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The University of British Columbia

Simon Fraser University

The University of Victoria

B.C. Universities Computer Network Feasibility Study

by

J.L. Leigh

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B.C. UNIVERSITIES COMPUTER NETWORK

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Work performed under Contract No. OSU5-0122 for the Educational Technology Branch, Department of Communications, Government of Canada, and under the sponsorship of the Computing Centres of the University of B C, Simon Fraser University, and the University of Victoria.

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Preface

For several years the Computing Centres of the three major British Columbia universities -- The University of B.C., Simon Fraser University, and The University of Victoria -- made sporadic attempts to share computing resources. A university which lacked a resource would access it, through remote batch or interactive terminals, at one of the other universities.

Most such attempts were short-lived and of limited success. A combination of technical and organizational problems, including some measure of indifference and inertia on the part of some of the participants, eventually caused the abandonment of such computer resource sharing activities. Currently, there is little shared use of computing facilities among the institutions.

Despite the failures, the question of the possibility of shared use of computing facilities on a permanent basis is often raised and has never been properly answered. This report offers an answer appropriate to the situation as it existed in March 1976.

Acknowledgments

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Network Study Coordinating Committee

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Table of Contents

I. Introduction 1

1. Philosophy 1
2. The Three Universities 2
3. Computing on the Campuses 3

II. Current Resources of the Three Centres 10

1. Hardware Resources 10
2. Software Resources 11
3. Data Collections 12

III. The Users' View 13

1. The Need for a Network 13
2. Uses of a Regional Network 17
3. Summary of the Users' View 22

IV. Network Implications 24

1. For the Computing Centres 24
2. For the Academic Communities 27
3. For University Administration 28
4. For British Columbia 29

V. Technical Considerations 30

1. Network Topology 30
2. Host Computers 32
3. Communications Computers 33
4. Communications Lines 33
5. Communications Protocols 34
6. Network Access 35
7. The Carriers' Networks 36

VI. Organizational Considerations 37

1. Management of a Network 37
2. Network Accounting 37
3. The Facilitating Network 38
4. Network Costs 39
5. Funding 40

VII. Summary 41

VIII. Recommendation 43

Appendix 1: User Survey Questionnaire 46
Appendix 2: Administrative Personnel Interviewed 47
Appendix 3: Bibliography 48

I. INTRODUCTION

1. Philosophy

This study was undertaken to determine whether shared use of computing facilities via a computer network linking the three major B C universities is possible and desirable. Since the phrase "shared use" has different connotations to different people, it is necessary to define the interpretation used here.

Specifically, "shared use" implies that the facilities of each Computing Centre are available to the others on a co-operative basis. Most importantly, there is no desire to consider alternatives to the existing, independent Computing Centres which meet most of the local computing needs of their respective institutions. Thus, "shared use" does not imply use of a single central computing facility serving all three universities.

Also, "shared use" implies that there would be little initial disturbance in each Centre's: operating philosophy, local services, and staff organization. Therefore, local expansion of services would not initially be modified by the introduction of "shared use" capability. (However, it would be naive to believe that "shared use" would have no effect upon the future of each Centre. Indeed, if it offered no new alternatives, then it would be a useless exercise.)

In keeping with this philosophy, the only development that will be considered is that of a distributed resource sharing computer network. Such a network involves the interlinking of the large host computers at each institution via communications computers and communications lines in such a manner that the data, hardware, and software facilities of each Centre are readily usable by all other participating Centres. Note that "distributed" implies that the participants retain their autonomy and no central network control exists.

Finally, it should be mentioned that the Computing Centres of the three universities have no wish to embark upon a research project. Instead, they wish to consider expansion, through a computer network, of services available to their customers.

2. The Three Universities

In order to set the stage for the discussion and conclusions which eventually follow, this section briefly describes the three universities, while the next section will describe the current state of computing on the campuses.

The University of B C (UBC) is situated in Vancouver. It is the largest educational institution in the province, with approximately 23,000 full time students taking courses of study in 12 faculties and 8 schools. UBC has several professional faculties and schools that do not exist at the other B C universities.

Simon Fraser University (SFU) is located in Burnaby, 14 miles from UBC. It currently has about 7,000 full time students in 5 faculties and is the youngest university, having started in 1966. SFU, unlike the other B C universities, operates on a year-round trimester system.

The University of Victoria (UVic) is located in Victoria on Vancouver Island, about 50 miles from UBC. After several years as a two-year college, UVic became a degree granting university in 1963. It currently has about 5,500 students enrolled in 5 faculties.

Table 1 lists the 1975/76 enrolment for each faculty of the three universities.

Table 1: Approximate 1975/76 enrolment at the universities.

The University of B C	
Agriculture	377
Applied Science	1,662
Arts	5,307
Commerce & Business Administration	1,601
Dentistry	196
Education	4,341
Forestry	340
Graduate Studies	2,937
Law	704
Medicine	462
Pharmacy	357
Science	3,731
Other	964
Total	22,979

Simon Fraser University	
Arts	3,333
Education	1,500
Graduate Studies	755
Interdisciplinary Studies	343
Science	882
Total	6,813

The University of Victoria	
Arts and Science	3,327
Education	1,325
Fine Arts	401
Graduate Studies	289
Law	72
Child Care	97
Total	5,511

3. Computing on the Campuses

A brief comparison of the current state of computing on the three Computing Centres is contained in this section.

Both the SFU and UVic Computing Centres can be characterized as medium-to-large centres, traditionally organized, with a heavy emphasis upon administrative computing. Each has large administrative programming groups, each has the operating systems software groups reporting through the Manager of Operations. Academic computer use, which has been growing rapidly in recent years, receives a smaller portion of the non-computer resources of the Centres than its share of the computing load would indicate. This is partially because of the self-sufficient nature of many academic computing customers and partially because of historical precedent. Both Centres have IBM mainframes (370/155 at SFU, 370/145 at UVic) and run traditional, vendor-supplied operating systems. Neither Centre is organized to undertake extensive software development work except in administrative applications. Both SFU and UVic have close ties to several British Columbia community colleges. These colleges use the universities' facilities to provide computing to the college campuses.

In contrast, the UBC academic Computing Centre is a large installation and in many ways non-standard. It is organized so as to emphasize academic software development, both in operating and applications systems. There is, at the same time, a heavy emphasis upon academic user services and very little administrative processing.

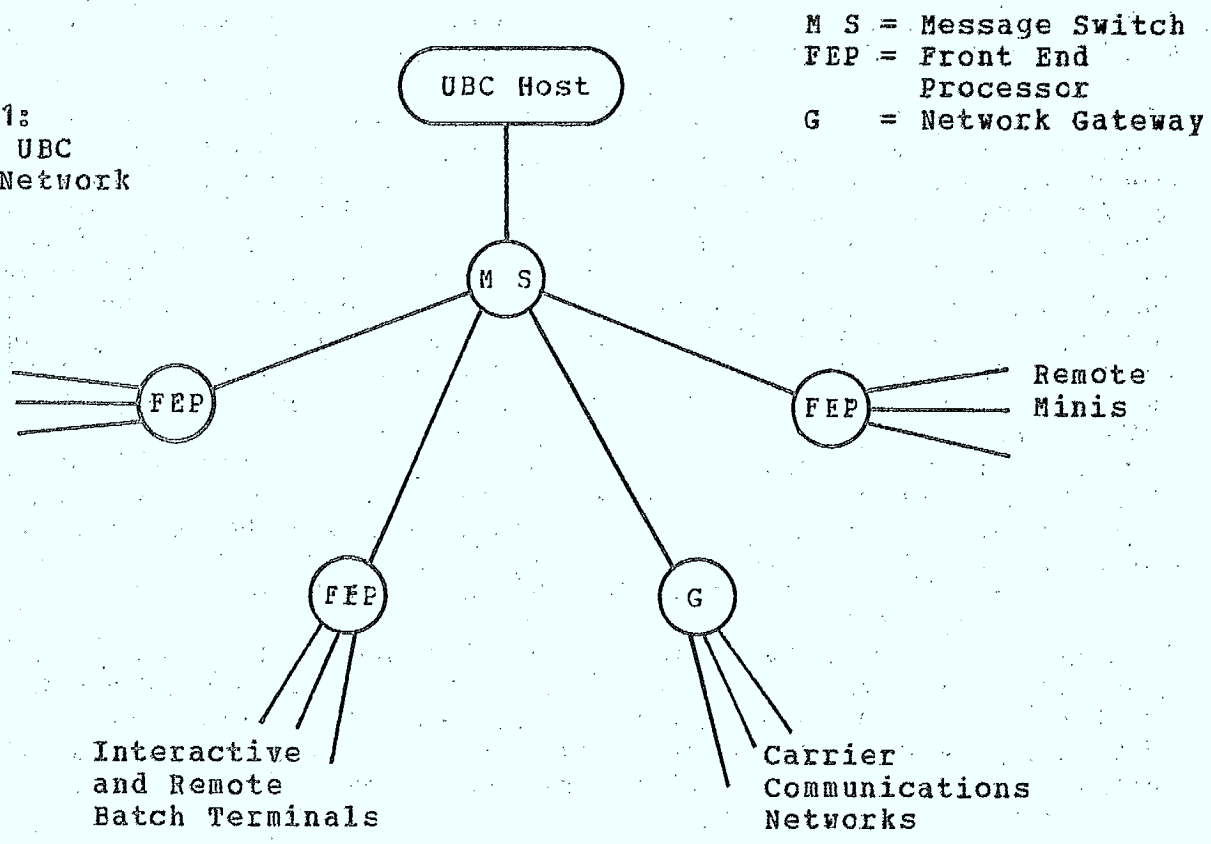
A non-standard operating system called MTS (the Michigan Terminal System) has, for the past 7 years, allowed the UBC Computing Centre to offer general purpose, virtual memory based, interactive computing capabilities to its customers. MTS currently operates at UBC on an IBM 370/168. Through its use of MTS, the UBC Centre has gained close cooperative ties with the Computing Centres of the University of Michigan, Wayne State University, the University of Alberta, and the University of Newcastle-upon-Tyne, all of whom use MTS.

UBC also has a small, traditionally organized, administrative Data Processing Centre. Its function is restricted to administrative computing.

The SFU Centre is unique among the three computing centres in that it actively markets its computing resources to external customers in order to obtain operating funds. Neither UBC nor UVic actively pursue outside business, but they do accept it. However, at UBC, funds obtained in this manner are channelled into general university accounts and do not go directly to the Centre. UBC has recently taken steps to limit further growth in external business.

An important matter related to the possibility of regional computer networking is the plans at each Centre for expanding their on-campus networks. Such plans are well advanced at both UBC and SFU. Briefly, UBC wishes to expand its current remote computing capabilities by developing mini-computer based, message-switched campus communications. It is hoped that the eventual campus network will look something like that illustrated in Figure 1.

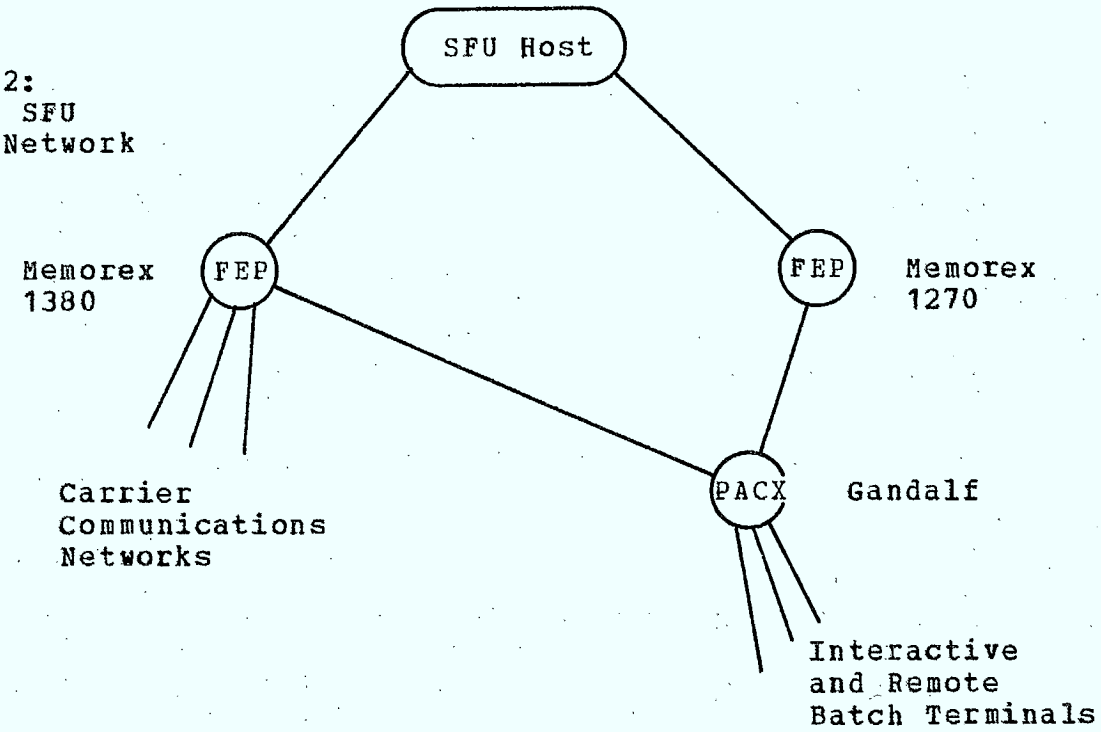
Figure 1:
Planned UBC
Campus Network



If these plans are approved, the software and some of the hardware will be developed by the UBC Computing Centre over the next few years. A reasonable completion date would be 1978. Note that the plans call for interconnection with packet-switched data communications networks which are currently being developed by the communications carriers.

SFU will be expanding its campus network in a different manner. Figure 2 illustrates their plans which are expected to be near completion by mid-1977.

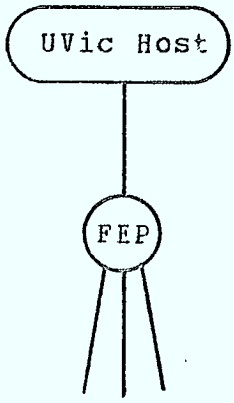
Figure 2:
Planned SFU
Campus Network



Their direction is heavily influenced by a wish to minimize local development work. Note that it is expected that software for interconnection with the carrier-based data communications networks will be commercially available for the equipment that SFU will be using.

UVic is currently developing a campus communications system as illustrated in Figure 3. They do not expect to expand beyond this for the next several years, although they do hope to have a larger host computer.

Figure 3:
Planned UVic
Campus Network



Interactive and
Remote Batch
Terminals

Looking briefly at the future for these Centres, both UVic and SFU must respond to recent growth of academic computing by providing access to modern virtual memory based, general purpose interactive computing. For this reason, both SFU and UVic have requested funds to obtain another computer system. At SFU, one option is that an IBM 370/158 would allow operation of either the VM/370 or MTS operating systems for academic computing; with this option administrative computing would remain on the purchased IBM 370/155. UVic would expect to operate an IBM 370/158 under control of the VM/370 operating system. At this time, it is not clear that the requests for funds will be granted.

The future of the UBC Computing Centre is bound up in a current uncertainty related to the growth of administrative applications. New administrative applications have outgrown the capacity of the UBC Data Processing Centre. The question is whether the Data Processing Centre should be expanded to allow further administrative application development or whether the applications should be moved to the Computing Centre. An indication of the possible resolution of this problem occurred in 1975 when student record processing for the Registrar's Office was moved to the Computing Centre.

The following tables allow a quick comparison of the three Computing Centres.

Table 2 illustrates three important points. The first is that UBC has two separate, administratively distinct, centres. The larger of the two is the Computing Centre (UBC-CC) which serves all of the general-purpose academic computing needs on the campus, as well as a small portion of the administrative needs. The smaller Data Processing Centre (UBC-DP) services the bulk of UBC administrative computer needs. The second point which should be noted is the relative sizes of the computer installations. The UBC academic Computing Centre is by far the largest. The third point is that SFU has a purchased computer with a correspondingly smaller operating budget. If purchased equipment were rented, the equivalent SFU operating budget would be approximately $1.9 million.

Table 2: Personnel, budget, hardware, and operating system software comparisons (1975/76).

	UBC-CC	UBC-DP	SFU	UVic
# of employees	82	27	69	43
# of professional & supervisory staff	48	12	42	33
Budget 75/76 (millions)	3.2	0.7	1.6	1.3
Major vendor	IBM	IBM	IBM	IBM
Major computer	370/168	370/135	370/155	370/145
Rental or purchase	rental	rental	purchase	rental
Operating system	MTS	VS1	OS/MVT	VS1

Tables 3 and 4 show the different service emphasis of the Centres. Table 3 gives the number of professional and supervisory employees working in different job functions, while Table 4 shows the distribution of computing load at each Centre.

Table 3: Professional and supervisory employees in different job functions (1975/76).

	UBC-CC	UBC-DP	SFU	UVic
General Management	2	1	2	4
Academic Services	23		10	11
Admin Services	7	9	16	11
External Services			3	
System Software	12		5	4
Computer Operations	4	2	6	6
Total	48	12	42	33

Table 4: Distribution of computing load (1974/75)[1].

	UBC-CC	UBC-DP	SFU	UVic
Academic use	67.3 %		44.8 %	59.9 %
Administrative use	6.4	100.0 %	23.9	19.6
Computing Centre use	19.6		15.0	14.5
External use	6.7		16.3	6.0

Finally, Table 5 shows the ten largest departmental customers of each Centre. At UBC, nine academic departments and one administrative department account for 45% of the computer usage; at SFU, seven academic and three administrative departments account for 59% of the usage; at UVic, seven academic and three administrative departments account for 72% of the usage.

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[1] The three universities measure computer resource consumption in different ways. At UBC, it is normally given in terms of CC$ usage, where a CC$ is an internal "monetary" unit which will purchase one dollar's worth of computing services, whether it be cpu, printing, card punching, memory usage, or whatever; at SFU, it is measured in machine units, a composite of cpu and memory usage; at UVic, the cpu time is the normal measurement of resource consumption.

An additional complication arises because UBC uses the academic year (September through August) for measurement of cumulative usage, while SFU and UVic use the fiscal year (April through March). Figures in Table 4 pertain to the 1974/75 academic year for UBC, and the 1974/75 fiscal year for SFU and UVic. Thus, figures for resource consumption cannot be directly compared. However, the flavour is obvious.

Table 5: The 10 largest departmental customers of the three largest Centres, and their % computer use.

The University of B C Computing Centre		
1.	Computer Science	10.1 %
2.	Commerce	7.9
3.	Economics	5.5
4.	TRIUMF	5.1
5.	Systems Services (Registrar)	4.2
6.	Chemistry	3.1
7.	Animal Resource Ecology	2.8
8.	Geophysics and Astronomy	2.3
9.	Electrical Engineering	2.2
10.	Forestry	2.2
	Total	45.4 %

Simon Fraser University Computing Centre		
1.	Chemistry	19.9 %
2.	Registrar	15.2
3.	Computer Sciences	5.5
4.	Bursar	5.3
5.	Physics	3.7
6.	Library	2.8
7.	Geography	1.9
8.	Biological Sciences	1.7
9.	Kinesiology	1.4
10.	Economics and Commerce	1.3
	Total	58.7 %

The University of Victoria Computing Centre		
1.	Physics	32.0 %
2.	Mathematics (including Computer Science)	12.5
3.	Registrar	6.7
4.	Chemistry	4.8
5.	Library	4.5
6.	Academic Systems	3.9
7.	Accounting (Bursar)	3.3
8.	Psychology	2.0
9.	Geography	1.3
10.	Sociology	1.3
	Total	72.3 %

II. CURRENT RESOURCES OF THE THREE CENTRES

A network should give access to a wider variety of resources and services than is available locally. From this point of view, the similarity of resources and services at the participating Centres is unimportant; it is the differences between the Centres that have a major bearing on the attractiveness of a computer network. Therefore, the discussion which follows emphasizes differences and ignores similarities.

1. Hardware Resources

a. Central Processors

The basic cpu speeds of the three primary computers at UBC, SFU, and UVic are roughly in the ratio 1:2:8. Thus, the availability of UBC's cpu could be a major advantage to SFU and UVic.

b. Graphics

UBC has a powerful Adage AGT-10 interactive graphics terminal. This is a unique resource in the three Centres, but does not lend itself to networking use because the graphics screen must be visible to the user. However, the general-purpose data transfer capabilities of a network would be an indirect advantage to facilitate graphics use by customers of the SFU and UVic Computing Centres. In general, however, the advantage to UVic and SFU would be minor.

c. Optical Mark Reading

SFU has an IBM 1230 optical mark page reader which is used to generate computer input data from optically readable questionnaires and surveys. Again, because of its nature, no direct network use of this machine is possible, although an advantage in data handling would be available. However, the low level of usage of the device makes this a minor consideration in networking.

d. Seven-track Magnetic Tape

UBC has a 7-track magnetic tape drive which is used by other installations to convert 7-track tapes to the more common 9-track form. Again, a network would allow more convenient data handling but the advantage would be minor.

In summary, the only major hardware resource that would be of significant benefit to a network is the UBC IBM 370/168 cpu.

2. Software Resources

a. The MTS Operating System

Access to UBC's MTS operating system with its general purpose interactive computing and data file handling capabilities would be of significant benefit to SFU and UVic.

b. Vendor-supplied Operating Systems

Access to the vendor-supplied operating systems at SFU and UVic would enable UBC to study, test, and use software packages that have not been converted to the MTS operating system. While not of primary importance to UBC, such access would enable the Computing Centre to round out its software service offerings and respond more successfully to requests for unconverted packages. In addition, Computer Science students at UBC would have easier access to operating systems more generally available than MTS.

c. Academic Software

A survey of the software offerings of each installation shows that the commonly used programming languages, statistical and numerical methods packages, and utility programs are duplicated at each Centre. However, the widest range of holdings is available through the UBC Computing Centre. Its selection of programming languages (general purpose, special purpose, interactive, and cross-computer), and statistical and numerical methods packages is without match in B C (and perhaps even in Canada). Access to this program library would be of some benefit to SFU and UVic. Of particular interest would be the interactive software systems, including IF (Interactive FORTRAN), and interactive statistics packages. However, enthusiasm must be tempered by the knowledge that UBC's wide selection of software is, in part, based on needs within departments that do not exist elsewhere. SFU and UVic do not have many of the departments and faculties (for example, Engineering, Medicine, Forestry, Agriculture) that UBC has.

The benefit is not completely one-sided. SFU and UVic have particular packages that are not available at UBC. These include more modern versions of language processors such as APL/SV and the PL/I Optimizing and Checkout compilers. In addition, SFU has the WYLBUR interactive text editing and remote job entry facility which is widely used and may be of some interest to UBC and UVic.

d. Administrative Software

Administrative applications are most highly developed at SFU where the current Computing Centre originated with the Registrar's Office. Of special interest is the ADABASE Data Management System which should allow the development of highly sophisticated, integrated data management systems for the university. UVic, and to some extent UBC, are currently considering the selection of data management systems of similar scope.

Another data management system, MARK IV, is duplicated on each campus.

Existing administrative applications would be difficult to use by universities other than the one for which the software was originally written. While the universities appear to require very similar systems, there are differences in detail which must be considered if an administrative application is to be used by more than one university. To date only the libraries have made an attempt to write software systems usable by more than one university.

3. Data Collections

UBC has a unique Data Library which is jointly supported by the Library and the Computing Centre. The Data Library currently contains about 560 data sets and subscribes to the offerings of many major data distributors including:

- Canadian Consortium for Social Research
- Statistics Canada
- Roper Public Opinion Research Centre
- Inter-University Consortium for Political Research
- International Monetary Fund

The data collection is expanded with a current annual budget of approximately $6,200. A network would allow easy access to these collections by users of the SFU and UVic Computing Centres, and would remove any need for duplication of the data sets on each campus.

III. THE USERS' VIEW

Since any Computing Centre development should take into account the needs and wishes of its customers, the perceptions of users of the three Centres were gauged via questionnaire. Questions concerned themselves only with the individuals view of the desirability of a network and the uses to which a network would be put. The questionnaire is reproduced in Appendix 1.

Questionnaires were distributed to faculty, staff, and graduate students who appeared on computer user mailing lists provided by each of the Centres. All serious computer users, except Computing Centre personnel, should have received questionnaires. Table 6 shows the number of questionnaires distributed and returned.

Table 6. Distribution and returns of questionnaire.

	UBC	SFU	UVic	Total
# distributed	1031	331	253	1615
# returned	241	51	53	345
% returned	23.4	15.4	20.9	21.4

Normally, surveys of Computing Centre users lead to less than 5% response. The response rates indicate a high degree of interest in the network study.

1. The Need for a Network

Table 7 indicates the users' feelings about the desirability of the Centres forming a regional computer network. In total, 60% of the respondents favour such development, 27% were unwilling or unable to reply, and 13% object. UBC respondents are less enthusiastic (57% in favour) than those from the other universities (68% in favour).

Table 7: Responses to the question: "Should the local Centre take part in a regional computer network?"

	#	% Yes	% No	% ?
UBC	241	56.9	14.5	28.6
SFU	51	66.7	11.8	21.6
UVic	53	69.8	3.8	26.4
All universities	345	60.3	12.5	27.3

(The 4th column gives the % that were unable or unwilling to respond.)

Responses for Faculty, Staff, and Graduate Students can be seen in Table 8, which again indicates that UBC faculty and staff are less enthusiastic than their counterparts elsewhere.

Table 8: Responses categorized by position.

	#	% Yes	% No	% ?
Faculty only				
UBC	148	53.4	14.9	31.8
SFU	27	74.1	14.8	11.1
UVic	39	64.1	5.1	30.8
All universities	214	57.9	13.1	29.0
Staff only				
UBC	19	57.9	26.3	15.8
SFU	14	71.4	0.0	28.6
UVic	10	80.0	0.0	20.0
All universities	43	67.4	11.6	20.9
Students only				
UBC	72	66.2	11.3	22.5
SFU	10	40.0	20.0	40.0
UVic	3	100.0	0.0	0.0
All universities	85	63.5	11.8	24.7

At UBC, a trend is evident when replies are categorized by the respondent's computer resource consumption, as in Table 9. As resource usage increases the number of respondents unwilling or unable to make a judgement decreases, while the number opposed to network development increases.

Similar trends are not evident in the data from SFU and UVic. At SFU the resource consumption of individuals is not easily determined (in fact, 39% of respondents did not reply to the request for their resource consumption). At UVic, heavy resource consumers are overwhelmingly in favour of network participation.

Table 9. Responses categorized by estimated annual computer resource consumption.

The University of B C

	#	% yes	% no	% ?
0 - 1000 CC$	90	54.4	13.3	32.2
1001 - 3000	77	58.4	11.7	29.9
> 3000	73	57.5	19.2	23.3

(At UBC, a CC$ is a "monetary" unit which will purchase $1 worth of computing. The "year" at UBC is the 1975/76 academic year, September through August.)

The University of Victoria

	#	% yes	% no	% ?
0 - 4 cpu hours	22	72.7	0.0	27.3
5 - 12	15	40.0	13.3	46.7
> 12	13	92.3	0.0	7.7

(At UVic, the "year" is the 1975/76 fiscal year, April through March.)

Many respondents qualified their responses. Most simply expressed the feeling that the benefits of networking must justify the costs. Some, however, expressed concern regarding possible bad effects that networking might have upon the local computer service.

From the comments and from interviews with individuals, the major concerns were determined to be as follows:

At UBC, the major concern is that the current high standard of

computing service may be jeopardized if an additional population of users gains access to the system via a network.

At SFU, the major concern is that an already complex system will be made more complex.

At UVic, the major concern is that local computing development may be curtailed if UVic joins a network as the smallest partner.

Table 10 shows the number of respondents who expressed concern about network effects on local computing service.

Table 10: Concern about effects upon local service.

	UBC	SFU	UVic	Total
% expressing concern	17.8	11.8	9.4	15.7

A final comment regarding UBC should be made. Early in 1975, interviews were held with UBC departments accounting for a total of 73% of academic computer usage. At that time, these departments listed national or international computer networking as one of the four top priority new computing services that they would like to see offered at UBC. Local networking was a much lower priority item and, in fact, local networking involving the Provincial Government was of more interest than a network involving SFU and/or UVic.

2. Uses of a Regional Network

A majority of respondents either did not reply, or indicated that they could not reply to the questions concerning possible uses of a regional network. Many indicated that they had no knowledge of facilities elsewhere.

Table 11 shows the number of respondents at each of the universities who did indicate uses for facilities located elsewhere. At UBC only 12% responded positively, while at SFU and UVic the combined number was a high 35%.

Table 11: Replies indicating uses for resources located elsewhere.

	UBC	SFU	UVic	Total
# of respondents	28	19	17	64
% of respondents	11.6	37.3	32.1	18.6

The actual resources which were mentioned are given in Table 12. UBC respondents mentioned most often the set of mapping programs available through the SFU Computing Centre and Geography Department. SFU and UVic respondents cited most often access to the MTS operating system at UBC.

Not listed in Tables 11 or 12, but of interest, is the fact that nine UBC respondents (4% of the total) favoured a regional network only as a start towards a larger network.

Table 12: Resources elsewhere of interest locally.

As Seen by UBC Respondents			
Mapping programs	at	SFU	7 replies
Optical mark page reader		SFU	4
B C Government data		UVic	4
Computer Aided Learning		SFU	3
Vendor-supplied operating systems		both	2
Agriculture, soil, climatology data		both	2
ADABASE Data Management System		SFU	1
PL/I Optimizing compiler		SFU	1
Magnetic tape testing program		SFU	1
TRIUMF program use and data analysis		both	1
Institutional Analysis data exchange		both	1

(It is interesting that Computer Aided Learning is no longer supported at SFU and the optical mark page reader does not lend itself directly to network use.)

As Seen by SFU Respondents			
MTS Operating System	at	UBC	5 replies
TRIUMF program use and data analysis		UBC	3
BCPL programming language		UBC	1
Animal Resource Ecology programs		UBC	1
INTURMAP programs		UBC	1
Program library		UBC	1
Integer programming packages		UBC	1
Standard & Poor's COMPUSTAT tape		UBC	1
Statistical data bases		UBC	1
Library Systems		UBC	1
Alumni Association data base		UBC	1
Text editor		UBC	1
Mathematics Department programs		UVic	1
Library Systems		UVic	1
APL/CAI		UVic	1

As Seen by UVic Respondents		
MTS operating system at	UBC	4 replies
TRIUMF program use and data analysis	UBC	4
Program library	UBC	2
Census data files	UBC	2
3-dimensional plotting	?	1
Library Systems	UBC	1
Radiotherapy treatment planning	UBC	1
MPSX program package	UBC	1
Coursewriter	UBC	1
ERIC bibliographic data base	UBC	1
Psychology data transfer	UBC	1
Content analysis program	UBC	1

The numbers in Table 12 do not relate directly to those in Table 11 because some respondents did not name actual resources while others named more than one.

Finally, respondents were asked to consider whether there were resources available locally which would be of interest to colleagues at the other universities. Responses are as given in Table 13.

Table 13: Responses indicating local resources of interest to colleagues elsewhere.

	UBC	SFU	UVic	Total
# of respondents	38	11	5	54
% of respondents	15.8	21.6	9.4	15.7

The actual resources mentioned are listed in Table 14.

Table 14: Local resources that might be of interest elsewhere.

As Seen by UBC Respondents	#
Text editing systems	7 replies
Adage graphics	5
Statistics programs	5
MTS operating system	4
TRIUMF programs	3
ERIC bibliographic system	3
Institutional Analysis data base	1
Research Forest information	1
Contingency table analysis programs	1
GIDS system	1
Artificial intelligence languages	1
Geographic programs	1
Animal Resource Ecology programs	1
Program library	1
Dun & Bradstreet data file	1
X-ray diffraction programs	1
ALGOL 68, LISP programming languages	1
Content analysis programs	1
ACL Audit Control Language	1
Archeological data reduction programs	1
Data Library	1

As Seen by SFU Respondents	#
TRIUMF programs and data	1 reply
Mapping programs	1
Institutional Analysis data base	1
Chemistry programs	1
MSLP program	1
ADABASE Data Management System	1
Alumni Association address data	1
Simulation of physiological systems	1
Bursar's commitment system	1
Optical mark page reader	1
TESTAT program	1

As Seen by UVic Respondents	#
TRIUMF programs and data	2 replies
Graph theory programs	1
Library serials and newspaper files	1
Statistical programs	1
Physics programs	1

The resources listed in Tables 12 and 14 indicate a high percentage of academic uses. This reflects the academic community's better understanding of the possibilities of a computer network. In fact, many administrative personnel, not unexpectedly, have little idea of the network concept. However, a series of interviews with administrative personnel at the three universities (see Appendix 2) generated a very favourable reaction. Many university administrators could see large potential benefits in the existence of a regional computer network. The potential for cooperative development in the areas of Library processing, Registrar's systems, Institutional Analysis, and possibly financial analysis and reporting appear to be large. A general feeling is that the existence of a regional network would act as a catalyst allowing the development of shared administrative systems of many kinds.

Most administrators, including those who could not see potential benefits, qualified their comments with remarks of uncertainty about the role of the B C Universities Council. Most felt that, depending upon the requirements of the Council, a regional network might become a necessity in the future.

3. Summary of the Users' Views

The previous sections dealt with the views of a wide variety of Computing Centre customers. Some of the respondents are relatively inexperienced computer users and have little knowledge of the concept of computer networking. Nevertheless the results are significant, particularly in a university environment. The following points are evident.

a. A 60% majority of computing customers at the three universities have no objection in principle to the idea of forming a regional computer network, but such development must ensure:

   - added benefits in terms of resources available or reduced costs
   - continued local computing development
   - eventual expansion beyond the regional network
   - ease of use

   However, UBC faculty and staff are noticeably less enthusiastic about regional network prospects than are their counterparts at SFU and UVic.

b. There are significant concerns, expressed by a minority of users, about network development. At UBC, there is a fear that service will suffer because of an additional population of users; at SFU, there is a fear that networking will add another layer of complexity to an already complex system; at UVic, there is a fear that local development will suffer in conjunction with larger and better equipped network partners.

c. Significant percentages of the respondents at SFU and UVic (37% and 32%, respectively) identified potential benefits in the formation of a regional network, while only 12% of UBC respondents identified benefits.

d. Users see immediate academic benefits to regional networking. However, most of these fall into the "it sure would be nice, but the priority isn't high" category.

e. Administrators see significant potential benefits to regional networking. The existence of a computer network would be a catalyst to the development of a wide variety of cooperative administrative systems which could lead to tremendous capability and cost savings in the future. In particular, the library development, institutional analysis, and registration functions could be significantly affected, as could the administrative reporting functions.

f. A significant desire of the UBC academic community is computer networking outside of regional and local institutional boundaries.

g. The identified uses of a regional computer network are:

- access by SFU and UVic to UBC's MTS operating system
- access by UBC to SFU's set of mapping programs
- program and data analysis by TRIUMF
- access to miscellaneous programs and programming languages
- access to miscellaneous data files, including B C Government and bibliographic data
- cooperative administrative program development and data sharing.

IV. NETWORK IMPLICATIONS

The preceding chapter dealt with the networking perspective of customers of the three computing Centres. This chapter presents a more general perspective gained through input from many sources including the aforementioned customers, the literature, interviews with academic and administrative university personnel, discussions with university and industry computer and communications professionals, and an intimate knowledge of the affairs[1] of the UBC Computing Centre, together with some knowledge of the SFU and UVic situations.

The potential impact of regional computer networking is discussed as it relates to the three Computing Centres, the academic communities of the three universities, the universities administrations, and the province.

1. Implications For the Computing Centres

Regional networking could have immediate direct benefits to the SFU and UVic Computing Centres. The recent rapid growth in academic computing on these campuses has created a need to provide general purpose interactive computing services. This need could be met by network access to UBC. (Of course, it could also be met by normal interactive terminal access.)

On the other hand, regional networking will have little immediate direct benefit to the UBC Computing Centre. There are no important services which a regional network will offer UBC customers that are not already offered on-site. Direct immediate benefits consist only of access to a vendor-supplied operating system with the software packages yet to be converted to MTS, and miscellaneous academic programs of low priority.

Potential benefits to all Centres lie in the possibility of shared purchase or lease of software, and division of programming development and support labour, i.e., the idea that individual Centres could develop into centres of expertise each concentrating their efforts upon specific areas.

The first potential benefit, shared purchase of software, will become of more importance as time passes, since university computing centres must maintain a wide variety of software offerings. Most newer software products are proprietary and must be leased or purchased from

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[1] Nothing nefarious intended!

their developers (often a computer vendor). Shared leasing and use would enable all three Centres to maintain a broader, more current selection of software, particularly in the programming languages and data management areas, and at cheaper cost. To give a rough idea of the costs involved, seven IBM program products[1] of interest to the UBC Computing Centre lease for approximately $3,000 per month, while the ADABASE data management system purchased by SFU cost $90,000. In the future, it will not be unusual to see universities spending $10,000 per month on software leases.

The second potential benefit, the idea of centres of expertise, will be very difficult to realize. Neither SFU nor UVic are organized for development, preferring to lease or purchase hardware and software. On the other hand, UBC is organized for development and has long experience in the sharing of maintenance and development workloads within the MTS group of university computing centres. Their experience is that it is not easy to reorganize the thinking of personnel so that they take into account the needs of remote installations, nor is it easy to convince management that what they lose in response to local problems they gain in quality and quantity of products supported. The benefits, of course, arise because the work load is shared across more people and because more thought must go into the implementation and maintenance of each product.

It is important to realize the eventual significance of shared development and maintenance work. Computing centre budgets do not grow at the same high rate as computer usage. Thus, while a centre's capability to produce work rises slowly, the need for more work rises quickly. For this reason, university computing centres are beginning to discuss the idea of sharing work loads; the idea will become a reality in the future.

Most of the manpower for initial network development can probably be released from existing staff given a long term, orderly, network development effort. This manpower would have to come from the Systems Programming Groups at SFU and UVic, and from the Systems and Communications Groups at UBC. However, continuing network development and maintenance will require one new systems programmer-analyst and one new electronics technician at each installation, with resulting salary and space requirements.

Additional impact upon the three Centres would be felt in the need for education, documentation, and consultation on network uses. An effective networking development must include the means by which users are educated in the use of the network. This implies knowledge at each Centre of the availability and use of the resources at the other Centres. It implies that not only must the network software be designed for easy use, but that local staff must be able to respond to users' problems regarding remote facilities. It is one thing to handle problems encountered by local users computing locally; it is

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[1] PL/I Optimizing and Checkout Compilers, Sort/Merge, ANS COBOL, FORTRAN H Extended, Assembler H, APL/SV.

quite a different matter to handle problems encountered by local users computing remotely. There is abundant evidence that these problems are overlooked in most network designs and have led to the failure of many projects.

At UBC, additional professional staff required to handle such consultation could be assimilated into the Documentation and applications programming groups. At SFU and UVic, the additional staff would go into the Academic Programming Groups. Continuing costs in terms of space and salaries for two additional professionals and one clerical employee would be required.

At this point, attention should be focussed upon the fact that the facilities of the UBC Computing Centre would comprise the largest resource on a regional network. In any development in which a single centre dominates, there is the possibility that network traffic will all be toward that centre. In fact, the major identified need that could be fulfilled by a network is access by SFU and UVic to the general purpose interactive computing system available at UBC. The potential for extremely high customer traffic towards UBC can only be appreciated by someone who has been through a conversion from non-interactive computing to interactive computing. Any large load brings nearer that time at which the computer system must be upgraded because local service deteriorates to an undesirably low level. To put it simply, the net effect upon the dominant centre can be a very severe averaging down. To prevent this, the dominant centre, UBC, must be assured that it will receive direct compensation for the services it offers the network so that its system can be upgraded as the network load grows. Currently revenues from external use of the UBC computer system do not go directly to the Computing Centre.

If SFU and UVic are successful in their attempts to obtain new computers, the possibility of heavy traffic to UBC is reduced. But then, the major need for a network disappears, also.

Actually, UBC's computer system is not capable, at this time, of handling a greatly increased load. While there are spare cpu cycles available, the system is relatively weak in terms of I/O capability and real memory. An appreciable network load would require immediate upgrading of the system at a cost of several thousands of dollars per month.

On the other hand, UVic would be the smallest centre on a regional network. There are different problems associated with small size. In particular, it is possible that UVic will have the highest outgoing traffic on the network. Funds which would otherwise go into local development would be diverted elsewhere. Taken to its extreme, the UVic Centre could conceivably be reduced to only the hardware and staff required to interface to the network. However, it seems reasonable to assume that there is a practical limit to the level of service a network can supply before it becomes more economic and convenient to supply it locally. Unfortunately most of the arguments involve factors which are difficult to cost, such as convenience, response to local needs and problems, affect on the local educational process, etc.

Perhaps the best hope to alleviate these worries lies in the belief that the days of university computing centre specialization are approaching. Inexpensive cross-Canada data communications will promote a move in this direction, and such communications is on the horizon. The answer then lies in a judicious choice of specialization so that, as time goes by, every centre, regardless of size, has something to offer the participants in a computer network.

SFU lies somewhere in between UBC and UVic. However, the cpu utilization at SFU is currently greater than 90% during most of the daytime. Clearly, SFU cannot support increased academic computer use with this situation. For that matter, it is difficult to see how they can offer any resources to a network.

2. Implications For the Academic Communities

Regional computer networking would give some immediate benefits to the academic communities at the three universities. A large percentage of the user population at SFU and UVic would benefit from access to the general purpose interactive computing offered by MTS at UBC. A small percentage of the UBC user population would benefit from access to specific data bases and programs available at SFU and UVic. The cyclotron laboratory, TRIUMF, would find a computer network of significant convenience in program development and use, and in data handling and analysis.

Potential benefits lie mainly in the possibility of cooperative data gathering, purchase, storage, and analysis. Statistical and bibliographic data collections are becoming more and more significant to the academic community. Duplication at the three universities would be unnecessary and eventual cost savings would be high (but very difficult to estimate).

Finally, it should be noted that many identified academic uses are currently possible through ordinary remote interactive or remote batch connection. Very little of this type of usage has been successful, largely because of: lack of adequate information, poor response to problems by both the Computing Centres and the telephone company, the reluctance of the largest resource centre (the UBC Computing Centre) to give encouragement to such attempts, and general inconvenience to the user who tries it.

3. Implications for University Administration

While academic computing will immediately benefit from a network development, it appears that administrative benefits are all potential. However, the potential administrative benefits are more exciting than the immediate academic benefits.

Where do these potential benefits lie?

First, with the Libraries. The university libraries organization, TRIUL, has fostered cooperation between the university libraries and has identified several areas in which cooperative computer development can occur. There is no doubt that cooperative development of library systems would be given a boost by the existence of a regional computer network. Applications in circulation, inter-library loans, and holdings (including serials) could be developed and maintained cooperatively.

There is a recent proposal for a separate B C Library Processing Centre. The eventual need for such a centre is probably indisputable. However, there are some systems (for example, serial holdings) which would be unlikely to be maintained on a central facility for some time. In this case, it seems that the use of a regional universities computing network as a basis for a cooperative library processing system could be considered.

However, even if a network existed, there is some question that the potential benefits could be realized by the libraries. The SFU Computing Centre feels that extensive library processing is unsuitable for their general purpose computer system and has not encouraged library applications development. At UBC, it still is not clear whether library applications will proceed on the Data Processing computer system or be moved to the Computing Centre.

Second, the Institutional Analysis functions of the three universities have a need for close cooperation and contact. Uniform reporting and estimating procedures for enrolment prediction, space utilization and requirements, and statistical gathering and reporting needs are potential candidates for regional networks.

Third, one of the more futuristic, but perhaps furthest reaching, capabilities of computer networking is teleconferencing -- the use of computers and communications to facilitate remote interpersonal contact. Teleconferencing will eventually revolutionize the methods of doing business (especially in areas where there are travel difficulties and postal disruptions).

Fourth, the Registrar's and Bursar's Offices, while less enthusiastic, are nevertheless potential beneficiaries of a regional computer network. Currently, the Registrar's function of the universities seems little interested in the prospects of computer networking. And yet, the potential for shared admissions information seems one example of a highly useful application.

Also, the university Bursars' Offices are little interested in the

prospects of a computer network. However, their current lack of interest is tempered by an uncertainty about the role of the Universities Council. Like other administrators, they are quick to point out that the universities Council may make demands of them that would require the close cooperation in computer systems that a network would allow.

Finally, smaller offices, including the Alumni Associations and Research Administration, see potential benefits in a regional network in allowing coordination of information and reporting.

4. Implications for British Columbia

There is a growing belief that education in the use of computers is a necessity within the secondary school and community college systems of B C. However, remoteness and small size make it currently impossible to meet this need. It is evident that adequate communications facilities across the province would enable the computer education goal to be met. One can envisage a data communications network linking high schools, school boards, community colleges, technical institutions, and universities, which would provide all institutions with the desired access to computer facilities.

How futuristic is this idea? Not as futuristic as is commonly believed. In fact, the technology has been developed and is currently being installed in Canada. A universities network would demonstrate the potential that this technology offers, and would provide a base upon which to build. Such a demonstration would be significant, not only to the educational system, but also to, for example, the library system and the hospital system, both of which have significant future needs for province-wide communications.

V. TECHNICAL CONSIDERATIONS

1. Network Topology

In 1972, several Canadian universities attempted to form a Canadian Universities Computer Network (CANUNET), based on the technology developed by the Advanced Research Projects Agency network (ARPANET) in the United States. CANUNET would have provided packet-switched computer communications between Canadian universities. A mini-CANUNET providing such communications between the three universities of concern to us would have looked like Figure 4.

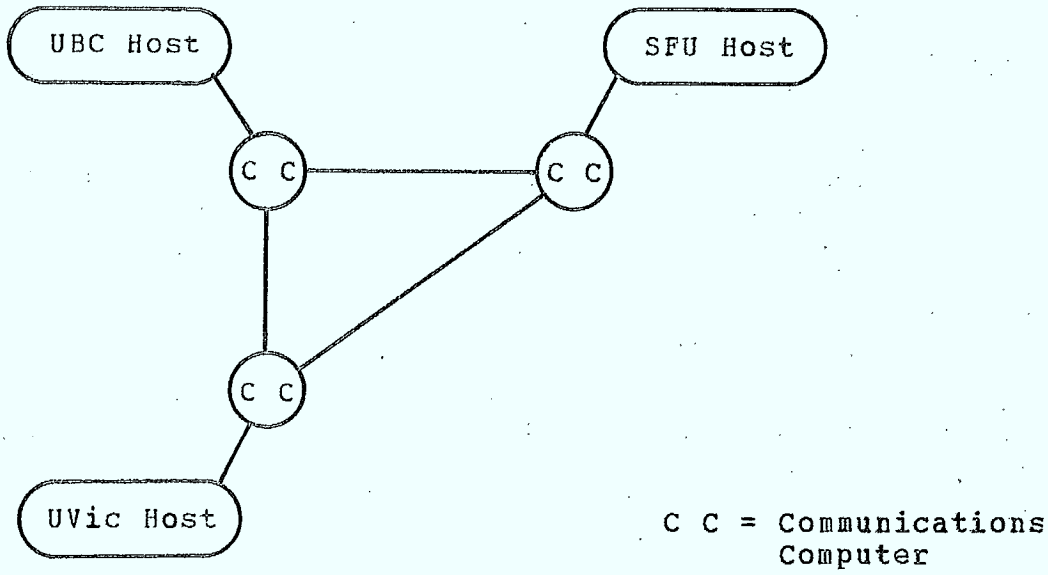

Figure 4: Distributed switched regional network.

In this type of network, the communications and message-switching functions are off-loaded from the large computer facilities (the hosts) by the use of communications computers. The communications lines run from communication computer to communication computer and would be leased high-speed dedicated telephone lines.

However, now, in 1976, the communications system which would have been the major development of CANUNET, is being developed by the Common Communications Carriers, the Trans-Canada Telephone System (TCTS) and Canadian National/Canadian Pacific Telecommunications (CNCP). These carriers are independently building packet- and circuit-switched computer communications networks which will eventually provide coast-

to-coast computer communications in Canada. With these networks performing all of the switching and communications functions, it will become a relatively simple matter to attach a host computer. Thus, a regional, and indeed national, university computing network could be based upon these data communications networks.

A carrier-based regional computer network connecting the three B C universities would have the topology shown in Figure 5.

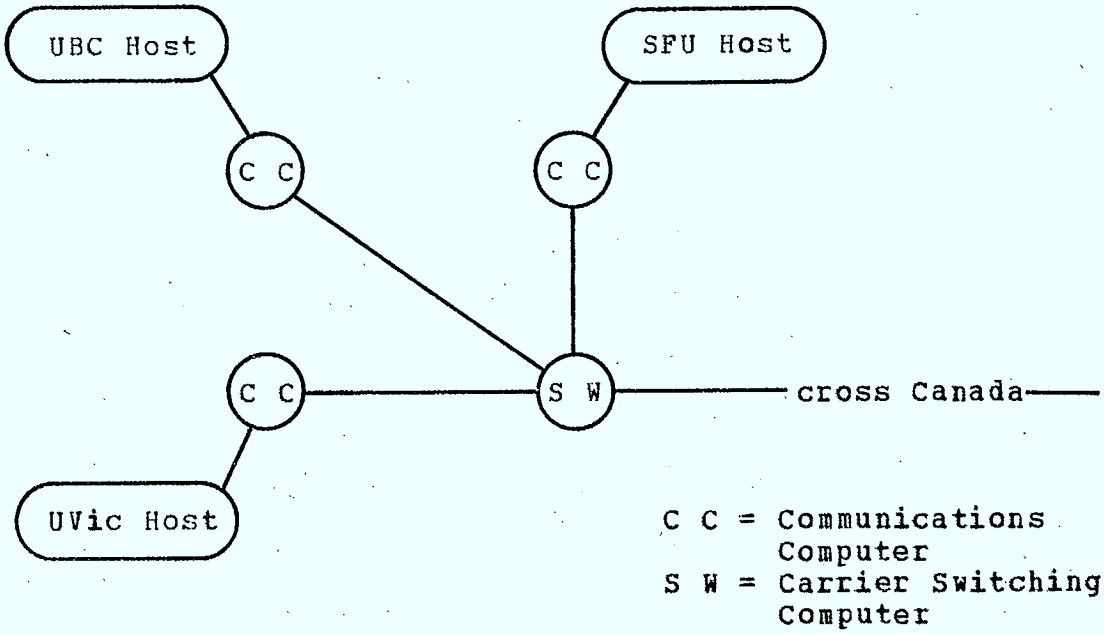

Figure 5: Distributed switched regional network utilizing a carrier switching computer.

Why might we want to develop a regional network in this manner? For the following reasons:

a. The carriers are responsible for all switching hardware and software. Thus the local hardware and software purchase and/or development costs are reduced.

b. The carrier's switching computer is the common interface between hosts. At the same time it serves to isolate them. Thus, local hardware and software development can proceed independently, if desired, except at the user protocol level.

c. The carrier's will dictate all communications protocols except the user level protocol. Their protocols are likely to be as close to a future international standard as anyone is likely to get in the near future. Thus, future retooling in the event of an accepted standard will be minimized and development work can

be concentrated on the user level protocol.

d. Given that the carrier's communications network will eventually provide trans-Canada service, expansion of the regional network to a national network is automatic without further work at the communications level. Naturally, user level protocols must be compatible between the regional network and expansion hosts.

e. Expansion to other institutions within British Columbia, such as Community Colleges or Public Libraries, is easily accomplished by connecting the expansion facilities (which can be simple and inexpensive) to the carrier switching node.

f. The carrier is responsible for the reliability and availability of the network switching facilities.

g. Communications costs will be related primarily to volume of use, with some dependence upon transmission distance and speed of local communications links. (However, it is not yet clear that total costs will be cheaper than dedicated leased lines. This will have to be determined after tariff rates are announced.)

The significance of individual local development should not be underestimated. Both SFU and UBC are developing appreciable on-campus communications networks. While similar in goals, these plans are much different in design, each being largely influenced by local conditions. Perhaps the main influencing factor relates to UBC's organization and history as a software and hardware developer, while SFU has neither the resources nor the wish to embark upon large-scale development projects. Thus, SFU's plans for on-campus networking -- and a regional network must fit into these plans -- calls for the use of vendor-supplied hardware and software of quite a different nature from UBC'S. The existence of a carrier's switching computer to which the universities can interface is an important factor in reducing organizational and compatibility problems which would arise from the differing philosophies of the institutions involved.

2. Host Computers

Network users must be able to access a host from interactive terminals and remote batch stations, and must have general purpose file transfer and shared processing capabilities. Ideally, network access would be independent of the local host in order that the network be available when the local host is unavailable, and in order that network users who only wish to access a remote host do not put additional load upon the local host. This implies that network access control and accounting must lie outside of the local host, a situation which increases the complexity of the communications computer hardware and software.

The host software must be modified to include a so-called Network Control Program. This program has the responsibility for moving data

to and from the network communications computer and user processes.

3. Communications Computers

Communications computers are required in order to attain network independence from hosts, eventual network access independent of hosts, and to offload the communications load from the local host. The type of computer and its software are not terribly important at this point since the carrier's switching node isolates each university and obviates the need for compatibility in this regard. Any number of computers -- for example, PDP-11, Memorex 1380, IBM 3705 -- would be suitable. Naturally, cost and performance would be prime factors in choosing from amongst the candidates.

Advantages gained in off-loading communications handling include a reduction of the processing load in the host, and the usual advantages gained because one component can be developed, modified, and debugged independent of the others.

Communications computer hardware and software would be made more complex by the desire to have network access independent of the local host. Network access control and accounting would then be part of the communications computer function in order that network traffic not be generated by unauthorized attempts at connection. It would be necessary to include disk storage devices on the communications computer in order to perform this function. For these reasons, network access independent of local hosts would probably not be included in an initial development.

Communications computer software must support communications between itself and the host and the carrier switching computer. In terms of the communications protocols described in Section 5, the software must support the data link control, packet protocol, and virtual call protocol.

4. Communications Lines

Communications lines to the carrier switching computer would be 4800 or 9600 bps full-duplex leased telephone lines. Network traffic is multiplexed onto these lines by the communications and switching computers. Line costs cannot be determined at this time since the carriers haven't yet announced tariff rates.

How are the figures 4800 and 9600 arrived at? The line speed should, of course, be a function of the network traffic since the lines must be fast enough to ensure that transmission delay is tolerable. Network traffic in a university environment is notoriously difficult to estimate, mainly because it is not under the control of a single

authority, but is under the whim of many individuals acting independently. The best explanation for the figures is that they are educated guesses based on experience elsewhere. For example, the MERIT Network linking the University of Michigan, Wayne State University, and Michigan State University is a packet-switched, distributed network utilizing 4800 bps lines. The total user population at those universities is very much larger than that at UBC, SFU, and UVic. In addition, Bell Northern Research in Ottawa has measured typical traffic from general purpose interactive terminal systems (including VM/370 and MTS) and concludes that a 9600 bps line can easily support the traffic from one hundred 300-bps terminals.

5. Communications Protocols

There are four levels of protocol involved in transmission of packet-switched data between user processes. At the lowest level there is the data link control which assures accurate transmission along the communications lines themselves. At the next level is the packet protocol which defines the format of a packet of information which may be sent along the communications lines. Such things as packet size and positions of control and address fields are defined by this protocol. The third protocol level is imposed upon the packet protocol and is the means by which the local communications computers identify and control transmissions between users tasks. This level is called the virtual call protocol. The final level is imposed upon the data itself and is termed the user level protocol. It is the set of rules by which user tasks interpret the data transmitted.

The first three protocol levels are currently the subject of intensive study with a view to arriving at international standards. Although standards have yet to be established, they appear sufficiently close that regional network development can do no better than to follow the protocols which will be used by the carriers.

The current state of user level protocols is quite different. Several broad classes of user level protocol are required. These correspond to the types of network service that are provided, and include, for example, interactive terminal protocol, batch processing protocol, and general file transfer protocol. It is important to realize that we are not concerned here with the specific form of the commands or job control that the operating system expects. That is, we aren't concerned with the Job Control Language or Command Language as the user sees it; rather we are concerned with the controls necessary to:

- form network connections to user level tasks
- reject requests for connection to user level tasks
- terminate connections to user level tasks
- delimit lines, files, transactions, data
- determine character sets, data compression techniques
- handle attention interrupts and other break conditions

and other user level control and communication mechanisms. The user

himself will not necessarily be specifically aware of these mechanisms. He will normally communicate in the job control language expected by the operating system.

In a small network with only a few hosts, or similar hosts with similar operating systems, there is no real problem at this level. The communications computer at each site will contain software to ensure that a network standard user level protocol is followed. This standard would likely be a compromise based upon the needs of the existing host operating systems. Any differences between the protocol and actual host system requirements would be resolved by the communications computer software.

However, if the ultimate aim of network development is to be part of a much larger national network of computing resources, the consequences of regional development using a different user level protocol from other regional network developments are serious. Looking at it locally, if UBC, SFU, and UVic all used different user level protocols, three sets of software to resolve differences would be required in each communications computer. If UBC then decided, through whim or necessity, to change its protocol, both UVic and SFU would have to modify the software which resolved differences between their protocols and UBC'S. Obviously standardization is much better, since it requires each installation to deal only with the differences between the local operating system and the standard.

The carriers are probably in a position to introduce de facto user level standards. (At least one carrier intends to offer user level connection to the packet switched network.) The B C universities should take note of the carriers' work in this area and take part in any larger standardization effort.

6. Network Access

A desirable property of network access is independence from the local host. Independence would allow the use of the network when the host is down, and would ensure that network communications placed no load on the local host when a network transaction involved only a remote host. Presumably, network communications would then be less expensive than if the local host were involved.

Independence can only be achieved by incorporating network access control and accounting into the communications computer. This implies a large software development effort in order to handle accounting transactions of all types, including limit controls on network use by an individual account. In addition, more hardware would be required in order to store accounting information. The assumption here, of course, is that the hardware is structured in such a way that a terminal has a path to the network independent of the host. This will indeed be the case in the plans for on-campus network development at UBC and SFU.

It may be reasonable for an initial network development to rely upon the local host for access control and accounting. In order to minimize such reliance, communications with the local host would be required only during initiation and termination of network connections -- during initiation in order to verify the right to network access and during termination in order to accumulate accounting information. While not meeting the desire for complete host independence, such a scheme would reduce initial network development costs. Naturally, if this approach were chosen the initial design would allow for eventual inclusion of host independent access.

7. The Carriers' Networks

Unfortunately, the carriers have yet to announce technical details regarding their switched data communications networks. The answers to such questions as network message delays, error rates, reliability, security, and tariff rates for connection and message transmission are as yet not officially available. Even the transmission protocols are not completely settled, although some details are known. If network development along the lines suggested in this chapter were to proceed, the technical details of the carrier networks must be closely considered. Despite the lack of information, there is no question that network development via the carriers' switching computers is the only reasonable way to form an expandable local network.

VI. ORGANIZATIONAL CONSIDERATIONS

1. Management of a Network

In a computer network in which there are several partners of equal status it is common to form a management structure to:

- formulate network policy
- administer the funds jointly contributed to the project
- organize and market network services such as education and consultation.

The network organization is often administratively distinct from that of the host computing centres.

With regard to a B C universities' computer network, a separate administrative structure to support network development and operation is unnecessary. It would be a mistake to separate network services from the other services cffered by the university Centres. Instead, network services must be integrated with all other services. Thus, network host operating system software would be developed and maintained by the normal operating systems group; network communications hardware and software would be the responsibility of the group which develops and maintains on-campus communications; network education, documentation, and consultation would be incorporated into the standard educational and consultative procedures of the Centres. In other words, a network project should be undertaken in exactly the same manner as any other complex project.

The suggested network topology, incorporating the switching computer of one of the carrier-based data communications networks, allows network development on a far less formal basis than would otherwise be possible. The inherent isolation of each network host, together with the pre-defined communications protocols, minimize the need for cooperative development work. In particular, with the differing philosophies cf the potential network hosts, and the well-advanced on-campus network plans, the carrier switching computer decreases the need for a formal organizational structure. However, a coordinating network committee, with members from each Centre, is required to organize the policy and technical cooperation required. Policy decisions must be made in, for example, the accounting area, while technical cooperation in user level protocol development must be started well in advance of actual hardware or software development.

2. Network Accounting

Payment for network use is an important management issue. This must involve the transfer of real funds between network participants, the amount being based, of course, upon differentials in network traffic between installations.

A successful accounting scheme must be simple to administer. Simplicity implies that funds to pay for network traffic should be transferred at the Computing Centre level and not at the individual level. In general terms the accounting scheme might work as follows:

- each network job would generate accounting statistics in a standard form. The accounting information for each job would be made available to the host at each end of the network connection on termination.
- accounting statistics would be accumulated by each host and periodically analysed. Each Centre would produce reports listing all local network use as well as remote use of the local host.
- the accounting reports would be used to determine the total amount to be billed or paid to other Centres. The Centres would transfer funds based only on the relative totals used.
- local Centres would be responsible for billing and collecting from local individuals; they would not deal with individuals at remote locations. Presumably, network billing would be incorporated into standard local billing procedures.

Of course, clerical procedures for checking accounting information and transferring funds are required.

It is important to realize that this broad presentation understates the problems that will be encountered in accounting development. Most operating systems do not currently include such things as individual usage limits which will be necessary for successful network operation.

Since the carriers have not announced tariffs or billing procedures, it is not yet possible to consider network billing in this regard.

3. The Facilitating Network

The so-called facilitating network refers to the services required to facilitate use of the computer network. Included in this context are:

- documentation
- education
- consultation
- response to hardware or software problems
- accounting

If a network is to be an effective service, it is important that the means to meet these needs be incorporated into the normal operation of

the participating installations. In network use, computer users should be able to deal with the same bureaucracy and personnel that they deal with for local computing. Users with computing problems identify with the operation of the local computer, regardless of whether they are computing remotely or whether a separate network organization exists.

Operation of a facilitating network is strictly a people problem -- personnel with responsibilities for network operation, maintenance, education, and accounting must be identified.

4. Network Costs

At this time, it is not possible to determine the costs of regional network development. Part of the difficulty arises because the carriers have yet to announce tariffs for their packet-switched networks. However, the major difficulty comes from the fact that regional network development is closely connected to on-campus network development. The cost of on-campus network development enccmpasses much of the cost of regional network development.

For UBC, once the on-campus switched network is in place, regional networking requires the addition of a mini-computer network gateway. This would involve a hardware expenditure of approximately $50,000.

Software development will benefit from on-campus network development. An estimate of 5 man-years for total on-campus and network gateway software development is currently being used in planning at UBC. This assumes both experienced personnel and a well-defined problem. The area which is currently ill-defined is the user protocols. An appreciable amount of time, including consultation and cooperation with other network participants will be required to settle this problem. This time is not included in the 5 man-year estimate. Also, this figure assumes that network accounting will reside with the host.

For SFU, the cost of adding regional network capability to the campus network depicted in Figure 2 is dependent upon Memorex 1380 requirements. Network software to connect the 1380 to the carrier networks will be commercially available in 1977. However, it will be some time before details are known.

For UVic, all options are still open. They could benefit from the work at either UBC or SFU.

Most of the personnel time for network development would come from existing staff. However, an additional systems/communications programmer-analyst would be required at each installation.

The existence of a network would put a varying load on each member of the applications programming groups at each university. The combined increase would require the addition of one applications programmer-analyst with responsibility for consultation in network use. However,

everyone in the applications groups would feel the effect of the availability of facilities elsewhere.

Because of the increased education, documentation, and consultation load, another professional with responsibility for network education and documentation would be required. Again, the increased work from these areas will impact every member of the applications groups.

Finally, clerical help would be required to carry out network accounting procedures, documentation distribution, and other network related clerical functions.

5. Funding

The possibility of external funding of a regional network has not been looked at closely. The Educational Technology Branch of the Federal Department of Communications has recently been disbanded. A new B C Provincial Government has recently been elected. As a result, the options for external funding are unclear at this time. Also, the economic climate throughout Canada argues against embarking on new, ambitious projects.

Furthermore, outside funding would raise the priority of a network project to an unjustifiably high level in relation to the serious service problems which must be solved by the universities in the near future. These problems include on-campus networking at all universities, interactive academic computing at SFU and UVic, and administrative computing at UBC. A network project could only be considered high priority if it tackled all of these problems.

Many university administrators have suggested that the B C Universities Council would welcome a universities computer network as a tool to further its goal of resource sharing, with eventual cost savings, between the universities. This suggestion was not pursued.

The universities should, in due course, obtain funding for a network project through normal channels, which automatically involve the Universities Council. Strong representation about the cooperative nature of the project and the potential cost savings could be made at that time.

VII. SUMMARY

To summarize, the major conclusions which can be drawn from each of the preceding chapters are:

Chapter I

A local network development would interlink two similar Computing Centres, SFU and UVic, with a third, quite different, Centre, UBC.

Chapter II

Current hardware and software resources of network interest are few and include only the UBC cpu, the SFU ADABASE Data Management System, the UBC MTS operating system, and the UBC program library.

Chapter III

Computer users have little objection in principle to the idea of forming a computer network, provided local development doesn't suffer and there are definite benefits. However, UBC users are noticeably less enthusiastic than SFU and UVic.

Users cannot identify important network benefits other than those described in the Chapter II summary, except for some data and program sharing possibilities.

Chapter IV

The greatest identified need that a network would fulfil is to provide general purpose interactive computing to SFU and UVic. Other than this, benefits to academics are immediate but of low priority. Benefits to administration are potential and could lead to major efficiencies and cost savings.

Chapter V

A computer network, based upon the existence of a carrier communications switching computer, is feasible and has many advantages, including ease of expansion within B C and across Canada. Also individual network development by each campus is feasible and in keeping with advanced plans for on-campus networking at UBC and SFU.

Chapter VI

A network development should include minimal formal organization. This is possible with the carrier based network.

The importance of network user services cannot be overestimated. Such services should be incorporated into the existing structure of each Centre.

Network development and operation would require three new professional employees at each university Centre, as well as one technician and one clerical employee.

In keeping with the idea of minimal formal network administration, network funding should be obtained through normal channels and not through outside agencies. Network development should not be given a priority inconsistent with the current needs of the Computing Centres.

VI. RECOMMENDATION

After all this then, what is the answer to the question:

> "Should the B C Universities form a local resource sharing network?"

There are two sets of arguments that are important but, unfortunately, they argue on opposite sides. One set deals with the current realities; these argue against networking. The second set deals with the future potentials; these argue for networking.

The current realities are:

a. SFU and UVic have a serious need to supply general purpose interactive computing to their academic users. This need could be met by access to UBC. However, no important benefit to UBC has been identified.

b. SFU currently has over 90% cpu utilization during the daytime hours from 10:00 am to 4:00 pm. It is clear that they cannot offer significant resources to a network. Similarly, UVic, being the smallest centre, offers few resources of interest elsewhere, and probably cannot consider networking before the installation of a larger computer.

c. SFU and UVic have each requested funds for a larger computer system. If they obtain these funds, they will be dealing with new operating systems, and other projects will be low priority for some time. If they don't obtain the funds, then they must solve their need for academic interactive computing some other way, perhaps by access to UBC. However, such access is unlikely to be in the form of an equal partnership in a network, since large sums of money would have to be transferred to UBC before such access is viable.

d. UBC user's cannot identify important needs that a regional network would fill.

e. UBC will probably experience a greatly increased local administrative computing load on its academic computer. SFU and UVic, with heavy emphasis on administrative computing, currently average approximately 22% administrative computing; UBC has 6%. The probability for a greatly increased local computer load at UBC is high.

f. UBC currently has an unbalanced computer system which is deficient in memory and I/O capability, relative to cpu performance. A significant increase in computing from network sources would require the expenditure of several thousand dollars per month.

The future potentials are:

a. A computer network would allow the development of many cooperative administrative applications with high potential for cost savings.

b. The potential cost savings in shared purchase of data and software resources, both academic and administrative, is high.

c. The potential savings from sharing of work loads, both academic and administrative, is high.

A current factor which argues for the creation of a regional B C universities network relates to the development of packet-switched communications in Canada. The university Centres' role as leaders in the use of innovative computer technology suggests an immediate network development to demonstrate the viability of shared computing using these communications.

This final argument notwithstanding, it is evident that the potential benefits of networking can only be realized after a successful network development. However, the current realities and uncertainties act against a successful network project. In the immediate future, such a project would be unable to compete with higher priority needs within the Centres.

Despite the current situation, it is evident that the three B C universities will be involved in computer networking in the future. In fact, trends in the computer field are inexorably in the direction of distributed, shared computer resources. The university Centres should be cognizant of this trend and must take it into account in all future planning and development.

Very few people seem to have realized the importance of the carrier-based switched data communications networks currently being developed. Relatively inexpensive cross-Canada data communications will have an astounding effect upon Canadian society. New ways of doing business, as well as new businesses, will be fostered by these developments. Computer specialization and resource sharing will become a reality. University computing centre resource sharing will be part of this reality, and so UBC must continue with its long term plans to connect to the carriers' networks, and SFU and UVic must allow for the possibility in their on-campus network developments. A computer network will result, in due course and in keeping with the service priorities of each Centre.

Meanwhile, senior university administrators and the Universities Council should be made aware of the potential benefits of a regional computer network. In this regard, a serious attempt to detail potential shared administrative applications, with costs and savings, would be useful. Such a project seems to be the responsibility of the Universities Council. In addition, the wider potentialities of the data networks should be brought to the attention of government and university officials; their significance to province-wide communication should not remain unnoticed for much longer.

Since network development is inevitable in the long term, the Centres should find some mechanism for continuing the fruitful dialogue that this network study has fostered. As a first step, the Network Study Coordinating Committee should meet periodically as a forerunner of the Network Management Committee which will eventually be needed. In particular, this group should ensure that the Systems and Communications personnel of the three Centres continue to meet to exchange ideas, experiences, and future plans. The Committee should also consider the emphasis in this report on user level protocols, network accounting, and network information services. This emphasis has derived from a realization that the success or failure of a network, at the user level rather than the technical level, hinges upon these areas. Many technically successful networks have yet to achieve acceptance by computer users because of neglect of the critical user/network interface. The Network Study Coordinating Committee can ensure that each Centre has a continuing awareness of this problem.

Appendix 1

User Survey Questionnaire

B. C. Universities Computer Network Study

U. Vic. User Survey September, 1975

1. Do you think the U. Vic. Computing Centre should participate in a regional computer network with S. F. U. and U. B. C.?

   No ___ Yes ___ Any comments?

   _____

   _____

2. Do you currently use any services, equipment, or computer programs of the S. F. U. or U. B. C. Computing Centres?

   No ___ Yes ___ If yes, at S. F. U.? ___ U. B. C.? ___. Please give details.

   _____

   _____

3. Are there services, equipment, or programs available at the S. F. U. or U. B. C. Computing Centres that you would like to use, but cannot?

   No ___ Yes ___ If yes, at S. F. U.? ___ U. B. C.? ___. Please give details.

   _____

   _____

4. Are there computer services, equipment, or programs available here at U. Vic. that your colleagues at S. F. U. and U. B. C. are using or would like to use? (Such services, equipment, and programs need not necessarily be supplied by the Computing Centre.)

   No ___ Yes ___ If yes, please give details.

   _____

   _____

5. What is your annual computer usage expressed in CPU hours?

   0 - 4 ___ 9 - 12 ___ 17 - 20 ___

   5 - 8 ___ 13 - 16 ___ > 20 ___

6. All replies are confidential. Please give your name in order that I can follow up your reply, if necessary.

   Name: _____ Faculty ___

   Department: _____ Staff ___

   Telephone: _____ Graduate Student ___

   Undergraduate ___

Appendix 2

Administrative Personnel Interviewed

University Libraries

UBC - R. W. Macdonald, Coordinator of Technical Processes & Systems
P. A. Simmons, Assistant Professor, School of Librarianship
SFU - D. Baird, University Librarian
UVic - R. Campbell, Library Systems Analyst

Student Record Processing

UBC - R. A. Jahelka, Director Systems Services

Bursars Offices

SFU - R. Horton, Management Information Accountant
UVic - D. Davis, Chief Accountant
G. Underhill, Accountant

Institutional Analysis

UBC - Dr. W. L. Tetlow, Director
UVic - Dr. J. Currie, Director

Research Administration

UBC - Dr. R. D. Spratley

Computing Centre Administration

UBC - Dr. J. M. Kennedy, Director
A. G. Fowler, Associate Director
SFU - P. Madill, Associate Director
UVic - H. Widdifield, Director

Appendix 3

Bibliography

The following references were found to be most helpful in putting the prospect of B C educational computer resource sharing into perspective.

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Department of Advanced Education
Steering Committee on Computer Development
May 1974

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Computer Networks: A Tutorial
IEEE Computer Society Publications
Long Beach, California
1974

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Computer Networks: Proceedings of the 1974 Symposium
IEEE Computer Society Publications
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1974

10. Kimbleton, S. R. And Schneider, G. M.
Computer Communications Networks: Approaches, Objectives, and Performance Considerations
ACM Computing Surveys 7 (129) September 1975

In addition, publications of the three principal, working, resource sharing networks: the ARPANET, the MERIT Network, and the ALOHA Network are of great interest. These appear in many places but the principal sources are:

for the ARPANET:
Proceedings of the Fall and Spring Joint Computer Conferences, starting in 1970

for the MERIT Network:
MERIT Computer Network Publications
The University of Michigan
108 Cooley Building
2355 Bonisteel Ave.
Ann Arbor, Michigan 48105

for the ALOHA Network:

The ALOHA System Technical Reports
University of Hawaii
2540 Dole Street
Honolulu, Hawaii 96822

Finally, Reference 10 (above) lists nearly two hundred additional titles.

LEIGH, J.L.
--B.C. universities computer network
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