# Physicists Dream About a Computer Network

*An NSF subcommittee says it is time to start providing funds for support of computational physics—now a field in its own right*

Physicists have traditionally divided themselves into two groups—experimentalists and theorists. Computers have been immensely helpful to both. Lately, those theorists whose main research tool is the computer have been calling themselves computational physicists—a third category. This group does computer modeling of complex systems and finds numerical solutions to equations of motion, whereas the traditional theorist develops models and uses analytical mathematical techniques to solve equations.

An ad hoc subcommittee of the National Science Foundation's Physics Advisory Committee has submitted to its parent body a plan for a computer network to serve the needs of computational physicists. The network could cost as much as $15 million per year to operate on top of initial capital outlays of $5 million. Interestingly, the plan comes just months after the National Science Foundation (NSF) and the Department of Energy declined to continue the National Resource for Computation in Chemistry (NRCC), a 3-year-old facility with an annual budget of under $2 million. Can physicists accomplish what chemists could not?

No one is likely to find out for some time because there is not yet a formal proposal in hand. At its most recent meeting the first week of February, the advisory committee deferred an endorsement of the plan, which subcommittee chairman William Press, a Harvard University astrophysicist, preferred to describe as a prospectus rather than a proposal. Instead it passed a cautiously worded resolution praising the subcommittee for its efforts and calling for further explorations by the NSF staff of the possibilities for initiatives of this sort.

In the meantime, committee members would try to gauge the level of support for a computational physics computer network within the physics community. Lack of community-wide support among chemists was one reason for the failure of the NRCC, which will gradually wind down its business and close for good this fall. As Richard Deslattes, director of NSF's physics division, told his advisory committee, "If it's going to work, there must be a sense that the community wants it. Even those who don't benefit will have to support it somewhat."

One morning of the 2-day advisory committee meeting was devoted to a review and discussion of a report, the prospectus, written by Press and his colleagues. Press began by noting that his subcommittee was charged to "think big." The idea was to come up with a complete program, not just a piece of a solution. Such a new initiative would probably also be funded with new dollars and not at the expense of any existing physics research. Because the initiative is seen as a long-term effort, the subcommittee did not discuss the realities of this year's budget prospects. Press disclosed that in fiscal 1980, NSF spent some $13.2 million on theoretical physics, but only 2.8 percent of this figure went for computer services and equipment. He called this paltry amount "shocking" because the estimated actual expenditures for computing by university-based theorists supported by NSF was over $10 million. In other words, the field of computational physics has grown entirely through case by case pleading to various sources having discretionary funds.

This entrepreneurial mode of financing computational physics is woefully inadequate for the future growth of the field, Press told the committee. Among other things, these "nonstandard" sources of support are drying up. Because of advances in computer technology, for example, universities can acquire several computers with different capabilities. This means that the "free time" once available from campus computer centers with a single underutilized, large machine is disappearing.

At the same time, computational physicists need access to more powerful computers. The problem is basically one of modeling increasingly realistic systems. Simple one-dimensional models give way to three-dimensional ones. Scalar quantities are replaced with vectors or tensors. Linear problems become nonlinear. And so on. But the computer power needed to tackle real-world systems increases much faster than the complexity of the model. If the spacing between the points in a three-dimensional simulation of a plasma in a fusion reactor is halved in order to obtain more realistic results, for example, the computer power to make the calculation is increased by a factor of 8. One increasingly common phenomenon traceable to lack of access to computers with the required capabilities is the travel of U.S. physicists to Europe. The Max Planck Institute for Plasma Physics in Garching, West Germany, has a supercomputer that visiting scientists can use, as does the British Science Research Council's Daresbury Laboratory.

Actually, computational physicists have two needs, which Press calls capability and capacity. Capability refers to the most complex job that a single machine can do. A very high speed and a huge memory may be prerequisites for certain complex calculations. Capacity is the throughput. Several medium-sized computers could handle just as many moderate-sized jobs as one supercomputer (same capacity or throughput), but might not be able to service a very large or complex one (smaller capability).

As it happens, the subcommittee determined, the cost of supplying computer capacity to physicists is approximately independent of that nature of the machines; one supercomputer and the equivalent number of medium computers go for the same price. This fortunate circumstance considerably simplified the matter of figuring out the optimum mix of larger and smaller machines. The subcommittee concluded that computational physicists face a "threshold" in the required computer resources below which a meaningful attack on important problems in the field would be unlikely. The threshold was estimated to lie in the wide range from $12,000 to $120,000 per year per investigator, roughly the same level of support that experimental physicists receive.

In announcing the specific form of the computer resources to be supplied to physicists, Press was careful to emphasize that the subcommittee was not calling for a centralized physics institute. Instead, it was proposing a computer network that would consist of a principal node and several regional nodes. The principal node would house a supercomputer and would have some 35 full-time employees. The institution that served as the site of the principal node would also be responsible for overall management


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of the network. Projected operating costs for the principal node are $6 million yearly, including lease of the supercomputer. Capital costs for the central site would be about $5 million.

The regional nodes would house medium-scale computers of the type also known as super-minis. There might be 20 of these at an average cost of $0.5 million, although the range of capabilities from node to node (memory size, for example) could be broad. In addition, certain of the regional sites might also incorporate extra features, such as interactive graphics. Others might serve as test vehicles for advanced facilities not yet reliable enough for the central site.

Press emphasized to *Science* that proposals to use these facilities would be judged by a broadly based panel of physicists to ensure that theoretical problems of importance to the entire community, not just to computational physicists, were addressed.

Press frankly admitted to the committee that the inspiration for the proposed network is the 7-year-old Magnetic Fusion Energy Computer Center at the Lawrence Livermore National Laboratory. Livermore, with a Cray-1 supercomputer and several other machines, is the principal node, and there are 13 service centers with minicomputers for fusion researchers across the United States that communicate with Livermore by way of leased telephone lines or microwave links. People who have used this network, the Defense Advanced Research Projects Agency's ARPANET, or other networks proclaim that communication between researchers at distant sites is so good that, in some ways, a network serves as well as a centralized institute for collaborations. Similarly, all the facilities on the network would be accessible to researchers at any node.

The physicists are certainly thinking big, but are they thinking big enough? NSF's Deslattes said at least three times that the network is expensive enough to be visible to Congress. It therefore behooves the physicists to have their act together before entering the fray for funding. One thing worth considering, he suggested, is banding with other research groups, including computational astronomers and quantum chemists (who are at loose ends with the loss of the NRCC). In this way, a plan for computer facilities that satisfied everyone's foreseeable needs could be presented to Congress, which would then have to wrestle with the issue only once. In this day and age, if each group pestered the legislators on its own, nobody would get anything.—ARTHUR L. ROBINSON

# A Fish in the Bush Is Worth . . .

In the middle of the Brazilian jungle, some 30 miles from the nearest river, a school of piranha wait patiently under a rubber tree. When one of the tree's pods explodes in the hot, equatorial sunlight, there is a mad rush among the fish to catch the seeds that are ejected. Few of the seeds ever reach the ground—at least until after they have passed through the fishes' digestive systems and have been carried far from their source.

No, these fish have not evolved legs. They are, however, part of an unusual ecosystem that, according to the International Union for Conservation of Nature and Natural Resources (IUCN), is in danger of destruction because of extensive deforestation in the Amazon basin. If the deforestation continues, IUCN says, the commercial fishing industry on Brazilian rivers will collapse and many species of both plants and fish could disappear. The government of Brazil argues that the total amount of deforestation is small and that new trees and other crops are being planted to replace the felled trees.

The Amazonian basin represents a type of delicate ecosystem that has virtually disappeared elsewhere in the world. Every year, between June and November, the waters of the Amazon and its tributaries flood some 40,000 square miles of forest. When this happens, fish from the rivers follow the water and become part of the fauna of the forest, feeding on the seeds and fruit falling into the water. Many fish of the region are evolutionarily adapted to these conditions, having molars to crunch nuts and bloated stomachs so that they can build up a store of fat for the period when the waters recede. Several types of piranhas have even been found, says Michael Goulding of the Instituto de Pesquisas da Amazonia, that have forsaken the pleasures of flesh for a vegetarian diet. The trees and other plants benefit also, since the fish disperse their seeds widely throughout the region. In 2 years of work, scientists participating in a survey of the region sponsored by IUCN and the World Wildlife Fund have already identified more than 200 species of fish and trees that rely on this symbiotic interaction.

New England Aquarium

Man also depends on the symbiosis. Fish are a major source of protein for residents of the Amazon basin, says Goulding, with three-quarters of the catch coming from the floodplain forest. The most important commercial species, the tambaqui, is a seed eater. But in heavily deforested areas, the IUCN scientists have already noted a drastic decline in the fish population. Some fishermen in those areas have already been put out of business by lack of fish, and this trend is expected to accelerate if deforestation continues.

And continue it does, according to IUCN. Thousands of acres of palm trees have been destroyed in harvesting palm hearts, which are much valued as an ingredient for salads. Elsewhere, IUCN says, large areas of forest have been cleared for agriculture, chiefly rice cultivation and cattle ranching. An extensive forested area along the Rio Tefé is now being zoned for a large agricultural experiment. The question that has not been addressed in many of these projects, IUCN argues, is whether the protein from rice, beef, and other crops will be an adequate replacement for that formerly supplied by fish. And even if the protein is adequate, the wisdom of destroying this natural ecosystem and, perhaps, innumerable species of fish and plants, is still highly questionable.—THOMAS H. MAUGH II