ENCYCLOPEDIA OF COMPUTER SCIENCE AND TECHNOLOGY

EXECUTIVE EDITORS

Jack Belzer   Albert G. Holzman   Allen Kent

VOLUME 6

Computer Selection to Curriculum

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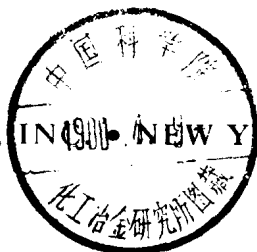
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UNIVERSITY OF PITTSBURGH
PITTSBURGH, PENNSYLVANIA

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Computer Selection to Curriculum

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COMPUTER SELECTION CRITERIA

The selection of a computer is a process dependent upon many factors. However the process proceeds, ultimately the monetary factor will govern. It is important to recognize the total costs involved; not only the obvious initial costs of the acquisition of the new hardware and the immediately attendant software and the continuing costs associated with the maintenance of hardware, software, and updating of the facility, but also the personnel costs that must be budgeted to continue the infusion of viable applications. It is from this trunk that the branches grow.[1]

ESTABLISHING THE NEED

The environment in which the computer is to function should be carefully defined. A research-oriented organization exhibits characteristics quite different from those of a commercial one, and the needs of both are again different from those of an educational institution. It becomes necessary, therefore, for each organization to study its own identity and to prepare a definition of its needs. The more thoroughly and clearly this is done, the easier it will be for the prospective vendors to configure suitable sets of computer components to meet these needs, but more importantly, the easier it will be to evaluate the proposals submitted. By way of example, the following study is illustrative. At a medium size university (6000 undergraduates, 1000 graduate students) the search for identity took the form of a marketing survey. A questionnaire was distributed to all faculty and staff soliciting information on their current usage, which was batch oriented, and on their expected usage for the next 10 years. While 10 years was probably too long a period for which to plan, the time from the initiation of the survey to the installation of the new equipment was estimated to be of the order of 2 years as a minimum. When coupled with the fact that the presence of the newer equipment will undoubtedly generate problems and create demands beyond those originally planned, and this in turn will consume resources at a rate higher than planned, a useful life of about 6 years may be expected. With the current rate of invention and innovation within computing, and the attendant obsolescence, 6 years is not an unreasonable period for which to plan.

The response of the faculty and staff was, as expected, in proportion to their current involvement. In those areas and disciplines currently heavily involved, 100% response was expected and achieved; in those areas and disciplines where computer involvement was sporadic or not realized, the response dropped to about 15%.

The survey should consist of more than a mailing of a questionnaire to

[1] The thrust of this article is toward those with computer experience who are contemplating upgrading rather than those who are venturing into the field. The stakes are too high for the neophyte.

[1]

individuals identifiable as potential users. A personal follow-up to review the information submitted or the reasons for failure to return the questionnaire is indicated if the full involvement and support of the users are to be obtained. In some instances potential applications had been dismissed either because the long-range significance of the commitment was not appreciated or because the cost had been improperly evaluated. In particular, the potential for sharing of resources across disciplines had to be developed.

From the user's articulated needs, hardware and software parameters can be approximated. Table 1 illustrates one method for organizing the data representing the needs for peripheral equipment. Similar tables should be prepared for storage requirements as well as processing needs. Research areas are designated under R and classroom courses under E; the numbers represent the number of courses or research areas requiring the devices, not the number of devices required.

The table indicates the extent to which the computer has pervaded both the education and research programs; in the fully developed survey it was extended to include administrative needs as well.

The possibilities for sharing devices need still be determined. However, the local geographic and political climate would undoubtedly be of such importance as to be the overriding considerations. Also, to err on the conservative side would not be disastrous; additional peripheral devices can be acquired at incremental costs.

The software requirements are summarized in Table 2 followed by a sample offering an intermediate degree of detail.

E, courses requiring: This heading includes both those courses presently requiring computer solutions for problem solving and those which have a high expectation of computer utilization, with the acquisition of the specialized peripheral devices and the possibility for interactive, time-sharing.

R, research area requiring: Only present research needs are included in this category because shifting research interests make forecasting too unreliable.

Area 1, Statistical analysis: This heading encompasses normal, binomial, Student's t, F and Poisson distributions, measures of central tendency of dispersion, elements of probability and probability sampling, estimation and hypothesis testing, chi-square analysis, analysis of variance, regression and correlation, time series analysis, index number analysis, and multivariate analysis. Also included are sets, functions, decision making under uncertainty, game theory, queuing theory and Monte Carlo techniques, Markov analysis, and reduction and processing of laboratory and research data.

Area 2, Solution of integral and differential equations: Included under this heading is the numerical integration of higher order differential equations and the finite difference and finite element solution of differential equations. Particular computer usage in the areas of research includes the numerical integration of the matrix equations of motion, a three-dimensional energy density function, and the fifth- and seventh-order nonlinear ordinary differential equations in semi-infinite domains.

TABLE 1
Peripheral Equipment Needs

Equipment	Art R	Art E	Eng-lish R	Eng-lish E	Philos-ophy R	Philos-ophy E	Soci-ology R	Soci-ology E	Archi-tecture R	Archi-tecture E	Elec-trical Engi-neering R	Elec-trical Engi-neering E	Me-chan-ical Engi-neering R	Me-chan-ical Engi-neering E	Ac-count-ing R	Ac-count-ing E	Mar-keting R	Mar-keting E	Biol-ogy R	Biol-ogy E	Geol-ogy R	Geol-ogy E	Mathe-matics R	Mathe-matics E	Chem-istry R	Chem-istry E	Physics R	Physics E	Com-puter Science R	Com-puter Science E	Total R	Total E
CRT																																
Vector	0	0	0	2	0	0	0	5	0	0	0	0	0	0	0	0	0	0	3	7	0	0	0	0	1	0	0	1	2	0	6	15
Light pen	0	0	0	0	0	0	0	0	0	0	0	2	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
Hard copy	0	10	0	0	2	0	0	4	0	11	4	3	0	2	0	0	0	0	0	0	0	0	0	0	5	10	2	8	0	0	6	21
Rotating perspective	0	5	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	7	11	41
Color	1	4	0	2	0	0	0	0	0	0	1	4	1	3	1	2	2	1	0	0	1	0	0	0	0	0	0	0	1	0	2	6
Alphanumeric	6	0	0	5	0	0	0	4	0	8	2	8	3	4	1	5	1	8	0	0	0	0	0	0	0	0	0	0	3	0	15	12
Remote conversational terminal	0	6	3	3	1	4	0	3	0	14	2	6	2	7	1	5	1	2	4	10	0	7	3	2	4	12	2	9	6	16	7	48
Paper tape (cassette) I/O	0	3	3	3	2	3	0	5	0	12	7	10	6	5	1	5	1	2	0	0	0	0	0	0	2	5	1	1	1	0	29	103
Remote card I/O	0	5	3	3	1	4	0	6	0	14	7	10	6	6	0	0	0	0	0	0	0	0	0	0	1	1	0	0	3	2	22	49
Remote printer	0	5	3	4	1	2	0	7	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	21	51
Optical character reader	0	9	1	0	0	0	0	2	3	1	1	2	2	3	0	0	0	0	2	0	0	0	0	0	1	0	2	5	0	0	8	26
Card or tape output	0	0	0	0	0	0	0	0	3	8	1	2	0	0	0	0	0	0	0	0	0	0	0	0	2	5	2	5	0	0	8	18
Scanning digitizer	1	2	0	0	0	0	0	0	0	2	0	4	0	0	0	0	0	0	1	2	0	1	0	0	0	0	0	0	0	0	2	13
Real time on-line monitored experiments	0	0	0	0	0	0	0	0	0	2	0	4	0	0	0	0	0	0	0	0	0	0	0	0	3	4	3	4	0	1	6	15
Two-dimensional plotting	0	0	0	0	0	0	0	3	2	2	1	3	1	1	0	0	0	0	1	2	0	3	0	0	3	0	3	0	2	0	13	14
Movie making	0	1	0	0	0	0	0	1	1	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	5	3

TABLE 2
Software Requirements

Areas in which software is needed	E, courses requiring	R, research areas requiring
1. Statistical analysis	115	102
2. Solution of integral and differential equations	49	34
3. Information storage and retrieval	48	24
4. Linear, nonlinear, static and dynamic programming	26	5
5. Matrix manipulation	41	6
6. Mathematical modeling (simulation)	83	39
7. Contour and graphical plotting	13	12
8. Simplified language	123	25
9. Structural analysis	10	4
10. Financial analysis	13	—
11. PERT and CPM analysis	5	—
12. Numerical taxonomy—Numerical classification procedures	6	1
13. Theoretical curve fitting	2	9
14. Linguistic stylistic analysis	4	1
15. Fourier series analysis	8	—
16. Numerical iteration techniques	4	1
17. Solution of boundary-value problems	4	3
18. General program for quantum chemistry	6	2
19. Spectroscopy program	4	10
20. Miscellaneous	29	21

Computing center records of past utilization of the computer by individuals, separately reported by course load and research interest, show the consumption of the current facility. These figures may be used to form a base for each user upon which to estimate his future needs. While such estimates may not be precise, they do offer the best information available at the time. Table 3 illustrates a method for collecting and exhibiting these present and future research needs; Table 4 extends the search for projected needs to the classroom. The administrative needs would be exhibited in another table.

THE REQUEST FOR PROPOSAL (RFP)

As soon as it becomes apparent that there is a reasonable expectation of acquiring a new computer, it is prudent to notify computer vendors of this expectation. From this time forward, the informal dissemination of the needs to the vendors and their active participation in helping to organize the requirements has the twofold advantage of getting independent and competing reviews of

TABLE 3
Computing Resources (hours:minutes of CPU time)

Department: Physics Chairperson: A. B. Carter

Researcher	Actual									Projected		
	1972–73			1973–74			1974–75			1983–84		
	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer
T. H. Remm	1:28	3:15	3:45	2:59	:32	2:25	2:15	1:45	2:30	10:00	10:00	10:00
K. L. Gelowe	7:37	7:04	7:09	18:51	16:22	17:22	20:00	20:00	20:00	30:00	30:00	30:00
S. F. Bleer	2:14	:43	2:19	2:12	1:57	2:39	1:45	2:00	1:45	10:00	10:00	5:00
W. L. Grasdon	1:10	:00	:01	1:50	:38	1:24	1:30	:30	1:00	6:00	8:00	5:00
H. J. Dolivier	:32	2:25	:54	2:01	1:27	1:48	1:00	3:00	2:00	6:00	6:00	6:00
Total	13:01	13:27	14:08	27:53	20:56	25:38	8:30	9:15	27:15	62:00	64:00	56:00

TABLE 4

	Actual						Projected					
	1972–73			1973–74			1974–75			1983–84		
Course Number	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer
11	0:07	—	—	0:12	—	—	0:10	—	—	0:50	—	—
67	1:15	7:21	2:41	12:35	—	0:26	2:30	5:00	2:30	5:00	10:00	5:00
123	—	4:15	—	—	5:47	—	—	5:00	5:30	—	7:00	—
127	—	—	6:32	9:50	—	—	—	—	2:00	—	—	10:00
129	4:29	—	—	2:46	—	3:46	5:00	—	—	—	10:00	—
216	:26	:16	1:53	2:07	—	2:05	3:00	2:00	—	5:00	5:00	—
247	2:47	1:44	—	5:01	4:12	—	5:00	1:00	—	8:00	2:00	—
298	2:49	2:01	—	2:33	2:47	—	5:00	1:00	—	8:00	2:00	—
302	3:05	3:22	—	1:55	3:49	—	5:00	1:00	—	8:00	2:00	—
317	4:35	2:45	5:52	6:12	2:33	4:47	8:00	6:00	8:00	20:00	10:00	20:00
398	1:45	2:16	—	—	2:49	1:01	2:00	3:00	1:00	4:00	5:00	2:00
501	2:38	2:01	4:29	2:57	2:45	12:07	3:00	3:00	6:00	8:00	8:00	30:00
Total	23:56	26:01	21:27	46:08	24:42	24:12	38:40	27:00	25:00	66:50	61:50	67:00

substantive data being collected as well as giving each of them (the vendors) as much time as possible to organize the proposal that will be offered. The more deeply enmeshed a vendor becomes in this preliminary work, the greater his initial financial commitment, the more anxious he will be to protect this investment. Also, realistically, it may not be possible to write an RFP which is totally unambiguous; giving the vendors access to the persons having input to the RFP tends to improve their understanding.

The formal RFP represents the distillation of the thoughts of many persons. As such, to insure that no need has been overlooked, it should be made available for comment to all members of the organization who may wish to examine it. As indicated, not only will this insure accuracy, but, since in every organization there are competing needs for resources, spokesmen for these competing needs will have had the opportunity to evaluate their own expenditure requirements, vis-à-vis this proposed acquisition. While unanimity of opinion may be desirable, : it is not necessary; adequate organizational commitment is.

In addition to submitting the formal RFP to the various vendors, it is desirable to follow this with a formal, technical review session to which all vendors are invited. The purposes of this technical review session are many. A senior officer of the organization can welcome them, stress the significance of the new facility to the organization, and indicate the commitment toward its acquisition. This will reinforce in the vendors' minds that the probability for acquisition is indeed high.

The presence of staff members to respond to questions raised by the vendors, as well as to insure that proper stress is placed on specific sections of the RFP, enhances the image of commitment to this project.

Assuming that no covert commitment had been made, either consciously or otherwise, the openness of this forum tends to insure a best effort on the part of each vendor. While some reticence is apparent, at least as may be sensed from the questions asked and inferred from those unasked, the effect is salutary.

Introduction to the RFP

The material to be presented in the RFP should, as a minimum, include the current usage and projected needs as ascertained, and details on the current hardware configuration and the available software. The philosophy of the current mode of operation and the change that is expected with the new equipment should be indicated.

Expected Mode and Level of Operation (Hardware Needs)

Following these introductory remarks, details of the expected mode and level of operation, as complete as possible, should be presented. For example, if the computer is to be used interactively, in a time-sharing mode, with remote terminals, the minimum number of ports to be available on installation should be specified. Expansion capabilities, and the time frame, should be indicated. The

distribution between hardwired and dial-up terminals should be given as well as the data transmission rates that are expected. Questions concerning the capability of the communications components of the equipment to recognize terminal speed and the character set used and to perform automatic translation are typical of those to be asked. If there is no compunction toward acquiring some of these components, i.e., the terminals, cabling, etc., from other sources, this should also be indicated.

For central site job entry, the desired operation characteristics of the I/O devices, i.e., card and tape readers, punches, and printers, should be specified. As for all items for which information is requested by indicating the operational need, permit the vendor to suggest alternatives which may improve the price/performance ratio.

If remote job entry is either an immediate need or has reasonable future expectation, indicate this. Ask for equipment description and prices for future expansion in this area, including, for example, the possibilities of multiplexing.

The possibility that much of the future requirements may be met by attaching the acquired computer to either a regional or national network should not be overlooked. It is not unreasonable to request that any additional equipment necessary to do so be indicated and its cost given.

Planning for enhancement of the facility during the time frame under consideration cannot be overlooked. Choices of equipment for initial installation may significantly affect the price of growth. Require adequate information from the vendor about the availability of devices and their prices to support your expected growth pattern. While a computer installation may not have the expected useful life of other capital equipment, its expected useful life may be substantially increased if initial planning allows for expansion.

Software Support

After covering the details of needs as may be met by hardware, another area in which information is needed is software support: (1) operating systems, (2) programming languages, and (3) applications packages. Also, there will probably be one or more specialized areas which will need software support. For example, the more specialized requirements associated with a data-based management system may assume significant importance. Adherence to the specifications and recommendations of industry-wide study groups may be weighed in evaluating the proposal. Again, details on the expected use should be given; it will behoove the vendor to be specific in his reply.

Conversion

Of the programs either operational or under development on the current equipment, some or all will have to be made operational on the new equipment. This conversion effort is generally never trivial and can be quite horrendous. Determine from the vendor the support he will offer to accomplish this

conversion and weigh this response carefully with other alternatives such as doing the work internally with current staff, hiring additional staff for this purpose, or contracting with a service bureau. The current usage data that had been accumulated will serve as the basis for the reply. Acceptable minima must be specified.

It is at this time that an enhancement to the current operation may be obtained at moderate cost. Programs in related areas may have accumulated over the past years and too little attention given to subsume these separate programs into an integrated one which could have such desirable characteristics as reduced running time, be easier for operations, and be less subject to external errors. The conversion of existing programs one-to-one may not be significantly less than converting a group into an integrated system. The comparative costs should be determined.

Emulation of the present computer may not be desirable but possibly can be tolerated. The justification for such acceptance would undoubtedly vary from one organization to the next, but should be articulated.

Special Projects

Attention must be called to those special projects currently operational which had required special hardware or software for their development. For example, analog-to-digital and digital-to-analog conversions at very high rates in real time may pose seemingly unrealistic requirements for some vendors. The vendor must be required to indicate how these special projects will be supported on the system he intends to propose.

Maintenance

Software

The request for proposal should inquire into the availability of software maintenance in the areas of operating systems, languages, and applications programming. The specific terms for the maintenance, including such factors as cost, times of availability, and location of dispatch points, as well as other factors deemed desirable for proper support, should be stated.

Hardware

The proposal should specify the costs for various levels of maintenance, including plans for hours covered, provisions for calls out of covered hours, and provision for on-site maintenance.

Internal Maintenance

The possibility exists that some installations may wish to consider supporting either software, hardware, or both internally. To do this, personnel will need to

be trained; additional needs could include detailed documentation for software, wiring diagrams, special test programs and equipment, spare parts, price lists for components, and sources of supply. Advice on training programs and support, as well as associated costs, should be included.

Third Party Support

While it may not be appropriate for inclusion in the RFP, it is not unreasonable to ask of a vendor if any other installations using his equipment is also maintaining it or using third party maintenance. Comparative costs should be developed.

General Considerations

Request information on those specifics of the installation which could have a material affect, i.e., special air conditioning and humidity requirements, water lines, power and voltage regulation requirements, special circuit breakers, etc. By offering detailed information on the proposed site for the installation of the equipment, misunderstandings resulting in last minute delays and overruns can be avoided.

Expected Performance

The history of the past utilization of the computing facility has been available. By coupling the statements concerning the expected mode and level of operation with the expected performance characteristics, a picture should emerge indicating the overall expected performance. Perhaps an illustration would suffice. A current computer facility consists of two machines, one dedicated to batch processing and the other supporting interactive time-sharing via remote terminals. The machine dedicated to batch processing runs under two distinct operating systems, one suitable for processing scientific and engineering-type problems, the other suitable for processing business-oriented-type problems. The overall requirements for the new machine are to process both business and scientific/engineering-type problems in batch mode when appropriate while concurrently supporting the interactive, time-sharing terminals. Whereas presently programs submitted for batch processing are run consecutively according to an algorithm prescribing priority, it is expected that (for definitiveness for this illustration) three batch streams would be available in the new computer, again with an algorithm assigning programs to each of the streams and allocating priorities for sharing such resources as the central processor(s).

If a mix of problems running on the present equipment was to be presented, such factors as throughput time minus I/O time could be measured and used as one of several criteria to specify the efficiency of the current facility. It could be required that the proposed computer process the same job mix similarly (single

stream) and that the resulting timings be no more than some fraction (i.e., $\frac{1}{2}$) of the present ones. Since, however, single stream operation is not the desired mode, this same mix of jobs could be run in the three stream mode and at the same time the time-sharing terminals would be active. Data on the resulting processing time for each job in the mix and for the entire mix could be recorded; the degradation, if any, in the response times at the terminals could be measured. From these data it would be possible to measure the expected performance of the new system; alternatively, expected performance criteria could be thusly specified.

Whether the procedure outlined above or another is used, it is important that the vendor clearly understands how the performance of his installed equipment will be measured. He should be in a position to *guarantee* this performance. The details of the text, carefully thought through, carefully documented, and carefully presented, should be at the apex of all criteria.

Growth

Times of rapidly fluctuating monetary conditions, coupled with uncertainties in the expected rate of growth in the utilization of the system, make long-range planning difficult. In order to minimize these uncertainties, commitments from the vendor fixing such items as long-term rental rates, interest, and maintenance rates are desirable. Provision for delivery of equipment several years hence, at current prices, protects growth plans. The additional stipulation allowing cancellation prior to shipment offers protection against obsolescence as well as an overoptimistic estimate of growth.

At this point the RFP is reasonably complete. The present situation has been detailed; the future expectations have been expressed; channels for communication have been established to eliminate ambiguities. Two subsequent events are anticipated: (1) receiving the proposals and evaluating these, and (2) entering into the contract negotiations. At this point a digression is appropriate.

At the time of contract negotiations the following posture may be expected on the part of the vendor. First, there will be a general disclaimer of the information presented in the proposal. This generally takes the form of a statement which indicates that the vendor will honor only the commitments specified in the contract and that the language of the contract supersedes all other statements, either written or oral, made by his representative. Thus, those sections of the proposal which are critical must be incorporated into and made a part of the contract.

A computer vendor would like to take the position that he will deliver and connect the various components, demonstrate that from an electrical and mechanical point of view these function, and demonstrate an operating system. At this point he would like to be paid.

As the purchaser (or lessor) of the equipment, it is necessary to insure that all of the promises made in the proposal have indeed been kept. A reasonably safe way to insure this is to indicate in the RFP the conditions for acceptance and to