SOME EFFECTS OF LSI ON MINICOMPUTERS

C. G. Bell — Carnegie-Mellon Univ.

L. Gale — Digital Equip. Co.

C. Kaman — Digital Equip. Co.

The minicomputer is entering the era of the consumer good; it is forced by a combination of market pressures (e.g. demands, and eventual desk calculator competition) and available low cost technology. If system costs are held low in the order of $10,000 to $20,000, then a number of functions can be incorporated to aid the user. (This means that the mini is an important contributor to the evolution of computer systems.) Thus, lower cost and higher performance technology provide three possible alternatives:

1. Hold technology constant and provide the minimal cost system for that technology (in essence, the factor creating the minicomputer).

2. Hold cost constant (at what users might pay) and incorporate as many functions as possible for the constant cost.

3. Build structures which would not have been possible with older technology (very large array and pipelined computers such as ILLIAC IV and CDC STAR, see Bell, Chen, and Rege, 1971).

The following discussion explores the first two topics.

HOLD TECHNOLOGY CONSTANT

We believe that the main effect of drastically reduced costs will be the creation of a very large market. Already the most dramatic realizations are the desk calculators and the programmable calculators.

The view of minicomputers is changing to handle the control within various terminals. Observe the use of minis in terminals--the so-called "smart terminal": for remote batch processing terminals with included card reader, punch and line printer (e.g. the UCC terminals and DEC DC71); for one-user graphics terminals (e.g. the DEC GT40 and VT08); and finally, we might expect that lower cost soft and hard copy terminals would be controlled in a similar fashion. Indeed, eventually yesterday's minis priced for the consumer market will be at today's calculator prices. Yesterday's large, general purpose computer is today's minicomputer. Dennis and Smith (1971), of IBM research, postulate a 5000 circuit and 20,000 byte computer integrated circuit cost in the late 1970's of about $75.

Now, almost every integrated circuit manufacturer has an MOS "microprocessor-on-a-chip" (e.g. Intel 8008), and by combining several dozen chips together with memory, a 5 ~ 10 microsecond cycle time minicomputer can be fabricated.

For a one user system with a keyboard-printer (or scope) terminal, the system price is beginning to be dominated by the mechanical parts of the terminal. For a small volume, the hardware and software costs are about equal. For the user, the applications' costs predominate. In fact, in an article (Coury, 1970) a "0" cost minicomputer was predicted, and still the system cost was over $10,000.

HOLD COST CONSTANT

From a computer structures and user viewpoint, the addition of more functions in a minicomputer has more promise. The total cost to buy, maintain, program, and use the mini is important--not the purchase cost alone. Admittedly, the manufacturer has difficulty communicating this to buyers who tend to look mostly at purchasing price.

For example, a larger primary memory provides probably the largest incremental improvement in cost-effectiveness because it permits a larger range of user and systems programs to be run.

There are other improvements already appearing in the more advanced minicomputers. The processing of floating data in hardware provides the single most direct improvement in performance. With floating point capability, there is less distinction between the larger general purpose computer (e.g. mid-range 360 and 370 models) and the minicomputer (e.g. DEC PDP-8 with floating point processor, Interdata computers, and PDP-11/45). Memory mapping capability (e.g. program paging and/or segmentation) also provide for multiprogramming and the execution of programs larger than the physical memory. This capability will no doubt be standard in five years.

In the future, other capabilities like those above, which have been derived from larger, general purpose computers (see Bell and Newell, 1971) will undoubtedly be available, for example, the use of caches to increase performance.

Although the above concepts have been "adopted" from the large computer, the minicomputer has also contributed to computer development. Perhaps the greatest influence has been to belie the myth that computers are hard to interface. The research necessary for multiprocessing is based on minicomputer processors (e.g. Wulf and Bell, 1972). Similarly, user microprogramming is available on several minicomputers. This capability is double edged; while giving higher performance, it does so at loss of generality and future compatibility.

OBSERVED EFFECTS SO FAR

Already the minicomputer, because of its simple structure and relatively short half life, has tracked technology. Thus, any change in circuit performance or availability is incorporated rapidly. The advent of LSI has effected the cost and market size as described above.

The direct effect of low-cost, high-performance LSI memories has permitted a large processor state (i.e. general registers); microprogramming (1/2K word read-only or read-write memories); various memory mapping (constructed of small arrays); eventual replacement of core by MOS; and the cache memory. Within the processor there has been a less dramatic effect; an MOS processor-on-a-chip is really only cost-effective in smaller systems where absolute low cost is required--or a certain minimum performance is acceptable. For example, the availability of the MOS PDP-8, running at 1/5~1/8 the current PDP-8 speed would not satisfy all the PDP-8 users. Instead, it would probably establish markets which currently are not available because of cost.

SUMMARY

The above discussion has explored the technological (LSI) and market pressures (lower cost and more capability at a constant cost) which have influenced the minicomputer. As technology improves, it is incorporated within the minicomputer so rapidly that the mini now plays an important role in the evolution of the computer specie.

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