Keynote Address

The Past and Future Development of Personal Computers

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This paper was presented as a keynote address at the ECA symposium on Standards and Interfaces in Personal Computing, held in Brussels in May 1987. It relates what the author remembers or has been able to learn about the way in which personal computers were developed, independently of the older computer industry, in the early 1970s. Up until recently serious users of computers, who require a lot of processor cycles, have continued to do their work on time sharing systems. Now with the advent of more powerful personal computers, or *workstations*, they are switching over, and the high end of the personal computer field is merging with, and enriching, the older industry.

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The personal computer movement gave the computer world something that it had hitherto lacked, namely a community of amateurs. The radio industry has long had its amateurs, who originally acted as pioneers and continue to provide a pool of experienced talent. I well know the value of the training that amateur radio provides, since I came up that way myself.

The people who started the personal computer movement in the United States were not computer scientists or software engineers. They were people with no previous reputation at all. They were tinkerers. Someone heard about the Intel 4004 and the tinkering began. Companies were started not for business reasons, but because friends or friends of friends wanted copies of the kitchen table computers. Few of these companies survived. It is, I think, right to call it a movement, like women's lib or opposition to nuclear power. For those involved it was a time of excitement, anticipation, and fulfilment.

What I have just given you is an American view based partly on a recent discussion with an American friend who saw it all happen. He was thinking of the personal computers themselves, rather than of the microprocessor chips on which they were based. Others would stress the role of young people with strong links with university laboratories like my old laboratory, the Computer Laboratory in Cambridge, England. However, they did not come into it until a few years after the amateur movement had started in the United States.

It is tempting for computer scientists to trace the development of personal computers to the Alto developed at Xerox PARC and to the PERQ that followed it. However, that is not how it happened. Microprocessors were not a product of the computer industry at all. They were the out-

come of the desire – and the imperative need – of the young semiconductor industry to find a profitable application for early VLSI when only a few thousand transistors could be put on a chip.

The story begins with the Intel 4004, which was a pocket calculator chip designed by Ted Hoff for Busicom, a Japanese company. Hoff's proposal for a programmable device was preferred on the grounds of economy to an original proposal for a special-purpose, non-programmable, device. The 4004 comprised about 2,300 transistors. It was a four bit device, as was appropriate for binary coded decimal operation. It was made generally available – that is, not only available to Busicom – in 1971.

In April 1972 came the Intel 8008, which comprised 3,300 transistors. This was sponsored by a company planning a terminal, although in fact it turned out to be too slow for that application. The 8008 was an 8 bit device suitable for ASCII.

Thus the immediate objective of the Intel engineers was to make programmable devices that would replace random logic. The long-term result was to reinvent the digital computer. Like the embryo in the womb, microprocessors went through all the stages of evolution of the digital computer, but faster.

Given the 4004 it was possible to play at making a personal computer; with the 8008 it was possible to do so more seriously. This was the tinkering that I referred to earlier.

In April 1974 Intel announced the 8080, which had 4,500 transistors. This looked much more like a digital computer; it was not aimed just at logic replacement. In January 1975 a kit based on it was offered, namely the Altair 8800. This had an open-bus architecture and CP/M. The bus ultimately became the IEEE 696. Some people would say that the Altair 8800 is the true ancestor of the modern personal computer.

In reply Motorola introduced the 6800. This was designed by Chuck Peddle, who shortly afterwards moved to MOS Technology for whom he designed the 6502, which was announced in September 1975. The 6502 was sold at a low price and formed the basis of many personal computers – Atari, Commodore Pet, BBC Micro, Apple, and others. At about this point Federico Faggin, who had played a major role at Intel in making the 4004 work, founded Zilog. One is reminded of the story of the small mid-west town which had four restaurants and only three good chefs. In 1976 Zilog announced the Z80. This had an instruction set similar to that of the 8080, but with some enhancements; it was faster and it supported dynamic RAM. The ZX80 announced by Clive Sinclair in February 1980 was based on the Z80. This was one of the first computers to be produced in large quantities and sold at a low price. When my wife and I were about to move to the United States in September 1980 we gave a farewell party. Some of the guests brought flowers for my wife; Sinclair brought a computer for me.

In 1978 Intel announced the 8086, which was a 16 bit processor. The 8088 was a version with an 8 bit interface making it compatible with 8080. The 8088 was used in the IBM PC (August 1981) and other personal computers. It had a floating point co-processor, the 8087, to go with it. In 1982 Intel announced the 80286, a much upgraded 8086, with built-in virtual memory management. This was adopted by IBM for the PC AT.

In 1979 Motorola released the 68000; this was a 16 bit processor, but internally had 32 bit registers. Earlier microprocessors had been hard wired, but the 68000 was micro-programmed. Next came the National 16032. By this time microprocessors were regularly established and I will not attempt to follow their detailed development any further.

Soon after micro-programming reached microprocessors, computer architects realized that memories had become fast enough for the packing of a lot of information in each instruction to be unnecessary; one could do as well – in fact better – with very simple instructions and no micro-code. This was the main technological driving force behind the RISC movement. With single-chip microprocessors there is an important bonus in doing away with micro-code; a lot of space is released that can be used for other purposes, particularly for on-chip memory. The economy of silicon space utilization is of paramount importance to microprocessor designers. For this reason, the 68000 used a version of microprocessing known as nanocoding, and the 8086 used PLAs instead of ROMs to hold the microcode.

RISC principles have been widely accepted by computer architects and designers of new processors are likely to go that way. Within RISC principles, however, there is much room for individual decision and we will, no doubt, see further

evolution. At present the older established lines of microprocessors are being made faster by improved process technology and shrinkage, together with minor improvements aimed at removing timing bottlenecks. RISC chips are new and architecturally immature, but I have no doubt that they will eventually outstrip the micro-coded chips. In fact, dramatic progress may be expected and the performance of the next generation of RISC chips will surprise many people.

What has this to do with mainstream computer development as established in the 1960s? At one time it was customary to distinguish between scientific and business applications. These are now seen as two aspects of the same thing, even if in one case it is called time-sharing and in the other case transaction processing. The Xerox PARC Group and their academic counterparts saw clearly that VLSI would lead to powerful desk-top computers, although as I have pointed out, they themselves played little part in the popular personal computer movement. They did not see so clearly that VLSI would also lead to better and lower cost time-sharing. The success story of the last 10–15 years for the older industry has been in departmental time-sharing systems such as the VAX.

Present personal computers are fine for word-processing, spreadsheets, small business applications, and so on. However, at the present time it is still generally true that work needing a lot of processor cycles is done on mainframes and large minicomputers. We have now arrived at a significant moment at which more powerful personal computers – known in the United States as work stations – are coming into use. These approximate in power to the middle of the minicomputer range and many time-sharing users will switch to them. They are ideal for work in areas such as simulation, CAD, numerical calculations, computer algebra, logic programming, and expert systems of the less ambitious kind. It is a mistake to conclude that work stations will do away with central services. On the contrary, work station users will, with one exception, need everything that central services offer – filing, program libraries, electronic mail, information services, etc. The one exception is processor cycles. Many workstation owners, particularly those with no computer science background, may also appreciate help with the management of their systems, particularly with the installation of software and its updating. Early experience at Project Athena at MIT has indicated that the provision of such services may come to form a major part of the work of central computer organizations.

The personal computer world took some important things from the older mainstream, especially Basic which originated at Dartmouth in 1964, innovations in computer graphics from Xerox PARC, and more lately UNIX from AT&T Bell Laboratories. As I have indicated the personal computer side of the industry grew up independently of the mainstream, which went on very much as though nothing had happened. With the development of more powerful personal computers – or work stations – the personal computer world is now merging with the mainstream and bringing with it a new vigour. It is to be expected that the low cost end of the personal computer field, including the home computer and hobby market, will continue to fluorish, although not perhaps with its former brio.

The semi-conductor industry has become expert in computer architecture. Managers have taken over the personal computer industry and the wild young men who created it have either retired with their millions or have learnt some computer science and become respectable citizens.

VLSI, which has made all this possible, still has a long way to go. The coming generation of RISC chips will push towards the top end of the present minicomputer range and beyond. How far they will eventually go it is impossible to say.

The full history of personal computers has yet to be written. In preparing this keynote address, I have had help from many colleagues and have drawn heavily on the articles listed below.

References

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