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Alternative versions of SKED: Current systems and future plans*

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SKED was originally designed to be the least expensive user-oriented system for on-line control and recording of behavioral experiments. Recent price reductions in the cost of memory and peripheral devices has permitted cost-effective development of more convenient and powerful versions of the software.

SKED originally was developed to be the least expensive and most cost effective experimental control and data acquisition system. As computer prices have decreased, more powerful peripherals and programming systems have become available.

The present report describes several systems of increasing power, complexity, and cost. Each system in the hierarchy has different advantages over its predecessor and each requires more initial cost. Several peripheral devices and their advantages and disadvantages for use as SKED peripherals will also be compared. Finally, the formation of a STATE NOTATION users group will be discussed.

SYSTEMS

Level 1

The minimal configuration on which SKED can be used is an 8K PDP-8/I, -8/L, -8/F, or -8/E with an ASR-33 Teletype and a small interface of the type described by Butler (1974). The cost of this system, with 12 inputs and 12 outputs, begins at about $4,800, with a used 8/L and ASR-33, to about $6,000, with a new 8/F. The software system for this level consists of the PDP-8 editor, a state notation compiler, a run-time system called RTS4PT, and the FOCAL programming language. A Level 1 system could run from 1 to 10 stations, depending on the level of complexity of each state program. Except for the case in which very simple programs are used (let's say in an introductory laboratory course), it could support four stations with programs of intermediate complexity. Quite complex experiments could be conducted with one or two stations.

The major disadvantages of this level are: (a) the limitation of core on program complexity; (b) minimal formatting of data with only the station number used to identify a recording; (c) a limited set of currently available F3s, in that most of those developed run only in 8K or more of core (of course, these could be rewritten by a machine-language programmer to operate in 4K); and (d) length of time required to program new experiments, load state tables, print data, and analyze data due to the slow speed of the ASR-33.

Level 2

The first expansion of the system is to include a faster input and output device to improve the performance of the Level 1 system. For approximately $500, a high-speed paper-tape reader can be obtained from State Systems. This device will increase the speed of loading programs, but will not increase the complexity or quantity of on-line experiments or data recordings. For approximately $1,500, a small magnetic cartridge system (Microdek from Tennecomp) can be obtained, which will provide both high-speed input and output. Through the use of a run-time system called RTS4, this device can be used to record data on-line at a rate of 100 counters/sec. The Microdek can also be used to increase the speed of programming new experiments and in loading programs into the computer. For approximately $3,000, a high-speed paper-tape reader and punch can be obtained from DEC; this will provide approximately the same increase in speed as the Microdek, but it may be somewhat less useful in terms of convenience in handling paper tape as opposed to the magnetic cartridge.

No other high-speed input-output devices are currently supported for the 4K system, but a variety of useful peripherals could easily be incorporated with the addition of appropriate machine language patches to the RTS and compiler.

The major advantages of the high-speed peripheral are: (a) an increase in speed of about 10 times in transferring data into or out of the computer, and (b) an increase in the ability of programs to acquire more extensive on-line data for further analysis off-line.

Level 3

The third level requires the addition of 4K or more of additional core memory to the Level 2 system. The cost of this will vary, depending on computer type and whether it is included in the initial order of the system, which permits some discount in the cost. Four K will

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vary between $1,500 to $2,750 for 8/L or 8/F. A PDP-8/L can be expanded to 12K, and an 8/E or 8/F to 32K of core memory. There are several supplies of additional memory that make expansion to 24K quite feasible for approximately $6,000.

The run-time system called RTS8 has been developed to use the additional memory fields for a variety of purposes.

The major advantages of this system include: (a) the ability to run more simultaneous experiments of greater complexity (this may require the purchase of additional state system interfacing); (b) the support of System F3s that have been produced by various users; (c) the capacity to read data recordings or the Microdek under either FOCAL or BASIC; (d) better DEC and DECUS software for editing and assembling machine language programs; (e) better format of data recordings in terms of identification codes, including date on which the data was obtained; and (f) more extensive data analysis both on- and off-line.

Level 4

The fourth level requires the purchase of one or more of many different peripheral mass-storage devices and the OS 8 software system to add to Level 3. This level requires a minimum of 8K of core for the OS,8 software system, which costs at least $300, and which can cost up to $1,200 for the whole system. OS 8 speeds up daily operation of the computer considerably. Program preparation and editing are much speedier and will be more convenient. Data analysis packages have been developed, and they are easier to develop under OS 8 for those interested in extensive off-line calculations. Currently under development are software routines to permit the RTS to store data on DECtape or disk on-line in a form that can be easily retrieved by OS 8 off-line.

The major advantages of this sytem are: (a) speed and convenience of programming; (b) quantity and quality of data analysis; and (c) more convenient and extensive data acquisition.

The price of the system will range from $2,000 for a Floppy-disk, under development by State Systems, to approximately $10,000 for DECtape or disk file from DEC. A word of warning is necessary at this point about the TD8E DECtape system. Although this type of DECtape operates quite well under OS 8 and is less expensive than the TCO8 system, it cannot be used to store data under the RTS. For the latter purpose, it is necessary to operate the program interrupt and to respond to the interface clock. The TD8E does not permit this to happen.

Level 5: Two Computers

All of the systems discussed so far share a common disadvantage. Data must be processed and programs prepared on the same computer that is used as the RTS. For those who wish to run experiments most of the day, it may be inconvenient to schedule large blocks of time for off-line data analysis and programming. Although it is theoretically possible to write software for a large OS 8 system with 16K or more of core so that programming or data analysis can occur simultaneously with the use of the RTS, two major difficulties suggest that this is not the optimal system. First, the amount of time available for the operation of the background analysis program will be severely limited in an RTS that is servicing 10 stations. The analysis routines will operate very slowly, and they might slow the system as a whole down to the point where it is impossible to run the number of experiments of which it is capable. Secondly, rewriting the DEC software completely for this purpose would be an impressive and costly amount of programming.

The more reasonable alternative to a full-time RTS and a reasonable amount of data analysis and programming capacity is to obtain two computers. With current computer prices low and perhaps still decreasing, it is economically feasible to obtain two parallel systems. This provides an additional advantage in the case of malfunction of the equipment, in that the RTS that is required for priority experiments can be replaced by the second computer if necessary.

The optimal system, then, can be described as two parallel computers. This might even be the best choice for the user with only four experiments to be run concurrently in 4K of memory, in that he can obtain, for example, a used PDP-8/L with 4K of memory for the same price that an additional 4K in his 8/E will cost. For the user with 8K of memory in both systems, it would be a big improvement in his system's performance if he could obtain identical mass storage devices for both computers. With DECtape, disk cartridges, or Floppy-disk, he could easily carry his data from the run-time computer to the data analysis system for extensive processing.

One additional word of warning to users planning to obtain two computers. It has been my experience, in every laboratory with two or more systems that I have seen, that the data analysis system acquires an interface and soon is used to run additional experiments, thus reducing its availability for data analysis and program development. However, strategic behavior modification techniques applied to the users of the system might prevent this type of expansionism. In any case, two used PDP-8/Ls with 12K of memory each and each with dual Floppy-disk systems, both with ASR-33 terminals (also used) and with high-speed tape readers, are less expensive now than the cost 8 years ago of the original PDP-8 with 4K of memory and high-speed tape reader and punch.

This optimal system would be capable of running up to 20 simultaneous experiments some part of the day, and the rest of the time 10 experiments would be conducted while data analysis progressed on the second machine.

A SKED users group has been formed to dis-

tribute the various levels of software, F3s data analysis routines, and to support a newsletter so that users can communicate quickly about new software, common problems, better documentation, etc. For the first year, the group will be centered at Western Michigan University. Interested users may contact A. Snapper at Western Michigan University to obtain information about joining the group.

REFERENCE

Butler, F. E. The bus-all: An inexpensive set of interfaces for the SKED system. Behavior Research Methods & Instrumentation, 1974, 6, 171-173.