Minnesota Supercomputer Center

June 1994

Program Evaluation Division
Office of the Legislative Auditor
State of Minnesota

Program Evaluation Division

The Minnesota Legislature established the Program Evaluation Division within the Office of the Legislative Auditor in 1975. The division's mission, as set forth in statute, is to determine the degree to which activities and programs entered into or funded by the state are accomplishing their goals and objectives and utilizing resources efficiently.

The division conducts six to eight major evaluations each year. Each evaluation includes a *program review*, which describes program activities. In addition, most evaluations address: 1) *compliance issues*, which examine whether the program is implemented consistent with law and legislative intent, 2) *economy and efficiency issues*, which assess whether the program is managed efficiently and cost effectively, 3) *program effectiveness issues*, which determine whether the program is achieving its objectives, and/or 4) *policy issues*, which concern the impact of current state policy and the costs and benefits of policy alternatives.

The division also conducts follow-up studies, updates previous research findings, and evaluates annual performance reports prepared by state agencies.

Topics for study are approved by the Legislative Audit Commission (LAC), a 16-member bipartisan oversight committee. The division's reports, however, are solely the responsibility of the Office of the Legislative Auditor. Findings, conclusions, and recommendations do not necessarily reflect the views of the LAC or any of its members.

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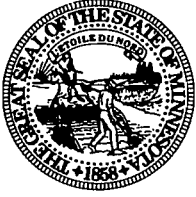Jo Vos
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Minnesota Supercomputer Center

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Program Evaluation Division
Office of the Legislative Auditor
State of Minnesota

June 22, 1994

Members
Legislative Audit Commission

In August 1993, the Legislative Audit Commission directed the Program Evaluation Division to evaluate the financial relationship between the University of Minnesota and the Minnesota Supercomputer Center, Inc (MSCI). Primarily, we were asked to assess whether the University is receiving adequate value from MSCI.

In a previous 1992 review, we were unable to determine whether the arrangement between the University and MSCI was financially advantageous because we were not given access to MSCI's financial records. Although created and owned by the University and the University Foundation, MSCI is a private, for-profit corporation and considers information about its finances and internal operations to be "trade secrets."

To do this review, we were given access to MSCI's financial records, but with the understanding that we would not disclose trade secret information. As a result, we have not published financial details about MSCI in this report and we cannot make that information public through our work papers.

Based on our review, we have concluded that the University is, on balance, receiving adequate value from MSCI. We have also concluded that the University is not subsidizing MSCI's commercial customers.

We received the full cooperation of the Minnesota Supercomputer Center and the University of Minnesota. This report was researched and written by Tom Walstrom (project manager) and Elliot Long.

Sincerely yours,

James Nobles
Legislative Auditor

Roger Brooks
Deputy Legislative Auditor

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Minnesota Supercomputer Center

EXECUTIVE SUMMARY

In 1992, at the request of the Legislative Audit Commission, the Legislative Auditor's Program Evaluation Division evaluated supercomputing services at the University of Minnesota. The commission asked for the review because the University's approach to obtaining supercomputing services through a for-profit, University-created company had become controversial and raised concerns. The controversy was caused primarily by the unusual secrecy with which the company, known as the Minnesota Supercomputer Center, Inc. (MSCI), operated.[1] This raised concern that the University might be subsidizing MSCI's commercial clients and not receiving cost-effective service.

In August 1993, the Legislative Audit Commission again discussed supercomputing at the University and directed the Legislative Auditor to do two additional reviews—a financial audit of MSCI and another evaluation by the Program Evaluation Division. The two reviews were performed separately.

The Program Evaluation Division was directed to address two key questions about the University's financial relationship with MSCI:

- **Is the University subsidizing the commercial clients of MSCI?**

- **Is the University receiving a good value for the funds the Legislature has appropriated for supercomputing at MSCI?**

MSCI's financial and business records are "trade secrets."

At the urging of University President, Nils Hasselmo, MSCI's Board of Director's agreed to cooperate and pledged that it would open the company's records to the Legislative Auditor. The Legislative Audit Commission and the Legislative Auditor agreed that MSCI 's "trade secrets" would not be made public.

As part of our evaluation, we examined MSCI's financial statements and other documents related to the company's financial operations. Aside from the University contract materials, all of the data and documents we examined are considered "trade secrets" under the Minnesota Government Data Practices Act and cannot be made public by us. This greatly limits our ability to show how we arrived at our findings and conclusions.

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1   Since 1992, MSCI has issued two annual reports and has generally made more information publicly available about the services it provides to the University.

**The University
pays a lump
sum amount
and receives
guaranteed and
non-guaranteed
computer time.**

In order to answer the evaluation questions, we made a number of different comparisons between service rates for computer usage paid by the University and commercial clients in calendar years 1991, 1992, and 1993. The comparisons are complicated by several factors. First, the University pays a fixed-fee lump sum amount and its rate must be computed from the total amount of money it paid to and on behalf of MSCI and the total number of service units it received. The University is MSCI's largest customer, and it received increasing amounts of service units from MSCI in each of the six six-month periods we looked at.[2] Second, the University receives a guaranteed amount of service units that it can use for interactive and normal priority batch computer access and support services and it also receives an uncertain amount of "gifted" low-priority service units.[3] The low priority service units have a value to University researchers, but the value is less than the higher priority guaranteed service units. Third, MSCI limits University researchers access to interactive computer use, which is the highest priority access to the computer.[4] Commercial clients primarily use the supercomputers in the highest priority interactive mode. Interactive use of the computer is more valuable than the University's batch use, but how much more valuable is uncertain.

We made adjustments for all of these differences between the University and commercial clients. We found:

- **The rates charged commercial clients are related to volume of business and the length of commitment. The largest dollar volume customers pay the lowest rates.**

- **The University service rate declined steadily throughout the study period.**

- **Without adjusting for differences in type of service, the University paid a lower rate per service unit than all commercial customers in all three years.**

- **When we valued the University's low-priority "gifted" service units as worth one-third to one-half of its higher priority service units, the University still paid lower prices than all commercial customers in all three years.**

- **When we also adjusted for the difference in the value of interactive computing, the University paid more than the largest commercial client in 1991 under some assumptions about how to value interactive**

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2   Service units represent about one hour of computer processing time.

3   Interactive computer jobs have the highest priority and are immediately executed by the computer. Batch computing uses computer queues to store computer jobs temporarily while they are waiting to be released to run on the computer. The computer determines the optimum number of computer jobs that can be currently run and releases jobs from the queue to run on the computer based on the size of the job, when the job was submitted, and the priority level of the job. It is the policy of the MSCI board to provide the University all of the unused computer time. All of this 'gifted" time is provided at the lowest priority level.

4   MSCI notes that, during 1993, the University researchers were still the largest users of interactive computing.

computer time. Our analysis also showed that under any assumptions, the University paid less than all commercial customers since the new contract with MSCI took effect in July 1992.

- The University also paid lower unit costs than all commercial customers for all other computer support services such as disk and tape storage, printing, dial-up communications and other non computer processing charges.

We also examined rates paid in 1994 by the University and by the largest commercial clients. We found that if the University continues to receive the same amount of lower-priority "gifted" time that it received in the last six months of 1993, then under any assumption it will continue to pay lower rates than the largest commercial clients over the term of its current contract with MSCI. After considering these findings, we conclude that:

- The University is not subsidizing commercial clients.

The second focus of our study was to determine if the University was receiving adequate value from its relationship with MSCI. The fact that the University pays lower prices than commercial customers for computer processing is a significant indicator of the value of the relationship, but services other than computer processing are also important.

We considered several other factors in judging the relationship between the University and MSCI.

We found:

The University is not subsidizing commercial clients.

- The University received a share of MSCI's computing resources that was more than proportionate to its annual financial contribution to MSCI.

- The effective service rates the University pays MSCI are in the same range as rates available at other supercomputer centers around the country.

Certain aspects of the service provided by MSCI to the University are intangible and difficult to quantify. In certain respects, the relationship between the University and commercial customers is mutually beneficial: commercial customers receive priority in terms of interactive access to the computers, but the University receives the unused time on the computers, which has allowed it to use large portions of the computer resource. In the past, the University has negotiated contracts that focused on the number of service units MSCI would provide. Because the University pays a fixed-fee, MSCI has no particular incentive to provide the University more of the other components of service such as disk access, technical support, and software access that might enhance the research program at the University.

We also found:

- **The June 1992 contract between MSCI and the University was vague in a number of key areas regarding what services that MSCI would deliver to the University.**

At least partially as a result of the vague contract language, University researchers have had numerous complaints about a lack of communication and cooperation from MSCI management in providing sufficient access to disk storage, technical and graphics support, and research software. Another area of frustration for the University researchers has been lack of consultation and consideration in MSCI's technology planning. Each of these areas has been addressed by a group of MSCI board members, MSCI management, University administrators and researchers have met over the last seven months to clarify the contract language. A restated contract has now been completed and signed. The contract is now specific enough to provide some assurance that the University will get an acceptable level of service, as well as access to computing time. As the result of these considerations, we conclude that on balance:

- **The University is receiving adequate value for its service payments to MSCI.**

The University is receiving adequate value for its service payments to MSCI.

Minnesota Supercomputer Center

In 1992, at the request of the Legislative Audit Commission, the Legislative Auditor's Program Evaluation Division reviewed supercomputing services at the University of Minnesota. The commission asked for the review because the University's approach to obtaining supercomputing services through a private, for-profit company created by the University had become controversial and raised concerns. The controversy was caused primarily by the unusual secrecy with which the company, known as the Minnesota Supercomputer Center, Inc. (MSCI), operated. In 1992, little was known about MSCI or what services the University and commercial customers were receiving.[1] This raised concern that the University might be subsidizing MSCI's commercial clients and not receiving cost-effective service.

During our 1992 review, we examined only records in the possession of the University because MSCI was unwilling to give us unfettered access to its records. As a result, we were unable to address several concerns about the University's financial relationship with MSCI. We concluded that it was an open question whether or not the University was getting "a good deal" from MSCI.

The University reacted to our evaluation and took several steps to improve accountability for supercomputing services. But information that would permit an independent assessment of whether the University's relationship with MSCI was financially advantageous remained secret. As a result, in August 1993, the Legislative Audit Commission again discussed supercomputing at the University and directed the us to do two additional reviews--a financial audit of MSCI and another review by the Program Evaluation Division. The two studies were conducted separately.

The Program Evaluation Division was directed to address two key questions about the University's financial relationship with MSCI:

- **Is the University subsidizing the commercial clients of MSCI?**

- **Is the University receiving a good value for the funds the Legislature has appropriated for supercomputing at MSCI?**

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1   Since 1992, MSCI has issued two annual reports and has generally made more information publicly available about the services it provides to the University.

At the urging of University President, Nils Hasselmo, MSCI's Board of Directors agreed to cooperate and pledged that it would open the company's records to us with the understanding that MSCI's "trade secrets" would not be made public.

As part of our review, we examined MSCI's financial statements and other documents related to the company's financial operations. Aside from MSCI's contract with the University, all of the data and documents we examined are considered "trade secrets" under the Minnesota Government Data Practices Act and cannot be made public by us. This greatly limits our ability to show how we arrived at our findings and conclusions.

This report is organized into four sections. First, we briefly review the history of the University of Minnesota's relationship with the Minnesota Supercomputer Center. Second, we review the methods we used to conduct this study. Third, we review various rate comparisons between the University and MSCI's commercial customers. And, finally, we examine several other aspects of the University service agreement with MSCI and discuss whether the University is receiving adequate value from its relationship with MSCI.

MSCI's financial and business records are "trade secrets."

BACKGROUND

In this section we briefly review the history of the relationship between the Minnesota Supercomputer Center and the University of Minnesota. Readers are referred to our 1992 report, *University of Minnesota Supercomputing Services*, for a more detailed historical account of the relationship. In this section, we focus primarily on events that have occurred since the release of that evaluation.

The University acquired its first supercomputer in 1981. To provide a corporate home for this and future machines, in 1982 the University of Minnesota created the Minnesota Supercomputer Center. The University believed that, by forming a private, for-profit company, it could sell services to private customers and provide supercomputing resources to researchers economically. In order to take advantage of tax benefits, it was necessary that the University Foundation become the company's principal owner.

The University created the Minnesota Supercomputer Institute to provide administrative support to a group of key researchers that use MSCI's computers. Unlike MSCI, the Institute is a part of the University and organizationally separate from the Center. In 1984, the Legislature appropriated $2.6 million to the Institute to support the purchase of computer time and services from MSCI and $5 million to remodel a building in the Minneapolis High Technology Corridor to house the Institute. Since that time, the Legislature has appropriated over $70 million to support the University's supercomputing services.[2] The University has supported the effort with at least $5 million in additional funds, not including the support provided to the Institute.

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2   Not all of the appropriations have been used to purchase services from MSCI.

Although legally created in 1982, MSCI's operational independence from the University developed over several years. In fact, from 1983 until 1985, University employees continued to operate the supercomputer at the University's computing facility in Lauderdale. In late 1985 and early 1986, the University and MSCI entered agreements that transferred the supercomputer management to MSCI. By December 1985, 18 staff had been hired (mostly from within the University) and a separate company began to take shape.

Since 1986, MSCI has operated as a separate company to provide supercomputer services to the University academic researchers as well as to commercial customers. The company has grown to have about 75 employees and over $20 million in revenues. The University accounted for about 55 percent of the Center's $22.6 million fiscal year 1993 revenues through its $8 million per year commitment and its Army High Performance Computing Research Center (AHPCRC). The federal government funds the AHPCRC research program. The University subcontracts the operation of the AHPCRC computers to MSCI. Figure 1 shows the operating revenue by source of funds for fiscal years 1991-1993.

The University accounted for about 55 percent of MSCI's 1993 revenues.

Figure 1: Operating Revenue by Source, Fiscal Years 1991 to 1993
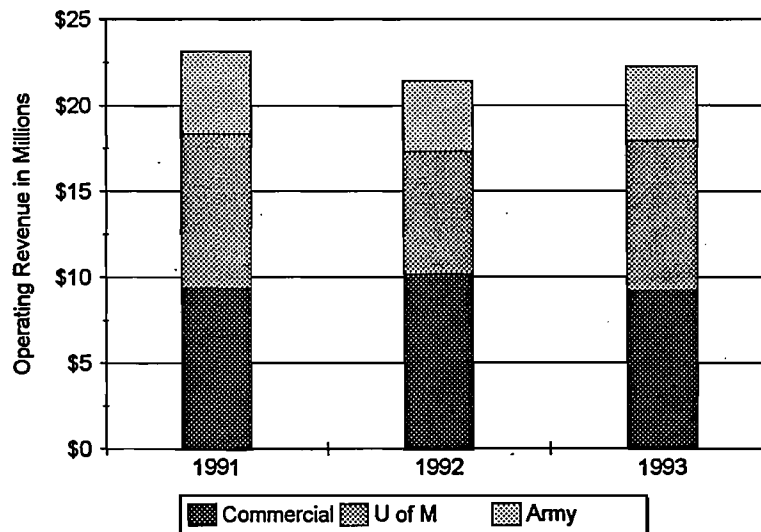
University's Response to 1992 Evaluation

The University has taken a number of steps to strengthen accountability and to modify its relationship with MSCI. However, despite these changes, relations between the University researchers and MSCI have remained contentious. In January 1993, the Supercomputer Institute Planning Committee (the members of which are high level University researchers) voted a resolution of no confidence in the management of the Center, calling for "an immediate change in the top management of MSCI, Inc." That resolution further stated: "The contractor is not providing acceptable management of resource delivery to the University, i.e., the

implementation of the contract by MSCI, Inc. is unacceptable. MSCI, Inc. has failed to manage our account [at] a minimally acceptable level." The MSCI Board responded to the fellows' resolution with a unanimous vote of support in its management.

In addition, several University Faculty Senate committees examined the issue of supercomputing at the University in response to our report's release. In particular, President Hasselmo and the Faculty Senate chair appointed an ad hoc task force to examine, among other issues, whether the University should sell its MSCI stock to the University of Minnesota Foundation. The task force met for several months and examined in detail the University's relations with MSCI. The task force recommended that the President take the following steps:

- The University should not sell its interest in the Center to the University of Minnesota Foundation. It should, instead, strengthen the relationship it has with the Center.

- A joint Institute/Center Steering Committee responsible to the Center Board of Directors and the University Board of Regents for defining and overseeing Institute/Center interaction should be formed immediately.

- The President of the University should recommend to the Board of Regents individuals to replace the two Senior Vice Presidents on the Center Board of Directors. These individuals should be interested in and knowledgeable about academic supercomputing.

- The Center must be held accountable to the University by requiring that it annually provide a full confidential disclosure of its financial and programmatic activities to the Chair and Vice Chair of the Board of Regents and to any other individual Regent who might request it.

- The Legislative Auditor must be invited to complete his full financial audit of the Center.

- The President of the University should insist that an external review of the management performance of the President of the Center be completed by September 1, 1993.

Responding to the task force, President Hasselmo recommended the following:

1. The University should not sell the Supercomputer Center.

2. The board of MSCI should update the Center's mission statement.

3. The University should update the mission statement of the Minnesota Supercomputer Institute (the organization serving the University supercomputer researchers within the University).

4. The board of MSCI should undertake a timely external review of the Center's management, focusing on the problems of communication and customer service.

5. A liaison committee should be formed to address Center/Institute joint planning and issue resolution.

6. The University Vice President for Research will complete the external review of MSI and make appropriate changes based on the reviewers' recommendations.

7. The existing service agreement between MSCI and the University will be reviewed by the Chair of the MSCI board, the Chair of the University Foundation, and the University's Senior Vice President for Finance, and Vice President for Research to remove any ambiguities that may exist regarding the nature, amount, or particulars of the service to be provided.

8. The Center will be requested to provide annually a full confidential disclosure of its financial activities to the President, the Chair and Vice Chair of the Board of Regents, and any other Regent who requests the information. A financial examination of all funds expended by the University at the Center, and the Center's performance under contracts between the University and the Center, are proper subjects for public audit.

9. The two University vice presidents will resign from the Board of MSCI and will be replaced by two faculty members with the appropriate technical and financial expertise.

The President further stated that in making these recommendations he had "been mindful of the public's right to know what goes on in a public university, of our obligation to provide full disclosure of the use of all public funds to the Legislative Auditor, the Legislative Audit Committee, the Board of Regents, the University community, and the public."

On August 24, 1993 President Hasselmo appeared before the Legislative Audit Commission to discuss the potential audit and reported that at his urging the board of the Supercomputer Center had directed the Center's management to cooperate with the auditor. As mentioned earlier, at the August meeting, the commission directed the Legislative Auditor's Office to conduct both a financial audit of MSCI and a review by the Program Evaluation Division of the two questions related to the financial relationship between the University and MSCI.

During the course of this evaluation, action on several of President Hasselmo's recommendations has been completed. For example, external review of both the Minnesota Supercomputer Institute and the Minnesota Supercomputer Center have been completed.[3] A liaison committee composed of MSCI board members and re-

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3 *Report of the External Review Panel on the Minnesota Supercomputing Institute*. August 18, 1993. *Minnesota Supercomputer Center, Inc. External Review*. KPMG Peat Marwick. January 1994.

searchers has also been formed, and has met three times, to monitor the relationship on an ongoing basis. The Center has also hired a person to serve as the University liaison. The University has also removed the two vice-presidents from MSCI's board of directors and appointed three professors and an alumni scientist to the board.

The University and MSCI have resolved many details left unclear in their 1992 contract.

Most significantly, the University and the Center have finalized many of the details that were left unclear in the July 1992 MSCI-University contract. This took a series of meetings over a period of seven months between Senior Vice President Robert Erickson, Vice President Anne Peterson, University researchers, Steven Pflaum the MSCI board chairman and Center managers. The revised contract addresses more specifically many of the detailed arrangements that were left vague in previous contracts.

Methodology

In a sense, we were directed to answer this basic question: Is the University getting a "good deal" in its relationship with the Minnesota Supercomputer Center? To facilitate our evaluation of the University's "deal," we structured our evaluation to address two related research questions. First, has the University subsidized commercial clients of MSCI with taxpayer dollars? Second, is the University receiving a good value for the funds the Legislature has appropriated for supercomputing. We approached these questions with an underlying premise. We think the University should be paying less for supercomputing resources than commercial clients. This is because the University is the largest provider of revenue for the Center, and because the University established and capitalized the Center. The Center exists as a means of providing cost effective supercomputing services for University researchers.

As part of our review, we made a number of general and detailed comparisons. This section describes the analytical approach we used to compare the prices paid by the University and prices paid by MSCI's commercial clients. These price comparisons are fundamental to the issue of whether the University is getting service from MSCI on favorable terms.

We chose to look at MSCI services and prices in effect during the period from January 1991 to December 1993. Because the contractual arrangement between MSCI and the University changed each six months during this period, we looked at the University's price and service data for six separate six-month periods. In addition, we examined the rates currently paid by the University and MSCI's large commercial clients.

We looked at MSCI's operating revenue by source and found that the University was by far MSCI's largest client in terms of services used and total billings. Thus, the best comparisons to the University are the largest commercial service buyers because prices and terms are more favorable for high volume users and customers who are willing to make a minimum commitment of future use. We looked at several of MSCI's large commercial customers during 1991 to 1993. We systemati-

cally examined comparable information on this group of commercial customers and compared services and prices to those charged to the University.

We obtained copies of the service agreements between MSCI and each large customer in effect during the study period 1991 to 1993. We obtained contract revisions, letter agreements, charging formulas and other information necessary to assemble complete information governing prices and services for each client.

The University pays a lump sum amount and receives both guaranteed and non-guaranteed computer time.

While the contracts with commercial clients specify prices for computer use, data storage, consultant time, etc., the University's contract with MSCI is different. During the time period we studied, the University paid a lump sum at the beginning of each contract year. The current contract agreement, for example, specifies an annual service fee of about $8,000,000. In return for its annual payment, the University received computer services that include a guaranteed amount of service units and the right to any unused computer time on a low-priority basis.[4] Unused time on the computer is "gifted" to the University by a MSCI Board policy. The University also received access to a portion of the available disk storage, MSCI provided software, and some dedicated technical support. The guaranteed service units could be used for interactive computing (subject to time limits established by MSCI), normal priority batch computing, and for disk and tape storage and other support services.[5]

As a result, in order to compare prices paid by the University to prices paid by commercial clients we had to compute an overall price for services received by the University. Our calculation of the University's service costs included the service fee, but also other payments made for the benefit of MSCI, chiefly utilities, property insurance, and other occupancy costs paid under lease arrangements in effect prior to July 1, 1992. We also adjusted the University's costs to reflect the fact that the University pays its service fee at the beginning of the year while the commercial customers pay by the month.[6]

In order to compare prices, we computed the service unit consumption and associated costs for representative computer runs and compared the charges incurred by the University and other MSCI customers. With the help of MSCI, we made these comparisons for prices in effect from 1991 through 1993. For the University, effective prices changed each six months until July 1992. Since July 1992, the University and MSCI have operated under the terms of a new contract but the amount of guaranteed service units has still varied somewhat during each six month pe-

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4 The MSCI Board has passed a resolution calling for the University researchers to receive all of the unused time on the computer. This "gifted" time is all available at the lowest priority level. That is, computer jobs running using the "gifted" time do not execute until all higher priority jobs are running or have been completed, and they stop execution if a higher priority job is submitted to the computer while they are running.

5 Interactive computer jobs have the highest priority and are immediately executed by the computer. Batch computing uses computer queues to store computer jobs temporarily while they are waiting to be released to run on the computer. The computer determines the optimum number of computer jobs that can be currently run and releases jobs from the queue to run on the computer based on the size of the job, when the job was submitted, and the priority level of the job. All of the University's low priority usage is through the batch queues.

6 We estimated the University's interest foregone at the average 90 day commercial paper rate in effect each year between 1991 and 1993.

riod. We looked at prices for representative computer jobs run on each computer in service during this time, and the prices for jobs using varying amounts of memory.[7] Finally, we performed selective tests of the charging formulas to see if we could obtain the same results as MSCI and were satisfied that the data provided by MSCI were accurate.

During the study period, actual computer use by the University exceeded the guaranteed contracted level in all but one of the six month periods. And use of the low-priority "gifted" time was very substantial and exceeded the contracted amount in each year between 1991 and 1993. These facts make the computation of unit costs complex. We computed unit costs three ways: based on the contract allocation, the actual usage excluding "gifted" time, and the total usage including low-priority "gifted time." Further, we made two assumptions about the value of the "gifted" time. We assumed, alternatively, that low-priority use was a) worth one-third of guaranteed usage, and b) worth one-half of guaranteed usage.

Interactive computer processing is more valuable than batch processing.

Any comparison of prices for computer time between the University and commercial customers has to take account of the fact that the service units used by commercial users are primarily for interactive computing and those used by the University are primarily for batch computing. We have taken this into account by examining unit costs separately for batch and interactive service, and by comparing prices making alternative assumptions about the relationship between interactive and batch prices.

We also reviewed rates charged at three other supercomputer centers to determine if the University rates were comparable to those charged elsewhere. Since there are real advantages to operating a supercomputer at the site where the research is being done rather than remotely, we make these rate comparisons only to determine if the University is paying a roughly competitive rate. The cost comparisons are somewhat misleading because other centers' cost structures are different than MSCI's. The rates charged are dependent on the amount and type of computer time available and the level of technical support services that are provided. In addition, we found that rate information is not uniformly available for all centers and special rates that are lower than the published rates are available at some centers. We also made adjustments to the rates to account for the differences in computer speed and the billing formula used.

Although most of the computing costs for the University are associated with actual computer processing, the University also has used a portion of its guaranteed contract allocation to pay for ancillary support such as disk and tape storage, printing, dial-in communication charges etc. We also made a comparison of the rates the University pays for these services compared to commercial clients.

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7   MSCI's Cray computers have multiple processors that share a pool of computer memory. For example, the four processors on the Cray X/MP computer share a common pool of memory. Because the memory is shared, if one processor uses all of the memory, then the other three processors must remain idle. MSCI's billing formula charges more service units per unit of time as the use of memory increases.

DOES THE UNIVERSITY SUBSIDIZE COMMERCIAL CLIENTS?

In this section we review rate comparisons for computing time and for ancillary services associated with using the computer for both the University and MSCI's commercial clients.

Rate Comparisons

In order to determine whether or not the University subsidizes MSCI's commercial clients, we compared the University's effective price for service units with the prices paid by commercial clients. Because MSCI's prices for commercial clients vary by the volume of business and the length of the contractual commitment, we reviewed the prices paid by MSCI's largest commercial clients. Our general conclusion is that:

- **The University did not subsidize commercial clients during 1991-93 under most of the assumptions we used to value computer time. Under most assumptions about how to value differences in contracts, the University has paid lower rates during the period 1991-93. Since the implementation of the July 1992 contract, the University has clearly paid lower prices per service unit than all commercial customers. Further, the University will continue to pay lower prices throughout the current contract period under reasonable assumptions.**

Under any assumptions, MSCI's commercial clients paid more than the University since July 1992.

We base this conclusion on our finding, detailed below, that even after adjusting for the differences in the services provided to commercial clients, they currently pay more than the University for supercomputer services. This was clearly true in 1992 and 1993 under any set of assumptions about how to value various services. In 1991 and the first six months of 1992, the largest commercial client's rate for service units was lower than the University's under some assumptions about how to value interactive computer time.

Both computer service providers and users benefit if the resource is managed efficiently. The way to make cost effective use of supercomputers is to queue the computer jobs by size and priority. In general, higher priority access costs more than lower priority access. It is not necessary here to go into the full complexity of how computer jobs are managed, but accurate price comparisons require a comparison of prices for major types of jobs: interactive, normal-priority batch, and low-priority batch. As noted earlier, most of the computing time used by commercial clients is interactive (the highest priority), while over 90 percent of the services used by the University are batch services (with a high percentage of the lowest priority). In 1993, for example, the University used about 8.5 percent of

its total computing time interactively, and of the remaining 91.5 percent batch service units, over 61 percent were low priority "gifted" service units.[8]

MSCI's billing formula is slightly different for the University and commercial customers.[9] But both are charged for service units of central processing unit (CPU) time, the amount of memory used, a factor measuring the ability to use more than one computer processor simultaneously, and a charge for input/output disk usage.[10] MSCI has structured the billing formula to encourage efficient scheduling of the computer usage. Commercial customers are charged a fixed price for a service unit of computer resources based on the number of dollars they have committed to spend and the term of the commitment. On the other hand, as noted earlier, the University paid a lump sum fee at the beginning of the fiscal year and in return received a contracted amount of service units plus some uncertain amount of lower priority "gifted" services. The University's rate must be computed from the total amount of computer time it receives and the total amount it pays.[11]

The University is the largest customer of the Center. Table 1 shows the total amount the University has paid MSCI over the last three years. Our approach was to include all money the University paid to MSCI as well as any costs it incurred on behalf of MSCI. Table 2 shows the number of guaranteed service units the University contracted for, the number actually received, and the number of non-guaranteed low-priority service units actually received.

We examined commercial client rates on the Cray 2 and Cray X/MP for large commercial clients during 1991 through 1993 for a typical computer run utilizing different amounts of computer memory. As one would expect, the largest customers received the best rates.

Rate Comparisons With No Adjustments

We chose to do further comparisons of rates with MSCI's largest customer, under the previously stated presumption that the University's rates should be better than the best commercial client.

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8   Despite using only 8.5 percent of its computer time interactively, the University was MSCI's largest user of interactive computer time in 1993.

9   The differences in the billing formulas are the result of requests from both the University and MSCI's commercial customers. We analyzed the effect that differences in the billing formula has on rates paid and found that it does not materially change the price comparisons presented in this section.

10 The computers central processing unit is the part of the computer that performs the arithmetic calculations.

11 We included the service fee paid by the University to MSCI for computing services plus other payments the University made on behalf of MSCI or to MSCI. Our estimate of service costs includes not only the contractual service payments from the University to MSCI but also certain building and occupancy costs paid by the University for the benefit of MSCI. In addition, we add include the money paid to MSCI on behalf of the University through research grants from Cray Research and the service units the University researchers buy with the Cray grants. Our approach to calculating the University's effective rate was the include all of the service units the University researchers receive and all of the costs associated with those service units.

Table 1: University Payments to MSC, 1991-1993

	Service Payment	Net Occupancy Costs	Interest Adjustment	Cray Grant	Total
1991					
January-June	$3,700,000	$531,995	108,158	280,000	$4,620,152
July-December	3,226,000	596,635	108,158	120,000	4,050,793
1991 Total	$6,926,000	$1,128,629	$216,316	$400,000	$8,670,945
1992					
January-June	$3,226,000	$596,635	$ 62,976	$120,000	$4,005,611
July-December	4,000,000	0	62,976	0	4,062,976
1992 Total	$7,226,000	$596,635	$125,952	$120,000	$8,068,587
1993					
January-June	$4,000,000	$ 0	$ 69,085	$ 0	$4,069,085
July-December	4,000,000	0	69,085	1,029,022	5,098,107
1993 Total	$8,000,000	$ 0	$138,170	$1,029,022	$9,167,192

Table 2: University of Minnesota Service Units Contracted For and Used, 1991-1993

	Normal Priority			
	Contracted	Actual	Low Priority	Total
1991				
January-June	9,755	13,581	8,438	22,019
July-December	11,495	13,065	16,077	29,142
1992				
January-June	13,420	13,857	24,479	38,336
July-December	26,468	22,621	16,267	38,888
1993				
January-June	24,505	29,688	28,749	58,437
July-December	30,197	32,108	50,433	82,541

We first examined rates paid for different memory size computer jobs without making any adjustments for differences in service. We compared MSCI's largest commercial client's rates to the University's rates in 1991, 1992, and 1993. We computed the University's rates three ways, using: a) the amount of service units the contract called for, b) the amount of service units the University actually used, and c) the amount of normal and low priority time the University actually received valued at 100 percent of the guaranteed time.[12]

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12 The official contract between MSCI and the University in effect prior to June 30, 1992 called for rates of $750 per service unit on the Cray 2 and $550 per service unit on the Cray X/MP. However, in fact, these rates were effectively renegotiated each six months when it was determined what the guaranteed number of service units available to the University would be in the next six month period. As a result, the University's effective rates were considerably lower than $750 and $550 per service unit. We used the number of service units guaranteed by these negotiations to calculate the contract rate.

Without making any price adjustments for differences in service, in all three years the University paid lower rates for most types of computer jobs compared to the largest commercial client. The University and MSCI redetermined the committed amount of service every six months. As a result, the University's effective service rates declined steadily over this period.

Rate Comparisons Considering Gifted Time

In 1991, the University's contractual rate of $474 was higher than the largest commercial client's rate. But, the University actually used more of the normal priority service units than called for in the contract. Considering these service units, the University's effective rate dropped to $340 per service unit.

A more refined comparison of rates requires a consideration of the value of the low priority "gifted" service units made available by MSCI to the University. It is widely agreed in the University community and at other academic supercomputer centers that these lower priority service units are less valuable than guaranteed normal priority batch or interactive computer time. It is not agreed exactly how much less valuable. It is also common to have discount queues on supercomputers. We examined the queue discount structure at six large supercomputer centers. Five of the six had some sort of weekend or evening rate. Three of the five charged 50 percent less for evening computer runs, and the other two charged 75 percent of the day rate.

Although less common than weekend or evening discount queues, three of the six also had low or "zero" priority discount queues similar to that which MSCI provides to the University. Access to the lowest priority queue at Lawrence Livermore National Laboratory was billed at 10 percent of the normal priority batch rate. San Diego Supercomputer Center has low priority queues that charged 20 to 50 percent of the standard rate depending on the amount of memory used. The National Center for Atmospheric Research has a zero-priority queue similar in priority to the University's that it accounts for at one-third of the standard priority batch rate although actual usage was free.

The value of the University's low-priority "gifted" computer time depends on the length of delays and the predictability of processing.

What value to place on the zero priority "gifted" time depends largely on how long it takes for the computer job to run, and how predictable the availability of the time is. Another factor affecting the value is alternative computing methods. It is now possible to run many of the computations formerly requiring supercomputers on smaller much cheaper workstation computers overnight. As a result of these factors, the appropriate value of the low priority time has probably varied in each of the periods we examined. Before the current University-MSCI contract was signed in June 1992, and the subsequent acquisition of the Cray C-90, the availability of the low priority time was less predictable and it sometimes took several days or weeks for low priority jobs to run. The acquisition of the C-90 has meant that lower priority jobs run much more quickly, sometimes even during the day, therefore raising the value of low priority time. On the other hand, workstation computers can now run many types of jobs in acceptable amounts of time at much less cost.

We also interviewed several University researchers about what value they placed on the low-priority computer time. Although some University of Minnesota researchers regard these lowest priority units as valueless for the type of computing they need to do, most regard them as having some value less than the guaranteed service units. Most agreed that a value of one-third to one-half the value of the guaranteed service units was reasonable. As a result of our discussions with researchers and a review of charging factors at other supercomputer centers, we concluded it was reasonable to value the "gifted" service units at both 33 percent and 50 percent of a standard batch service unit in order to calculate the University's effective service rate. In our view, this is a conservative way to value "gifted" services.

Our analysis showed that if one calculates the value of low-priority service units at either one-third or one-half of guaranteed time, then the University paid lower prices than MSCI's largest customer in every six month period during 1991 to 1993.

Rate Comparisons Considering Interactive Time

A major difference between the University and MSCI's commercial clients is that the commercial clients run most of their computer jobs interactively at the highest priority while the University's interactive computer use is limited by job size and time. The University's interactive use of the Cray 2 was limited to jobs of less than 5 minutes and 64 megawords before July 1, 1992 when the limits increased to 20 minutes and 72 megawords of memory.[13] The University's interactive use of the Cray X/MP is limited to 8 megawords of memory and was increased from 3 to 20 minutes in July 1992. The University does use about 19 percent of its contracted computing service units (or about 8 percent of its total computing service units) interactively.[14] All of the low priority "gifted" time is provided through the batch queue system. In contrast, the largest commercial client did most of its computing interactively in 1993, and commercial clients generally do most of their computing interactively. In 1991-93, the largest commercial client had no cost differential for interactive computing. Currently, all commercial clients pay a premium for interactive service. The effect of commercial clients having no restriction on interactive computing can be, and reportedly was in the past, to force University researchers off the machine during normal working hours, delaying their computer runs to the evening hours. MSCI did respond to University complaints about day time access to the computer, but University researchers believe MSCI did not respond satisfactorily and that they had a problem with day time access until the new computers were purchased in 1993.

Commercial use of interactive computing has delayed University researchers in the past.

It is difficult to know how to value interactive access to the computer. It is clearly more valuable than the University's normal and low priority batch access to the

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13 A megaword is a million words of computer memory. The Cray 2 computer has 512 megawords of memory.

14 Because all of the University's gifted service units are batch, the percent of the total service units received interactively from MSCI is less then ten percent. Despite, the percentage of the University's interactive computer use being low, the University was MSCI's largest user of interactive time in 1993.

computers. Interactive access to the computer allows many more iterations of scientific problems that leads to faster results. The University and commercial client rates must be adjusted to account for the difference in service. The amount of adjustment depends on how much the University is affected by the limits on its interactive use. When commercial client interactive use delays University research, then a higher premium for interactive use would be appropriate. When the University researchers receive good turn around time on their batch computer runs, then a lower premium would be appropriate. Since MSCI's acquisition of the Cray C-90 computer, University researchers report good turn around time on their computer runs. Prior to the acquisition of the new computer, there were times when their jobs did not run promptly. As a result of these considerations, we used a series of bracketing assumptions about the value of interactive computer time. We used three selected rate premiums, representative of those currently charged for interactive access at other centers, rate premiums formerly charged to MSCI customers other than the largest customer, and MSCI's current interactive premium, as our assumptions about interactive time value.

Unless there is large surplus capacity, it is not possible to efficiently run a computer center if every user is given unlimited access to interactive services. Therefore, almost all centers either impose on all users a limit on interactive use similar to the University's limit at MSCI, or they charge a much higher rate premium. For example, the National Center for Atmospheric Research charges twice the batch rate for interactive computer time on their Cray Y/MP. Lawrence Livermore Laboratories charges a factor of three times more than batch for interactive use of its Cray C-90 and Cray 2 computers. The San Diego Supercomputer Center charges a factor of two times more for interactive access to its Cray C-90 and Y/MP and limits interactive users to six megawords of memory and 20 minutes of CPU time. The North Carolina Supercomputer Center doesn't charge more for interactive use, but limits it to less than 24 megawords and 10 minutes so that almost all of the actual usage for production runs is through batch queues.

MSCI also charged commercial clients, other than its largest, differential rates for interactive use before July of 1992. The premiums varied by client. Since the second half of 1992, MSCI began bringing all commercial clients to a common billing formula that adds a premium for interactive use. Thus, the new formula raises the relative cost of interactive computing for its largest commercial customer and lowers the cost of interactive computing for its other commercial customers. Because not everyone can use the computer interactively, commercial clients have been able to run mostly interactively because of the limits placed on the University use.

We adjusted both the University's and the largest commercial customer's rates to reflect their respective use of interactive computer time. We used a) a 10 percent adjustment, b) a 50 percent adjustment and c) a 100 percent adjustment. The analysis shows that if the interactive time premium is 10 percent, then the comparison between the University's rate and the largest commercial customer's rate is close during the first six months of 1991, but that during the second six months of 1991 the University paid a lower rate. University rates were lower in both 1992 and 1993 if the interactive premium was 10 percent.

> **University researchers currently report good turn around time on their computing requests.**

If interactive time is valued at a 50 percent premium, then the University paid higher rates than the largest commercial customer during the first six months of 1991 and lower rates during the last six months. If interactive time is valued at twice the batch rate, then the largest commercial client paid less than the University throughout the whole of 1991, but during 1992 and 1993 the largest commercial customer paid more than the University.[15]

Our analysis also showed that the University paid less than the largest commercial customer under any assumption in 1993. Our analysis showed that since the University's new contract with MSCI in July 1992, the University's rates are lower under any assumptions about the valuation of "gifted" or interactive computer time.

Rate Comparisons in 1994 Contracts

We also looked at rates currently in effect for MSCI's large commercial customers. An accurate statement of the University's unit cost should reflect the "gifted" low priority use it will make in 1994. The University has been getting excellent turn around time on the "low priority" service units since the purchase of the Cray C-90 computer. If all low priority service units are counted fully in calculating the University's rate, the University's unit cost was about $62 in the last six months of 1993. If the University continues to receive as many low priority service units as it received in the last six months of 1993, its effective rate for service units will remain lower than current commercial clients over the term of its contract with MSCI.

Rates for Other Services

While charges related to the central processing unit account for most of the cost of computer use for the University, the cost and availability of other services is an important issue and needs to be considered in addressing the question of whether the University is obtaining services from MSCI on favorable terms.

As noted earlier, the University does not pay separately for permanent or temporary data storage and backup. The University's use of these services is paid for through the service fee that pays for computer center services as a whole. Data storage is paid for in service units which count against the University's contracted allocation. Because the University's disk storage is denominated in service units, the University's cost per service unit of disk storage declined as the total number of service units increased during the three year period. During the 1991 to 1993 period, the University's consumption of service units for services other than computer processing (primarily disk and tape storage) amounted to 12 to 13 percent of the University's guaranteed service units.

We computed the cost of permanent and temporary data storage for the University and compared it to the prices charged to MSCI's largest commercial customer. As

Effective service rates will remain lower for the University than for current commercial customers.

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15 During the first six months of 1992, when interactive time is valued at twice the batch rate, the largest commercial client did pay slightly less than the University if gifted time is valued at one-third the guaranteed rate.

in the case of computer processing, the largest commercial customer purchased data storage and backup under terms that were the most favorable of the commercial clients we looked at in detail.

We found the largest customer's rates for disk storage were higher than the University's in all three years if all "gifted" time is included in calculating the University's rate. We believe this is the most appropriate way to calculate a service unit cost for disk storage. Thus, the University paid lower disk storage rates in all three years.

As noted, the University has not been satisfied with the amount of disk storage available to its researchers. Because the University has paid a lump sum to MSCI, MSCI's incentive is to not provide services such as disk storage in excess of the contracted terms if it would require the expenditure of additional funds. The largest commercial customer in contrast receives as much disk storage as it is willing to pay for. The University had access to 24 gigabytes of permanent disk storage prior to the new contract with MSCI effective July 1, 1992. At that point, MSCI agreed to increase the University's permanent disk storage in three stages to 64 gigabytes.[16] In contrast, the largest commercial customer had access to much larger amounts of storage during the whole period.

Commercial customers and the University incur other costs for temporary disk storage, printing, tape mounts and storage, dial-up communications, and graphics services. These costs are relatively minor, but in every case the University pays lower unit costs than commercial customers.

Discussion of Rate Comparisons

What conclusion should one draw from these comparisons? It is clear that if a premium is placed on interactive time, the University receives a less favorable effective service rate than is portrayed by previous comparisons in this report. If interactive time is valued at twice the University's normal priority batch time and the University "gifted" time is valued at 33 percent, then the University paid more than MSCI's largest commercial client until the new contract took effect in July 1992. Since July 1992, the University effective rates have compared favorably with all commercial client rates under any set of assumptions. The University's unit costs have improved considerably since the new contract took effect. It is quite clear to us that the University is not subsidizing commercial clients today. Today, as we discuss in the next section, the University is receiving adequate value for the funds it is transferring to MSCI.

The University paid lower unit rates for disk storage and other ancillary services.

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16 There is also a temporary disk storage area, shared by all MSCI customers, of 43 gigabytes of disk storage.

IS THE UNIVERSITY RECEIVING ADEQUATE VALUE FROM ITS RELATIONSHIP WITH MSCI?

The second major question in this study was whether the University has received adequate value from its relationship with MSCI. As noted in the previous section, during the periods we studied, the University paid lower prices under most assumptions than commercial customers. This in itself is one significant indicator of the value received by the University. However, to make our assessment we also asked the following questions:

- Does the University receives a share of MSCI resources available yearly that is at least proportionate to its annual support?

- Could the University get supercomputer services elsewhere at a comparable price?

- What additional services does MSCI provide besides access to raw computing resources?

After examining these questions, we conclude:

- The University is receiving adequate value for the funds it transfers to MSCI. However, we continue to have concerns about the cooperation and support provided by MSCI to University researchers.

Does the University Receive a Proportionate Share of MSCI's Resources?

A broad test of whether the University is receiving reasonable value for its financial contribution to MSCI is whether it is receiving a share of total computing services which is at least proportionate to its annual financial contribution. We examined this question and found:

- During fiscal years 1991 to 1993, the University contributed about 40 to 50 percent of MSCI operating revenues, and received well more than half of the computing cycles used by all clients.

As we have noted previously, the University and commercial customers receive different kinds of computing services for their service fees. But, by this global measure (which ignores the issues of access, support, or ancillary services, or the historical capitalization of MSCI by the University) the University receives more than a proportionate share of the computing resource.

Could the University Get Comparable Services Elsewhere?

There are non-economic advantages to having a supercomputer center and high performance computers located in proximity to the researchers that are using the computers. Nonetheless, at least for the purpose of our analysis, we examined the rates and billing policies at some other supercomputer centers that made rates available.

Comparisons with other supercomputer centers must be viewed with caution.

Some caveats about comparisons with other centers are necessary. First, centers do not have the same set of computing resources. Therefore, it is necessary to adjust the computer rates based on processing speed benchmarks. Second, the level of service and support varies among centers. In comparison with MSCI, other centers we contacted tended to have more computer and graphics support and scientific staff and fewer marketing positions. In other words, each center has a unique service and cost structure based on what the center perceives are important priorities for its operations. Third, not all centers are willing to reveal their rate structure. Some of those who do quote a rate also make individual arrangements based on how much and what type of service is made available. Thus, because of these limiting factors, comparisons with other centers can only show whether or not the rates the University is paying are "in the ball park." In other words, these comparisons are tentative due to site-specific differences. Nonetheless, based on these limited comparisons we conclude that:

- **The effective service rates the University pays MSCI are in the same range as the rates available at other supercomputer centers around the country.**

We examined rates from three different types of supercomputer centers. The National Center for Atmospheric Research (NCAR), the San Diego Supercomputer Center (SDSC), and the North Carolina Supercomputer Center (NCSC) made rates available. Rates are available from other centers as well, but we believe these three are representative of the broad spectrum of differing types of centers around the country. NCAR is a government and university supported center, San Diego is one of the four National Science Foundation centers, and North Carolina is a state supported center that provides services to researchers and local companies.

The centers' billing formulas vary, but each takes into account fewer factors than MSCI's formula. North Carolina calculates system units for its Cray Y/MP computer strictly on the basis of central processing unit (CPU) clock hours.[17] There are no charges for the other resource factors or disk storage. Interactive use of the machine is restricted to 10 CPU minutes. Usage is regulated by running all production jobs through batch processing. North Carolina charges $200 per service unit for commitments greater than 1,000 service units. We adjusted for the speed

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17 The central processing unit, or CPU, is where computer calculations are actually performed. CPU use is the major factor in most billing formulas we examined.

of the processor, included disk storage, and non-CPU components included in MSCI's billing formula to calculate a comparable rate to the University's.[18]

We also adjusted for disk storage being included by discounting the service rate using the percentage of the University's service payment that goes for disk storage. The University of Minnesota system unit formula includes charges for memory use, input/output, and other factors that are included in North Carolina's all-inclusive rate. The average (across all MSCI machines) percent of the University's system unit charge that is actually related to the central processing unit is 86.3 percent.

Using the assumptions detailed above we calculate that, at North Carolina, a roughly comparable rate to the University of Minnesota's would be about $122 per service unit. Other factors pertinent to supercomputing in North Carolina include the state's high speed network which makes transferring information within the state much faster. NCSC employs 11 full-time equivalent staff in scientific support and training and eight staff in graphics and visualization support. Another limiting factor is that North Carolina's Y/MP computer does not allow computation of computer jobs requiring more than 64 megawords of memory.[19]

San Diego Supercomputer Center is an National Science Foundation (NSF) funded center that provides high performance computer services to NSF funded researchers, and to academic and industrial affiliates. San Diego also uses CPU clock hours for its service unit charges but it also has a priority charge that is multiplied times the CPU time to determine the charge. Interactive and high priority jobs are charged 2.0 times as much, high priority jobs 1.5 times, normal priority 1.0, and deferred priority at between .2 and .5 times as much depending on memory use. In addition, there are batch queues for large memory and large disk usage that have priority weightings of 2.0, 1.8, 1.6, and 1.5. Interactive use is limited to 12 megawords of memory and 20 CPU minutes, so almost all production computer jobs use the batch interface to the computer.

According to the deputy director, San Diego currently charges academic affiliates $167 per Cray Y/MP C-90 hour. Commercial customer rates are higher and vary depending on the level of support the industrial affiliate needs to solve its computing problem. Dividing the $167 per hour rate by a factor reflecting the relative speed of the two computers gives one a roughly comparable rate of $49.70.[20] Calculating a rate more comparable to the University's requires assumptions about how much of the usage would be at what priority level. Our rough approximation is that allocating the University's usage across the different priority levels and pri-

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18 The University's service unit billing formula uses a Cray X/MP speed as a factor of one. A Cray Y/MP is faster. We used the 100x100 single processor Linpack benchmark to calculate the speed difference between the X/MP and Y/MP. According to Jack Dongarra, a benchmarking expert at Oak Ridge National Laboratories, if one has to pick one number, this benchmark is probably representative of the speed difference between the two machines. The Cray Y/MP calculated this benchmark 1.33 times faster then the Cray X/MP.

19 MSCI reports that memory costs represent a substantial part (in some cases the largest single element) of supercomputer system expense. Services on large memory systems are, therefore, generally more valuable.

20 This adjusts the rate by the rate factor of 3.36 for the C-90 included in the restated University contract.

ority queues would raise this rate somewhat. In addition, there are charges for disk storage that would be incurred. As we have noted elsewhere, the University will pay a portion of its service payment for disk storage at MSCI. Making these adjustments would likely raise the effective rate to between $50 and $75 dollars per service unit.

Like North Carolina, San Diego's cost structure is different than MSCI's, and it enjoys funding from the National Science Foundation. San Diego is connected to the national backbone high speed network allowing faster transfer of information between sites. It has from 125 to 130 employees, about 100 of whom are researchers that give 25 to 50 percent of their time to assisting other users in their fields. SDSC also has a graphics and visualization group of 18 personnel. Another limiting factor is that San Diego's C-90 only has 128 megawords of memory, so some of the large simulations run at MSCI would not be possible to run there.

The National Center for Atmospheric Research, Scientific Computing Division (NCAR) provides supercomputing resources to atmospheric and oceanic researchers throughout the country. NCAR has a staff of 100 full-time-equivalent employees and a budget of $13.9 million in fiscal year 1993. NCAR's General Accounting Unit (GAU) charging factor on its Cray Y/MP 8/64 is more like MSCI's. There are charges for CPU hours, input/output, memory residency, and average memory use. NCAR also has a priority surcharge of 2.0 for interactive sessions, 1.5 for premium queue, 1.0 for regular, .5 for economy, and .3 for standby. Interactive sessions are restricted to 20 CPU minutes and 16 megawords of memory. NCAR charges a rate of $240 per GAU which fully amortizes its capital and operating costs. Figure 2 shows the costs at NCAR and the University of Minnesota of a comparable computer job run at different memory usage levels.

Figure 2: U. of M. Service Rates Compared to NCAR 1993
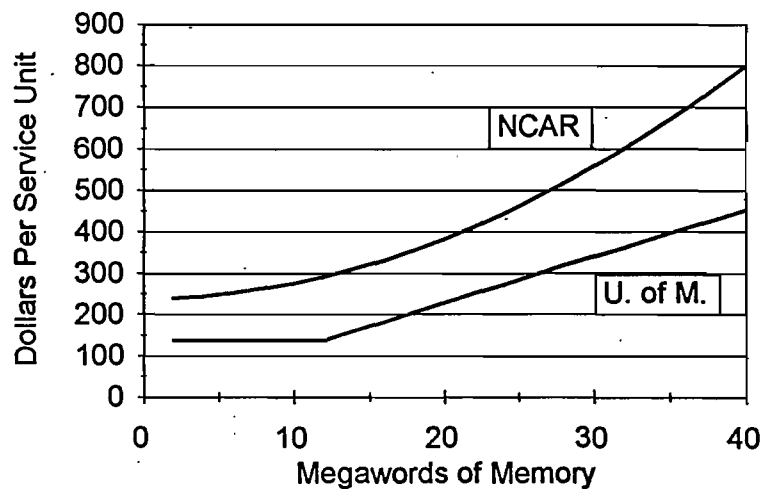
Like the other two centers discussed, NCAR's rate structure is different because of the special purposes it serves in the computing world. It has an emphasis on graphics with nine full-time staff working on using graphics to organize large amounts of information on weather and climate research topics. It also works with organizing and maintaining large datasets of oceanic and climate data for use by the national research community. It is also a "backbone node" on the National Science Foundation high speed network. These factors lead it to employ relatively more technical support staff than MSCI. Also, none of the computers at NCAR can run the large memory computer simulations currently possible at MSCI.

Discussion of Other Centers' Rates

The University's service rate is competitive with other centers.

We found that the rates at other different types of supercomputing centers were in the range of $50 to $240 per service unit. The University of Minnesota's current guaranteed contract rate is very competitive within that range, and, depending on how one values the "gifted" computer time, the effective rate approaches the low end of that range. Given the imprecision of these comparisons, we conclude that the University's rates are in the same range as rates available elsewhere. However, as we have noted several times, these comparisons are somewhat misleading because a significant portion of what one pays for at other centers and at MSCI is services and the cost structure and amount and type of service provided varies from center to center.

What Additional Services Does MSCI Provide Besides Access to Computing Cycles?

When purchasing supercomputing resources, universities or commercial entities generally receive access to the computer, storage of programs and data on the disk and tape storage system, access to software, and routine and expert help in using the computer to solve scientific problems of different types. Almost all of our discussion to this point has focused on the effective service rates for the raw computer "cycles" of the central processing unit (CPU). Focusing on the CPU aspect of the service rate has led us to the general conclusion that the University was currently paying lower rates than commercial customers and receiving adequate value for the service payments it makes to MSCI. In fact, from our examination, we believe University of Minnesota researchers have access to as many computer "cycles" as any other University in the country.

The relationship between the University and commercial customers is mutually beneficial.

However, certain aspects of the service provided by MSCI to the University are intangible and difficult to quantify. It is quite clear that MSCI sells largely interactive access to its commercial customers and largely batch access to the University. The relationship between the University and commercial customers is a symbiotic one: the University receives the unused time on the computers, which has allowed it to use large portions of the hardware resource, but the tradeoff for the University has been that commercial customers receive priority in terms of interactive access to the computers. Because the University fees are fixed and paid at the beginning

of the year in a lump sum, MSCI has no incentive to grant University requests that cost money, no matter how beneficial they might be to the research program of the University. University researchers have had long standing, and, in our view, legitimate, complaints about lack of access to disk storage, software support, and technical support especially for graphics and visualization.[21] Many University researchers clearly lack confidence in the management of the Center to provide them good service. On the other hand, University researchers can sometimes be overly demanding since they are not directly responsible for the finances of operating the supercomputer.

We believe some problems have been caused by vague contract language regarding what the University is purchasing from MSCI. For example, when the contract was extended for four years in July 1992, the University agreed to pay minimum charges of $8 million per year and MSCI agreed to charge the University rates that would result in "the University being provided with access to substantially two times (or more) the computational processing capability ..." than the previous contract agreement. Although not part of the actual contract, University researchers also believed that MSCI had agreed that there would be equivalent interactive limits and equivalent access to batch queues, memory, disk, and support as is afforded to comparable and smaller commercial clients. MSCI officials say this was not agreed to. Partially as a result, there has been tension associated with implementing the new contract. In any event, it was unclear exactly what "substantially two times more" computer processing capability amounted to, and the contract did not specify what in the way of services, software, support, disk storage, and other services that the University was buying for its lump sum payment.

As one researcher told us: "High level discussions between the University and the Center always focus on the amount of the payment, whereas no attention is given to the amount of services to be delivered. The researchers are then informed by mid-level officers at the Center what they have decided we will receive in return. This information process is sometimes referred to as 'negotiations', but since the money has already been handed over this is totally misleading." The University official who conducted the "negotiations" agreed that sometimes they were conducted after the amount of money had been agreed to, and that in some cases MSCI made "unilateral determinations of what we were to receive in one or another area of resource delivery."

The 1992 contract has been made more specific.

The 1992 contract remained vague, but in recent months University officials, MSCI board members, and Center management have specified in much more detail what the University is guaranteed to receive under the contract terms.

There have been several service areas where the University researchers have historically had complaints. The foremost is probably access to sufficient disk storage services. Some of the University researchers' supercomputing research generates large amounts of data. There have been many times, according to University researchers, that their computer jobs would not run because there was insufficient disk storage space remaining either in the temporary disk working area

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21 Although graphics support for the Institute has been noted as needing improvement, some researchers have access to state of the art graphics at the AHPRC.

used when computer jobs are running or on the University's disk quota. As part of the specification of the new contract, MSCI and the University have agreed to raise the disk storage limits from 64 to 100 gigabytes and to provide an additional 150 gigabytes of automated fast tape storage for University users.

Another area of concern has been technical support for University computer users. Two of MSCI's support personnel worked primarily on University technical support and graphics support. In addition, MSCI runs a help line telephone support service (staffed by two full-time-equivalent positions) that is used primarily by University users (in the period we reviewed, over 90 percent of the calls were from the University). Some other technical support is provided to University users, but the focus of the technical support has been largely on the commercial customers and on system enhancements that benefit all users. Little support for University researchers' graphics and visualization needs has been provided by the Center, other than that provided by the one dedicated position.

Because of a perceived lack of technical support for University users, the Supercomputer Institute has spent funds on technical support from its budget for the academic program. It employs additional staff to provide technical support and also purchases and maintains equipment for researchers to use to access the supercomputers. MSCI owned equipment is not generally available to University researchers. The Institute also purchases research software for use by researchers. The Institute spent $215 thousand in fiscal year 1992, $247 thousand in fiscal year 1993, and has spent and budgeted $217 thousand in fiscal year 1994 on technical support, software, and computer equipment. MSCI also purchases some software for University users, but has not agreed to purchase some packages that were needed by researchers. MSCI notes that remote users of other supercomputer centers also incur some of these expenses. However, other centers we reviewed all provided technical support, software, and equipment for on-site users like the University of Minnesota researchers.

As part of the specification of the University's current contract, the two positions that were formerly employed by MSCI to support the University have been moved to the University payroll, and the funds to support the positions have been subtracted from the contract amount. In addition, the University will receive 320 hours per month of support for projects defined by the University. MSCI will also spend up to $35,000 for software determined by University researchers.

Discussion of Services Provided

University researchers are largely satisfied with how MSCI actually operates the computer, and they generally have praise for the efforts of individual technical staff of the Center. However, over the past several years, researchers have numerous complaints mostly revolving around a lack of communication and cooperation from MSCI's management. These complaints have been noted in several previous reviews.[22] In our view, as it is currently organized, the fundamental reason for the

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[22] See Report of the External Review Panel on the University of Minnesota Supercomputing Institute, August 18, 1993, Report of the Task Force on Supercomputing, May 4, 1993, and Minnesota Supercomputer Center, Inc. External Review, KPMG Peat Marwick, January 1994.

Center to exist is to serve the University and its researchers. Not every wish of the researchers should necessarily be granted, but their needs have to be given high priority. In our view, the nature and structure of the University's contract with MSCI contributed to the problem. A contract which does not clearly specify the services to be provided for service payments will always generate disputes. As noted earlier, the University pays in a lump sum at the beginning of a contract year, but because the contract language was vague, particularly about services other than computer time, in some cases it only received the services that MSCI decided to provide.

Through the efforts of the Chairman of the Supercomputer Center Board, and University Senior Vice President Bob Erickson, and Vice President for Research Anne Peterson the contract has been made somewhat more specific. There is now enough specificity in the contract to provide some assurance that the University will get an acceptable level of service as well as access to computing cycles for us to be comfortable saying that the University is gettting adequate value for its service payments to MSCI.

In our view, the University is getting adequate value from MSCI.

Minnesota **Supercomputer** Center, Inc.

June 9, 1994

Mr. James R. Nobles
Legislative Auditor
State of Minnesota
Centennial Building
St. Paul, Minnesota 55155

Dear Jim:

This letter serves as the written response of Minnesota Supercomputer Center, Inc. ("MSCI") to the final report of the Program Evaluation Division of your office regarding MSCI (the "Report"), which response you requested in your letter of June 6, 1994 enclosing the Report.

We are pleased to read your conclusions which substantiate the fact that the University receives good value for the service payments it makes to MSCI. Equally important, the Report confirms that MSCI has been successful at providing University of Minnesota researchers with an unsurpassed level of supercomputing capability in relation to other universities in the country. The success which MSCI has had in actively pursuing academic, governmental, and commercial opportunities has allowed it to leverage the funding provided by the State to the University into far more supercomputing resources than those funds could independently support. We are gratified that the Report reflects those conclusions. We also appreciate that your office has respected the non-public nature of the information it reviewed in producing the Report.

Lost in much of the discussion over the past few years has been the fact of the uniquely sophisticated, plentiful, and strategically valuable resources that have been made available to the University user community by MSCI. These resources are available because of long-term adherence to principles of sound business management which strike a balance between the desires of customers and the constraints of financial viability. Good service is an important part of this value. MSCI recently completed an extensive survey of all University of Minnesota users of its services. The results received show that users are, in roughly equal measure, either "very satisfied" or "satisfied" with the overall quality of the services the company provides, with no response to that question indicating dissatisfaction.

We appreciate the positive findings of the Report. The company is proud of the world-class benefits and results which it provides to the University and the State. It believes it has few, if any, rivals and is unique in its ability to aggressively pursue and capitalize on opportunities in running a successful high-performance computing services business. Now the focus must be on the future, with the intention of preserving the value of the resources which have been assembled and leveraging them to maintain the national leadership in this field which MSCI and the University each currently enjoys.

Thank you for the opportunity to have this response placed in the Report.

Sincerely,

Stephen R. Pflaum
Chair of the Board, MSCI

cc: Board of Directors, MSCI

Recent Program Evaluations

Evaluation reports can be obtained free of charge from the Program Evaluation Division, Centennial Office Building, First Floor South, Saint Paul, Minnesota 55155, 612/296-4708. A complete list of reports issued is available upon request.