

Needed: more computers in universities

The next decade ought to see an astounding growth in scientific computing capability for basic research in universities. The total increase in capacity could exceed a factor of 10^7 . Most of this capacity would (I believe) be used by theoretical scientists and engineers performing computer simulations.

There are several reasons why this growth should take place. First, basic theoretical science is moving away from analytically soluble model systems, such as the hydrogen atom, to problems of real-life complexity, such as the chemical bond, turbulence, first-order phase transitions, the life history of astronomical objects, and quark confinement. Computer simulation is needed in all these subjects to provide quantitative examples confirming (or disproving) qualitative theoretical concepts. See the articles in this special issue (page 23).

Second, industry will want to make increasing use of computer simulation. Rapid changes in raw materials, industrial processes and designs will force increased use of basic science (via simulation) to solve industrial problems, especially problems for which industry has no backlog of experience. Third, the fantastic developments in computer technology now taking place will open up new opportunities for computer simulation with the reliability and accuracy needed by both industry and basic science. Fourth, these developments should be speeded by current developments in Japan. A shock wave should go through industry as Fujitsu and Hitachi start delivering supercomputers to Japanese industry (about a year from now) that are likely to be competitive with systems soon to be delivered by US manufacturers.

In view of these developments, I hope that we will soon arrive at the point where computer usage in basic theoretical science will be limited only by the total world manufacturing capability for scientific computers. The university market should become the main driving force behind commercial technological development in scientific computing, because universities can place more emphasis on innovation and less emphasis on reliable operation in their purchases of scientific computing equipment than can either private industry or national laboratories. In addition, university personnel-training programs, advanced software development, and breakthroughs in basic research all are of critical importance for growth in the supercomputer market. Moreover, universities have always functioned well as demonstration sites for new commercial computing systems.

Ultimately, the financing of computing in universities is likely to come from private industry, as universities become recognized as critical to industrial development. However, this will require time as well as changes of attitude in universities and private industry.

Universities must recognize the scientific importance of large-scale scientific computing; today only a very few universities take it seriously. Industry must recognize that financing the scientific computing market at universities is a legitimate business expense subject to a cost-benefit analysis, and that too little expenditure on this market is as disastrous as too much. Meanwhile, government has a critical role to play in the computing buildup.

As a first step, powerful supercomputers about to appear should be placed in universities at a very early stage so that industry can observe the role that universities play in the supercomputer scene. For example, a Cray-II, as soon as one is built, should be placed at the University of Illinois, which is one of our most active campuses in large-scale scientific computing and supercomputer software research.

The National Science Foundation should give very high priority to building a clone of ARPANET (a computer-linkage network) serving all scientific disciplines in universities and industrial research. This second network is needed to provide remote computer access, thereby equalizing computing opportunities for young people at different universities. Even more important, the ARPANET "electronic bulletin board" facilities provide interdisciplinary communication and technology transfer: A user of ARPANET can ask for help by placing a message on the relevant bulletin board; the appropriate experts reply (if they don't they won't be known as experts!). I believe that the US is currently losing tens, if not hundreds, of billions of dollars in lost opportunities for economic growth from the matchups that such a network would provide. A network sponsored by NSF should provide the same bulletin-board facilities as the present ARPANET.

Finally, there is the issue of computer planning. Universities must plan to accept major increases in scientific computing equipment and establish vigorous programs of instruction and research built around these systems. Government agencies (especially the NSF) need to plan for much larger programs in computing and computer science than now exist. The computing industry should plan for major additional capacity to meet university needs. They must also plan for much more extensive use of tax-deductible donations to place their equipment in universities at minimum cost to the universities. Private industry ought to be considering much closer ties with universities. Modern industrial problems are becoming of increasing scientific interest as the growth in computing capabilities makes these problems accessible to basic research.

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