Memory Trends in the 70's

An Introduction By This Issue's Guest Editor,
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A modern data storage system is designed in three independent phases. The first design, that of the memory element and subsystem, has the objectives of providing functionally simple storage units of high capacity and operating speed at low cost. This discipline embraces the design of core, film, semiconductor and optical static memories as well as a variety of moving media memories.

The second design, accomplished by the computer architect, has as a key objective the organization of many diverse memory subsystems together with ancillary logic into an effective hardware data storage system. Also, the computer architect employs memory units for a variety of logic and control functions not directly related to data storage. By virtue of ingenious buffering techniques, overlapping memory accesses and concurrent memory operations within multiprocessors, the resulting data storage system can have substantially improved performance relative to that of individual memory units. The use of read-write, read-only, and associative memories as logic and control elements, such as microprogram storage, instruction decoding, display character generation and executive control tables, further enhances system throughput and improves adaptability to diverse task environments.

The third design, performed by the systems programmer, attempts to organize the complex data structures, dictated by application programs, to facilitate retrieval from and modification of the structures, and also to conserve memory capacity. Since there are now few hardware aids to this task, the efficiency of a storage system can be substantially degraded when complex data bases are stored and manipulated.

Through the past decade there have been various attempts to better adapt the product of one storage design phase to requirements of subsequent phases. A number of logic-in-memory schemes have been proposed to better adapt memory subsystems to architectural requirements or to improve manipulation of complex data bases. Examples of these include associative or content-addressable memories, First-In, First-Out, and Last-In, First-Out buffers, and static sequential-access or block oriented memories. Machine architectures have been proposed which are optimized for processing branching and re-entrant list structures of multi-dimensional arrays as well as architectures which employ higher level languages as machine languages. These architectures do use or could effectively use unconventional memory subsystems. While limited features from some of these architectures have appeared in delivered machines (e.g. list manipulating instructions, stack pointers, associative control memories to implement memory paging), most unconventional architectures are still at the paper or laboratory stage.
The ensuing collection of papers attempts to identify present trends in each of the three disciplines contributing to design of modern data storage systems and to forecast these trends through the next decade. Each author also attempts to forecast interrelations between his and correlating disciplines.

In the first paper, Mr. D. C. Gunderson describes the potential impact on computer system organizations of advances in memory technology expected during the 70's. He discusses the system impact of three specific memory advances; availability of competitively priced associative memories, significant cost reduction of low-capacity random access memory, and availability of block oriented mass memories. He describes a variety of control functions performable by associative memories, particularly within multiprogrammed and multiprocessor systems. He also forecasts the impact of small low-cost random access memories on distributed and array processors and the potentiality of block oriented mass memory to reduce main memory storage requirements. Several novel computer organizations are presented to support his arguments.

In the second, R. J. Petschauer discusses trends in memory element and subsystem technology. He gives reasons why core technology has remained dominant as static memory through the past decade in the face of significant efforts to supplant it with other magnetic elements. He points out that semiconductor, optical, and some new magnetic memory technologies offer challenges which are different in character than earlier displacement technologies, and suggests areas in which these new technologies will replace existing magnetic technology together with the timing and extent of such replacement. He also comments on the cost effectiveness of logic-in-memory concepts.

In the third paper, Dr. P. C. Patton reviews trends in data organization and access methods. He discusses a trend toward data directed and transaction oriented systems in which activity sequences are determined by the structure of the data base rather than by control programs. The inordinate overhead in present operating systems and large on-line application programs is described as a symptom of "static" and "dynamic" mismatch problems in the storage hierarchy. Some new data organization techniques are described which allow a programmer to separately store the structure and the content of his data and thus to effectively use complex data structures.

The authors recognize that long-range technological forecasting is an imprecise art, especially in a field so dynamic as data storage techniques and that forecasts in this field are subject to gross error. However, to the extent that change is evolutionary rather than revolutionary, our extrapolation of present trends can be meaningful. Also, by projecting results from current trends, we hope to stimulate further innovative effort in this field.