A PILOT STUDY OF THE DEMAND

FOR

NON-VOICE TELECOMMUNICATION

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The Canadian Department of Communications (DOC) contracted the Institute of Applied Economic Research (IAER) to carry out a pilot study on the demand for non-voice telecommunication services in Canada.

The work was carried out at the IAER in late 1977 and early 1978 by the following team of researchers:

Project Director:	Jon A. Breslaw
Researcher:	Jose Vrljicak
Research Advisor:	Vittorio Corbo.

We would like to acknowledge the assistance we received from L.A. Shackleton of the Computer Secretariat and Prabir Neogi of the Department of Communications. We would like to thank the members of the DOC and the FCC for their cooperation, and for the beneficial discussions with us, while carrying out this study, as well as Melanie Neufield who provided secretarial assistance throughout this project and Esther Massa for her typing.

FORWARD

Sir George Williams University and L'Ecole des Hautes Etudes Commerciales affiliated to the Université de Montréal jointly established on June 2nd,1969 the International Institute of Quantitative Economics (I.I.Q.E.) to initiate original research and promote international scientific collaboration in the field of quantitative economics.

A major reorganization of the I.I.Q.E. took place in April 1976 resulting in the adoption of a new policy statement and set of objectives as well as the renaming of the I.I.Q.E. to the Institute of Applied Economic Research (I.A.E.R.). Consequently, the I.A.E.R. located at the Sir George Williams Campus, has been established as Concordia University's institute for programs of socio-economic research and training related to both the developing world and Canada.

Nations both rich and poor, individually and collectively share many common domestic and international problems, which contribute to the growing threat of global deterioration. Prominent among these problems are the need for economic development of less developed countries and the need for readjustments in the economic policies of industrialized societies. Recognition of the importance of these problems should lead institutions and interested individuals to apply existing socio-economic knowledge to their solution.

The I.A.E.R. believes that a major step towards finding acceptable solutions to the above problems is domestic and international cooperation. To this end, the I.A.E.R. utilizes the most modern methods of scientific analysis available, as well as the services of internationally recognized experts in the relevant fields in:

1) initiating, organizing and implementing major economic research projects, at both international and Canadian levels, occasionally in collaboration with other research institutes and interested specialists;

2) organizing seminars and conferences on specific economic issues of particular international and Canadian interest;

3) serving as a link between Concordia University and the Canadian private sector with the objective of increasing the latter's awareness of, participation in and support for applied economic research.

The I.A.E.R. believes that it has a necessary and useful role to play in both Canada and the developing world, particularly Latin America and Francophone Africa, given the accumulated experience and expertise of its research staff.

Professor V. Corbo
Director

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EXECUTIVE SUMMARY

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Objectives

The overall objective of this study is to obtain forecasts for the demand for non-voice telecommunication services which are likely to be available over the next ten years. A secondary objective is to evaluate the impact of this demand on rural users of telecommunication services.

Structure

The research was developed along two separate paths. The first path, reported in Part I, involved a comprehensive literature search in the area of non-voice telecommunication services, with particular emphasis on

1 the state of the art, and

2 the impact on rural telecommunications.

The second path, reported in Part II, consists of designing a model to give an indication of the growth of demand for non-voice telecommunication, and then applying the model to produce predictions for non-voice data transmission in Canada until 1985.

SUMMARY

Part I

An extensive bibliographical search was carried out as a basis prior to the main project. A selection of the bibliography is presented both in the text and as appendices. Specifically, an appendix is presented with bibliography concerning developments in the field of computer communications outside North America.

A description of some of the main trends in the field of computer communication is presented. The main trend in the field to be noted is the ever growing interconnection among computers, specially since the introduction of packet-switching networks.

Another innovation to be noted are optical fibres, which are expected to have an important impact on the cost of telecommunications.

The continuing decrease in the cost of electronic devices, specifically the ones that are needed to make use of broad-band channels (multiplexing) are expected to make possible the introduction of real improvements in the quality of rural communications. This could be called the extension of the "wired-city" to the rural milieu.

Part II.

The level of EDP activity was determined by scaling down the US level of all-user EDP expenditure; scaling factors were determined by comparing EDP expenditure and employment for a number of sectors. Since the scaling factor changes over time, a model was built to simulate the scaling factor, and to allow for future forecasts of the scaling factor. The difference in use of data communications in Canada and the U.S. was investigated, and a technological lag factor was derived.

The growth of data transmission in the U.S. was modelled, based on various estimates. This allowed for a prediction of U.S. non-voice data transmission, and hence, by applying the scaling factor, a forecast of Canadian non-voice data transmission until

1985. A comparison of the predictions derived in this study with those derived by the Computer Secretariat is also carried out. A summary of the results is given in the conclusion.

PART I

COMPUTER/COMMUNICATIONS

It is common place nowadays to state, when dealing with the subjects of computers and communications, that they have become so intertwined that it is impossible to say where one ends and the other begins.[1]

As V.G. Cerf[2] puts it, the communication aspect of computing is more visible because the availability of wideband transmission media. On the other hand, the computing aspect of communication is more apparent now as computers are used to control the swtiching and allocation of transmission bandwidth.

COMPUTERS[3]

The present status of the computer field could be described around its uses and technical characteristics. The users of the computer can be classified, following Ruth M. Davis[4] into three sets of applications.

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[1] D. Farber and P. Baran. The Convergence of Computing and Telecommunications Systems. Science. Vol. 195, No. 4283, 18 March 1977, pp. 1166-
D.F. Parkhill. Society and Computer Communication Policy. In Proc. of the Third International Conference on Computer Communication. Toronto 3-6- August 1976.
See also the January 1977 issue of IEEE Trans. Commun. (Vol. COM-25), devoted to computer communications.

[2] V.G. Cerf, Research Topics in Computer Communication. Planning Conference on Computer Communications, Washington, D.C.1976.

[3] The American Federation of Information Processing Societies, Inc. (AFIPS) publishes a series of volumes of State-of-the-Art reviews on developments on the field: Annual Review of Information Science and Technology. Edited by Carlos A. Cuadra and Ann W. Luke. AFIPS Press. Montvale, New Jersey.

[4] Ruth M. Davis, Evolution of Computers and Computing. Science. op.cit. p. 1101

Scientific calculation applications, characterized by relatively small amounts of input and output, and large amounts of (often complex) computations. It also required little amount of software support as the scientific community can provide its own software.

Data processing applications, characterized by large amounts of input and output and relatively small amounts of data computation. The users of these applications rely more on the suppliers to provide a more complete system, including the software.

Computer control applications, are the less known of the computer applications. This appears to be the area with more potential for growth in the near future.[5]

As for the technical aspects, following are the main characteristics that can be observed with regard to computers nowadays.

- large scale reduction of the size of computers and their cost
- increasing computing power and reliability
- a trend towards more and more sharing of computing resources
- the growth of smart terminals
- the use of the superconductivity properties of some materials at very low temperatures
- use of fibre optics in the circuitry within the computer[6]

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5 G.U. Merkel and D.E. Doyle. Trends in industrial computer communications. Proceedings of the 8th Annual Southeastern Symposium on System Theory, Knoxville, Tenn, April 26-27, 1976. (New York: IEEE 1976), p. 295-305
K.D. Mueller. Instrumentation system trends in European Laboratories. IEEE Trans. Nucl. Science (USA), Vol. MS-24, No. 1, p. 336- 73, (February 1977)

6 R.G. Burke, Fibre optics in computing systems. 1977 IEEE International Symposium on Circuits and Systems Proceedings, Phoenix Arizona, 25-27 April 1977, (New York: IEEE 1977), p. 176-8

The physical limits to large scale integration (LSI) do not appear to be near, so we should expect more and more computing and memory power in the already small units (chips). It is possible to expect[7] by the early 1980's, the existence of a complete mini-computer chip of a squared inch, with a 16-bit CPU, 32K bits of memory and simple I/O interfaces, with manufacturing costs of less than $10. Robert Noyce[8] calculates that if the present rate of increase of complexity (in the chips) were to continue, integrated circuits with 10^9 elements would be available in 20 years. This trend towards miniaturization is permitting the existence of smarter terminals, those which do part of the processing by themselves, and this is part of the distrubuted computing trend.

One area that is, for the time being, acting as a barrier in the reduction of both size and cost of electronic apparatuses in general, are the input-output (I/O) devices (interfaces), the transducers and the interconnections. Another, and related, problem is how to assemble the great variety of equipment produced by the many manufacturers to work economically and realiably.

As a whole, in spite of all the encouraging signs, some authors expect a slowing down on the rate at which imaginative uses of the computers are going to be introduced, when comparing to the first 25 years of computer history.[9]

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[7] Ruth M. Davis. Evolution of Computers and Computing. Science. Vol. 195, p. 1098, quoting D.A. Hodges, Computer Design 15 (2), 77 (1976).
See also the September 1977 issue of Scientific American, which is devoted entirely to the subject of Microelectronics.

[8] Robert N. Noyce. Large-Scale Integration: What is yet to Come, Science, Vol. cited, p. 1103

[9] See Ruth M. Davis. op-cit p. 1102

COMMUNICATIONS

In the above section, we highlighted the situation and trends in the computers. In this seciton, we shall review developments in the communication among computers and other devices.

Computers have usually attached to them a variety of devices which provide input and receive their output. These computer terminals can be located almost anywhere as long as communication links exist.

Computers also communicate among themselves forming what are called computer networks.[10] In turn, computer networks can communicate among themselves, in what is called internet-working.[11] These computer networks could be located in different countries (and continents), which raises the issue of international standardization (where the regulatory agency has an important role to play).

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10 N. Abramson and F.F. Kuo. Ed., Computer Communication Networks. Englewood Cliffs, N.J.: Prentice-Hall, 1973. Since 1976, there is a quarterly journal devoted to the subject: Trends and Applications 1976: Computer Networks. New York: IEEE (1976), v + 186, (Conference held at Gaithersburg, Md. Date 17 November 197

11 See P. Marin. Interconnection of networks. Convention Informatiqu Pt.I, Paris France, 20-24 Sept. 1976. In French.
C.A. Sunshine. Interconnection of computer networks. Computer Networks (Netherlands), Vol. 1, No. 3, p. 175-95, (Jan-1977).
L.G. Roberts. International Interconnection of Public Packet Networks. In ICCC 76, pp. 239-245.

The development of computer networks is parallel to the increased use of distributed computing.[12] Distributed computing is defined by Vinton Cerf[13] as follows:

- A computation performed in parallel and generally asynchronously, but co-operatively, by many processors
- A general term for a computing system in which processing and storage facilities are geographically dispersed, but loosely coupled by transmission media

In 1961, Frederick R. Kappel, then President of the AT&T gave a speech where he predicted that "in the forseeable future, perhaps within fifteen years or so, the volume of information communicated between machines may be even greater than the amount of communication between people".[14]

This was understood for a good while to mean that the number of calls between machines will be greater than those between people. This is turn helped the wave of very optimistic predictions

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[12] J.P. Spencer, Ed. Distributed systems: internation state of the art report. Maidenhead, Berks, England: Infotech International (1976), viii + 488 pp. Main analysis section deals with the following topics: distributed systems concepts; distributed computer systems; systems design; systems implementation; software implications and distributed data bases. In addition to an annotated bibliography the report includes papers from a number of contributors. (317 refs).

[13] Vinton G. Cerf. Research Topics in Computer Communication in Planning Conference on Computer Communications, FCC 1976.

[14] See R.W. Hough. Future Data Traffic Volume, Computer, Sept-Oct. 1970, pp. 6-12.

made in the sixties about data traffic in the seventies.

Hough explains that the meaning of Kappel's quotation should be understood as saying that the amount of nonredundant information conveyed by the voice conversations will be similar to the amount of information that the machines exchange among themselves.

So, even if not exploding as fast as it was once thought, the field of non-voice telecommunications is growing and quite rapidly so.

Next, we are going to see some of the new developments affecting the field of telecommunications, especially the non-voice type.

Digitalisation and Packet-Switching

In all aspects of communication there is a tendency towards the use of digital communication. This holds even for voice (that is,for long distance links). Once in digital form the information can be compressed and divided, can be multiplexed and packed. This way, the amount of information that can be transmitted over a particular line increases greatly and also prevents distortions in the information carried.

So the trend is towards networks of computers systems communicating using packet-switching methods.

The concept of packet switching systems has evolved from message switching (store and forward) systems in order to meet the needs of computer resource sharing networks, or large networks of distributed terminals.

Vinton Cerf[15] gives a definition of packet switching and packets as follows:

- Packet switching is a form of message switching which facilitates asynchronous time-division sharing and switching of transmission resources. It is particularly suited to bursty communication requirements; permits the sharing of common switched transmission resources among both high bandwidth and low delay applications.
- Packet is a short (1000-2000 bits) block of data, prefixed with addressing and other control information, which is used to carry information through a packet switching network.

Packet-switching networks exist and are being planned over all the industrialized world. These are some of them:

ARPANET (US Defence Communication Agency (DCA))

AUTODIN II (under development by the US DCA)

TELENET (Telenet Communications Corp. (US))

DATAPAC (Bell Canada, TCTS)

INFOSWITCH (CNCP Telecommunications)

EPSS (British Post Office)

TRANSPAC (French PTT)

BELL DATA NET (under development by Bell Telephone Laboratories US))

TYMNET (operated by Tymshare Corp. (US))

EIN (European Informatics Network, operated by the European Council for Science and Technology)

EURONET (Proposed within the EEC)

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[15] Vinton G. Cerf, Research Topics in Computer Communication, in FCC, Planning Conference on Computer Communications. Washington D.C. 1976

CYCLADES (French packet-switching system used for inter-communication between computers in universities and research centres)

There is one development in the technology for voice transmission that has relevance to non-voice transmissions. We refer to the trend towards digitalization of voice signals. The idea is to transform the voice to digital form (bits). This way the voice information can be packed and transmitted the same way that non-voice information is transmitted. Thus, with the use of multiplexing, telephone lines could be shared by both voice and non-voice uses. However, it is not expected, this technology to replace present analog circuits for some time.

Fibre Optics

One field that is now in the frontier of technological development is the use of fibre optics for communications. In this technology, modulated light is used to transmit through optical glass or plastic fibres. This method is potentially very superior to communicating information over conventional electrical wires or even coaxial cables.

These fibres are made of dielectric materials (they are non-conducting and non inductive), and thus provide optimum immunity to radio and other electromagnetic interference. These fibres have electrical isolation, avoid crosstalk, are light in weight and have low volume.

The principle advantage of the use of fibre optics is the high frequency at which it operates, which allows it to carry much more information than copper cables. Fibre optics is used in short-distance transmission and fibre optic transmission is emerging as an attractive alternative to coaxial cable for wideband multi-used data distribution networks.

In the communications applications, it is expected that fibre optics are going to be used first to link stations and cities with heavy traffic load. At the moment, the problem with fibres is their cost. However, since the raw material for the fibres is so common and inexpensive, it is expected that once mass production gets under way, the cost will sharply drop. These fibres are expected to become the most revolutionary advance in the field of electronics since the transistor and integrated circuits.[16]

Business Week of June 13, 1977, published a story about a new method of glass fibre production that could cut production costs by 90%. The process was developed by Theodore A. Litovitz and Pedro B. Macedo, both professors of the Catholic University of America. If the mentioned process can be turned into factory reality, the cost of fibre optic cable could drop to 1¢ a metre, about one-tenth of present costs.

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16 John R. Pierce. Electronics: Past, Present, and Future. Science, Vol. 195, 18 March 1977, p. 1093
See also:
Electronics, August 5, 1976, p. 81 ff. which presents a series of articles on the state of the art.

S.R. Cole, T.A. Eppes and P.N. Steensman. Optical fibre databus networks. EASCON'76 Record, Washington, D.C. 26-29 Sept. 1976 (New York): IEEE 1976), p. 120A/1-8.

Y. Veno and N. Oogi. Data highway using optical fibre cable. Conference on Laser and Electro-optical Systems. (Digest of technical papers), San Diego, Calif, 25-27 May 1976, (New York: IEEE 1976), p. 78

D.N. Williams. Fibre optics for data transmission. Instrum. Technd. (USA), Vol. 23, No. 9, p. 61-6 (September 1976).

Satellites

Besides telephone lines (private or switched), radio and microwaves, the other vehicle for telecommunication are the satellites. The first communication satellite (Telstar) was in operation in 1962. Intelsat 1 was launched in 1965, carrying international commercial traffic.

In Canada, the first domestic satellite (Anik) was launched in 1972; today there are three Canadian domestic satellites forming the Telesat system.

The first American domestic satellite was launched in 1975, now there are six of those in operation in the United States.

According to Edelson and Pollack[17], the U.S. domestic market for data transmitted by satellite is much larger than that for voice, since the public-switched telephone network is extensive and efficient for voice, while for high-speed data transmission it has become inadequate. The same should hold also for Canada.

Satellite communication, due to its characteristics, which make them suitable for multiple-origin and multiple-destination communications, can be used for a wide range of applications.

In the US, a Company (Satellite Business Systems, SBS) was formed owned jointly by Comsat General, Aetna Life & Casualty Company and IBM. The company will operate a domestic satellite system which

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17 B.I. Edelson and L. Pollack. Satellite Communications. *Science* Vol. 195, 18 March 1977, pp. 1125-1133

will be in direct competition with the common telephone carrier in the market for business communications. Their satellite system is expected to be in operation by 1979, and will operate in a range of frequencies which allows the use of small earth stations which are relatively inexpensive.[18] It is expected, though, that a major confrontation is going to take place between IBM and AT&T which should have repercussions in Canada.

In the technology of satellite systems, the tendency is towards earth stations which are small and relative inexpensive, and this is already changing our views about communication among distant and isolated areas. In the satellites themselves, the tendency is to incorporate more switching and processing capabilities.

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[18] S. Caswell. Satellite Business Systems: The Start of Something Big. Computer Decisions (USA), Vol. 9, No. 3, p. 16D.21 (March 1977).

N. Abramson. "Packet Switching with Satellites", Proc. of the National Computer Conference, AFIPS Press, 1973, p. 695-702

N. Abramson. "The ALOHA System", in Computer Communications Networks, (Ed. N. Abramson, F. Kuo), Prentice-Hall, Englewood Cliffs, New Jersey, 1973.

D.E. Weese. A Satellite Data Network Model Employing Packet and Circuit Switching. in ICCC 76, pp. 111-116.

The Canadian Data Telecommunications Systems

Following a summary description is made of the Canadian telecommunication systems.[19] Two main systems are in operation: one is provided by the telephone companies, and one by CNCP Telecommunications. The telephone companies, where Bell Canada is clearly dominant with control of about 70% of the market, have agreements of interconnection mainly through the Trans-Canada Telephone System (TCTS). Bell Canada also has agreements with the AT&T in the US, and this accounts for the compatibility of the Canadian and US systems. The TCTS has microwave systems and provides , accross Canada, every type of telecommunications service, except telegraph. The TCTS provides a TWX service and data transmission services: Multicom, Dataroute (not switched digital service) and the public packet switching Datapac[20], introduced in 1976.

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[19] For a complete review of data communication services in Canada see; S. Pallavicini (Economic Policy and Statistic Branch, DOC): The Characteristics of Data Communications Tariffs, Ottawa, June 1976.

See also G.D. Hutchinson. The Search for orderly development in computer/communications. Canadian Business, August 1973, pp. 34-38.

Also D.G. Hartle. The Regulation of Communications in Canada. In Ontario Economic Council: Issues and Alternatives: Government Regulation. Toronto, 1978.

[20] W.W. Clipsham, F.E. Glave and M.L. Narraway. Datapac Network Overview. In ICCC 76, p. 131-136.

CNCP Telecommunications is a consortium of the telegraph operations of CN and CP. It has also a microwave network that carries telegraph, data and some voice traffic. CNCP provides a Telex service (which is much larger than the one provided by TCTS). Telex and TWX are essentially identical services, both being trade names.

Among CNCP services, we find Infodat (which is not switched) and the switched Infoswitch (operational since late 1976).

Telesat is a Crown Corporation which oeprated the satellites, while Teleglobe, also a Crown Corporation, is in charge of overseas communications.

Some policy and regulatory issues

In the US, two regulatory decisions shaped the relation between the common carrier and the very many manufacturers of computer/communication equipment. We refer to the Carterphone Decision (FCC Dockets # 16942 and # 17073) and the Direct Interconnect (FCC Docket # 19528).

The Carterphone decision of 1968 allowed connection of "foreign attachments" to Bell phone lines using a protective device. The Direct Interconnect decision, when fully implemented, will allow users to attach directly to the common carrier network without using the Bell-supplied device.

These decisions in the US helped to further the competition in the telecommunications industry while working in the direction that computing is taking: distributed processing and the growing role of computer networks.

According to M. Irwin et al[21], the impact of the new technology and the consequent introduction of competition, is likely to question the very premise of a private monopoly subject to public regulation.

The blurring of the differentiation between computing and communication comes not only because computing uses more and more communications, but also because the telephone carriers are using computers in switching and billing. Also, it is possible that the carriers will be offering computation services on a tariff basis (op. cit. p. 17).

Thus, it is possible that the same service might be offered both by a regulated carrier and an unregulated firm.

Another area of interest to the regulatory agency is the interaction between the Telex and TWX network with the data networks. This is so because the regulatory body is in a position to enforce standards of interconnection among the systems. Our feeling is that the Telex and TWX are on their way out, or rather, that these networks are going to be absorbed into the data networks.

Cerf and Curran [22] point to limitations due to regulation that appear to have stopped the implementation of new and innovative application of the technologies that already exist. They see as a solution the relaxation of the regulation of the common carriers, which protect them from competition, to allow new ideas to be implemented by innovative firms.

[21] M. Irwin et al, Future of Telecommunicstions. Journal of Systems Management. April 1976, p. 12-18

[22] V.G. Cerf and Alex Curran. The Future of Computer Communications. AFIPS Technical briefing to the FCC, Washington, D.C. Nov-7-8, 1976. In FCC, Planning Conference on Computer Communications.

In the US, the development to look at is the power struggle between the AT&T and IBM. According to C.P. Lecht[23], "the IBM vs AT&T battle will heat up during the 1978-80 period, and the outcome of this confrontation could dramatically change the scope and shape of the data processing market in the 1980's."

In Canada, a major policy decision is in the process of being formulated. We refer to the issue of interconnection between CNCP data networks and the TCTS network.

The services provided by CNCP are of the private type only. They are not integrated with the public telephone system because the TCTS wants to maintain its competitive advantage. Thus, CNCP has applied to the Canadian Radio and Television Commission for an order that would force the TCTS to permit CNCP the use of the common carrier telephone system; in its application, CNCP is not asking for interconnection between the TELEX and the TWX nor between the Infoswitch and the Datapac network but rather is asking for the right to use the telephone system to interconnect its customers with CNCP's system. The hearings before the CRTC are being carried out at the present time. At the hearings before the CRTC, a good number of organizations and commercial enterprises gave testimonies in favour of interconnection, among them some of Canada's larger banks (Royal, Nova Scotia),the Canadian Manufacturer's Association, IBM Canada, Westinghouse Canada and many others.

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23 Quoted in Computing Canada: IBM, AT&T Strategies to be discussed at Datacomm 78. December 1977.

One organization that also is supporting the CP Telecommunications application is the Canadian Information Processing Society.[24] The CIPS not only supports the CP application, but goes further and asks for interconnection between Datapac and Infoswitch. Furthermore, the "CIPS considers the question of interconnection between Datapac and Infoswitch to be of such importance that we recommend that no extension of either network be allowed until effective interconnection of the two networks is available to subscribers to either network".

It is felt by many that after the decision of allowing Telesat to join the TCTS[25], the three-way concurrence that existed in Canada, was now transformed into a non-balanced concurrence between two (TCTS and CNCP). The market for computer communications is now dominated by TCTS, i.e. by Bell Canada. This market structure (duopoly) is not likely to continue if CNCP is not allowed the interconnection, as CNCP itself admitted recently that it will be forced to close down its data-transmission operations in the event of a refusal by the CRTS (or by a Cabinet overruling, of an eventual approval by the CRTS, for that matter). In 1976, CNCP accounted for some 9% of the data-transmission market, and it is estimated that without interconnection that share will reach some 4% before 1982, leading

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24 J.B. Reid, President, Canadian Information Processing Society. Statement of Position Regarding Application Before the CRTC by CP Telecommunications for Interconnection to Bell Canada System. Ste. Foy, 24 October 1977.

25 On Nov.3-1977, the decision of the Federal Cabinet was announced to permit Telesat to become a member of TCTS. This decision is being appealed by CNCP before the Supreme Court of Ontario.

to a possible closing of data transmission operations by CNCP. To deny interconnection will exclude CNCP of participating in this growing market. Especially since the development of computer/communication is occurring at the expense of TELEX-like systems.

James C. Criner. Regulation of Computer Communications, Computer Networks 1 (Nov.1977) 306-310

Robert W. Donaldson. Communications for Text Processing: with Application to Electronic Information Services. A Report to the Department of Communications (Ottawa), January 1977.

D.G. Hartle: The Regulation of Communications in Canada. In Ontario Economic Council: Government Regulation, Toronto, 1978.

M.R. Irwin and S.C. Johnson: The Information Economy and Public Policy. Science, Vol.195.

W.H. Melody, "Relations between public policy issues and economics of scale," IEEE Trans. on Systems, Man, and Cybern., Vol. SMC-5, pp. 14-22, January 1975.

D.F. Parkhill, "Society and communications policy", Conf. Rec., Third Inter. Conf, Comp, Commun. Philadelphia, Penn., Aug-1976, pp. 11-17.

H. Von Baeyer, "The quest for public policies in computer/ communications- Canadian approaches," In Conf. Rec., Second Inter. Conf. Comp. Commun., Stockholm, Sweden, August 1974 pp. 19-23.

Constraints to growth of computer/communications

One could think that with computers becoming more powerful, smaller and cheaper, the need to communicate with other (big) computers will be diminished. However, while this is a force working against the necessity for more communication, it is believed that the basic reasons for the need for computers to communicate are going to persist. Furthermore, the tendency is towards distributed computing thus the need for data communication should increase.

In looking at the future, Irwin and Johnson[26] distinguish three differend trends.

The first trend is the trend in services. More and new services are being provided every year using the computer/communication technologies. Even if some of these services did not grow as fast as was expected some years ago, nevertheless, the trend is clear.

The second trend is in the terminals; more and smarter terminals are appearing and being used.

The third trend is the development of computer networks, referred to already.

In the study by Cerf and Curran[27], it was found that the earlier expectations about the growth of computer communications were not materialized. Furthermore, their calculations projecting the demand for information transfer in the next decade gave results surprisingly lower than the ones that they expected. They see as

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26 Irwin M.R. and S.C. Johnson: The Information Economy and Public Policy. Science, Vol. 195 p. 1174

27 Cerf and Curran op.cit.

a possible reason a decreasing in the imaginative drive that characterized the industry some years ago. A possible solution for this would be, they suggest, a relaxation of the regulatory constraints.

Among the limitations that can be identified on the growth of computer/communication services are the following[28] :

- -user learning costs in the markets serving non-computer professionals.
- -regulatory constraints inhibiting technological change.

Alex Curran[29] identifies two areas where the progress has been slow. The first one is to reduce the cost of network access for smaller centres. The second one is to reduce significantly the cost of intercontinental transmission.

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28 D.A. Dunn . Limitations on the Growth of Computer Communications Services. In FCC, Planning Conference on Computer Communications.

29 Alex Curran. Dimensions of the need for Computer Communications. AFIPS Technical briefing to the FCC, Washington, D.C. , Nov-7-8, 1976, in FCC: Planning Conference on Computer Communications.

NEW SERVICES

In early 1970 a study performed at the Stanford Research Institute[30] studied the demand for information transfer in a broad sense, i.e., considering that almost any information (voice, pictures, photography, etc.) can be transmitted electrically.

To begin their study, a very long list of possible uses (old and new), was drawn. Some 400 such possibilities were listed.

Following, we list here some of the new services, (some already started, some that are only possibilities) not to be exhaustive but to give an idea of the many possibilities that exist.

Electronic Mail

Remote Library Browsing

Electronic Funds Transfer Systems (EFTS)

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30 Hough R.W., Carolyn Fratessa, Virginia Holley, A.H. Samuel and L.J. Wells, A Study of Trends in the Demand for Information Transfer, Stanford Research Institute, Menlo Park, California, February 1970, see also Hough R.W., Future Data Traffic Volume, Computer, Sept-Oct 1970, pp. 6-12.

Videophone

Law Enforcement

Brokerage

Teleconferencing[31]

Reservation System

Electronic Shopping

News Services

Security Surveillance

Metering and Load Control for Energy Use

Tele-Education

Computing as a Hobby

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31 S.R. Hiltz. A Social Scientist looks at Computer Conferencing in <u>ICCC 76</u>, pp. 203-207

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Text Editing/Publishing[32]

Facsimile Transmission

Real-Time Inventory Control in Business

General Information Retrieval

Access to Insurance Records

Credit Checking

Archiving

Computed Assisted Instruction[33]

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[33] H.A. Peele and E.M. Riseman, W. . Brown and J. Brahanm "The "The four faces of HAL: a framework for using artificial intelligence techniques in computer-assisted instructions, "IEEE Trans. on Systems, Man and Cybern., Vol. SMC-5, pp. 375-380, May 1975.

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Electronic Mail

The application of the electronic revolution to the field of the postal services makes it possible to replace the transportation of the physical letter or document by the electronic transmission of its content.

In fact, electronic mail has been with us since the invention of the telegraph. The telegram, the telex/twx and the mailgram are also forms of electronic mail. The transmission of facsimile copies of documents is also increasingly used among institutional users. Computer networks are also used to interchange messages and other information (eg. the firm Bolt, Beranek and Newman provides the Hermes service, which is a public message switching facility via TELENET).

The idea behind electronic mail is that it is not the actual letter that is transmitted, bur rather that an image of the letter, or the letter's contents properly coded, which will be transmitted electronically to a distant point where the letter will be reconstituted.

To analyse the possible future evolution of the electronic mail, it is useful to divide the regular mail into several types.[34] Following there is a brakedown of the mail in five types, with their percentage in the total.[35]

1) Transactions (such as statements, invoices, cheques, bills purchase orders - 40%

2) Advertising - 26%

3) Correspondence - 22% (13% personal, 5% business, 4% government)

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[34] See R.J. Potter. Electronic Mail, Science , Vol. 195, p. 1160

[35] US Figures. President's Commission on Postal Organization. Toward Postal Excellence. (Government Printing Office , Washington, D.C., 1968).

At the 1976 IEEE International Conference on Communications (Philadelphia, Penn), several papers were presented on the matter of electronic mail, among which:

C.M. Laucht, Electronic mail for the Canadian environment, (pp. (15-3)-(15-4). See Also:

G.D. Hodge, "An electronic mail system-- will it happen? in Conf. Rec., Int. Conf. Comp. Commun., Stockholm, Sweden, August 1974, pp. 351-357.

C.R. Kraus, "Meeting the Public's communication needs," in Conf. Rec., IEEE Int. Conf. Commun., Seattle Wash., 1973 pp. (6-1)-(6-6).

4) Magazines and newspapers - 11%

5) Merchandise - 1%

The first type of mail is also the one that will be cheaper to do electronically, thus allowing an economic start to electronic mail on a large scale.

There are three aspects to consider in dealing with electronic mail, they are: origin, transmission and printing.

The message can be originated either writing it conventionally (handwriting, typewriting, drawing) or typed using some device which will code it for subsequent transmission.

The transmission can be made using the telephone network, microwave systems, satellites, and packet-switched networks.

The information, once arrived at its destination, can be printed in several ways: impact printers, xerogratic printers, electro-graphic, thermal or ink-jet printers.

The obvious advantage is the speed with which a piece of electronic mail can be delivered.

At the beginning, it is expected that the main users of these technologies will be large business and government agencies.

For the time being, the cost of originating and printing terminals are too high to be at the reach of most people. However, it is possible to envisage local post offices having printing terminals, which will receive the messages, print them and distribute them as ordinary mail is distributed nowadays.

Point of Sale and Electronic Funds Transfer Systems

Point-of-sale (POS) refers to the devices which, located at the retail store, accomplish some of the following functions:

- Credit verification. - this is done by simple terminal devices which verify credit cards or accept keyed account numbers, communicate with files of credit information, and indicate the level of credit purchase allowable. This market is expected to grow significantly as credit card gain increases in acceptance.

- POS Systems and Terminals - Electronic cash registers operating on-line to a controlling computer (located either in the store or outside) to assist salesmen and to record sales data for cash, inventory, and sales analysis; these devices frequently also incorporate price mark scanning devices. The market for this device is expected to grow rapidly (25% per year).

The electronic funds transfer system(EFTS) is the basis of any chequeless and cashless society. To have an operating EFTS two things are needed. First, a terminal at each point-of-sale, of the second type described above, which will not only verify and authorize the account of the customer, but which will also begin to execute the transaction, crediting and debiting. In the future, these POS terminals could also accept deposits. The second thing that is needed is a switching network which will connect all the institutions (stores and banks) that will be affected by the transactions. Adoption of EFTS will certainly affect the way business transactions are carried out, and the structure of the financi institutions such as banks, since in fact, most if not all the banking could be done at the store (if not at home).

In the words of R. Donaldson[36], "it is not difficult to visualize an extension by stages whereby electronic banking and POS systems are merged and developed to the point where cheques become obsolete, credit cards are replaced by one EFT card which identifies the bearer and fits into terminals for automatic recording of the bearer's EFT account number, and cash is reserved for payment of paper boys, parking meters and the small corner grocer".

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36 Robert W. Donaldson. Communications for Text Processing: With Application to Electronic Information Services. A Report to the Department of Communications (Ottawa), January 1977.

Certainly EFTS raises many legal questions which will have to be settled before a truly widespread EFTS is in operation and before the cashless society is with us.

EFTS, which was hailed by many as the beginning of cashless society, appears to have failed the test of the marketplace. Early estimates of the growth of EFTS did not materialize. It would appear that the consumer and his reaction were not considered when the planning of the first stages was carried out. Now, since the cost of the investment to set up networks of EFTS can only be paid if the volume is big enough, then the initial partial rejection by the customer meant that only very large and strong institutions could afford it. But the non-enthusiastic reaction by the consumer implied a small market, which turned out to be unprofitable.

There are three reasons to explain the consumers reaction to EFTS. One is the mistrust with respect to machines, especially by older people.

The second reason is a concern about privacy: a fear that electronic banking will breach it. The idea being that if EFTS is expanded widely enough, people will not be able to keep private their financial transactions.

The third reason, is having been trained to consider a cancelled cheque as a receipt, a re-education is required before consumer acceptance is achieved.

Canadian banks and other financial institutions are presently at different stages of computerization.[37] That evolution is not presently effectively oriented, as government policy in the area is not yet well clear. The Canadian Bank Act, which is revised every ten years, was due in 1977, but it is still in the process of elaboration, in fact the bill has yet to be introduced in the Commons. While the Bank Act revision is not completed, the government has provided some guidelines that restrict the data processing services that the banks are allowed to offer.

The aspects data processing that the Canadian banks are allowed to operate on are the following two. In the first place the provision of wholesale banking services (i.e. to other financial institutions), of computer services that are an integral part of banking business. In the second place, the banks are allowed to carry out automated payment services like eg. pre-authorized payments.

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[37] D.F. Parkhill, Society and Computer Communication Policy. In <u>ICCC 76</u>, pp. 11-17.

E.M. Awad. Issues of Electronic Funds Transfer: An overview and Perspective, Computers and People, Vol. 26, No. 6, June 1977, pp. 7-9, 22.

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RURAL COMMUNICATIONS

One of the goals of this pilot project is to study the repercussions of the future demand for non-voice telecommunications on rural users.

We feel that the technologies that are being developed for intra- and inter-city communications will find ready applications for rural uses.

Furthermore, the economies of scale attained once mass production to serve urban users gets under way will allow the economic application of those new thchnologies to rural communication.

We refer specifically to the mass introduction of fibre optics (and other wideband communication channels such as coaxial cables)[38], and to the further development of domestic (commercial) satellite systems.

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38 In connection with these matters, several studies were done lately or are being carried out presently for the Department of Communications:

M. Hannid. Feasibility study of using leaky coaxial cable for rural communications. 1976.

Canada Wire and Cable Co. Ltd. and Northern Telecom Ltd. Program definition study of a proposed field trial of fibre-optic communications technology in a rural environment. 1978.

Bell-Northern Research Ltd. Systems engineering study of fibre optic communication systems for switched and non-switched broadband communications. 1976-77.

Wideband cables (or optic fibres) will permit the provision of a wide range of services to the rural user, on a single-party basis. With the technology that already exists, it is possible to provide at the same time, and for each (say rural) subscriber, all of the services that depend on electronic communication, including: telephone, cable TV, pay TV, telemetry, alarm and two-way video services (videophone).

One example of the application of wideband communication channels that are designed to serve groups of rural subscribers (forming local loops, the same way that nowadays there are several-party telephone lines) is the "CS^2 System II" a product of 3M. It is an advanced broadband coaxial digital transmission and distribution system, to provide all-single-party service to remote groupings of subscribers. For this particular system the maximum distance is 30 to 50 miles, and is capable of providing all the services mentioned to the above, according to the needs of the specific exchange. A two-way system dedicated entirely to telephone subscriber service could accomodate 2040 circuits, with an additional eight one-way (central office-to-subscriber) broadband channel.

These types of services depend both on the characteristics of the cable (coaxial or fibres) and on the multiplexing techniques being used to permit many communications to be carried by the same cable.

As we saw before, it is expected that the cost of optical fibres will decline, once mass production gets under way. On the other hand, the general trend observed in the computers and other electronic devices will affect the services provided to the rural user. The cost of electronic devices (such as those needed for multiplexing) is decreasing (as is their size) while their reliability and power keeps on increasing.

The other technological development that is already improving communication with isolated areas are the satellites. As we saw before, the trend is towards smaller (and cheaper) earth stations. These technologies are already in use in the Canadian North and there is every reason to expect that these techniques will be used to service rural communities, where, for example, the local central (telephone) office can have a small earth station for satellite communication. In turn, from that central office local loops of wideband channels would distribute to and collect the information from the individual subscribers, using techniques as the one described previously.

Robert N. Noyce, writing in Science and Scientific American[38], gives the dimension of the microelectronic revolution. We quote some facts and trends expected.

- In 1970 the total world consumption of integrated circuits was some $1 billion. In 1976 the figure was $3.5 billion.

- The cost of the hand-held calculator declined by a factor of 100 in the past decade.

- The cost per bit of random-access memory has declined an average of 35 percent per year since 1970.

- The number of components per circuit in the most advanced integrated circuits has doubled every year since 1959 when the transistor was invented.

- The product of the microelectronic industry falls in price by 25 percent per year.

- By 1986 the number of electronic functions incorporated into a wide range of products each year can be expected to be 100 times greater than is today.

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39 R.N. Noyce. Large-scale Integration: what is yet to come, Science, Vol. 195, No. 4283, 18 March 1977, pp. 1102-1106, and Microelectronics, Scientific American. Vol. 237, No. 3, September 1977, pp. 62-69

The other technological development that is already improving communications in isolated areas are satellites. As we saw before, the trend is towards smaller (and cheaper) earth stations. These technologies are already in use in the Canadian North and there is every reason to expect that these techniques will be used to service rural communities, where, for example, the local central (telephone) office can have a small earth station for satellite communication. In turn, from that central office, local loops of wideband channels would distribute to and collect the information from the individual subscribers, using techniques as the one described previously.

Rural Communications and Bell Canada

Bell Canada has a plan[40] to upgrade its basic non-urban service offering from a multi-party to a four-party service. (Non-Urban Service Improvement- NUSI- programme). The plan is to replace the multi-party service with the four-party one on an exchange-by exchange basis, "as facilities become available". It is expected that the completion of the transition to the four-party service will take some five years.

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40 The proposed plan: Non-Urban Service Improvement - Comprehensive Program" was submitted to the CTC in February 1975. It was partly based on the findings of a 1974 survey on the demand for urban grade service in non-urban territory. The construction expenditures were outlined in the November 3rd, 1976 application for a general rate increase (Exhibit B-76-300). The NUSI programme was not available to us at the time of writing this section.

The NUSI programme began to be implemented in January 1977; by mid-1977 it became clear that the demand for urban-grade type of services were much greater than was thought. Thus, additional expenditures were planned. According to the 1978 revision of the plan, it is expected that by 1980 19.7% of the non-urban sucscribers will have individual or two-party service, compared to the 47.3% of 1977.

In our reading of the available Bell Canada documents (mainly exhibits to support increases in rates), we did not detect any plan to use the type of technology that was mentioned above, i.e. the use of multiplexed wideband channels to provide single-party service.

One should note also that Bell Canada's construction expenditures in the non-urban areas are a small percentage of the total. In 1967 that percentage was about 1.5%. In 1977 the percentage was 10%, while the plans call for 14% in 1978 and 16% in 1970. Although this is certainly an improvement, past experience had proved that construction expenditures in non-urban areas are particularly sensitive to cutbacks.

A BIBLIOGRAPHICAL REVIEW OF DATA NETWORKING OUTSIDE CANADA AND THE U.S.

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G.P. Taylor. Processor Occupancy Optimization of the Australian Common User Data Network (CUDN). In ICCC 76, pp. 98-101

The Australian Common User Data Network (CUDN) is a message switching system developed for Telecom, Australia by the Sperry Univac Division of Sperry Rand, Australia.

It started full operation in 1975 and has two (government) customers with nationwide operations requiring connections to all centres.

(Address: Telecom Australia. 59 Little Collins Street, Melbourne, Vic. 3000, Australia)

FRANCE

Cyclades/Cigales

CYCLADES is a heterogeneous general purpose computer network operated by IRIA (Institut de Recherche en Informatique et Automatique, France).

CIGALE is an experimental packet switching network within CYCLADES, operated also by IRIA.

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In 1971, the French PTT Administration decided to develop an experimental packet-switching network, which was given the name of Réseau à Commutation par Paquets (RCP).

The RCP network is serving as a testing ground to gain experience for the planning and implementation of TRANSPAC whose creation was announced in late 1973.

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EUROPE

EURONET

Is a computer network proposed within the European Economic Community. Initially the network will be based on four switching centres (in London, Frankfurt, Paris and Rome), with two "host" computer centres in Cologne and Frascati.

EURONET is expected to begin operations in early 1978; various countries in Europe that are planning national networks of either the Circuit switching or the packet switching types are going to connect these networks into EURONET.

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PART II

NON-VOICE DATA TRANSMISSION IN CANADA 1973 - 1985

I. Introduction

Non-voice data transmission (NVDT) is the most rapidly growing sector in telecommunications. CN and CP telecommunications predict growth rates for Infoswitch and Telenet[1] of 21% and 23.1% respectively for 1978-1982 [1]. Presumably this is also the most rapidly growing component of "other toll" reported by Bell Telephone.

There are two main components involved in data communication - the media conversion hardware (machine, terminals etc.), and the line cost. Both have been characterized by steeply falling costs, which have made interactive and remote batch processing a far more attractive proposition than at the beginning of the decade. The fall in the cost of integrated circuits is well documented by Noyce [2]; this has had an effect on terminals whereby a typicial CRT low speed terminal can be purchased for less than $1000. Similarly, the fall in the cost of data transmission by the use of dedicated digital data network has also had a profound effect on costs. Dataroute is already operational in Canada, and DDS will be nationwide by the end of the 70's in the U.S. Coupled with the growth of pocket switching, this has led to, and will continue to lead to significantly reduced costs for large volume, long hauldata transmission. By 1985 a large portion of the signals carried by the U.S. telephone network will be digital [3] ; this will make data communication easier and less expensive. In passing, it also opens the way to upgrading rural circuits, using the same technology.

Once a user starts to use distributed computing, he rapidly becomes hooked. Consider the use of distributed computing in the following sectors:

Large insurance companies

Police

Brokerage houses

Research and Academic Institutions

Health Industry

Banking.

There is no doubt that all of the above now rely on distributed computing - that is, the right amount of processing power where it is needed. Consequently the processing elements are strung out in different physical locations, and communications links are required to interconnect them.

The purpose of this study is to estimate the present level of NVDT in Canada, and to make forecasts until 1985. The methodology is presented in Section II, the estimates of Canadian non-voice data transmission in Section III, and forecasts in Section IV. A comparison with other results and conclusions is given in Section V and Section VI respectively.

II. Methodology

The approach that has been used in this study is to use U.S. data when available, on the grounds that the U.S. data is far more comprehensive and reliable than the Canadian data; indeed no Canadian data for all-user EDP[2] expenditure exists. Consequently, predictions for the U.S. are estimated, and these estimates are scaled down to derive Canadian values. In the process of scaling, it is clear that the scaling factor changes over time, and this we also allow for.

To facilitate discussion, two concepts are defined.

a. Scaling Factor (SF):

The ratio of EDP activity in Canada to EDP activity in the U.S. for a particular year.

b. Technological Log Factor (TLF):

The ratio of an EDP factor use in Canada to the same factor use in the U.S., after correcting for differences in scale.

The problems of forecasting, are well known, and need no repeating. However, in the fields of computer communications there are a number of "classics". Western Union turned down an offer to buy the Bell system, presumably because of erroneous forecasts. More recently, in the early 1950's, computer scientists estimated that the U.S. would never need more than 8 to 10 large computers. Finally, in 1972, Carl Hammer predicted that "during the 70's the revenue from machines conversing will surpass that of people conversing" [4].

III. Canadian Non-Voice Data Transmission - Estimates

A. Scaling Factor

Three approaches are used to estimate the Canadian/U.S. scaling factor. These are based on:

1. Occupational scaling
2. Computer Service industry
3. Government EDP activity.

Using the estimates derived from these approaches, a model is built to a give a time series estimate of the scaling factor 1969-1985.

1. Occupational Scaling.

Statistics Canada undertook a detailed study of occupational distribution of the labour force for 1975, which was published in 1977 [5]. The data base consists of the employed labour force, excluding agricultural workers, fishermen, military defence and domestic service. SIC 2183 consists of systems analysts, computer programmers and related occupations.

In the U.S., the annual report "Employment and Training Report of the President" [6] gives employment data for detailed occupations 1973-1976 for the civilian labour force. The totals can be made comparable to the Canadian study by removing farm workers and domestic service. Occupational codes 003-005 consist of computer programmers, computer systems analysts and computer specialists n.e.c. respectively.

The data for 1975 is shown in Table 1; a scaling factor of 7.15% is observed. If the occupational distribution for computer professionals were the same across both countries, the ratio would have been close to the ratio of the two totals, 9.7%.

Table 1

Occupational Scaling for the Employed[3]
Civilian Labour Force, 1975 $\times 10^3$

	CAN	US	CAN/US
Computer Specialists	25.96	363	.0715
Total	7858	80676	.0974

2. Computer Service Industry.

A firm requiring EDP services may acquire these services either by using in-house equipment, or by using a computer service bureau. The choice made depends on a mix of task-size, in-house expertise, finances etc. Data is available for the computer service industry in both the U.S. [7] and Canada [8].

Statistics Canada considers the industry to be composed of these types of firms:

(a) Establishments primarily engaged in providing computer services.

(b) Establishments primarily engaged in sales and lease or rental of ADP hardware.

(c) Companies and institutions engaged in public offering of computer services as a secondary utility.

The Adapso report includes all companies which offer computer services as an independent business, while excluding manufacturers who offer services solely to support the use of the hardware manufactured by them.

To compare the industry in the U.S. and Canada, we delineate the industry as it is defined by the Adapso report; this eliminates firms of type (b) (hardware firms). The hardware firms were responsible in 1974 for 15% of all revenue derived from sales of processing, software and educational services in Canada ([8,9]).

The services provided by this industry consists of:

- a. Processing
- b. Input preparation
- c. Software-sales & rental
- d. System development
- e. Education & other.

We exclude any sales of ADP equipment, as well as excluding equipment leasing and maintainance. The industry, as it is here defined, is totally software.

To compare employment figures, only firms which are primarily engaged in providing computer services are considered in the Canadian case. In the U.S., the Bureau of Labor Statistics provides employment data in all occupations for the computer service industry [10]. These are shown in Table 2. Also shown are software operating revenue 1972-1976 for both the Canadian and the U.S. industry. In each case, the column CAN/US gives the appropriate scaling factor for each year.

Table 2

Computer Service Industry US and Canada

	Employment			Revenue $m		
	CAN	US	CAN/US	CAN	US	CAN/US
1972				149.1	2760	5.4%
1973	6565*			186.0	3200	5.8%
1974	8956	138300	6.5%	256.5	3960	6.5%
1975	9693			318.6	4550	7.0%
1976				385.5*	5325	7.2%

* estimated

See Footnote 4.

3. Government

The Treasury Board publishes an annual report: 'Review of EDP in the Government of Canada' [11]; a similar, though not as detailed report is issued by the GSA - 'Summary of Federal ADP Activities in the United States Government' [12]. The reports are comparable, with the following provisos:

a. Coverage: The Canadian report covers general purpose systems for most government agencies. It does not include data for commercial and semi-commercial crown corporations such as Air Canada, the Bank of Canada, CBC, CNR and CMHC. The US report covers most US agencies; however it gives breakdown by General management classification and Special Management Classification. Broadly, the General management description is comparable to the Canadian data. Although coverage is not 100%, it can be reasonably assumed that the major general systems are included.

b. Capital expense: Data for the US is given annually, while in the Canadian case an imputed rent is given. Similarly "overhead" appears to be non-compatible for the two reports. Consequently, cost comparisons are only made for direct operating expenses; excluding overhead and imputed rent.

Data is shown in Table 3, for the US and Canada, FY 1969-70 to FY 1976-77. No attempt has been made to correct for rate of exchange changes. Again the column CAN/US gives the respective scaling factor.

Table 3

EDP/ADP Activity in Government

Year	Employment (Man years)			Operating Costs $m (Direct)		
	CAN	US	CAN/US %	CAN	US	CAN/US %
1969-70	4160	12750	3.26	54.2	1833	2.96
1970-71	6560	12200	3.72	64.5	1981	3.26
1971-72	5800	124286	4.67	85.2	2091	4.07
1972-73	6180	118801	5.20	107.4	2273	4.73
1973-74	7110	114286	6.22	138.0	2310	5.97
1974-75	7440	117374	6.34	169.3	2575	6.57
1975-76	7734	114014	6.78	201.4	2689	7.49
1976-77	8030	117301	6.85	234.4	2949	7.95

See Footnote 5

4. Model

From Tables 1, 2 and 3 a consistent pattern emerges. First the scaling factor for every year is not dependent on its derivation. Both population and revenue data produce similar values for the SF, and the value is robust across sectors. Second, the level of E.D.P. activity in Canada, as expressed as a percentage of U.S. E.D.P. activity, has increased fairly steadily over the decade. The trend reflects the closing of the gap between the two countries in the utilization of computer technology. The ratio will increase over time, but at a slower and slower rate as an asymptotic level of the scaling factor is reached.

All the data points for scaling factors shown in Tables 1 through Table 3 were used for a pooled time series regression. Equation (1) was estimated, using a non-linear procedure.

$$SF_t = e^{[a_0-(e^{-a_1 t})/a_1]} + \mu_t \qquad (1)$$

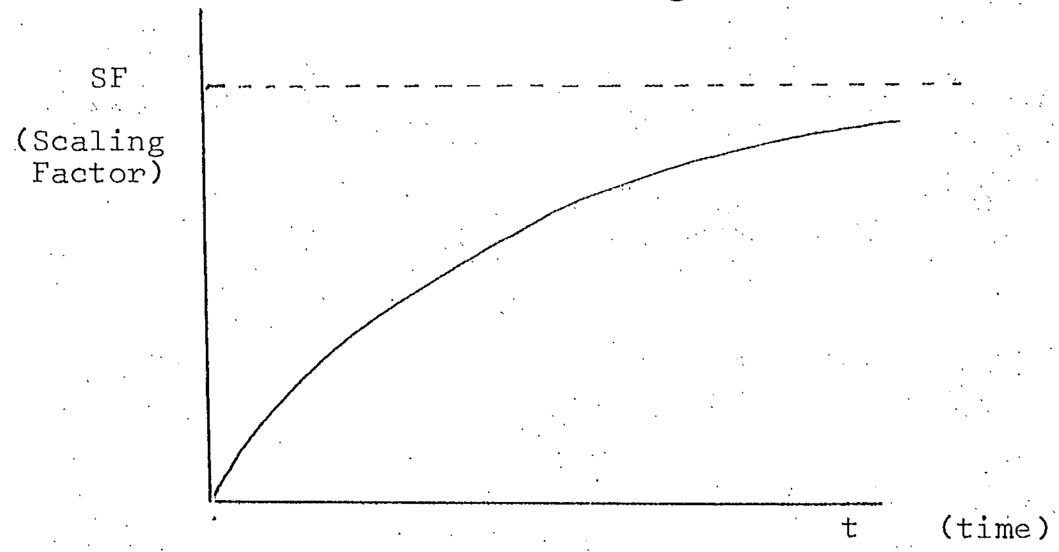
Equation (1) has certain desirable properties. As $t \to \infty$, $SF \to e^{a_0}$, a constant. The percentage rate of change of SF is given by

$$\frac{\partial \log(SF)}{\partial t} = e^{-a_1 t} \qquad (2)$$

Thus when t is low, the percentage growth rate is high, and as $t \to \infty$, the growth rate tends to zero. A graph of the function is shown in Figure 1.

Figure 1

Scaling Factor Model



The results of the regression are shown below:

Coeff.	Value	t-stat
a_0	2.0384	65.6
a_1	.4311	24.6

R^2 = .9296 DW = 2.0212 SER = .4068

The fitted values are shown in Table 4; these fitted values will be used as the scaling factor for the remainder of the paper.

It is worthwhile to note that not only does a very good fit exist, but also the assymptotic value obtained is quite reasonable.

$$\lim_{t \to \infty} SF = e^{a_0} = 7.678\%.$$

Table 4

Fitted Values of SF (Scaling Factor)

Year	S.F.
1969	1.701
1970	2.883
1971	4.063
1972	5.077
1973	5.868
1974	6.448
1975	6.854
1976	7.132
1977	7.319
1978	7.443
1979	7.524
1980	7.613
1981	7.636
1982	7.650
1983	7.660
1984	7.666
1985	7.670

For comparison, the ratio of the employed civilian labour force in Canada to the U.S., excluding agriculture and domestic service is 9.74% (from Table 1). The difference can be mainly attributed to differences in industrial structure in Canada and the U.S. As can be seen from Table 5, the primary sector accounts for a low percentage of non-governmental EDP spending, while the secondary and tertiary sectors account for quite a high percentage. Since Canada has an industrial structure more heavily weighted toward the primary sector, it is evident that the scaling factor will fall short of the ratio of employed civilian labour force in the two countries. If the US distribution of EDP spending is weighted by the Canadian industrial structure, the effect, after correcting for scale is a reduction to 81% of the U.S. level. Applying .8073 to the 9.74% figure gives 7.86%, which is close to the assymptotic value of 7.68 reported above.

Table 5

	1974 Distribution of EDP spending		1975 Non-government Labour Force Distribution		
	U.S.		U.S.		CAN.
Agriculture, Mining & Construction	4.7%		.113		.151
Manufacturing	34.0%		.280		.225
Transportation & Utilities	11.7%		.069		.093
Wholesale/Retail	11.6%		.259		.188
Banking, Insurance & Finance	22.5%		.065		.053
Education	9.7% }		.019 }		
Health Services	3.2% }	3.4	.064 }	.214	.289
Other	2.6% }		.131 }		

See Footnote 6.

U.S. Total = 100%

Canadian Total, weighted by labour force figures = 80.73%.

B. Homogeneity

In this analysis, we have assumed that the use of EDP in Canada resembles that in the U.S.; the only difference being one of scale. This assumption can be tested by considering the input and output mix for various sectors of the EDP industry. Again the main data services are the computer service industry reports [7,8] and the use of EDP in government reports. [11,12]

For the computer service industry, Statistics Canada breaks down expenses for establishments primarily engaged in providing computer services as a percentage of total operating revenue. In the U.S., the 1977 Adapso report gives less detailed expenditure categories by comparing size, as a percentage of total expenses. Since profit margins are also given, these figures can be transferred to a percentage of total operating revenue, and thus made comparable to the Canadian data. The data for each type of company was weighted by total revenue share to give an industry picture. The results are shown in Table 6.

A similar, but more detailed analysis, can be carried out on the government sector. Much more detailed data is available for EDP use in both countries, and a comparison of factor shares is possible. Since purchased equipment is reported as a capital cost in the U.S. case, and as an imputed rent in the Canadian, the analysis is restricted to operating costs so that

Table 6

Factor Shares for EDP Output

	CANADA	U.S.
Computer Service Industry		
Expenses as a percentage of Total Operating Revenue		
Salaries, wages and employee benefits	42.3	43.2
Rent, depreciation on computer equipment, plus data communication expenditure	22.4	24.1
EDP/ADP in Government		
Expenses as a percentage of Net operating expenses		
Salaries and employee benefits	55.6	59.5
Actual Equipment rent	19.8	17.1
Contract services	20.8	18.9
Production supplies	3.8	4.5

See Footnote 7.

the data is compatible. These results also are shown for FY 1973 to FY 1976 in Table 6.

As can be seen from Table 6, there is no reason to reject the homogeneity of imputs hypothesis; at least in the broad classes so far discussed. That is, as a whole, the Canadian user resembles the U.S. user in the use of factors.

Even though the Canadian user resembles the U.S. user in terms of broad factor use, this assumption may not carry through when considering a factor at a finer level of detail. Consequently an investigation of data transmission use was also carried out. A comparison of data transmission costs, given as a percentage of full EDP costs (including overhead) is given in Table 7. Looking first at the U.S. data [12] a steadily increasing trend is clear. The level for the computer service industry is in the same order as the other U.S. data, but slightly higher. The computer service industry in Canada[8] and the government sector are also not too dissimilar; the computer service sector has a higher % than the government sector, which is reasonable given the different nature of EDP activity in each sector.

If we conclude from the U.S. data that the level of data transmission usual in the computer service industry is at least as great (and probably greater) than for EDP users as a whole, it follows that use of the level of data transmission in the Canadian service industry as a proxy for all-user data transmission activity is an upper bound.[9] Accepting the 3.2% level

Table 7

Data Transmission Costs as a % of Full EDP Costs.

	74	75	76	77
U.S.				
User EDP expenditure	3.6	3.9	4.1	4.1
Computer Service Industry			4.4	
CANADA				
Computer Service Industry		3.2		
Government EDP expenditure	2.0	2.7	3.0	3.1

See Footnote 10.

for 1975 as the percentage of users cost for data transmission, it follows that a correction has to be made for technological lag in data transmission.

For 1975, the upper bound for this would be 3.2/3.9 = .82. 3.2 is the upper bound for Canada; 3.9 is an all-user level which is less than the US computer service sector level. Thus 0.82 is an upper bound. Over time, in a static industry, this value would rise to unity as the lag is closed. Since technological change is likely to remain rapid in telecommunications over the period considered, it is unlikely that the gap will close: consequently .82 is taken as the value for the technological factor lag over the whole period.

C. Results

To compute the level of data transmission in Canada, on the basis of U.S. data, two factors must be utilized.

(i) Scaling Factor (SF.). Utilize the data shown in Table 4, section A.

(ii) Technological Lag Factor (TLF.) Utilize a value of 0.82, derived in section B.

Thus:

Canadian Data Transmission = SF. TLF. U.S. Data Transmission.

The results are shown in Table 8. A comparison of these results with other reported values is given in Section V.

Table 8

Canadian EDP Expenditure

CEDP = SF · USEDP

CDT = SF · TLF. USDT

CEDP - Canadian EDP expenditure

USEDP - U.S. EDP expenditure

CDT - Canadian Data Transmission

SF - Scaling factor - from Table 4

TLF - Technological lag - 0.82

USDT - U.S. Data Transmission

Year	USEDP	USDT	CEDP	CDT
1973	23815	885	1400	43
1974	29935	1091	1930	58
1975	34315	1350	2350	76
1976	39620	1640	2825	96
1977	46510	1910*	3405	115

See Footnote 11

* estimate

IV. Data Transmission Forecasts

Forecasts for the growth of data transmission costs, and associated hardware costs, are available from a number of sources. It is assumed that terminal usage remains constant; thus the growth of terminals can be considered a proxy for the growth of traffic.

Curran [13] estimated the number of installed terminals will increase by a factor of 2.4 to 3.1 between 1975 and 1980 [14,15]. Assuming per terminal usage decreases over time, a forecast traffic growth of 2.2 times is suggested.

Irwin [16] testified to a U.S. House Committee that data terminal equipment connected to computers has been increasing at greater than 30% p.a. since 1970. Salzman [17] reports a similar finding - the terminal sector of the data processing industry has been growing at a rate significantly higher than that of the industry as a whole, and this trend is expected to continue. Dolotta et al. [3] also endorses this view.

Communication News [18] forecasts that front-end processors, stored programs and electronic control hardware will increase at an annual rate of 18.8% 1975-1980.

AFIPS [19] gives estimates of the installed base of data entry equipment in the U.S.: .554m in 1971, 1.8m in 1976 and (in $1976) $9 in 1976 to $20 m in 1981.

IDC [20] reports on general purpose terminals, 0.6 m rising to 1.5 m by 1980; these figures exclude an equal number of autotransaction and special purpose terminals.

Datamation [15] reports on the installed base for both general purpose and special purpose terminals. In 1975, a US value of .918 m GP and .315 m SP terminals was given with a 1980 forecast of 1.99 m GP and .975 m SP terminals.

Cerf and Curran [21] considered the maximum possible reasonable estimates for data transmission in the U.S. by considering the growth of 3 key sectors: EFTS, POS & electronic mail. Their conclusions were that the maximum expected level of new data traffic in 1986 is $4.5 b p.a. In 1976 the level of data transmission was $1.64 b; thus a growth rate of 10.6% is implied. Cerf and Curran point out that in terms of revenues, non-voice in 1986 will not exceed 7% of voice revenues.

ATT have given estimates of the potential market for data communications and data transmission costs. [22,23]

$b	1965	1975	1980	1985
Communication Costs	1.0	5.5	12.0	22.5
Transmission	.55	1.7	3.2	5.5

Transmission falls as a percentage of total communication costs as intelligent (smart) terminals take over some of the data handling functions.

For comparison, some non-U.S. growth forecasts are given. These data points are not used in the subsequent analysis.

A Eurodata [24] study on European Computer and Communications Markets 1973-1985 predicted an average annual growth rate of 20% for data communications traffic. Curran [ ] cites reports for Canada and the UK in which a growth rate of 25% p.a. were estimated, based on 1970 figures.

In 1977, IDC undertook a study of EDP users in thirteen Western European countries [25]. The growth rate for expenditure on terminals and communications 1977 to 1982 is 20.3%. In a related study on distributed processing/data communications, IDC estimated communications related costs (hardware, remote services and lines) rising from $5 b in 1973 to $30 b in 1983.

Finally, to check whether these growth rates were possible, a telephone interview with company personal from Texas Instruments was undertaken [26]

Texas Instruments is one of the leading manufacturing firms of distributed processing equipment. In terms of terminals, minicomputers and calculators, Texas sees its volume increasing by a factor of 5 from 1977 to 1985. The demand is so high that in March 1978 their backlog on terminals was over six months.

These results are summarized (for the US) in Table 9.

Table 9

Forecasts of Installed Data Transmission Equipment and and Traffic in the U.S.

	Period	Mid Yr Point	Average Growth Rate %
Irwin [16]	1970-	1970	30.0
AFIPS [19]	1971-76	1974	26.6
Curran [13]	1975-80	1978	19.1-25.6 (22.25)
Curran [13]	1975-80	1978	17.1
Comm. News [18]	1975-80	1978	18.8
Datamation [15]	1975-80	1978	19.2
A.T.T. [22]	1975-80	1978	13.5
I.D.C. [20]	1976-80	1978/9	25.7
AFIPS [19]	1976-81	1979	17.3
Cerf & Curran [21]	1976-86	1981/2	10.6
A.T.T. [22]	1980-85	1983	11.4

From Table 9, it is clear that the rate of growth of data transmission decreases over time. This is in keeping with other reports on the diffusion of a new technology - a rapid growth at the period, followed by a slower rate of growth over time.

A suitable form to estimate such behaviour is:

$$GR = a_0 + a_1 e^{-\alpha T} \qquad (2)$$

where GR = growth rate

T = mid point of estimate.

Since only 11 data points exist, and there is very little information about the asymptotic level a_0, a number of options are open. The method chosen was to choose a medium value of 10%, and to run a sensitivity analysis for $a_0 = 6\%$ and $a_0 = 14\%$. Consequently 3 forecasts are given - low, medium and high.

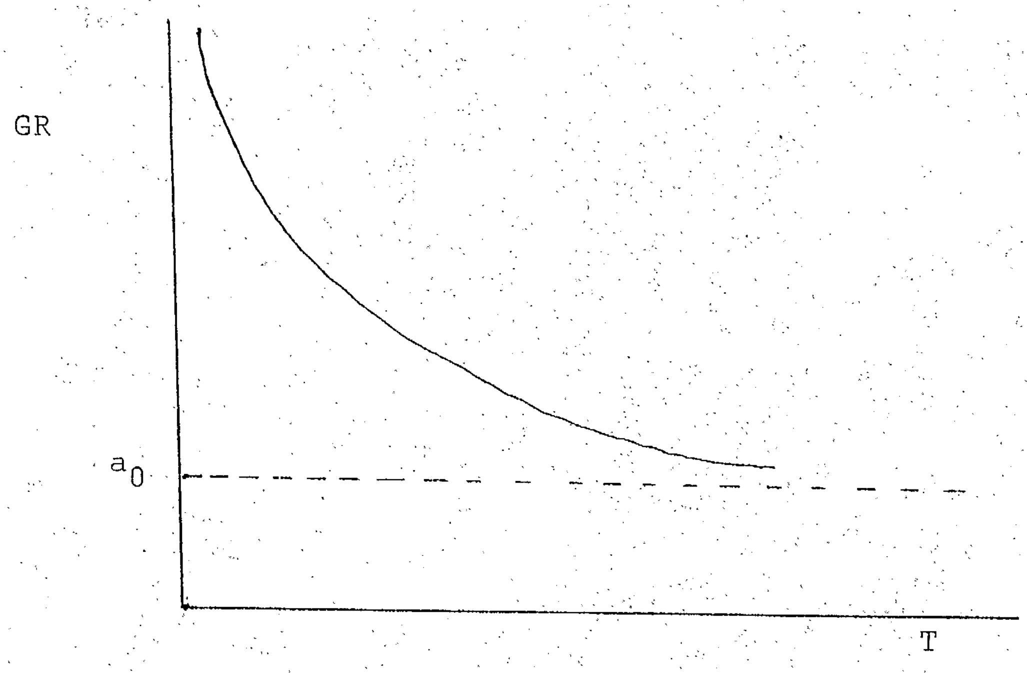
The graph of Equation 2 is shown in Figure 2. As $T \to \infty$, the growth rate tends asymptotically to a_0. At $T = 0$, $GR = a_0 + a_1$. The results for $a_0 = 10$ are shown below:

Coeff.	Value	t-stat.
a_0	10	-
a_1	21.7961	5.7
α	.1171	4.0

DW · 2.2449 R^2 = .6254

Figure 2

Data Transmission Growth Rate Function



$$GR = a_0 + a_1 e^{-\alpha T}$$

The fitted values for the growth rate of data transmission 1970-1985, is shown in Table 10. As can be seen, although the fitted values are sensitive to the choice of a_0, there is not a great deal of difference between the three estimates.

This process is one of a number of possible ways of obtaining the growth rate of data transmission from the data shown in Table 9. It is not particularly sophisticated; rather it attempts to use as much information as possible from various expert forecasts. In a sense that an average is taken, the process can be compared with the Delphi techniques (for surveys) which reduces the variance of survey responses by a feedback mechanism. In this case the variance is reduced by a best fit mechanism.

To compare the growth rates shown in Table 10 with actual data, the rates are applied to the 1973 value for U.S. data transmission (from Table 8).

Year	Achieved USDT	Predicted USDT		
		Low	Med	High
1973	885	885	885	885
1974	1091	1113	1109	1103
1975	1350	1380	1371	1357
1976	1640	1690	1675	1650

The predicted values track well. Not a great deal of difference occurs between the 3 estimates, since the asymptotic values

Table 10

U.S. Data Transmission Growth Rates

	Low	Medium	High
a_0	6%	10%	14%
1970	31.89	31.80	31.54
1971	29.65	29.39	28.84
1972	27.61	27.24	26.56
1973	25.74	25.34	24.63
1974	24.04	23.64	22.99
1975	22.48	22.14	21.60
1976	21.06	20.79	20.44
1971	19.76	19.60	19.45
1978	18.57	18.54	18.61
1979	17.48	17.60	17.90
1980	16.49	16.76	17.30
1981	15.58	16.01	16.79
1982	14.76	15.35	16.36
1983	14.00	14.76	16.00
1984	13.31	14.23	15.69
1985	12.68	13.76	15.43

only have an effect at high values of T. The "high" prediction has lower values since the function has a steeper slope initially.

Forecasts for the U.S. are shown in Table 11, using 1976 as a starting value. The Canadian estimates are derived in the same way as for Table 8, i.e.

$$CDT = SF. TLF. USDT.$$

Canadian data transmission rates are shown to grow at 22.1% 1975-80, and 15.6% 1980-85. The difference between the medium forecast and the high value for 1976 is 4%; this is the largest difference. Consequently the medium figure - which gives a 1985 value of $426 m, will be taken to represent the Canadian forecast.

Table 11

Predicted Data Transmission; U.S. and Canada

$m

Year	U.S. Low	U.S. Med	U.S. High	Canada Low	Canada Med	Canada High
1973		885			43	
1974		1091			58	
1975		1350			76	
1976		1640			96	
1977	1985	1981	1975		119	
1978	2377	2369	2359		145	
1979	2819	2809	2798		173	
1980	3312	3303	3299	207	206	206
1981	3858	3856	3870		242	
1982	4469	4473	4520		281	
1983	5117	5160	5260		324	
1984	5834	5922	6102		372	
1985	6610	6764	7059	416	426	444

Annual Average Growth Rate	U.S. Low	U.S. Med	U.S. High	Canada Low	Canada Med	Canada High
1975-1980	19.7%	19.6%	19.6%	22.2%	22.1%	22.1%
1980-1985	14.8%	15.4%	16.4%	15.0%	15.6%	16.6%

V. Comparisons

There are two separate comparisons that can be made, the first is a U.S. occupation summary, and the second the computer/communications report.

In the U.S., it is known that the ratio of the computer service industry to total EDP spending is approximately 14%. Taking the Computer Manpower outlook figures [27] figures:

	Employed persons: Programmers, Systems Analysts and computer specialists n.e.c.		
	Computer Service Bureau	Total	Service Bureau / Total
1970	38365	279204	13.74%
1980	56058	415000	13.51%

Taking a 1975 figure of 13.6%, and applying it to total Canadian and U.S. EDP spending (Table 8):

$m	US EDP Total	CAN. EDP Total	Computer Service Bureau U.S. Actual	Computer Service Bureau U.S. Predicted	Computer Service Bureau CAN. Actual	Computer Service Bureau CAN. Predicted
1975	34315	2350	4550	4666	318.6	320

The actual and predicted values are very close, thus giving our results a confirmation for internal consistency.

The Computer Secretariat [9, 28][12] gives estimates for the level of EDP expenditure in Canada, as well as levels of data transmission. These are based on the data given by Statistics Canada for the computer service industry [8], scaled up to represent total EDP expenditure. The results for total EDP expenditure for 1975, $2705 m, given by the secretariat in the Dec. 1977 estimates - compares moderately well with the figures reported in Table 8 ($2350 m).

However, the estimates for data transmission in Canada are very different from those reported here. The Secretariat estimates data transmission levels of $120 m in 1975 rising to $690 m in 1985; from Table 11, our respective values are $76 m and $426 respectively. The main source of discrepency is the 1975 figure. Much of the reason for this discrepency arises from assuming data transmission was responsible for 4% of computer service bureau costs, based on the 1974 Statistics Canada report.[8] Based on the 1975 report, which gives data transmission levels separate from other communication charges, a figure of 3.2% is given for the percentage of total costs accounted for by data transmission. Prorating the Secretariat's figures respectively would reduce the $120 m figure to $96 m.

The other discrepency is the difference in total EDP expenditure. The Secretariat assumed that simple scaling of the computer service sector was not admissible (as was done in the 1976 report) because of high levels of importation of computer services. Thus it was suggested that the size of the computer service industry in Canada is biased low compared to the size it would be if it reflected all purchased outside services [29]. Preliminary estimates suggest that imports may be as high as 50% of the Canadian computer service total revenue in 1975.

In 1975, the Canadian computer service industry reported services valued at 2.8% of total revenues. In 1976 the U.S. computer service industry (software type) has international sales valued at 7.9% of total revenues. Thus the supposition that Canada is a net importer of computer services seems reasonable.

However many of the services offered in the U.S. are not available in Canada (e.g. specialized data bases), though the situation is changing. Consequently much of the imports are not substitutes for domestic operations. Since the scaling factor for computer services is in good agreement with both the occupational scaling factor and the governmental scaling factor, and since also both in the U.S. and Canada the revenue of the computer service industry is $\approx$ 14% of total EDP expenditure, there appears no reason to reject the value of total EDP expenditure of $2350 m in 1975 for Canada. Prorating the figure of $96 m by 2350/2705 gives $83 m, which is close to the value of $76 m given in this report.

Finally, the growth of data transmission between 1975-1985 is seen as very similar in percentage terms. The Secretariat predicts an increase from $120 m in 1975 to $690 m in 1985, equivalent to an annual growth rate of 19.1%. The medium forecast given in Table 11 predicts a growth from $76 m in 1975 to $626 m in 1985, equivalent to an annual growth rate of 18.8%.[13]

VI. Conclusions

The level of non-voice data transmission in Canada for 1975 has been estimated at $76 m, and is expected to rise to $206 m by 1980, and to $426 m by 1985. This implies annual growth rates of 22.1% and 15.6% respectively. For 1975, non-voice data transmission represents only 2.7% of total operating revenue of the Canadian Telecommunication Carriers [30].

Footnotes

1 Without interconnection. With interconnection these growth rates are substantially higher. Caution must be used with these estimates since they reflect market share assumptions by CN-CP.

2 EDP - electronic data processing. The term ADP - automatic data processing - is synonymous.

3 Source [5, 6]. Totals exclude military, agricultural workers and domestice servants.

4 Source [7,8]. 1973 employment figures for Canada assumes the ADP equipment sector was responsible for 48% of the employment for this sector. On the revenue side, certain data was not published by Statistics Canada to preserve confidentiality. The following assumptions were used: Computer facility management: 45% systems maintainance, as in 1975. Education: 2.2% of operating revenue (excluding hardware and maintanance). In 1973, hardware firms responsible for 15.4% of software operating revenue, as in 1975. 1976 revenue based on 21% growth rate estimated by Evans [31].

5 Source [11,12]. Operating costs are defined as:

U.S. Personnel, rent, contract and production supplies.

CAN. All direct EDP operating costs, excluding imputed rent, including employee benefits. For early years, imputed rent was calculated based on percentages shown in later years. Both sets of data are for general systems.

6 Source [19,32,33,34]. The data presented in this table excludes government. The Canadian weighted total is given by

$$\Sigma \frac{CL_i}{USL_i} \cdot USEDP_i$$

where

CL_i = % Canadian labour force in sector i

USL_i = % U.S. labour force in sector i

$USEDP_i$ = % US EDP expenditure for sector i.

7 Source [7,8,11,12].

For the computer service industry, the U.S. data is for 1976, the Canadian data is the average of 1974 and 1975. The expenses for Canadian firms are based on a panel of establishments primarily engaged in providing computer services. For 1974, the Canadian computer service industry structure is assumed to be the same as in 1975.

For the government sector, data for both countries is the average of FY 1973-4 to FY 1976-7. Net direct operating expenses include all direct operating expenses except imported rent, and also include employee benefits. Contract services (cost of commercial services) includes equipment maintainance, data transmission costs, external facilities, software acquisition and consultants.

8 Data transmission for the computer service sector in Canada as a percentage of total revenue is significantly less in 1975 than in 1976. In 1974, the entry for communication

costs covered all voice and non-voice communications - telex, telephone, telegraph, postage and data communications. The 1975 entry gives separate data communications costs.

9 Datacom '76 [35] reports on a survey of traffic by industry. Service bureaus generate 42% of the data communications traffic, even though they operate only 21% of the central site hardware. On a per company basis, the service bureau respondents generate far more data communications traffic than any other type of company.

10 Source: U.S. EDP expenditure from IDC [36] and Hopewell [37]. Overhead was assumed as 22% of total EDP expenditure.

U.S. Computer service industry data based on ADAPSO report [7]. Transmission costs were taken as .64 of data communications costs (Hopewell [37]).

Canadian computer service industry expenses based on a panel of firms primarily engaged in providing computer services [8].

Canadian government EDP data are taken from Treasury Board report [ ]. Data transmission costs are for fiscal years, and are given as a percentage of Net EDP costs.

11 U.S. Data Transmission from I.D.C. [11] and Hopewell [37]

12. The estimates given by the Secretariat in December, 1977 [28] are preliminary, and the discussion using this data should be considered in this light.

13. The growth rate 1975 to 1985 for the low estimate is 18.5% and for the high value 19.3%. Thus the Secretariat's growth figure is in good agreement with the growth rates utilized in this report.

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