COMPUTER GENERATIONS

There's never been anything like the computer in the history of civilization. Historians will eventually have a field day. Computers have changed more in five years than the automobile since its invention. In the twenty-five years of computing, many performance and cost indices have improved by factors of 100,000. Every two years nearly twice as much computing power is available for the same money; or conversely, every two years computers halve in price.

Although computing goes back to the Chinese Abacus—or the Japanese version, the Soroban—the roots of modern computers are found in punch card equipment, particularly its ancestor, the Jacquard loom, which may have operated in the DEC mill at one point. Calculators were built by mathematicians Pascal and Leibetz, but modern mathematicians have given up computer design—leaving computers to the engineers. Though calculators are historically and technologically interesting, they're really dull in comparison to the modern stored-program computer, which gets its power by variable programs, with the ability to calculate rapidly, hold lots of information and even learn.

We mark computer generations by the logic technology they're built from. We're currently in the fourth generation, called large-scale integrated circuit technology. The first generation began in 1945 with vacuum tubes and ran until about 1958. The single transistor package started then and lasted until about 1966. At that time, multiple transistors were put in a package to form a single functional array. In 1972 the fourth generation began, at which time a whole processor was put on a single substrate.

The first modern stored-program computer was probably the Manchester University prototype and we have a valve (tube, to us) from it—so Prof. Sumner, who sent it to us, said (it's clearly not from his TV set). The first useful stored-program computer was EDSAC of Cambridge University, built by Maurice Wilkes' group; Wilkes also invented the micro-programming concept. Wilkes was at the University of Pennsylvania where Eckhart, Mauchly and von Neumann worked to conceive the stored-program computer, which we now also call the von Neumann computer.

We now, overzealously I suspect, attribute Charles Babbage as being the father of modern computing. He had the notion of the stored-program calculator in the mid-1800's, but never got one of his computers to run, because each time he got a better idea for a new computer before the old one worked. In fact, he established other traditions carried into modern computing, including working with unbuildable technology. This caused him to solve a number of peripheral problems, such as making gears better than they had ever been made before. He also was about the first person to receive a government grant—for calculating nautical tables. These research projects were late and had cost overruns.

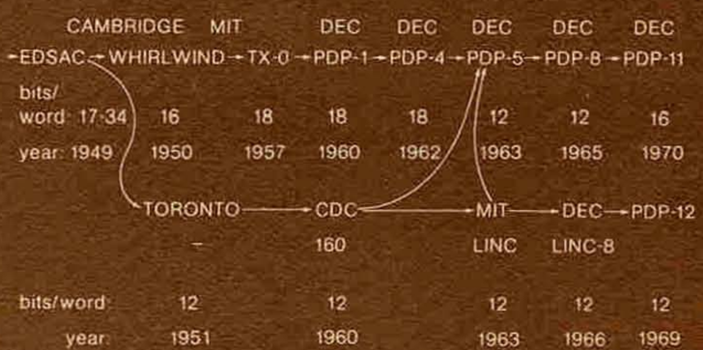
If Charles was the father of computing, then Lady Loveless, his benefactress, co-worker, and friend, was at least a midwife. But more importantly, she was probably the first programmer. Another tradition established there was that she complained that the machine specification was always changing.

If we look at the ancestry of the minicomputer, it is clearly MIT's Whirlwind. These machines and people had a profound effect on DEC. Ken Olsen, Dick Best, George Gerelds and several others of DEC are Whirlwind alumni, and I even wrote a program for it once. The PDP-1 was very much like Lincoln Lab's TX-0 (one of the earliest transistorized machines), and TX-0 like Whirlwind. Beginning with Whirlwind, we can see four generations of minicomputers. It was operational in 1950 and was packaged in a two-story building. The second, our own PDP-1,

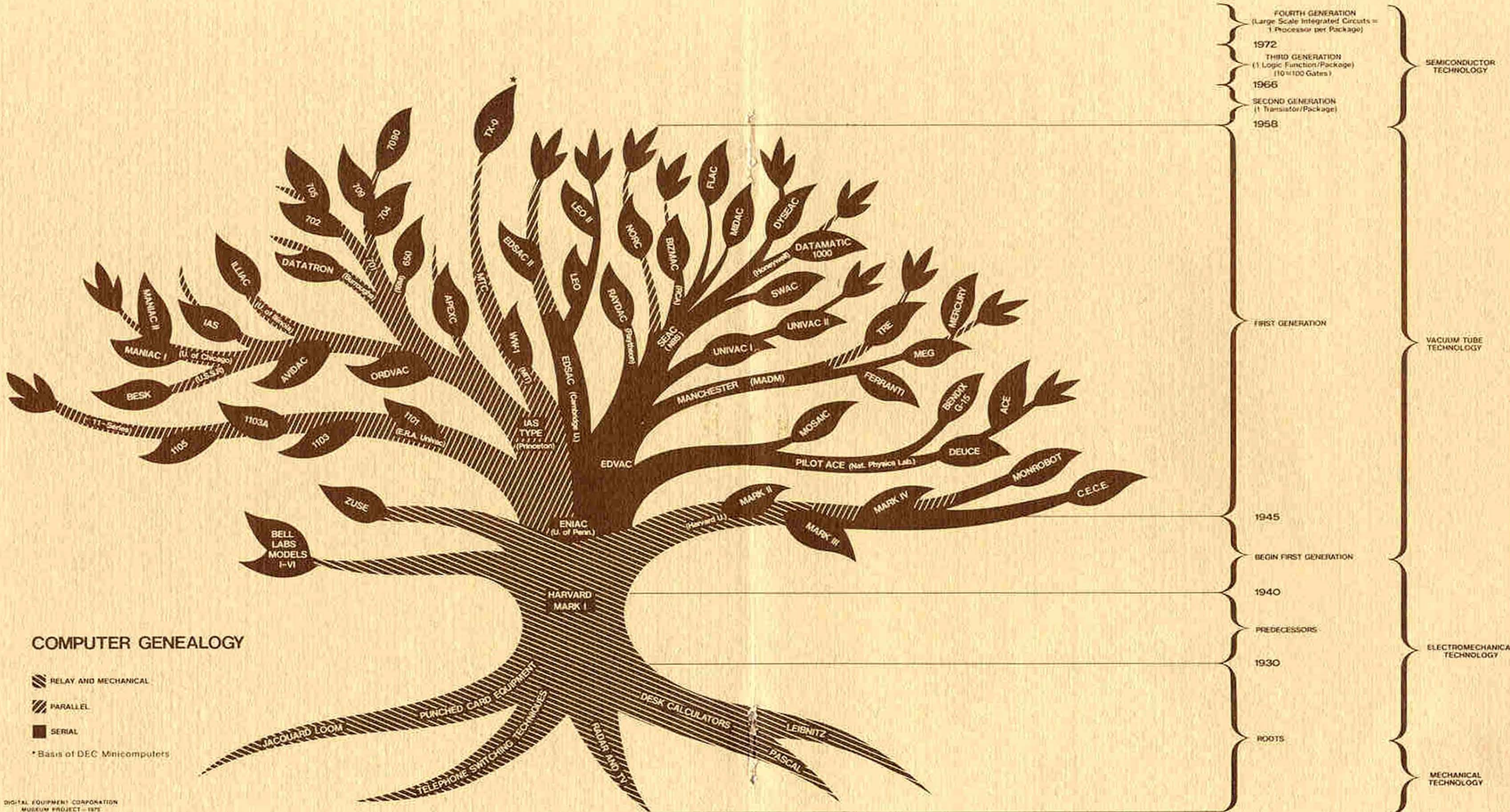
FOUR GENERATIONS OF MINICOMPUTERS

	MIT WHIRLWIND	DEC PDP-1	DEC PDP-8/I	DEC LSI-11
GENERATION	first (1950)	second (1960)	third (1968)	fourth (1975)
PRICE	?	$120,000	$10,000	$650
PACKAGE	Building	4 Cabinets	Box	Board
SIZE	50'x50'x20'	8'x2.5'x6'	2'x2'x2'	8.5"x10"x.5"
POWER (Watts)	150,000	2,500	250	50
SPEED (Memory accesses/ second)	80,000	200,000	600,000	833,000

(PART OF) EARLY COMPUTER HISTORY INFLUENCING MINICOMPUTERS



COMPUTER GENEALOGY



* Basis of DEC Minicomputers

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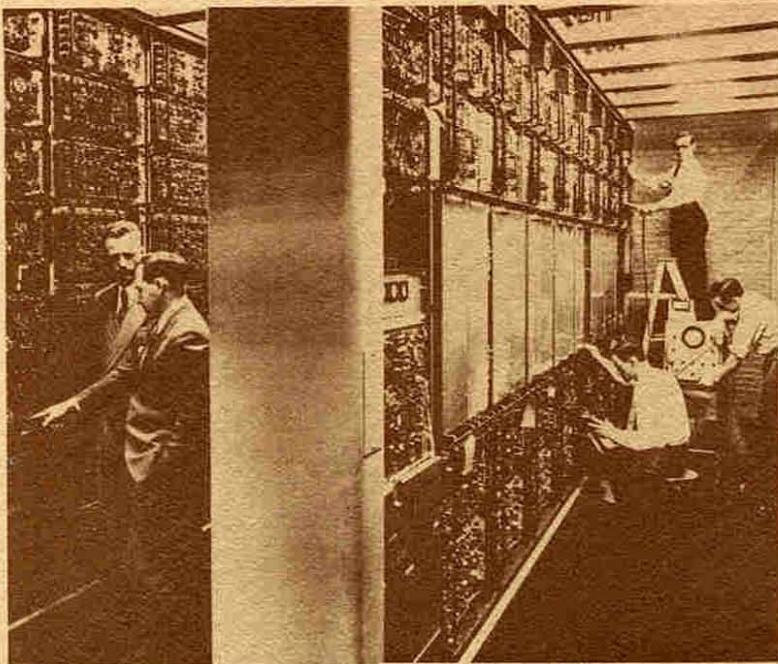
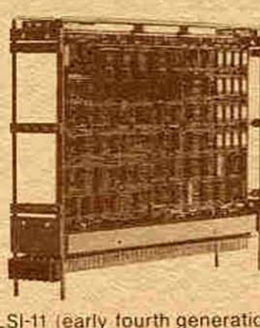


MIT Whirlwind (very early first generation)

PDP-1 (early second generation)

PDP-8 (late second generation)

PDP-8/L (8/I derivative; mid third generation)



LSI-11 (early fourth generation)

was packaged in only four six-foot cabinets. The third generation PDP-8/I occupied about eight cubic feet and now, in the fourth generation, we have the single-board LSI-11, which is ½" x 8" x 10", but it also has over ten-times the calculating power of Whirlwind. Most important, the price has come down by a factor of nearly 200 these last 15 years, which amounts to about 41% compounded per year; that is, every two years the price has halved. This permits new uses of the computer that are in the scale of the application.

The size too has changed, going from a building to a single board. The input power has decreased by a factor of 3,000 from Whirlwind. Whirlwind required 150,000 watts and when it ran, the lights in Cambridge dimmed. A Whirlwind flip flop, which stores a single binary-digit (bit) occupied a volume of about eight cubic feet. In the LSI-11, the same function takes an area of silicon that is only about one hundredth by one hundredth of an inch. Whirlwind had the five conventional computer elements: input, output, control, arithmetic, and storage. Control was an area of the room that one walked through. The storage tube invented at Manchester University was initially used. The arithmetic element gives us the notion of word length. Whirlwind word length was thirty-two feet and a bit slice took up about two feet. We could walk along the bits and the various registers were piled on top of one another. The console was also a place one walked around to look at lights and flip switches. Here we've not made similar strides in console design because there haven't been advances in miniaturizing people.

Whirlwind made important contributions to computing including the cathode ray tubes and light pen input which most computers still don't have, but eventually will if they communicate with people. But Whirlwind is probably most remembered for its innovative magnetic core memory, which is still in use over three generations.

The University of Illinois was particularly prolific. They used the storage tube (invented at Manchester University) in ILLIAC I, a direct descendent from the Princeton Institute for Advanced Studies' machine. A number of the ILLIACs were made and distributed around the world. Illinois built ILLIAC II, and ILLIAC III, second generation machines, but their most recent machine, ILLIAC IV, built with Burroughs, is still to be fully operational.

Industry began building computers in the early 1950's. English Electric built a machine called the Deuce which came out of the English National Physics Laboratory. Contrast this with modules from the IBM 650, and the 704. Probably one of the most easily produced second-generation packaging technologies was that of IBM for the 7090. Burroughs had an interesting package called Cordwood.

DEC's own modules came at the beginning of the second generation. The first modules allowed experimenters to easily build digital systems together. The systems modules allowed permanent digital systems to be made, but more important, they provided the basis for building digital computers. These were the modules from which the PDP-1, -4, -5, and -6 were made.

The flip-chip modules were built for the PDP-7 and -8 so that modules could be made more easily and the back panels could be wrapped automatically. Subsequently, this style of module packaging has been used to include more components and has lasted us through the third generation with the integrated circuits and on into the fourth generation, where it is used for the LSI-11. And there's really no reason to change unless the fifth generation is a big surprise, but that's a few years away, if past generations are any indication.

Gordon Bell

GORDON BELL
Vice President, Engineering

DIGITAL EQUIPMENT CORPORATION
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digital

digital equipment corporation
maynard, massachusetts 01754

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