A user's view of A.D.P. systems design

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The development of A.D.P. equipment is briefly examined in relation to the needs of business users. Their needs do not appear to have strongly influenced the design of past systems, and lead to some thoughts for the future. This paper was first presented at the Joint Computer Conference held in Edinburgh in April 1964.

It has been said that users, programmers and engineers share the common aim of providing efficient data-processing systems. This truism implies more positive cooperation than has existed. There are inherent conflicts between what programmers want, what engineers provide and what users can afford: and the user, necessarily last on the scene, has been the least regarded.

The first computers were complete novelties: only their designers knew what results they sought, and what limitations of ideas, methods and materials they endured. The first business users could do little more than guess their requirements, without experience to guide them, and with no clear understanding of what the new machines might reasonably be asked to do. In such circumstances users may distort their methods to accommodate, and so perpetuate, some passing clumsiness of design.

Efficiency includes effectiveness and economy. Effective data processing requires speed, logical power, flexibility, expansibility, variety of input, output and processing, and easy operating. Economy takes account of all costs including those of: purchase, accommodation, air-conditioning, power, initial training, file conversion, programming, depreciation, interest, operating, maintenance and consumables.

The development of A.D.P. machines

The first computers were designed for mathematicians, and adapted for office users. Still pioneering, users have been too busy to distil from their experience the essential principles of the automatic handling of business data. No clear, general formulation of business requirements, an experimenter's disdain for costs, and continual advances in electronics, have caused the development of A.D.P. machines to be dominated by technical factors. One of the more significant has been the continued mismatch between the speeds of calculation and of entering and removing data.

At first, computers completed each operation before beginning another: next, machines overlapped calculation, input and output to some extent. Then, buffer stores matched the slow periphery to the fast centre, and some peripheral units operated with considerable autonomy. Different parts of the system could work on different parts of a program at the same time.

However, in most programs later operations depend on earlier ones, which limits the number of units that can be kept going. Arrangements were, therefore, made to share the central computer between several independent programs, in order to allow it to operate a large number of peripheral units concurrently. Time-sharing imports complications, and rests upon the expectation that it will be cheaper to divide one large fast computer between interleaved programs than to use several smaller, slower ones, each working independently on a single program. This largely remains to be proved under field conditions.

The insidious growth of paper work, and rising office costs, focussed attention on clerical processes and started a swing towards integrated data processing. Integration incurs the well-known risks of bottle-necking. Delays in data transmission need not be significant, but delays at the centre are potentially troublesome, and place heavy premiums on the reliability of the data-processing equipment, and on its effective operation.

The rough path to integration may be smoothed by a gradual approach, which mechanizes individual activities with equipments able to exchange data. With related activities in automatic correspondence a loose integration exists, which can be tightened gradually as machines are replaced. This pragmatic approach does not immediately require the use of large computers, but large computers have been said to be cheaper to use than small ones. Certainly they waste money more rapidly when idle.

Large fast machines are being manufactured as a by-product of scientific requirements; and as machines go faster people find it hard to avoid using them. Hence, attempts will be made to extend time-sharing in clerical work, even though this is more difficult to plan and control than independent running. Thus, the size of the store, and the peripheral devices available, restrict the selection of programs to run together. This makes operating schedules more difficult to compile, and to revise at short notice. In machines with unguarded stores programs must be minutely checked for a realistically wide range of data, before they can be allowed to run with others. In practice, time-sharing may be restricted to associating one major A.D.P. program with subsidiary tasks, such as printing from magnetic tape, card-to-tape conversion, or answering routine enquiries.

The most recent attempt to exploit in office work equipment designed for a different field is the introduction of "real-time" systems developed for military use. Certainly, genuine real-time applications exist in A.D.P., especially when the analogy with the military use is closest, as

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when the environment is competitive and stocks are volatile; but many office processes lose little by batching, and a sense of proportion is necessary.

Business users' needs

(*a*) *The environment.* A.D.P. machines should fit inconspicuously into ordinary office accommodation. In fact, they demand electrically quiet and steady power supplies, air-conditioning, acoustic absorbers, high ceilings, raised and strengthened floors, and large pillar-less rooms to accept cabling restrictions; and some enter spectacularly by crane through the window.

(*b*) *Reliability.* "Fit and forget" is still an ideal for A.D.P. machines. True, their failures are few for their complexity: true, it is fairer to assess the work done between failures: true, they are intensively used. True, finally, that some thermionic evils do not plague the solid state: but this highlights mechanical troubles.

(*c*) *Preparatory costs.* The initial costs of analysis, programming, data conversion and load building can equal those of equipment. Users are as interested in these costs as in those of equipment, but less development effort has been applied to their reduction.

(*d*) *Compatibility.* As A.D.P. spreads, and as more machines need replacement, the transfer of data and programs between machines will increase in importance to users. Here, also, development has been slow, and mainly sponsored by users rather than by designers.

The future

For whatever reason the needs of A.D.P. users do not seem to have strongly influenced past design. What of the future?

Central processors will become faster and more reliable through the use of integrated circuits. If these became cheap, redundant-logic design could greatly improve reliability. High speed demands narrow pulses and wide bandwidth trunks which may eventually be provided by lasers and fibre-optics. The limit may well be set by noise, for precise timing requires a good signal-to-noise ratio as well as a wide bandwidth.

If speed became cheap, A.D.P. users would be suited by using it to simplify programming. Thus, if it became cheaper to waste machines' time than programmers' time, the refinement of procedures would be less necessary and common languages would become economic, which would largely solve the problem of program exchange.

Data storage which requires mechanical access to each location is clumsy, and purely electronic means of access may well be developed. It is perhaps a pity that the Williams tube did not receive the attention given to magnetic forms of storage.

Peripheral equipment is already the principal source of A.D.P. failures, and urgently needs attention by professional engineers. Its design cannot be left to technicians—however good—for it depends on the analysis of transient dynamic phenomena. This equipment also poses the principal requirement for operating staff, due to its need for frequent reloading: processing times, costs and errors could all be reduced by automatic loading. Peripheral equipment also should be designed for data exchange between systems.

A major A.D.P. installation now consists of a single, large processor surrounded with an array of peripheral equipments, and by time-sharing it aims at maximum usage of every item. A more convenient arrangement would be a small processor—complete with arithmetic unit, store, control unit and coupling registers, which could work alone, with appropriate peripheral equipment, on small jobs. For larger jobs several such processors might be linked through their coupling registers to operate as a single large central-processor capable of truly parallel operations. In this way the machines could be matched to the characteristics and volume of the work, instead of vice versa. For example, large magnetic-tape files could be divided for processing by the several small machines acting independently, with one machine allocated to enquiries.

For complex jobs with several machines linked together the failure of any one need not halt all work. The diagnosis and correction of faults in an isolated, but complete, small machine would be simpler than in a single large machine working under the heavy operational pressure of delays to several concurrent programs.

The complications and risks of a large machine system would be restricted to those processes for which it was essential. Simple processes would be performed by simple machines. Under time-sharing, simple processes are combined to yield a compound process, for the machine's action depends only on the sequence of instructions obeyed, whether these come from one or many programs. When the compound process is sufficiently complex it justifies a complex machine; but this has not been done primarily to meet the needs of users.

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