumanns Proposals:
> 1. Fully Electronic Computers
> 2. Binary Number System
> 3. Internal Memory
> 4. Stored Program
> 5. Universal Computer
>
> First of all, he argued that the computers of the day, which depended heavily on mechanical parts, were much too slow to be useful. Therefore he proposed an entirely electronic design. He went on to argue that, while the decimal system was perfectly practical for mechanical devices, a binary system would be much easier to implement electronically because of the efficiency of on-off devices. Next he pointed out that if we had faster machines it did not make sense for human beings to have to interfere after each step. He advocated the existence of an 'internal memory' in which partial results could be retained so that the computer could automatically go through many rounds of operations. Next he pointed out that it is not necessary to build specialized computers for different tasks. The English mathematical logician A. M. Turing had shown that a machine which could carry out a few basic operations could, in principle, carry out any calculation. He therefore proposed that computers be such 'universal Turing machines.' His

> most important proposals, however, concerned the logical control of computers. Von Neumann proposed that one should be able to store a set of instructions within the internal memory of the machine so that the computer could go from step to step by consulting its own memory without waiting for human interference. Such a set of instructions in now known as a 'program.'

He described the structure and the main components of modern computers as well. There is a need for input and output devices, an arithmetical and control unit (CPU = central processing unit), for memory and storage devices.

The 'first draft' of the *Analyzer with Stored Programme* was finished by Neumann on 30 July 1945. This is considered to be the most important document of the Computer Era. Universities in California, Chicago, Columbia, Harvard and MIT were competing for Johnny and his computer.

"Neumann was undoubtedly a genius. This meant among others that he was able to learn a new subject in an incredibly short time. Before designing the computer he took two weeks off to learn electronics, thus became able to supervise the construction of the hardware." (Maurice Saphiro to George Marx, 1994.) It was decided to build the von Neumann computer in Princeton. The Institute for Advanced Studies covered one third, the army the other third, and the navy the rest of the 300.000 dollar budget. Johnny convinced the military that it would be a good investment to publish regularly about the project, because in this way also the army and the navy would get more computer experts. The reports made a huge impact worldwide. Later Neumann approached *Vladimir Zworikin* to discuss the possible use of the cathode ray tube, developed for RCA, then Zoltán Bay in 1948 to try the electron multipliers for speeding up the rate of computers.

The Princeton computer became ready in 1952, but by that time, thanks to the Princeton reports, seven further sister computers entered the field practically simultaneously, the MANIAC in Los Alamos National Laboratory, the JOHNNIAC at the Rand Corporation, the AVIDAC at Argonne National Laboratory, the ORDVAC in Aberdeen, the ORACLE in Oak Ridge, the ILLIAC in Illinois, and the IBM-701, which led IBM into its dominance of the market. Today millions and millions of von Neumann computers operate worldwide.

Johnny's second wife Klára Dán became one of the first coders of electronic computers. As an error message she used "E2 A BIDE5 10" (the Hungarian phrase *EZ A BIDES LO,* meaning "this stinking horse"), because only the characters ABCDE and 1234567890 were available (George Gamow to George Marx).

Neumann had the vision that computers will open a new era of (predictive) science. His attention turned to improve the reliability of weather forecasts; he set his goal to turn meteorology from a kitchen art into a predictive science. He wished to rely on electronic computation. But the first computers needed two days to make a weather forecast for the very next day. In modern warfare forecasting the weather could have strategic importance, thus the air force encouraged Neumann's effort. Computerized weather forecasting started in 1955 for military purposes.

Neumann's last book was *The Computer and the Brain* in 1957. The roots of his ideas on automata can be traced back to 1939. Neumann's frequent correspondence with his friend **Rudolf Ortvay**, professor of theoretical physics at Budapest University, served as a supply of new ideas. Ortvay wrote to Neumann:

> As I see, the operation of the brain is going to be ripe for understanding. The mentality of medical doctors, however does not make them able to solve this problem. Physicists and mathematicians are better trained for such a task. I think only an outsider could give an appropriate push, in a certain cooperation with physicians and physiologists.

In a letter dated in 1940 Ortvay wrote

> The brain is a network with neurons as nodes. Each neuron may receive impulses from several others, and may send impulses to them. The state of the neuron (its sensitivity for incoming signals, and its activity for emitting signals) may depend on previous inputs. The state of the brain may be given by the state of its specified neurons. Each mental situation could be characterized by the set of these data. This reminds me of a telephone switching central." Neumann reacted to these ideas favorably: "Your comments about brain structure are interesting. I think one has to take this seriously."

Is it possible to design a reliable machine using unreliable components? Nature has done it in the case of the brain, which is made of neurons. In a Princeton lecture in 1948, Neumann considered the computer as a metaphor for the living cell. He distinguished the two main components of automata: the machine (we now call it hardware) and the stored information (we now call it software). These represent two main functions of life: metabolism and reproduction. In this way, John von Neumann was a **forerunner in modern biology**. (In an unfinished paper he discussed the critical size of an universal automata, built of simple cellular modules, which is able to reproduce itself, or may even be capable of evolution, perhaps producing more and more efficient automata in successive generations.)

Neumann's wife Klára wrote about the story of this book in its foreword:

> John von Neumann was invited to present the Sillman series of lectures in the spring of 1956 at Yale University. The Sillman lectures are one of the most well-known and prestigious traditions in the scientific life of the U.S. It is an honor to be invited to become the speaker of such a serial of lectures. The papers of the lectures are published by Yale University Press. The Sillman family had an important role as sponsor in the history of the university. Neumann felt being honored by the invitation and decided to speak about the computer and the brain. He asked the organizers to concentrate the

> program for one week (instead of two which was the general practice before) because of his other activities at the presidentially appointed Atomic Energy Committee, but promised to elaborate more on this subject in the written version. While working very actively on the manuscript, the first indications of his mortal illness appeared. From January 1956 he had a wheelchair and had to cancel his planned travels and public appearances but was working on the manuscript. He was fighting with death. He wanted to finish his book.

Neumann was hospitalized in April 1956, and he continued to write his book even in his terminal hospital bed. The book was published only after his death, but initiating a new direction of research, leading to new types of computers, and new ways of understanding human intelligence.

Neumann did not live long enough to see the future developments. Cancer was diagnosed in his collar bone. The cancer was caused by the radioactive contamination during the development of the atomic bomb. When **Zoltán Bay** visited him to discuss how to speed up the computers, he told Bay (in Hungarian): – "I don't understand why people are afraid of nuclear energy. They have to be afraid of a diagnosis finding cancer in their body."

A few months later he received the Freedom Medal from President Eisenhower with the president standing and Neumann sitting in a wheelchair. At his hospital bedside politicians and generals asked for his strategical advice. Johnny was still able to run economical, political and military simulations on computers, which were accepted because they worked.

During the Korean War, when Douglas McArthur intended to attack Chinese territory, Neumann's simulations indicated that the losses would overweigh the advantages and in this way he may have helped to prevent a dangerous escalation of the conflict.

Edward Teller who always admired von Neumann wrote once. "Neumann's brain was working faster than the brain of any other humans."

When cancer attacked his brain, he himself tried to plan a radiation therapy, but it was too late. "It was depressing for him to experience the decay of his brain. He asked me to visit him frequently, just to have a chance to test and use his logic." [Teller to George Marx in 1994.] – For safety reasons an army colonel was present in his bedroom, to make sure that in a state of delirium Johnny did not blurt out any state secrets. (The security guard, however, was uncomprehending because in his sleep Johnny spoke Hungarian.)

When Neumann saw the state of his health deteriorating irreversibly, he turned to the Catholic faith, saying: "It is probable that God exists. Many things can be explained more simply in this way than without Him." He died on 8 February 1957, and he was buried in the Princeton cemetery. At his tomb Bradbury said: "If Johnny is where he thought he was going to, there must be some very interesting conversations going on about now." [Macrae]

Kemény János– John G. Kemeny
(1926–1992)

Johnny G. Kemeny, a boy from Budapest, became one of the most publicized scientists in the American press in 1979 during and after the completion of his investigation on the Three Mile Island nuclear power plant failure. His necrology in *The New York Times* filled three columns in 1992. Obituaries were published among others by the *Washington Post,* the *International Herald Tribune* and *The Guardian.*

His father Tibor Kemény had worked in agricultural trade and banking in Budapest. János Kemény attended the same primary school as **János Neumann.** Later, he was enrolled to the Berzsenyi Gymnasium (**George Soros** attended the same school). About this period he said, "I was very happy in the Berzsenyi Gymnasium. I had a wonderful mathematics teacher."

In 1938 Hitler marched in to Vienna, and on this occasion his father had said: "This is the beginning of the end." Taking advantage on his export-import connections, the older Kemény travelled to the United States to develop his business in America. In January 1940 his family followed him. (John G. Kemeny revisited Hungary only once in 1964.) The fourteen year old boy from Budapest landed in the New World, as many other immigrants he did not know a word of English. He understood Hungarian, German and Latin. In New York he went to the George Washington High School. Certainly this was not a bad school, Henry Kissinger attended it, too. But still, Kemény was not too satisfied with it. "There was a great difference between Budapest and New York. I have learned good mathematics from Mr. Bölcsházy in the Berzsenyi Gymnasium. The next occasion to learn more mathematics was at Princeton University." At this famous university, after a successful exam the professor noticed his alien accent, and asked him about his origin. When Kemeny answered, the professor raised his hands and said, "My God, one more Hungarian!"

The nineteen old young man fulfilled his military service in Los Alamos.

> When Kemeny obtained the American citizenship, wrote the news happily to his parents, saying that it went without any complication and delay: – 'Nobody asked me silly questions whether I had been a communist or like that.' – But the letter like other ones mailed from Los Alamos – were censored, even those written in Hungarian. The security officers called Kemeny to a hearing. All his excited friends were waiting for him outside. One hour elapsed, then another one. Finally, after two and a half hours Kemeny emerged. We asked, – 'What happened?' – He answered, – 'Well, I let the security officer acknowledge that there are problems in capitalism as well.' – Kemeny excelled indeed in debates; as freshman he was the head of the Debating Team in Princeton. Otherwise Kemeny was a very liberal man." (Peter Lax, 1994.)

Kemeny worked in the computer laboratory of the theoretical department under *Richard Feynman.* His interest towards computers had originated from here. He had a chance to work with **John von Neumann,** who highly impressed Kemeny. He noted, (*Yankee,* March 1980 issue): "Neumann was quite a normal man, and the greatest mathematician alive. He taught me among others that I don't have to look terrible like some other professors try to do if I wished to become a successful mathematician."

When his army service was over, he got his B. A. degree from Princeton University as the best student in the class of 1947. Later in 1949 he obtained his Ph. D. in logic. In 1948 **Robert Oppenheimer,** the director of the Institute for Advanced Studies elected John G. Kemeny as the assistant of **Albert Einstein**. They worked on unified field theory.

> Einstein was the kindest man I ever met. His assistant was always a mathematician. He did not need any assistance in physics, but he could use some help in mathematics. Although Einstein was educated in mathematics he did not know up-to-date mathematics. This is why he needed an assistant. To be frank, I was more familiar with modern mathematics. Certainly I had to know a bit of physics as well. I have become interested mainly in the theory of relativity, I have read a lot about it. (The Voice of the Martians).

Thanks to Einstein's recommendation, Dartmouth College invited John G. Kemeny to be the chair of mathematics. This college (founded in 1759) was older than the United States itself and had inherited very conservative traditions.

Professor Kemeny – feeling the utmost relevance of mathematics in society – considered mathematics teaching to be his profession for life. Once Kemeny complained, "You can study mathematics for fourteen years without meeting any topics created after 1800." He really wanted to change this. That is why he wrote his famous study book *Introduction to Finite Mathematics.* More than 200,000 copies of it were sold. Kemeny wrote about the aim of the book in the Preface to the first edition

> In the usual introductory mathematical curriculum the courses are those leading to the calculus. A few years ago, the Department of Mathematics at Darthmouth College decided to introduce a different kind of freshman course, which students could elect along with the more traditional ones. The new course was to be designed to introduce a student to some concepts of modern mathematics early in his college career. While primarily a mathematics course, it was to include applications to the biological and social sciences and thus provide a point of view, other than that given by physics, concerning the uses of mathematics. Our aim was to choose topics which are initially close to the students' experience, which are important in modern day mathematics, and which have interesting and important applications.

This is why the book includes mathematical logic, theory of information, mathematical statistics, linear algebra, theory of games and many exciting problems from behavioral science (business, economics, marriage customs, even genetics.) The book, written forty years ago, makes fresh reading even now.

As Lax said to Professor Marx, "Each generation has one textbook or two, which changes the character of teaching a subject, Kemeny's book was one of them."

Kemeny was deeply interested in education. He chaired the American Committee on Mathematics Education and wrote intensively about the theory of probability, about random walks, games. Even in his late years, when he had heart problems, Professor Kemeny insisted that "teaching is the only cure that helps me".

As early as the first half of the 1960s Kemeny wanted to have computer capacity available for each student of the college.

With Thomas Kurtz John G. Kemeny brought the first computer to the college in his own car. It was as big as a freezer, with a memory of 60K and with a speed of 60 operations per second. But Kemeny was the most dissatisfied with the way computers were used

> These computers were huge and expensive beasts. The directors of computer centers considered keeping the user at safe distance from the computer to be their main duty. The user punched the code onto cards and handed the batch to the operator in the morning. The operator collected about a hundred batches, then fed them to the computer. The machine performed all the operations one after the other according to the instructions of the code, then printed the outcome on a page. Then came the next batch. On the next day the user obtained a page with a message like ERROR ON CARD 27. Or there was nothing on the page because the user forgot to add the instruction PRINT X to the programme. Then the search of errors followed, new batch, a new day...

In the old batch environment the typical user needed ten to twenty trial attempts before his program worked correctly. While batch processing is completely efficient from the point of view of keeping the machine busy at all times, it is most inefficient from human point of view. Kemeny started to think about how to change the situation and how to make the computer available to several users. He came out with the idea of time sharing. (In 1990 he received the ever first Robinson Prize from IBM for his pioneering work in investing and realizing the time sharing system.) In a time shared system each user works on his/her own terminal, and the central computer shares the working time of its processor among the users. Each millisecond will be utilized, each user will be satisfied. To organize time sharing is the duty of the central computer, not of people. Such a system was highly needed at Dartmouth, because it was decided to make an introduction to the use of computers a regular part of the Liberal Arts program.

Over 700 students a year received computer training. The time sharing system was established at Dartmouth College (1963). "It was one of the happiest moments in my life: I did not have to punch cards any more," remembered Kemeny.

The DTTS (Darthmouth Time Sharing System) became the prototype not only of time sharing but large education networks as well. Hundreds of terminals (located in New England, and many other parts of the U.S. and in Canada) were connected to the GE computers of the Kiewit Computational Center in Hanover. There were terminals all over the Dartmouth campus. In many cases not only the dormitory building had one or two but the rooms of the students had installed terminals, too. Thus a chance was offered to each student to reach the computer through a terminal.

Dartmouth through its network offered a kind of e-mail service as well as an electronic bulletin board. The author has clear memory of a historical moment. It happened on August 6, 1974. He was working at one of the terminals when all the current jobs were interrupted for a moment and the following message was printed out: "President Nixon resigned." Some seconds later the whole system was up and running again, but business was not as usual.

FORTRAN – the most common programme language at that time – was far from being user-friendly. Kemeny noticed that an *interactive language* had to be developed, at which the machine reacts to the input immediately. In this way the user can build up the program by trial and error, a method used so efficiently by kids. Kemeny formulated the required properties (He described them in his book *Back to BASIC*).

1. *The computer language should be versatile to satisfy different purposes.*
2. *The language should be easy for beginners.*
3. *Its instructions of high level could be learned by the user at a later stage.*
4. *It should be interactive between user and computer.*
5. *It should give error messages which are easily understandable and can help to correct the error.*
6. *It could be used without knowing the specific computer architecture.*
7. *It protects the user from the problems of the operating system.*

This is how BASIC, the *Beginners' All Purpose Symbolic Instruction Code,* was born in the hands of John G. Kemeny and Thomas Kurtz

> I did not invent BASIC just to make one more computer language. I made it because I felt that the computer had to be made available for each student. The first BASIC program ran at 5:00 a.m. on May 1st, 1964.
> When we applied for support from the National Science Foundation, the referees criticized us that we did not use the computer scientists but students. This was where the NSF erred. I am sure today that we succeeded at first because others relied on computer experts, but we worked with university students! Students are able to work through endless hours, full of new ideas, they attack creatively even the difficult problems.

BASIC is today the most widely used computer language, it is one of the languages that most people understand.

Once Henry Ford created the T-model because he wanted each citizen to have a car. Time sharing and BASIC achieved something similar. They the first steps towards making computers available for everyone.

Everyone was welcome to use or adopt the language freely. As Kemeny remembered in 1988

> Microsoft planted BASIC at first into 4K memory, that was a miracle at that time. It is no wonder that one had to make compromises in case of having 4K or 16K memory. Since then the ROM memories grew larger, the necessity of compromising does not exist any longer. Today BASIC is a completely structured language with an international standard. In 1985 we launched the TRUE BASIC, this language (and its graphic) is completely independent of the type of machine. In Dartmouth College each student uses a PC, the Faculties of Humanities, Economy, Medicine included. And each student has access to the mainframe computer of the College with time sharing. Now 90% of the students are computer literate.

The 1960s were the era of student protest movements in the USA. This was the time when the popular and future sensitive John G. Kemeny was elected to be the President of Dartmouth College. On this occasion he learned the rule: "The President may not give lectures." But he revolted "I always considered teaching to be my profession, not presidency." While being the President of the College in the 1970s, Professor Kemeny kept all his classes. He only complained that "professors don't know computer programming and don't know teaching either." When the Security Service of the college asked the president what to do if the revolting students would occupy the president's office, as had happened elsewhere, Kemeny answered: "Give them all the unanswered letters, and oblige them to burn the letters!"

The name of Dartmouth College's football team was the INDIANS, but it was President Kemeny who in the 200 year-long history of the college made it first possible for native Indians to be enrolled. In spite of strong opposition, he achieved also the admittance of girls to the old conservative college.

John G. Kemeny liked crossword puzzles, Sherlock Holmes and Agatha Christie. He kept a teddy bear from his grandson on his bedside table. When he wanted to buy a new house, he sold his present one to the parents of Ms. Harriet Mayor, who later became the second wife of Senator Fulbright. Mrs. Fulbright's parents made changes but kept the patio unchanged. Once Professor Kemeny visited his previous house. Looking around he seemed to like the house in its present form but commented, "It is kind of you that you kept everything in the original form but why was it needed to change the patio?" (The real situation was just the opposite. Kemeny was much more interested in the details of improving BASIC than in his previous house.) Anyway, the old and the new owner of the house were good friends. (Mrs. Fulbright to the author in 1996.)

John G. Kemeny wrote his famous book *Man and the Computer* in 1972. Let's listen to him about it:

> I was delighted to receive an invitation from the American Museum of National History in New York City to deliver the „Man and Nature" lectures in the fall of 1971. It gave me an opportunity to pull together many ideas I have had over the years concerning the impact of computers and their future potential. It was not my intention to present encyclopedic treatments of modern computers, since such treatises are usually thoroughly boring. Since it is too early to write a definitive history of the development of computers, I present instead a personalized view of what has happened in the first twenty-five years of modern computers. From this I go on to a critical evaluation of the present state of the art and the various applications of computers. I conclude with an examination of what seems possible and likely to occur in the next twenty years and a description of several exciting new uses of computers which most of us will live to see.

He envisioned different educational applications, the new electronic library, applications at home, solving social problems, he even elaborated in detail on computers and communication, predicted the Internet, and many many more uses. He confessed, "I belive that next to the original development of general-purpose high-speed computers the most important event was the coming of man – machine interaction. I feel that the true significance of computers in the future will lie precisely in this teamwork of man and computer." He was perfectly right.

Professor Kemeny was always deeply interested in the problems of society. He noted in one of his lectures in 1973,

> The average citizen trusts the statement of an engineer concerning the savety of a bridge, or in that of a medical doctor concerning sickness. But where are social scientists whom we could trust in a similar way? When an excellent social scientist predicts something, it is probable that another equally respected social scientist will make the opposite prediction. After the successful breakthroughs achieved in physical sciences and biological sciences, the incoming generation has to make an equally reliable breakthrough in social studies. Those young people have to do it who are now our students, otherwise no time will be left to prevent the catastrophe endangering humankind.

John G. Kemeny became an honorary doctor at nineteen universities, received the prize of the New York Academy, and was an honorary member of the Eötvös Society. The peak of his career came when he entered the Oval Office of the White House by the invitation of President Carter.

> At 4:00 a.m., on the 28th of March 1979, near the town of Harrisburg in the state of Pennsylvania, a very small and completely insignificant technological incident happened in a nuclear power station. Within a week this was made the greatest media sensation of the year. Two weeks after the incident, the President of the United States nominated a Commission of twelve members to investigate the case, and he charged me to chair the Commission. On April 11th, 1979, as we were driving with my wife toward the White House, we tried to figure out what NCR could mean, which I was supposed to cooperate with. Perhaps National Research Council? Because I never had heard about the existence of a Nuclear Regulatory Commission. Then after six months the NRC wished that they had never heard of me." (Kemeny's talk to students at Dartmouth College, 1979.)

He summarized his findings as follows:

> At the Three Mile Island nuclear power station there were a few minor disturbances in the machines, but these were not extraordinary. All the real errors were made by people at different levels: operators, operator trainers, on up to the Nuclear Regulatory Commission. I was shocked by the huge number of human errors. For me the most important message of the Three Mile Island accident was that humans commit all the mistakes which can be committed. The other important conclusion was that in spite of human errors practically no radiation leaked out. The main problem in the U.S. is that since the case of Three Mile Island people are afraid of nuclear power. I tried to explain that coal mining and smoke is risky as well but public opinion is completely irrational. While we were writing the Report of our Commission, there was a huge explosion in a chemical factory in Canada, not far from the border of the U.S. The escaped chemical poison killed people. A much larger area was evacuated than in the case of the Three Mile Island accident. But the chemical accident made headlines only for one day, the public reaction was negligible compared to that of the Three Mile Island nuclear accident. The anxiety with respect to nuclear power is based on the psychologial fear from the atomic bomb. *(The Voice of the Martians)* – And he concluded – The modern machines are already reliable. The humans are not yet reliable enough.

President Carter personally thanked Kemeny for the report of the Kemeny Commission. In October Professor Kemeny returned to the Dartmouth College. His students asked him to speak about Three Mile Island. Over 1.000 students assembled, including environmentalists. Professor Kemeny began his lecture by saying: "You can't image how good a feeling it is to return to civilization after six months spent in Washington." Following the lecture, the environmentalists cancelled their intended demonstration.

John G. Kemeny died on December 26, 1992 due to a sudden heart attack. The obituary of the New York Times quoted his words told to his students when he retired from the college presidency in 1981:

> In the years to come you will hear a voice heard in many guises throughout history, which is the most dangerous voice you will ever hear. It tries to divide us by setting whites against blacks, by setting Christians against Jews, by setting men against women. And if it succeeds in dividing us from our fellow beings, it will impose its evil will upon a fragmented society. Don't listen to this voice! Listen much more to the internal voice which says that mankind may live in harmony, mankind may respect the right and dignity of each human being. I ask you to use your talent for the creation of a better world, for making a liveable world, in which there will be a place for all of us. Sons and daughters of our College: the whole of humankind is your brother and sister, and you are the custodians of your brothers and sisters.

Charles Simonyi joined Microsoft in 1980 as the thirty-third employee. Microsoft had been founded by Bill Gates in 1976, and the software company had managed to plan BASIC first into 4K memory.

In a way the first computers imitated typing machines. The human brain receives more information by seeing images, shapes and colours. When Simonyi met Gates, they decided to change the way of communication between man and computer. "Already at our first meeting it was clear for us that graphics will play the central role in the contact between the computer and the outside world. This is the real precondition to the universal public acceptance of personal computers." *(The Voice of the Martians)*

In Budapest the Russian-made URAL computer consisted of 2000 vacuum tubes. In the mornings, when the URAL was turned on, due to overload a few tubes frequently burnt out. To avoid it, high school students took the position of night custodians. So there was no need of turning the URAL off for the night in the 1960s. During these long nights the young Charles Simonyi collected his first direct experiences on computing, and on the clumsy way of accessing the early computers. In 1966 he sailed to America via Denmark, graduated from Berkeley, and took a job at XEROX in the Silicon Valley. There the user-friendly ALTO computer was under development, and Simonyi constructed the BRAVO word processor for the machine, which was able to show on the screen how the printed page will appear. But the ALTO's cost was about $20.000, it was not yet for the average person. This is why Charles Simonyi joined Microsoft on February 6, 1981. Even at that time Simonyi was already an ardent prophet of the MENU interface.

He declared, "We have to offer a menu. Everybody can see the option, and simply points to one of them. One should not need to study thick books to find out what he has to do."

The first important creation of Simonyi was the MULTIPLAN spreadsheet with a menu. By making use of the BRAVO experiences, in 1981 Simonyi started to develop the WORD, a user-friendly word processor. which applies mouse and opens several windows to look at the text. Bill Gates, director of Microsoft, declared: "We shall create the most beautiful spreadsheet of the world!" Thus Charles Simonyi has created EXCEL with others. Soon after this Scott McGregor and Charles Simonyi developed WINDOWS.

Simonyi is at present the chief architect of Microsoft and is responsible for showing people that computers are not meant only for number crunching and word processing, but they can communicate with the user through icons, serve humans by regulating traffic, steering cars, and navigating space ships. And they may create virtual reality by interactive graphics capabilities.

The CNN Universal Machine and Supercomputer and the CNN Bionic Eve

The computing power of a modern supercomputer is really breathtaking. There are tasks, however, which are 'solved' by nature quickly. Yet these supercomputers are either very slow to solve them, or they are even unable to solve some 'simple' tasks. A pigeon recognizes its mate in a fraction of a second but a supercomputer cannot process the visual information at such a high speed. Recently researchers started to use simple analog replicas of neurons for computations. These neurocomputers are more efficient in some tasks.

The first breaktrough came on 1988 when in Professor L. O. Chua's laboratory in Berkeley a new computer architecture the 'cellular neural network' or CNN was discovered. This invention set a new stage high speed image processing computations. The tiny analog electronic circuit cells were placed on a regular grid and the interconneciton was local like in the cellular automata of John von Neumann. The major difference is that these elementary computing cells are nonlinear analog dynamic elements (like in the retina), and not just the nearest neighbors are interconnected. The first chips based on this idea showed enormous computing speed-about 300 billion operations per second (calculated on a one square centimeter area).

A typical application: Image processing

We are familiar with image processing systems such as fax machines and television, which carry arrays of visual information from one domain to another. The function of this system is simply to reproduce at the output what appeared at the input. In other cases, like biological visual systems the function is to interpret, or to make some sense out of the visual scene. Other sensory systems, such as touch, audition and smell also convey 'images,' that are two dimensional arrays of data. All of these systems are designed to recognize objects, to navigate through, and to interpret meaningful entities in the visual scene.

These more sophisticated functions involve some image analysis and interpretation. From what we know about both man-made and biological systems, this interpretation involves transforming the original visual scenario into a variety of altered forms. For example, one of the first visual transformations involves enhancing the edges in a visual scene or increasing the contrast so that one is left with a 'line drawing' of the original scene. This is valuable because, almost all the information is contained in the edges.

A CNN chip is able to process an image with one million frames per second, though we would need separate chips for different problems. So the CNN chip can be a good solution, but the key bottleneck of the CNN was the lack of the programmability.

Professor Leon O. Chua and Professor Tamás Roska started to work closely together in 1988 and since 1989 Professor Roska spends two to three months in Berkeley every year. Their research is supported also by a joint National Science Foundation (NFS-US) and Hungarian Academy of Science grant. In 1988 Roska was working on a peculiar problem: how to combine the two computing disciplines, the 'neural' analog array computation and the logical one. His motivation was to imitate some functional asymmetries at the human brain. The CNN proved to be an excellent platform to do this.

In the summer of 1992 in Berkeley, Roska and Chua made the breakthrough, and they invented the 'CNN Universal Machine and Supercomputer,' the first programmable analog array computer architecture. In this computing engine, each CNN cell is a tiny computer with its own analog memory and logic as well. A new type of stored program, the analogic software, controls all the cells. The nonlinear dynamics of each cell is programmed parallel.

The CNN Universal Machine architecture represents a new paradigm in computing. More and more sophisticated retina models were developed. In Budapest Roska's group started to co-operate with Professor János Hámori's group of neurobiologists. Based on phenomenological evidence they developed some CNN retina models as well.

The CNN chip can be programmed, within a microsecond, to behave like the eye of a cat, an owl, or a salamander. Similarly, other topographic sensory organs (tactile, somatosensory, etc.) can be represented using this chip. In addition, the different sensory modalities can be combined by an analogic program. The 'CNN bionic eye,' on a single chip, can solve some image processing tasks as fast as the huge digital supercomputers.

A recent issue of *IEEE Spectrum* (May 1996) is devoted to the challenging subject: "Towards an Artificial Eye." The projection of the editors is than around the year 2015 we may have artificial eyes to help, to some extent, the visually impared. There is another striking possibility: the use of artificial vision systems or bionic eyes in sophisticated machines, such as (robots), or in everday appliances.

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Literature

Bay, Zoltán. *Life is Stronger.* Budapest: Püski, 1991.

Blumberg, S. A., G. O. Owens, Gy., Egri: *A Trefort utcától a hidrogénbombáig.* Magyar Világ Kiadó, 1989.

Brückner, Huba. *Neumann János az informatika úttörője.* Budapest 1987.

Goldstein, H. H. *A számítógép Pascaltól Neumannig.* Budapest: Műszaki Könyvkiadó, 1987.

Kemeny, John G. *The Man and the Computer.* Charles Scribner's Sons. New York: Library of Congress Catalog Card Number 72—1176, 1972.

Macrae, Norman. *John von Neumann.* New York: Pantheon Books, 1992.

Marx, George. *At the Crossroads of History.* Budapest: Eötvös Physical Society, 1991.

Marx, George. *The Voice of the Martians.* OOK: Eötvös Physical Society, 1994

Marx, György. *Atommag-közelben.* Szeged: Mozaik Oktatási Stúdió, 1996.

MTESZ Neumann János Számítógéptudományi Társaság. *Neumann János élete és munkássága.* Budapest 1979.

Nagy, Ferenc editor. *Hungarians in the History of Science and Technology.* (biographical lexicon in Hungarian) Budapest: OMIKK, 1992.

Nagy, Ferenc. *Neumann János és a ,magyar titok' a dokumentumok tükrében.* Budapest: OMIKK, 1987.

Nagy, Ferenc. *Harsányi János — A játékelmélet Nobel-díjasa.* Budapest: Akadémiai Kiadó, 1995.

Neumann, János. *A számítógép és az agy.* (The Computer and the Brain – Yale University Press, 1959) Budapest: Gondolat, 1972.

Neumann, János. *Válogatott előadások és tanulmányok.* (John von Neumann: Collected Works I.–VI., General editor: Taub, A. H. Pergamon Press, 1963), Budapest: Közgazdasági és Jogi Könyvkiadó, 1965.

Partner in Fortschritt

Die Ungarn in der Kulturgeschichte der Naturwissenschaften und Technik, Budapest: Better-OMIKK, 1996.

Wagner, Francis S. *Zoltan Bay, atomic physicist.* Budapest: Hungarian Academy Press, 1985.