University of
Waterloo Research Institute

CANUNET

Inter-University Computer Service
Traffic Study

CANUNET

INTER-UNIVERSITY COMPUTER SERVICE

TRAFFIC STUDY

Prepared by

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under the conditions of a
temporary appointment to the
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of Waterloo

For the

Utilization Sub-Committee
CANUNET Advisory Committee

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TRANSMITTAL LETTER AND SUMMARY

February 28, 1973.

Dr. D.D. Cowan, Chairman
Utilization Sub-Committee
CANUNET Advisory Committee
Department of Applied
Analysis and Computer Science
University of Waterloo
Waterloo, Ontario.

Dear Dr. Cowan:

With this letter we submit our report entitled "CANUNET - Inter-University Computer Services Traffic Study" which describes the work carried out over the past nine months under a contract with the Waterloo Research Institute and based on funding from the Department of Communications, Ottawa. The report is divided into six sections which are summarized as follows:

INTRODUCTION

The CANUNET Advisory Committee report of March, 1972, entitled "A Proposal for a Canadian University Computer Network", recommended that a detailed study be undertaken of potential network applications to form the basis for a more quantitative forecast of network traffic.

Following from this recommendation, and with Department of Communications financial support Mr. T.A. Croil was retained by The University of Waterloo Research Institute on behalf of the CANUNET Utilization Sub-Committee to carry out a more detailed analysis of the potential for inter-university computer services.

The survey approach adopted was to first identify the components of the inter-university computer service market - sellers, buyers, products - and then to estimate the size and growth rate of this market.

THE CURRENT MARKET FOR INTER-UNIVERSITY COMPUTING SERVICES

A questionnaire was sent to 45 Canadian universities to determine the current supply and demand for on-line computing services. The conclusions drawn from an analysis of the survey results were as follows:

* A majority of respondents have general computer service needs they cannot satisfy with their existing facilities and staff.

* Some university needs for enhanced computer services are partially satisfied by on-line services provided by other universities.

* The total value of current inter-university services within regions is less than 1% of the total expenditure on computing services at Canadian universities; the value of services between regions is insignificant.

* Expansion of on-line services within regions could satisfy most of the current computing of universities.

POTENTIAL GROWTH AREAS

Growth in inter-university computing is expected to occur in the provision of both generalized and specialized services. The greatest growth in generalized services should result from smaller universities meeting their general computing needs through terminals connected to computers at larger universities, similar to Trent's present arrangements. Major opportunities for growth in specialized services, defined as those which provide the remote user with access to either specific applications services or facilities dedicated to specific computational functions, appear to exist in centralized administrative and bibliographic data bank services.

FACTORS AFFECTING GROWTH

There are a number of factors which will have a major influence on the rate and direction of growth in inter-university computing services.

* Universities in their current financial situation may be interested in sharing resources.

* There are limited funds available to computer users for off-campus computing.

* Universities have little experience in marketing computer services.

* Support for remote users will be a new and important requirement for successful off-campus services.

* Communications costs make on-line computer services at some remote locations too expensive.

* Data banks are generally still in the early stages of development.

* Networks are planned or under development which will influence the growth patterns of inter-university computing services.

All these factors, except for the first one, will tend to impede the growth of network services unless some significant changes are made in the organizational and administrative framework in which computing services are currently offered.

Consideration of these factors, together with the current market and opportunities for growth in inter-university computer services, form the basis for the forecast of CANUNET traffic.

FORECAST OF INTER-UNIVERSITY TRAFFIC

Both an optimistic and a pessimistic forecast are presented to reflect the uncertainty which exists about the future development of the inter-university computer service market. The pessimistic forecast is based on inter-university traffic continuing to account for about 1% of the total university expenditure on computing, even if it is not possible to remove the major barriers to growth. Assuming that the cost of computing in universities will grow at 10% per annum compounded, then the pessimistic forecast is for a 10% growth rate in inter-university services. It is expected that this growth will come primarily from an expansion of generalized services provided by larger universities to smaller ones. The optimistic forecast is based on achieving an annual compound growth rate equivalent to that projected for the data communications industry in general, or almost 20% per annum. Development of new unique services from data banks or specialized computational facilities is expected to account for the difference between the two forecasts.

Based on communications representing on average 20% of the cost of inter-university services, the optimistic forecast indicates that communications services, as a component of university computer expenditure, could reach $2.66 million per year by 1990.

CONCLUSION

It has been estimated elsewhere that an 18 node CANUNET with 50 Kbps lines would cost between $2.2 and $3.3 million and with 9.6 Kbps lines between $1.5 and $1.9 million per year to operate. Assuming that the optimistic forecast of communications usage is achieved, and that it is all on CANUNET, then, based on these network operating cost estimates, it is possible that CANUNET could be running on an annual cost recovery basis with 9.6 Kbps lines between 1986 and 1988, and with 50 Kbps lines between 1989 and 1991.

We have enjoyed this opportunity to participate in the CANUNET project and trust that this traffic study will provide useful additional data for continuing examination of the network's feasibility. It is also our hope, if it is decided to proceed with the project, that this report will be of use in formulating a basic strategy for the successful implementation and operation of a Canadian University Computer Network.

Yours truly,

J.A. Croil

cc. Waterloo Research Institute
Department of Communications, Ottawa.

1 INTRODUCTION

There are three basic issues relating to the development and operation of university computer networks:

* Are computer networks technically feasible?

  This issue is really already resolved. There are operational university networks in the U.S. and U.K., and the necessary skills and technology are available in Canada to build similar networks.

* Is there a suitable administrative framework for university network operation which will ensure that users get efficient and effective services?

  Proper coordination and management of a network will be a complex job and will be a key requirement for successful operation.

* Is there a potential market for university network services which will support the cost of operating the network?

  If the universities are to build a network as a technical research project and then hand it over to another organization for its use, then this is not a relevant issue. However, if universities are to build a network for their own use, it is an important issue. For only by identifying a long term need for the network, will it be possible to develop the on-going commitment necessary to make it work.

Organizations building or operating university networks in other parts of the world have not yet fully resolved the last two issues. In fact, in some cases, efforts have focussed primarily on the technological aspects, and the difficult problems relating to the effective and efficient use of the network are only now being identified.

The approach to CANUNET has been somewhat different. From the outset it was felt that all three issues must be addressed as part of any proposal for CANUNET, because of their interrelationships and ultimate impact on the success of such a project.

This report deals specifically with the potential market issue by attempting to forecast the value of inter-university computing services in Canada over the next twenty years. The background and approach to this project are as follows :

1.1. Background

If CANUNET is to be a viable operational network, then clearly some estimate of the traffic, its value and distribution, are required for the financial planning of its design, development and operation.

This need was recognized by the CANUNET Advisory Committee in November 1971 when it established four sub-committees, one of which was assigned the task of studying network utilization. The Utilization Sub-Committee's first report formed part of "A Proposal for a Canadian University Computer Network" prepared

by the CANUNET Advisory Committee for the Department of Communications, Ottawa in March 1972. This report was presented in two parts: the first part examined the problems inherent in implementing various applications on a computer network, and the second part surveyed the specialized computer applications presently under active development in Canadian universities. In most cases these applications were identified in very general terms, and a detailed study was recommended to form the basis for a more quantitative forecast of network traffic.

Following from this recommendation, and with Department of Communications financial support provided through the Waterloo Research Institute, the Utilization Sub-Committee was asked to carry out a more detailed analysis of the potential for inter-university computer services. Mr. T.A. Croil of T.A. Croil Associates was subsequently retained by the sub-committee, commencing in May 1972, to carry out the necessary surveys and interviews and to develop a forecast of potential network traffic.

1.2 Study Approach

The study was planned in three steps: preparation, survey and analysis.

a. Preparation:

The first step was a preparatory one designed to ensure that the approach to developing the forecast was well thought out and tested prior to the survey. This step

included appointment of provincial representatives to provide local liaison during the survey, a survey of foreign experience, and the development and pre-testing of a questionnaire.

* Representatives were appointed primarily from the CANUNET Advisory Committee membership, to represent the universities in each province during the course of this study. (Appendix 1.1)

* Foreign experience in network forecasting was found to be very limited. There were no traffic studies preceding the commitment of funds and the construction of the two major British university networks at Bristol and Edinburgh. On the continent, the only study identified was a general one on data communications conducted by IBM Zurich and based on salesman's forecasts. In discussions with personnel directly associated with the ARPA and MERIT networks in the U.S., it was determined that no traffic studies had been conducted prior to construction of either network. The National Science Foundation, which is becoming increasingly interested in network development, recognizes the need for such forecasts but believes an operating pilot network is necessary to provide the basic forecast data.

* A questionnaire was prepared to be sent to all data centre directors, pre-tested by the Provincial Representatives,

and commented on by DOC and university personnel at Waterloo, York and Toronto.

b. Survey:

The survey approach adopted in the study was to first identify the components of the inter-university computer service market - sellers, buyers and products - and then to estimate the size and growth rate of this market. Two surveys were conducted to identify the market components: the first to establish for each university in Canada its potential as both a buyer and seller of generalized computing services, and its current buying and selling habits; the second to establish, with the help of key workers in the field, the market potential for specialized services, many of which are not yet generally available at universities, but which could, in time, be substantial generators of inter-university traffic.

c. Analysis:

In this last step the results of the surveys were analysed and an assessment made of the factors affecting growth. This data and information formed the basis for a forecast of the growth in the inter-university computing service market.

Following from this approach, the body of the report is organized into four main sections. Section 2 describes the current market for inter-university services; Section 3 identifies the areas of potential market growth in terms of both generalized and specialized services; Section 4

describes the major factors which may encourage or impede growth in the market; and, based on the foregoing, Section 5 contains a forecast of inter-university computing to 1990.

2 THE CURRENT MARKET FOR INTER-UNIVERSITY COMPUTING SERVICES

In order to help establish a basis for making projections of future network traffic, a survey was carried out to determine the current supply and demand for on-line computing services at universities. A questionnaire was developed for this purpose and sent to the Directors of Computer Centres at 45 Canadian universities. Appendix 2.1 contains a copy of the questionnaire and a list of the directors to whom it was sent. Questionnaires were completed and returned by 40 universities with answers based primarily on services offered by the main computer centres. Other significant university computer centres were reported and are listed in Appendix 2.2. The conclusions drawn from an analysis of the survey results are as follows :

2.1. A majority of respondents have general computer service needs they cannot satisfy with their existing facilities and staff.

a. 34 of the universities responding indicated that they were unable to satisfy all their on-campus computing needs. The distribution of these universities indicates that this is a common problem in all regions.

Region	Total Universities	Total Respondents	Universities Reporting Unsatisfied Needs
Atlantic	10	8	7
Quebec	7	7	6
Ontario	17	15	14
Prairie	8	7	5
B.C.	3	3	2
	45	40	34

b. In order of priority, the categories of general services needed across the country, as ranked by the universities, are as follows :

- Time-sharing
- Computation software packages (e.g. statistical and mathematical routines)
- Plotting
- Data base management software packages
- Other (e.g. specialized data conversion, back-up, production of documentation)
- Remote batch services
- Graphics
- Administrative services software
- Local batch services
- Education software (e.g. CAL)

In some cases universities are planning to meet high priority needs, such as time-sharing services, in the next twelve months. Appendix 2.3 contains a detailed breakdown of the needs at each university. Of course, because of response time requirements, some of these needs could not be satisifed from remote locations.

c. Respondents reported on the extra resources they would require to provide these additional services. In order of priority they are :

- Software
- Peripherals
- Memory capacity
- Application programs
- Time-sharing facilities
- CPU capacity
- Extra staff

RESOURCES REQUIRED TO MEET UNSATISFIED NEED

EXTRA RESOURCE REQUIREMENT	PRIORITY OF RESOURCE REQUIREMENTS					
	ATLANTIC (5)*	ONTARIO (13)	QUEBEC (4)	PRAIRIE (4)	B.C. (2)	CANADA (27)
COMPUTER CENTRE						
1. CPU Capacity	4	5	4	1		6
2. Memory Capacity	1	5	5	2		4
3. Peripherals	2	2	3	2	2	2
4. Timesharing Facility		3	4	5	2	5
5. RJE Support					4	9
6. Software	5	1	2	2	1	1
7. Application Programs	3	4	1		4	3
8. Staff				3	3	7
9. Staff skills				4	5	8
TERMINALS	NUMBER OF TERMINALS REQUIRED					
1. Timesharing	YES**	125	28	35	12	200
2. RJE	NR	4	NR	2	7	13

* Numbers in brackets indicate number of universities reporting this information.

** Atlantic universities indicated a need but did not specify the number.

NR - Not reported.

- Additional skills
- RJE support

In addition they reported a requirement for 200 teletype compatible terminals and 13 batch terminals which is about a 20% and 25% increase respectively over current figures. It can be seen in Exhibit 2.1, which shows a breakdown by region, that priorities for additional facilities and staff vary across the country.

2.2. Some university needs for enhanced computer services are partially satisfied by on-line services provided by other universities.

21 respondents indicated that they had the capability and capacity to provide on-line services to other universities, and of these 16 reported that they are currently engaged in this activity. The services offered by these universities, the related terminals in use (both on and off campus), and the extra terminals which could be served are shown in Appendix 2.4. From this data, the following estimates were made of terminal distribution across Canada :

Number of Individual Terminals: (TTY, 2741, 2260, etc.)

	In Use	Potential Extra Capacity
Atlantic	21	42
Quebec*	290	290+
Ontario**	409	172
Prairie	199	174
B.C.	132	87
Total	1,051	765+

* Excluding Sherbrooke
**Excluding Western, Ottawa and some of Toronto. The office of Computer Coordination estimate is 500 for all Ontario universities.

Number of Reader Printer Terminals: (CDC 200, 2780, etc.)

	In Use	Potential Extra Capacity
Atlantic	9	9
Quebec	10	20
Ontario*	12	9
Prairie	11	40
B.C.**	6	14
	48	92

* Exluding Western, Ottawa, Waterloo. The office of Computer Coordination estimate is for 25 in all Ontario universities.
** Excluding U.B.C. on-campus terminals.

The major university suppliers and customers for these inter-university services are as follows :

Region	Major Supplier University	Universities & Colleges Receiving Services
Atlantic	Dalhousie	N.S. Tech., St. F. Xavier, Acadia, St. Mary's.
	U.N.B.	Mt. Allison, Moncton, U.N.B. (St. John), St. F. Xavier.
Quebec	Montreal	Laval, McGill, Sherbrooke, Ottawa, Quebec.
	McGill	Loyola, Sir George Williams, and also FRI services to Sherbrooke, Ecole des Hautes Etudes, York, Toronto, McMaster, Western, Manitoba, Sir George Williams.

Region	Major Supplier University	Universities & Colleges Receiving Services
	Laval	Quebec, Sherbrooke, CEGEPS.
	Quebec (UQSS)	Chicoutimi, Rimouski, Trois-Rivières, Montreal, campuses of U. du Québec.
Ontario	Carleton	Ottawa, Trent.
	York	Toronto, McMaster, Ryerson.
	Waterloo	Waterloo Lutheran.
	Toronto	York, Brock, Ottawa, Western.
	Western	York, Toronto.
	Ottawa	Carleton, Queens, St. Lawrence College.
Prairie	Manitoba	Brandon, Winnipeg.
	Saskatoon	Regina.
	Calgary	Lethbridge, Community College.
B.C.	U.B.C.	Simon Fraser, Victoria, Alberta (TRIUMF).

These major suppliers and buyers of computing services are shown on the maps in Figure 2.1 and 2.4 along with the patterns of data traffic which currently exist between them. Additionally these maps illustrate that a majority of universities in each of the 3 eastern regions and B.C. are in reasonable communications distance with each other. This is clearly not true in the Prairie

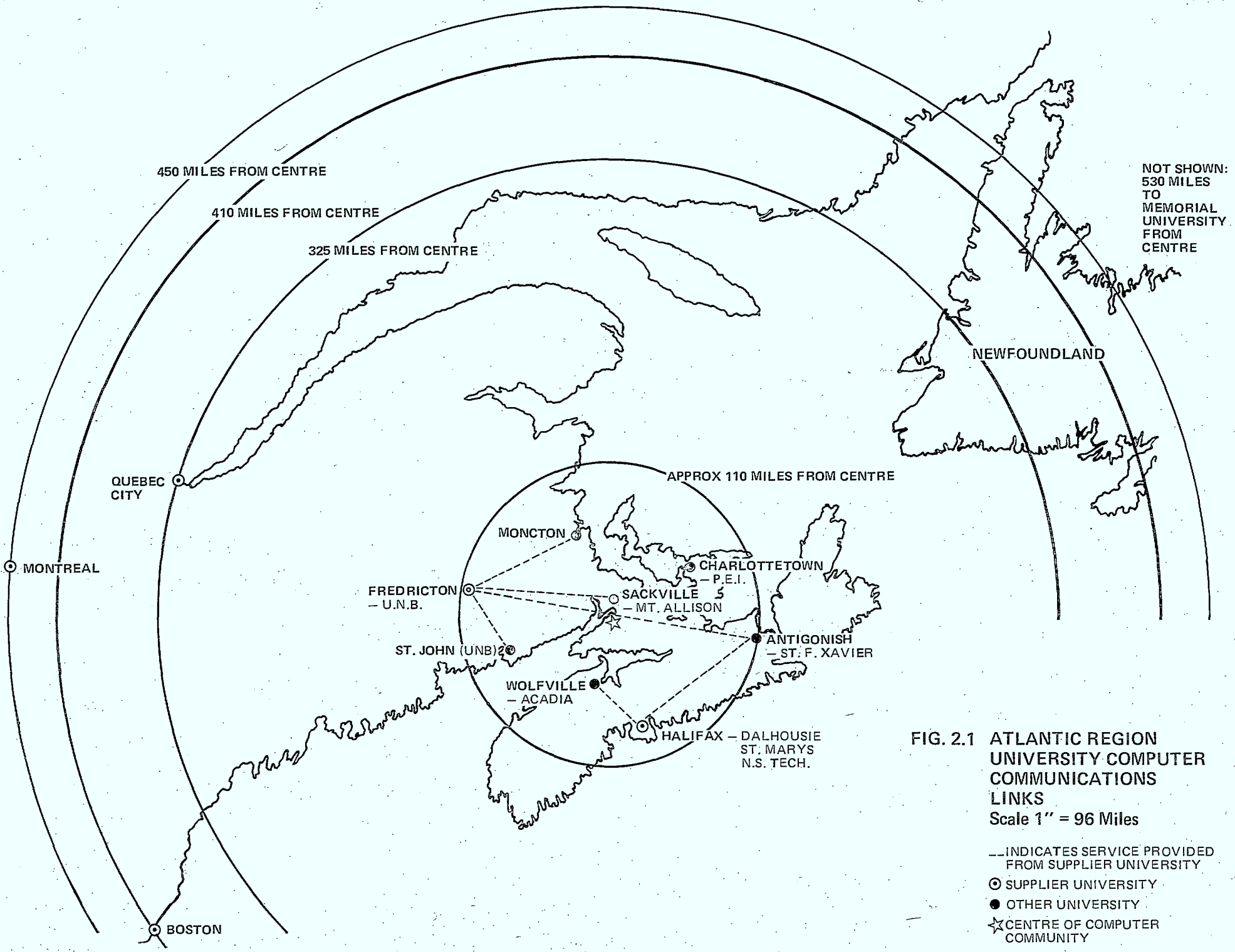


FIG. 2.1 ATLANTIC REGION UNIVERSITY COMPUTER COMMUNICATIONS LINKS
Scale 1" = 96 Miles

—— INDICATES SERVICE PROVIDED FROM SUPPLIER UNIVERSITY

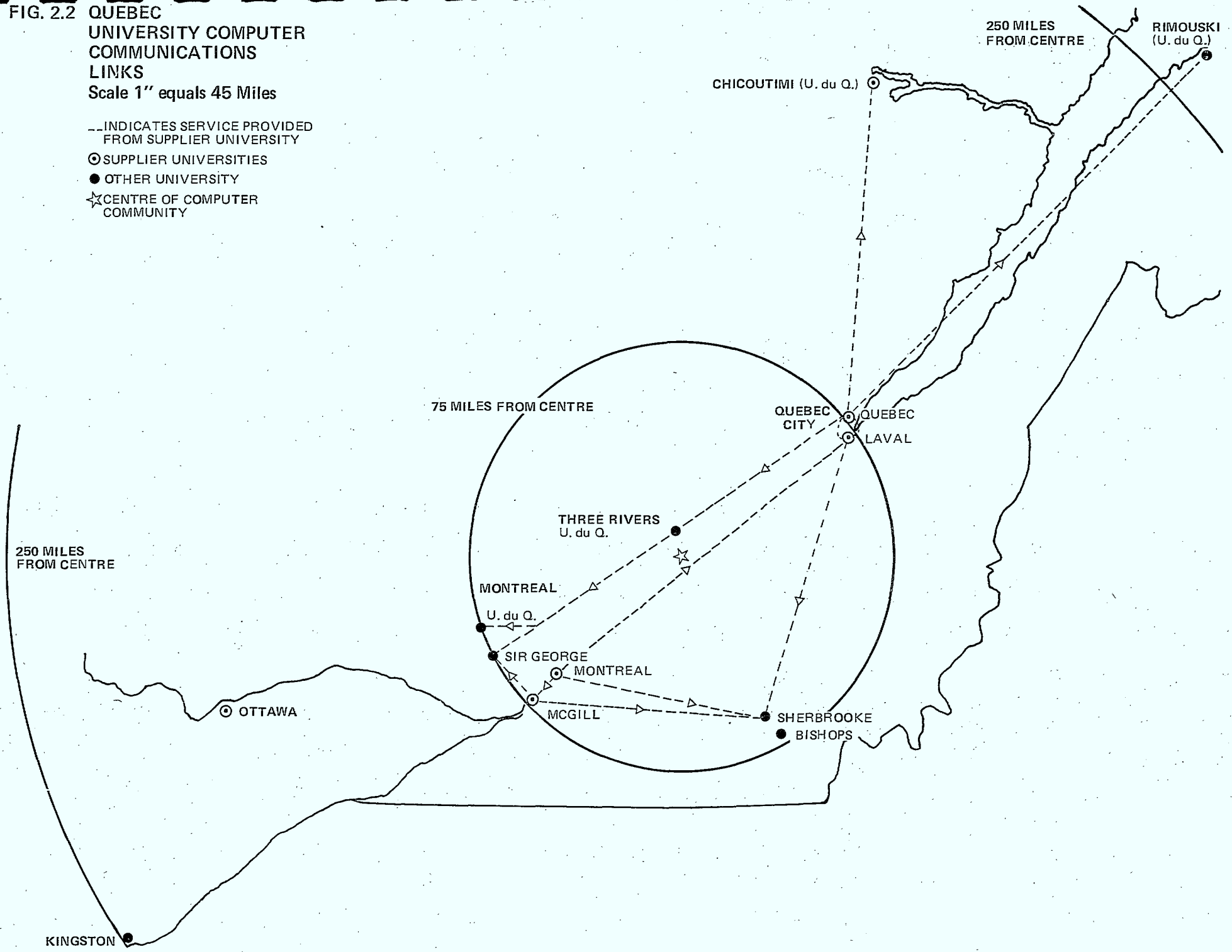
⊙ SUPPLIER UNIVERSITY

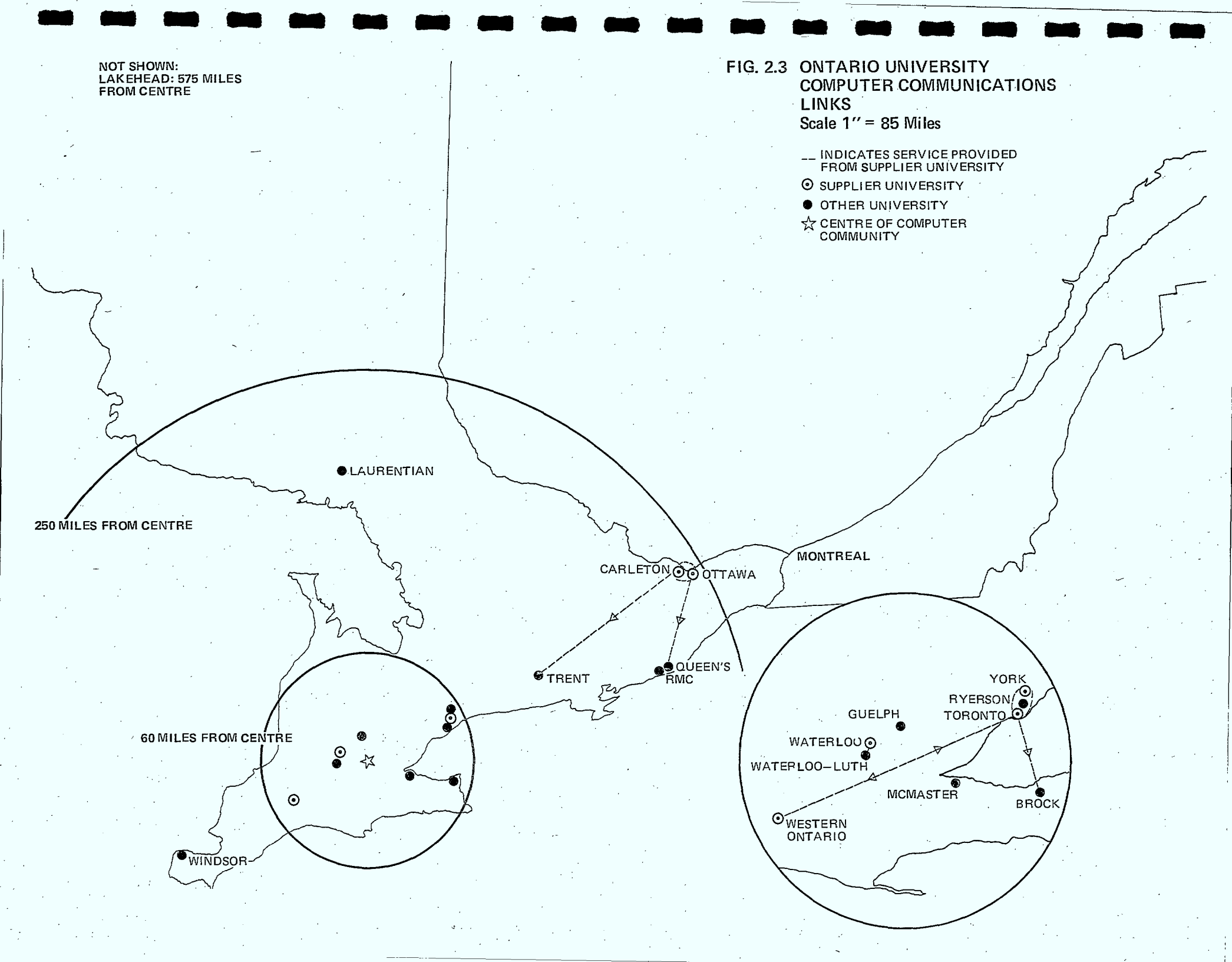
● OTHER UNIVERSITY

☆ CENTRE OF COMPUTER COMMUNITY

FIG. 2.2 QUEBEC UNIVERSITY COMPUTER COMMUNICATIONS LINKS

Scale 1" equals 45 Miles




NOT SHOWN:
LAKEHEAD: 575 MILES
FROM CENTRE
FIG. 2.3 ONTARIO UNIVERSITY
COMPUTER COMMUNICATIONS
LINKS
Scale 1" = 85 Miles
-- INDICATES SERVICE PROVIDED
FROM SUPPLIER UNIVERSITY
SUPPLIER UNIVERSITY
OTHER UNIVERSITY
CENTRE OF COMPUTER
COMMUNITY
LAURENTIAN
250 MILES FROM CENTRE
CARLETON
OTTAWA
MONTREAL
TRENT
QUEEN'S
RMC
60 MILES FROM CENTRE
WINDSOR
YORK
RYERSON
TORONTO
GUELPH
WATERLOO
WATERLOO–LUTH
MCMASTER
BROCK
WESTERN
ONTARIO

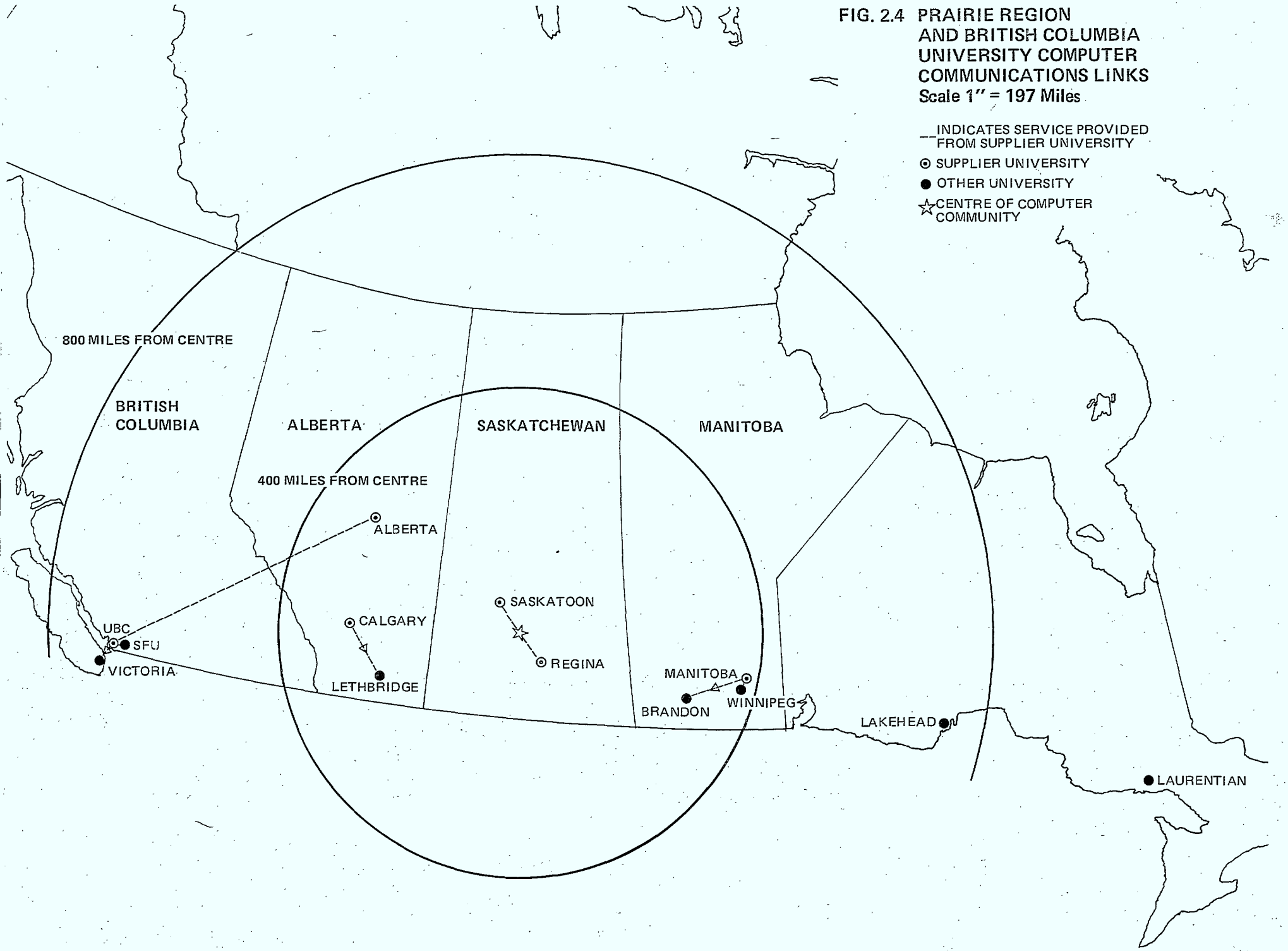


FIG. 2.4 PRAIRIE REGION AND BRITISH COLUMBIA UNIVERSITY COMPUTER COMMUNICATIONS LINKS
Scale 1" = 197 Miles

__ INDICATES SERVICE PROVIDED FROM SUPPLIER UNIVERSITY
⊙ SUPPLIER UNIVERSITY
● OTHER UNIVERSITY
☆ CENTRE OF COMPUTER COMMUNITY

region and probably accounts in part for the limited inter-university traffic in that area.

It can also be seen from these maps that on-line services are normally provided to universities in the same region.

2.3. <u>The total value of current inter-university services within regions is less than 1% of the total expenditure on computing services at Canadian universities; the value of services between regions is insignificant</u>.

The total expenditure on computing services (staff and facilities) at Canadian universities is estimated to be about $50 million per year. The value of inter-university computing services reported by the respondents for 1971-72 is $315,250 or less than 1% of the total. When consideration is given to unreported revenues and communications costs, subsidized services, etc. it is probably reasonable to assume a true value of $500,000 for inter-university computing services in 1971-72. This does not include internal communications costs within universities.

Appendix 2.5, which contains the detailed analysis of reported revenues and expenditures from off campus services, is summarized as follows :

Region	Estimated Value of Inter-University Computing Services 1971-72
Atlantic	72,000
Quebec	55,250
Ontario	108,000
Prairie	10,500
B.C.	69,500
	$315,250

Of this amount only a small fraction is accounted for by inter-regional services such as the FRI service from McGill to Manitoba and Ontario.

2.4. Expansion of on-line services within regions could satisfy most of the current needs of universities.

In comparing unsatisfied needs with service offerings (Appendix 2.3 and 2.4) it is apparent that most of the needs could be satisfied within the same region either with existing or planned facilities.

In summary, most universities have unsatisfied user requirements for computing services which may be resulting in reduced effectiveness of research or the inefficient use of other resources. Some of these user requirements have been met by buying services from other universities. However, the current expenditure on inter-university computing services is very small compared to the total expenditure on computing at Canadian universities. Moreover the data traffic

generated by these services is largely within regions, as there is at least one university in each region which can satisfy most regional needs.

While the current market for inter-university services is quite small, there are indications that it will grow as the benefits of shared resources become more evident. Certainly if the services received from outside the university community could be provided by the community itself, this factor alone would add substantially to inter-university trade. But in addition to this possibility there are a number of areas of both generalized and specialized services where growth is expected to occur. The next section describes the major generalized and specialized inter-university computing services and identifies those areas of potential growth.

3 POTENTIAL GROWTH AREAS

Growth in inter-university computing is expected to occur in the provision of both generalized and specialized services. Within these two categories there are a number of applications which appear to have the greatest potential for growth over the next 10 to 20 years.

3.1 Generalized Services.

Generalized services are defined as those which provide the user with tools such as a general purpose computer, systems software, general computational routines and programming assistance if necessary, which he can use to program and solve his problems. These are the types of services which universities have the greatest identified need for and most of them in the past have concentrated on improving and expanding them. Included in this group of services are:

- computer capacity and power - for large computational jobs.
- compilers such as WATFOR, FORTRAN, COBOL, APL, ALGOL, etc.
- data handling and formating routines.
- mathematical and statistical routines.
- file maintenance routines.
- time-sharing and multi-programming operating systems.
- RJE and CRJE terminal support.
- information retrieval software.
- plotting.
- computer graphics.

Most universities provide these services from an on-campus computer. Nevertheless there are reported deficiencies in the generalized services some of them can offer, as listed on page 2.2, and to the extent that they will be unable to satisfy their own needs locally, these are areas where growth is expected to occur in inter-university services.

However, the greatest growth in generalized inter-university services is expected to occur as a result of the rationalization of computing resources. For example, if 15 or so smaller universities gave up their computers now and were served by terminals connected to larger university computer centres, then it is estimated that there could be a resultant $2,000,000 per year of generalized inter-university computing services. This estimate is based on the expenditures of Trent University which is currently buying all its computer services from off-campus sources. However, this process of rationalization is dependent on the removal of political and economic barriers which currently make it difficult for one university to give up its computer and buy its services from another.

Load leveling, although a possible generator of inter-university traffic, is not considered to be a major factor in future developments. As most traffic is expected to be regional traffic, any advantage from time zone differences may only be marginal. More important, however, are the file sharing problems and operating system differences which currently make load leveling a questionable concept.

3.2 Specialized Services.

Specialized services are defined as those which provide the remote user with access to either specific applications services or facilities dedicated to specific computational functions. The areas in which specialized services were identified as being potential generators of inter-university computer service traffic are :

- Education
- Health
- Law
- Economics
- Social Science
- Physical Science
- Library
- Specialized computer facilities.

These areas of specialization which were dealt with in some detail in Appendix K of the Proposal for a Canadian University Computer Network, March 1972, are discussed here only in terms of their potential for increasing the size of the inter-university computer service market.

* Education

There are two specialized services in the educational field which could increase inter-university computer activity, namely administration and computer assisted learning (CAL).

In the next ten years, the greatest potential for the computer education is likely to be in administrative

applications [1], although this is not a unanimous opinion [2]. In 1975 the post-secondary institutions are forecast to spend about $250 million on administration.

In order to rationalize the development of administrative computer systems and to keep the expenditure on administration in check, several projects are underway which envisage joint development and use of administrative systems. The most notable is the CESIGU (Comité d'elaboration d'un système d'informatique et de gestion des universités) project. CESIGU is a joint project by the universities of Quebec to develop an administrative group of programs for such functions as financial accounting, space inventory and student and staff information systems. When parts of the project are operating, cooperating universities will start to use the system on their own computer or, possibly, on other university computers via a computer communications network. As reported in Branching Out, even a conservative estimate of 5% of the post-secondary administrative budget spent on computer services could amount to $12.5 million by 1975. Thus this type of project, which may be duplicated in other provinces, could add substantially to inter-university computer service activity if the network approach is taken.

[1] Branching Out, Vol II p. 110, Department of Communication, Ottawa, 1972.

[2] A Response to Branching Out, Committee on Computer Services, Council of Ontario Universities, November 1972.

CAL as an area for potential growth in inter-university computing is less certain. At present NRC, in conjunction with some universities, is developing a common CAL author language which, if widely adopted, will allow a free exchange of course material between educational institutions in Canada. During the development phase, which is seen to continue until 1980, there is expected to be a limited amount of inter-university traffic between those universities engaged in the project. Once the language is available for use there will be a major effort required to produce CAL courses. As these courses will be machine independent it is expected that they will be offered from local or regional centres. Current estimates indicate that the establishment of about 40 dedicated centres, similar to the PLATO project in Illinois, would be required in Canada to deliver 20% of the course material at the post secondary level in 1975 [3]. Even if these centres were located at universities, it is unlikely that they would generate any substantial inter-university computer traffic. However, they could generate a substantial amount of local traffic which might benefit from a network.

* Health

There are two areas of health care which will have a continuing and growing need for computer processing -

[3] Ibid, p. 112.

medical research and hospitals. The use of computers for medical research is a relatively new development, and many of the applications require real-time responses which necessitate local computers. While hospitals are potentially big users of computers, there are only one or two which could be considered integral parts of the university community, and, even if they were interdependent for computer services, could not be expected to produce substantial inter-university computer traffic. In summary the health care field is not seen to be a major area for potential growth in the inter-university computer service market.

* Law

Terminal based legal services are currently being offered from computer data banks at Queen's University and the University of Montreal. The Queen's approach is to have the lawyer or student use the terminal while the Montreal approach, which began in the same way, has reverted to providing telephone and mail service to the lawyer from a campus terminal operated by an expert. This change in approach at Montreal occurred as a result of some rather unsuccessful experiments with lawyers making direct use of terminals. However, workers on both projects agree that substantial long term growth in the market for these services will depend on extending them to lawyers' offices.

Inter-university traffic is expected to be somewhat limited, possibly to the extent of one teletype terminal equivalent per university Law Library on average, and, legal services are therefore not considered an area of major potential growth.

* Economics

The Financial Research Institute (FRI) in Montreal provides terminal based financial services from a data bank connected to a McGill computer for 34 supporting members (banks, brokerage houses, etc.). In addition FRI provides its services free of charge (except for computer time and communications) to 8 universities from Winnipeg to Sherbrooke.

On the basis of one teletype terminal in each of, say, 30 universities, the potential market value of inter-university computing and communications associated with this service is not likely to exceed $300,000 per annum in the foreseeable future. (It is possible to make a financial forecast in this case because, unlike most of the other specialized services, FRI has been fully operational for some time).

* Social Science

The Institute of Behavioural Research at York University is planning to offer data services beginning this year.

They will begin with batch services and move to full interactive services perhaps by 1980, including both bibliographic searching and analytical routines. The Institute feels that industry rather than universities will be their major market. Because of the relatively slow growth of on-line service offerings, and the questionable university market for them, Social Science services are not expected to make a major contribution to inter-university computing, at least over the next ten years.

* Physical Science

The major users of computers at universities are very often researchers in Chemistry, Physics, Crystallography and Meteorology. Their needs are normally for larger, faster computers and more time on them. As such this group represents a special requirement for computing which might best be satisfied by a dedicated central facility serving these researchers at a number of universities. If such centralized services were developed, then inter-university traffic would follow, but probably only on a regional basis. The probability of centralizing large user services seems sufficiently remote at this time that Physical Science is not considered a major area of potential growth in inter-university computing in the foreseeable future.

* Library

Interactive on-line bibliographic searching and shared cataloguing will likely be one of the major inter-university computer services in the future. Access to information for research is one of the major requirements in all disciplines and services of this kind will be of use to faculty and students at all post-secondary institutions. Unfortunately very little has been done so far in the development of these services, which depend primarily on the establishment of large data banks on library holdings. The 1970-71 Bell Delphi Study suggests that it will be 1980 before there is extensive adoption of such services. Both the National Library and the National Science Library estimates tend to support this forecast.

* Specialized Computer Facilities

Cost effective communications may make the establishment of specialized computer facilities serving a whole region, or the nation, a reality in the near future. Even with existing communications services, the establishment of a national APL centre appears economically attractive. Other specialized centres might offer proprietory software services to all universities or, as was mentioned earlier for Physical Sciences, a computer facility especially configured for a

particular type of computational problem. These centres are certainly possible and would create additional inter-university traffic. However, before they could be considered as a major potential growth area, the mechanisms for dealing with the jurisdictional, organizational and administrative aspects of their establishment and viable operation would need to be clarified.

In summary, many of the areas discussed here may contribute to the growth of inter-university computing as the services develop and become more generally useful. However, the greatest potential for growth is expected to be in the development of common university administrative systems, if the services are offered centrally, and in large central information banks requiring immediate access. In the latter category, bibliographic banks which would be of value to all students and faculty across Canada are expected to be of major importance. The technology is available for the development and use of these banks but many years of work are required to organize the data and convert it to machine readable form. This and some of the other major factors affecting growth in inter-university computer services are discussed at greater length in the next section.

4 FACTORS AFFECTING GROWTH

While the number and variety of new service offerings made available to the university community by its members will certainly affect the growth of this market, there are a number of other factors which will have a major influence on the rate and direction of growth in inter-university computing services. These are as follows :

4.1 Universities may now be interested in sharing resources.

The escalating costs of education and the current downturn in enrollment is making universities increasingly receptive to proposals for the rationalization and sharing of their computer resources with other universities. The support and encouragement of university management for this type of activity should promote the growth and development of inter-university computing services.

4.2 There are limited funds available to computer users for off-campus computing.

Universities provide a computer centre on the campus based on the premise that all staff and students will use it, and that any funds allocated to computing from research grants will be used to support the centre. The facilities of the centre are normally allocated to individual departments who are issued an appropriate number of "computer dollars" to spend at the campus centre. Campus users are therefore generally restricted to use the campus

computer because they are not provided with real funds and they are morally committed to use their research grants to support the campus centre. What little inter-university computing service there is has resulted from making a convincing case for accessing a service which is not available on-campus, or from arranging an exchange of computing services with another university.

It seems evident that inter-university computing services will not expand significantly until there is a freer market environment for university users. This will require that a user be provided with some real funds to purchase computing at whichever campus centre provides the most effective and efficient services for his needs. The computer centres in this environment will, in effect, be in competition for whatever funds are allocated for this purpose.

4.3 Universities have limited experience in marketing computer services.

Most universities are not actively marketing inter-university computing services. On the contrary what services exist have often occurred as a result of an initiative taken by a university with a service need. This lack of marketing stance means that in most cases universities have no formal organization to publicize service offerings, prepare quotations or liaise with potential customers.

If inter-university services are to grow, there is a definite need to establish a marketing organization which will promote the use of remote service offerings. This function could be undertaken by each university independently or by national or regional marketing organizations serving all universities.

4.4 Support for remote users is an important requirement for successful off-campus services.

Computer centre staff currently spend a substantial percentage of their time ensuring that on-campus users understand how to use the systems and related software available to them. This is achieved through documentation, newsletters, special instructional sessions and private conversations.

Off-campus users will require at least the same level of support. Because of their remoteness, the support may have to take a different form and be intensified to overcome the disadvantages of distance.

4.5 Communications costs make on-line computer services at some remote locations too expensive.

For a computer user to be interested in an off-campus facility it must provide him better service at equal or less cost. Better service implies either better turn around and support than can be offered locally, or access to a unique service not available locally. In either case the communications and support costs

to provide the service remotely must be off-set by economies of scale and/or uniqueness of service at the supplying computer centre before the service becomes attractive. For many locations it is unlikely that remote services can be attractively priced based on current communications costs. Therefore, the growth and development of remote computing services may be very dependent on future reductions in data communications rates.

4.6 Data banks are generally still in the early stages of development.

One of the major potential benefits of a network is that it can give users across the country on-line access to specialized data banks. However, to be of use, a data bank must contain accurate and complete information and be readily accessible at reasonable cost. Accessibility and low cost of access are, at least partially, communications objectives which should be achievable through the application of new communications technology where applicable. The completeness and accuracy of the data, on the other hand, which are the most critical aspects of the service, are much more difficult objectives to achieve. Many data banks, for example bibliographic data banks, are of limited value until the user is confident that if he makes a search it will be of a complete and accurate bank of data on his subject. Developing a complete data bank and maintaining its completeness and accuracy is a very time consuming and costly operation. In addition proprietary and copy-right restrictions and the lack of binding standards in the

production of data bases have held back progress in this area. For these reasons Canadian university data banks, with a few exceptions [4], are in the early stages of development and have tended to lag behind the communications and computer technology which allows instant access to data banks from remote locations. And yet growth in the inter-university computer service market will depend significantly on the rate of development of data banks which are useful to a broad cross section of university researchers and students. The growth in data bank usage will in turn depend on the extent to which development effort is rationalized to avoid duplication, and progress is made in developing standard user access procedures which can be easily followed.

4.7 Networks are planned or under development which will influence the growth patterns of inter-university computing services.

In addition to CANUNET, a number of regional computer networks, such as METANET in Ontario and the University du Quebec network in Quebec, are in various stages of development. These networks have the advantage of serving a smaller geographical jursidiction thus reducing the influence of communications and support costs and avoiding, in some cases, the problems of trading across provincial boundaries. These regional networks are expected to eventually meet most of the regional needs for computing services.

[4] For example: Engineering (COMPENDEX), Physics (SPIN) and Educational Research (ERIC) Data bases at Calgary; Law (QUIC/LAW) at Queens and (DATUM) at Montreal.

Some regions may require services from other regions and this could generate inter-regional traffic but the major growth is expected to occur within regional boundaries.

Other networks are expected to emerge based on a single computer providing specialized services on-line to a large number of remote terminals. These "Star" networks could be national or regional in scope and offer services like APL, or access to alpha numeric data banks, such as the Legal Bank at Queens or the Financial Bank at the Financial Research Institute in Montreal. The area covered by these networks will be largely a function of the communications and support costs and the market. If there is any economy in scale in serving a national or regional market this should off-set the communications and support costs, at least in some instances.

Star networks could promote the growth of inter-university computing services by establishing some national services using existing communications facilities, before any computer networks are operational. Then, if CANUNET is developed, these Star networks could be incorporated into it to form a base traffic load.

This section has identified some of the major factors that are likely to affect the rate and direction of growth in inter-university computing services in the next few years. Previous sections on the current market for inter-university services and their potential growth areas, combined with this section, form the basis for the CANUNET traffic forecast which follows.

5 FORECAST OF INTER-UNIVERSITY TRAFFIC

The current value of inter-university computing services in Canada is estimated to be $500,000 per annum, allowing for miscellaneous revenues and communications costs not reported. This forms the starting point for this forecast which has been developed from the combined information on potential growth areas, factors affecting growth and other related forecasts. Both an optimistic and a pessimistic forecast are presented, to reflect the uncertainty which exists about the future development of the inter-university computer service market.

5.1 Optimistic Forecast.

There have been a number of projections based on national expenditure on communications services, terminals and communications oriented computers. Table 5.1 lists these projections and identifies their sources :

Table 5.1

ESTIMATED COMPOUND GROWTH RATE 1972-1980

1.	CN-CP	- Datacom market	15%	CN-CP Study, 1971
		- Computer services	10%	
2.	TCTS	- TWX/TELEX	8%	Bell Canada/BNR Long Range Network Study, 1970
		- Low Speed	25%	
		- Medium and High	10%	
3.	CCC/TF	- Communications oriented computers	21%	Branching Out, 1972
		- Terminals	20%	
		- Communications	17.9%	

It would seem unlikely that inter-university computing services would grow faster than these overall estimates indicate. However, it does seem reasonable to assume that inter-university services could keep pace with general market growth, or say 20% per annum on average. This is considered to be an optimistic estimate because it assumes universities:

a. Are committed to resource sharing and its implications.

b. Function like a free market in that faculty and staff may buy services at any university they wish.

c. Operate an effective marketing and support organization.

d. Develop comprehensive data banks in a rational and timely way.

e. Can access suitable communications facilities at reasonable cost.

f. Develop regional networks in the framework of a national plan.

Also, computer networks (together with data banks) may be necessary to develop a 20% growth rate. Since it is expected that they will only begin to be available in 1975 and be generally in use at universities by 1980, growth in inter-university services may be slower than 20% in the intervening period.

Table 5.2 shows the effect of a 20% compounded annual growth rate on the value of inter-university computing services.

Table 5.2

OPTIMISTIC FORECAST

20% COMPOUND GROWTH RATE

Year	Value of Inter-University Services ($,000)
1972	500
1975	864
1980	2,150
1985	5,354
1990	13,321

Even though 20% growth rate is considered optimistic, inter-university computing services would still only represent about 5% of the estimated total university expenditure on computing in 1990 (see Table 5.3).

5.2 Pessimistic Forecast.

Inter-university services are expected to grow to some extent even if it is not possible to remove the major barriers to growth. It seems unlikely that inter-university services would ever represent less than 1% of the total expenditure on computing at universities in Canada, but in the extreme, it could conceivably stay at that level. This is considered to be a pessimitic estimate because it assumes universities cannot or may not wish to :

a. Commit themselves to a resource sharing program which reduces their autonomy and which in some cases may result in the reduction of their local computer resources.

b. Assume the proper role of "Sellers" and provide adequate marketing and support services.

c. Cooperate in a national program of rational data bank development.

d. Build their regional networks with adequate reference to national needs.

e. Afford the cost of communications in some instances.

Assuming that the cost of computing in universities will grow at 10% per annum compounded [5], then the forecast of inter-university computer services based on 1% of that expenditure would be as shown in Table 5.3.

Table 5.3

PESSIMISTIC FORECAST

1% OF TOTAL ANNUAL EXPENDITURE ON COMPUTING
(ESTIMATED ANNUAL GROWTH RATE: 10% COMPOUNDED)

Year	Annual Expenditure on Computing ($,000)	Value of Inter-University Services ($,000)
1972	50,000	500
1975	66,000	660
1980	107,000	1,070
1985	172,000	1,720
1990	276,000	2,760

[5] Provides for inflation, use of computers in new areas and moderate growth in student enrolment.

5.3 Comparison of the Optimistic and Pessimistic Forecasts.

Chart 5.1 shows the two forecasts in graphical form. The services generating the revenue to support these forecasts are expected to be as follows :

a. Pessimistic Forecast:

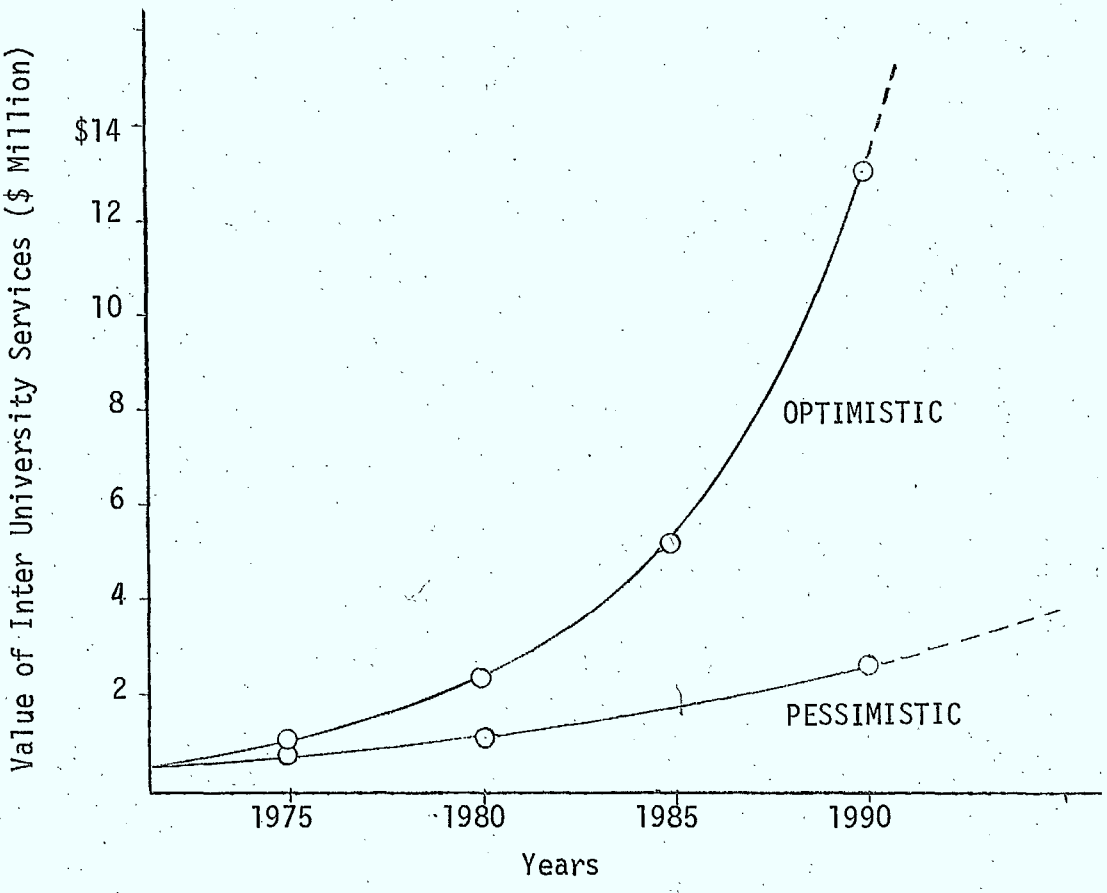
This forecast reflects a continuation of the present types of service which are not likely to cause any dramatic growth in inter-university computer usage. These are mainly general services - in particular the sale of computer time - which would probably grow primarily within regions where smaller universities look to the larger ones for their computing needs. Even if all 15 universities with full time student populations of under 3,000 decided to obtain all their computing from remote facilities, as Trent does at present, the total value of this service would probably not exceed $2,000,000 per year at present levels of usage. Furthermore the exchange of general services between the larger universities is seen to be limited for the following reason.

If a service can be provided locally without communications or support costs, the cost to provide the same service from a remote location would have to be substantially less to off-set the added cost of additional support and communications. The following example, using hypothetical

CHART 5.1

FORECASTS OF INTER-UNIVERSITY

COMPUTER SERVICES



OPTIMISTIC - 20% COMPOUNDED ANNUAL GROWTH RATE

PESSIMISTIC - 1% OF NATIONAL EXPENDITURE ON UNIVERSITY COMPUTING (ESTIMATED TO GROW AT 10% COMPOUNDED ANNUALLY)

percentages, helps to illustrate this point:

Cost from Local Centre			Cost from Remote Centre
Service	100%	Service	60%
-		Additional Support	10%
-		Communications	20%
	100%		90%

Here the remote cost is shown as 90% of the local cost to give the buyer some incentive to use the remote services. Because there is perhaps a 30% overhead for support and communications, the remote computer facility will have to produce the identical service at 60% of the cost of the local facility. This might be possible if the remote computer had a considerably better price/performance than the local computer. In the university environment this seems unlikely, especially over long distances, since each region has at least one large computing facility with a competitive price/performance which can or will be able to provide most general services in the near future.

b. Optimistic Forecast.

The difference between the two forecasts represents a major expansion of inter-university services revenue which is expected to come from unique specialized services, and in particular:

- specialized computational services offered from national or regional centres (e.g. APL, administrative).
- specialized information services offered from central data banks.

Of these by far the largest generator of inter-university service revenue is expected to be the data bank services and, in particular, bibliographic data bank services. Bibliographic services are expected in time to cover all fields of university study and therefore will be of interest and value to faculty and staff of all universities (not to mention community colleges, schools and the public in general). The job of creating and maintaining these data banks is enormous and it requires a very orderly and rational approach to development if it is to be completed within a reasonable time and cost. This may imply an acceptance of responsibility by most universities to specialize in the development of one or more bibliographic data banks and to provide continuing services from those banks to other universities.

While there is some evidence of data banks in use (e.g. law, economics, engineering, physics, educational research) the major development is yet to come. The 1970-71 Bell Delphi Studies indicate that computerized library systems in post-secondary institutions will be undergoing refinement

and early adoption between 1975 and 1980 and will be in general use by 1990. While these are some notable exceptions to this forecast in the U.S., such as the Ohio State Library System which is operational, it appears reasonable to expect that major Canadian bibliographic data banks will be developed and reach operational status during this period also.

5.4 The Communications and Service Components of Inter-University Services.

The forecasts presented here are for total inter-university computer service billings. In other words, for both the service cost from the computer centre and the communications costs. It is not clear at this stage what percentage of the total billings would be required to cover the cost of communications. Analysis of current data from Trent University which obtains all its services remotely and from Harvard Business School experience [6], indicates that 20% of billings may be a reasonable estimate for communications costs. On this basis the optimistic forecast of growth in inter-university services breaks down into service and communications components as follows:

[6] p. 102, Networks for Higher Education, EDUCOM, 1972.

Table 5.4

SERVICE AND COMMUNICATIONS COMPONENTS

OF INTER-UNIVERSITY COMPUTER SERVICES

OPTIMISTIC FORECAST

Year	Value of Inter-University Services ($,000)	Service Component (80%) ($,000)	Communications Component (20%) ($,000)
1972	500	400	100
1975	864	691	173
1980	2,150	1,720	430
1985	5,354	4,284	1,070
1990	13,321	10,657	2,664

The communication component does not include any provision for extra support for the remote user which may be a substantial extra cost for effective remote computing services. Offsetting this could be a lower cost of communications resulting from inter-university computing which is carried on using cars or mail service.

As the communications component remains constant at 20% of the total, Table 5.4 assumes that any improvement in price/performance of the service resulting from lower cost and more efficient hardware (e.g. mass storage devices) will be matched by a similar improvement in communications and vice-versa. If these improvements occur then it may be difficult to sustain the revenue projections indicated unless the market for services expands accordingly.

5.5 Distribution of Inter-University Computer Service Traffic.

From the foregoing, the distribution of inter-university computer service traffic in 1990 is expected to be as follows, assuming the optimistic forecast :

1990 Forecast Distribution

	Service ($ M)	Communications ($ M)	Total ($ M)
General Services	$2.2	$0.6	$2.8
Specialized Services	8.4	2.1	10.5
Total	10.6	2.7	13.3

Traffic from generalized services may be distributed by region in proportion to the number of smaller universities in each region, for example :

	No. of Smaller Universities*	1990 General Service Revenue ($ Million)
Atlantic	6	1.1
Quebec	1	0.2
Ontario	5	0.9
Prairie	3	0.6
B.C.	-	-
	15	$2.8

* Universities with less than 3,000 but more than 1,000 full time students in 1971. Does not include colleges.

On the other hand, the distribution of traffic from specialized services will depend primarily on the location of major data banks. As an illustration, assume that each of the 16 identified "supplier" universities develops a specialized data bank service. Then the distribution of these banks would be as follows :

Atlantic	2
Quebec	4
Ontario	6
Prairie	3
B.C.	1

Assuming that all banks are subject to the same usage, regional usage is proportional to the regional student population, and the cost of communications is a function of mileage and usage, then the distribution of the 1990 specialized service costs, computed in detail in Appendix 5.1, is summarized as follows:

Table 5.5

ESTIMATED DISTRIBUTION OF SPECIALIZED SERVICE COSTS, 1990

	Bank Distribution	Approximate Distribution of Student Population	Approximate Distribution of Specialized Service Costs ($,000) Service	Communications	Total	Communications as % of Total.
Atlantic	2	10%	$840	$227	$1,067	21%
Quebec	4	20	1,680	321	2,001	16
Ontario	6	40	3,360	538	3,898	14
Prairie	3	20	1,680	561	2,241	25
B.C.	1	10	840	453	1,293	35
	16	100%	$8,400	$2,100	$10,500	20% avg.

The last column of Table 5.5 shows the variation in communication costs resulting from this particular distribution of data banks. The sensitivity of regional communications costs to the location of banks is illustrated in Table 5.6 with a different distribtuion of data banks.

Table 5.6

EFFECT OF ALTERNATE BANK LOCATION

	Bank Location	Communications Costs ($,000)	%
Atlantic	2	245	22
Quebec	3	420	20
Ontario	4	760	18.5
Prairie	5	380	18.5
B.C.	2	295	26
		$2,100	20% avg.

In summary, taking into account both generalized and specialized services, the distribution of inter-university computer service traffic in 1990 could be as follows :

	Approximate Distribution of Inter-University Services Costs ($M)		
Region	General Services	Specialized Services	Total
Atlantic	1.1	1.1	2.2
Quebec	0.2	2.0	2.2
Ontario	0.9	3.9	4.8
Prairie	0.6	2.2	2.8
B.C.	-	1.3	1.3
	$2.8	$10.5	$13.3

However, the actual distribution will depend on many interrelated political and economic factors, discussed earlier in this report, and it is difficult to predict their full impact with any degree of accuracy at this time.

6 CONCLUSION

A forecast of growth in inter-university computer services to 1990 has been developed based on knowledge of the current market, areas of potential growth and factors affecting growth. The distribution of inter-university computing into service and communications components indicates that communications revenues could reach $2,664,000 by 1990.

It has been estimated [7] that an 18 node CANUNET with 50 Kbps lines would cost between $2.2 and 3.3 million and with 9.6 Kbps lines between $1.5 and $1.9 million per year to operate.

Assuming that the forecasted communications revenue is achieved, and that it is all from the use of CANUNET, then based on these network operating cost estimates, it is possible that CANUNET could be running on an annual cost recovery basis with 9.6 Kbps lines between 1986 and 1988, and with 50 Kbps lines between 1989 and 1991.

[7] p.8, THE CANUNET PROJECT, A Progress Report, C.D. Shepard, July 1972

CANUNET TRAFFIC STUDY

PROVINCIAL REPRESENTATIVES

R. McKinnon	Atlantic Provinces
J. Reid	Quebec
M. Brown	Ontario
P. Dirksen	Manitoba
G. Peardon	Saskatchewan
D. Norrie	Alberta
J. Kennedy	British Columbia

CANUNET TRAFFIC STUDY

UNIVERSITY QUESTIONNAIRE

ON COMPUTING SERVICES

Contents

54 DANESWOOD ROAD • TORONTO 12 • ONTARIO, CANADA • (416) 486-1607

3 August, 1972.

The federal Department of Communications is currently supporting a number of projects on computers and communications in Canada. One of these projects is a feasibility study for a Canadian University Computer Network (CANUNET). Work on CANUNET began in March, 1971 and substantial progress has been made by the universities and DOC in defining the requirements and costs of such a network. However to date there has been little emphasis on defining the potential usage of CANUNET and this is the subject of my letter.

Because of our background in similar work with universities, we have been asked, in conjunction with the University of Waterloo, to develop a traffic forecast for CANUNET. Our approach is based on the belief that if it is possible to develop a reasonably comprehensive picture of the current supply and demand for remote computing services at universities, then this information will form a useful basis for projections of future network traffic. Therefore as an initial step in this study we are attempting to get an overview of: (1) the unsatisfied demand, i.e. on-campus service needs which universities have been unable to satisfy with their existing equipment, and (2) the supply, i.e. services universities may be able to offer remotely to users at other universities.

This letter is to ask for your cooperation in supplying this data about your own university situation. The attached questionnaire, which is being sent to computer centre directors at 44 Canadian universities, has been designed to assist you. Only one questionnaire has been sent to your university, so we would like your answers to reflect the total university situation as far as that is possible.

/Cont. 2

While we are certainly aware of the administrative and political problems associated with using and charging for off-campus services, and also the questions of communication and support for the user, we ask that these issues not be considered in developing your answers at this time. These are real issues and ultimately must be addressed, but at this initial stage of our investigation, we do not want them to influence your answers.

We hope that by your helping us in this way, we will ultimately help you to achieve a more effective level of university resource sharing. Therefore we welcome any suggestions you may have for improving our approach and the quality of the data we are gathering.

Your prompt attention in completing this questionnaire will be greatly appreciated.

Yours sincerely,

Thomas A. Croil

UNIVERSITY QUESTIONNAIRE ON COMPUTING SERVICES

UNIVERSITY: .....

COMPLETED BY: .....

TELEPHONE: .....

A. THE UNIVERSITY AS A USER OF COMPUTING SERVICES

1. Are there needs for computing services on the campus which you have been unable to satisfy with your current staff and facilities ? Yes ..... No .....

2. If the answer to (1) is NO, please describe the conditions which make this possible on a separate sheet.

3. If the answer to (1) is YES, check (✓) the appropriate service types or categories in which these needs fall and rank (1 indicating greatest need):

	Check (✓)	Ranking of Need
a. General Purpose Services		
1. batch - local	.....	.....
2. - remote	.....	.....
3. time sharing	.....	.....
4. graphics	.....	.....
5. plotting	.....	.....
b. Application Software Packages		
6. Computation	.....	.....
7. Data Base Management	.....	.....
8. Education (CAI)	.....	.....
9. Administrative Services	.....	.....
c. Other (Specify)		
10.	.....	.....
11.	.....	.....

4. Please complete Table 1 by answering the following questions:

Column 1 and 2: What are the service needs (hardware and software), associated departments (and faculty member's name if available) that you are unable to satisfy ?

Column 3 and 4: What are the extra facilities needed at the computer centre and by the user to satisfy his requirements ?

Columns 5, 6 and 7: What is the total amount of money users spent off-campus in the 1971-72 fiscal year to satisfy their computing service needs from all sources, including commercial, and, where applicable, the amount spent at other universities and their names. If figures are not available, please give estimates and notate accordingly.

Column 8: Which needs, if any, are planned to be satisfied in the next 12 months ? Indicate with a check (√) mark.

5. Please indicate at the bottom of the page (or on the back) future requirements for computing services you may have difficulty satisfying with existing or planned facilities and staff.

B. THE UNIVERSITY AS A SUPPLIER OF COMPUTING SERVICES TO OTHER UNIVERSITIES:

ASSUMPTIONS:

In answering these questions, please assume the following:

a) There are no political or administrative problems in using or charging for off-campus services.

b) Off-campus services are provided from existing hardware (plus additional communications equipment) and with existing staff complement.

c) The requirements for communication with and staff support for the remote user are satisfied.

Please complete Table 2 by answering the following questions:

Column 1: What are the names and type of services (both hardware and software) you can provide on-campus users ?

Column 2: Which of your services are not suitable for remote users ? Check (√) the appropriate row and give reasons on a separate sheet.

Column 3: Which department (including the computer centre) is offering the services ? (eg. Statistics Dept. may make a data base available for other users)

Column 4: What method would be used to provide the service to the remote user ? Remote batch or time-sharing ?

Column 5: What off-campus revenue did your university derive from computing services in fiscal 1971-72 ?
Of this revenue how much came from universities ?
(Note: If figures are not available, please give estimates and notate accordingly.)

Column 6: What universities did you service in that year ?

Column 7: What is the typical user terminal and communications facility requirement for this service offering ?

Column 8: What are the current number of terminals and what additional terminals could you handle (for each service offering) from your existing facilities ?

C. ADDITIONAL INFORMATION

To assist us in our study we would appreciate receiving some additional information on your computing activities.

1. Have you any documentation on your computer centre (e.g. an annual report). If so please send us a copy.
2. What plans, if any, do you have for changing or upgrading your centre's hardware ? Please explain on a separate sheet.
3. Are there any other significant computer centres on your campus ?

Name of Centre	Director	Was this Centre and its users included in your Questionnaire answers ? YES NO
_____	_____	

Table 1

UNIVERSITY QUESTIONNAIRE ON

COMPUTING SERVICES

THE UNIVERSITY AS A USER **

(1) SERVICE NEED	(2) DEPARTMENT AND FACULTY MEMBER	(3) EXTRA RESOURCE REQUIREMENTS COMPUTING CENTRE * 1 2 3 4 5 6 7 8 9 10	(4) TERMINALS (#) T/S	RJE	(5) EXPENDITURE ON OFF-CAMPUS COMPUTING TOTALS	(6) AMOUNT AT OTHER U's	(7) NAMES OF OTHER U's	(8) PLANS FOR SATISFYING NEED IN NEXT 12 MONTHS Check (✓)

Notes

* Extra Computer Centre resource requirements.

Check (✓)

1. C.P.U. Capacity
2. Memory Capacity
3. Peripherals
4. Time-Sharing Facility
5. RJE Support
6. Software
7. Application Programs
8. Staff Shortage
9. Staff Skills
10. Other (Specify)

** If you have difficulty using the above format, please feel free to modify it as necessary.

Table 2.

UNIVERSITY QUESTIONNAIRE ON

COMPUTING SERVICES

THE UNIVERSITY AS A SUPPLIER**

(1) NAME OF SERVICE OFFERING	(2) NOT SUITABLE FOR REMOTE SERVICE CHECK (✓)	(3) DEPARTMENT OFFERED BY	(4) METHOD CHECK (✓) RJE	(4) METHOD CHECK (✓) T/S	(5) OFF-CAMPUS REVENUE ($) TOTAL	(5) OFF-CAMPUS REVENUE ($) FROM U's	(6) UNIVERSITIES SERVICED	(7) TYPICAL USER TERMINAL AND COMMUNICATIONS REQUIREMENT	(8) NUMBER OF TERMINALS CURRENTLY IN USE	(8) NUMBER OF TERMINALS ADDITIONAL WHICH COULD BE SERVED

** If you have difficulty using the above format, please feel free to modify it as necessary.

APPENDIX 11

QUESTIONNAIRE RECIPIENTS

1. British Columbia (3)

Dr. Jim Kennedy,
Director Computer Centre,
University of British Columbia,
Vancouver 8, B.C.

Mr. Ross Jewell,
Director Computer Centre,
Simon Fraser University,
Burnaby, B.C.

Mr. Peter Darling,
Director Computer Centre,
University of Victoria,
Victoria, B.C.

2. Alberta (3)

Prof. D.H. Norrie,
Director Information Services,
University of Calgary,
Calgary 44, Alberta.

Dr. D.H. Bent,
Director Computer Centre,
University of Alberta,
Edmonton, Alberta.

Director Computer Centre,
University of Lethbridge,
Lethbridge, Alberta.

3. Manitoba (3)

Professor Paul Dirksen,
Director Computer Services,
University of Manitoba,
Winnipeg, Manitoba.

Mr. B. Chalmers,
Director Computing Services,
University of Winnipeg,
Winnipeg, Manitoba.

Mr. T. Robertson,
Director,
Computer Services
Brandon University,
Brandon, Manitoba.

4. Saskatchewan (2)

Mr. Glen Peardon,
University of Saskatchewan,
Saskatoon,
Saskatchewan.

Professor L. Syme,
University of Saskatchewan,
Regina, Saskatchewan.

5. Ontario (16)

Mr. Peter Lewis,
Comptroller,
Trent University,
Peterborough, Ontario.

Dr. John Wilson,
Computer Centre Room 105,
Stanford Fleming Building,
University of Toronto,
Toronto, Ontario.

Mr. Ray Skilton,
Director Computer Centre,
Brock University,
St. Catherines, Ontario.

Dr. Walter Dieticher,
Computer Centre,
Carleton University,
Ottawa, Ontario.

Professor J.W. Graham,
Director Computer Centre,
University of Waterloo,
Waterloo, Ontario.

Mr. W. Jenkins,
Director Computer Centre,
Queens University,
Kingston, Ontario.

Mr. Gerry Keech,
Director Computer Centre,
Room 139 Temporary Building # 14,
McMaster University,
Hamilton, Ontario.

Mr. F.D. Simpkin,
Director Computer Centre,
York University,
Downsview, Ontario.

Mr. George Lake,
Director Computer Centre,
University of Western Ontario,
London, Ontario.

Mr. Bill Lamb,
Director Computer Centre,
University of Ottawa,
Ottawa, Ontario.

Mr. Leo Mernicki,
Computer Centre,
University of Windsor,
Windsor, Ontario.

Dr. Katz Okashima,
Director Institute of Computer Science,
University of Guelph,
Guelph, Ontario.

Mr. Alan McEwan,
Director of Computer Centre,
Lakehead University,
Thunder Bay,
Ontario.

Mr. Bruce Byce,
Computer Centre,
Laurentian University,
Sudbury, Ontario.

Dr. J.A. Smith,
Royal Military College,
Kingston, Ontario.

Mr. J. Kitchen,
Director Computing Services,
Waterloo Lutheran University,
Waterloo, Ontario.

6. Quebec (7)

Prof. Jacques St. Pierre,
Directeur Centre de Calcul.,
Universite de Montreal,
Montreal, Quebec.

Mr. J.L. Redding,
Chairman Computer Centre Committee,
Bishops University,
Lennoxville, Quebec.

Professor W.D. Thorpe,
Computer Centre,
McGill University,
Montreal, Quebec.

Mr. Joe Reid,
Universite du Quebec,
Quebec City, P.Q.

Dr. Graham Martin,
Assistant Vice President Communications,
Sir George Williams University,
Montreal, Quebec.

M. Louis Robichaud,
Director Computer Centre,
Universite Laval
Quebec City, Que.

M. Andre Croteau,
Directeur Centre de Calcul.,
Universite de Sherbrooke,
Sherbrooke, Quebec.

7. Nova Scotia (5)

Mrs. Elizabeth Payne,
Director Computer Centre,
Dalhousie University,
Halifax, Nova Scotia.

Dr. J.H. Ahrens,
Nova Scotia Technical College,
Halifax, Nova Scotia.

Mr. M. Tingley,
St. Mary's University,
Halifax, Nova Scotia.

Dr. R. MacKinnon,
Director Computer Centre,
St. Francis Xavier University,
Antigonish, Nova Scotia.

Dr. D.A. Bonyun,
Director Computer Centre,
Acadia University,
Wolfville, Nova Scotia.

8. New Brunswick (3)

Mr. G.W. Hannah,
Assistant Director Computer Centre,
Mount Allison University,
Sackville, New Brunswick.

Professor Dana Wasson,
Director Computer Centre,
University of New Brunswick,
Fredericton, N.B.

Mr. R. Cyr,
Computer Centre,
Universite de Moncton,
Moncton, N.B.

9. Newfoundland (1)

Mr. R.J. Kelly,
President,
Newfoundland and Labrador Computer Services Ltd.,
100 Elizabeth Avenue,
St. John's, Newfoundland.

10. Prince Edward Island (1)

Mr. Jim Hancock,
Director Computer Centre,
University of Prince Edward Island,
Charlottetown, P.E.I.

CANUNET TRAFFIC STUDY

OTHER UNIVERSITY COMPUTER CENTRES REPORTED BY RESPONDENTS

NAME	CONTACT	INCLUDED IN SURVEY	NOT INCLUDED IN SURVEY
TORONTO			
Computer Research Facility	J.R. McBride		x
Library Automation System	E.J. Minett		x
Information Systems Division	H. Mikkelsen		x
Medical Computing	R. Julius		x
MONTREAL			
Ecole Polytechnique	B. Lanctot		x
Haut Etudes Commerciales	J. Melis		x
Administration, U of M	J.G. Benoist	x	
MEMORIAL			
Engineering Computer Centre	A.N. Betz	x	
Psychology	R. Taylor	x	
U.N.B.			
Hybrid Laboratory - E.E.	D. Pincock		x
DALHOUSIE			
Biophysics Computer Centre	M. Connelly		
U.B.C.			
Administration			x
Animal Resource Ecology			x
Electrical Engineering			x
McMASTER			
Health Services	G. Anderson		x

CANUNET TRAFFIC STUDY

UNIVERSITY COMPUTING SERVICE NEEDS

UNIVERSITY	SERVICE NEED	PLANS TO SATISFY NEED	
		NO	YES
ATLANTIC REGION			
Dalhousie	Improved time-sharing		In 12 months
	APL		Under consideration
	Administrative Systems		Software being developed
	Law Retrieval System		Under consideration
	Library System		Some development
	CAI	x	
	Graphics	x	
U.N.B.	CAI	x	
	Student Info. System		In 12 months
	Computation (Chemistry)		370/158 to help
	Legal, Economic Services	x	
Mt. Allison	Faster printer		In 12 months
	On-line storage	x	
	Administrative Services	x	
St. F. Xavier	Computation (Chemistry)		Met by Dalhousie
	Geology applications	x	
	Psychology applications	x	
	Sociology applications	x	
Acadia	No indicated needs		
P.E.I.	Unknown needs		
N.S. Tech.	All needs		Met by Dalhousie
Memorial	APL		In 12 months
	Time-sharing		In 12 months
	CAI	x	
	Graphics	x	
	A-D Lab equipment	x	

UNIVERSITY	SERVICE NEED	PLANS TO SATISFY NEED	
		NO	YES
St. Marys	NR*		
Moncton	NR		
QUEBEC REGION			
Montreal	PL/I	x	
Laval	No needs		
McGill	APL with file handler like I.P. Sharp Sophisticated interactive programs like Dartmouth time-sharing system		
Bishops	Scientific computer Business games	x x	
Sir G. Williams	Graphics Business packages		In 12 months In 12 months
Quebec			
- Siege Social	ASKA APL POP 2 GPSS STRUDEL PL/I Coursewriter SCEPTRE ISIS Linear Programming Time-sharing		
- à Montreal	Conversational terminal service Conversational language Graphics applications		
- à Chicoutimi	NR		

* NR - Not Reported

UNIVERSITY	SERVICE NEED	PLANS TO SATISFY NEED	
		NO	YES
- Institut National de la Recherche Scientifique	APL		In 12 months
	Plotting		In 12 months
	Computation		In 12 months
	Process Control		
- à Rimouski	Plotting		In 12 months
	CAI		In 12 months
- à Trois-Rivières	Graphics		
	APL/CDC		In 12 months
	Electrical Circuit Analyses		In 12 months
	Linear Programming		
	TTY's and CRT's		In 12 months
	Library inventory and on-line control		
	Students scheduling		
Sherbrooke	NR		
ONTARIO REGION			
Waterloo	Data base systems	x	
Toronto	Big word length batch		From Western
	Time-sharing	x	
York	Basic		From Dartmouth
	Plotting		In 12 months
	Media conversion		In 12 months
	Scientific computing		From McMaster
	HS Remote batch	x	
	CRJE	x	
	Advanced Admin. Systems		
	Research Data bases		
Queens	APL		In 12 months
	Basic	x	
	CAI	x	
	Data base management	x	
	Graphics	x	
	Computation Software	x	
	Info storage and Retrieval	x	

UNIVERSITY	SERVICE NEED	PLANS TO SATISFY NEED	
		NO	YES
McMaster	Time-sharing		In 12 months
Guelph	Time-sharing	x	
	Text editing		In 12 months
	Graphics	x	
Carleton	CPU for Physics, Chemistry	x	
	ICES Software	x	
RMC	All services	x	
W-Lutheran	Data base management		Provided by Waterloo
	SPSS package		
Brock	BMD package for Sociology	x	
	Plotting	x	
	Time-sharing	x	
	CAI	x	
	PL/I	x	
Trent	All services		Continue to buy
Laurentian	Larger memory; faster CPU	x	
	Time-sharing	x	
Lakehead	Library system	x	
	Scheduling system	x	
	Data base management	x	
	University planning	x	
Windsor	Improved service for physicists		In 12 months
Western	NR		
Ottawa	NR		
Ryerson	NR		
PRAIRIE REGION			
Brandon	Statistical package(SPSS)	x	
	Plotting	x	
	CPU for Physics	x	

UNIVERSITY	SERVICE NEED	PLANS TO SATISFY NEED	
		NO	YES
Manitoba	Time-sharing		In 12 months
	Graphics	x	
	Computation	x	
	Data bases	x	
	CAI		In 12 months
Winnipeg	Most Services		Provided by Manitoba
Saskatoon	Digitizing seismic data	x	
Regina	Plotting		In 12 months
	Admin. data base	x	
	CAI		In 12 months
	CPU for Physics, SPSS	x	
Alberta	Time-sharing and batch for peak loads		
Calgary	APL		In 6 months
	Coursewriter		In 6 months
	Data base management systems		In 6 months
Lethbridge	NR		
B.C. REGION			
Simon Fraser	Remote batch		
	Time-sharing	x	
	Graphics	x	
	Computation	x	
	Data base management	x	
Victoria	Remote batch	x	
	Time-sharing		In 12 months
	Graphics	x	
	Real-time	x	
U.B.C.	None		

CANUNET TRAFFIC STUDY

UNIVERSITY COMPUTING SERVICE OFFERINGS

UNIVERSITY AND SERVICE OFFERED	TYPE	TERMINALS In Use		TERMINALS Extra Capacity	
		T/S	RJE	T/S	RJE
ATLANTIC REGION					
Dalhousie:					
1. Computer Time					
- Batch	Mixed speed	6	5		5
- Time-sharing					
2. Software Systems					
- Student information					
- Financial reporting					
- Library Programs					
- Multiple choice exam analysis					
- Statistical Analysis systems					
- Scientific programming packages					
U.N.B.:					
- RJE	2780; 1130		4		4
- Time-sharing	2741; TWX	3		12	
- APL	2741	12		30	
TOTAL Region Terminals		21	9	42	9

UNIVERSITY AND SERVICE OFFERED	TERMINALS TYPE	In Use T/S	In Use RJE	Extra Capacity T/S	Extra Capacity RJE
QUEBEC REGION					
Montreal:					
- Batch remote	CDC 200		6		10
- CRJE	2741; TTY	24		40	
- Computation packages					
- Text data bank information retrieval					
- Simula, L6, Special languages					
- Text handling package					
- Datum					
Laval:					
- APL	2741	120		NR	
- TSO	2741; TTY				
- RJE	2780	NR			NR
- Application packages					
McGill:					
- RAX Time-sharing	10-30 ch/sec	100		100+*	
- MVT/HASP RJE	2780		4		10+*
- MVT/HASP CRJE	10-30 ch/sec	20		100+*	
- ATS	2741				
Sir Geo. Williams:					
- Normal services	TTY	25		50	

UNIVERSITY AND SERVICE OFFERED	TYPE	TERMINALS In Use T/S	In Use RJE	Extra Capacity T/S	Extra Capacity RJE
Quebec Region .. contd.					
Siege Social:					
- Time-sharing	KSR 33	1		0	
- Remote job entry	200 UT		0		0
TOTAL Region Terminals**		290	10	290+	20+

* Reported as having no practical limit
** Does not include the terminals at Sherbrooke.
NR - Not reported.

UNIVERSITY AND SERVICE OFFERED	TYPE	TERMINALS In Use T/S	In Use RJE	Extra Capacity T/S	Extra Capacity RJE
ONTARIO REGION					
Waterloo:					
- Terminal Services	2741; TTY	200	NR	NR	NR
Toronto:					
- General purpose OS 370	2780; 2741	NR	7	64	3
- High speed batch					
- APL	2741	60			
- ATS	2741; TTY	10		16	
- CPS	2741; TTY	10			
York:					
- In-core student processor	slow, high speed		1		
- OS batch	" "		0		
- APL	2741; TTY	18		22	
- Social Science data base					
- Financial data base					
McMaster:					
- Scientific DP	CDC 200		3		3
- Conversational statistics system	CDC 200				
- Statistics Canada data base (future)					
- CAI (Plato) Service (Future)					

UNIVERSITY AND SERVICE OFFERED	TYPE	TERMINALS In Use T/S	In Use RJE	Extra Capacity T/S	Extra Capacity RJE
Ontario Region .. contd.					
Guelph:					
- APL	2741	21		20	
- TOTAL					
- MARK IV					
- WATFIV, PL/C, WATBOL	2501/1403		1		3
Carleton:					
- Remote batch					
- Time-sharing	TTY	70		40	
Lakehead:					
- APL	2741	20		10	
TOTAL Region Terminals		409*	12*	172*	9*

* Does not include expansion possibilities at Waterloo or data from Western and Ottawa.

UNIVERSITY AND SERVICE OFFERED	TYPE	TERMINALS In Use T/S	In Use RJE	Extra Capacity T/S	Extra Capacity RJE
PRAIRIE REGION					
Brandon:					
- CAI and problem solving	TTY; CRT	7		9	
Manitoba:					
- OS batch	2780; 2770; 2741	10	5	5	4
- APL	2741	2		5	
- Data bases - agriculture - health services - settlement studies					
Saskatoon:					
- Batch and teleprocessing	TTY	25		5	
Calgary:					
- RJE	CDC 200		6		6*
- T/S (KRONOS)	TTY	70		150*	
- Data base - ERIC, SPIN, COMPENDEX					
Alberta:					
- Time-sharing (MTS)	TTY	85		0	
- Processing Admin. data for universities (potential)	RJE		0		30+
TOTAL Region Terminals		199	11	174	40+

* Estimated

UNIVERSITY AND SERVICE OFFERED	TYPE	TERMINALS In Use T/S	In Use RJE	Extra Capacity T/S	Extra Capacity RJE
B.C. REGION					
U.B.C.*					
- Remote batch					
- Conversational services			6		
- Specialized programming languages	2780 2741, TTY]	90			
- Application packages					
- CAI					
Simon Fraser:					
- APL	2741				
- CAI	2741	32		50	
- CRBE	2741, 2260				
- MINERVA	2260	6		10	
- IBM 1030 data collection		4		15	
- Other software	2780				10
Victoria:					
- Local batch	3780		-		4
- Compilers	2741; TTY		-	12	
TOTAL Region Terminals*		132	6	87	14
CANADA					
TOTAL NATIONAL TERMINALS**		1,050	48	765	92

* Based on an estimated 90 -2741 type terminals at U.B.C. RJE terminals are off-campus only.

** Subject to the notes given under each regional section.

CANUNET TRAFFIC STUDY

OFF-CAMPUS COMPUTING SERVICES

REVENUES AND EXPENSES 1971-2

Under normal circumstances the total inter-university expenditure and revenue from computer services should nearly balance. However, in many universities departments may use off-campus services and pay for them out of departmental funds. This means that there is no central record of off-campus computing expenditure which is available to the Computer Centre Director. Therefore the expenditure data provided by the Directors has been estimated based on their knowledge of projects being processed off-campus and is subject to error. On the other hand the computer centre would normally receive all revenues from the use of its facilities by other universities and therefore the revenue data provided is considered to be more accurate. For this reason the revenue figures have been used in this report to represent the value of inter-university computing services. The following tables show the revenue and expenditure figures in summary form and as reported by the individual universities.

CANUNET TRAFFIC STUDY

OFF-CAMPUS REVENUE AND EXPENSES

REGIONAL SUMMARY	ALL SOURCES		UNIVERSITIES	
	REVENUE	EXPENSES	REVENUE	EXPENSES
Atlantic	205,000	8,250	72,000	4,250
Quebec	198,200*	53,450	55,250	24,250
Ontario	225,100	368,600	108,000	110,400
Prairie	311,100	2,080	10,500	600
B.C.	260,000	3,000	69,500	2,000
	$1,199,400 *	$435,380	$315,250	$141,500

* Does not include data from McGill (estimated to be close to $1,000,000) and five universities which did not report.

	ALL SOURCES		UNIVERSITIES	
	REVENUES	EXPENSES	REVENUES	EXPENSES
ATLANTIC REGION				
Dalhousie	100,000	4,000	42,000 *	0
P.E.I.	0	0	0	0
N.S. Tech.	NR	NR	NR	NR
St. F. Xavier	5,000	4,250	0	4,250
Acadia	0	0	0	0
Mt. Allison	0	0	0	0
UNB	100,000	0	30,000	0
Memorial	0	0	0	0
Moncton	NR	NR	NR	NR
St. Mary's	NR	NR	NR	NR
	$205,000	$8,250	$72,000	$4,250

* Includes $30,000 in research grants to Dalhousie.

NR - Not Reported

	ALL SOURCES		UNIVERSITIES	
	REVENUES	EXPENSES	REVENUES	EXPENSES
QUEBEC REGION				
Montreal	135,000	6,500	1,500	0
McGill	NR*	5,000	40,150	NR
Sir Geo. W.	50,000	3,000	0	NR
Quebec**	13,200	35,450	13,600	22,250
Laval	NR	3,000	NR	2,000
Sherbrooke	NR	NR	NR	NR
Bishops	NR	600	NR	0
	$198,200	$53,450	$55,250	$24,250

* Previous surveys indicated that this amounted to nearly $1,000,000.

** Universite du Québec

Siege Social	9,050	17,900	3,550	17,900
à Chicoutimi	NR	8,000	10,000	NR
à Trois-Rivières	4,150	1,350	50	1,350
INRS	NR	8,200	NR	3,000
à Rimouski	NR	NR	NR	NR
à Montreal	NR	NR	NR	NR
	$13,200	$35,450	$13,600	$22,250

ONTARIO REGION	ALL SOURCES REVENUES	ALL SOURCES EXPENSES	UNIVERSITIES REVENUES	UNIVERSITIES EXPENSES
Ottawa	NR	NR	75,000	NR
Carleton	26,500	12,600	26,400	2,000
Queens	NR	185,000	0	75,000
Trent	0	90,000	0	26,400
Laurentian	NR	1,000	0	NR
Lakehead	40,000	0	0	0
Windsor	0	3,000	0	3,000
Western	NR	13,500	NR	NR
Brock	0	200	0	200
McMaster	112,600	5,000	600	NR
Guelph	15,000	NR	NR	NR
RMC	0	7,500	0	NR
Ryerson	NR	NR	NR	NR
Toronto	30,000	8,800	6,000	2,800
York	1,000 *	23,000 *		10,000 *
Waterloo	NR	NR	NR	NR
Waterloo-Luth.	0	19,000	0	1,000
	$225,100	$368,600	$108,000	$110,400

* Does not include exchange of services with Toronto, McMaster, Ryerson.

	ALL SOURCES		UNIVERSITIES	
	REVENUES	EXPENSES	REVENUES	EXPENSES
PRAIRIE REGION				
Edmonton	24,000	NR	0	NR
Calgary	NR	0	NR	0
Lethbridge	NR	NR	NR	NR
Saskatoon	105,000	500	0	0
Regina	NR	980	NR	NR
Manitoba	180,500	0	10,500	0
Winnipeg	NR	NR	NR	NR
Brandon	1,600	600	NR	600
	$311,100	$2,080	$10,500	$600
B.C. REGION				
B. Columbia	150,000	NR	60,000	NR
Simon Fraser	65,000	NR	9,500	2,000
Victoria	45,000	3,000	0	0
	$360,000	$3,000	$69,500	$2,000

CANUNET TRAFFIC STUDY

DISTRIBUTION OF COMMUNICATIONS COSTS

OPTIMISTIC PLAN

Assuming that by 1990 :

1. 80% of the communications costs are associated with access to data banks.

2. Data banks are distributed in proportion to the major "supplier" universities. For this example :

Atlantic	2		
Quebec	4	Prairie	3
Ontario	6	B.C.	1

3. Usage of all data banks is identical.

4. Regional usage of banks is in proportion to the percentage of university students in each region.

5. Cost of communication to a bank in the same region is zero. Cost of communication to other banks is related to gross mileage between regions. For this example the following mileage table applies:

	Atlantic	Quebec	Ontario	Prairie	B.C.
Atlantic	-	500	1000	2500	3500
Quebec	500	-	500	2000	3000
Ontario	1000	500	-	1500	2500
Prairie	2500	2000	1500	-	1000
B.C.	3500	3000	2500	1000	-

6. Usage of the data banks is in proportion to the student population in each region :

	University Student Population, 1971	Approximate % of Total
Atlantic	21,000	10
Quebec	56,000	20
Ontario	104,000	40
Prairie	56,000	20
B.C.	29,000	10
	266,000	100%

Then the cost of communications can be expressed as follows :

$$\text{Total Cost} = C_T = \sum A_x \, Cm \left[\sum m_{xn} \frac{b_n}{b_t} \right]$$

where A_x = Number of accesses from region x

C_m = Cost per access-mile (constant)

m_{xn} = Mileage between region x and region n, where n = 1 to 5

b_n = Number of data banks in region n

b_t = Total number of data banks

$$\text{Thus} \quad C_T = \$2.1 \times 10^6 = A_1 \frac{Cm}{b_t}(37{,}000) + A_2 \frac{Cm}{b_t}(23{,}000) + A_3 \frac{Cm}{b_t}(11{,}000)$$
$$+ A_4 \frac{Cm}{b_t}(13{,}000) + A_5 \frac{Cm}{b_t}(19{,}000)$$

If $A_T = A_1 + A_2 + A_3 + A_4 + A_5$

$= .1A_T + .2A_T + .4A_T + .2A_T + .1A_T$

$\frac{A_T C_m}{b_t}$ = \$120/bank-mile

Substituting we get :

C_1	=	$.1A_T$ x $\frac{120}{A_T}$	x	37,000	=	\$453,000 (B.C.)
C_2	=					561,000 (Prairie)
C_3	=					538,000 (Ontario)
C_4	=					321,000 (Quebec)
C_5	=					227,000 (Atlantic)
C_T	=					\$2,100,000