25 YEARS AGO

Cooperative Systems—An Evolutionary Perspective

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This issue, "25 Years Ago" looks back at some thoughts on cooperative systems with excerpts from Tibor Vámos, "Cooperative Systems—An Evolutionary Perspective," *IEEE Control Systems Magazine*, vol. 3, no. 3, pp. 9–14, Aug. 1983.

Several coherent trends that originated from different sources can be formalized now as a new and relevant perspective of system philosophy. The nomenclature is different—hierarchical, distributed, cooperative—but the profound reasons of this evolution are analogous and contain a significant message for understanding the existing and future design.

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THE ROOTS OF COOPERATIVE SYSTEMS

The problem of system organization is closely connected with the problems of system building (design) and control (analysis). A simple one-loop feedback control of early technology, or a transparent and few-purpose, few-level human organization, could easily be modeled (mathematically or verbally-conceptually)... These models of direct, well formulated, simple controls were transmitted for larger systems also by applying more hierarchical levels. The deficiencies of operation were attributed mostly to inadequate technical or human realizations, not to the systematic character.

Against these generally adopted principles of early and simple rationality, some systems emerged which were basically different. The first of these "anti-rational" systems was the market (local, national, world), an exchange of goods, without a visible control. The next area was international communication—messages and transport.

The book of Douglas R. Hofstadter discusses the society of ants, comparing the genetic information and neuronal processing capability of the single ant to the complexity of their anthill organization, and results in a similar conclusion: the interaction of many different, rather simple, but balanced control laws results in a very high-level performance without any explicit "description" or "formulation."

The next impetus came from the computer field. We can identify the same process—first independently of each other—leading to similar conclusions. The fast growth of hardware availability soon led to hypertrophy problems. It turned out that more distributed-task systems are more

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powerful than one single giant. Operating systems concentrated in one bulk architecture began to show the typical bureaucratic performance requiring more and more of the increased capacity for self-administration.

Artificial intelligence—intelligent programming and problem solving—by its very nature reached the limits of conventional approaches and began to move towards the new ones. As usual, exaggerated, superoptimistic forecasts of early results on simple model-examples led to the realization of the intrinsic problems previously covered by the thin layer of the simplified paradigms. The history of computer chess was the same: in the late fifties and early sixties, a world champion's level computer program was predicted within reach in just a very few years. In the seventies this forecast was shifted to the end of the century. Now, having several orders of magnitude more powerful computers, all predictions are discouraged.

As Hofstadter concludes that Bach's music, Escher's art, and Godel's mathematics cross all levels, mathematics, neuroscience, psychology, sociology, technology, and computer science cross at a certain level of complexity, namely, the failure of hierarchical structures determined in advance and a need for a much more adaptive, creative cooperation.

All the early technological examples of cooperative systems are based on information transmission. This is an essential feature—cooperation is possible by a two-way information exchange only (sending and receiving). According to the hypothesis of some anthropologists, the superiority of human ancestors over any other kind of hominids lay in their palatal development, in the ability to form consonants, and by that articulated signals—a communication superior to any other creatures. Postal, telegraph, and telephone communication contained information as their own substance; the development of railway networks was closely connected with telegraphy.

NEW AREAS OF RESEARCH AND DEVELOPMENT

The fast expansion of similar ideas, necessity and availability extends the various fields of application, and the realization raises several unclarified problems for research.

Ethernet, the various other further local network systems making use of the same basic principles, and the standardization effort concentrated in the IEEE 802 committee, are not only new formulations of inhouse communication but the heralds of new working organizations.

It is not an exaggeration that the mentioned 802 standard proposals contain a 32 bit address-space! We have to remember the example of telephone and power networks started about 100 years ago when nobody could foresee the application-services spectrum that had to be integrated into the early conceptual frame!

A two-building software factory in Japan has fast outgrown the proposed international bandwidth for local networks, the 10 Mb/s rate. Bell Labs is working on a 100 Mb/s system.

Starting from various technologies, needs, evolution trends, and realization possibilities, a new perspective of system architecture is evolving that feeds back its revolutionary effects, not only to technology but to a broad spectrum of human activity. The new levels of complexity force this process inevitably.

—Contributed by Kent Lundberg