John[1] Louis Von Neumann

Born December 28, 1903, Budapest, Hungary; died February 8, 1957, Washington, D. C.; brilliant mathematician, synthesizer, and promoter of the stored-program concept, whose logical design of the IAS became the prototype of most of its successors—the von Neumann architecture.

Education: University of Budapest, 1921; University of Berlin, 1921-1923; chemical engineering, Eidgenössische Technische Hochschule [ETH] (Swiss Federal Institute of Technology), 1923-1925; doctorate, mathematics (with minors in experimental physics and chemistry), University of Budapest, 1926.

Professional Experience: Privatdozent, University of Berlin, 1927-1930; visiting professor, Princeton University, 1930-1953; professor of mathematics, Institute for Advanced Study, Princeton University, 1933-1957.

Honors and Awards: DSc (Hon.), Princeton University, 1947; Medal for Merit (Presidential Award), 1947; Distinguished Civilian Service Award, 1947; DSc (Hon.), University of Pennsylvania, 1950; DSc (Hon.), Harvard University, 1950; DSc (Hon.), University of Istanbul, 1952; DSc (Hon.), Case Institute of Technology, 1952; DSc (Hon.), University of Maryland, 1952; DSc (Hon.), Institute of Polytechnics, Munich, 1953; Medal of Freedom (Presidential Award), 1956; Albert Einstein Commemorative Award, 1956; Enrico Fermi Award, 1956; member, American Academy of Arts and Sciences; member, Academiz Nacional de Ciencias Exactas, Lima, Peru; member, Acamedia Nazionale dei Lincei, Rome, Italy; member, National Academy of Sciences; member, Royal Netherlands Academy of Sciences and Letters, Amsterdam, Netherlands; member, Information Processing Hall of Fame, Infornart, Dallas Texas, 1985 (posthumous).

Von Neumann was a child prodigy, born into a banking family in Budapest, Hungary. When only 6 years old he could divide eight-digit numbers in his head. He received his early education in Budapest, under the tutelage of M. Fekete, with whom he published his first paper at the age of 18. Entering the University of Budapest in 1921, he studied chemistry, moving his base of studies to both Berlin and Zurich before receiving his diploma in 1925 in chemical engineering. He returned to his first love of mathematics in completing his doctoral degree in 1928. He quickly gained a reputation in set theory, algebra, and quantum mechanics. At a time of political unrest in central Europe, he was invited to visit Princeton University in 1930, and when the Institute for Advanced Studies was founded there in 1933, he was appointed to be one of the original six professors of mathematics, a position which he retained for the remainder of his life. At the instigation and sponsorship of Oskar Morganstern, von Neumann and Kurt Gödel became US citizens in time for their clearance for wartime work. There is an anecdote which tells of Morganstern driving them to their immigration interview, after their having learned about the US Constitution and the history of the country. On the drive there Morganstern asked them if they had any questions which he could answer. Gödel replied that he had no questions but he had found some logical inconsistencies in the Constitution that he wanted to ask the Immigration officers about. Morganstern strongly recommended that he was not to ask questions, just to answer them.

During 1936 through 1938 Alan Turing was a visitor at the institute and completed a PhD dissertation under von Neumann's supervision. Von Neumann invited Turing to stay on at the institute as his assistant but he

[1] Originally named Johann, but called Jancsi by the family.

preferred to return to Cambridge; a year later Turing was involved in war work at Bletchley Park. This visit occurred shortly after Turing's publication of his 1934 paper “On Computable Numbers with an Application to the Entscheidungs Problem,” which involved the concepts of logical design and the universal machine. It must be concluded that von Neumann knew of Turing's ideas, although whether he applied them to the design of the IAS machine 10 years later is questionable.

Von Neumann's interest in computers differed from that of his peers by his quickly perceiving the application of computers to applied mathematics for specific problems, rather than their mere application to the development of tables. During the war, von Neumann's expertise in hydrodynamics, ballistics, meteorology, game theory, and statistics was put to good use in several projects. This work led him to consider the use of mechanical devices for computation, and although the stories about von Neumann imply that his first computer encounter was with the ENIAC, in fact it was with Howard Aiken's Harvard Mark I (ASCC) calculator. His correspondence in 1944 shows his interest with not only the work of Aiken but also the electromechanical relay computers of George Stibitz, and the work by Jan Schilt at the Watson Scientific Computing Laboratory at Columbia University. By the latter years of World War II, von Neumann was playing the part of an executive management consultant, serving on several national committees, applying his amazing ability to rapidly see through problems to their solutions. Through this means he was also a conduit between groups of scientists who were otherwise shielded from each other by the requirements of secrecy. He brought together the needs of the Los Alamos National Laboratory (and the Manhattan Project) with the capabilities of, first, the engineers at the Moore School of Electrical Engineering who were building the ENIAC and, later, his own work on building the IAS machine. Several “supercomputers” were built by national laboratories as copies of his machine.

Postwar von Neumann concentrated on the development of the Institute for Advanced Studies (IAS) computer and its copies around the world. His work with the Los Alamos group continued, and he continued to develop the synergism between computer capabilities and the needs for computational solutions to nuclear problems related to the hydrogen bomb.

Any computer scientist who reviews the formal obituaries of John von Neumann of the period shortly after his death will be struck by the lack of recognition of his involvement in the field. His Academy of Sciences biography, written by Salomon Bochner (1958), for example, includes but a single short paragraph in 10 pages “. . . in 1944 von Neumann's attention turned to computing machines and, somewhat surprisingly, he decided to build his own. As the years progressed, he appeared to thrive on the multitudinousness of his tasks. It has been stated that von Neumann's electronic computer hastened the hydrogen bomb explosion on November 1, 1952.” Dieudonné (1981) is a little more generous with words but appears to confuse the concept of the stored program with the wiring of computers:

> Dissatisfied with the computing machines available immediately after the war, he was led to examine from its foundations the optimal method that such machines should follow, and he introduced new procedures in the logical organization, the “codes” by which a fixed system of wiring could solve a great variety of problems.

Among the views of von Neumann's contributions to the field of computing, including the application of his concepts of mathematics to computing and the application of computing to his other interests such as mathematical physics and economics, perhaps the most comprehensive is by Herman Goldstine (1972). There has been some criticism of Goldstine's perspective since he personally was intimately involved in von

Neumann's computing activities from the time of their chance meeting on the railroad platform at Aberdeen in 1944 through their joint activities at the Institute for Advanced Studies in developing the IAS machine.[1]

There is no doubt that his insights into the organization of machines led to the infrastructure which is now known as the “von Neumann architecture.” However, von Neumann's ideas were not along those lines originally; he recognized the need for parallelism in computers but equally well recognized the problems of construction, and hence settled for a sequential system of implementation. Through the report entitled *First Draft of a Report on the EDVAC* (1945), authored solely by von Neumann, the basic elements of the stored-program concept were introduced to the industry. A retrospective examination of the development of this idea reveals that the concept was discussed by J. Presper Eckert, John Mauchly, Arthur Burks, and others in connection with their plans for a successor machine to the ENIAC.[2] The “Draft Report” was just that, a draft, and, although written by von Neumann, was intended to be the joint publication of the whole group. The EDVAC was intended to be the first stored-program computer, but at the summer school at the Moore School in 1946, there was so much emphasis on the EDVAC that Maurice Wilkes, Cambridge University Mathematical Laboratory, conceived his own design for the EDSAC, which became the world's first operational, production, stored-program computer.

In the 1950s von Neumann was employed as a consultant to IBM to review proposed and ongoing advanced technology projects. One day a week, von Neumann “held court” at 590 Madison Avenue, New York. On one of these occasions in 1954 he was confronted with the Fortran concept; John Backus remembered von Neumann being unimpressed and that he asked, “Why would you want more than machine language?” Frank Beckman, who was also present, recalled that von Neumann dismissed the whole development as “but an application of the idea of Turing's 'short code.”' Donald Gilles, one of von Neumann's students at Princeton, and later a faculty member at the University of Illinois, recalled that the graduate students were being “used” to hand-assemble programs into binary for their early machine (probably the IAS machine). He took time out to build an assembler, but when von Neumann found out about it he was very angry, saying (paraphrased), “It is a waste of a valuable scientific computing instrument to use it to do clerical work.”

One last anecdote about von Neumann's brilliant mathematical capabilities: the von Neumann household in Princeton was open to many social activities and on one such occasion someone posed the “fly and the train” problem to von Neumann.[3] Quickly von Neumann came up with the answer. Suspecting that he had seen through the problem to discover a simple solution, he was asked how he solved the problem. “Simple,” he responded, “I summed the series!”

QUOTATIONS

“If people do not believe that mathematics is simple, it is only because they do not realize how complicated life is.”

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[1] Goldstine 1972, p. 182.

[2] See Aspray, WE, “Pioneer Day '82: History of the Stored Program Concept,” Ann. Hist. Comp., Vol. 4, No. 4, 1982, pp. 358-361.

[3] Suppose two trains on the same track are 20 miles apart, heading towards each other, each traveling at 20 miles per hour. Suppose a fly, capable of flying at 60 miles per hour, leaves the first train, flies to the other, turns around and flies back and forth until the two trains collide. How far will the fly travel before it is squashed between the crashing trains?

“Anyone who considers arithmetical methods of producing random numbers is, of course, in a state of sin.”

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UPDATES

JAN Lee is mistaken when mentioning Alan Turing's PhD thesis—it was actually under the supervision of Alonzo Church, not von Neumann. (MRW, 2012).