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DOCUMENT TITLE

PRELIMINARY POCKETPUTER PROPOSAL

JEF RASKIN/ MAR 1977 / PAGES: 16

SOURCE

JEF RASKIN/ APR 1997

DOCUMENT NO. 55

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Draft

Rtn to Jef ✓

PAGES: 16

PRELIMINARY POCKETPUTER PROPOSAL Jef Raskin March 77

Many dreams have been spawned by the microcomputer. This pre-proposal is not the place to document and examine these dreams, but a few examples will indicate the tenor and direction they tend to take. Many of these dreams predate the microcomputer, but they take on new force with the small size and extraordinary inexpensiveness of present and forseeable electronic devices.

The examples span many fields: Education, communication, prosthetics, all engineering and the sciences, visual art, music, and librarianship. There is not a human endeavor, save perhaps religion, that has not engendered suggestions. To go a level further and mention a more specific application in each area is not difficult. In education, computer assisted instruction; in communication, a handheld newspaper able to select pertinent articles from the gamut of publications given merely a few keywords for which to search; in medicine prostheses for the mind-- perhaps augmenting the memory of a learning handicapped--as well as for the body, say by printing voice input for the deaf and vocalizing words keyed in by the mute; nothing need be said about the hard sciences; in visual art a portable sketchpad with memory; the computer is so widely used in music at the present time that examples from a composer's notebook to an ethnologist's automatic transcriber are practically obvious.

It is essential to recognize that the device must be a general purpose computer, not a calculator or special device made to do a particular job. The power of a computer, like a library, lies in its catholicity.

The personal computer should have these elements and abilities:

1. Tactile input. Some form of keyboard would probably be included. The computer should also be cognizant of "finger pointing" so often used to indicate position, direction and vehemence. Current technology can build devices to respond to pointing when referenced to a computer's visual display.

2. Audio input. The microphone hears. To a very limited extent present computers can understand the spoken word, distinguish musical pitches and timbres, and analyze the operational status of machinery by interpreting what the microphone hears.

3. Visual input. The arrays of light sensitive cells that are currently operational allow compact and inexpensive cameras that have outputs suitable for computers to use. Understanding the visual patterns is not an easy matter, but the ability to see in a naive way is not hard to provide.

4. Other inputs. A complete analog to the human senses is concievable. Temperature sensing is trivial, and might well be included. Some form of time sense, likewise, is of no technical difficulty. Chemical sensors, to simulate taste and smell have many applications, but will not be considered for the present proposal. Attitude and acceleration, as any aircraft pilot knows, are easy to capture mechanically. Again, for the time being they will be ignored.

5. Tactile output. Especially necessary for the blind, there are limited applications elsewhere. The grosser form of tactile output, such as a robot's arm, which can perform mechanical tasks, is considered to be inappropriate for a carryable computer.

6. Audio output. A speaker driven by relatively simple circuitry could serve many purposes. Warnings, results in voice, music and (in the future) simple conversation could issue from it. The circuitry is simple, but see below about the software.

7. Visual output. A rectangular array of dots set on a .2mm grid which can be made visible or invisible in any combinatin could reproduce pictures with the fidelity of a magazine half-tone. Such a screen, flat and requiring little energy, is within the scope of present technology. One such technology is that of liquid crystals. Line drawings, animation as well as

half-tones are possible. As mentioned under "tactile input" above, the screen could be made to also note at what point or points it is being touched, rendering superfluous such devices as joysticks, lightpens or the mouse for graphical input. Visual output via lighted indicators is unnecessary in view of the screen. Color graphics are not out of the question, but will be put off for the time being.

9. Other output. Energy considerations preclude the device from giving output via thermal changes or significant self-motion. Emitting odors (intentionally) or other chemical substances as a signalling mechanism seems silly--although the imagination can find plausible applications.

Aside from input and output devices for interfacing to humans the computer should be able to communicate with other computers whether similar or not. The standard EIA RS-232 interface, the ability to couple to the telephone lines, and perhaps the parallel IEEE 488 interface should be part of the system. Analog to digital converters are essential for many of the built-in I/O (input/output) devices. Inputs to the A/D converters could be brought out so that the computer can sense voltages and currents. Similarly it can "speak to" electronic devices by means of digital to analog components already necessary for other functions.

STRUCTURE OF THE SYSTEM

There are many possible implementations. One example will give the flavor of the kind of considerations that go into the design. Physically the computer is probably a rectangular box with a screen, keyboard, speaker and microphone built in. A panel might cover various electrical connectors: for communications, for charging the internal batteries, to plug it into the wall or telephone jack. It should be rugged, and as small and light as possible. It is probably equipped with a handle.

A large quantity of memory is a nearly absolute requirement. The quantity is difficult to estimate, but there can't be too much of it. 64 thousand words of 16 bits per word might be a good starting place. If the screen is 5 by 5 cm. then 62500 bits are required to describe an image. About 5000 words are therefore required to store a picture, a reasonably small fraction of memory. This primary memory should be fast, 200 nanoseconds might be a useable access time. A secondary memory that ~~can~~ is removable and non-volatile is necessary. In a prototype it might be a small disk. In practice it might be charge coupled devices (CCD's) or some derivative of bubble memory technology. Somewhere in the neighborhood of 2 to 5 million words would be a working minimum. Many manufacturing processes are converging on the required memory density.

There might be three CPU's (central processing units). They would all have direct access to memory. The first would be the master computer, executing programs and controlling the other CPU's. The second would control the secondary memory or disk, and do file organization and I/O. The third would be the screen display controller. CPU's are cheap, and each could have its primary task program on ROM (read only memory). In any case, it is not appropriate here to choose one plan or another, but merely to indicate how it might be done.

SOFTWARE

This is the nub of the problem. And <u>not</u> covered in this proposal. Yet once the hardware is built and debugged, far more effort will go into the software, orders of magnitude more than the hardware required. The specific hardware (or, more likely, some emulation of it) must be used to develop the software.

As an example of the challanges to be met in software design, each of the I/O facilities will be re-examined from a software point of view.

1. Tactile input. What actually is supplied to the program is switch closures of a keyboard--which is very well understood--and pairs of signals representing the cartesian co-ordinates where the screen has been touched. From the rate at which the values of the pairs are changing the acceleration (or vehemence) of the pointing is known. This alone is a full-time task for a microcomputer for the entire time the screen is being touched. Not too difficult but

2. Audio input is another matter. The most powerful of voice recognition programs can only distinguish between a dozen words or two without knowing more about the context in which they are spoken. Furthermore most present systems have to be trained to the speaker. Having a computer respond to spoken commands (so beloved of science fiction writers) is definitely <u>not</u> a solved problem. The prototype can, however, easily respond to a handful of useful words, such as "stop", "next", and other words controlling processes.

3. As stated above naive visual input is possible. Optical scanning of printed matter, so that the computer can "read" books and periodicals and store them away, is possible, but quite difficult, and usually considered a major product in its own right. One magazine is currently publishing software (programs) in the form of a bar-code. Such a code is easily

read by primitive computer eyes. If this practice becomes prevalent (as it should) then a visual input would be readily justified. Sensing degrees of light and color, and analyzing motion are other uses that are in varying degrees possible. Recognition of faces or objects is just beyond the state-of-the-art. The computer can easily have enough hardware to accomplish the goal, but the software is another matter.

4. The personal computer should contain a clock and keep track of time of day, date, and year. This is necessary if it is to be a truly automated date book and alarm clock. Software for this is quite as easy and cheap as the hardware. When the user tells the computer to remind her or him to call Aunt Matilda at 4:30 PM next Tuesday, it should sound a beep (or whatever) and display on the screen what should be done when the time comes. If it is plugged into the phone lines at the time it could easily place the call. A telephone directory is certainly to be part of almost everybody's computer, by the way.

While it would be fun to have attitude sensors, a first model probably would not. Combined with the camera a sufficiently precise attitude sensor could turn the device into a surveyors tool. With acceleration sensors it could be an inertial guidance systme, or judge performance of an automobile.

Sensitive accelerometers could measure roughness as the computer's corner was dragged over a surface being tested. These are "blue sky" thoughts, but the point is important: given a number of different kinds of sensors and a general purpose computer, the system can be programmed to do an incredibly wide range of tasks, most of which are unforseeable by the designers of the system. The same is not true of shovels.

Chemical sensors could warn the owner of fire danger, excessive pollution or other hazards. Again this will probably not be part of even a production model, but if technology devises cheap sensors that are easy to interface, why not include them?
5. Since stored energy from batteries is limited, and solar cells are not useful in small sizes for power hungry devices such as motors, any tactile output will have to be minimal. It would be easy to make a device so that a program could make a group of "dots" rise and fall on command. They could present information in Braille, or even print via a ribbon or some similar stuff (such as carbon paper) and a strip of paper pulled across them. Other tactile, or physical, output might be a small solenoid that could easily be hooked up to many devices (such as light switches in a house) not originally intended for computer control.

6. Audio output is easy. Elementary, but still useful music synthesis would not be difficult. Voice simulation, given enough memory, is a well-known art. Good voice simulation is hard, but understandable speech made by reproducing selected items from a recorded vocabulary is readily accomplished. Many attempts have been made to have a computer able to converse with humans. Some are adequate for a few sentences of interchange. Still, it would be an interesting avenue to explore, and the people who owned such a carryable computer would probably explore the problem on their own. This brings up another important point. What has to be provided is a relatively inexpensive personal computer, with some software. Most of the applications will be developed by the users. That is the nature of computers.

7. The visual output screen is certainly the heart of the personal computer. None truly suitable have been manufactured. From a software standpoint the most useful screen is one that is, in the jargon, "bit-mapped". That is, each point on the screen corresponds to a bit in memory. Since bits in memory can be controlled absolutely, the screen can be so controlled. One special provision in the computer will be a "screen register" which will hold the address at which the screen's bit map begins. Thus if five or six different pictures are stored in memory one can "flip through" them by merely changing the

contents of the screen register. Animation can be accomplished through these means. However, memory constraints preclude serious animation beyond a flip-book effect of a few frames. If the screen is of Liquid Crystal manufacture then the 0.1 second decay time of the screen (with present technology) is another speed limiting factor. A light-emitting-diode (LED) based screen has, for the present, excessive power consumption as well as a thermal design problem. Whatever screen is used, it will have its own processor that will handle the display. The screen processor will also probably have a character generation mode, and do some editing and perhaps graphic transformations.

9. It would be interesting if the computer had wheels and could move about. It would then become something of a pet. With its sensors it could avoid obstacles, seek out the wall plug for recharging when its batteries got low (hungry is perhaps a good word to describe its state). In some ways this is the beginnings of a useful robot. But not for the first prototype probably. Chemical emitters are also of limited use, although arguments could be made for their utility.

EXTRASENSORY I/O

Considering the biofeedback electronics now employed there is no reason why the computer could not detect brainwaves and electrical signals due to muscular activity. If it can detect them and distinguish one from another (as is being done with computers at present) then it could react appropriately. Again the user could write programs that would use such inputs. Extrasensory outputs require too much specialized medical (to say nothing of surgical) skill to be practical for the time being. The possibilities are endless. Certainly a portable computer would be a prosthetic device <u>par excellance</u> compared to the fixed-function devices now made for the handicapped.

PROGRAMMING SUPPORT

The user will have to be given utility programs and at least one higher level language. It is hoped that BASIC will be avoided. It would spoil such an advanced device to have such a crude programming language. Of those languages presently available FORTH would seem a good choice. Others are in development stages.The language should be structured, allow mnemonic names for variables as well as program structures, and allow full control of the CPU and I/O devices. It should be internally self-consistent, with few rules (to simplify parsing). It must also be interactive, either interpeted, incrementally compiled or partially compiled. It should link easily with machine code, and allow for explicit machine code construction within the language. The language should contain its own editor as part of the structure. Execution must be re-entrant, and the user must have explicit control over locality of variables.

SCHEDULE AND BUDGET

To build the pocket (or rather, attache case size) computer might take a year given the required components. No essential difficulties are seen except for the display, which requires an independent development that may well take a year. Software design will go on forever. Emulation will allow the primary software design to go on while the hardware is being designed. The two problems are not independent, and developments in either area affect the other. There is the possiblity of designing an architecture specifically for the computer, but for the present the PDP-11 architecture will be assumed. Large scale integrated (LSI) circuits are available for this computer. But it would be foolhardy, considering the rate at which new computers-on-a-chip are being designed, to fix the choice of an architecture prematurely.

A two year completion time, while not over-optimistic, requires a brisk rate of development, and few setbacks. A crash project, well funded, and with the backing of a liquid crystal display maker could possibly succeed in a single year. As was stated before, this is for hardware development. Software tasks would have to be scheduled on an individual basis.

Costs are divided into four main areas: 1. Display development 2. Salaries 3. Other hardware development, 4. Overhead.

1. If the required display is on a drawing board somewhere, the industry rumor mill doesn't know about it. Thus it is likely that it will have to be built on a custom basis. The cost of such a display is hard to estimate without seeking quotes from a manufacturer. $50,000 to $100,000 is a reasonable range. If patentable such patents would have considerable worth.
2. A staff of one expiditer, one secretary, and two full time designers (including the author) would be required, with some as-needed consultation and electronic assembly labor. $100,000 per year total should suffice.
3. Aside from the display the remainder of the hardware should not exceed $45,000. It may well be considerably less than that.4. Everything from paper clips to phone expenses would probably not exceed $20,000 per year.

Budget: $365,000 over two years.

MARKETING

At the current rate of growth of the microcomputer industry the market potential of this device seems unlimited. It can be nearly all things to all users, from a digital multi-meter (DMM) to the technician to an object of study in a computer science curriculum, from a musical instrument tuning device for a guitarist to a prosthetic memory. It could run a house, keep track of a library, and do business inventory and payroll accounting. It is a computer. Marketing seems limited only by advertising budget.

PROPOSAL DEVELOPMENT

These ideas are presented here without documentation or external support. To make firm the viability of the concepts, to find a proposed staff, and obtain vitae, to seek estimates of construction costs and to survey the appropriate literature for supporting evidence we should first seek a small contract, in the order of $2500 to do a preliminary study to culminate in a proper proposal. The proposal would include more precise budgets, be referenced to existing marketing studies, and spell out in somewhat more detail the nature of the device to be built, and its possible manners of use.

CONTRACT DETAILS

The firm of Bannister & Crun, for which this report was prepared, would undertake to negotiate any necessary contracts. If consummated, B&C would form a project under the aegis of Mr. Raskin to construct and program the computer described above. Mr. Michael Weisberg, president of B&C should be contacted about details of terms of ownership of patents, and distribution of benefits if the project proves marketable. B&C would stand in the status of consultant to PCRG or to Dr. Sarfatti.

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